

CONSUMER SOVEREIGNTY AND ENTREPRENEURSHIP

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by

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CONSUMER SOVEREIGNTY AND ENTREPRENEURSHIP

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This dissertation is dedicated to my wife Jenna. Partners in everything we do.
Eternal friends.

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CONSUMER SOVEREIGNTY AND ENTREPRENEURSHIP

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ABSTRACT

In this dissertation I explore the role of the consumer in the entrepreneurship process. Whereas so far entrepreneurship theory has paid cursory attention to consumers, recent research has begun to uncover an increasing role for the consumer in entrepreneurship processes, from idea generation to outcome determination. Theorists so far understand this consumer involvement as exceptional and strictly unnecessary. I challenge this view, offering a novel framework founded in the Austrian School of economics and the principle of “consumer sovereignty,” which suggests that entrepreneurship is universally consumer-driven. That is, consumers are not in some cases involved in entrepreneurship. Instead, I suggest that if we trace back entrepreneurship to its very origin, we will find in each and every case an unsatisfied consumer. Here I outline a general theory of entrepreneurship built around the consumer sovereignty principle. I then explore the importance of a profound knowledge of consumer needs, in conjunction with technical knowledge, in generating valuable innovations, and test these factors in an experimental design. Finally, I revisit the new product diffusion and industry formation theories, and reconsider the role of the consumer in determining new product success. I propose that consumers’ uncertainty may be the primary and driving mechanism that underpins new product diffusion, and demonstrate its theoretical viability in an agent-based model.

1. INTRODUCTION

Entrepreneurship research has come a long way since its emergence as a separate and legitimate field of academic study. In spite of this progress, however, it remains plagued by fundamental issues that continue to be hotly debated. Even the very essence of the entrepreneurial function, or the role that the entrepreneur performs in economics, remains widely disputed, as many believe it to be a discovery function (e.g. Kirzner, 1973; Shane, 2003), some consider it an innovation function (e.g. Alvarez & Barney, 2007, 2013; Schumpeter, 1934), others insist that it is a judgment function (e.g. Foss & Klein, 2012; Knight, 1921; Mises, 1949), and still others hold that it is simply a managerial function (e.g. Parker, 2009). The result of this disagreement is that entrepreneurship theory has remained foundationally weak and unstable, unable to adopt a single, viable lens through which the various effects that are incrementally discovered can be interpreted. Furthermore, without a single foundation, we have so far been unable to explore the origins of the entrepreneurial process. That is, we have yet to ascertain *how* and *why* entrepreneurship emerges.

At the heart of these issues, I contend, is a supply-side focus that has narrowly circumscribed our theoretical vision to the intentions, abilities, and actions of the producer, the entrepreneur. My intent is to highlight the demand side of the equation, or the consumer's role in productive activities, which has historically been largely ignored in economic theory. This tendency dates back to the early days of economics, as economist Ludwig von Mises (1949: 62-63) lamented of his day:

“[T]hey could not trace back the phenomena of market exchange and of production to their ultimate sources, the behavior of the consumer... They had to

satisfy themselves with a theory explaining only the activities of the businessman without going back to the choices of everybody as the ultimate determinant. They dealt only with the actions of businessmen eager to buy in the cheapest market and sell in the dearest. The consumer was left out of their theorizing.”

More recently, however, there has been an incremental shift of attention toward demand-side factors as they relate to management and entrepreneurship (e.g. Adner & Levinthal, 2001; Adner & Zemsky, 2006; Bogers, Afuah, & Bastian, 2010; Fabrizio & Thomas, 2012; Priem, 2007; Priem, Li, & Carr, 2012; Shah & Tripsas, 2007; von Hippel, 2005; Webb, Ireland, Hitt, Kistruck, & Tihanyi, 2011; Zander & Zander, 2005). That the consumer can have a role in the process of innovation and entrepreneurship is now generally acknowledged. The extent and magnitude of this role, however, remains largely unaddressed. It is to this issue that I direct this research.

While modern demand-side research suggests, broadly, that consumers *can* have a role in entrepreneurial and innovation processes (e.g. Baldwin & von Hippel, 2011; Franke & Shah, 2003; Lüthje, Herstatt, & von Hippel, 2005; Shah & Tripsas, 2007) a more in-depth inspection of these processes reveals that consumers are at their very heart. That is, consumers are *always* and *necessarily* involved in innovation and entrepreneurship.

The basis for this rather radical claim is in the concept of *consumer sovereignty*, a term attributed to economist William H. Hutt (1936), which has been fundamentally integrated into the Austrian theory of entrepreneurship as outlined by Mises (1949). In short, consumer sovereignty suggests that individuals hold two key roles individually and within society: a producer role, and a consumer role. It is the consumer's role to

ascertain what the individual needs to maximize their well-being. It is the producer's role to procure satisfactions for those needs given the resources available. In this sense, it is the consumer who directs economic production and not the producer, as the producer only acts as instructed, directly through specific demands or indirectly through economic demand, by the consumer.

Adopting this notion of the sovereignty of the consumer into the concept and role of the entrepreneur in economic activity, Mises (1949: 270) says:

“The direction of all economic affairs is in the market society a task of the entrepreneurs. Theirs is the control of production. They are at the helm and steer of the ship. A superficial observer would believe that they are supreme. But they are not. They are bound to obey unconditionally the captain's orders. The captain is the consumer.”

If we are to understand from whence entrepreneurship emerges, how, and what makes it successful or not, we must turn our attention to the consumer, and not the entrepreneur.

In the following chapters I begin to explore these questions. In Chapter 2 I begin an exploration of where the idea for a new venture comes from, when and why it is or is not determined to be a good idea, and how entrepreneurial intent is formed. In it I challenge modern definitions of entrepreneurial opportunities at a fundamental level, attempting to push the concept of opportunities away from socially constructed demand toward a more individualist and objectively justifiable notion of unmet consumer needs. As unmet needs, the process of opportunity recognition becomes a task of the consumer who learn of their needs over time through experience (Witt, 2001). The personal and tacit nature of this knowledge of consumer needs has important implications regarding

the source of ideas, their value, and firms' ability to generate or acquire such ideas. The process of entrepreneurship, then, can be understood as being comprised of three stages, a discovery or recognition stage (consumer), a solution generation stage (innovator), and a judgment stage (capitalist). Delineating this process as such, we can therefore better understand and reconcile different approaches to entrepreneurs, i.e. the discovery (Shane, 2003), creation (Alvarez, Barney, and Anderson, 2013), and judgment (Foss and Klein, 2012) perspectives, as not different sources of entrepreneurship per se, but rather as different aspects of the general entrepreneurship process.

Chapter 3 focuses on the second stage of entrepreneurship, the process of innovation, and the role of needs knowledge in this process. In brief, innovation can be understood as a problem-solving process whereby the innovator applies possessed knowledge of various resources, technologies, and their capabilities toward the resolution of recognized consumer needs. It is in the interaction of needs knowledge and technical knowledge that innovations can emerge. I examine the cognitive processes involved in this creative process, and the factors that may be involved in facilitating the successful combination of these distinct types of knowledge. I test this explanation in an experimental design, finding good empirical support for this knowledge-based approach.

Finally, Chapter 4 looks at the consumer's role in determining new product performance. Specifically, I highlight consumers' uncertainty regarding the value of new product introductions in producing understood diffusion patterns, including diffusion results that so far have gone largely unaddressed such as new product failures. Employing complex agent-based modeling techniques, I simulate the new product diffusion process using individual-level decision criteria, demonstrating the theoretical

capacity of the consumer uncertainty construct to successfully explain the traditional S-curve at varying rates, new product failures and the “chasm” phenomenon (Moore, 1991), and other key results.

In all, I emphasize the under-appreciated role of consumers in and throughout entrepreneurship processes. Scholars, I contend, have so far focused too much of their attention on the entrepreneur, her creativity, characteristics and abilities, decision processes, and so forth at the exclusion of key demand-side factors that are at the heart of entrepreneurship. The consumer sovereignty principle redirects attention to consumers, who are the source and purpose of entrepreneurship and the determinants of its outcomes.

2. CONSUMER SOVEREIGNTY AND THE EMERGENCE OF ENTREPRENEURSHIP

ABSTRACT

Entrepreneurship, as a field, has struggled to address fundamental issues regarding the nature of entrepreneurship and its origins. Here I propose that these issues may be addressed to a great extent by taking a demand-side approach to entrepreneurship. Specifically, I employ the consumer sovereignty approach espoused by the Austrian School, and propose that opportunity be reconceptualized in terms of unmet consumer needs. Under this new definition, I offer a new theory of entrepreneurial emergence which places the consumer at the source of entrepreneurial ideas. I propose that consumers alone can recognize and understand their needs due to the complex and tacit nature of needs. This recognition may drive consumers to ameliorative action, which action may include innovation and entrepreneurship. Under this new framework I construct a three-stage theory of entrepreneurship which begins with consumers' recognition of unmet needs, involves a creative process of solution generation through the innovator, and ends with the judgment of the capitalist.

INTRODUCTION

“Necessity is the mother of invention.” – English proverb

Webb and coauthors (Webb, Ireland, Hitt, Kistruck, & Tihanyi, 2011) recently asked, “Where is the opportunity without the consumer?” That the customer can play an important role in the innovation process has long been acknowledged (e.g. Shane, 2000;

Chesbrough, 2003; Vargo & Lusch, 2004; Shah & Tripsas, 2007; von Hippel, 2005). Still, the consumer has not gained a strong place within entrepreneurship theory, but has largely played an outsider role in the current framework. As a result, we know comparatively little about the antecedents of entrepreneurship, such as where the opportunity comes from (Shane, 2012), how ideas are generated, and what drives certain individuals and not others to take on the risks of entrepreneurship. Addressing this gap, I offer a new theory of entrepreneurship which incorporates the role of the consumer into its framework and suggests, ultimately, that entrepreneurship has at its core the consumer.

An important part of the entrepreneurial process is finding a problem to solve (Pounds, 1969; Runco, 1994; Chand & Runco, 1993). These problems are not simply manifest, but must be discovered (or created) and understood. That we know little of how this process unfolds is evident by common references to idea generation as the “fuzzy front end” of the innovation process (Smith & Reinertsen, 1991; cf. Brentani & Reid, 2012; Eling, Griffin, & Langerak, 2013). How do these entrepreneurial opportunities emerge? How is their value determined? Why are entrepreneurs alert to some opportunities but not others? I would contend that much of the ongoing debate and confusion regarding the nature and process of entrepreneurship is the result of little investigation into the foundations of entrepreneurship which underpin the process of finding a problem to solve. Unraveling this process may offer key insights into how and why entrepreneurship emerges, who decides to become an entrepreneur, and how or why some ventures are successful while other are not.

In this paper I propose that the key to unlocking the source of the entrepreneurial problem, and thus the initiation of the entrepreneurial process, is in understanding the consumer. By acknowledging that new markets emerge as multitudes of individual consumers begin to recognize a particular product or service offering as a viable solution to some yet unmet need, we begin to see that the consumer plays a pivotal role in the entrepreneurship process and in determining its success. Indeed I contend that the consumer provides a central piece to the entrepreneurship puzzle that has so far been largely missing.

Modern entrepreneurship theory, and especially the discovery approach (Kirzner, 1973; Shane, 2003) speaks primarily to the discovery and exploitation of existing and recognizable solutions to consumer problems, thereby establishing new means-ends frameworks. How those problems and their solutions first come to exist, however, remain largely unexplored (Shane, 2012). Notable exceptions (e.g. Shane, 2000, Hsieh et al., 2007) have highlighted the role of prior or acquired knowledge in the discovery process, but the details surrounding this knowledge and its origins are notably sparse. By incorporating the consumer into entrepreneurship theory, we gain a new perspective on who or what is at the source of the entrepreneurial opportunity and how creative new product solutions emerge. Specifically, I posit that the entrepreneurial process, when traced back to its source, ultimately originates with a consumer who experiences and recognizes a need. That is, while, as Steve Jobs famously suggested, *many* consumers discover what they want only once someone provides them with a solution, I propose that such a solution necessarily originates with some consumer who first recognized an unmet need and set out to resolve it. This approach differs from previous theories of user

innovation and entrepreneurship (e.g. Priem, Li, & Carr, 2012; Shah & Tripsas, 2007; von Hippel, 2005) in that they have named users as an alternative source of entrepreneurship, that consumers *can* be sources of innovation or opportunity, whereas I place the consumer at the very heart of entrepreneurship theory, suggesting that *all* entrepreneurship begins, ultimately, with a consumer.

At the core of this approach is the consumer sovereignty perspective (Hutt, 1936; Mises, 1949), which suggests that consumers, and not producers (i.e. entrepreneurs), ultimately dictate the allocation of productive resources toward the satisfaction of their needs. Entrepreneurship, then, is a process by which consumers seek to newly address their unmet needs. Thus it becomes critical to better understand these needs, their source, and how they are recognized in order to capture from whence the entrepreneurial opportunity emerges. I invoke the two-process model of individual needs recently developed by Sheldon (2011) to explore the nature of consumer needs. This model incorporates self-determination theory (Deci & Ryan, 1985, 2000), as well as motive disposition theory (McClelland, 1985) to suggest that individuals experience needs which are manifest at different levels. Under the two-process model I distinguish between innate *needs*, which are basic necessities required for proper human functioning and subjective well-being, and motivating *wants*, which are derived expressions or perceptions of underlying basic needs, and also distinguish these from consumer demand and willingness to pay, which bring affordability into consideration. To get to the source of opportunity we must explore below the superficial level of consumer demand and investigate the underlying source of that demand.

In all, I bring together these theories and the emerging demand-side or customer-based view of strategy (Priem et al., 2012; Zander & Zander, 2005) to offer a demand-side theory of entrepreneurial emergence, i.e. how and from whence entrepreneurship originates. Prior demand-side research on entrepreneurship has built on Kirzner's (1973) concept of alertness to suggest that entrepreneurs may benefit from their association with their customers (Priem et al., 2012). That is, entrepreneurs may be able to recognize more or better opportunities by maintaining close relationships and regular communications with their expected customers (Zander & Zander, 2005). I push this notion further to suggest that consumers are the source of all entrepreneurial opportunity and that they alone can recognize needs due to the personal and tacit nature of those needs. I propose that new product ideas are primarily the result of an individual need, and are derived from both the recognition of that need and a sufficient familiarity with resources which might be employed toward the resolution of those needs. As such, I posit that entrepreneurs (producers) may discover new product opportunities only through the consumer, either through their own experience as a consumer (i.e. user entrepreneurship) or through observation or communication with other consumers (i.e. non-user entrepreneurship). This theory offers important insights regarding how and why some become entrepreneurs where others do not, and gives a new glimpse into the determinants of entrepreneurial success.

THEORY

Building on economics' notion of consumer sovereignty, I propose a model of entrepreneurial emergence in which the entrepreneurial opportunity emerges as an unmet

figure that the solid arrows reflect strong causal links, which have been well established and understood in the literature. The dotted arrows, however, denote weak causal links, meaning that only in some circumstances will they lead to the indicated outcome. I argue that it is toward a deeper understanding of these conditional paths, of how and when they lead to the outcome of interest, that we must turn our attention moving forward.

Consumer sovereignty

The notion of the sovereignty of the consumer dates, at least, to Adam Smith, and is recognizable in popular slogans such as “the customer is always right.” It was formalized by economist William H. Hutt (1936), who suggested that it is through consumer demands (or refraining from demanding) that production is directed. He perceived that individuals have a twofold relationship to society, as a consumer and as a producer. As producers, they are servant to the community of consumers, utilizing their own resources, skills, and knowledge to produce consumable outputs, both for their own selves and for others in exchange for claim on others’ outputs. As consumers, they command other producers, demanding products and services which satisfy their needs. We perform our role of producer so that, ultimately, we may consume according to our desires, whether that consumption be of products, services, or of enjoyable activities (including even, perhaps, the productive work they perform). In other words, it is the role of the *consumer* to maximize the individual’s well-being through the satisfaction of their personal needs, and the needs of those they care for, from the limited resources available to them. The role of the *producer* or entrepreneur is, then, to enable the

consumer role by developing and providing those resources that may provide value and satisfaction for the consumer (Mises, 1949).

For clarity, let us define the role of the consumer as the seeking out and consuming solutions to their various needs for the general improvement of their subjective well-being. At all times where the individual is performing this role he or she is acting as a consumer. The role of the producer, then, is defined as the application of personal resources and capabilities toward generating consumable outputs. The individual is a producer, then, only when he or she produces (or attempts to produce). While these roles are distinct and are generally performed separately, they are interrelated and inform one another.

Because it is the consumer role which is tasked with the maintenance of the individual's well-being, it is the consumer who dictates value (Priem, 2007). Consumers experience satisfaction and value through the experiential use of products and services which provide them with benefit toward their well-being (Vargo & Lusch, 2004). If an individual was perfectly well, there would be no potential for value, as there would be nothing which could improve their subjective well-being. But, of course, consumers can never achieve "perfect" well-being, but can always be more well, or achieve a higher quality of well-being, through the providing of more, better quality, or more effective solutions to their various needs. As such, consumers provide, in this sense, endless possibilities for value creation.

The nature of needs and opportunity

Here it is important to clearly define and understand the notions of needs, wants, and demand and their relationship with the concept of entrepreneurial opportunity (see Figure 2). I employ Sheldon's (2011) two-process model as a framework for understanding the nature of needs and wants. According to the two-process model, there are levels of needs which are reflected in the mutual exclusivity of human action and subjective well-being. At the lower level, needs are innate and, to an extent, homogenous, the satisfaction of which is explicitly tied to subjective well-being, as reflected in self-determination theory (Deci & Ryan, 1985), which posits that humans share the same basic needs, which may be satisfied in different ways. At the higher level, needs are personalized in specific tastes and preferences that drive action, as in motive disposition theory (McClelland, 1985), which posits that human needs are heterogeneous, and motivate a person to action toward resolving those needs. To properly distinguish these distinct types of needs, I term them, respectively, *needs* and *wants*. Note that the language employed here and throughout the paper is specific, and is not to be confused with popular, non-academic usages.

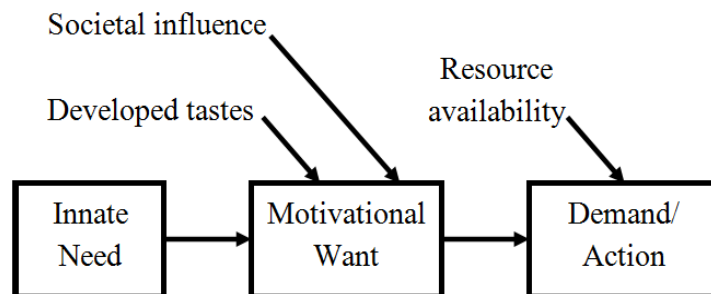
Needs

Consumer *needs* are defined in terms of latent "innate, organismic necessities" (Deci & Ryan, 2000: 229), or inherent physiological and psychological requirements for the maintaining of an individual's subjective well-being (Sheldon & Gunz, 2009). Each individual experiences these basic and fundamental human needs, but the extent to which they exist and are felt may vary widely between individuals (Sheldon, 2011). Further, these needs may evolve over time as we age, incur illness or injury, or experience other

changes. The satisfaction of these base-level needs can come from a variety of distinct and substitutable methods, but there is no finite limit to their satisfaction. Needs comprise two dimensions, i.e. a qualitative and a quantitative dimension, both of which may (depending on the need) present a potential for satisfactions *ad infinitum*. Note, however, that the satisfaction of needs is fundamentally distinct from one's life satisfaction or happiness (e.g. Hsee, Yang, Li, & Shen, 2009; Nicolao, Irwin, & Goodman, 2009; Richins & Dawson, 1992). One may be content with a particular level of satisfaction of any given need where another with an even higher level of satisfaction may not yet be content. Here I do not seek to address happiness, but to only speak to needs satisfaction, which directly impacts the subjective well-being of the consumer and only indirectly their happiness.

Consumers are not inherently aware of their needs. They are not born with an intuition of what, specifically, is needed, but only experience a recognizable sentiment of unwellness or dissatisfaction when a need is not met. This latency may dissolve over time as consumers learn through experience what satisfies them (Witt, 2001). Yet, because this learning occurs only through the experiences of existing solutions, it becomes difficult to isolate specific needs and deficiencies. Instead we only gain a more

FIGURE 2
Two-process Model of Human Behavior, adapted from Sheldon (2011)



general sense of what satisfies us by which we extrapolate an interpretation of the underlying needs. Thus consumers often become mistaken in their assessments of their own needs, or may never come to know certain needs at all.

Wants

The second type of needs which Sheldon (2011) distinguishes is the higher-level motivating needs which drive action (McClelland, 1985). These *wants* take on a more personal and subjective form, derived both from the aforementioned basic and fundamental needs as they are understood as well as the individual's developed tastes and their knowledge of existing solutions. While *needs* are, to some extent, homeostatic, consumer *wants* are malleable and can take various forms as there are multiple substitutable paths or solutions by which consumers' underlying needs might be satisfied. These wants form in a hierarchical manner, with more foundational cultural values, goals and aspirations, and acquired tastes leading to specific higher-level preferences (Huffman, Ratneshwar, & Mick, 2000). It is these highly transient end-level wants (and not necessarily needs) which drive human action (McClelland, 1985; Mises, 1949; Sheldon, 2011).

These wants become the explicit and recognizable expressions of one's interpretation of their own basic needs. Wants can be expressed and articulated, as they take the form of specific solutions which may or may not satisfy underlying needs. These wants are shaped by one's aspirations as they seek to reach or reflect some ideal self-image (Sirgy, 1980). But these aspirations may also be molded by social pressures, as individuals seek to shape what others think of them toward an ideal social self-image

(Sirgy, 1980). Thus some wants are derived directly, albeit imperfectly, from the needs which the consumer experiences. Others are socially derived, and may have little to do with underlying needs, except in terms of relatedness to social actors. For example, we may seek out something solely due to its popularity with some in-group, with little regard to any particular benefits it might afford toward specific needs satisfaction (Belk, 1988; Escalas & Bettman, 2005).

In sum, consumers act in response to their wants, but these wants often differ from their innate, basic needs. As a result, consumers often fail to properly address their needs, leaving them perpetually unsatisfied and unwell. Consider a young college student with a sweet-tooth who, when hungry, eats ice cream instead of the nutritious meal he knows he should eat. The hunger pangs inform him of his need for nutrition, but his want drives the action. By feeding the ice cream craving, the want is satisfied, but the innate need of proper nutrition is left largely unsatisfied, leaving him relatively unwell. It is only when wants become congruous with needs that subjective well-being can be better achieved.

Demand/Action

Action and demand are two sides of the same coin. Action occurs when the individual is both able and willing to expend personal resources (e.g. time, energy) on satisfying a particular want. If the want cannot be satisfied through personal action, whether it is because the consumer does not have sufficient resources to resolve the want or s/he is unwilling to expend those resources toward its resolution, s/he can instead pursue solutions to the want in markets, whereby individuals who may be more capable

of producing a solution can offer solutions to the want at a price the consumer may be willing to pay. *Demand*, then, is derived both from consumer wants and from their resource constraints, such that what consumers want may differ from what products they actually seek out for purchase. Specifically, consumers are limited in what they can actually demand of producers by what they have available to offer in exchange. What we *want* and what we can *afford* are very often different. It is this demand, then, that is most appropriately conceptualized as willingness to pay.

Opportunity

It is at the abstract level of demand that the opportunity has been traditionally conceptualized. Defined as “competitive imperfections... in product or factor markets” (Alvarez, Barney, & Anderson, 2013: 302), the typical concept of opportunities reflects a disconnect between the supply of and demand for a particular product or service. The entrepreneur, then, can potentially supply the unmet demand, correcting the market imperfection and capturing a profit as reward (Kirzner, 1973; Shane, 2003). However, as we see, demand is a high-level and abstract representation of consumer behavior which omits the causal systems which underlie it. This aggregation leaves many questions unresolved, such as what the source of the opportunity is, and how the opportunity comes about. The ambiguity which this definition leaves has led to difficulties and disagreements in uncovering the process by which these opportunities emerge (see, e.g., Alvarez & Barney, 2013; Dimov, 2011; Klein, 2008; Shane, 2012). But by coming to understand that what we call market imperfections are really abstract and aggregated

reflections of unmet consumer needs, we gain important insights both as to what opportunities are and how they come about.

Instead of the abstract market-level definition traditionally assigned the entrepreneurial opportunity, I define opportunity as *an unmet consumer need that some number of consumers experience and may be willing to pay to satisfy*. At this individual level, the issues which have so far proved aggravating and irreconcilable appear to evaporate. While this foundational level certainly has proven difficult for empirical measurement and testing, it allows a necessary theoretical soundness that has hitherto been elusive.

Following this alternative definition, the total economic value of any given opportunity may be represented by the total number and magnitude of the unmet needs that are satisfied by a solution in its final usage relative to the cost of producing and providing that solution (McMullen, Plummer, & Acs, 2007). Thus the perceived magnitude of the opportunity is contingent on an assessment of the pervasiveness of an unmet need and the extent that the need is such that those who experience it will be willing to pay to satisfy it. This economic value may be captured through business interaction in some division between the consumer (consumer surplus) and the producer (producer surplus). Notably, this economic value cannot be determined until the product is consumed, as it is in consumption that value is realized (Priem, 2007; Vargo & Lusch, 2004). As a result, the producer (entrepreneur) must make judgment under uncertainty regarding the future value a proposed solution will provide consumers (Foss & Klein, 2012).

