Sources, characteristics and effects of emerging technologies: Research opportunities in innovation

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**Abstract**

Diverse technological developments across information technology, biotechnology, nanotechnology, and satellite communications technology have the potential to dramatically alter industry landscapes, with important economic and policy implications. Not surprisingly, therefore, managers are challenged to develop strategies to cope with the threats posed by emerging technologies and leverage the opportunities posed by them. Indeed, there is growing anecdotal evidence that firms’ inabilities to cope with emerging technologies have produced high product and firm failure rates. From an academic perspective, I argue that emerging technologies have important distinctive features that have not been examined in current theory in marketing, and specifically, in organizational innovation. In this article, I identify several research questions that emerge from the sources, characteristics and effects of emergent technologies in the area of organizational innovation. Insights generated from such a line of inquiry have the potential to broaden the canvas of innovation theory and provide valuable insights to managers who confront these onerous challenges on a daily basis.

1. Introduction

Diverse technological developments across information technology, biotechnology, nanotechnology, and satellite communications technology have the potential to not only affect products and services, but consumer behaviors and firms’ strategic advantages with important economic and policy implications. Emerging technologies dramatically affect firms, markets and marketing as we know it. Indeed, while some firms have been benefited by the effects of emerging technologies, other firms and sometimes, even industries have been overwhelmed by them. For example, developments in voice over-Internet protocols (VOIP) technologies are threatening the current business models of traditional land-line based telecommunications firms. While the long arm of emerging technologies has affected firms across diverse industries, their effects vary across industries with some industries (e.g., communications, information technology, health sciences) being more subject to these tumultuous forces than others. However, no industry appears to be immune to the effects of emerging technologies.

Following Day and Schoemaker (2000, p. 2), I define emerging technologies as science-based innovations with the potential to create a new industry or transform an existing one. Thus, by definition, emerging technologies offer a rich source of technological and market opportunities for some firms and threaten other firms. The large body of insights in innovation research in the marketing literature has been developed, for the most part, without explicit consideration of the distinctive features of emerging technologies. Given this background, important questions for managers and academics alike are: How can firms innovate in the face of these emerging technologies? How can they effectively overcome the threats and leverage the opportunities posed by emerging technologies?

This paper’s thesis is that emerging technologies have distinctive features which create conditions both externally (in the marketplace) and internally (within the firm) which significantly affect firms’ strategies and performance and therefore their innovation strategies. I conceptualize emerging technologies in terms of three broad sub-heads: their sources (where do emerging technologies come from?), their characteristics (what defines emerging technologies?) and their effects (what are the effects of emerging technologies on firms’ strategies and outcomes?). I propose that the sources, characteristics and the effects of emerging technologies pose several challenges for organizational innovation resulting in opportunities for interested scholars.

Specifically, I consider two aspects of the sources of emerging technologies—the ‘relay race evolution’ of emerging technologies, and ‘revolution by application’—four characteristics of emerging technologies—
the clockspeed nature of emerging technologies, convergence, dominant designs, and network effects—and three effects of emerging technologies—shifting value chains, digitization of goods, and the shifting locus of innovation (from within the firm to outside the firm). I describe these three aspects of emerging technologies and identify resultant research questions in organizational innovation.

I proceed as follows. I first provide a brief overview of emerging technologies. Following that, adopting a retrospective lens, I discuss the specific features of the sources, characteristics and effects of emerging technologies respectively, and discuss their implications for business practice and outcomes. For each aspect of emerging technologies, I develop specific research questions that follow from the characteristics of the emerging technologies.

2. Emerging technologies: an overview

Following Day and Schoemaker (2000, p. 2), emerging technologies are science-based innovations with the potential to create a new industry or transform an existing one. They include radical technologies that emerge from new technologies or incremental technologies that arise from the convergence of existing technologies. Thus, by definition, emerging technologies offer a rich source of market opportunities for some firms and challenges for others, in some cases destroying the existence of incumbent firms. Like Day and Schoemaker (2000), I use the term ‘technology’ to the process of transforming basic knowledge into useful applications, so that technology is a set of discipline-based skills that are applied to particular products and markets.

