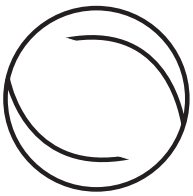

Innovation and Virtual Environments: Towards Virtual Knowledge Brokers

Gianmario Verona, Emanuela Prandelli and Mohanbir Sawhney

Abstract

We examine the implications of virtual customer environments for supporting the innovation process. By building on the literature of knowledge brokers, we introduce the concept of virtual knowledge brokers — actors who leverage the internet to support third parties' innovation activities. These actors enable firms to extend their reach in engaging with customers and they also allow firms to have a richer dialogue with customers because of their perceived neutrality. Consequently, virtual knowledge brokers help firms to complement the knowledge they can acquire through traditional physical and virtual channels for customer interaction. We highlight the capabilities and contributions of virtual knowledge brokers, and we discuss the implications of these entities for theory and practice in the management of innovation.

Keywords: innovation, virtual environments, knowledge brokers, customers, networks

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In recent years, researchers in organization and management theory have become interested in the capacity of firms to manage innovation on a continuous basis (e.g. Brown and Eisenhardt 1997; Christensen 1997; Tushman and O'Really 1997). To sustain the pace of innovation demanded by rapidly changing technology and customer needs, firms need to improve their ability to produce, integrate, and recombine knowledge (Teece et al. 1997). This knowledge is becoming more diverse as industries converge and markets collide (Prahalad and Ramaswamy 2004). Firms need to cast their nets far and wide to garner the knowledge they need to create new products and processes (Powell et al. 1996).

Information and communications technologies, including the internet, have greatly enhanced the ability of firms to expand their repertoire of knowledge by engaging external actors in the innovation process (Arora et al. 2002). While this is true for all the actors in the firm's environment, perhaps the most important is the interaction between firms and their customers. Enhanced connectivity allows customers to become active contributors and collaborators in value creation (Iansiti and MacCormack 1997; Prahalad and Ramaswamy 2004). The internet enables the creation of *virtual customer environments* — platforms for collaboration that allow firms to tap into individual and social customer knowledge through an ongoing dialogue

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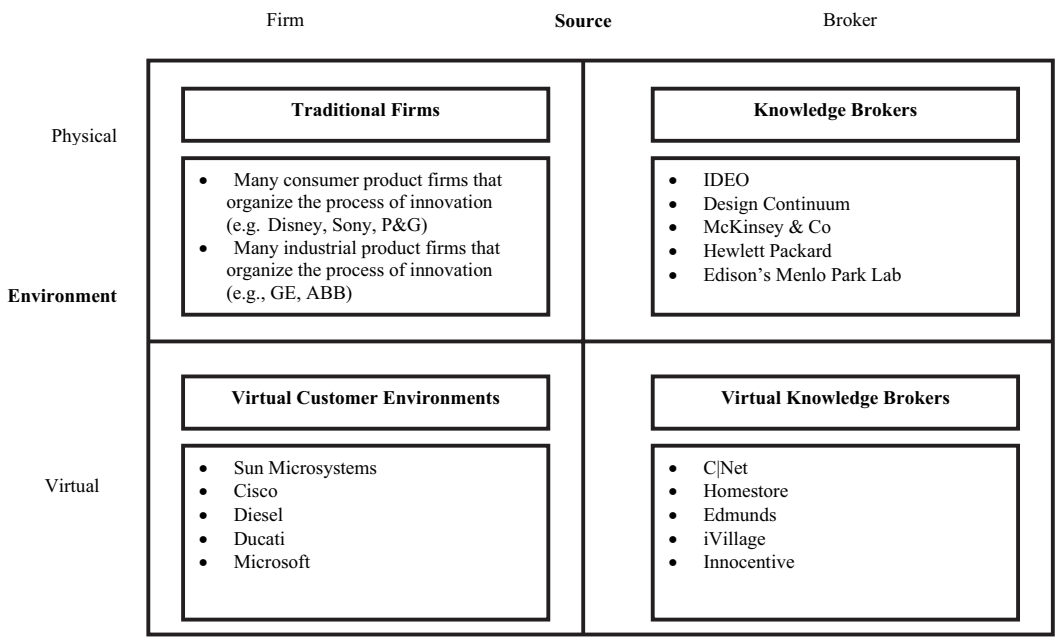
(Nambisan 2002; Sawhney and Prandelli 2000). Customer toolkits that enable leading-edge customers to provide input into innovation can greatly reduce the cost and improve the speed and quality of the innovation process (Von Hippel 2001; Dahan and Hauser 2002).

While firms can benefit greatly from engaging directly with customers in virtual environments, our premise in this article is that direct engagement is not enough. To fully leverage the power of virtual environments, we propose that firms need to combine *direct* channels of customer connection with *mediated* channels that include virtual knowledge brokers (VKBs). These actors manage their own virtual environments and provide these environments as a service to firms. In so doing, they extend a firm's scope of interaction to include knowledge that comes from diverse and previously disconnected sources.

VKBs are the virtual manifestation of knowledge brokers (KBs) — third parties who connect, recombine, and transfer knowledge to companies in order to facilitate innovation (Hargadon and Sutton 2000). In the physical world, KBs work close to their business customers to provide specific innovation solutions, and have traditionally taken the form of innovation and design consulting firms (Sutton 2002; Hargadon 2003). However, in the virtual world, VKBs take the form of information intermediaries who leverage the unique capabilities of the internet to absorb valuable market knowledge for innovation. VKBs' activities can be more diverse, their reach is broader, and their influence on the innovation process is qualitatively different. Figure 1 provides a comparison of operators who use different mechanisms to facilitate innovation.

Figure 1. Examples of Operators that Exploit Different Mechanisms in the Management of Innovation



In physical environments, firms can autonomously innovate or they can involve KBs, like the design firms IDEO and Design Continuum, to support their innovation activity and obtain specific design solutions. In virtual settings, firms can directly leverage the internet to engage customers in the innovation process. But they can go beyond direct channels by using VKBs to extend their reach and increase the speed and improve the quality of their innovation activities. Internet firms like CNET.com, Homestore.com, Edmunds.com have evolved into VKBs in the technology, home ownership, and automobile markets, respectively, by gathering customer feedback on industry-specific products and developing communities of interests around these industries. VKBs collect dispersed individual and social customer knowledge, and distribute it to firms after organizing and elaborating it to support innovation. They augment the firm's 'network resources' (Gulati 1999) by enabling the process of distributed innovation (Arora et al. 2002), where the firm becomes the focal node of an inter-organizational network of knowledge (Powell et al. 1996; Ahuja 2000).