Recognizing unmet needs

Needs can only be proactively addressed once they are recognized and understood. It is this recognition of unmet needs that constitutes the so-called discovery of opportunity which begins the entrepreneurial process (Shane, 2003). Understanding how these needs come to be recognized, then, is critically important for the further development of entrepreneurial theory.

It has long been suggested that the key to the discovery of opportunities is *alertness* (Kirzner, 1973). But what is alertness? Here I argue that the concept of alertness to opportunities is an oversimplified and misleading metaphor for the process of recognizing unmet consumer needs. I propose that it is not a unique quality of observance, but a coalescence of consumers' unique needs, possessions, personality, and contextual factors which lead to their recognizing that there must be a better way to satisfy their needs. In other words, it is generally in strong consumer *dissatisfaction* that opportunities to satisfy unmet needs can be recognized.

The model summarized in Figure 1 suggests that *consumption* is at the origins of opportunity recognition. Consumers learn of their distinct needs through consumptive experience, as they are able to compare their satisfaction levels as a result of that consumption to past experiences and expectations (Oliver, 2010; Ratneshwar, Shocker, Cotte, & Srivastava, 1999; Witt, 2001). Thus consumers are expected to be more able to understand their own needs, and how to satisfy those needs, by engaging in new consumption experiences. These experiences *may* increase their understanding of certain needs, depending on how that experience impacts those needs. For example, a strongly satisfactory or dissatisfactory experience may offer strong evidence regarding the

existence of a need, and may provide clues regarding its nature. Weak experiences, however, will likely offer little feedback to the consumer. Another important result of this point is that consumers' understanding of their needs is necessarily tied to the consumption options which already exist (Bennett & Cooper, 1981).

It should also be noted that the consumption experience may be influenced by factors other than the product or service itself (see Figure 1). For example, a sizeable literature finds generally that the timing and context of consumption influences the overall experience of satisfaction (e.g. Morrin & Ratneshwar, 2000; Frederick, Loewenstein, & O'Donoghue, 2002; Hirschman, 1984). Personality has also been named as a key factor in the consumption experience. For example, research suggests that positive personality orientations create a contagion effect which, in the end, positively influences the consumer's experience (Gountas & Gountas, 2007; Tan, Foo, & Kwek, 2004). Additionally, mood, which is strongly influenced by personality, has been shown to influence the consumption experience (Faullant, Matzler, & Mooradian, 2011; Knowles, Grove, & Pickett, 1999).

Another key factor in the experience of the consumer involves the consumers' personal affinity toward the particular activity. This affinity has been called many things, including passion (Belk, Ger, & Askegaard, 2003), involvement (Richins, Bloch, & McQuarrie, 1992), and engagement (Higgins, 2006). Notably, this engagement can be due to positive (e.g. a love for the activity) or negative (e.g. as a result of a threat) factors (Higgins, 2006). In sum, a strong involvement or engagement in a particular activity generally heightens the consumer's sensitivity to the experience, such that the experience is especially satisfying or dissatisfying, as the valence may be.

Unmet needs are generally recognized in the experience of dissatisfaction (rather than the lack of satisfaction) resulting from some consumption experience which leaves a need unfulfilled. That is, we typically do not recognize a need until we experience frustration from it, which experience makes us cognizant of its presence. Consider in Table 1, for example, some anecdotes from various entrepreneurs regarding how they came to recognize an opportunity. In these (and many other) examples, consumers discovered a problem that they initially were unaware of, to which they decided that there simply had to be a better solution. It was in their frustrated state that the recognition came.

As the examples in Table 1 show, if the consumer is left feeling unfulfilled (according to their various needs and desires) in the use of a product, they are more likely to become dissatisfied and desire a superior satisfaction of the need (Fennell, 1978; Oliver, 2010). This dissatisfaction may trigger ameliorative behavior, which response may be as simple as a longing for a solution, or may incorporate responsive action (Sheldon & Gunz, 2009; Sheldon, 2011). The strength of the dissatisfaction plays an important part in determining the resultant behavior. Where the dissatisfaction is strong, consumers are more likely to take action toward amelioration. When this dissatisfaction is weak or absent, consumers may content themselves with current solutions, even when their needs could potentially be better met (Leonard & Rayport, 1997).

Because of their personal, subjective, and tacit nature, these needs can only be recognized by the individual consumer. As consumers experience dissatisfaction in the use of existing solutions, they may begin to understand what, specifically, is keeping them from meeting their needs. Shah and Tripsas (2007) argue that, due to their unique

TABLE 1
Opportunity Recognition Anecdotes

ID	Founder(s)	Company	Anecdote
1	James Ambler	Paparazzi Proposals	"Paparazzi Proposals came about 4 years ago when I proposed to my wife, and after we started to tell friends and family about our engagement the first question everyone asked was 'how did he do it?' It got me thinking -- it would have been so cool to have pictures of me down on one knee. So I started looking into it and researching to see if there was anybody or any company out there offering this unique service, and there wasn't."
2	Curtis Williams	Belly Buds	"When my wife was pregnant with our oldest daughter, she used what she had [to let the baby listen to music] which was her regular tiny ear buds and pressed them to her stomach. But those are made for your ears, not your belly. So that's where the idea for Belly Buds was conceived."
3	Abe Geary	PetPaint	"I tried to get a shirt to stay on my dog and she tore it off immediately. I was like, there's gotta be something out there that they don't know they're wearing. So a couple of years of research and we have PetPaint now."
4	Paul and Cindi Pedrazzi	Yubo Lunchbox System	Paul: "It all started 4 years ago. As the proud parents of two beautiful little girls, we'd send them to school with your typical fabric lunchbox filled with those plastic baggies and 'personalized' with a permanent marker on the outside." Cindi: "We were going through nearly 2000 plastic baggies a year, not to mention these lunchboxes would come home completely nasty. They were not dishwasher safe, so I would do my best to wipe it down and, it was clean right? Wrong."
5	Jenn Deese and Kelley Coughlan	Pursecase	Paul: "We looked everywhere for a lunchbox that was easy to clean and good for the environment, but we couldn't find it. So we created Yubo." Jenn: "How many times have you heard [your phone ring] and had to dig through your oversized handbag to find your phone? And who wants to shove their smartphone in the back pocket of their skinny jeans? Not cute." Kelley: "So this leaves you with one option, and that is, carry your phone around with you in your hand, which you might accidentally drop, or you're gonna eventually pit down somewhere and forget about it and lose it. We kept asking ourselves, why isn't there something that keeps everything we need easy to access and secure?"
6	Melissa and Rick Hinnant	Grace and Lace	"Our story starts a couple of years ago. I had an idea for a cute little lacey sock that stuck out of my boots. So after about 9 hours on the sewing machine and a ton of frustration, I finally made my first pair. Everywhere I wore them people would stop me and ask me where I got them. When I said I made them, literally strangers would give me their phone numbers and ask me to make them a pair."
7	Jocelyn Fine and Kelly Dineen	Fohawx	"This whole concept... was inspired by my daughter. We were doing a family bike ride and my son, who was seven at the time, refused to wear his bike helmet. And my daughter, she ran into the garage, got some glue gun and some purple tissue paper, and she created a Mohawk right down the center of his helmet. And his whole attitude changed. He loved it. He thought he looked so cool. And I loved it because he was wearing his helmet."
8	Al "Bubba" Baker	De-boned Baby Back Rib Steak	"Sadly, I married a woman that doesn't like ribs because they're too messy. So I vowed to find a way for my wife to enjoy ribs. But how do you make ribs less messy? You take the bones out! After 20 years I found the perfect method and the De-boned Baby Back Rib Steaks were born."

experience as users, consumers have a privileged understanding of both what their needs are and how they may be addressed. This understanding may be further advanced in discussing their dissatisfaction and desired end-states with others (Gemmell, Boland, & Kolb, 2012), especially with those who might share that dissatisfaction, such as online user communities (Franke & Shah, 2003; Shah & Tripsas, 2007). The process of needs recognition, especially regarding how consumers refine their understanding of needs, warrants further elaboration and exploration.

Communicating needs

While I contend that the recognition of needs is confined to the consumer alone, they can be *perceived* by others through explicit or even implicit communications. Consider, for example, Rob Campbell's narrative of how the idea for PowerPoint software came about:

"I was sitting in the back of the plane... and I noticed half the people on the plane had their briefcases open, and they had overhead transparencies, and they were thumbing through them and marking them up. That really was kind of the genesis of why PowerPoint."

In this example we see that needs can be perceived in the communications and even behaviors of others, even if the entrepreneurs do not experience the need themselves. However, as I will show, this communication is imperfect, and often results in an inaccurate understanding of consumer needs.

Consumer needs communications are perhaps best thought of as being communicated from consumer to consumer. Recall that, under the framework of

consumer sovereignty, all individuals are consumers and act in the role of consumer as necessary to understand and satisfy personal needs. Because needs are learned and understood in the consumer role, it is most correct to say that needs are communicated to consumers, as the recipients of these communications can only understand those needs in the context of their own role as consumer.

When needs knowledge is expressed, only the explicit, and not the tacit, aspects of knowledge can be transferred in communications (Polanyi, 1958; Ribeiro & Collins, 2007). For knowledge which is more tacit, such as personal needs, once the explicit skeleton of that knowledge (i.e. information) is offered in communication, it is translated by the recipient into coherent knowledge through its interpretation using already held stores of personal knowledge. Like a game of ‘telephone,’ each passing of information representing tacit knowledge involves subjective interpretations and contextualization as it moves from “more satiated” to “less satiated” environments (Czarniawska & Joerges, 1996). This translation process necessarily suggests that individuals of varying personal needs knowledge stores will interpret these communications differently. A full communication of knowledge requires some requisite level of shared underlying knowledge structures so that an understanding may be complete . In the case of needs knowledge, such requisite underlying structures cannot fully exist across individuals as each individual possesses a unique learning experience gained throughout their life. Between some parties, the underlying structures may be reasonably similar, such as the case of user communities, allowing a more complete communication of needs knowledge (Franke & Shah, 2003; Shah & Tripsas, 2007). However, in the typical case, such

structures are generally too different between producer and customer due to inherent differences in experience to achieve a high level of mutual understanding.

The metamorphosis of market research serves to illustrate how needs can be perceived by others, and how firms have adapted to improve their understanding of tacit consumer needs. Early market research typically sought information regarding consumer needs through verbal articulation or explicit communication (Bayus, 2008). These techniques included customer surveys, projective tests, focus groups, suggestion systems, and preference mapping. Market researchers then turned to more implicit communication methods such as observation to try to capture those needs that often go unarticulated (Bayus, 2008). Extending this principle further, recent research has explored the value of empathic observation or perspective taking, that is, in placing market researchers within the context and situation of the consumer (e.g. Leonard & Rayport, 1997; Liedtka, 2011; McMullen, 2010). Various methods that take this approach in one form or another have emerged, including the “experiential interviews” of the ‘voice of the customer’ approach (Griffin & Hauser, 1993), customer visits (McQuarrie, 2008), journey mapping (Liedtka, 2011), contextual inquiry (Holtzblatt & Jones, 1993), and ethnographic design (Blomberg, Giacomi, Mosher, & Swenton-Wall, 1993). In some cases, customers are even invited to participate directly in the design of new products (Chesbrough, 2003; Fang, 2008; Schuler & Namioka, 1993), thus partially avoiding this communication altogether.

In all, while firms have taken steps to increasingly learn and understand the needs of their customers, the process of communicating needs is inherently fallible. The personal, unique, and subjective nature of needs cannot be fully communicated. Indeed,

as I have argued above, consumers themselves do not fully know or comprehend their own needs. As a result, firms and perceptive entrepreneurs are left to their own imperfect interpretations of needs, which they resolve imperfectly, resulting in a high variability of outcomes.

THE THREE-STAGE ENTREPRENEURIAL PROCESS

Following the revised definition of opportunities above, entrepreneurship may be defined as the process by which unmet consumer needs are newly addressed (Mises, 1949), in contrast to the typical definition as the exploitation of entrepreneurial opportunities, understood as corrigible market imperfections (Shane, 2003). Recall that it is consumers, in recognizing their needs, who direct the efforts of the entrepreneur. In Schultz's (1975, 1980) human capital approach to entrepreneurship he suggests that we all act entrepreneurially in some aspects of our lives by employing our human capital toward the reallocation of resources for a better satisfaction of our needs (cf. Mises, 1949). Homemakers, for example, purchase household equipment, acquire food items, provide care and education for children, and seek to reallocate the various resources at their disposal for the most efficient and effective production of daily necessities for their families. The more skill they have, and the higher the quality and quantity of resources available, the greater the quality of production, and the greater the satisfaction of needs, they can attain for their families (Priem, 2007).

Yet, while we each act entrepreneurially according to this framework, only in some rare instances does the response to a need result in new business venturing. Most consumer responses result in market searches for superior solutions, or even household

bricolage (Baker & Nelson, 2005; von Hippel, de Jong, & Flowers, 2012). This section outlines when and how innovation and new business formation generally come about and the primary factors which influence their possibility.

Figure 1 summarizes a general three-stage entrepreneurial process. The first stage, detailed in the preceding section, comprises the discovery or recognition of unmet consumer needs as opportunities for value facilitation. In the second stage, once a consumer problem has been found, a solution to the problem may be created through an innovation process. In the final stage, the entrepreneur must judge whether the innovation has enough total economic value, i.e. value for consumers relative to the cost and effort required, to warrant taking action in bringing it to market. Only when all three stages are successfully completed will new venture or corporate entrepreneurship occur.

Stage 1 in this process has been detailed in the preceding section. In this section I introduce the second and third stages of this general entrepreneurial process, i.e. innovation and judgment/action.

The innovation of solutions

The second stage involves the innovation of a solution to the previously recognized unmet consumer need, which is the role of the *innovator*. In contrast to Kirzner's (1973) arbitrage approach to entrepreneurship, Schumpeter's (1911) seminal work equates the entrepreneur with the innovator. Innovation, according to Schumpeter (1934), involves the creative combination of resources in novel applications, which include new products or services, new processes and methods, entering new markets,

obtaining new resources, and restructuring an industry (such as gaining or destroying a monopoly position).

It is this classic definition of entrepreneurship which underscores the debate regarding the origins of opportunities, i.e. whether they are discovered or created. For while it may be argued that an innovation is the result of astute recognition of a more efficient means-ends relationship (Shane, 2003), it may similarly be argued that such solutions can be generated over time through iterative processes of trial and error, and its resultant feedback (Alvarez et al., 2013). However, when we recognize innovation as only one part of the entrepreneurial process, and do not equate entrepreneurship with innovation, but instead apply a more broad definition, namely the process by which consumer needs are newly addressed, we may see that discovery and creation are in fact two distinct parts of the entrepreneurship process.

While consumer needs latently exist and must therefore be “discovered” as detailed above, solutions to these needs do not exist *ex ante*, where they are simply discovered and chosen. Instead they are creatively constructed by the application of useful knowledge to a recognized consumer need in creative combinations (Schumpeter, 1934). This creative process may involve an iterative process between the innovation stage and its preceding stage of needs recognition, as innovators may use feedback loops to gain a better understanding of the needs which they are trying to address (Alvarez & Barney, 2007; Alvarez et al., 2013).

As Figure 1 indicates, innovation can only occur where the recognition of an unmet consumer need and the knowledge of and access to resource affordances which could be employed to satisfy those needs intersect. *Affordance* refers to a use to which a

resource may be employed given the proper circumstances (Gibson, 1966; Ratneshwar et al., 1999). This also relates to the relationship between the form and function of an object (e.g. Faulkner & Runde, 2009). As Penrose (1959) perceptively notes, a resource may have infinite possible uses to which it might be applied because of its various properties. Only when an individual has a knowledge and understanding of a resource's various affordances can s/he apply those affordances to recognized problems.

Knowledge of affordances is derived from technical knowledge and expertise. Experience with certain resources, for example, offers the technician familiarity with the properties of those resources, and how those properties may interact with other items. Such learning has long been advocated in the innovation literature as critical to the creation of new solutions (e.g. Brown & Duguid, 1991; Thornhill, 2006). That is, firms (or individuals) with broad knowledge and understanding of various resources have a greater likelihood of recalling an affordance that may be used in resolving a particular consumer need (Leiponen & Helftat, 2010; Taylor & Greve, 2006). Furthermore, a more specific but profound understanding of certain resources involves a better understanding of what those resources can plausibly do, allowing the creative application of those resources to a more broad application of consumer needs (Sawyer, 2012; Csikszentmihalyi, 1997).

New knowledge (scientific) discovery is another factor which promotes an increase in affordance knowledge. That is, scientific discovery often generates a new understanding of resource affordances as various resource properties are uncovered. This spike in affordance knowledge often generates a wave of innovations as common and

familiar consumer needs are newly addressed with the newly discovered affordances, often resulting in what are considered to be more radical innovations (Nemet, 2009).

In sum, innovation only occurs at the intersection of needs knowledge and the knowledge of resource affordances which may be applied toward the resolution of those needs. It is not sufficient to recognize one factor without the other. There must be both a problem to solve and a solution to it, else no value is to be gained (Chand & Runco, 1993). All solutions to consumer needs are thus created by innovative combining, as Schumpeter described. This principle of creation applies equally to less obvious cases of arbitrage, as an opportunity for arbitrage requires the same creative combination of the knowledge of a problem with a solution which resolves it. Thus, even where the solution does not require creation, it requires creative application to a new domain, which falls squarely within Schumpeter's definition of innovation. We see, then, that entrepreneurship of all types follows this path of discovering needs and creatively applying solutions to them.

Order of antecedents

Notably, it is not necessary that the recognition of a need precede the knowledge of affordances. Indeed, it is likely that in most cases innovation happens in the reverse order. That is, an innovation typically occurs when the innovator is already familiar with various resource affordances when a consumer need is recognized or perceived (Weisberg, 1999). Because the innovator has the wherewithal to resolve the need, a solution may be immediately conceived if the individual is cognitively able to make the connection. In the more rare instances that the knowledge of the need comes first, the

innovator must act uncertainly regarding whether a solution is possible in actively searching out resource affordances toward the resolution of the perceived need (see, e.g. anecdotes 3 and 8 in Table 1).

In many cases, the knowledge of a need or an affordance may lay dormant until the other factor is newly learned. In the aforementioned case of Rob Campbell, his affordance knowledge of computer software was being applied only to familiar applications until the need for an effective way of creating presentations was newly perceived. Consider also the invention of the steam engine by Thomas Savery. Mills had been used for centuries, powered by animals, water, wind, or whatever other sources of power could be found. When the power of steam was discovered, Savery immediately saw the use of it in the already well-established and familiar need of milling. Other uses for steam power, such as transportation, would not be recognized until much later.

It is likely, though, that availability (i.e. the ease by which something is brought to memory) may facilitate higher levels of creative cognition. It may, for example, be easier to creatively combine needs and affordances which have been recently recognized or recalled than to conjure old memories of experiences long past or technical knowledge long since used. Such cognitive limitations as this and others may be important factors in understanding why many may have the wherewithal (i.e. both the knowledge of needs and the knowledge of affordances) to create innovative solutions yet fail to do so.

In some rare cases, an innovation may precede the recognition of the need. Pharmaceuticals, for example, may sometimes follow this path, discovering a drug's primary benefit to be different than the one intended (e.g. Viagra). This unintended result, however, is not the culmination of a reverse entrepreneurship process, but is instead the

result of separate innovation processes. That is, innovations in this case are still the causal result of some perceived need intersecting applicable resource affordances. It also may happen that the perceived need that an innovation is intended for is not the need that others find for it. Creative consumers, for example, may innovatively apply the recognized affordance(s) of a certain innovation toward a different “technical identity,” or toward resolving a different need unanticipated by the innovator (Faulkner & Runde, 2009). WD-40, for example, was designed as a water displacement solution to prevent rust on aeronautical equipment, but became popularized by the many alternative uses consumers found for it, such as stopping squeaky hinges, loosening rusted nuts and bolts, or cleaning sticky substances.

Judgment under uncertainty

The creation of an innovation, even if potentially very useful, cannot be said to be entrepreneurship, for a product is only valuable when used (Menger, 1871; Vargo & Lusch, 2004). The innovation must reach those who would benefit from it. As such there remains a final step which must be taken, namely a process of judgment. In following Kirzner (1973), I assign the role of judgment to the *capitalist*, who is a risk taker.

While Kirzner’s metaphoric notion of the ‘pure entrepreneur,’ which he defines as an alert arbitrageur who need not own resources, reflects his assumptions which lead to a conclusion of opportunity discovery (Kirzner, 1973), critics have noted that the entrepreneur *must* own resources if they are to generate profits or losses from those resources (e.g. Rothbard, 1985; Foss & Klein, 2010). Indeed, in Mises’ (1949) view, the

entrepreneur is *defined* by his ownership of resources, or more specifically, by his judgment of the use of those resources which he owns for productive purposes (Foss & Klein, 2012). More specifically, Misesian entrepreneurship is determined by the action taken in utilizing resources for some consumer application as determined by the resources' owner. Any decision rights over resources given to non-owners are merely derived or delegated, while the ultimate decision rights are retained by the owner (Foss, Foss, & Klein, 2007). Thus entrepreneurs, who are the owners of resources, are the ultimate bearers of risk, as they stand to lose up to all of those resources which they employ for entrepreneurial purposes (Foss, Foss, Klein, & Klein, 2007).

Because product value is determined at the temporal end of the value chain (i.e. in consumption) and is subjective to the experience of the consumer (Priem, 2007; Vargo & Lusch, 2004), entrepreneurs cannot have any assurance at the time of judgment that the solution that they might offer (as created by the innovator) will ultimately be accepted by the target consumer market. This *producer uncertainty* is the hallmark of entrepreneurship. Entrepreneurs are noted for their willingness to bear this uncertainty in taking action in spite of a low likelihood of success (e.g. Busenitz & Barney, 1997; Kihlstrom & Laffont, 1979; Koellinger et al., 2007). Indeed, it is this process of judgment and subsequent action in producer uncertainty that is sometimes described as the primary function of the entrepreneur (Knight, 1921; Mises, 1949; Casson, 2005; Foss & Klein, 2012). We conclude that entrepreneurship cannot occur without the judgment of the capitalist, whether s/he be the intimately involved in the business or merely an investor.

While I do not seek here to elaborate on the underlying process of judgment, we may observe that there are three primary estimations which must be made by the capitalist in this judgment. The first is a judgment of the total expected cost (monetary and otherwise) of the venture and its overall viability. The resource owner must estimate the costs of producing the proposed solution and bringing it to market (including the opportunity costs) against their own willingness to bear and risk those costs (e.g. Kerins, Smith, & Smith, 2004; Fonseca, Lopez-Garcia, & Pissarides, 2001). As Evans and Jovanovic (1989), as well as others (e.g. Fonseca, Lopez-Garcia, & Pissarides, 2001; Parker, 2004), have found, various factors may influence this willingness to bear the costs, not least among these being the availability of resources. That is, individuals are much more likely to be willing to bear the risk of loss if they have enough wealth as a buffer to protect them from financial ruin should the venture fail. Other factors may include whether they are unemployed, married, educated, and so forth (Parker, 2004), which arguably influence the availability of resources and the risk of employing those resources in an uncertain venture.

The second judgment to be made regards the total economic value of the solution, i.e. the demand for and total relative benefit that consumers will gain from the use of the product (Casson, 2005). Potential entrepreneurs, I would suggest, generally form this estimation based on their own experience of needs, and refine their expectation based on their perception of others demonstrating the same need, such as asking friends what they think of the idea, or testing the idea in some form of market research. It should be noted that individuals are prone to overestimate how similar others are to themselves when grouped together (e.g. Gump & Klik, 1995; Read & Grushka-Cockayne, 2011).

Entrepreneurs, who typically have the need which they intent to address, thus tend to overestimate value, perceiving the need to be more strongly or widely-held than really is (Camerer & Lovallo, 1999; Bernardo & Welch. 2001). As a result, they tend to be overconfident in their idea (De Meza & Southey, 1996; Hayward, Shepherd, & Griffin, 2006). Other factors that may influence this decision include economic trends and friendly business environments (Zahra, 1993; Acs & Audretsch, 1989), among others.

The third and final judgment which must be made toward a judgment to exploit or not regards the capitalist's perception of potential entrepreneur's (e.g. their own) abilities to effectively manage the venture (Amit, Glosten, & Muller, 1990; Chamley, 1983). Effective management of the venture is necessary to achieve long-term success. Potential entrepreneurs must judge if they are capable, willing, and able to manage the project. If not, they must either choose to involve others whom they would trust with the responsibility (Amit *et al.*, 1990) or forego the opportunity altogether (Chamley, 1983). In general, individuals, and especially entrepreneurs, tend to be overconfident in their own abilities to effectively manage (Hayward, Shepherd, & Griffin, 2006).

In summary, I conclude that the capitalist's function is to assess the merits of the solution created by the innovator, which was created in response to needs discovered by the consumer, and to take action accordingly. The capitalist, who is a resource owner, must make deliberate judgment under conditions of producer uncertainty regarding how to best make use of those resources which s/he owns. If the capitalist(s) judges that a particular solution to a consumer need is adequately economically viable based on estimations of production costs and expected demand, and that they are sufficiently capable of effectively managing its production, they will employ their resources toward

the implementation of that solution. This subjective judgment is made based on imagined expectations ranked against the perceived risks involved, the uncertainty of outcomes, personality factors, and other influential external and internal factors involved in the individual judgment process (Klein, 2008; Shackle, 1961; Lachmann, 1976).

Entrepreneurship, then, is the full and completed process of a consumer's need recognition, an innovator's solution generation, and a capitalist's judgment. Only where all three processes successfully complete can we say that entrepreneurship has occurred. Thus the entrepreneurial function is not one but three functions, culminating in the final and determinate judgment function, which results in entrepreneurial action.