Emerging technologies are highly complex, and volatile. The players in the emerging technologies are unknown and changing with existing technologies and firms are continually overthrown by newer technologies and entrants. The domain of the technology in terms of the substantive knowledge underlying it, the products and processes emergent from them, the viable marketing strategies and profitable business models are also not only hard to predict, but also in a state of constant flux. The potential returns to investments in emerging technologies are impossible to ascertain not only because of the uncertainty of the value of the technology but also because the value could be potentially eroded by newer, emerging technologies. Indeed, the only certainty with the emerging technologies is the high degree of uncertainty associated with them.

An interesting aspect of emerging technologies is that in the past two decades, emerging technologies and their effects have not been confined to the traditionally defined “technology-intensive” industries (e.g., computing, telecommunications). More recently, the pervasive effects of emerging technologies are felt across diverse industries including some that have not traditionally considered to be “technology-intensive” such as pharmaceuticals, retailing, music, movies, and media industries. For example, genetic engineering and material science technologies combined with computing technologies represent emerging technologies posing threats and opportunities to several industries including health care delivery, pharmaceuticals, and forensics.

I conceptualize emerging technologies in terms of three broad subheads; their sources (where do emerging technologies come from?), their characteristics (what defines emerging technologies?) and their effects (what are the effects of emerging technologies on firms’ strategies and outcomes?).

3. Sources of emerging technologies

In the next section, I discuss the two aspects of the sources of emerging technologies, the ‘relay race evolution’ of emerging technologies and ‘revolution by application’ followed by the research questions for organizational innovation arising from them.

3.1. Relay race evolution

A review of the evolution of several emerging technologies across diverse industry contexts suggests that emerging technologies are typically developed in small, de novo firms explicitly set up to develop the new technologies (Basalla, 1988; Christensen, 1997). At the early stages in the technology evolution process, the new technology is “buggy” with low performance–price ratios. Its applications and benefits are not always apparent to even the developers of the technology. While emerging technologies evolve a long period of time (sometimes spanning more than several decades), in their early stages of evolution, emerging technologies have limited if any functionality and are suited only for limited, narrow applications with low commercial value. Given this background, the potential of emerging technologies may be overlooked by most firms in industries that are likely to be affected by them. The early versions of the emerging technologies are immature and imperfect with limited benefits. For example, pictures from early digital cameras were not as good as those obtainable from analog photography, and early personal computers developed before IBM’s PC in 1983 were clunky and did not offer users any computing benefits which would merit their serious consideration by users of minicomputers (the previous generation of computing technology).

Over time, there is a process of prolonged, extensive and incremental (although not necessarily continuous) process of innovation across several firms in the industry (not just the firm that pioneered the emerging technology). Indeed, sometimes, the changes in the emerging technologies occur in firms across multiple industries encompassing several, diverse knowledge domains. Over time, the nature of innovation in the technology changes from developments in the technology’s science to applications with growing commercial potential.

In addition, as the technology develops, its “bugginess” is eliminated, the technology is applied to product applications with well-defined consumer benefits, and the performance–price ratios improve, and the potential benefits from the emerging technologies appear to shift from consumers in the previously, narrow niche market to the consumers in the broader, larger mass market.

With growing commercial potential of the emerging technologies, large, incumbent firms concerned about the effects of the emerging technology on their current business models begin to participate in the development of the emerging technology. Such participation could be through acquisition of the de novo firms, or partnerships with the firm or purchase of the new technology through licensing arrangements. As a result, the locus of innovation in the emerging technology shifts from the small de novo firms to larger, more well-established, incumbent firms, and the nature of the innovation shift to commercialization of the technology in the product-market application from development of the underlying fundamentals of the technology.