The purpose of this article is to propose the concept of virtual knowledge brokerage and the important role that third-party VKBs can play in enhancing a firm's innovation process. Understanding the role and the functioning of VKBs has important implications for theory as well as for practice. From the theoretical standpoint, VKBs extend the concept of KBs to virtual environments, highlighting the ways in which virtual environments enhance the reach and richness of the knowledge brokering function. From the managerial perspective, VKBs are a way to bridge knowledge gaps created by the inability of firms to reach the right customers at the right time in the right context to benefit from market knowledge.

The article is organized as follows. We begin with a review of the research on KBs and highlight the capabilities of knowledge brokers. We then show how these capabilities are substantially amplified in virtual environments. Next, we develop a theoretical framework of VKBs where we highlight their contributions to the innovation process and the main differences between VKBs and more traditional sources of customer knowledge. We conclude by discussing the implications of our conceptual framework for theory and practice, and by highlighting directions for future research.

Research on Knowledge Brokers

The concept of technology brokering was first introduced by Hargardon and Sutton (1997) to show how the innovation outcome of a company could benefit from its inter-industrial and inter-organizational technology exposure. The concept of technology brokering is rooted in the theory of *structural holes,* which explains how certain firms can play a key role in bridging knowledge gaps in a market (Burt 1992). The idea of bridging structural holes has found fruitful applications in several socio-economic fields, particularly in technological innovation (Hargadon and Sutton 1997). Technology brokering across industries is a four-step process that involves (1) *access* — i.e. filling the gap in the flow of technology between industries and between firms

by occupying a central node, or 'bridging' position, between subgroups of a more extended network that do not interact with each other; (2) *acquisition* — absorption of knowledge about a specific technology through intensive inter-industrial exposure and in-depth experimentation activity; (3) *storage* — memorizing the solutions by way of people, artifacts, and concepts in the organization; and (4) *retrieval* — applying the stored and old technological solutions to create new solutions by using analogical thinking and brainstorming procedures.

In their study of the design consulting firm IDEO, the authors find that the company patches technology produced in different industries by brokering models and ideas from one context to another, using the four-step process described above. This idea of technology brokerage is consistent with the historical role played by Thomas Edison's Menlo Park Laboratory, where, for instance, knowledge gained in electromagnetic power from the telegraph industry was effectively transferred to the lighting, telephone, phonograph, railway, and mining industries (Hargadon 1998). Likewise, it provides an explanation for the impressive productivity results that Ford Motor Company gained in automobile manufacturing through the introduction of the electric motor, by capitalizing on ideas of the machine tool industry, granaries, breweries, and the meatpacking industry (Hargadon 2003: Ch. 2). In summary, technology brokers are actors who improve innovation by transporting ideas between unconnected industries, blending old technologies with new ones in order to stimulate innovation, and transferring these new combined technologies to new contexts.

Recently, technology brokers have been associated with the more general concept of knowledge brokering (Hargadon and Sutton 2000; Sutton 2002; Hargadon 2003).[1] Moving beyond design consulting firms (such as IDEO) and invention labs (such as Edison's Menlo Park Laboratory) to strategic consulting firms (such as McKinsey & Co.) and knowledge management practices of highly innovative multinational organizations (such as Boeing and Hewlett Packard), the concept of technology brokering can be extended to other forms of organizational knowledge. In this broader view, KBs may be defined as 'intermediaries … between otherwise disconnected pools of ideas. They use their in-between vantage points to spot old ideas that can be used in new places, new ways and new combinations' (Hargadon and Sutton 2000: 158). Further empirical evidence highlights the presence of a similar 'brokering cycle' consisting of *network access*, *knowledge absorption*, *knowledge integration*, and *implementation*, whose objective is not simply technological knowledge but any kind of organizational knowledge that can support a specific invention (Sutton 2002; Hargadon 2003).

Knowledge brokerage enhances the *dynamic capabilities* of the firm (Eisenhardt and Martin 2000) in markets characterized by rapid and abrupt technological change. In these dynamic market contexts, knowledge creation, integration, and reconfiguration become vital to sustaining competitive advantage (Teece et al. 1997). Knowledge brokers support innovation by connecting, recombining, and transferring to new contexts otherwise disconnected pools of ideas.

Knowledge Brokerage in Virtual Environments

The explosion of connectivity by means of the internet, together with the development of new information standards (Shapiro and Varian 1998) permits an open and almost cost-free exchange of information between actors in any market (Evans and Wurster 1999). Digital networks allow a large number of players to systematically share ideas and create distributed learning systems (Sproull and Kiesler 1991). As a consequence, a number of intermediaries have emerged to facilitate knowledge exchange in digital environments, mediating between customers who make buying decisions and the companies that want to reach these customers (Bakos 1997). These 'middlemen' operate as information intermediaries or 'infomediaries' (Hagel and Rayport 1997) by making it easier for customers to obtain information about sellers and by allowing sellers to reach customers.

By going beyond their traditional role as intermediaries who work on behalf of *customers* to facilitate *transactions* (Hagel and Singer 1999; Kaplan and Sawhney 2000), some infomediaries have evolved into VKBs by working on behalf of *firms* to facilitate *customer knowledge import* to support innovation. For instance, Edmunds (www.edmunds.com) is an infomediary that empowers automotive customers to make better buying and ownership decisions by providing detailed and unbiased information for automobile buyers. Edmunds focuses on editorial content and community management, and generates revenues by referring qualified leads to marketing partners that include automobile dealers, manufacturers, and finance and insurance companies.