DISCUSSION

The intent of this article has been to unify and integrate the various perspectives of entrepreneurship into one subsuming theory of the entrepreneurial process. Fundamental to this task was the determination and establishment of proper assumptions at the various stages of the process (Gartner, 2001). Missing in these assumptions was the critical role of the individual consumer in determining value.

In replacing the consumer into modern entrepreneurship theory, it became necessary to reevaluate the definition and assumptions of entrepreneurial opportunities, which have traditionally been defined at an inconsistent level from the typical subjectivist and individual-level treatment of entrepreneurship. By redefining opportunities consistent with this level, namely as the unmet needs of individual consumers, we are able to align the assumptions underlying the processes of entrepreneurship and produce a coherent whole.

The entrepreneurial process has been outlined here in three separate and semi-sequential functions, namely that of opportunity recognition as perceived by consumers themselves, innovation, and of entrepreneurial judgment regarding the use of resources. Each of these functions *can* be performed by the same individual, as is often the case (see Table 1), but each may also be performed by distinct actors, such as may be the case in open innovation or co-founded ventures. These three processes individually are each necessary but insufficient alone (or in pairs) for the completion the entrepreneurial process, but all three are required for this process to be completed and for entrepreneurship to occur.

Theoretical Contributions

The relevance of this framework for understanding entrepreneurship can be clearly seen in several different contexts. For example, this framework places innovation completely within the domain of entrepreneurship. While I diverge from Schumpeter's (1934) theory by separating the role of the innovator and that of the entrepreneur, the role of the innovator remains encapsulated within the process of entrepreneurship such that entrepreneurship cannot occur without some extent of innovation, nor can innovation be exploited without the entrepreneur. Furthermore, the role of the consumer in the entrepreneurial process is established, and the definition and function of the entrepreneur is defined and delineated from alternative conceptions, which conceptions are subsumed in other subprocesses.

Relatedly, it can clearly be seen how this framework may offer a unification between the various factions regarding the nature or entrepreneurial opportunities.

Specifically, three distinct camps have weighed in on their perception of whether opportunities are discovered (Shane, 2012; Shane & Venkataraman, 2000), created (Alvarez & Barney, 2007; Alvarez et al., 2013), or imagined (Foss & Klein, 2012; Klein, 2008). However, the entrepreneurial process as outlined here suggests that opportunities, as defined here, must be conjointly *discovered* by the consumer, a solution *created* by the innovator, and expected outcomes *imagined* and judged by the capitalist for entrepreneurship to occur. This conception does not presume profitability, but only *action* as a result of the entrepreneurial process (Klein, 2008). The model presented here thus combines and unifies the various perspectives within a multi-process whole.

This paper further builds on the work which has been done toward an understanding of why some people become entrepreneurs whereas others do not (e.g. Shane & Venkataraman, 2000; Kihlstrom & Laffont, 1979; Baron, 2000; Sarasvathy, Simon, & Lave, 1998). Past studies have struggled to find significant and relevant differences between entrepreneurs and non-entrepreneurs. In the application of this framework, however, we might note that, although individual-level differences are meaningful in determining the desire and willingness to pursue entrepreneurial opportunities, the most relevant individual-level factors are not necessarily technical knowledge or personality differences, but are likely to be found in differences in interest-levels and preferences. Specifically, those who are most likely to need, search for, and create an innovative solution to a consumer need are those who have the greatest consumer involvement (Havitz & Mannell, 2005; Bloch & Ritchins, 1983), that is, those who have a deep passion and interest in a specific product or activity (cf. Belk, Ger, & Askegaard, 2003; Higgins, 2006). Sports enthusiasts, for example, are more likely to

modify or innovate equipment for use in their preferred sport than passive users or non-participants (Franke & Shah, 2003; Lüthje, 2004). Similarly, those who have the greatest functional or professional need are likely to have the greatest frustration with, understanding of, and desire to resolve any shortcoming in the resolution of that need leading to valuable solutions. For example, chemical buyers (Freeman, 1968), scientific instrument users (von Hippel, 1988), and homemakers (Pavitt, 1984) each contributed many of the most important and widely adopted innovations within their respective industry domains (von Hippel, 2005).

In support of lead-user theory (von Hippel, 1986), I suggest that high use consumers generally hold the highest needs and thus represent the most potential value from innovation. They are most likely, then, to take action in creating a solution if none exist. Others (e.g. low need consumers, non-users) may also innovate within a domain, but must do so by assuming their role as consumer within that sphere or by communicating with higher-needs consumers, which communication is highly fallible due to the tacit nature of needs. Because their knowledge of consumer needs may be inadequate, such innovations are less likely to meet the early adopters' needs, and may fail before they can reach the broader but less needful consumer market. Successful innovations must meet the needs of the earliest adopters before they can reach the broader markets (Bass, 1969; Rogers, 2003). This knowledge gap between users' knowledge of needs and producers' understanding of those needs might be more successfully addressed through alternative models of innovation, such as an open innovation model (Chesbrough, 2003).

There has been significant interest in the antecedents, drivers, and sources of innovation and creativity at various levels of analysis (e.g. Amabile, 1996; Marvel, Griffin, Hebda, & Vojak, 2007; Khandwalla, 1987; Shane, 1992). However, to date, little of what we have learned has directly answered the question of how innovation comes about, but has merely outlined various factors which influence the process. This framework, however, offers new insights into the creative process of generating ideas and innovative solutions. Specifically, I propose that creativity emerges in response to recognized problems, in connecting the knowledge of a problem or need with the knowledge of resource properties. The cognitive proximity of that knowledge, such as the recent use of some resource and/or the recent experience of some need (i.e. recency effects), may certainly influence the individual's ability to connect the pieces. There may be additional factors, many of which have already been investigated (e.g. Sawyer, 2012; Csikszentmihalyi, 1997), which impact this process, but the mechanism by which this influence is achieved has been difficult to establish. For example, autonomy has been linked to creativity and innovation, presumably because it allows the innovator to be unrestrained in creative thought (Amabile, 1996). This framework, however, suggests further that individuals alone can make connections between needs and technical knowledge, and that creative groups may often serve to obscure or direct thought within a specific frame ("group think"), preventing individuals from accessing more personal and unique stores of needs or technical knowledge.

Entrepreneurship has increasingly been viewed as a process or function rather than an occupation or type of firm (Shane, 2012; Klein, 2008). Such a conception allows for the application of entrepreneurship theory to more non-traditional contexts, such as

the incumbent firm (e.g. Zahra & Covin, 1995; Sharma & Chrisman, 2007), venture financiers and shareholders (Foss et al., 2007), or even to the public and political realm (Klein, Mahoney, McGahan, & Pitelis, 2010). This theory supports this trend and builds on past conceptions of the entrepreneurial function. Specifically, I support and build upon the entrepreneurial judgment perspective (Foss & Klein, 2012) in defining the entrepreneur as a resource owner who makes judgment regarding the use of those resources, and expand this framework to include the roles of the consumer and innovator within the entrepreneurial process. This removes the *entrepreneur* label from traditionally-named entrepreneurs such as start-up founders, and applies the label more broadly to the funders of innovations (such as the start-up) who put their resources at risk. This does not, however, remove the founder from the entrepreneurial process, but the founder generally (but not necessarily) plays a critical role in recognizing the need and innovating a solution, and is often (but not necessarily) a contributor of personal resources to the venture. By being specific in our definitions and defined roles, we may achieve a higher level of clarity and theoretical soundness.

It follows from this framework that the entrepreneurial process ends where the role of the manager begins. That is, after the entrepreneur has made specific judgment regarding the application of owned resources toward the innovative solution of some recognized consumer need, the manager is tasked with organizing the action taken toward the completion of the project (Schumpeter, 1934). Certainly many would argue that the process of entrepreneurship extends into the first several years of the life of the venture. However, except we clearly delineate the roles of management and entrepreneur, the line between these roles can easily confound, resulting in unsound theory. Thus, while the

entrepreneurial process *can* certainly continue through a venture's first years and indeed through its entire existence, the entrepreneurial process stops once final judgment is made and resources have been directed toward a new use. In the early years of a firm, this resource allocation is often flimsy as entrepreneurs adapt in finding the most efficient and effective solutions for consumers. The entrepreneurial process ends once this allocation and reallocation of resources ends. Firms may be continually entrepreneurial in reallocating resources toward new and innovative solutions (Schumpeter, 1942), or may instead focus efforts solely on managerial tasks, i.e. managing their current product portfolio.

CONCLUSION

While entrepreneurship studies have been helpful to our broader understanding of the entrepreneurial process, an incompatibility of assumptions has led to a lack of an overarching and comprehensive framework and, resultantly, generated fragmented and piecemeal theory-building. The framework presented here represents a novel attempt at resolving the underlying incongruities by bringing the individual consumer into the frame, who has gone largely unrecognized in management and entrepreneurship theory (Priem et al., 2012; Web et al., 2011), and by redefining long-held assumptions regarding the definition and nature of opportunities in terms of unmet consumer needs. The result of this effort is a unified framework which incorporates the contributions of the individual strands of entrepreneurship research, resolves their differences, and unifies them in a comprehensible process.

In resolving these incongruities, it has become necessary to distinguish and delineate the three primary functions within the entrepreneurial process, namely the discovery of opportunities (i.e. unmet consumer needs), the creative innovation of potential solutions, and the imaginative judgment of economic viability and risk regarding whether owned resources should be employed toward the proposed solution. While much work has been done toward our understanding of each of these processes individually, much more work remains to be done, especially in uncovering the interplay between subprocesses and the role of the consumer determining outcomes. Investigating and understanding the conditions in which consumer needs become recognized, where recognition generates a solution, and when solutions drive entrepreneurship are vital to our moving forward in developing and refining entrepreneurship theory.

3. NEEDS AND TECHNOLOGIES: COMBINING KNOWLEDGE FOR INNOVATION

ABSTRACT

Innovation has been understood as “New Combinations” of knowledge since Schumpeter. How that knowledge is combined and what types of knowledge are combined, however, have remained obfuscated as individual-level studies of creativity and innovation have focused instead on personal characteristics of the innovators as primary factors in determining innovativeness. This study examines knowledge itself as a key factor in the innovation process. I propose that innovative ideas are the result of a cognitive process by which two types of knowledge intersect: knowledge of consumers’ needs (the problem) and a knowledge of certain resources or technologies and their affordances (the solution). I hypothesize that only where both of these types of knowledge are present can innovation emerge. I further posit that the knowledge combination process is moderated by other key factors, namely personality, cognitive accessibility, and engagement. I find general support for the knowledge interaction model, showing that innovativeness increases where both needs knowledge and technical knowledge are high. I also find “Einstellung” effects, i.e. where innovativeness decreases for experts, where the expert innovator is high in one type of knowledge only. Of the proposed moderators, only accessibility was supported.

INTRODUCTION

Innovation is the combination of knowledge of what can be done with knowledge

of what needs to be done (Runco, 1994; Nickerson & Zenger, 2004). Theories of innovation have long held that creative ideas are largely spontaneous, and that they come to those who are particularly apt to creative thinking (Shalley, Zhou, & Oldham, 2004). Such theories, however, “[tell] us almost nothing about the mental operations that actually occur” (Guilford, 1950: 451; Lubart, 2001). Empirical evidence suggests that process models of creativity, which suggest that creativity follows a generalized sequential process, that are today widely accepted (e.g. Amabile, 1996; Wallas, 1926) may be inadequate for the universal description of innovation (Lubart, 2001). Furthermore, findings from studies of creativity and innovation are likely weakened by their empirical reliance on simplistic creative tasks rather than more realistic innovation tasks. In contrast, I adopt insights from creative cognition theory (Smith, Ward, & Finke, 1995; Ward, 2004) and the knowledge-based approach to creativity (Weisberg, 1986, 1999) to propose a new cognitive model of innovative insight. This model suggests that insight is not the result of a sequential process, but is primarily a knowledge-driven phenomenon, and that it occurs at the cognitive intersection of the knowledge of some problem with the knowledge of some way to resolve that problem. In other words, innovation emerges more or less spontaneously where there is the necessary knowledge for it to occur. Other relevant factors in innovation, such as context and personality (Amabile, 1996; Oldham & Cummings, 1996; Shalley et al., 2004), are hypothesized to influence this cognitive mechanism by influencing how and to what extent such knowledge is available for combination.

Modern conceptions of the innovation processes are to a large extent extensions of the classic four-stage model, which outlines the innovation process as: (1) preparation,

(2) incubation, (3) illumination, and (4) verification (Guilford, 1950; Lubart, 2001; cf. Wallas, 1926). Amabile's componential theory (1996, 2013) adds to this model a key initial stage, which is problem or task identification. But while theoretical and empirical evidence strongly suggests that the recognition and understanding of a problem is indeed a critical component of innovativeness (e.g. Chand & Runco, 1993; Csikszentmihalyi, 1997; Getzels, 1975; Runco, 1994), how such problems are found in relevant contexts such as business has remained largely unexplored (Baer, Dirks, & Nickerson, 2013). Furthermore, evidence suggests that innovation *does not* adhere strictly to a process, but occurs rather spontaneously and non-sequentially (e.g. Cawelti, Rappaport, & Wood, 1992; Elias, 2016; Getzels & Csikszentmihalyi, 1976; Weisberg, 1986), suggesting that the mechanisms by which innovation occur are still rather misunderstood.

Here I propose a knowledge-based theory of innovation (cf. Weisberg, 1999) that suggests that innovativeness is not primarily a personality- or context-driven phenomenon, nor is it necessarily the result of a sequential process, but instead may occur spontaneously to anyone who has the relevant knowledge for insight to occur. While much of the organization literature approaches innovation as group- or organization-level creative activity (Sawyer & Bunderson, 2013), I approach it here at the individual-level because, in this view, idea generation is a cognitive process that occurs within the individual mind (Csikszentmihalyi, 1997; Finke, Ward, & Smith, 1992). While ideas may certainly pass through iterative cycles of development as the idea is communicated to others who contribute ideas of their own (Sawyer, 2012), each additional contribution may be viewed as a separate, incremental innovation or solution to a recognized problem, or weakness in the currently conceived solution, which may culminate in a group- or

organization-generated solution. However, at the very core of innovation are the individual insights that occur to individuals, which are the focus of this research.

Extending existing knowledge-based approaches to innovativeness, which point to evidence suggesting that high levels of knowledge and expertise are required for groundbreaking innovation (Csikszentmihalyi, 1997; Gardner, 2011; Hayes, 1989, Weisberg, 1999, 2006), I propose that the *type* of knowledge matters, and that the combination of knowledge entails the combination of two specific types of knowledge. Adopting insights from the demand-side framework (Priem, Li, & Carr, 2012) and the problem-solving perspective (Nickerson & Zenger, 2004; Hsieh, Nickerson, & Zenger, 2007), I highlight the role of *needs* knowledge, or knowledge of consumers' unmet needs, in conjunction with the well-established function of *technical* knowledge, in generating innovative insight. That “[p]roduct users also possess knowledge that is fundamentally different from the knowledge developed by researchers within firms” (Chatterji & Fabrizio, 2014: 1429) has been recently acknowledged, but we have yet to fully explore and describe what this knowledge is and how or why it is uniquely important to innovation generation. I explore consumer knowledge in depth, arguing that a sufficient understanding of unmet needs is a critical and necessary input to innovation. That consumers *may* innovate has long been recognized (e.g. von Hippel, 1988; Shah & Tripsas, 2007), but I posit that the consumer plays a key and necessary role in *all* innovations. Because idea generation occurs within the mind, this tacit knowledge of consumer needs (Ogawa, 1998) must either be communicated through complex and imperfect means or must already reside within one who has the technical wherewithal to resolve those needs. Other factors, such as personality and context (Amabile, 2013), are

therefore seen as factors only inasmuch as they promote the acquisition of relevant knowledge, bring that knowledge to mind, and facilitate knowledge combinations.

THEORY AND HYPOTHESES

The “consumer sovereignty” principle suggests that consumption is the ultimate goal of economic production, and that economic success is most aptly determined in the satisfaction of consumers’ needs (Hutt, 1936; Mises, 1949). According to this view, consumers dictate what should be produced for the satisfaction of their own needs by demanding, or abstaining from demanding, certain solutions. The success of an innovation has been shown to depend greatly on the consumer needs that it satisfies and the satisfaction it provides that need (Cooper, 1979, 1999; Szymanski & Henard, 2001; Oliver, 2010).

While innovation has long been associated with total knowledge at the organization level (e.g. Fleming, King, & Juda, 2007; Leiponen & Helfat, 2010; Rosenkopf & Nerkar, 2001; Taylor & Greve, 2006), at the individual level innovativeness has been tied primarily to personality and context (Amabile et al., 1996; Barron & Harrington, 1981; Csikszentmihalyi, 1997; Sawyer, 2012; Shalley et al., 2004). Because organization-level phenomena emerge from individual-level actions (Udehn, 2002), it becomes necessary to integrate the role of knowledge in individual-level innovation theory. Toward this end I adopt a knowledge-based approach (Weisberg, 1999, 2006), suggesting that greater knowledge facilitates novel combinations of that knowledge, and that this process is influenced by other modifiers inasmuch as they influence the knowledge cognitively available for combination. I highlight two distinct

types of knowledge, needs and technical knowledge, as especially and necessarily relevant to this knowledge combination process.

The Role of Needs Knowledge

Consumers have been shown to possess unique knowledge critical to innovation (Chatterji and Fabrizio, 2014; Cohen, Nelson, & Walsh, 2002; Lilien, Morrison, Searls, Sonnack, & von Hippel, 2002; Ngo & O’Cass, 2013; Zander & Zander, 2005), and may even become innovators themselves (Bogers, Afuah, & Bastian, 2010; Shah & Tripsas, 2007; von Hippel, 2005). Past studies suggest that different types of users are more likely to innovate. These include professional users (Chatterji & Fabrizio, 2012), users with an “emergent” nature (Hoffman, Praveen, & Thomas, 2010), and “inventive” users (Lettl, Rost, & von Wartburg, 2009). Fang (2008) suggests that the *way* customers participate, be it as an information source or as a co-developer, impacts the innovation process. Bogers et al. (2010; cf. Lüthje, Herstatt, & von Hippel, 2005) suggest that the distinction between “intermediate” users (i.e. users of resources, equipment, etc. to produce other goods or services) and “consumer” users (i.e. those who use a product for their own personal benefit) may be relevant to innovativeness. While these studies contribute to our understanding of the innovation process broadly, they have not yet explored in depth the mechanisms by which this process is bettered by users.

I propose that consumers’ most valuable and critical contribution to innovation is their knowledge and understanding of their own and others’ unmet (or suboptimally met) personal needs and preferences. Unmet consumer needs present a problem with valuable implications for its resolution (Hsieh et al., 2007). The potential economic value of these

unmet needs can be represented by the combined factors of the *magnitude* of the need individually and the *extent* of the need across the population (McMullen, Plummer, & Acs, 2007). Understanding these needs then, to whatever extent they can be understood, is a critical aspect of innovation in that it motivates and directs the innovative process. This needs knowledge encompasses both breadth and depth of experience (Schilling & Green, 2011). That is, it includes both the total *number* of needs in various domains that consumers possess as well as the *amount* of knowledge that is possessed regarding those specific needs. I propose that it is those consumers who have greater needs knowledge, both broadly and deeply, that are more likely to innovate, and whose ideas are more likely to become successful.

Acquiring needs knowledge. While all have the same basic needs (Deci & Ryan, 1985; Maslow, 1954), the extent of those needs, how different individuals perceive and understand them, and how they are addressed may vary (McClelland, 1985; Sheldon, 2011). Knowledge of needs is gained experientially over time through consumption (Witt, 2001), resulting in unique distributions of needs knowledge (Hayek, 1945). These distinct distributions of needs knowledge lead to important differences in understanding whether, what, and how to innovate.

Because needs are personal and subjective, needs that are unmet are uniquely learned *by individual consumers* over time through experience, especially in dissatisfactory consumption experiences. This learning process is influenced by various experiential modifiers such as context, time and past experience, and personal and physical characteristics (e.g. Morrin & Ratneshwar, 2000; Frederich, Loewenstein, & O'Donoghue, 2002; Hirschman, 1984). This knowledge of unmet needs may be used by

entrepreneurs and innovators to better satisfy those needs by, for example, redirecting the factors of production. Fabrizio and Thomas (2012), for example, find that local consumer trends influence the nature of products that firms develop, including those intended for global distribution. This is because, it may be argued, the needs knowledge that was employed in innovation is locally (contextually) generated.

Because needs knowledge is inherently tacit or “sticky” (Ogawa, 1998; von Hippel, 1994), those who experience needs directly can most appropriately apply that knowledge in innovations. Communications of needs knowledge involves an inherent knowledge loss due to individual and interpretive differences between consumers (Czarniawska & Joerges, 1996). Whether a need is experienced personally or communicated, innovators must act in their role as consumers in order to grasp the problem to solve, whether they are actual users of the intended product (e.g. lead users, co-developers; Fang, 2008; Schuler & Namioka, 1993; von Hippel, 2005) or empathic users (i.e. imaging or observing how one might use a product; Bayus, 2008; Liedtka, 2011; McMullen, 2010).

In summary, needs knowledge reflects an understanding of the problem that needs resolving. Those innovators who possess or acquire greater needs knowledge are ultimately expected to produce more successful innovations.

Hypothesis 1: Needs knowledge is positively related to innovativeness in generating a solution to a recognized consumer problem.

The Role of Technical Knowledge

In contrast with needs knowledge, which is knowledge of what needs to be done, technical knowledge offers the innovator an understanding of what *can* be done.

Technical knowledge is comprised of both skill (tacit) and technological knowledge (explicit) (Jensen, Johnson, Lorenz, & Lundvall, 2007). Skill allows the individual to manipulate available resources in various ways. Technological (educational) knowledge provides an understanding of the various properties of resources, facilitating a greater perception of their possible uses.

Resources have infinite possible uses (Penrose, 1959). A paperclip, for example, is designed to attach papers, but can also be used to close electrical circuits, clean fingernails, or receive radio signals. A profound knowledge of a resource's various properties, and the skill to use them, facilitates the application of those properties in innovative solutions.

The link between technical (especially technological) knowledge and innovation has been well-established in the literature (e.g. Damanpour, 1991; Nemet, 2009; Fleming, 2001; Rosenkopf & Nerkar, 2001; Thornhill, 2006; Tsai, 2001). Like needs knowledge, both breadth and depth of technical knowledge are relevant to innovativeness (Schilling & Green, 2011). Breadth provides a greater array of possible resources and technologies from which to draw a solution to a recognized problem (Leiponen & Helfat, 2010; Rodan & Galunic, 2004; Rosenkopf & Nerkar, 2001; Taylor & Greve, 2006). Depth of technical knowledge involves a strong familiarity with the multiple properties of a resource or technology, facilitating insight into its potential use in various applications (Csikszentmihalyi, 1997; Godart, Maddux, Shipilov, & Galinsky, 2014; Weisberg, 1999).

Supporting the assertion of a tie between technical knowledge and innovativeness, Von Hippel, de Jong, and Flowers (2012: 1676) observed in a study of household consumers that more educated consumers are "*much more likely* to engage in innovation"

(emphasis added). I therefore propose:

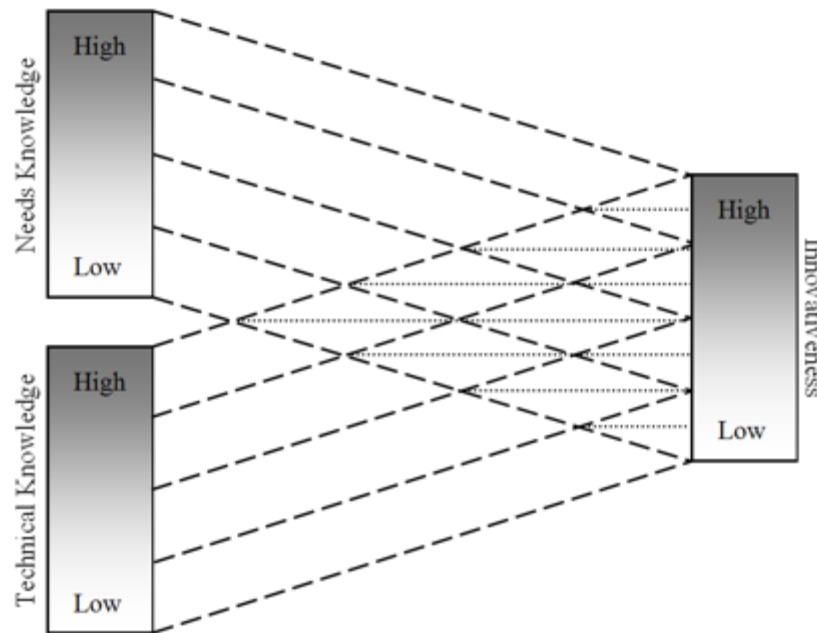
Hypothesis 2: Technical knowledge is positively related to innovativeness in generating a solution to a recognized consumer problem.

Combining Knowledge

We have so far noted the vital roles of two distinct types of knowledge, needs knowledge and technical knowledge, in facilitating innovative insight. Needs knowledge is a knowledge and understanding of the problem to be solved. Technical knowledge consists of a familiarity with certain and various resources, technologies, and skills that might be useful in producing certain desired effects. Innovation occurs where these types of knowledge *intersect* (see e.g. Jensen et al., 2007; Ogawa, 1998; Shane, 2000).