Viewed in this perspective, the evolution of emerging technologies may be characterized as a cooperative (albeit competitive at some level) ‘relay race’ played over time between the small, de novo firms explicitly set up to develop the new technologies and larger, well-established, incumbent firms who develop and leverage the emerging technologies, creating value for both firms and consumers. Sometimes, of course, the incumbents fail to respond to the emerging technologies and find that their technologies’ and business models are rendered obsolete by the emerging technologies, so that the market leadership in the industry changes with the emerging technology.

3.1.1. Research questions

The ‘relay race’ nature of the evolution of emerging technologies generates interesting questions for research in organizational innovation, which I discuss next. What happens to the small, de novo firms that pioneered the technology? A few of these de novo firms are able
to leverage the new technology, and successfully market products. Other firms may not have the resources to independently compete in the race to commercialization of the technology. Some of them may be acquired by the larger, perhaps more well-established, and incumbent firms in the market place while others may fail and exit the market. What is an appropriate exit strategy (e.g., become an acquisition target, go public through an IPO, merge with a large well-established incumbent) for these small, de novo firms who may not have the resources or the marketing capabilities and assets (e.g., brand equity, distribution channels) to independently create value for their firms using a go-it-alone strategy? In terms of acquisition exits, if the small de novo firms offer themselves as acquisition targets to well-established firms, what is the optimal timing for such acquisition plays, from a value-creation perspective?

Large, incumbent firms also face several challenges when confronted with an emerging technology that is developed in the small, de novo firms. From the perspective of the large, well-established firm confronting a potentially disruptive emerging technology, what are appropriate collaboration and rent-sharing models? When should the large firms undertake such efforts? Typically, there may be multiple technologies battling out in the marketing place for the dominant design (see below). In such a situation, are there an optimal number of technologies that the established firm should take positions as only of the several emerging technologies is typically likely to emerge as the dominant design? In addition, acquisition of the small, de novo firms may be an important innovation strategy raising questions about what types of skills and capabilities do incumbent firms need to acquire in the face of the emerging technologies? While they would vary by the characteristics of the incumbent firm, it would be useful to examine whether they also vary by industries (e.g., biotechnology, computing, telecommunications etc.).

Further, the corporate and innovation cultures of the large, well-established firm may be dramatically different from that of the small, de novo firm. An important issue for large, well-established incumbent firms as they acquire new, innovating firms is whether and how they can best leverage their acquisitions for innovation and profit, in the light of the potential conflict in cultures across them.

Finally, given the high level of failure of new firms in technologically-intensive markets, there is a destruction of knowledge when these new firms die. What mechanisms can industry organizations develop to institutionalize the new knowledge, routines and skills developed by these new firms with a view to ensuring that this knowledge is not lost to the industry?

3.2. Revolution by application

Technological evolution scholars (Adner & Levinthal, 2002) have used evolutionary biology principles to develop models of how new technologies emerge. These studies argue that as in the evolution of biological organisms, relatively small developments in one, sometimes peripheral technology domain have wide-reaching effects for the technology developments. Evolutionary biologists Stephen Gould and Niles Eldridge (1977) describe this evolutionary process as the process of “punctuated equilibrium” when a gradual, small change in an underlying system in one domain can have significant, large impacts in other seemingly, unrelated domains. Thus, the technology undergoes a process of evolutionary development within a given domain of application. At some juncture, that technology, either independently or in conjunction with other technologies is applied to a new domain, which results in a significant technological revolution in the new application domain in terms of the technologies’ benefits and costs. Indeed, the technology frequently changes and adapts to the needs of the particular application. The new environment may have an abundance of resources that supports the development of the technology in the new application, in areas that are valued by the users of the new application. As a result of the application, there may be different selection criteria (with different characteristics and benefits) for the technology’s development in the new environment from that in the original, underlying technology in the parent environment.