More recently, Edmunds has begun to play the role of a VKB. The company realized that its community named Town Hall could be a valuable resource for its automobile OEM partners. It now allows automobile OEM executives to host discussions as guests and answer customers' questions. OEM product managers can even create their own sub-communities about, for example, a new model that they may be bringing to market in the future. Some automotive companies have gone further, creating private communities for which they pay Edmunds a monthly fee to host and run their part of the site. For instance, Edmunds' partners like Subaru have begun to make use of its million-strong customer community to obtain specific feedback from a diverse group of customers regarding their products. This feedback is analyzed and repackaged by Edmunds to suit Subaru's specific knowledge needs and to support its new product development activities. By partnering with Edmunds, Subaru can maximize the quality of customer contributions and filter out less insightful conversations. When Edmunds hosts live chat events, it is able to engage more than 200 participants per session, who act as a clinical group, providing comments and advice about products and product experiences to product managers, who can intervene appropriately to stimulate their knowledge sharing. Beyond operating ad hoc virtual communities, Edmunds has also created an offering called Edmunds Information Solutions for automotive manufacturers, which provides competitive intelligence, consideration sets, customer preferences and buying behavior to support the new product development and marketing processes for automotive

Table 1. The Impact of Virtual Environments on a Knowledge Broker's Distinctive Competences

Brokering cycle	Specific dimensions	Impact of virtual environments	Contributing literature
Network access	Direct ties	• Low-cost and easy-to-use platform • Elimination of geographic barriers • Blurring up of the trade-off between richness and reach • Network externalities	Afuha (2003); Craincross (1997); Gladwell (2000); Evans and Wurster (1999); Shapiro and Varian (1998); Downes and Mui (1998); McAfee and Oliveau (2002)
	Indirect ties	• Open standard allowing entry to partners' partner competences	Afuha (2003); Ruefli et al. (2001)
	Structural autonomy	• Syndication • Convergence among unrelated skills • Opportunities for sharing innovative labor	Linder et al. (2003); Prahalad and Ramaswamy (2004); Werbach (2000); Afuha (2003); Porter (2001)
	Tie modality	• Real-time, two-way, low-cost communication • Low costs of conversion of the platform of interaction	Prahalad and Krishnan (2002); Hagel and Singer (1999); Hoffman and Novak (1996)
Knowledge absorption, integration, and implementation	Knowledge absorption	• Tools enhancing knowledge acquisition from individuals — online tracking; surveys and pools; user-friendly toolkits for product configuration • Communities of creation	Dahan and Hauser (2002); Nambisan (2002); Thomke and von Hippel (2002); Urban and Hauser (2002); Burke et al. (2001); MacCormack et al. (2001); von Hippel (2001); Kozinets (1999); Bhattacharya et al. (1998)
	Knowledge integration	• Formal mechanisms increasing information distribution • Informal social integration through extended connectivity • Communities of practice facilitating assimilation through distributed learning	Prahalad and Ramaswamy (2004); Sawhney and Prandelli (2000); Kozinets (1999); Wayland and Cole (1997); Hoffman and Novak (1996); Rheingold (1993); Brown and Duguid (1991); Lave and Wenger (1991); Sproull and Kiesler (1991)
	Knowledge implementation	• Information digitalization increasing the inputs for knowledge transformation • Electronic archives facilitating knowledge retrieval and recombination • Availability of the same knowledge to more potential users	Afuha (2003); Sawhney et al. (2003); Ruefli et al. (2001); Fahey and Prusak (1998)

OEMs. In this way Edmunds helps OEMs to connect with customers who are more committed, active and informed than those who visit websites run by individual manufacturers.

In a similar way, but in a different industry, the community operator Liquid Generation (www.liquidgeneration.com) provides information useful to firms interested in better understanding teenagers who belong to the so-called Generation Y, a segment whose economic importance is growing. When the company was funded in August 2000, the original plan was to start out as a portal and generate revenue through advertising and the selling of merchandise. However, soon the firm realized that the real opportunity lay in addressing a problem faced by every firm that seeks to market to teenagers: understanding the fickle needs of this population, and motivating hard-to-reach teenagers to provide information about their needs and preferences. When the website started in April 2001, it was conceived as an entertainment site, bringing in young people who understood the culture and could proficiently interact with the target that the company wanted to involve in deep conversations. This content is analyzed and reinterpreted by Liquid Generation to answer its clients' needs of specific feedback and ideas related to individual products. For instance, one of the firm's clients — a company that makes stuffed shirts — wanted to survey the age group about a new product and its most appropriate attributes. Liquid Generation incorporated the survey questions into a funny online presentation, leveraged its relationships with 3.5 million unique visitors a month, and in about 36 hours was able to provide relevant customer input to its client.

VKBs such as Edmunds and Liquid Generation are the virtual manifestation of KBs. The fact that they operate in a virtual environment makes their reach broader and the scope of intervention in the innovation process more extensive. Based on the four-step KB model we presented in the previous section, we now discuss how virtual environments substantially amplify the competences of a traditional KB. We summarize our observations in Table 1.

VKBs and Network Access

The use of virtual environments enhances all the potential drivers of network access for KBs — *direct* and *indirect ties*, *structural autonomy*, and *tie modality*. Virtual environments enhance the ability of knowledge brokers to generate direct ties in at least three ways. First, the internet is a far more cost-effective and ubiquitous network relative to previous proprietary networks — such as EDI (Afuha 2003). The internet is a global medium with unprecedented reach, so VKB can broker knowledge across participants in virtual environments without regard to constraints of time and geography (Craincross 1997). Second, virtual environments break the age-old trade-off between richness and reach (Evans and Wurster 1999). In the physical world, communicating (and absorbing) rich information requires physical proximity or dedicated channels, whereas sharing information with a large audience requires compromises in the quality of information. Therefore, the number and quality of direct ties that KBs can develop in the physical world are

limited by this reach versus richness trade-off. In virtual environments, VKBs can overcome this trade-off and create direct ties with a large number of actors without compromising on the richness of the ties. Third, positive network externalities create further incentives to extend the number of direct ties (Downes and Mui 1998). On the supply side, the incremental cost to reach a new participant progressively tends to decrease, because of the predominance of fixed cost compared to variable costs (Shapiro and Varian 1998). As a result, VKBs have an incentive to attract new customer and, therefore, new direct ties. On the other side of the network, consumers find more value in a network as the number of users of the network increases (Gladwell 2000), favoring the emergence of a virtuous cycle.[2]