Shane (2000) proposes, and finds some qualitative evidence suggesting, that technological change must be combined with existing consumer market knowledge for opportunities to emerge. Ogawa (1998) finds that the locus of innovation depends on the tacitness of needs and technical knowledge such that, where the technical knowledge is more tacit, innovation is more likely to occur within the firm and, where needs knowledge is more tacit, the user is more likely to do the innovating. In short, innovation occurs at the *intersection* of technical and needs knowledge. It cannot happen without one or the other. The innovativeness, then, of individuals depends on the combined level

FIGURE 3
Combining Technical Knowledge and Needs Knowledge



of knowledge, both technical and needs, that they have (see Figure 3).

New combinative knowledge may be sought and learned through search mechanisms. For example, if an unmet need with high perceived value potential is recognized but no solution to it is initially recognized, the potential innovator may initiate a search for technical knowledge which might be employed toward the resolution of the need. Similarly, the discovery of a new technology may prompt a search for a valuable use for it. Such searches may span the innovators local networks (e.g. Rodan & Galunic, 2004) or extend more broadly (e.g. Leiponen & Helfat, 2010). Most innovations, however, and especially those which are generated by user-innovators, rely primarily on “local” or already held knowledge, both of consumer needs and the technology to resolve them (Lüthje et al., 2005).

Hypothesis 3: Technical and needs knowledge are interdependent such that a high level of technical (needs) knowledge facilitates a stronger relationship between needs

(technical) knowledge and innovativeness, whereas a low level of technical (needs) knowledge inhibits the relationship.

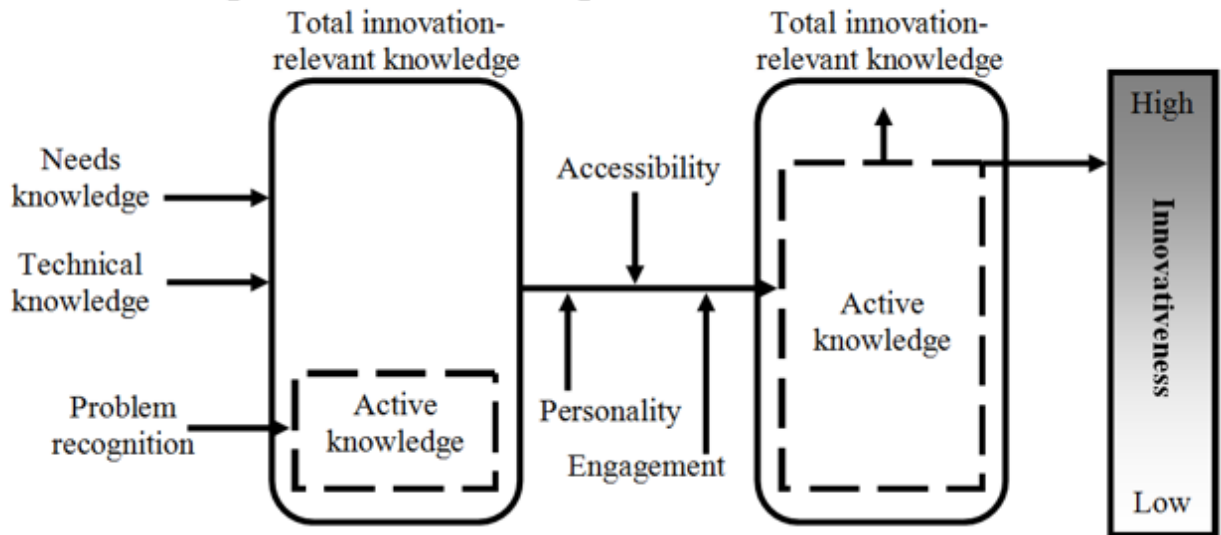
A Cognitive Model of Innovation

The mind's active cognitive or "reasoning" capacity is limited (Halford, Cowan, & Andrews, 2007). That is, the mind can actively consider only a limited number of subjects and their interrelationships in working memory. Memory is grouped into clusters of associated knowledge, termed schemata (Dane, 2010; DiMaggio, 1997). By default, when a problem (e.g. a need) is identified it brings the schema in which the primary problem components are found from memory to the active knowledge state. Because this default schema is comprised only of already associated technical and needs knowledge, innovative possibilities at this point are limited.

Unassociated needs and technical knowledge in one's memory generally exist outside of the knowledge that is currently active. Here let us limit our discussion only to innovation-relevant knowledge to preserve our ability to understand the process¹. This knowledge can be brought into consideration (that is, into active knowledge) through more purposeful or inherent means, facilitated by various factors such as *personality*, *accessibility*, and *engagement*, each of which has been highlighted in past studies of creativity (Kahneman, 2011). That is, these key factors influence the creative process *indirectly* through their influence on the knowledge made cognitively available for innovative problem-solving. These factors have well-established connections to the creative process, as put forth in componential theory (Amabile, 2013) and other creativity and innovation research (see, e.g., Shalley et al., 2004).

¹ While it is impossible to distinguish between relevant and irrelevant knowledge *a priori*, it is helpful to limit the scope of relevant knowledge for theoretical modelling and empirical testing.

FIGURE 4
A Cognitive Model of Knowledge Consideration and Innovativeness



Personality. Personality has long been acknowledged as a key contributing factor in creativity and innovation (Amabile et al., 1996; Feist, 1998; Shalley et al., 2004), but the mechanism by which personality influences the innovative process is not well-developed. Historically, personality’s connection to creativity has been their shared focus on uniqueness and individuality (Feist, 1998). More recent research has presented several core characteristics that are fairly consistent across creative individuals, which traits are typically associated with uniqueness and non-conformity, such as openness to experience, hostility, and impulsivity (Fiest, 1998). Here I posit that creative personalities, or individuals with these associated personality traits, tend to transition the mind to a search of inactive knowledge more readily, making seemingly unrelated knowledge more available for creative combination. That is, it is not in making the individual necessary unique by which personality influences innovativeness (as uniqueness cannot necessarily be equated with innovativeness), but in the tendency of certain personalities to “think outside the box” in searching for knowledge that is not necessary already held within the immediate and active schemata. Thus creative

personality *facilitates* the primary creative mechanism of knowledge combination, and is not a direct or primary factor in generating innovativeness.

Hypothesis 4: Personality moderates the interactive relationship between technical and needs knowledge and innovativeness such that a more creative personality strengthens the relationship.

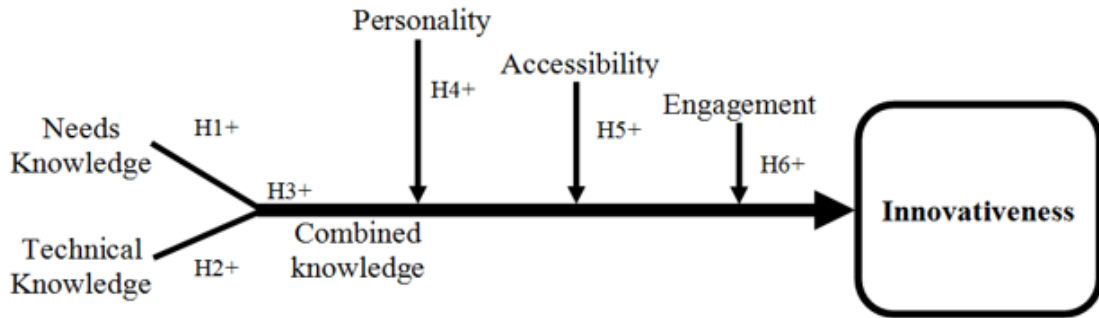
Accessibility. Knowledge accessibility refers to the ease or speed with which the mind is able to retrieve a particular schema and bring it to the active state (Bruner, 1957; Higgins, 1985; see also *availability*, Tversky & Kahneman, 1973). Accessibility, then, also is expected to influence the creative process by making some knowledge more available for combination than other knowledge. The accessibility of knowledge can be influenced by various factors, such as prominence, recency, and priming effects. Prominence, here, refers to the magnitude of a schema, such that a domain of expertise (large/dominant schema) tends to be more readily brought to active mind. Also, recently (re)acquired or employed knowledge schemata should generally have higher accessibility as they will be still be “close” to active memory, facilitating its return (Kahneman, 2011). Contextual cues may also be relevant for bringing unrelated memory to the active state. These priming cues use subconscious processes to bring schemata forward in memory to make it more easily accessible, in case it is needed. For example, Gick and Holyoak (1983) show that difficult puzzles are more easily solved if a less difficult puzzle with a similar solution is first administered. Once the solution to the easy puzzle is in recent memory, analogical reasoning processes may allow the mind to adapt the primed solution to the more difficult puzzle (Green, Kraemer, Fugelsang, Gray, & Dunbar, 2012; Maitland & Sammartino, 2014).

Hypothesis 5: Knowledge accessibility moderates the interactive relationship between technical and needs knowledge and innovativeness such that a more creative personality strengthens the relationship.

Engagement. Engagement refers to being “involved, occupied, and interested in something. Strong engagement is to concentrate on something, to be absorbed or engrossed with it” (Higgins, 2006: 442). Engagement may induce the innovator to consider inactive knowledge in memory that is not brought to mind as easily by other factors. Csikszentmihalyi (1990, 1997) describes this engagement as a process of “flow,” where time and the world evaporate within a state of high conscientiousness, involvement, and enjoyment in a particular activity. In an engaged state, the limited capacity of the mind appears to become expanded as the attention that might be given to time, environmental conditions, and other concerns are forgotten or ignored, and the cognitive space that is vacated by these is reallocated to the problem at hand. Arguably, this focused state allows the mind to allocate more resources toward consideration of inactive knowledge schema toward the resolution of the problem.

Hypothesis 6: Engagement moderates the interactive relationship between technical and needs knowledge and innovativeness such that a more creative personality strengthens the relationship.

FIGURE 5
Summary of Hypotheses



METHODS

To measure and test the proposed model, I conducted a controlled experiment. Experimental design allows control over various influential factors, allowing us to manipulate their impact on the outcomes as the case may be, and is especially useful in determining causal mechanisms (Bono & McNamara, 2011; Krause, Whitler, & Semadeni, 2014). Experimental designs have been especially common and salient in studies of creative processes (e.g. Amabile, 1996; Finke et al., 1992), as spontaneous creativity is difficult to capture in field studies. The present experimental design is a between-subjects design in which participants are assigned innovative tasks in one of four technical and needs knowledge states as randomly assigned.

Sample

Two samples were collected for this study. The first is a sample of undergraduate business students who voluntarily participated as part of their course instruction. A \$25 gift card was also offered for the winners of the creative task to incentivize strong participation. Because innovativeness as modeled here is a cognitive process which is generally not age-dependent except in its effects on knowledge accumulation and

cognitive abilities, undergraduate students are an acceptable sample for testing. Using undergraduates allows us to control for age effects by using a homogenous sample. A total of 74 students participated in the study. A secondary sample was collected from Amazon.com's Mechanical Turk (AMT) program, which has been validated as an adequate source of response data for behavior theory analysis (Buhrmester, Kwang, & Gosling, 2011; Casler, Bickel, & Hackett, 2013; Weinberg, Freese, & McElhattan, 2014). Recent concerns over the use of AMT in research (e.g. Chandler, Mueller, & Paolacci, 2013) regard the effects of repeated studies on participants, and do not apply in this case. A total of 107 online participants completed the online survey in exchange for a \$1 payout, again with a promise of a \$25 gift card for the top creative ideas. Because differences between samples were statistically negligible, samples were combined for a total of 181 participants. Each participant was asked to produce two independent solutions to consumer problems, as detailed below. Blank, illegible, and irrelevant responses were removed from the sample, yielding a total of 325 usable responses.

Experiment

Self-report information regarding participants' personality as well as their technical knowledge of and consumer experience within domains and activities relevant to the tasks they would be assigned were first collected. Participants were also asked to complete 10-question quizzes designed to approximate their technical knowledge of the domains of interest.

The experiment is comprised of two innovative tasks designed to replicate real-world innovation tasks based on real consumer problems, the first task requesting help

designing a better golf ball and the second looking for a better cooking aid (see Appendix A). There are four versions of each task where the state of knowledge is manipulated. The first version provides a simple explanation of the task with a brief motivation, but no further information is provided. The second provides, in addition to the basic task outline, additional *needs* information regarding the consumer experience and needs, how consumers currently go about resolving the issue, and reasons for frustration. The third version omits the consumer information but provides additional *technical* information instead with respect to the technologies underlying current solutions. The fourth version provides both the additional needs and technical information. Participants were given ten minutes per task to imagine and describe a solution to the given consumer problem. At the end of each of the creative tasks, participants were given a brief post-task survey.

Dependent variables. The dependent variable for this study is *innovativeness*. This variable is estimated using the Consensual Assessment Technique (CAT; Amabile, 1996; Sawyer, 2012), where ideas were rated by two judges for their novelty, their usefulness, and their viability (technical and economic), scaled 1 to 5 (Finke et al, 1992). The judges were individually experienced in the domains of interest, and were trained for the rating task through a joint evaluation session. An arbitrator was also employed to assess and resolve discrepancies between raters, either by selecting the more appropriate rating if one rating was clearly more appropriate, or by averaging the ratings otherwise.

Independent variables. The independent variables for this study are *technical knowledge* and *needs knowledge*. These are manipulated by the task design as previously described. The two tasks are intentionally designed to be within consumer domains that are significantly different from each other, such that it is moderately unlikely that any

participant has any expertise in both, if either.

Moderators. Moderators include *personality*, *accessibility*, and *engagement*.

First, creative personality was obtained using an abbreviated version of the Creative Personality Scale (CPS; Gough, 1979). This scale has participants check whether they would describe themselves according to a list of 30 adjectives or not (e.g. “curious”, “careful”). If the participant checks the adjective as descriptive of themselves, a +1 (–1) value is added to the *creative personality* score according to its positive (negative) relation to creativity. Following Zhou (2003; Zhou & Oldham, 2001) I employ an abbreviated CPS, surveying fifteen adjectives most prominently associated with creativity both positively and negatively (Barron & Harrington, 1981; Feist, 1998). As is standard for this scale (e.g. Shane & Nicolou, 2015; Zhou, 2003), reliability was calculated following a weighted composite technique (Oldham & Cummings, 1996), obtaining $\alpha = 0.76$.

Cognitive accessibility is ascertained as a *primed* or *not primed* binary variable.

Participants are considered “primed” if they are high in both needs knowledge (i.e. if self-reported experience is 3 of 5 or higher; mean = 2.6) and technical knowledge (i.e. if they score 7 or higher on the domain knowledge quiz; mean = 5.4) and are also given the corresponding manipulation of that knowledge—i.e. needs knowledge manipulation with high experience (≥ 3), technical knowledge manipulation with a high technical knowledge score (≥ 7), or both. In such cases, the knowledge is expected to already be possessed by the participants, but the experiment primes its memory.

Finally, *engagement* data were collected by self-report in the post-task surveys using the Utrecht Work Engagement Scale (UWES; Schaufeli, Salanova, González-

Romá, & Bakker, 2002). This scale posits three aspects to engagement: absorption, dedication, and vigor. Because I have defined engagement following Higgins (2006) as being “involved, occupied, and interested in something... to be absorbed or engrossed with it,” engagement is most accurately equated with absorption ($\alpha = 0.86$) only, and not with the combined components.

Controls. For this study, I control for factors which may influence innovativeness outside of the manipulated knowledge factors. Potentially relevant knowledge is approximated and controlled for by the self-reported experience levels and knowledge quizzes administered to the participants. Also, whereas engagement is estimated as the absorption aspect of the UWES only, dedication ($\alpha = 0.84$), or importance and meaningfulness of the task to the individual, and vigor ($\alpha = 0.79$), or the mood of the individual in terms of energy and excitement, were also collected as controls. Mood (vigor) is also expected to control for issues related to time of day, state of health, and other issues regarding their overall state of being. Gender is also controlled (0 = male, 1 = female).

RESULTS

Because participants each produced two creative solutions, the analysis was performed using hierarchical linear regression models, nested around the participant, with needs knowledge and technical knowledge as randomly distributed according to the manipulation. Descriptive statistics for the independent variables are provided in Table 2. Results from the various analyses are presented in Table 3, as described in following.

TABLE 2
Descriptive Statistics and Correlations

Variable	mean	s.d.	1	2	3	4	5	6	7	8	9	10	11	12
1. Sample	0.579	.0494	1.000											
2. Task	0.459	0.499	-0.050	1.000										
3. Gender	0.406	0.492	0.159**	-0.012	1.000									
4. Experience	2.594	1.151	-0.159***	0.356***	-0.119	1.000								
5. KnowledgeQuiz	5.405	1.942	-0.264***	-0.109**	-0.182**	0.116**	1.000							
6. Expert	0.179	0.384	-0.122**	-0.071	-0.166**	0.368***	0.568***	1.000						
7. Creative Personality	1.501	2.613	-0.204***	-0.014	-0.202***	0.130**	0.191***	0.086	1.000					
8. Engagement (Absorption)	12.461	3.724	0.222	-0.065	-0.053	0.047	0.081	0.081	0.093*	1.000				
9. Importance (Dedication)	17.832	3.846	0.405***	-0.50	-0.068	0.015	0.033	-0.001	0.040	0.596***	1.000			
10. Mood (Vigor)	21.483	4.023	0.075	-0.029	-0.024	0.060	0.077	0.023	0.284***	0.247***	0.308***	1.000		
11. Needs Knowledge	.0490	0.501	-0.023	0.019	0.052	0.054	0.016	0.072	0.001	0.052	0.035	0.051	1.000	
12. Technical Knowledge	0.475	0.475	-0.073	0.106*	0.069	-0.017	0.007	-0.038	0.034	0.045	0.054	0.032	-0.01	1.000

* p < 0.10 ** p < 0.05 *** p < 0.01

Hypotheses 1 and 2 suggest that needs and technical knowledge, respectively, will individually impact innovativeness positively. These are tested in the second model (“Knowledge Test”) of Table 3. As the results indicate, neither technical nor needs knowledge were statistically significant in determining the overall innovativeness of participants, and in fact each had negative estimates. Neither hypothesis 1 nor hypotheses 2 were supported.

Hypothesis 3, the interactive effect of needs and technical knowledge, was tested in the third model (“Knowledge Interaction Test”), exhibiting a positive and significant result ($p < .05$; see Figure 5), suggesting, as expected, that it is in the combinatory existence of both needs and technical knowledge by which innovative ideas can emerge.

Hypotheses 4, 5, and 6 each suggest a moderating effect on the relationship between combined knowledge and innovativeness. Hypotheses 4, which suggests that creative personality moderates this relationship, is tested in model 4 (“Personality Moderation Test”) of Table 3. The interaction term of this model is insignificant, failing to support Hypothesis 4. Whereas creative personality appears to have a modest impact on overall innovativeness directly (see Models 1-3, 5-6), its influence does not appear to be through the knowledge combination process (see Figure 7).

TABLE 3
Regression Results

Variable Name	Model							
	Naïve Model	Needs Knowledge	Technical Knowledge	Knowledge Test	Knowledge Interaction Test	Personality Moderation Test	Accessibility Test	Engagement Moderation Test
Sample (0 = student, 1 = online)	0.286* (0.168)	0.290* (0.167)	0.309* (0.168)	0.305* (0.168)	0.314* (0.165)	0.318* (0.166)	0.354** (.164)	0.308* (0.166)
Task (0 = golf ball, 1 = cooking)	0.296** (0.141)	0.277* (0.140)	0.270* (0.136)	0.278* (0.135)	0.281* (0.136)	0.263* (0.134)	0.272* (0.136)	0.275* (0.136)
Gender (0 = male, 1 = female)	0.242 (0.219)	0.222 (0.221)	0.222 (0.224)	0.243 (0.224)	0.211 (0.216)	0.180 (0.218)	0.341* (0.206)	0.214 (0.215)
Experience	-0.182*** (0.069)	-0.174** (0.069)	-0.173** (0.067)	-0.166** (0.068)	-0.156** (0.068)	-0.144** (0.068)	-0.155** (0.068)	-0.157** (0.068)
KnowledgeQuiz	0.043 (0.045)	-0.043 (0.045)	-0.046 (.044)	-0.045 (0.044)	-0.057 (0.043)	-0.044 (0.043)	-0.040 (0.043)	-0.049 (0.044)
Expert (Experience ≥ 3 and KnowledgeQuiz ≥ 7)	0.270 (0.233)	0.255 (0.233)	0.282 (0.227)	0.281 (0.226)	0.258 (0.225)	0.233 (0.225)	0.533 (0.362)	0.259 (0.227)
Creative Personality	0.063** (0.029)	0.060** (0.029)	0.061** (0.029)	0.060* (0.023)	0.060** (0.029)	0.126** (0.056)	0.059** (0.028)	0.060* (0.029)
Engagement (Absorption)	0.055** (0.023)	0.053** (0.023)	0.058** (0.023)	0.055** (0.023)	0.059** (0.023)	0.061** (0.024)	0.058** (0.023)	0.064 (0.039)
Importance (Dedication)	-0.008 (0.024)	-0.007 (0.024)	-0.009 (0.024)	-0.007 (0.024)	-0.013 (0.024)	-0.015 (0.024)	-0.018 (0.024)	-0.013 (0.024)
Mood (Vigor)	-0.051*** (0.019)	-0.054*** (0.019)	-0.054*** (0.019)	-0.055*** (0.19)	-0.051** (0.019)	-0.050** (0.019)	-0.049** (0.018)	-0.051** (0.019)
NeedsKnowledge		-0.100 (0.132)		-0.099 (0.130)	-0.436** (0.195)	-0.239 (0.223)	-0.302 (0.213)	-0.495 (0.677)
TechKnowledge			-0.201 (0.123)	-0.195 (0.123)	-0.502*** (0.182)	-0.431* (0.209)	-0.378* (0.207)	-0.473 (0.615)
NeedsKnowledge x TechKnowledge					0.613** (0.265)	0.490 (0.300)	0.362 (0.289)	0.880 (0.919)
Creative Personality x Needs Knowledge						-0.113 (0.075)		
Creative Personality x Tech Knowledge						-0.047 (0.070)		
Creative Personality x Needs Knowledge x Tech Knowledge						0.072 (0.101)		
Expert x Needs Knowledge							-0.924 (0.541)	
Expert x Tech Knowledge							-0.610 (0.454)	
Expert x Needs Knowledge x Tech Knowledge							1.572** (0.690)	
Engagement x Needs Knowledge								0.005 (0.053)
Engagement x Tech Knowledge								-0.003 (0.047)
Engagement x Needs Knowledge x Tech Knowledge								-0.021 (0.071)
n	325	325	325	325	325	325	325	325
df	1	6	6	15	15	15	15	15
χ^2	2.08	4.34	7.20	8.32	7.87	8.26	7.76	7.83

* p < 0.10 ** p < 0.05 *** p < 0.01

FIGURE 6
Needs Knowledge x Technical Knowledge

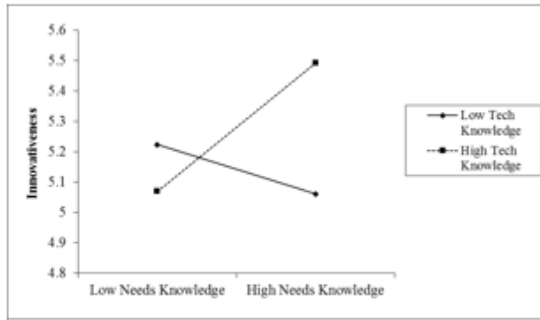
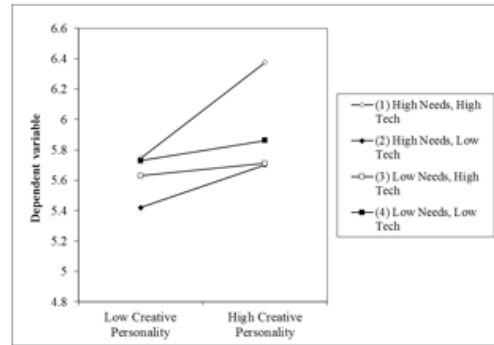


FIGURE 7
Creative Personality x Needs Knowledge x Technical Knowledge



Hypothesis 5, the moderating effect of accessibility, is tested in model 5 (“Accessibility Test”). As indicated (see also Figure 8), the impact of priming is shown to be positive and significant for the interaction term ($p < .01$), supporting Hypothesis 5.

Hypothesis 6 suggests that engagement moderates this knowledge interaction effect. This is tested in model 6 (“Engagement Moderation Test”) of Table 3. The results suggest that engagement has a *direct* effect on innovativeness, but not a moderating effect. Hypothesis 6 was not supported.

DISCUSSION

The purpose of this paper has been to examine the nature and effects of different

FIGURE 8
Accessibility x Needs Knowledge x Technical Knowledge

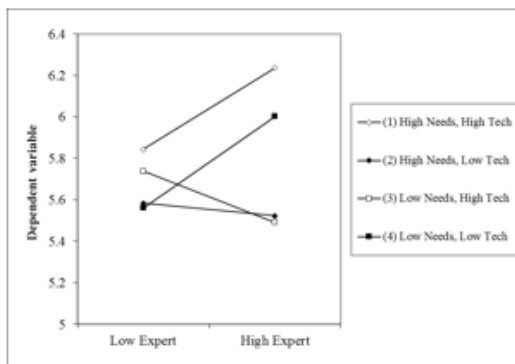
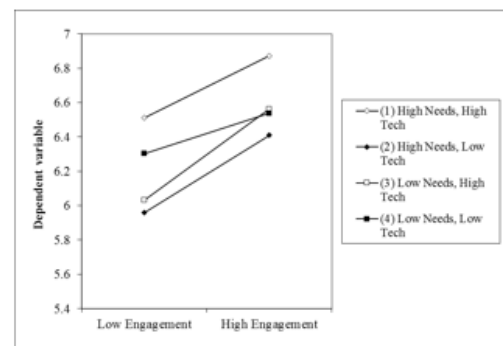


FIGURE 9
Engagement x Needs Knowledge x Technical Knowledge



types of knowledge, specifically the knowledge of consumer needs and technical knowledge of resources and technologies, on the innovation process. This investigation prompted a theoretical expectation that more knowledge of these, generally and independently, should provoke higher abilities to combine knowledge in creative combinations. After conducting explorative experiments, the evidence suggests, to the contrary, that needs and technical knowledge, independently, appear to *inhibit* innovativeness. It is only where these types of knowledge come together interactively that innovation can more successfully emerge.