Consider, for example when the ARPANET technology evolved from academic and defense labs into the ubiquitous Internet technology in the 1990s when Netscape developed what, in retrospect, was a relatively minor technical development in the user-friendly HTML interface resulting in a mass market for Internet technologies, changing the face of computing and communications.

Applying the technology speciation lens to emerging technology evolution suggests that while scientific development of the technology in its original domain may be incremental, the shift in application domain of technologies produces discontinuous “creative destruction” observed across several industries (Christensen, 1997). Sometimes, the emerging technology grows rapidly in the new application domain displacing an existing technology, causing the destruction of the incumbent technology.

3.2.1. Research questions

The ‘revolution by application’ view of emerging technologies focuses on the intersection between a technology’s development and its potential market application. For the firms involved in the emerging technology or likely to see their existing business models threatened by the new technologies, an interesting question is which, if any of the several applications of the emerging technology in question, is likely to emerge as the “winning solution”? Such identification requires flexibility in sense-and-respond capabilities to scan the environment for the applications, a capability that may be especially problematic for technically skilled research and development and product development managers, who are experts in a given, typically narrow domain and not trained to look outside the “technology domain” for ideas for new products and services.

In addition, by design, some of the applications where the technology finds its “value” may be outside the scope of the firm’s activities. What are the appropriate governance mechanisms (e.g., alliances, joint ventures, industry consortia) to develop insights on the application domains? What are the best ways to minimize the firm’s risk exposure even as they collaborate or partner with firms in applications, which may be downstream to this technology?

4. Characteristics of emerging technologies

I next discuss the characteristics of emerging technologies and their implications for organizational innovation. Specifically, I discuss four characteristics of emerging technologies—the clockspeeds of emerging technologies, convergence in emerging technologies, dominant designs and network effects.

4.1. Fast clockspeed

Over time, there appears to be a compression in the time for the development of emerging technologies, with a marked increase in the overall rate of technological progress. For example, Internet time, like dog years, passes more rapidly than standard time. While the Internet is at the leading edge of the speeding up of time in industries, similar forces are at play in a number of other industries, reflecting the frenetic pace of technological change. In addition, developments in communications technologies, satellite technologies, and materials research and biotechnology domains are converging upon each other (see below) to hasten the pace of emerging technologies. Further, the overall trends toward free markets and globalization are accelerating the developments of emerging technologies around the planet, so that key developments in emerging technologies are no longer happening only in Silicon Valley in California or along Route 128 in Boston, but
also in research and hubs in Germany, England, China, Singapore and India. Fine (1998) proposed the concept of industry clockspeed, which he defined as the rate of evolution, with respect to their products, processes, and organizations. In fast clockspeed businesses, firms have a narrow time window for decision making, as a result of which they may have to generate hedging strategies, with positions in more than one emerging technology. An important effect of fast clockspeed industries is the narrow window for making important decisions relating to product-marketing decisions. When the pace of technological progress is more measured, firms can sit back and wait for other firms to take the “pioneering risks”. Failure to respond nimbly to market changes could result in lost market share or worse still, technological lockout from an entire generation of technology and subsequently from the market. Finally, increased clockspeeds of industries renders obsolete the concept of “sustainable competitive advantage.” All competitive advantage is fleeting, and the faster the clockspeed, the shorter the window for competitive advantage. Fine (1998) suggested that the movie entertainment industry is one of the fastest-clockspeed industries, whose products, motion pictures have half-lives measured in hours, or days. The biggest returns for films often come from a film introduction during the Christmas season, when the number of viewers is the greatest and the movie can make a big impression before the Academy of Motion Pictures, Arts and Science who nominate films for awards. Process clockspeeds in the movie industry are also very fast as there are several new developments of new processes and services for the development, production and distribution of movies. Organizational dynamics are also turbulent in the movie industry with several alliances and agreements being negotiated and renegotiated across the various players in the industry. Like the movie industry, other industries, both within the technology-intensive sector (e.g., telecommunications, networking, computing) and in traditional industries (e.g., music, retailing) are experiencing fast clockspeeds, with important implications for firms’ strategies.