While direct ties play a key role in determining the network access, indirect ties are also useful, since firms learn not only from knowledge of their partners but also from knowledge of their partners' partners (Gulati and Gargiulo 1999; Ahuja 2000). In this respect, the internet also serves as an important tool for generating indirect ties. It is a low-cost open platform (e.g. Ruefli et al. 2001): anyone anywhere can connect to it and contribute to the public discussion. For this reason, it is much easier to access the knowledge of partners once removed from direct partners (Afuha 2003), as well as a customer's customer knowledge. The internet positively impacts on the number of indirect ties that VKBs can develop because it allows them to access electronic archives and virtual communities of a partner's partner, absorb this already codified and digitized knowledge, and recombine it in new ways.

The network property of having 'relationships free of structural holes at their own end and rich in structural holes at the other end' (Burt 1992: 45) — called structural autonomy — helps the broker be the sole owner of the innovation outcome to transfer to the innovating firm. This is a key property of KBs, as shown in several cases of manufacturing industries (Hargadon 2003). By making it easier to sell the same information to many different users who do not have any tie either among themselves or with the actors that originated such information (Werbach 2000), the internet contributes to a substantial structural autonomy of a VKB network of relations. Also, virtual environments influence structural autonomy to the extent that they push industries to become more global. Boundaries between industries tend to blur on the web (Prahalad and Ramaswamy 2004), and at the same time, the division of innovative labor tends to develop across geographies (Linder et al. 2003). The joint effect is that it is much less likely that all the competences needed to support innovation can be found within the same organization. As a consequence, emerging structural holes across industries need to be filled. The internet can be used to coordinate activities and information sharing between otherwise disconnected pools of knowledge and competences on a global basis and at a lower cost than in traditional, offline environments (Afuah 2003; Porter 2001). In the convergent world of several industries, the role of VKB in expanding structural autonomy becomes extremely relevant. For instance, the internet community operator iVillage.com has created a vibrant virtual community of women who share thoughts and preferences online. Discussions about clothes, cosmetics, and automobiles are unrelated

to specific brands and can be repackaged by iVillage.com to make them useful for innovation. In such cases, innovation is based on VKB leveraging structural holes between different communities and specific companies, and benefiting from its position to absorb and recombine broadly dispersed customer knowledge and then redistribute it. This characteristic of the internet suggests that actors can serve as VKBs quite effectively, by occupying central positions within a network and dialoguing with a wide variety of players.

Finally, the use of virtual environments has also a significant impact on the tie modality of the network. Tie modality is an important additional variable to be considered when analyzing network access, because it affects the quality of knowledge that may be absorbed and imported. While weak ties are extremely helpful and economically efficient in searching for new knowledge (Granovetter 1973), they are less efficient and effective at transferring complex knowledge. Transfer of complex knowledge that is contextual and interdependent requires strong (i.e. direct and frequent) ties, while weak ties may be effective for less complex knowledge (Hansen 1999). Likewise, direct ties allow complex and in-depth knowledge sharing, whereas indirect ties seem to foster learning mainly from knowledge spillovers — i.e. information (Ahuja 2000). The internet has a powerful effect in increasing the flexibility of the network, allowing not only different partners to be involved at different times, but also weak ties to be transformed into strong ties and vice versa, depending on the complexity of the knowledge that needs to be transferred. Real-time, two-way, and low-cost communication makes it easy to consolidate specific customer relationships on a contingent basis through ad-hoc virtual communities and online conversations (e.g. Hoffman and Novak 1996; Hagel and Singer 1999). As a consequence, VKBs can benefit from high plasticity in the organization of their ties with different actors, on a very dynamic basis and with low costs of conversion, once the platform of interaction has been created (Prahalad and Krishnan 2002).

VKBs and Knowledge Absorption, Integration, and Implementation

When knowledge brokerage operates at the virtual level, four specific kinds of internet-based tools may support *knowledge absorption* from individual customers as well as communities of customers. First, the internet makes it possible to directly acquire knowledge through observation of online consumer behavior. Marketers can track what customers do on their site (Burke et al. 2001). Second, customers may be asked to play an active part in surveys and opinion polls or online focus groups to obtain specific feedback. Third, customer preferences for new product concepts can be measured through web-based conjoint analysis tools (Dahan and Hauser 2002). The internet also allows customers to self-configure and self-design products, bringing customers directly into the design and development process (Thomke and Von Hippel 2002). User-friendly toolkits for customer innovation may even be purposefully assembled to leverage new technologies like computer simulation (Von Hippel 2001). Successful applications might be found in several industries, ranging from software to consumer goods (MacCormack

et al. 2001; Thomke and von Hippel 2002). Finally, the internet allows for extending knowledge absorption from individual customers to customers within their own communities, leveraging the social knowledge that develops through spontaneous conversations among them (Kozinets 1999). Groups of customers can communicate to produce insights that might not have been identified in any other way (Urban and Hauser 2002). More generally, customer knowledge absorption through open source-based mechanisms has been extended from the development of information products, such as software, to a variety of industries where new products need to be developed on a continuous basis (Von Krogh and Von Hippel 2003).

Since, in virtual environments, any kind of interaction is mediated through electronic interfaces (Hoffman and Novak 1996), virtual environments have the capability of storing knowledge, enhancing not only absorption but also *knowledge integration*. First, virtual environments empower formal mechanisms of knowledge sharing because information can be transmitted and shared more broadly. Internet-based tools enable knowledge distribution at the intra-company level, through intranet and groupware systems; at the inter-company level, through extranets and portals; and at the market level, through the internet and public databases (Wayland and Cole 1997). Such formal mechanisms facilitate systematic information access and increase the awareness about available knowledge, thereby making it easier to internalize and recombine the assimilated knowledge. Second, virtual environments also influence informal social integration, intensifying the relational dimension of social interaction through extended connectivity (Kozinets 1999). Many virtual communities on the internet are excellent examples of behavior driven by social and community benefits rather than short-term economic benefits (Rheingold 1993). Such a context provides good conditions to support effective knowledge creation and exploitation through spontaneous and collective participation. Hence, virtual 'communities of practice' (Brown and Duguid 1991) can be purposefully developed in order to favor situated (Lave and Wenger 1991) and distributed learning (Sproull and Kiesler 1991).