Beyond the testing of hypotheses, there are a few additional observations from the data that may be worthy to note. The first is that the task itself had a meaningful impact on the innovativeness of participants. Specifically, participants found it easier to innovate in the cooking task than in the golf ball task. This may be due to the complexity and limitations of the golf ball task, as the nature of the problem does not lend easily to a wide variety of plausible solutions. As it were, a majority of solutions to this task (i.e. finding a more successful solution to the oft-lost golf ball) offered by participants involved some kind of electronic tracking mechanism embedded within the ball. Some experienced golfers even explicitly suggested that no solution was possible given the constraints of the game and of current technology, suggesting that ball findability might be improved only by “hitting the ball straighter.” On the other hand, the cooking task might be adequately solved in a variety of possible ways, such as through reminders, smart stoves/ovens, new pan technology, etc. This would suggest that the nature of the problem, its complexity, limitations, and other factors may be important factors in facilitating new product innovation and the innovativeness of solutions. Such factors

might be the focus of future research.

A second point of interest is that experience had a clear and observable *negative* effect on innovativeness. The measure of technical knowledge (KnowledgeQuiz) also had a negative sign, although it was not statistically significant. This, along with the negative signs of the effects of each type of knowledge individually, may suggest that “Einstellung” effects (i.e. expert inflexibility) are present for the more expert subsample (Bilalić, McLeod, & Gobet, 2007). That is, it may be that experience facilitates cognitive entrenchment, making innovation more difficult (Dane, 2010).

Finally, it is also interesting to note that an energetic mood (vigor) has a significantly negative influence on innovativeness ($p < .05$). This counterintuitive finding stands in contrast to the observed positive effects of engagement (absorption), which is often closely associated with vigor (e.g. Schaufeli et al., 2002). This finding may be related to cognitive research that suggests that creativity tends to emerge in relaxed cognitive states, such as daydreaming or mind wandering (Baird et al., 2012; Mason et al., 2007), and that too much focus can inhibit creativity (e.g. Amabile, Hadley, & Kramer, 2002).

This research offers important insights into the nature of innovation. Whereas knowledge has long been understood as a factor for innovativeness, the nature of this relationship has been unclear. Here it is demonstrated that *types* of knowledge are a critical factor in facilitating innovativeness. It is not enough to merely build and attain new knowledge. Instead, that knowledge must include *both* knowledge of consumers’ needs and the issue they face *as well as* knowledge regarding resources and technologies, and the affordances those provide in producing potentially useful effects. Then, in

bringing together these types of knowledge, the problem can be more effectively addressed in an economically viable manner.

The perhaps counterintuitive finding that experience, as well as priming needs or technical knowledge independently, appears to *reduce* innovativeness is actually very much in line with research on the so-called “Einstellung” effect (Bilalić et al., 2007; Luchins, 1942). In brief, Einstellung suggests that “too much experience within a field may restrict creativity because you know so well how things *should be done* that you might be unable to escape to come up with new ideas” (de Bono, 1968: 228; Wiley, 1998). The evidence for this effect is somewhat mixed. Indeed, classical experiments show that, when participants have been shown a way to solve a problem, they tend to try to solve other similar problems in the same way even if there is a better solution available (Luchins, 1942; Saariluoma, 1990). Bilalić and coauthors (2007), however, provide evidence that such effects can be overcome by the very highly expert, showing that chessmasters, i.e. those players higher than five standard deviations in skill level above the mean, did not fall prey to the same Einstellung effects as other experienced players (i.e. those ‘only’ three SDs above the mean) did. This finding is in line with the knowledge-based innovation approach, which suggests that innovators need somewhere along the lines of ten years of experience and expertise before having sufficient knowledge to generate breakthrough innovations (Ericsson, 1998; Hayes, 1989; Weisberg, 1999, 2006).

Dane (2010) offers a cognitive entrenchment perspective to reconcile these different findings. In short, he proposes “that the inflexibility-related limitations often ascribed to expertise are more accurately classified as consequences of cognitive

entrenchment—a high level of stability in one’s domain schemas” (2010: 590).

Einstellung effects can be mitigated, he suggests, through the regular access of new and unrelated knowledge.

The results obtained here offer a more nuanced explanation of this cognitive entrenchment, suggesting that Einstellung appears to occur where one type of knowledge, either problem-focused or solution-focused relevant knowledge, is attained without the other. That is, we see Einstellung effects here where one obtains high needs knowledge without technical knowledge, or vice versa. This may be because a high level of understanding of one side of the problem-solution pair without the other opens up concerns or limitations within that domain that are unresolvable with the limited knowledge of the other knowledge domain. As a result, ideas become *more* rather than *less* constrained, as possible solutions become discarded due to the acknowledged constraints of the one type of knowledge that are unable to be overcome with the limited knowledge of the other type. For example, in the golf ball task, a knowledge of all the considerations of golfers for the spin, compression, softness, and durability of the ball may give the innovator pause when considering the effects of embedding electronics within the ball, which would likely alter the ball’s ability to perform as needed. As a result, a simpler and less innovative solution may be conceived, such as brighter-colored plastics or paint. On the other hand, a knowledge of the technical limitations of production, such as the size and weight specifications or production materials, may cause innovators to question the feasibility of certain solutions, such as embedding electronics within the ball.

These Einstellung effects are overcome, however, where both sides of the

problem-solution knowledge domain are jointly attained. When high levels of needs knowledge *and* technical knowledge were offered, innovativeness strongly increased, producing better ideas. Indeed, where both types of knowledge are combined, they produce better ideas, generally, than the low knowledge innovator.

Personality, in this study, proved again be relevant to innovativeness, but its effect remains obscured, as it was found to have a direct effect on innovativeness rather than a moderating role through the cognitive mechanisms here described. It remains to be further explored, then, how and why personality impacts creativity and innovativeness. It may yet prove, however, that its impact is indeed through the cognitive knowledge combination mechanism, but that its effects are outside the limits of this study. For example, certain personalities (e.g. open-minded, non-conforming) may facilitate more exploratory knowledge accumulation over time, thereby improving their own capacity to innovate. Such an effect would go unnoticed in this study, but might be teased out in future studies. Clearly, however, the effect of personality should not be taken to be a direct and primary effect, as there must be some explanatory mechanism for its effects on creativity and innovativeness that remains to be uncovered.

Accessibility, on the other hand, was found to positively moderate innovativeness. The effects of the priming of knowledge that experienced participants expectedly already possessed was found to be very relevant, suggesting that the cognitive processes by which innovation occurs may be rather complex. If innovation can only occur within active memory, then knowledge alone is insufficient in generating novel insights. Instead, the right types of knowledge must first be activated in memory before it can be involved in innovative processes. How and why such processes do or do not occur may

be the subject of future work.

Engagement was also found to be positively related to innovativeness, but again, contrary to expectations, the effect of engagement did not prove to exhibit through its interaction with knowledge. Instead it had a direct effect on innovativeness in this study. This may be, simply, because engagement heightens open-mindedness and motivation and thereby facilitates greater efforts to look “outside the box” for solutions. This is in line with a body of work by Csikszentmihalyi (1990, 1997) regarding the nature of “flow,” or that state of engagement in which individuals find time whisking by while they are immersed in their task, and its effects on creativity. However, this effect may alternatively be causally reversed, where it is instead understood that engagement is heightened for those who have the better ideas. That is, participants’ sense of engagement, and therefore their self-report of it, may be inflated due to the quality of idea that they came up with. If they came up with an idea that they found especially innovative, their interest and engagement with the task might *resultantly* elevate, whereas a participant that is unable to come up with any ideas may be left feeling disappointed and unengaged. Disentangling this issue may also require further empirical work.

This study suggests that the theoretical focus on innovation processes may need to turn toward an exploration of knowledge, and the different types of knowledge, to further our understanding of how innovations are generated. It suggests that a greater understanding of innovation is likely to derive from an increased attention to cognitive processes, and the neuro-mechanical functions that the brain utilizes to conceptualize problems, to activate knowledge within memory, and to generate new links between various knowledge schemata.

Finally, this research breaks new ground in the empirical investigation of innovativeness by replicating real-world innovation tasks. Past studies have relied on simplistic creative tasks to facilitate the examination of novelty generation. Such studies, however, may be critically flawed in that they oversimplify the innovative process such that findings become non-generalizable to the real-world innovation context. Performing simple creative tasks may show an individual's propensity to produce imaginative or divergent thinking, but such creativity may be useless in creative problem-solving where real solutions are sought. Indeed, it may be that the simplicity of such studies has led to an over-prominence of certain factors in current theoretical frameworks, highlighting only those aspects of creativity while obfuscating others. For example, the confusion regarding Einstellung may derive from the limited types of creative tasks that have hitherto been studied. Where the tasks have been simple, with limited domains of problem or solution knowledge, Einstellung effects appear to be merely an effect of knowledge generally. By tasking participants with real consumer problems, the observable innovation process is able to be more completely studied, allowing more nuance and other important factors to emerge.

Practical Implications

The results of this study offer several insights that may produce helpful guidelines to facilitate more innovative outcomes. For example, research has suggested that expert “star” employees can improve a firm's innovativeness (Groysberg, Lee, & Nanda, 2008; Groysberg & Lee, 2009; Hess & Rothaermel, 2011). However, as has been indicated, technical knowledge alone is insufficient to the innovative process, and may in fact

inhibit this process through Einstellung. Therefore a greater emphasis on problem formation must also be made in order to facilitate and enhance the needs knowledge employed in problem-solving processes (Baer, Dirks, & Nickerson, 2012; Foss, Frederiksen, & Rullani, 2015; Hsieh et al., 2007). Indeed, research has shown that better problem finding or formulation leads to greater creative insights (Chand & Runco, 1993; Getzels, 1975).

Lead user theory would suggest that the involvement of users themselves may be the best way to facilitate the integration of this knowledge (von Hippel, 1986, 2005; cf. Chesbrough, 2003). In other words, the most successful innovators are likely to be those who have *local* knowledge (Lüthje et al., 2005), i.e. who are personally very high in needs knowledge (i.e. they themselves are high-needs consumers, or lead users) and also very high in relevant technical knowledge (i.e. they are expert in one or more relevant technical domains). The pursuit or development of such employees may be worth investment.

It appears that traditional HR practices tend to focus their search efforts too much on pursuing candidates with high technical knowledge, and not enough on those with high needs knowledge. Rarely are candidates' consumer needs and experiences considered in a job interview. Firms might do well, however, to broaden and expand their search for employees that are high-needs consumers of the firm's products. Technical knowledge can be taught and trained. Needs, however, are personal, subjective, and tacit, and therefore cannot be instilled. Capturing such knowledge from external sources (e.g. through market research or even open innovation) can be very difficult and imprecise. Firms might then consider bringing such knowledge within the

firm by way of employing or otherwise integrating lead users within the firm's innovative activities.

CONCLUSION

I have sought to address a key oversight in innovation studies, which is the often overlooked role of needs knowledge in producing innovative ideas. In the problem-solving literature, problem formulation is a critical aspect in strategy, opportunity, or innovation development (Baer et al., 2012; Hsieh et al., 2007). The role of knowledge in this process, and the difference in this type of knowledge from other types, have not yet been deeply explored. This paper fills this gap by demonstrating that innovation is benefited by the *combination* of needs and technical knowledge, and not necessarily by the possession of one or the other type of knowledge alone. A deep and broad understanding of both the problem needing to be solved and of available resources and technologies that might resolve it are required for insights to emerge. The stronger this joint knowledge, the more novel, useful, and technically and economically viable those solutions will tend to be.

**4. CONSUMER UNCERTAINTY, HETEROGENEITY, AND
SATISFACTION: A DEMAND-SIDE INSTITUTIONS THEORY OF NEW
PRODUCT DIFFUSION**

ABSTRACT

Diffusion research has long advocated the role of word-of-mouth processes in facilitating the diffusion of new product innovations. However, such models have more recently been met with significant criticism regarding their simplicity and general inability to account for market failures. In this paper I propose an alternative model that highlights the role of consumer uncertainty in the decision to adopt, and how this uncertainty and its resolution is at the source of diffusion processes. Employing a disaggregated agent-based model, I show that the familiar S-curve is reproducible where innovations are sufficiently valuable to overcome the uncertainty of early adopters, which success serves to reduce the uncertainty of other potential adopters through word-of-mouth (WOM) processes. I also highlight institutional (legitimation) processes resulting from industry formation as a key source of uncertainty reduction. This uncertainty model not only successfully produces the familiar S-curve but also offers a plausible prediction of market failures, as new products often fail to satisfy early adopters enough to provoke a sufficient reduction of the uncertainty of others so as to reach a critical mass of adopters. I also show how other important factors such as price and innovation can be incorporated into the model.

INTRODUCTION

Published anonymously in October of 2008 and released a few months later, the digital cryptocurrency Bitcoin has sparked a great deal of intrigue, speculation, and debate. It quickly incited interest among consumers due to its stable and politically impervious method of creating its currency supply via the block chain, a low risk of inflation due to the constant and restricted supply (and even expectations of appreciation), its inaccessibility to oversight and regulations due to untraceability, its relative security, its ease of use, and the many potential electronic applications that it can facilitate (such as a digital wallet with preset spending restrictions). In spite of these benefits, however, consumers have been slow to adopt the technology due, primarily, to high levels of uncertainty regarding its technological, legal, and economic viability. Concerns over the stability and security of the technology, its legal status, its volatility, and its overall legitimacy mounted, and there were few businesses willing to accept it as payment early on. As these concerns began to be assuaged over time, more consumers and businesses invested, and by the end of 2012 larger companies were beginning to accept bitcoins as payment for their products. Skepticism, however, again grew with the downfall of Mt. Gox, one of the largest bitcoin exchanges at the time, which somehow allowed hundreds of millions of dollars-worth of bitcoins to disappear. In spite of this setback, technology continued to develop around bitcoins as a medium of exchange. Still, mainstream use of the digital currency appears to be a ways off, and many consumers remain skeptical that it will ever achieve viability. There are many examples of such consumer uncertainty regarding the value of new product or service. This uncertainty, however, has so far been sidelined as a determinant of new product

performance. Here I explore the effects of consumer uncertainty on new product diffusion, underscoring it as a key and primary factor in new product diffusion processes. I also consider how industries form, and the effects of industry formation on consumer uncertainty and diffusion.

In recent years, research on innovation diffusion has become largely neglected (Forbes & Kirsch, 2011; Tidd, 2010). The S-curve contagion model (Bass, 1969; Rogers, 2003) continues to be the dominant model for research and practice in spite of long-recognized issues, such as a pro-innovation bias, where demand for a new product is assumed to be homogenous and universal. Such assumptions are clearly unrealistic, and have been widely challenged (e.g. Bemmaor & Lee, 2002; DeSarbo, Jedidi, & Sinha, 2001; Rahmandad & Sterman, 2008). These assumptions have produced a poor predictive track record, calling into question the reliability and usefulness of the traditional models.

In response to these criticisms, demand-side models of new product diffusion have more recently emerged, which focus on demand characteristics rather than supply-side firm activities in determining diffusion outcomes (e.g. Adner, 2004; Adner & Levinthal, 2001; Agarwal & Bayus, 2002). These models highlight consumer characteristics, and especially their heterogeneity, as key factors in diffusion processes, thereby explaining why and how new products diffuse to only a subset of the population, rather than the entire population.

Building on these demand-side approaches, I integrate marketing, management, and institutional theories in examining the role of uncertainty in determining the success, rate, and reach of diffusion processes and the process of industry formation (e.g.

Carpenter & Nakamoto, 1989; Kalish, 1985; Schmalensee, 1982). Specifically, I examine uncertainty on the demand-side, that is, *consumer's* uncertainty in estimating the value of some new innovation. This uncertainty derives from heterogeneity in the value consumers experience in consumption (Priem, 2007; Vargo & Lusch, 2004) and the fact that consumers must judge a new product's use value before that product can be consumed. Uncertainty plays an important part in purchase decisions, as research demonstrates that it must be sufficiently alleviated for consumers to become willing to pay for a new product (Akerlof, 1970; Bee & Madrigal, 2013; Castaño, Suján, Kacker, & Suján, 2008; Korhonen & Kaarel, 2011; Roselius, 1971). This suggests that it is a vital and so far missing factor in theoretical models of diffusion. I argue that consumer uncertainty is a primary factor in determining the popular acceptance of a new innovation and the subsequent formation of a new industry, and serves to explain various diffusion phenomena that have so far gone largely unexplained, such as early failure and the "chasm" phenomenon, where promising innovations fizzle out quickly after short-lived initial success (Kiesling, Günther, Stummer, & Wakolbinger, 2012; Van den Bulte & Joshi, 2007).

Because of the broad and important consequences of this diffusion process, there are many implications to this research that extend across several domains. First and perhaps foremost, I address key entrepreneurship questions regarding the success rates of new ventures and/or innovations and the mechanisms that determine these outcomes. Understanding the demand-side factors in this process offers key insights into the determinants of entrepreneurial outcomes. Second, I contribute to the growing demand-side literature in highlighting the role of consumer uncertainty in demand-side processes.

Third, I offer a novel contribution to theories of industry formation, suggesting that industries are primarily emergent, and that they are formed in large part by demand-side, rather than supply-side, factors. Finally, I provide theoretical support for these developments through agent-based modeling, demonstrating the theoretical feasibility and coherence of these mechanisms and providing evidence that the consumer uncertainty model generates plausible outcomes that so far have gone unaccounted for.

REVIEW OF DIFFUSION THEORY

Innovation diffusion processes have long been recognized as important factors in determining the firms' performance over time. How quickly and to what extent an innovation becomes adopted by the consumer population determines, for example, the magnitude and extent of the first mover advantage in a nascent industry (Rogers, 2003), and thereby plays an important role in determining industry structure and characteristics. The mechanisms of these diffusion processes, then, are critical to our understanding of new industry formation, entrepreneurial survival rates, and long-term strategies and strategic change (i.e. the industry life-cycle). Modern theories of new product diffusion can be delineated into two general types: aggregate-level (supply-side) models and individual-level (demand-side) models, reviewed here.

Aggregate-level Models

The traditional and most common models are aggregate-level models, most prominently the standard S-curve hazard model (Rogers, 2003). Originally formalized by Bass (1969), this model is generally conceived as an epidemic or contagion model, where

the diffusion of new product information is spread socially by marketing and word-of-mouth (WOM) processes, as formalized in the following hazard model:

$$n(t) = \left(p + q \frac{N(t)}{M} \right) (M - N(t))$$

where $n(t)$ is the number of new adopters at time t , p is a parameter determined by the firm's marketing activities, and q is a parameter representing WOM activity. $N(t)$ is the number of consumers that have adopted the new product at time t , and M represents the total market potential (generally the total population) of the product.

The contagion model has certain strengths, for which it has become popular in management theory. One attractive strength is that its (partial) supply-side analysis suggests practical managerial implications that firms can apply toward greater control over the diffusion process for new product introductions. Another strength is that it has been shown to have good retrospective coherence, fitting empirical data of successful product diffusion processes quite well, even when compared to more complex models (Bass, Krishnan & Jain, 1994; Tidd, 2010).

However, this model is also plagued with important weaknesses that call into question its continued theoretical viability. Primary among these is its extremely poor performance in *ex ante* predictions, especially for radical innovations (Kiesling et al., 2012; Tidd, 2010). One recognized cause of this is a pro-innovation bias—an assumption of “clearly beneficial innovations” (Gibbons 2004: 940)—where the entire population is expected to be universally benefitted and, resultantly, all products to successfully diffuse (Chandrasekaran & Tellis, 2007; Rogers, 2003). Studies of innovation failure rates put these between 20 to 70 percent after five years (Yang & Aldrich, 2012), resulting in a poor predictive track record for this model.

Another weakness is its inherent focus on purely social factors, ignoring product attributes, contextual factors, and individual or cognitive differences between potential adopters (Chandrasekaran & Tellis, 2007; Kiesling et al., 2012). Furthermore, the Bass model necessarily assumes a stable or stagnant product, whereas it is clearly observed that products can and do change over time, especially early on in its lifecycle (Agarwal & Bayus, 2002; Klepper, 1997). While many of these factors have been acknowledged over time, and attempts to address them made, the general model has changed little since its initial conception (Rogers, 2003).

Individual-level Models

More recently, “disaggregate” or individual-level models of diffusion have begun to emerge, focusing attention on the attitudes, attributes, and behaviors of individual consumers in attempting to understand their differences and how these relate to their individual decisions to adopt (Chatterjee & Eliashberg, 1990; Eliashberg, Chatterjee, Mahajan, & Wind, 1986). Because new product adoption ultimately occurs at the individual level, these models’ emergent approach offers important insights and foundational strength that generally avoid the aforementioned weaknesses of supply-side models.

Where supply-side models make sweeping assumptions of uniform demand, demand-side models employ more realistic assumptions of demand heterogeneity. As a result of such assumptions, ex ante predictions become more difficult and uncertain but accurate, depending to a great extent on the assumed individual differences and preferences (Chandrasekaran & Tellis, 2007). Thus a demand-side approach can offer

potential explanations of weak or unsuccessful product launches, consumer segmentation, limited product reach, and other empirically observable phenomena that supply-side models cannot. Differences in consumers' wealth, for example, have been shown to produce different diffusion outcomes. Approximations estimate a generalized market potential parameter—the percentage of a total population that adopts a successful innovation—of 0.52 (52 percent of the total population) for developed countries and only 0.17 for developing countries (Talukdar, Sudhir, & Ainslie, 2002; cf. Van den Bulte & Stremersch, 2004). Demand-side models distinguish the supply-side *perception* of a new product's market potential (i.e. the firm's expectation of the product's marketability) and its true demand-side determinants. So far these demand-side models have focused primarily on single-attribute drivers, such as affordability (Golder and Tellis, 1998; Horsky, 1990), expected utility (Delre, Jager, Bijmolt, & Janssen, 2007; Horsky, 1990; Roberts and Urban, 1988), and risk aversion and information asymmetry (Chatterjee and Eliashberg, 1990; Oren & Schwartz, 1988).

These individual-level models, however, also have important weaknesses. First, like supply-side models, demand-side models have limited *ex ante* predictive ability, although this limitation is acknowledged in its assumption of consumer heterogeneity whereas in aggregate models it is not (Bemmaor & Lee, 2002). Also, demand-side models of diffusion are still quite nascent, and remain relatively undeveloped. This is reflected in the simplistic and generalized nature of the individual on which models are based, typically allowing heterogeneity within one or two attributes only, while assuming away all others. Additionally, some key environmental and behavioral attributes are extremely difficult to reproduce synthetically in models. For example, while

theoretically acknowledging consumer uncertainty (e.g. Chatterjee & Eliashberg, 1990; Horsky, 1990; Oren & Schwartz, 1988), so far these models only account for behavioral tendencies (i.e. risk aversion) and do not reflect the actual uncertainty faced by consumers.

An important development in facilitating individual-level models has been the emergence of agent-based modeling (ABM) techniques, described in more detail below (see Keisling et al., 2012 and Wall, 2016 for reviews). Theorists have successfully employed ABMs in reproducing the Bass model's S-curve through emergent social processes. However, so far they have been employed almost exclusively in social networking theories in accordance with the Bass contagion model. Individual differences in decision processes (e.g. expected utility maximization) have not been considered, or have been considered in a very limited sense (Keisling et al., 2012). One of ABMs' potential strengths, however, is its ability to simulate heterogeneity of individual attributes and behaviors among agents as well as between various contextual factors, which heterogeneity allows for more complex and realistic representations of social interaction phenomena.

A DEMAND-BASED INSTITUTIONS MODEL

The model here proposed is intended as a general and integrated theory of new product diffusion that incorporates and explains the various processes that have so far been proposed and examined in past studies of the diffusion process. Adopting a demand-side logic and, especially, insights offered by Priem (2007), I highlight the role of individual consumer experiences in facilitating or impeding innovation diffusion

processes. Underlying this model is *consumer uncertainty* and the theoretical implications of this uncertainty on the consumer's decision to adopt. I integrate the logic of institutions to explain how uncertainty affects the adoption process, how uncertainty changes over time, and what these mean to diffusion theory.

The Role of Uncertainty

A key weakness of current approaches to diffusion, both aggregate and disaggregate, is their general failure to account for consumers' uncertainty throughout the process. Exceptions (e.g. Kalish, 1985) have been limited, and only involve uncertainty as an influential factor, and not as a foundational mechanism. Seminal contributions by Schmalensee (1982) and Carpenter and Nakamoto (1989), however, proffered that consumer uncertainty regarding new product value may be the preeminent mechanism generating the observed "pioneering" or first-mover advantage—early adopters are more certain of the value of the pioneer, whose product they have already purchased and experienced, than that of imitators, and are thus less likely to switch. This mechanism, however, was never extended into the general diffusion process, which remains steeped in more superficial rationales. A failure to account for differences between expected (uncertain) and actual consumption value (Vargo & Lusch, 2004; Priem, 2007) is arguably the source of the pro-innovation bias and the presumption that social interaction is the primary driver of market diffusion. While this may simply be an oversight, it may also be due in part to difficulties in capturing true (Knightian) uncertainty empirically or synthetically. However, by embracing the existence and effects of uncertainty in this process, the mechanisms by which products do or do not diffuse may be better elucidated.