4.1.1. Research questions

Can firms respond too slowly to changes in their environment so that they miss opportunities with the newer generation of technologies or products? Is it possible, a priori, to identify, the right time to switch to an invading technology? Given that well-established incumbent firms may have organizational routines inculcated over time that may prevent them from responding quickly to market changes, what organizational mechanisms (e.g., joint ventures, alliances, partnerships etc.) may be most effective for developing capabilities to respond in the market?

In addition, the faster an industry evolves, i.e. the faster its clockspeed, the more temporary a company’s advantage. In such a situation, a company’s products and services can, at best, achieve only temporal market dominance, only to be overtaken by the next invading technology. A key challenge for companies in such a situation is to evolve faster than their competitors or risk being left behind. An interesting question is how and why some firms (e.g., IBM, Microsoft, Amazon) are successfully able to develop new offerings and capabilities and achieve competitive advantage, albeit temporary, over and over again, while others (e.g., Digital Equipment, Polaroid) are unable to successfully make this transition?

4.2. Convergence in technologies

The emergence of a new technology is more complex than the simple and straightforward migration of a single technology from one domain to another. Frequently, the new technology may draw on several underlying families of technologies that fuse together in the new application domain (Yoffie, 1997). New technological trajectories evolve as the result of melding or fusion of two or more formerly distinct technologies in a common application domain. This may occur through a process of convergence, in which the common domain is the application domain in which one of the two antecedent technologies is applied (e.g., digital cameras). Alternatively, two technologies may undergo fusion in which the resulting technology is applied to a new domain (e.g. Internet technology).

The power of creative combinations of new and technologies, new and old methods of producing products, and business models can open entirely new markets, while destroying current business models and markets. Moreover, an incumbent firm in an existing market may be blindsided by the convergence of emerging technologies, over which they may have very little control. In addition, the convergence of technologies creates new knowledge domains, which will not only be new to the incumbent firms, but also sometimes new to the world.

Some examples of such convergence in technologies include digital imaging, hand held computing, Internet multimedia players, and video-on-demand. Consider the convergence of technologies in the digital imaging industry. The advent of digital imaging technology in 1991 shook up the traditional photography industry as CCD technology (charge-coupled devices that convert light images to binary data) replaced traditional film-based photography. The creation of the digital camera involved the integration of diverse technologies covering microelectronics, integrated circuit design, image processing, software design, CAD/CAM design, and filter optics. In the early years of the digital camera market, there was uncertainty about form factor (e.g., the digital camera as a computer or a consumer durable) and revenue models (e.g., hardware or consumables) which are likely to be both viable and sustainable.

4.2.1. Research questions

In the face of digital convergence, where competition spans different technologies and revenue models, what are self-sustaining and revenue models for firms? How can firms develop and implement multiple revenue models for different market segments to ensure appropriation of rents, even as they prevent “leakage” of this information across the segments? Moreover, with digital convergence, there may be blurring of product and service forms and functions? Is a digital handheld with several capabilities—including telecommunications, web-browsing and computing capabilities and related service features such as video games—a cell phone, an address book, a pocket book computer or a gaming toy? What are the implications of developing these offerings with blurring product boundaries for the firm’s marketing mix options, including pricing and distribution approaches?

Given the uncertainty associated with digital convergence, firms may have to use “market experimentation” a strategy making approach to explore the various options in the emerging converging. Also, given the large span of technologies under the rubric of digital convergence, firms may need to have the peripheral vision capabilities to both effectively sense-and-respond to these converging, emerging technologies (Srinivasan, Lilien, & Rangaswamy, 2002). What “market experimentation” strategies and “sensing” capabilities are likely to be more or less effective markets and why?