Virtual environments also influence the process of *knowledge implementation*. Any kind of knowledge shared on the web has to be codified in order to be digitized (Afuah 2003). If this makes tacit knowledge more difficult to exchange on the internet, it also facilitates knowledge memorization, retrieval, and recombination (Fahey and Prusak 1998). Electronic archival and retrieval facilitate the finding and recombining of modules of knowledge, making it easier for VKBs to internalize and convert knowledge. Data can be received on demand from a networked system, with no delay or zero latency (Ruefli et al. 2001). By allowing low-cost, real-time access to broad knowledge, virtual environments facilitate the process that combines apparently incongruous sets of information into a new schema that fosters entrepreneurial action and innovation. At the same time, the internet can make information available to more potential users, thereby increasing the likelihood of finding other users for firms (Afuah 2003). The same piece of knowledge can be leveraged more extensively; the absence of geographical barriers and the

opportunities of connectivity across industries enhance the possibilities for knowledge exploitation. In virtual environments, it is possible not only to identify and get in touch with more users interested in the same knowledge, but also to allow them to identify themselves and directly cooperate in developing a specific application of that kind of knowledge. In traditional environments, KBs have to identify new potential users of their knowledge and discover effective ways to reach them; in virtual environments, VKBs can benefit from a reversed process, creating a public repository of their knowledge and promoting contests to stimulate users to find the best applications for their ideas. Even more radically, VKBs can transform themselves into *marketplaces of ideas*, where needs for new applications are directly solicited by some users, and other users with specific knowledge can spontaneously cooperate with the VKBs to identify the required applications, as in the case of the internet-based operator InnoCentive (Sawhney et al. 2003). InnoCentive was created in 2001, by the pharmaceutical firm Eli Lilly, to support innovation by facilitating direct dialogue between the company and communities of scientists. Today it has evolved into an innovation marketplace, acting as an independent third party to connect a broad range of 'solution seeker' companies with a vast base of potential problem solvers in different industries, from pharmaceuticals, chemicals, and biotechnology to agribusiness and consumer products.

The Role of VKBs in the Management of Innovation

Having understood how virtual environments amplify the traditional competences of KBs, we now discuss their impact on the management of innovation in contrast to traditional mechanisms. Figure 2 provides a description of our conceptual frame.

The goal of a firm that wants to innovate is to produce products and services that are relevant to the market they serve. To achieve this, firms have always sought to develop a market orientation (Kohli and Jaworski 1990), because customer solicitations play a strategic role in creating better new products faster. Firms seek to improve the fit between their offerings and customer needs by surveying customers and importing customer understanding into the firm (Von Hippel 1986) through their market-sensing ability (Day 1994). Other ingredients of the innovation success include the firm's effective R&D and manufacturing routines (Hayes et al. 1988) and the right balance of organizational competences (Verona 1999).

Since internal barriers to continuous innovation — referring to the people, structures, managerial systems, and values that constitute the firm's capabilities to develop and integrate knowledge — create inertia that prevents adaptation of the innovation system (Leonard-Barton 1992; Tushman and O'Really 1997), firms may outsource part of their creative activity to knowledge brokers. These actors provide specific design solutions to firms thanks to their inter-industrial and inter-organizational exposure (Hargadon and Sutton 1997). Their special vantage point in the knowledge network helps

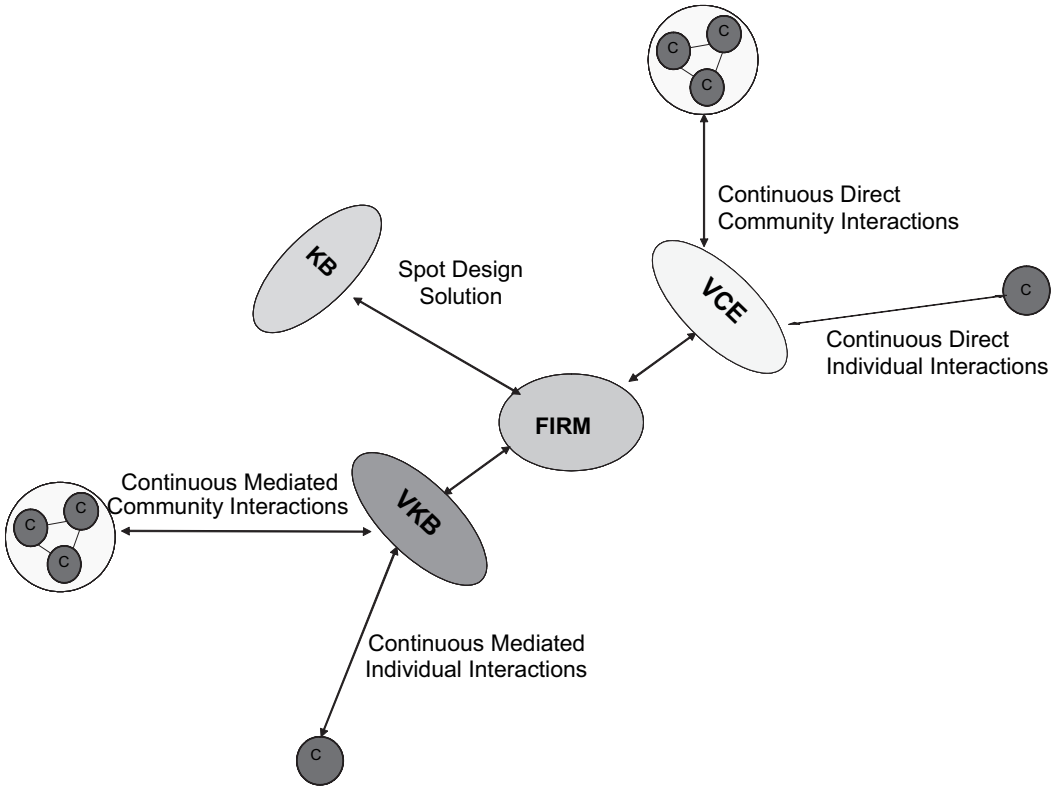


Figure 2. Virtual Knowledge Brokers as a Complementary Source of Knowledge in Managing Innovation

them to bridge the differences between different worlds and enhance creativity by connecting previously separated nodes.