There are two key sources of consumer uncertainty at the heart of the diffusion process. First, consumer uncertainty is inherent in the nature of the purchase decision. Value, according to the service-dominant logic (Vargo & Lusch, 2004), is determined in consumption, and not before (Priem, 2007). Expected benefit or utility, then, is inherently uncertain, as products must be judged for their value before they can be consumed and their true value be determined. Consumers will only adopt when expected benefit is sufficiently certain relative to their individual risk aversion. As they begin to purchase new products, their subjective consumption experiences produce new knowledge concerning the true value of those products, which experience can then be communicated to others, thereby influencing future purchases. As such, the S-curve derived here is conceived not as a strict contagion model, as in the Bass model, but as a learning or uncertainty reduction model, only partly or indirectly derived from marketing and WOM communications. Indeed, research suggests that WOM activity is derived and motivated *from* consumers' experiences of satisfaction (Chevalier & Mayzlin, 2006; Oliver, 2010), and is therefore not a true first-order factor.

The second source of consumer uncertainty is derived from consumers' inherent lack of awareness of their own needs (Leonard & Rayport, 1997; Witt, 2001). That is, consumers are often unaware of the precise nature of their own subjective needs and the best ways to satisfy those needs. Consumers experience and thereby learn how their needs are best met over time through (dis)satisfactory consumption (Witt, 2001). Their needs and experiences are unique and subjective, provoking sometimes substantial differences between the consumption experiences of individual consumers. Consumers' understanding of their own needs is, then, limited to their past experiences and their

ability to translate those experiences into causal knowledge.

The introduction of a new consumable good produces a necessarily uncertain context, as consumers are unable to draw on past experience to ascertain the subjective value of the new item. Indeed, the unique historical experience of each consumer necessarily produces a distinct perception of the need which a new product is intended to address and, as a result, different assessments of the anticipated value of that product. Relatedly, the uncertainty that is perceived surrounding the value proposition is also heterogeneous, as each individual's knowledge and perception of the solution and its viability may differ, and the impact of this uncertainty must also be heterogeneous as individuals differ in risk tolerance (Meertens & Lion, 2008).

Consumer uncertainty may resolve over time as new information and experience becomes available (Sheth & Venkatesan, 1968). With respect to the relevant factors that influence consumer uncertainty, there are five general levels of analysis of interest: individual, product, firm, industry, and environment. First, individual-level factors include general personality, risk-aversion, personal needs, wealth and income, influence, trust and influenceability, and other heterogeneous factors (Adner & Levnithal, 2001; Bermúdez-Edo, Hurtado-Torres, & Aragón-Correa, 2010; Chatterjee & Eliashberg, 1990; Iyengar, Van den Bulte, & Valente, 2011; McMichael, 2011; Rogers, 2003; Watts & Dodds, 2007). Second, product-level factors include utility, price, brand, endorsements, trialability, observability, guarantees and warranties, various marketing techniques, and so forth (Akerlof, 1970; Benner & Tripsas, 2012; Castaño et al., 2008; Erdem & Keane, 1996; Erdem & Swait, 2004; Rogers, 2003; Roselius, 1971; Shimp & Bearden, 1982). Third, firm-level factors include image and reputation, (Roberts & Urban, 1988;

Roselius, 1971), size, and distribution networks. Fourth, there are industry-level factors, such as the number of competitors, general availability, industry growth, and so forth. Fifth and finally, environmental factors that influence consumer uncertainty include communication technology, social heterogeneity and culture, environmental dynamism, environmental concentration (i.e. the extent to which output market resources are perceived as controlled by, or concentrated in, a few or many organizations), and environmental capacity (i.e. perceived total reach) (Achrol & Stern, 1988; Goldenberg, Libai, & Muller, 2001). While these environmental factors may certainly be relevant, the scope of this paper is limited to consumer-, product-, firm-, and industry-level factors that directly or indirectly influence consumers' uncertainty.

Consumers account for uncertainty in adoption decisions by lowering their willingness to pay; that is, loss aversion provokes consumers to be conservative in expected value estimations of new products (Dubourg, Jones-Lee, & Loomes, 1994; Thaler, 1980). The presence of uncertainty, then, slows the rate at which innovations diffuse and industries form (Alexander, 2008; Wang, 2010). As this uncertainty resolves over time through consumers' experiences and the diffusion of positive information regarding the true value of that product (Sheth & Venkatesan, 1968), consumer willingness to pay and, with it, the rate of diffusion and the number of potential consumers increase (if the product indeed proves, and continues to prove, valuable).

Product Industries as Consumer Institutions

A sizeable literature outlines the role of institutions in reducing uncertainty and facilitating behavior in the face of strong uncertainty (e.g. North, 1991; Foss &

Garzarelli, 2007). Institutions, when unfettered, form organically as individual members of a group explore new behaviors. The most successful behaviors in terms of outcomes are communicated to others, implicitly or explicitly, who learn and adopt those same behaviors. If a behavior proves broadly advantageous, the gradual diffusion of information regarding the behavior through social pathways facilitates its adoption across the population (Kennedy & Fiss, 2009; Westphal, Gulati, & Shortell, 1997). Over time, the new behavior becomes solidified as an institution. In this way, best known practices in society emerge as commonplace, even when individual members of that society do not necessarily understand how or why the behavior is advantageous. Institutions serve as a “common signpost” to effectively guide behavior in the midst of uncertainty (Lachman, 1971). Conformity to such institutions, then, can facilitate beneficial behavior even in extremely complex and uncertain environments, where it is likely that no member fully understands all the mechanisms by which any behavior derives its outcomes.

Taking a demand-side perspective, we can observe this institutionalization process occurring in the diffusion of new products. Early adopters pave the way for subsequent adopters (Rogers, 2003). As the new product prove successful in satisfying early consumers’ needs, the positive growth rates and a high total perceived reach attract competitors to the market (Porter, 1998; Schumpeter, 1934). As imitators enter the market, an industry is formed, and competition begins. Agarwal and Bayus (2002) suggest that this competition serves to accelerate new product acceptance in multiple ways, namely by increasing demand through product innovations (Gort & Klepper, 1982), new product offerings (both by the first mover and by imitators) (Bayus & Putsis, 1999), and through price competition (Golder & Tellis, 1997). These effects indirectly

influence new product adoption through their impact on consumers' uncertainty.

The formation of an industry can be thought of as a consumer institution. As new entrants to an industry emerge, these imitators signal to consumers that their confidence in the product is such that they expect sufficient market to grow to warrant investing a sizeable amount of capital to develop a product that competes with others from a disadvantaged position (e.g. first mover advantages) for market share. Such a strong vote of confidence in the value of the product may have a significant impact on consumers. Krishnan, Bass, and Kumar (2000), for example, show that the cell phone industry's market potential and diffusion rates increased when a new competitor entered the market, suggesting that the mere entrance of a competitor facilitates greater acceptance of the product. Consumers' perception of legitimacy may be especially strong where the imitator is a known and respected brand. The formation of industries, then, is a key factor in resolving consumer uncertainty, and pushes new products from a state of questionable value into mainstream acceptance. The existence of a competitive industry signals to consumers legitimized value, even where such value is not fully understood.

The Uncertainty Chasm

In the language of institutional theorists, the early adopters of a new product can be thought of as institutional entrepreneurs (DiMaggio, 1988; Dacin, Goldstein, and Scott, 2002). Although the earliest adopters of a new product are typically distinguished as especially curious, venturesome, and risk tolerant (Rogers, 2003), needs heterogeneity considerations would suggest that they will be characterized primarily by especially strong needs that the product purports to satisfy (Adner & Levinthal, 2001). It is the

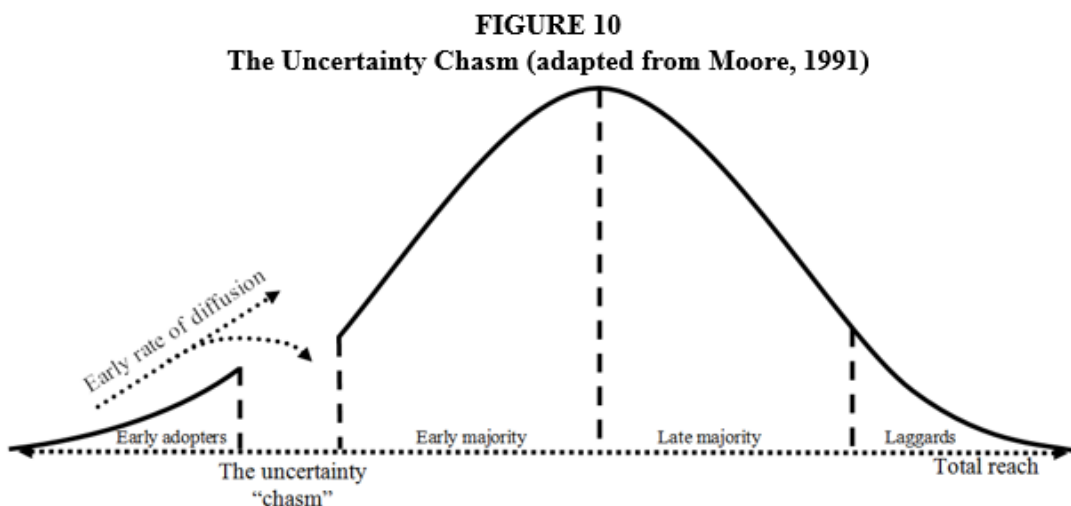
need, then, that provokes the atypical anticipation, enthusiasm, and willingness to bear uncertainty more than some generic characteristic of the individual—otherwise we should expect these consumer “innovators” to be first to adopt in *all* product categories. It is those highest in a need who also have both the means and risk tolerance, then, that first adopt a new product and then report to other consumers the success or failure of the product in satisfying the expected need.

Early reviews of the product are considered by other high-need individuals (i.e. the “early majority;” Rogers, 2003) who are either higher in uncertainty or lower in tolerance for uncertainty (e.g. because they have lesser means), who await verification of the product’s value. If the reviews are positive, the uncertainty of the early majority, a much larger consumer segment, is reduced, prompting many of them to adopt. This process continues until the uncertainty is significantly reduced, and all who sufficiently value the new product (i.e. they have a sufficient need to warrant its purchase) have adopted. Note that uncertainty can never be completely eradicated in consumer products because of the nature of the purchase and situational factors in value determination (Bauer, 1960; Sheth & Venkatesan, 1968). Even with well-established and highly reliable products, there is no complete guarantee that the consumption experience of a product will fully replicate past consumption experiences. At uncertainty’s minimum, only a subset of the population will be expected to have adopted most successful new products as heterogeneous needs assumptions suggest that for some the need is so small that the advantages of satisfying it would not merit the time, costs, and effort of purchasing it, even at a near-zero price.

The gap between the early adopters and the early majority, which is generated by

the distinction between those whose perceived need outweighs their uncertainty and those whose uncertainty outweighs their need, has been aptly described as a “chasm” (Moore, 1991; Van den Bulte & Joshi, 2007). The chasm metaphor helps to explain the fizzling out of a great many innovations that failed to reach mainstream markets. This chasm has in the past been attributed to differences in persuasion requirements, likely due to the Bass model’s theoretical focus on social persuasion processes. As a result, Moore (1991) proposes that it can be hurdled through relentless marketing campaigns. However, this explanation does not appear to be robust to considerations of various product innovations that met the market with significant campaigning and anticipation, only to fail to live up to the hype (e.g., movie “flops” such as *Waterworld*).

Here I attribute the existence of the chasm to uncertainty (See Figure 10). While the diffusion of new product information may take time, few consumers are likely to adopt immediately upon learning of the product’s existence (Golder & Tellis, 1998). Even when they are aware of a new product and anticipate its market arrival, most consumers will wait to buy the product due to the uncertainty of its value (Chatterjee & Eliashberg, 1990). To cross this chasm, products must sufficiently reduce consumer



uncertainty on their own merit by proving sufficiently valuable to the early adopters so as to incite positive feedback from them. Subsequent WOM processes and competitive entry (industry formation) then serve to reduce the uncertainty of other consumers over time, and the product diffuses toward its market potential (Chevalier & Mayzlin, 2006).

If a new product fails to sufficiently satisfy the early adopters, those early adopters are not sufficiently motivated to generate positive WOM or, if the dissatisfaction is strong enough, may result in *negative* WOM. The uncertainty of the early majority, who await the recommendation of the early adopters, fails to be adequately resolved, or is resolved in a more certain recognition of insufficient value, and willingness to pay remains below the price. As a result, the product fails to cross the chasm, and falls to its failure and eventual exit.

Product Changes over Time

A final point regarding the diffusion of innovations regards the non-static nature of product development, even after the product has been released. Feedback from the early adopters not only influences other consumers, but also provides the product's producer with information regarding how that product's value might be improved. If the firm can apply that feedback quickly and effectively, it may improve the value of the product before reaching the chasm and thereby improve its chances of hurdling the chasm (Agarwal & Bayus, 2002).

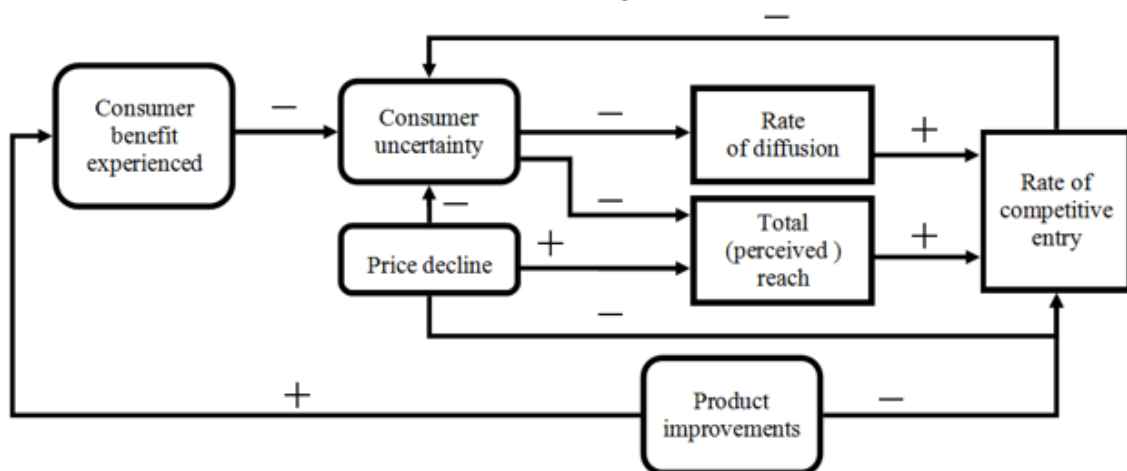
It is also not always the case that the price remains constant over time. Instead, learning curves, increases in product and the resultant economies of scale, and innovative improvement to the production process can reduce the cost of production. These savings

may be electively passed on to the consumer in order to increase affordability and reduce the risk the consumer must bear (Golder & Tellis, 1998; Horsky, 1990). By dropping the price point below some consumers' willingness to pay, producers increase the early adopter pool, thereby increasing the product's chances of positive WOM processes (Krishnan, Bass, & Jain, 1999).

The impact of this innovation process, however, may be Janus-faced, as both product improvements and price reductions also erect a competitive entry barrier, reducing the threat of entry (Porter, 1998). While this allows for an extended first-mover advantage, the institutional effects of industry formation may be resultantly delayed, thereby slowing the diffusion process.

In all, the general model is summarized as in Figure 11.

FIGURE 11
The Consumer Uncertainty Diffusion Model



METHODS

In line with recent individual-level work, I employ an agent-based model (ABM) design for this study. ABMs have been used as “generative” tools to illustrate and test theoretical developments, especially those concerning the emergence of phenomena (Epstein, 1999). These models are exceptionally useful in demonstrating possibilities of

theoretical complexities where empirical limitations tend to fail (Harrison, Lin, Carroll, & Carley, 2007). That is, simulations provide observable reproductions of theoretical phenomena such that we can observe their logical outcomes. If these simulated outcomes reproduce actual, observed phenomena to a reasonable extent, we may presume that the theoretical underpinnings of the model are reasonably true, or that they may be true. Thus, while ABM is not intended as a substitute for empirical testing, it is more precisely useful in generating evidence that a theory is *plausible* in explaining observed phenomena (Axelrod, 1997). In other words, agent-based models serve primarily as *predictive* models, demonstrating that social phenomena *can* occur through predicted theoretical mechanisms, which predictions can then be empirically validated through other methods (Burton & Obel, 2011).

ABMs are generative, or bottom-up, approaches to social simulation in that simulated agents (individual actors) are not given a universal social script to follow, but rather are self-contained entities that act according to a provided set of rules given their individual context and perspective (Wooldridge & Jennings, 1995). Their governing rules are intended to represent theoretical mechanisms by which actors are presumed to act. As these actors interact with other actors or environmental variables, their present behavior may be modified according to the rules provided. Over time, as multiple autonomous actors continue to act individually and interact with each other and/or the environment, we might observe the emergence of social phenomena (Axelrod, 1997; Fioretti, 2013). ABMs, for example, have been used to model organizational culture (Harrison & Carroll, 2006), learning behavior (March, 1991), decision behavior (Rivkin & Siggelkow, 2003), firm organization (Bylund, 2015), organizational search (Siggelkow

& Rivkin, 2006), and innovation diffusion (Kiesling et al., 2012; Wall, 2016).

Because ABMs are relatively new to the social sciences and can be rather complicated and difficult to understand, a standard protocol for the documentation and description of ABMs was developed. Here I follow this protocol, the ODD (Overview, Design concepts, Details) protocol (Grimm et al., 2010) in outlining the model. The simulation is generated using the NetLogo (ver. 5.1.0) software platform.

Purpose

The purpose of the model, and its use of agent-based techniques, is to emphasize the utilitarian nature of the decision to adopt, rather than rely on social persuasion as the sole or even primary determinant of new product diffusion. That is, while social influence certainly plays a role in the purchase decision, its role is indirect inasmuch as it affects the individual's perceptions of value and their uncertainty toward the product. ABMs have been used increasingly for such emergent phenomena because they can simulate independent decision-making from multiple participants, both of the same and of different types. Furthermore, ABMs are capable of reproducing heterogeneity at individual and organizational levels simultaneously, producing a more realistic and, therefore, justifiable representation of phenomena than other simulations.

Entities, State Variables, and Scales

There are four levels of interest in this simulation: the market, the firm, the product, and the consumer. These are described below, as summarized in Table 5. Time should not be assumed to scale perfectly to real market processes, but it can be estimated

that a single iteration of the simulation represents about one day.

Market. The simulation landscape represents a marketplace where firms and consumers interact toward the maximization of consumer utility and firm profitability. For this simulation, the market environment is assumed to be stable, with no relevant state variables.

Product. For simplicity, firms are assumed to offer only one product within the given marketplace. Products are introduced randomly in the marketplace as immobile entities sought out by consumers. Products are assigned a *benefit* variable that represents the extent to which the new product is superior in resolving consumer needs to current solutions. This assignment is done randomly using a gamma distribution that tends toward incremental innovations. A price is also assigned based in part on the benefit variable as well as a randomly generated component. A price floor is guaranteed based on the assumption that the firm will offer the product at a price above its cost of production. The product's *brand* is also given a random initial value (gamma distribution) with a mode of zero for the first-mover (I assume it is a new venture) and somewhat higher for imitators (imitators are presumed more likely to have an established brand identity).

Firm. The firm also possesses unique attributes. *Perceived potential* is the total market potential of a product that the firm perceives, which is assumed to be generally biased above the true market potential (the extent of this bias is randomly generated). This attribute influences firms' entry and investment decisions. I also generate two randomly (normal) distributed attributes to represent the innovativeness of the firm. First, *product innovativeness* represents the firm's ability to continually improve their

product. Second, *efficiency innovativeness* represents the firm's ability to cut costs and thereby lower the price. The firm's initial *capital* endowment is also randomly generated, following a normal distribution. Based on the limits of this capital endowment along with the total expected profitability of the innovation, a project budget is set. For this simulation, it is set to be a third of the expected profits to account for uncertainty. Based on this budget a marketing budget is also assigned, which is randomly assigned to be 1/4th, 1/5th, or 1/6th of the total budget so as to represent heterogeneous marketing philosophies. Finally, there is an *imitator threshold*, which signifies the number of adopters needed before a potential imitator will consider the market sufficiently proven and viable to enter.

Consumer. Each individual consumer is assigned a heterogeneous value (normally distributed) for the following attributes: *need level*, *uncertainty* (per existing product), *risk tolerance*, *wealth*, and *social influence*. Three other key variables, i.e. *need sensitivity*, *price sensitivity*, and *legitimacy gains*, are assumed to be constant. Social networks are also generated following a random network topology (Bohmann, Calantone, & Zhao, 2010), where each consumer is assigned a circle of friends based on their random initial location. While this type of network does not generally offer the same degree of clustering found in actual social networks, it is a simple design that is easy to simulate while adequately replicating the small-world properties of social networks (Bohmann et al., 2010).

Process Overview and Scheduling

The simulation generates autonomous consumers that are distributed throughout

the simulation landscape (market) randomly. As is typical of ABMs, the market process occurs through continuous iterations of research-justified subprocesses. The general process here is outlined by behaviors at two levels: consumer- (demand-side) and firm-level (supply-side). For each iteration of the simulation, consumers search the market for products they want, making a purchase decision if they come across a product, and update their uncertainty according to whatever information was gleaned in that time (e.g. advertising, WOM, or new product announcements). Existing firms attempt to innovate, and update their budgeting and marketing practices with regard to their success and income. Finally, potential imitators evaluate the market landscape in terms of its potential profitability and decide whether to enter the market.

Design Concepts

Simulation modeling is a fine balance between simplicity and realism (Harrison et al., 2007). It may be desirable to create complex and realistic models that more accurately resemble actual phenomena, but such complexity may come at the expense of clear and interpretable results. Some suggest, generally, that simpler is better so as to maintain the purity of the effects being examined (Axelrod, 1997). But oversimplification can inadvertently exclude important factors relevant to the process of interest (Harrison et al., 2007). This balance, then, between simplicity and elaboration becomes something of an art. My aim here is to examine the influence of consumer uncertainty while reproducing realistic diffusion processes. To achieve this balance, I introduce greater complexity and realism to the model than is typical of simulation, and run the model repeatedly to examine the effects of certain factors in view of, and in

conjunction with, other factors.

However, to achieve sufficient simplicity so as to reasonably isolate the intended processes and effects, I make the following simplifying assumptions. First, the environment is assumed to have stable and uniform conditions so as to focus on the market processes alone. Second, I assume that the simulated products satisfy a single consumer need, and that the product's benefit in satisfying needs is universal across all consumers. Heterogeneity and subjectivity in the decision process, then, result from differences in consumers' needs only where, realistically, such differences would result from a multitude of factors, including differences in needs, personal tastes, timing and contextual factors, and product quality factors. I also assume there are no network externality benefits (i.e. that the product becomes more valuable the more others adopt), but that the product's value is strictly utilitarian. Finally, all marketing is assumed to be product specific such that there are no marketing spillovers, where products are benefited from the advertising of others within the same industry, and brand influence is assumed to be constant over this period.

The design of the model, in following the ODD, is provided in Table 4. Details of the decision rules provided in a subsequent section (Subprocesses), and in Table 6.