4.3. Dominant designs

With many emerging technologies, technological evolution results in a single product design which emerges as the dominant design (Utterback, 1994). The emergence of the dominant design is a watershed event significantly affecting the market and technological evolution, the performance of firms and ultimately, the market structure. In the early stages in the market, there is a diversity of product designs driven by the high levels of both market and technical uncertainty. At this stage, product designs are fluid, manufacturing processes are loosely and adaptively organized and generalized capital is used in the production of the product. Early competition among
firms is manifest as competition between the different product designs, which are generally different from each other. At some point, after considerable trial and error in the marketplace, one design, the dominant design, begins to emerge as the more promising, finding acceptance among a large number of users in the market. A dominant design is not necessarily one that embodies the most technical performance; it is usually a satisfying design in terms of the interplay of technical possibilities and market choices (Srinivasan, Lilien, & Rangaswamy, 2006).

Dominant designs affect the performance of firms operating in the market affecting the distribution of rents between firms and, in some cases, locking out other firms’ product designs (which did not become the dominant design) sometimes, for years to come. The survival of firms in five industries (typewriter, automotive, television, tube, transistor, and the calculator) is related to the emergence of the dominant design such that firms entering the market before the emergence of the dominant design have a higher probability of survival than those entering the market after the emergence of the dominant design (Suárez, 2004).

4.3.1. Research questions

If there are several emerging technologies trajectories, only one of which will emerge as the dominant design, what is the real-options value of a firm taking positions in several emerging technological trajectories in the market? Are there an optimal number of technologies that the firm should take positions in? And does this number vary across industries and if it does, what influences the number of technologies in which the firm should take positions? It takes all the energy of the organization to pursue one clear and simple strategic aim—especially in the face of aggressive and focused competition—and that hedging by taking positions in a number of alternative technologies is not only resource-intensive but also dilutes the firms’ commitment to a given technology trajectory. So an important challenge for firms is how to manage commitment to their core technologies (and business models) even as they remain flexible with respect to emerging technologies.

Second, do firms’ marketing strategies (e.g., pioneering versus late entry), and capabilities (e.g., incumbency, brand equity, complementary assets) influence the timing and the emergence of the dominant design? A related question when considering dominant designs is whether or not the resultant standards from the dominant design should be open or closed i.e. whether the owner of the standard should appropriate or share the rents with other firms in the market. Insights on this issue would be useful to firms in technology-intensive market who are frequently confronted with whether they should go it alone in standards development and marketing (e.g. Beta format in video recorders) or cooperate through a consortium (e.g., fax machines, DVD players)?

4.4. Network effects

Increasing connectivity of products and users of products has resulted in more and more product categories in industries such as computing, telecommunications and consumer electronics industries that exhibit network effects (Yoffie, 1997). A positive network effect exists when customer value for a product increases as the total number of customers who use the identical or compatible products increases (Katz & Shapiro, 1986). The telephone is a classic illustration: the value of a telephone to the first user is zero if no else has one. As the number of people who own telephones increases, its value to each user increases. Some recent examples of products with network effects include the DVD player, the digital camera, instant messaging, interactive television, the Internet browser, the MP3 player and the wireless personal digital assistant.

When the value of the product to each user in the network depends on the total number of users of the product, the product-market exhibits direct network effects. An oft-cited example is the product-market for the fax machine. The value of a fax machine is zero if no else has a fax machine. As the number of people (n) who own fax machines increases, the value of the fax machine to each user in the network increases, in some proportion to the number of two-way connections, n(n−1). Indirect or complementary network effects arise when the link between consumer utility and the number of users occurs through the variety of complementary products. In this setting, to be of value, durable (i.e., hardware goods) require complementary software. Increases in the total number of users of compatible hardware goods lead to increases in the number of complementary products, which in turn, lead to increases in the value (utility) that customers derive from the durable good. Videocassette recorders, compact disc players, and personal computers are examples of product categories experiencing these effects.