While many of the innovation practices are still rooted in physical environments, the internet is emerging as an important channel to support a firm's innovative capacity. The creation of virtual customer environments helps the firm building direct customer connections in the served market, increasing its ability to manage the innovation process through the properties of the internet (Nambisan 2002; Sawhney and Prandelli 2000). When a firm develops a virtual customer environment, it has the chance to extend its interaction to a bidirectional mode and improve the richness of its content. The interaction evolves from one-way knowledge import to interactive dialogue. This two-way dialogue helps firms to progressively learn about each specific customer and groups of customers and to refine the content of their innovation as the idea turns into a product to be launched in the market. Firms can embrace a value co-creation perspective in managing innovations with their customers (Prahalad and Ramaswamy 2004). The richness of the interaction increases because virtual communities of customers help firms to tap into social knowledge as well as individual customer knowledge. Virtual communities permit the firm to participate in the experiential and social contexts of customer consumption.

For this reason, firms in industrial markets (e.g. Microsoft, Sun Microsystems, and Cisco) as well as consumer markets (e.g. Ducati, Hallmark, and Diesel) are building virtual environments to support their innovation processes. For instance, Sun Microsystems has developed an effective community to involve both individuals and organizations in developing the Jini device-to-device communication technology, giving them specific incentives, while Cisco manages online customer forums to support collaborative advice for its customer base. Likewise, the Italian motorcycle company Ducati realized that its fans have deep technical knowledge and they love sharing experiences. To support this interaction, the company has created Tech Café, a forum for exchanging technical knowledge. In this virtual environment, fans can share their projects for customizing motorcycles, suggest improvements for Ducati's next-generation products, and even post their own mechanical and technical designs, with suggestions for innovations on aesthetic or performance grounds.

While virtual customer environments may be a tremendous source of knowledge for innovation, direct customer engagement is not enough. Direct engagement has, in fact, a limited network access, which may turn into a weakness in the innovation process. Individual firms have limited reach in terms of contexts in which they can dialogue with customers (Sawhney and Prandelli 2000). Customer websites are primarily visited by firms' customers or prospective customers (Nambisan 2002), but not necessarily by the innovative and knowledgeable customers that are invaluable for ideas. Likewise, a firm website is rarely visited by competitors' customers or by non-adopters. For all of these reasons, VKBs provide an important service to firms in overcoming the structural problem of limited reach between firms and their potential customers, by creating single points of contact between firms and millions of potential customers belonging to specific segments (Burke et al. 2001). Thanks to their extended reach, VKBs allow firms to overcome any possible myopia arising out of listening only to current customers in limited contexts.

A further limitation that firms face is their inability to access social customer knowledge. To the extent that consumption phenomena are increasingly influenced by social contexts, knowledge development through peer-to-peer customer interactions becomes critical in defining new product attributes and uses. Customers influence each other considerably in their choice of new products (Rogers 1995) and contribute to the development of collective meanings (Rheingold 1993). On the internet, the opportunity to tap into social customer knowledge is greatly enhanced by virtual customer communities. However, firms need specialized competences to select the right communities to analyze, share their languages, and manage and opportunely synthesize the huge amount of customer knowledge emerging through spontaneous interactions and online conversations. Hence, in contexts where social knowledge is important for innovation, firms might find it difficult to collect this distributed knowledge on their own, and therefore may benefit from working with independent actors who can enrich their understanding of customer needs. For example, the casual wear company Diesel uses third-party websites and communities to obtain crucial social customer knowledge (Verona and Prandelli 2002).

VKBs also help firms to overcome perceptions of bias that firms may face in soliciting customer input for innovation. Customers often perceive firms as having vested interests, and therefore may be reluctant to share information openly with them. Customers are much more likely to trust an unbiased third party whose sole purpose is to help them by understanding their preferences concerning products, brands, and manufacturers (Hagel and Rayport 1997). This is why customers rarely tend to speak about their lifestyle and interests on company websites, preferring independent communities where they feel their knowledge will not be exploited for commercial purposes (Sherry and Kozinets 2001). Customers are also biased by their past experience with a firm, and may not be able to think differently about the firm and its products. Rogers (1995) illustrates the role of incompatibility with existing products and behaviors as an important barrier to adoption. Customers are not even always completely aware of their own specific needs and specific solutions that might address their needs. Therefore, they tend to consult autonomous and unbiased third parties earlier in the decision process, before they engage with specific firms and products (Maes 1999). Firms are also informed by their prior experience, which limits their ability to absorb customer knowledge that may not fit in with their own ideas (Christensen 1997). Therefore, firms that limit their collaboration to existing customers tend to self-confirm their own mental models and so risk creating innovation that is not relevant for the market at large, and too incremental to sustain competitive advantage (Christensen and Bower 1996). To gain insights that facilitate innovations, firms need to complement the knowledge that they can get from current customers with other knowledge from potential customers that the firm may not normally deal with, knows little about, and cannot reach in a credible manner.

The role of VKBs in the management of innovation is also different from that of traditional KBs. The latter specifically offer new solutions to design problems to firms and therefore contribute primarily to their *inventive* activity. Clients, typically, hire a KB to design part or all of a product that they would like to manufacture and sell but lack the expertise or staff levels to design it. Results range from sketches of product concepts to complete new product design, and the collaboration between the KB and its client tends to last, depending on the specific design project, from a few weeks to three years, with an average of about one year (Hargadon and Sutton 1997). KBs innovate by combining in new ways existing technologies that originated in various industries (Hargadon 1998). Hence, they absorb knowledge from other companies. Innovative firms located in different industries are often the source of their ideas, and the main skill of KBs involves finding opportunities by arbitraging knowledge across industry contexts. This recombination and arbitrage allows KBs to serve as a valuable clearinghouse for technological solutions (Hargadon and Sutton 1997).