Initialization

The simulation begins with the introduction of a single new innovation in a marketplace with 1000 consumers, with heterogeneous attribute assignments as per Table 5. Mean initial values can be manipulated, but each of the key attributes were manipulated (“shmooed”) so as to ascertain an appropriate initial value. A shmoo entails

TABLE 4
ABM Design Concepts

Design Concept	Description
Basic Principles	The design of the model is founded on decision principles at both the consumer and firm level derived from management, decision making, and marketing literatures. For consumer behavior I rely most heavily on Zhang and Zhang (2007), who employ a model similar to the one here to examine consumer reaction to the decoy effect. I also permit firms to alter their initial course of action (Agarwal & Bayus, 2002; Hastie, 2001; Klepper, 1997; McMullen and Dimov, 2013), thereby standing in contrast to standard diffusion models. This produces a more realistic view of new product diffusion, allowing us to observe the interaction of multiple factors in facilitating or inhibiting diffusion processes, especially through the mechanism of consumer uncertainty.
Emergence	The interaction of heterogeneous and uncertain consumers and heterogeneous firms and their products is expected to produce a much wider array of diffusion outcomes than is typically found in the literature. We may expect, in particular, to be able to reproduce the traditional S-curve in some cases, but find market failures under other conditions, as new products fall into the chasm. We should also see variability in takeoffs, diffusion and entry rates, and total market reach.
Adaptation	Runtime adaptations may occur at all four levels: consumer, product, firm, and market. At the consumer level, agents adapt in terms of their purchases of products and in terms of their uncertainty regarding the value of market products. Products can adapt over time as firms continually try to improve them through innovation, both in terms of value and of cost. Firms adapt their resource allocation according to their financial constraints. Finally, the market landscape changes over time as firms enter or exist based on performance and potential.
Objectives	The objectives of the consumer and firm are straightforward. For the consumer, it is to maximize their satisfaction through the consumption of products in accordance to their resource constraints. For the firm, it is to maximize its profits through the marketing and sale of products to as many consumers as possible.
Learning	Consumers reduce their uncertainty over time as they learn of products and their value through advertising, WOM, and new product announcements. Potential entrants also learn about the potential market value over time as consumers adopt or not the new product.
Prediction	For model simplicity, the benefit of a product is assumed to be universal across consumers. Heterogeneity, then, is generated in the needs of the consumer. Consumers' predictions of satisfactions, then, are made with respect to their need level and the uncertainty they perceive around the product. Imitators also predict total market value of a product when deciding whether to enter using the total market potential (total consumers with a sufficient need and wealth level) with added random error.
Sensing	Sensing refers to the observable attributes of others that acting agents use in their decisions/behaviors. Consumers are assumed to be able to observe the benefit of products once they discover them, as well as their price. Consumers can also sense the benefits obtained within their group of friends, i.e. through WOM. Firms sense certain consumer and market attributes, such as the total number of consumers and their need and wealth levels, which are assumed to be ascertained through market research.
Interaction	Interaction occurs throughout the simulation between consumers through WOM processes, between consumer and firm through advertisement and purchase, between consumer and product in consumption (satisfaction), and between firm and product in innovation.
Stochasticity	Stochastic processes may be used in simulations to represent unpredictable events. In this model, firms may innovate at random (or pseudo-random) intervals.
Collectives	In this model collectives are not defined, nor are they expected to form. Consumers are assigned a small group of friends, but these groups will not be the same even among friends, and do not constitute a collective in any meaningful sense. Consumers are assumed to act in their own personal self-interest, and products are assumed to be utilitarian in nature such that there are no network externality benefits.
Observation	The data we are primarily interested in are the total number of product sales of the new innovation (regardless of the brand), and the total number of adopters. I distinguish these to observe whether and how industry growth, firm performance, and/or product sales can continue beyond full market penetration and saturation. I also track the number of firms/products in the marketplace and consumers' average uncertainty over time.

a cyclical repetition of a process while incrementally altering key inputs, holding all other factors constant (where possible), so as to isolate the specific effects of those inputs on the overall process (Baker & von Beers, 1996). The following key variables were shmoosed (see Figure 12): mean need level, mean wealth level, mean risk tolerance, mean influence, mean uncertainty, mean consumer value, price, price sensitivity, need

sensitivity, the legitimacy gains from imitation, and the imitator threshold (i.e. at what point is the market sufficiently proved for potential imitators to warrant action?).

Because of the randomness and complexity of the simulation, several mechanisms could not be fully controlled, which resulted in inconsistent shmoo results. However, the results clearly show the general functionality of the mechanisms outlined above, and have provided sufficient reliability to determine appropriate mean levels for each variable (see Table 5). Two exceptions, price sensitivity and legitimacy gains, failed to produce a clear effect on diffusion outcomes, although a legitimacy gains effect appears to be present but comparatively small. Price sensitivity, it may be noted, does not come into play until after an industry has already formed, once there are multiple price points to compare, and therefore produces little overall effect on the diffusion outcome. The small effect of legitimacy gains, however, are more surprising, as they are theorized to have an important impact on industry formation. It may be that this effect is defused or mediated to an extent by other key factors. For example, the effect of *when* the uncertainty reduction of legitimacy gains due to imitation and industry formation (Figure 12, Imitator Threshold) occur appears to produce a much more salient effect on diffusion outcomes.

Input Data

The model does not use input data to represent time-varying processes.

Subprocesses

Behavior and decision processes are performed within several subprocesses,

FIGURE 12
Variable Shmoos

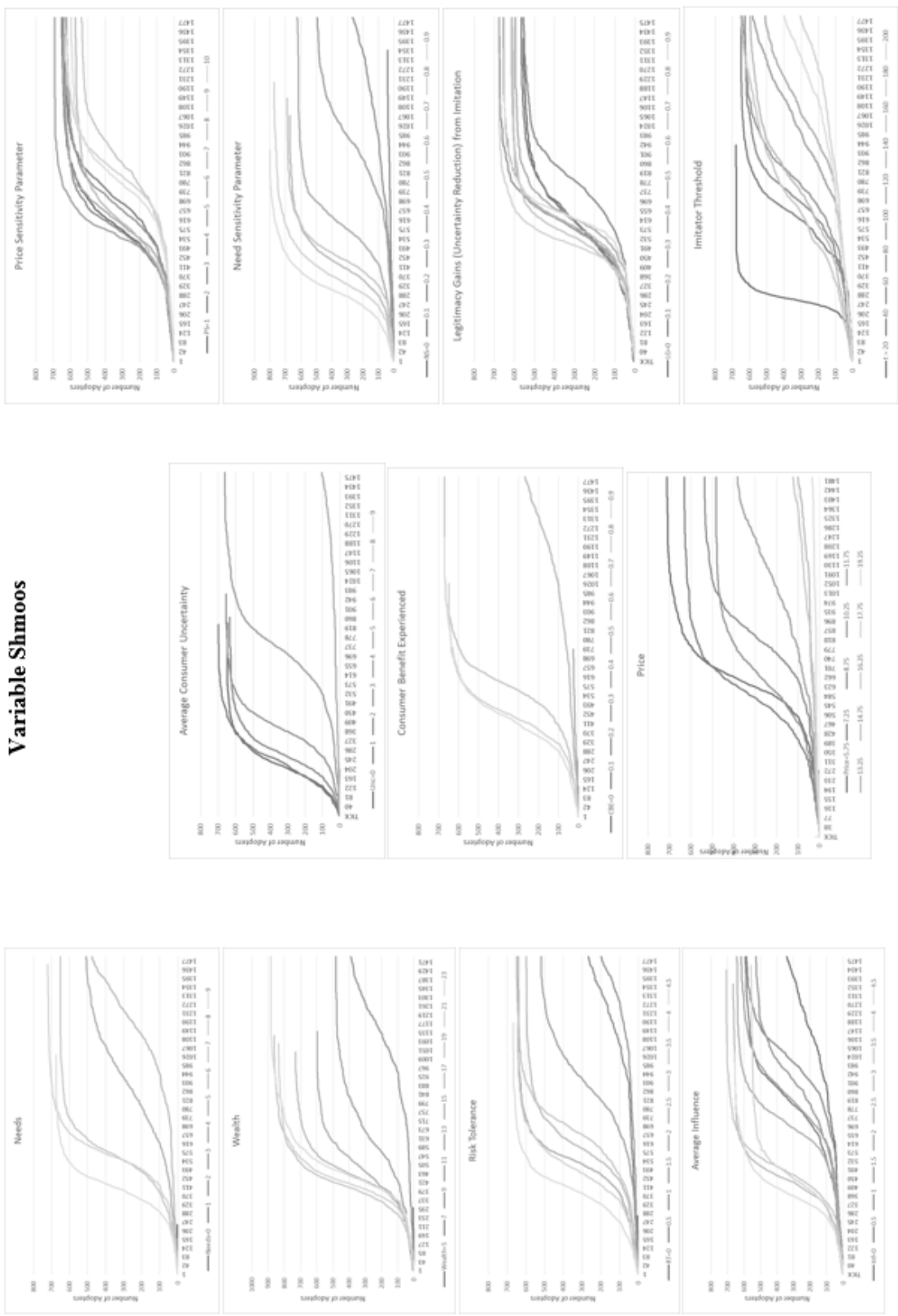


TABLE 5
Simulation Parameters

Variable	Entity	Distribution	Value	s.d.	α	β	Minimum
Mean Need Level	Consumer	Normal	7	4			0
Mean Wealth Level	Consumer	Normal	15	4			5
Mean Risk Tolerance	Consumer	Normal	3	1			0.1
Mean Influence	Consumer	Normal	3	0.5			0
Mean Uncertainty	Consumer	Normal	4	2			0.5
Price Sensitivity	Consumer	Constant	5				
Need Sensitivity	Consumer	Constant	0.7				
Legitimacy Gains	Consumer	Constant	0.3				
Capital (first mover)	Firm	Normal	150	30			50
Brand (first mover)	Firm	Gamma			0.5	2	
Capital (imitator)	Firm	Normal	200	30			50
Brand (imitator)	Firm	Gamma			2	2	
Marketing	Firm	Random	[1/4, 1/5, or 1/6] * Capital				
Product Innovativeness	Firm	Random	[0-2]				
Process Innovativeness	Firm	Random	[0-2]				
Imitator Threshold	Firm	Constant	50				
Benefit	Product	Gamma			1	1	
Price Multiplier	Product	Normal	3	1			0
Perceived Reach	Product	Random	market potential + [0-30]				

which are detailed below. The decision criteria employed are summarized in Table 6.

Search market. Consumers search the market by means of a simple search protocol in which the agents move around the world semi-linearly (moving in a straight line could limit the possibility of finding a product) in search of satisfactions to their needs. The speed at which they search depends on their respective *need level*. If consumers come across an existing product, they decide whether or not to purchase the product. If they purchase the product, their *need level* reduces incrementally as a result, and they continue their search at a slower rate for an even better satisfaction. Otherwise their search continues as before.

Adapting Zhang and Zhang (2007)'s consumer motivation function, the purchase decision is shown in Table 6 (eqs. 1, 2, and 3). Based on Kim and coauthors' (1995) work, price sensitivity is formulated based on consumers' individual wealth and their price expectations, such that an unexpectedly low price reduces price sensitivity,

TABLE 6
Simulation Decision Models and Criteria

ID	Factor	Model	Description of Variables
(1)	Purchase Decision (buy if $M_i > 1$)	$M_i = PS_i * P_x + NS_i * E_x - RT_i * U_x$	M: consumer motivation or willingness to pay PS _i : consumers' price sensitivity NS _i : consumers' needs sensitivity P _x : price of product x E _x : expected benefit of product x RT _i : consumers' risk tolerance U _x : consumers' uncertainty regarding the value of product x α: price sensitivity parameter, α > 1 k _i : consumers' wealth
(2)	Price Sensitivity	$PS_i = -\alpha^{P_x - P_x} + k_i$	
(3)	Need Sensitivity	$NS_i = \beta * NL_i + k_i$	P _e : consumers' expected price (average price of all existing products) β: needs sensitivity parameter, 0 < β < 1 NL _i : individual consumers' needs level δ: a parameter, 0 < δ < 1
(4)	Change in Expected Value (from WOM)	$\Delta E_{ix} = \delta * CBE_{if}$	CBE _{if} : friend's experienced benefit
(5)	Friend's CBE	$CBE_{if} = E_x - V_x$	V _x : actual benefit of product x
(6)	Change in Uncertainty (from WOM)	$\Delta U_{ix} = -\lambda * I_{if}$	λ: a parameter, 0 < λ < 1 I _f : friend's social influence
(7)	Change in Expected Value (from marketing)	$\Delta E_{ix} = \gamma * M_x(t) + \tau * B_x$	γ, ε, τ, and φ: parameters, 0 < γ/ε/τ/φ < 1
(8)	Change in Uncertainty (from marketing)	$\Delta U_{ix} = -\epsilon * M_x(t) + \phi * B_x$	M _x (t): marketing rate of product x over time t B _x : brand of product x
(9)	Change in Uncertainty (from new entrants)	$\Delta U_{ix} = -\mu * N(t)$	μ: a parameter, 0 < μ < 1 N(t): number of new entrants to the industry in time t
(10)	Decision to Imitate	$\begin{cases} 1 & \text{if } S_{max} > H, \text{ and} \\ & \text{if } PP_{max} > H + G \\ 0 & \text{otherwise} \end{cases}$	S _{max} : total sales of the best-selling product PP _{max} : total perceived market potential of that product H: threshold constant
(11)	Innovation Generator	$\omega = \sigma * C_x + \theta * D_x$ $\begin{cases} 1 & \text{if random } \omega = (\frac{\omega}{2} - 1) \\ 0 & \text{otherwise} \end{cases}$	G: constant representing the minimum market growth potential the initiator requires ω: innovativeness of the firm (inverse) C _x : capability trait D _x : number of resources allocated toward innovation σ and θ: parameters, σ/θ > 1

whereas a higher-than-expected price increases it. Because expected price is difficult to reconstruct artificially, I follow Zhang and Zhang (2007) in estimating expected price as the average price of all existing products. When there is only one product (i.e. the introduction of a radical innovation), price sensitivity is based solely on affordability factors relative to expected benefit. Need sensitivity is given in Zhang and Zhang (2007) in terms of actual versus expected product quality, as well as the consumers' wealth. However, because the consumer cannot ascertain the actual benefit of the product before the decision must be made, I leave need sensitivity as a randomly assigned characteristic of the consumer. Gardyn (2002) provides evidence suggesting that wealthier consumers are more sensitive to product quality and benefits, so wealth is also a factor.

Update uncertainty. After consumers adopt the product, they tell their friends about it, thereby altering their friends' expectations of value and reducing their uncertainty. The friends' change in expectation of the value of a product is given in equations 4 and 5 of Table 6. The amount of uncertainty that is relieved based on the experience of a consumer's friend is given in equation 6 according to the influence those consumers have over their friends' beliefs (Watts & Dodds, 2007). Various marketing and brand-building techniques have also been shown to reduce consumer uncertainty and heighten expectations. The rates at which consumer expectations and uncertainty are modified by marketing are given in equations 6 and 7. Consumer uncertainty is also reduced through institutional factors, as new entrants to the market signal product legitimacy. This reduction is modeled in equation 9. Note that, in theory, uncertainty is never completely eliminated, so uncertainty is given a hard floor above zero.

Update firm. Firms also make dynamic decisions over time (McMullen & Dimov,

2013), especially with regard to how their resources are most effectively allocated. While such decision processes can be extremely complex, for the purposes of this simulation budgeting is updated over time based on its expenses (i.e. fixed costs, marketing expenditures) and profits from sales. If the project runs out of budgeted money, the project is abandoned, and the product is removed from the market. Marketing expenditures are also modified based on product performance. Specifically, if the product is selling, the firm increases marketing expenditures to try to push uncertainty surrounding its product down more quickly to accelerate growth and beat out competitors. If the firm is running out of budgeted money, or if consumer uncertainty has sufficiently dissipated already, the firm stops spending on further marketing. Finally, if the firm runs out of budgeted money entirely, it exits the market.

Another key issue with current diffusion models is their inability to account for frequent innovations to the design and production of a new product as market feedback is obtained. Innovation is unpredictable, making its simulation difficult. The pseudorandomness² of computer random number generators, however, can serve as a satisfactory substitute for creative spontaneity. To do so, an innovation function is run in each time interval in which a random number is generated from zero to some upper limit parameter, which, inversely, represents the innovativeness of the firm. This innovativeness is determined by its randomly generated capability trait and the number of resources it allocates toward innovation, as given in Table 6, equation 11. If the

² Random number generation in computer science is considered “pseudorandom” because, strictly, generated numbers are not truly random. Given the exact same inputs, a computer’s random number generator would return the exact same number each time. However, because the number generator employs the system clock, which generates one million clock cycles per megahertz processing speed (the CPU on which the simulation was run operated at 3.4 GHz), as an input, at the level of the operable program the passage of time makes such conditions practically impossible to perfectly replicate, thereby generating a viable random (or *pseudorandom*) number.

randomly generated value equals an assigned constant, the firm innovates, the benefit of which is also randomly generated following a gamma distribution (i.e. most improvements will be incremental). This process is done once for product innovations and once for process innovations, in accordance with to the firm's innovation capabilities and investments toward each. It is generally acknowledged that firms focus on product innovations until a standard is set, at which point the focus turns toward processes (Abernathy & Utterback, 1978; Agarwal & Bayus, 2002; Klepper, 1997). As such, firms initially invest more heavily in product innovations, then shift investments to process innovation investments as the industry grows. Because process innovations are limited by various factors (e.g. the cost of production cannot be lower than the cost of its inputs), a price floor is set for all products.

New entrants? A second key firm-level decision is the decision of potential imitators to enter the industry. First, potential entrants consider whether the product has been sufficiently proven in the market as a valuable and viable innovation. They then consider the total reach of the market leader's product, and whether there is still growth potential that could be tapped. The decision model is given in Table 6, equation 10. If the industry is growing, and is perceived to have sufficient future growth potential, the imitator enters the industry, imitating the current solution of either the market-leading differentiator or the low-cost leader, depending on the strategic approach chosen (determined randomly). The other attributes of the imitator are determined as previously described except for the imitator's capital and brand, which are both assigned randomly with a higher potential value because existing firms with greater capital and established reputations are more likely to enter than low-capital firms or entrepreneurs.

RESULTS

After functionality was demonstrated and initial values determined, the simulation was run freely multiple times with simulated heterogeneity. As expected, at times the simulation produced the typical S-curve. At other times, it produced a market failure, the firm unable to reduce uncertainty sufficiently before running out of money.

The results of these simulations show various interesting and plausible market outcomes according to various distinct initial and progressive factors. Specifically, we can observe four key phenomena that so far have not been fully explained in theoretical models of diffusion. First, when and why do new products fail to diffuse to the general population? Second, why do imitators often overtake the innovator in market share, and when are the first-mover advantages sufficient to sustain a competitive advantage? Third, why do we often observe continued and prolonged industry growth and sustainability for durable goods once it has already become saturated? Finally, how does leadtime impact the diffusion process and overall industry success?

Determinants of New Products Success/Failure

Given the observed high failure rates of new products, the current inability to theoretically explain these failures is disappointing. Here I proffer a mechanism, namely consumers' uncertainty regarding the new product's value, that provides a viable explanation. If consumers' uncertainty is such that it pushes their willingness to pay below the price, sales will be hard to come by early on. Products that succeed in diffusing to the broad market, then, are those that are able to overcome consumers' initial

uncertainty, incrementally alleviating that uncertainty such that willingness to pay rises above the price.

While the mechanisms for uncertainty alleviation include branding and marketing, these are not necessarily sufficient to produce the expected S-curve, as can be seen in the many market flops of highly-anticipated products (e.g. Waterworld, the Apple Newton). These products failed because their value, as experienced by the early adopters, was insufficient to reduce the value uncertainty of the early majority. Consumers remained unwilling to pay for the product given the unsatisfactory experience of the early adopters.

Average consumer wealth was another key factor in consumers' uncertainty in the simulation. Where consumers are wealthier, concerns over product dissatisfaction are comparatively low as the personal loss (opportunity cost), in relative terms, is low. Where consumers are relatively poor, however, value uncertainty is a critical issue, as a value loss would be relatively severe when considering the sacrificed opportunity costs of adoption.

However, perhaps the most important factor in uncertainty reduction, according to simulation results, is the true, experiential value of the new product, or "consumer benefit experienced" (Priem, 2007). As the simulation shows, where the *benefit* of the product was relatively high, uncertainty was reduced rather quickly, both through positive WOM and through industry formation and growth. These effects compound exponentially, producing the expected S-curve. The effects of legitimization by imitation were especially pertinent as, where it appeared that a product might not quite reach that critical mass of consumers to hurdle the chasm, the entry of an imitator generally produced a strong enough reduction in uncertainty to create a takeoff point and push the product over

the chasm. This is in line with diffusion research that suggests that later entrants can increase the market potential of the new product and/or increase its diffusion rate (Agarwal & Bayus, 2002; Krishnan et al., 2000).

The First Mover Advantage

A second key question that is addressed by the simulations regards the question of how and when the first-mover advantage is sufficient to capture and maintain market dominance. The first-mover or pioneering advantages of innovators has been widely researched, with mixed conclusions (Boulding & Christen, 2003; Suarez & Lanzolla, 2007). Lieberman and Montgomery (1988) suggest that first-movers can maintain their advantaged position if they can maintain technological leadership via learning processes, gain and maintain strategic control over key resources, and/or prevent their customers from switching due to high switching costs or consumer uncertainty. It is this last factor, according to the simulation, that is likely the predominant cause of a sustained first-mover advantage. That is, the first mover can capture and maintain the advantaged position in an industry if the value of the new product is especially large, if the imitator does not have a large enough brand identity, or if the imitator is too slow to enter the emerging industry, such that the uncertainty of the first mover's product is lower than all other entrants.

First, where the value of the new product is especially large, the early rate of adoption is so high that the uncertainty of consumers is adequately reduced before imitators can respond. While imitators will still enter, they do so after the first mover has established a strong brand identity and has captured a large segment of the target market.

The first mover advantage, in this case, is sufficient to generate a shift in competitive positioning advantaging the new firm (Schumpeter, 1934). This is in line with the argument that first movers are at an uncertainty disadvantage because a dominant design or standard has not yet emerged (Schilling, 1998). If the first mover's product is successful enough early on at reducing uncertainty, new entrants, even with strong brands, will enter with higher-uncertainty offerings compared the first-mover's product (e.g. Roku vs. Apple TV/Google Chromecast/Amazon Fire Stick).

Second, where the first imitators are relatively small or new brands, the formation of an industry facilitates consumer uncertainty reduction, but the imitators' brands are not sufficiently developed to reduce their own product's uncertainty below that of the first mover. The first mover's brand development is instead accelerated by the product's legitimization with the industry's formation. When established brands finally enter the competitive space, they face a formidable opponent in the first mover, while their own brands may be sullied by their late arrival. If a big brand imitator is too slow to enter the market—that is, if it arrives after the new product has already achieved legitimacy—it allows the first mover to capture those legitimacy gains into their brand alone (e.g. Netflix vs. Blockbuster) (cf. Brown & Lattin, 1994).

However, where an established firm with a strong brand imitates the new product before the product has gained sufficient legitimacy to hurdle the chasm, that imitator plays a large role in producing the additional legitimacy needed to get over the chasm and to set the industry takeoff point. Because the product uncertainty at this early stage is lower for the big brand product due to the firm's reputation, the established firm can capture away from the first mover the legitimacy gains from industry growth (e.g. Apple

iPod vs. EigerMan F20/Diamond Rio). This is consistent with research that suggests that a longer leadtime to imitative entry increases the likelihood of a first-mover advantage (Huff & Robinson, 1994).

Also, if an imitator, even of a new or lesser brand, enters the industry with a superior product, the benefit of the new product may be sufficient to overcome consumer uncertainty (e.g. the Palm Pilot). Even the early adopters may be willing to switch, in spite of having already invested in a product, if the benefit is sufficiently superior. In the end, the best product often (but not always) wins, as long as that product has enough brand and money behind it.

The Effects of Continuous Innovation

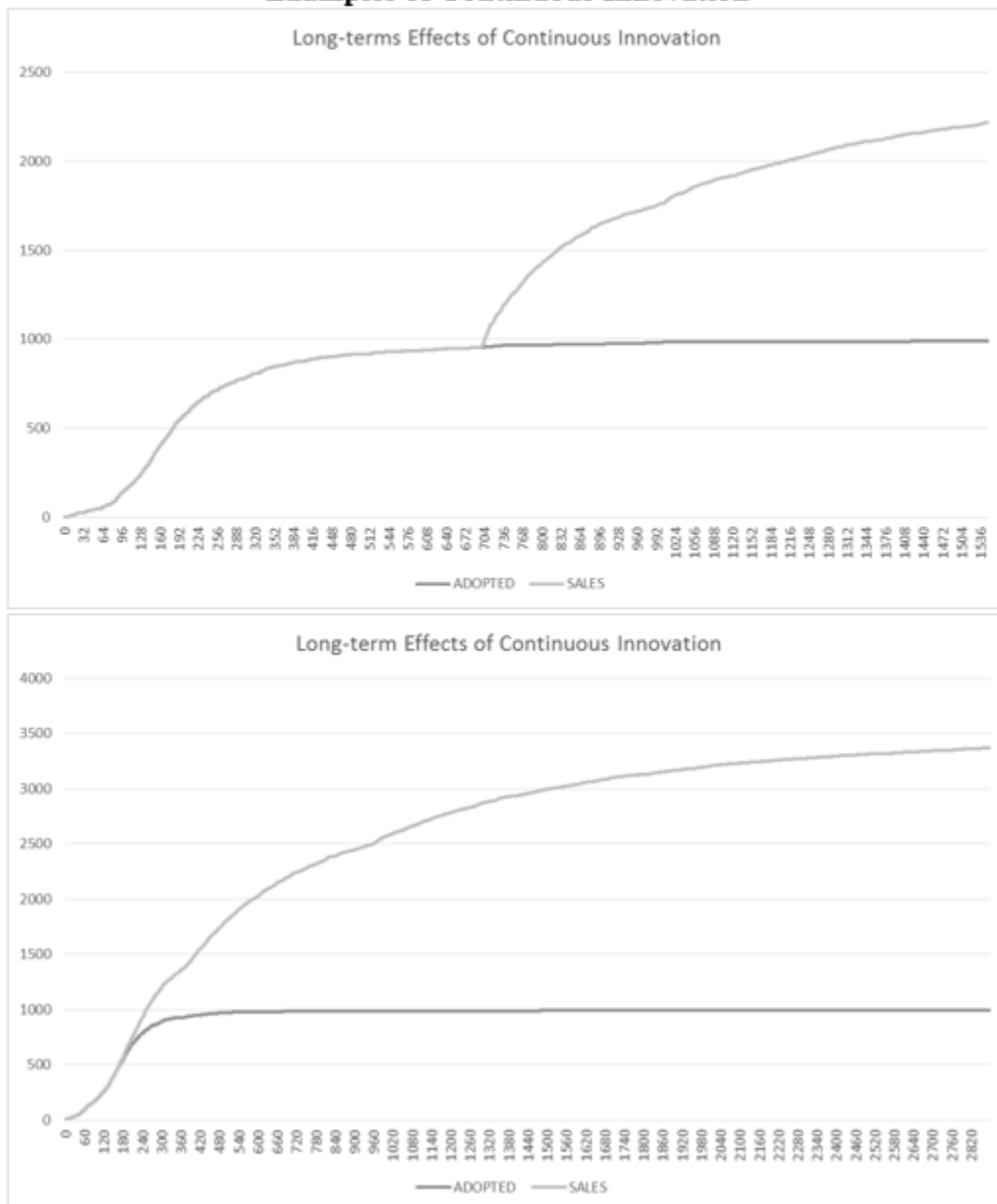
How do firms like Apple continue to generate continuous profitability and growth in spite of producing relatively few new innovations over time? Certainly some products are non-durable, and therefore require cyclical repurchase. However, the most successful products grow at a faster rate than their repurchase cycle, suggesting additional growth factors at play. This question has so far been avoided by the diffusion literature as current models clearly have no explanation for the phenomenon. The model here posited highlights one viable and obvious explanatory mechanism: continuous innovation.

Current diffusion models describe the diffusion process as if no change occurs within the timeframe of the diffusion process. A new product's diffusion, for them, depends wholly on its attributes at the time of introduction. Clearly, this is an overly simplistic assumption (Agarwal & Bayus, 2002; Klepper, 1997). To understand how industries such as Apple and Nike oversaturate—that is, how they grow beyond the

bounds of full market diffusion—we must break free of these assumptions and allow change to occur *during* the diffusion process.

One mechanism of change is continuous innovation processes. This ability of firms to incrementally improve the value of its product(s) can partially explain why some products' life cycle can extend well beyond the market's saturation point (see Figure 13). If the value of new releases of the product is perceived to be sufficiently worth the

FIGURE 13
Examples of Continuous Innovation



upgrade, product owners may purchase the new edition even before their already owned product is no longer useful. Such incremental improvements may also attract others who had not previously purchased, as the increased value may finally be such, relative to the uncertainty those consumers still hold, as to warrant purchase. Together, this suggests that continuously innovating firms can in essence restart the diffusion process anew with each incremental innovation to its existing product, if such innovation is sufficient to warrant a new release of that product. Each new iPhone, for example, outsold its predecessor, with about 80 percent of its new purchases coming from existing iPhone users.

Continuous innovation can also facilitate new product acceptance and diffusion. Once a new product is introduced, the value of the product is market tested. The results are, more often than not, less positive than anticipated (Hayward, Shepherd, & Griffin, 2006; Koellinger, Minniti, & Schade, 2007). However, the feedback obtained from the early adopters not only signals to the early majority of the value of the product, but can also signal to the innovator what changes can be made to improve the valuation of the product. Simulations show that, if the new firm can endure a lukewarm reception of its product long enough to produce a value-adding innovation to the product design (e.g. incorporate consumer feedback), the firm may still be able to overcome its weak start and accelerate growth sufficiently to cross the chasm.

Innovations can also facilitate cost reductions rather than value increases. If innovating firms can innovatively reduce costs quickly, achieving efficient production processes and scale while still in the introduction stage of diffusion, it may be able to either (1) improve margins sufficiently to outlast the legitimization process, allowing

uncertainty to slowly reduce over time until it hurdles the chasm, or (2) pass on the cost savings in reduced prices, thereby reducing the risk to consumers and accelerating the growth rate (Nascimento & Vanhonacker, 1988). Simulations suggest that each of these strategies has certain advantages. By keeping the price high, the firm may signal higher value to consumers while capturing greater profits from sales (Ariely, 2009; Wolinsky, 1983). If the firm can survive the legitimization process, these higher margins will mean very large profits after the takeoff point is reached. Passing on the cost savings to consumers, on the other hand, can facilitate and accelerate takeoff, allowing the firm to reach legitimacy sooner. This can facilitate brand legitimization before imitators can reach the market. Furthermore, the lower price point creates an additional barrier to entry, making profitable imitation less likely or attractive (Porter, 1998).

Strategically, then, cost saving in the early stage of new product diffusion should be captured by the firm *if* the firm has a sufficient budget to outlast the uncertainty chasm and if it has a strong enough brand to attract sales against lower-cost imitators. Apple, for example, has done extremely well at a high price point, capturing large profit margins from its various devices. Smaller firms, such as startups, that do not have the budget or brand name of potential imitators should be expected to pass cost savings from innovations to their consumers as a competitive move to stave off competitors as they strive to develop and establish their own brand.

The result of both of these types of continuous innovation is a far more dynamic diffusion process than is typically understood. Not only is the potential for takeoff altered by the ability of the firm to innovate *after* the new production introduction, but also the duration and continued growth of the product industry even beyond the point of

market saturation. Through continuous innovation processes, the growth stage of the diffusion process can extend indefinitely (Wiggins & Ruefli, 2005), as exhibited by some of the most successful products, such as Apple's iPhone, Microsoft Windows, and Nike's Air Jordans.

Leadtime

Broadly, research on leadtime (i.e. the time between first mover and first imitator) suggests that a longer leadtime produces a stronger advantage to the first mover(s) (Huff & Robinson, 1994; Suarez & Lanzolla, 2007). While, strategically, such an outcome is desirable, first movers should not always pursue leadtime maximization. As the simulation suggests, a long leadtime can *prevent* a new product from achieving the necessary legitimacy to diffuse, and could therefore lead to poor product performance and venture failure. In other words, if it takes too long for an industry to form, the prolonged uncertainty may kill even good products, preventing them from clearing the chasm.

First movers perform best where they capture the first-mover gains of a longer leadtime while still achieving broad market acceptance and legitimacy. But skirting the line between leadtimes that are *long enough* and *too long* can be precarious. Ventures may be wise to strategically facilitate a reduced leadtime if they can control who the first imitators are. For example, if they can facilitate imitation by lesser brands while protecting from imitation by larger brands (perhaps by selectively sharing intellectual property), they may be able to maintain leadership status while facilitating industry formation and market acceptance. A similar strategy is presented by Pacheco-de-

Almeida and Zemsky (2012), who provide evidence that Intel strategically confers intellectual property to its top competitor, Advanced Micro Devices, who then becomes a fast follower, thereby securing for Intel technology leadership status over time (Lieberman & Montgomery, 1988).

CONCLUSION

New product diffusion research is due for a radical shakeup, as long-acknowledged issues have gone unexplained for decades, producing very weak prediction models. There has been, as a result, little improvement to new product launch processes, as firms continue to pursue well-established product introduction routines, which continue to produce low success rates.

The theory outlined here is a large step toward a new approach to new product introduction, diffusion, and industry formation. By acknowledging consumer uncertainty as a key factor in determining adoption rates, we are able to reproduce the familiar S-curve for predictively successful products while allowing other products to fail, a feat not accomplished by the traditional contagion model. With the consumer uncertainty model we can better explain how and why products fail, which market participants emerge on top, and what factors are most important to success. In this model marketing and word-of-mouth processes are still seen as important factors, but are seen as *indirectly* related to diffusion inasmuch as they influence consumers' uncertainty regarding the value of the new product.

The most important factors, as suggested by the consumer uncertainty model, are consumers' present dissatisfaction with extant solutions (i.e. their need level), the true

value of the new product in terms of experienced benefit (especially the satisfaction of the early adopters), and the legitimizing effect of industry formation as competitors come to recognize the potential value of the idea and imitate it, thereby signaling legitimate value, increasing market reach and accessibility, and promoting competition.

Interestingly, none of these factors play a primary role in established theories of new product diffusion, which instead focus on persuasion and contagion factors. Turning attention toward these factors, however, we may gain new insight into successful strategies for assessing market potential, developing and marketing ideas, and introducing new products to the market. For example, this model suggests that competitive imitation might in some cases strategically be encouraged and facilitated rather than strictly avoided. It also emphasizes the critical role of the early adopters as “swing voters,” determining at that early stage the ultimate fate of new products. These factors warrant greater attention and consideration in research and in practice moving forward.

The uncertainty model also offers many future research possibilities. Certainly, empirical hurdles regarding uncertainty testing must be addressed. Consumer uncertainty as a primary theoretical mechanism for new product performance, however, can facilitate the theoretical incorporation of many empirically observed mechanisms. For example, brand loyalty has long been acknowledged as one of the most key factors in long term firm or product performance (e.g. Chaudhuri & Holbrook, 2001). But why do some consumers become so rabidly loyal where others do not (Oliver, 1999)? Uncertainty may be the missing piece to this puzzle, as consumers’ uncertainty for brands with which they have personal experience is expectedly far lower than with those brands they have not personally experienced (cf. Carpenter & Nakamoto, 1989; Kalish, 1985; Lieberman &

Montgomery, 1988; Schmalensee, 1982). Uncertainty avoiders, then, might be expected to be more loyal to satisfactory brands than others. Consumer uncertainty may also help to explain supply-side puzzles, such as how or why larger or smaller firms are considered more innovative. Are such innovations only *perceived* to be more innovative as a result of higher or lower consumer uncertainty? Are larger firms' innovations more successful only because they emerge from strong and established brand names? These and many other questions can be more thoroughly explored under a demand-side framework highlighted by consumer uncertainty.

5. CONCLUSIONS

The intended purpose of this research has been to introduce a comprehensive and general theory of entrepreneurship. Admittedly, this is a daunting and ambitious task, attempting to succeed where modern entrepreneurship scholars have so far fallen short (see Arend, 2014; Blackburn & Kovalainen, 2009; Casson, 2005; Davidsson, 2015; Davidsson, Low, & Wright, 2001; Korsgaard, 2013; Low, 2001; Phan, 2004; Zahra, 2005). Yet we find the key to the puzzle that has long eluded theorists on the demand side of the market exchange (cf. Webb et al., 2011). By incorporating the role of the consumer in the entrepreneurial process, a general theory of entrepreneurship comes into focus, overcoming or avoiding the many problematic inconsistencies that have plagued alternative entrepreneurship frameworks. The result is what I believe to be a consistent, coherent, and viable general theory of entrepreneurship, facilitating a more robust and holistic understanding of the entrepreneurial process from its origination to its outcomes.

I do not intend to disparage the theoretic contributions made so far in this field. Indeed, the frameworks that have so far been developed have provided a useful initial foundation on which many key empirical questions have been elucidated. This very work is developed on many of those insights. However, valid concerns over key assumptions have caused serious reflection over the generalizability of these frameworks. Modernly, most scholars generally accept that entrepreneurship can emerge from one of many proposed origins (Davidsson, 2015; Dimov, 2011; Short et al., 2010). Such ambiguity, however, is unappealing and restrictive in furthering entrepreneurship theory.

The demand-based theory proposed here, however, argues that each of these recognized sources of entrepreneurship are not mutually exclusive, but reflect *different*

aspects of a single and generalizable entrepreneurship process. That is, the recognition, creation, and judgment of perceived opportunities are each individually necessary and insufficient conditions for entrepreneurship. Only where they are conjointly realized can entrepreneurship occur.

This framework is facilitated by a revised concept of entrepreneurial opportunities, eschewing the traditional concept of market imperfections in favor of a more nuanced and concrete notion of imperfectly satisfied consumer needs. As such, we may view the process of entrepreneurship, in following the Austrian tradition (Mises, 1949), as the result of *consumer* behavior, as consumers actively pursue better satisfactions for their recognized needs. In this sense, entrepreneurship is universally and inherently a demand-pull phenomenon (Kirzner, 1999), facilitated by the continuous development and dissemination of new knowledge, especially regarding the technical properties of various resources and their affordances.

In short, entrepreneurship begins with consumers' pursuit of their own subjective well-being (and that of their dependents) in seeking to understand their inherent needs and especially those needs that are comparatively unsatisfied. Once an unmet need is recognized (e.g. through experienced dissatisfaction), a solution is pursued through innovative ideation (Hsieh et al., 2007). This innovation process is facilitated by both a strong understanding of the need to be resolved and a broad and applicable knowledge of resources and technologies that might afford a solution. An experimental design illustrates the need for both types of knowledge (i.e. needs and technical knowledge), as having only one or the other instead produces "Einstellung" effects, where innovativeness is instead *inhibited* due to cognitive entrenchment (Dane, 2010). Finally, I argue and

demonstrate how consumers are the arbiters of entrepreneurial performance, and how that arbitration is made especially difficult by the inherent uncertainty that consumers face regarding newly introduced solutions. An agent-based model shows that this uncertainty, and its resolution over time, can replicate the familiar S-curve diffusion model (Bass, 1969) while also facilitating a viable explanation for new product failure and other under-explained phenomena (e.g. first mover advantage sustainability and continuous innovation).

We can see, then, that without the consumer thoroughly embedded throughout the process, a strictly supply-side view of entrepreneurship is forced to look for the sources of ideas and motivation to exploit those ideas within the producer alone. We are pushed to make assumptions of opportunity pre-existence and of a predictability that has been inherently elusive (Dimov, 2011), entrepreneurship is assumed to be motivated by expected profit (Kirzner, 1973), and entrepreneurs are understood to be the source of economic growth through their ingenuity (Schumpeter, 1934). By acknowledging instead that market phenomena are inherently two-sided, and that the “sovereign” of the exchange is the *consumer* rather than the producer (Hutt, 1936; Mises, 1949), we come to realize that the purpose of entrepreneurship is not profit but well-being, that consumers themselves are the well-spring of economic growth in their search for satisfactions, that entrepreneurship is inherently and necessarily unpredictable until the time that satisfactions can be precisely measured and predicted, and that marketing and consumer behavior research are very much intertwined with entrepreneurship in ways previously unacknowledged.

The principle of consumer sovereignty facilitates a whole new approach to entrepreneurship that, as I hope is evident from this research, far exceeds the predominant supply-side frameworks that we have hitherto relied on. This is therefore a call for a paradigm shift in entrepreneurship theory.

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APPENDIX A

Task 1: The Golf Ball Dilemma

Golf is a frustrating pleasure to thousands of golfers across the globe. One of the most frustrating aspects of the game, aside from never quite being as good as one would like, is how easy it is to lose one's ball. Even when the golfer feels like s/he made a great shot, it sometimes happens that, when they approach the area where they expect the ball to be, the ball is nowhere to be found. Golfers can be regularly seen scouring the weedy rough or lush tree line searching for their ball.

According to official rules (see rule 27-1.c), if the ball cannot be found within 5 minutes, the golfer must play a new ball from the previous spot and is assessed a one stroke penalty. This slows the game for everyone, including those golfers in following groups who are waiting to hit, who must wait for the lost ball to be found or for the golfer to give up the search and replay. It hurts the score of the player who, due perhaps only to bad luck, could not find their ball. And finally, the golfer has lost one of their limited supply of balls (a good ball costs up to \$5 each).

Your task is to design a golf ball that is easier to find.

Only for high needs knowledge sample

There are several types of golf balls that golfers of varying levels of skill might consider. Many amateur golfers have a problem with a hook or slice, which occurs when the golfer hits the ball with an "open" or "closed," rather than perpendicular, face of the club, spinning the ball one way or the other and causing it to curve. These golfers will tend to do better with "distance" balls that are designed to minimize spin. Distance balls can also have firmer covers to help create more power. However, the firm cover and lack of spin can be very challenging around the green, where control is important.

Ball softness and spin allow golfers to have greater control, both over the flight of the ball and over its roll. A firm ball will generally come off of the club face quickly, not letting the ball roll up the face of the club for higher spin and control. If the club speed is not just right, firmer balls can fly "hot" of the clubface and go too far. This is especially a problem close to the green, where touch and control are essential in getting the ball close to the hole. Softer balls general allow better "feel" and control.

In addition to softness, some golfers, especially experts, want to be able to use ball spin for additional control. First, they can use the ball's spin to control the flight of the ball rather than simply hitting a straight shot each time. For example, a "draw" or "fade" (slight versions of the hook and slice, respectively) can combat winds from one side or another, or it may be needed to go around an obstacle such as a tree. Experts may even look at the shape of the fairway or green and shape their shot so as to minimize the risk of missing it. Also, high-spin balls provide stopping power, preventing the ball from rolling too far. Firm and low-spin balls will often continue to roll after hitting the green, reducing the amount of green the golfer has to work with. A hit onto even the front of the green with a low iron or wood will often roll all the way off the back of the green. A ball with higher spin, on the other hand, will tend to "check" on the green, spinning to a stop

close to where it lands. Very high spinning balls can even “bite,” or roll back toward the golfer a ways after hitting the green, which expert golfers often find desirable for control as they hit the ball past the hole and roll the ball back toward it.

The best (and most expensive) balls create counteracting forces against ball spin in flight, providing straighter flights and greater distance, while still allowing high levels of spin on approach shots for better control. This is desirable because, by rule, a golfer cannot switch balls once they’ve teed off a hole without incurring a one-stroke penalty.

The key issue at hand is that, especially off the tee, the small ball can be very difficult to watch as it reaches distances of 250 yards or more from the tee. Seeing where the ball ends up, then, can be a challenge, especially where the shot is not straight. This issue can be compounded when the ball enters covered areas such as trees or tall grass, and even more so when the sky is cloudy or relatively dark. Specially designed sunglasses are said to help see the ball against darker skies, but the benefit relative to cost has made it an unnecessary accessory for most golfers.

Some balls are available in colors other than traditional white. Yellow is the most common of these, as it is the most visible color of the spectrum, especially at a distance. The brightness of these ball is, for most, easier to spot in the air, especially at twilight or in overcast skies. However, golfers say that these are no easier to find in the tall grass of the rough. Some have even complained that they are *more* difficult to find in grass than white, especially in the fall, and that the yellow is not enough of a contrast to the green grass, especially of the brighter green fairways. Some also complain that the bright ball makes lining up and hitting the ball less comfortable visually. Recently, two-toned balls have been designed, which are white on one side, and colored on the other. So far, golfers have suggested that these are somewhat easier to see, and are useful in lining up putts, but its strange design is somewhat distracting.

Only for high technical knowledge sample

By rule, a golf ball must be no smaller than 1.68 inches in diameter and weigh no more than 1.62 ounces. While the ball may be larger or lighter, larger balls cause more aeronautical drag, thereby reducing distance, and would be more difficult to hole. Lighter balls also would be more adversely affected by drag and would not carry the same distance. In general, the preferred ball will be precisely 1.68 inches in diameter and 1.62 ounces in weight.

The composite of the ball is an important consideration for performance. Golf balls have at least two key components: its core and its cover. The rubber core of the golf ball is critical to power and spin control. High core compression when the ball is struck powers a strong launch and minimizes spin. For faster swing speeds, a harder rubber core can be used for good, efficient compression while, for slower swings, a softer core would create more launch.

The cover is generally made of a rubber or plastic material. Urethane (rubber) covers are soft, but not very durable. Thermoplastic ionomer covers, on the other hand, are more versatile, durable, and resistant to cutting, but not as soft. Some balls also have a “mantle” in between the cover and core, which can be engineered to improve the spin

performance of the ball.

2-piece golf balls consist only of a cover and a core, and are therefore the cheapest ball construction. Different core softnesses are available. Generally, these balls also have firmer ionomer covers. These balls produce less spin and, typically, more distance.

3-5 piece golf balls are more complex and expensive, but can produce interesting effects. The additional layers between the cover and core serve to counteract the effects of excessive spin generated from stronger swings, allowing reasonably straight ball flights, especially off the tee. While counteracting the spin, however, these inner layers do not actually reduce the spin, especially for the higher irons and wedges, but only mitigate its in-flight effects. These balls, then tend to be high spin balls. Various core compressions are also available for these ball types.

Again, your task is to design a solution to make the golf ball easier to find. Your solution should not interfere with the golfer's ability to play. Describe your solution in as much detail as possible.

Task 2: I guess I'll have mine well done...

Cooking is an art. Most of us are not artists. Some of the most delicious foods require very complex and precise cooking techniques. Consider the steak. To the untrained eye, cooking steak seems as simple as throwing a slab of meat on the grill until it's cooked through. The trained chef, however, knows that *how* that slab of meat is cooked makes an enormous difference in how it will taste.

Untrained home cooks often struggle with the ability to properly cook their food. They regularly overcook their meat, noodles, rice, eggs, and their minds in the process. Even the trained home cook can get distracted and forget to tend their cooking food. The simplest of recipes can be botched just by leaving the dish on the stove or in the oven just a minute or two too long.

Your task is to design a solution to the home cook's steak woes. Devise a solution that assists cooks in properly cooking a steak to their desired doneness while avoiding overcooking due to distractions or other factors.

Only for high needs knowledge sample

Generally, the best-cooked steaks have a seared, crusty exterior, but are juicy and tender inside. Culinary experts generally agree that a medium-rare steak (mostly pink with a slightly red center, internal temperature between 130° and 140° F) is ideal because it maximizes the tenderness and juiciness. Cooking the steak longer will result in an incrementally drier and tougher steak. Steaks cooked well-done are generally very tough and chewy.

To cook the "perfect" steak at home, using a stovetop and oven is an ideal way to go. To prepare the steaks, the steaks should be brought to room temperature (a cold meat will contract when it hits the heat, resulting in a tougher steak). Pat the steak dry with a paper towel (moisture on the steak will cause it to steam cook, resulting in a poor sear

and tough, gray meat). You may choose to salt the steak to have a salted sear, but doing so brings internal moisture to the surface, resulting in a drier steak. Some professionals advise to season the steak after cooking, but the seasons are less likely to adhere.

To cook, preheat the oven to 500°F. In an oven-safe skillet (preferably cured cast-iron), oil the skillet with ~2 Tbsp of olive oil (or 1 Tbsp of butter and 1 Tbsp of oil) and heat the pan on high until it gets very hot. Cook the steaks in the skillet on one side for 1-2 minutes without moving to create a good sear, then flip with tongs and sear the other side for another 1-2 minutes. Remove the skillet from the stovetop (the handle will be hot, so use protection) and carefully place it in the preheated oven. Cook an additional 3-5 minutes, depending on the thickness of the steak.

To check for doneness, avoid using a meat thermometer, as puncturing the crust will release juices. Instead skilled cooks typically use a touch method. Press your fingers into the center of the steak. The steak should have some give, but spring back after being pressed. If it is mushy, it is underdone. If it is firm with little give, it's probably overcooked.

Once cooked to the desired doneness, remove the steak from the pan and place it on a cutting board or warm serving platter. Cover the platter with foil and allow to rest for about as long as it was cooked (or ~5 minutes for every inch of thickness). The steak will continue to cook as it rests, but resting allows the meat to cool enough for the juices to flow back in, so that the steak remains juicy once cut rather than letting the juices pour out. If desired, season (if you haven't done so already) and serve the steaks with a sauce or compound butter.

Only for high technical knowledge sample

Most modern homes come with a gas, electric, or infrared stove in the kitchen. The concept of a gas stove is fairly simplistic. Natural gas is provided the stove from the main gas supply to your house. The burner control knob controls how much gas is released to the burner, which mixes the gas with air. An ignition system, typically electronic in modern homes, lights the gas, creating a blue flame.

Electric stoves and ovens function by passing electricity through heating coils. These coils are resistors (resistant to electrical current), which means that electrons flowing in a current through a coil will tend to collide with other molecules as it passes through, turning some of its energy into heat. Heating coils are specifically designed resistors that are very effective in turning nearly all of an electric current's energy into heat.

The heat from electric heating coils can be transferred to food through two mechanisms: conduction and convection. Conduction occurs when the coil is in direct contact with the object being heated, like a pan on the stove. Convection processes occur through an intermedium, such as air. A hair dryer or an oven, for example, heat air that is then circulated to the thing that needs to be heated (i.e. hair or food).

Infrared heating coils work a little bit differently. All objects radiate infrared light. The hotter an object is, the more infrared light it radiates. This infrared light travels through the air without heating it much, but when it reaches another solid object, it is

absorbed and turned back into heat. Infrared heating coils such as those used on flattop electric stoves are insulated so that all the heat they produce is trapped inside. This heats the coil up to an extremely high temperature. The coil produces a lot of infrared light, which is absorbed by the pan above it and turned back into heat.

Temperature variation depends on the type of technology being used. With gas or conduction electric, temperatures are generally passed through a metal pot or pan to food items. Generally, gas sensitivity is higher and more precise to control with the knob than electric, which typically takes much longer to reach a stable temperature, which temperature can vary.

In ovens, conventional (thermal) ovens use heating coils at the top and bottom of the oven to generate convection processes to heat the food, but are not specifically described as “convection ovens.” This term is reserved for ovens fitted with air circulation devices (usually a fan at the back of the oven) that move air continually through the oven to move heated air consistently through the space and prevent heat spots from building. The most efficient convection ovens also provide a third source of heating behind the fan to ensure hot air is being blown. While convection ovens generate a more uniform heat for even cooking, most recipes are designed for conventional ovens. When following a recipe, then, using a convection oven, bakers should consider reducing the temperature by about 25°F and reducing the time by about a quarter. Also, the air tends to be drier in a convection oven, so some dishes that prefer some moisture (e.g. soufflés, breads) generally do better in conventional ovens.

Again, your task is to design a solution to the home cook’s steak woes. Devise a solution that assists cooks in properly cooking a steak to their desired doneness while avoiding overcooking due to distractions or other factors. Describe your idea in as much detail as possible.

VITA

Mark Packard earned his BS in Computer Engineering from Brigham Young University in 2004. He spent two years working as a computer engineer at Micron Technologies Inc. in Boise, ID. When Micron formed a joint venture with Intel, he joined the joint venture, IM Flash Technologies in Lehi, UT, where he continued to work as an engineer for five more years before returning to school to study Management in the PhD program in the Trulaske College of Business at the University of Missouri.

He is a member of the Academy of Management and the Strategic Management Society. He has taught the Strategic Management Capstone course for six semesters, and was recently awarded the Outstanding Graduate Teacher Award. His research has been presented at several national and international conferences. He has served as a reviewer for Strategic Entrepreneurship Journal and the Quarterly Journal of Austrian Economics. He has accepted a tenure track position as Assistant Professor of Management at the University of Nevada, Reno beginning in July of 2016.