VKBs differ from KBs in several key respects. First, they do not offer completely developed design solutions, but provide a service that extends to the entire scope of the *innovation* activity. Second, they do not leverage solutions and technologies already developed within other companies, but absorb new ideas and knowledge from customers. This requires the creation and ongoing management of two-way interactions with individual customers and

virtual communities on a systematic basis. Third, as a consequence, the collaboration between VKBs and firms who work with them is often not limited to an individual project, but can expand over time to support different knowledge needs on an as-needed basis. Clients, typically, hire a VKB to gather market knowledge that will enhance their ability to generate and select new ideas — stimuli to incremental or even radical innovation — or enhance their their ability to develop, test, and refine new products. Hence, by managing knowledge of distant customers, VKBs may be useful at the front-end as well the back-end stages of the innovation management process. So, while KBs tend to have a strong client orientation to serve the needs of a firm looking for a specific design solution, VKBs tend to favor a network orientation, providing knowledge absorbed from customers to different companies, repackaged in different ways, to support different stages of the innovation process.

It is also important to highlight the limitations of VKBs. The processes of absorption and usage, and hence transfer between a firm and a VKB, are all influenced by the nature of knowledge and, specifically, by the level of knowledge codification. When knowledge is codified, it can also be replicated (Szulanski 1996).[3] Virtual environments do not allow all types of knowledge to be exchanged. Tacit knowledge is more difficult to exchange over the internet than explicit knowledge (Afuha 2003). This does not mean that, on the internet, tacit knowledge is not present, since in a virtual community people may exchange ideas and feelings, and also solve problems. It simply means that the lack of codification may limit the ability of a VKB to capture tacit knowledge. Other things being equal, the ability of a VKB to contribute to a firm's innovative activity will be moderated by the level of codification of the knowledge to be absorbed. This is exactly the opposite in the case of a traditional KB. The fact that KBs are rooted in physical contexts reduces their ability in network access, but increases their ability to absorb, integrate, and implement knowledge. The fact also that they work in close proximity to their customers helps them deliver customized solutions. Table 2 summarizes the main differences between VKBs and other channels for supporting innovation.

Table 2. A Comparison between Mechanisms for Supporting a Firm's Innovation Process

	VKB	KB	VCE
Type of contact	Mediated	Mediated	Direct
Source of knowledge	Industrial and inter-industrial	Inter-industrial	Industrial
Type of outcome	Knowledge for innovation	Product design	Knowledge for innovation
Role in the process	Invention and innovation	Invention	Invention and innovation
Type of orientation	Network orientation	Client orientation	Firm orientation
Type of interaction	Continuous	Spot	Continuous
Core competence in the brokering cycle	Network access	Absorption and integration	Absorption and implementation
Main limit	Knowledge implementation	Network access	Network access

Discussion and Conclusion

To maintain the pace of innovation in today's rapidly evolving markets, firms need to extend their ability to absorb customer knowledge that lies beyond their reach and influence. Towards this end, the internet and communications technologies have greatly enhanced the connectivity between firms and customers by enabling the creation of virtual customer environments. Developing and managing these kinds of virtual relationships requires specialized competences that firms may lack. This gap in capabilities motivated our conceptual framework that suggests the need for VKBs to facilitate innovation by enhancing the reach and richness of interactions between firms and their customers in virtual environments. We grounded our framework in the existing literature on KBs, which helps us to understand how firms can better manage the division of innovative labor within a network of specialized entities that support innovation.

Our conceptual framework contributes to a better understanding of the process of innovation by showing how different actors can play specialized roles in producing innovation-related knowledge, and how firms may need to collaborate with third-party KBs to absorb such knowledge. From a theoretical standpoint, we believe that we are contributing to a better understanding of the process of knowledge brokering, continuous innovation, and the firm–customer relationship in several ways. First, our model extends the insights on KBs to the emerging context of virtual environments. It highlights that the process of knowledge brokerage can play a major role in virtual environments by amplifying the network accessed by any firm that needs market knowledge for innovation. Also, by providing customer knowledge to support the entire innovation process, we go beyond the traditional role of KBs, which is generally limited to design solutions for new products. Second, our research contributes to the larger body of literature on continuous innovation, which has traditionally adopted an endogenous perspective and has centered mainly on a firm's dynamic capabilities (e.g. Teece et al. 1997). We highlight the fact that processes that support dynamic capabilities often take place at the inter-organizational level. Independent KBs play a key role by enabling combination and reconfiguration of knowledge to support innovation. Towards this end, VKBs can help overcome core rigidities (Leonard-Barton 1992) and improve strategic patching (Brown and Eisenhardt 1997), thanks to the continuous contribution of new pieces of knowledge from external sources that can be creatively combined. Third, our model highlights the fundamental role of customer knowledge in the process of product development. While the role of the internet in supporting customer knowledge absorption has been widely explored (e.g. Hagel and Singer 1999; Sawhney and Prandelli 2000), key questions still remain on how to leverage this knowledge capital in practice. We show that customer knowledge, by virtue of its being difficult to grasp, is best gathered and disseminated by specialized operators who work to facilitate innovation. Our framework sheds light on how new mediators specialized in customer knowledge absorption can support the firm's innovation processes by leveraging virtual environments in

a way that stretches the opportunities available for the individual firm both in time and space.

Our model also presents important managerial implications. The concept of VKB is extremely useful for firms that need to develop new products with continuity. Despite the internet promise of being a truly global medium, a single firm can rarely interact with prospects, competitors' customers, and non-adopters in nascent markets. Any company presents several structural holes that limit the scope of its interactions and relations. These structural holes become especially problematic in the process of innovation, because innovation rarely comes from existing perspectives and traditional interactions between firms and customers. Therefore, the indirect connections that VKBs offer are extremely useful for enhancing the innovation capacity of firms. Moreover, it is important to note that firms are limited in their ability to reach customers when and how they need to. VKBs can span structural holes across space (by engaging different types of customers and prospects) as well as time (by spanning all stages of the customers' decision-making process). In so doing, they greatly extend the reach and enhance the richness of customer collaboration in innovation.

The concept of VKB is also useful for internet operators that are looking for new avenues for value creation after the bubble that hit the global medium. The nodal position they occupy between the demand and supply sides puts them in a good position to aggregate customer preferences, solicit customer feedback, and gather knowledge that emerges from spontaneous conversation among customers and may be useful for a company innovation process. In this sense, the emergence of VKBs parallels the birth and development of information intermediaries. Infomediaries gather and organize information on products and services for individuals who are considering a purchase; they also organize communities of customers on the basis of common interests or specific industries. They use content and community to facilitate transactions in a way that complements a company's direct e-commerce channel. In contrast to direct connections, they help firms reach a wider customer base, and are trusted by customers because of their perceived neutrality. As an interesting parallel, VKBs concentrate on aggregating and disseminating customer knowledge to support innovation. This suggests that infomediaries can evolve into VKBs because customer knowledge is a by-product of connecting actors on the supply and demand sides of transactions. By packaging customer knowledge in ways that are useful for companies to improve their innovation process, an information broker can also play the role of a VKB.

The ideas that we propose need to be refined in further conceptual and empirical research. We propose at least four important directions for future research. First, quantitative analysis is needed in order to measure the specific impact of the VKB phenomenon on the innovation process. This can be done by developing specific propositions regarding the impact of VKBs on innovation. Past theoretical and empirical literature on product development has identified *time to market* and the *fit with the market needs* as the two most important metrics of the innovation process (Brown and Eisenhardt 1995; Verona 1999; Krishnan and Ulrich 2001). Specific propositions relating the

contribution of VKBs to these two variables would be extremely relevant. In this respect, it would be important to compare the efficiency and effectiveness of the innovation process at firms that use VKBs and at firms that do not collaborate with VKBs.

Second, it will be important to monitor the process of knowledge transfer between a VKB and a firm that wants to innovate. While the network access capability of a VKB is indisputable, it is also important to understand the factors supporting knowledge transfer between the VKB and the innovating firm.[4] Several organizational variables might act as integrators of knowledge between two actors. As also indicated by Zahra and George (2002), the relationship between a potential absorptive capacity and its actual realization is moderated by *social integration mechanisms*, whose presence lowers barriers to information sharing while increasing the efficiency of knowledge assimilation and transformation. Knowledge is often social in nature (e.g. Polanyi 1966; Kogut and Zander 1992), so spot and contractual agreements are not conducive to the effective incorporation of knowledge absorbed by a VKB into the innovation process. Integration mechanisms (both formal and informal) make all contributors to innovation more aware of the potential knowledge that is workable for innovation.

Third, it would be useful to understand how different types of VKBs can provide knowledge that supports different stages of the firm's innovation process. It would be helpful to develop a taxonomy of VKBs that recognizes the fact that VKBs can specialize along two key dimensions: the type of knowledge they create and the stages of the innovation process that they focus on. Assuming that the innovation process is divided into several steps — from concept development to product launch — there are several informational needs that must be fulfilled in order to develop new products. A further qualitative analysis may contribute to a better understanding of how VKBs can help the individual firm at each of these stages: by observing customer conversations and behavioral paths to support ideation; by directly asking customers about their perceptions; by presenting customers with prototypes of new offerings and product concepts; and by describing customer profiles and responses to new products. A likely finding might be that firms cannot rely on a single VKB for all stages and for all types of knowledge. Rather, they need to rely on a portfolio of VKBs that together have the capacity to bridge all structural gaps between them and relevant customers.

Fourth, the similarity between a KB and a VKB requires closer attention. A VKB stems from an infomediary, which means that, first of all, it shows strong ability in managing virtual environments. In this sense, the two operators are substantially different. Also, as indicated in Figure 1, KBs so far have mainly been design and consulting firms like IDEO, Accenture, and Design Continuum. These companies are good at consulting in physical environments but not necessarily at bridging and absorbing knowledge in virtual environments. In fact, the cases of VKBs such as Edmunds, Liquid Generation, and Innocentive show idiosyncratic web-based abilities. Specifically, VKBs need to develop robust competences in carefully tracking and profiling customers; managing two-way communication channels to create emerging individual

customer knowledge; moderating virtual communities to create emerging social customer knowledge; creating incentives to enact mechanisms of self-selection from the most involved customers; deploying content analysis to map and subsequently recombine relevant pieces of customer knowledge. These web-specific competencies are difficult for KBs to develop, if they lack the ability to manage virtual relationships with a broad customer base. Future research could explore this area further.

In conclusion, in a world that is becoming increasingly connected, we hope that future research will follow our general guidelines to demonstrate the concrete benefits of knowledge brokering in virtual environments.

Notes

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1 We emphasize this point, because historically literature on innovation has been primarily focused on the role of technological knowledge. Only recently, scholars have started to stress the fundamental role of organizational and customer knowledge (e.g. Christensen 1997; Adner 2002). Moving from 'technology brokerage' to the more general process of 'knowledge brokerage' is an important generalization of the brokerage concept.

2 According to Metcalfe's law, the value of a network increases in proportion to the square of the number of people using it (e.g. Downes and Mui 1998). So the first player to achieve a critical mass of customers can potentially achieve dominance. As a consequence, when a VKB has reached the critical mass of direct ties, these ties tend to increase further in a virtuous cycle. This virtual cycle can extend far further in a virtual network than in a physical network (McAfee and Oliveau 2002).

3 Tacit knowledge does not necessarily mean that it is knowledge that cannot be codified. Individuals and firms can undertake processes of socialization and externalization that may help to codify tacit knowledge (Nonaka and Takeuchi 1995). Still, some knowledge is unlikely ever to be explicated because it may be embedded in individual or organization cognition and abilities (Leonard and Swap 1999). In this sense, the quantity and quality that may be transmitted depends very much on the level of knowledge codification: codes help transmission, and with low codifiability knowledge transfer is weak.

4 We are indebted to one of the reviewers for suggesting this limitation.

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