Network effects are especially acutely felt in the high-technology sector. Given the growing prominence of products with network effects in the economy, there is an extensive literature, largely in economics, (e.g., Katz & Shapiro, 1986) that has examined the strategic and welfare implications of network externalities. A consistent finding from this literature is that network externalities alter customer behavior, with important implications for marketing strategy formulation and performance (e.g., Srinivasan, Lilien, & Rangaswamy, 2004).

4.4.1. Research questions

In networked markets, user-installed base, and standards offer opportunities for firms to build and hold loyal customers, even as the technologies change. Viewed in this perspective, standards ownership, I suggest, takes the place of brands in the traditional, non-technology-intensive markets. An interesting question therefore from a market-based assets (Srivastava, Shervani, & Falbe, 1998) perspective, is whether and how the firm’s standards and user-installed bases are “value relevant” (i.e. do they inform shareholders about the firm’s intangible assets) in terms of their effects on shareholder value metrics (e.g. stock returns, systematic risk and intangible value)?

Much of the insights on new product development research have been generated in the context of traditional, non-networked markets. Given the several distinctive characteristics of products with network effects (e.g., standards, complementary products), do the templates and models developed in non-networked products apply to the development of products with network effects?

A key characteristic of the networked market is the important role of standards in communication, whether direct or indirect between the various users of the network. An important consideration for policy makers when considering policies for encouraging the development of networked markets, and subsequently managing their evolution is what are the policy implications of designing networked products that speak/connect across networks for firm and consumer welfare? Finally, networked markets are associated with stickiness whereby new innovation is thwarted because of excess inertia in the markets, lowering consumer welfare. An interesting issue from a policy perspective is the extent of consumer welfare loss in such situations and what, if any, policy changes can reduce this loss in consumer welfare?

5. Effects of emerging technologies

I next discuss the effects of emerging technologies and their implications for organizational innovation. Specifically, I discuss three effects of emerging technologies—shifting value chains, digitization of goods, and the shifting locus of innovation to outside the firm.

5.1. Shifting value chains

An important effect of emerging technologies is that the innovation rents or the “value” in the value chain migrates over time, so that
a given technology’s potential to generate innovation rents may vanish from the value chain, rendering a firm’s business model obsolete. This shift in value chain may arise from an un-harnessed emerging technology, which creates new innovation rent opportunities in the value chain in the industry. Combined with the convergence of technologies discussed earlier, firms may unexpectedly find themselves with fierce vertical and horizontal competition with unlikely rivals both up and down the value chain respectively.

In a shifting value chain landscape, firms must be cognizant of the continuous reorganization of the “rent pockets” in the landscape, think beyond company, technology and industry boundaries to find unexploited rent potential, and organizes ideas, players and customers to exploit the available rents in the value chain. One important way to achieve improved economic performance in the ever-shifting value chains is the leveraging of alliances and partnerships within the network to not only offer superior value to customers but also to co-opt competition in the value chain.

The shifting value chain now characterize a number of industries. Consider for example, the music industry, where online digital music downloading (a song is downloaded at a cost of 99c) has resulted in a number of critical changes which have rendered obsolete the business models of a number of incumbent players in the music industry including traditional music retailers, the record companies, and the artists. The same appears to be happening in the film industry with digital downloading of movies which is negatively impacting the film studios, actors, the theaters, and the cable companies who offer movies to their customers. Consider the personal computer industry, where over the past 25 years, the source of “innovation rents” has migrated around the various components including the hardware (e.g., memory, processors, and monitors) and software (e.g., operating system, office applications). Indeed, in the computing value chain which encompasses the semiconductor, hardware, software, and computer retailing industries, both Intel and Microsoft have deployed effectively strategies to leverage rents in a shifting value chain. Intel, with the view to generate and appropriate rents in the value chain, has undertaken ingredient branding strategy, trying to create value in the face of value erosion in hardware, while Microsoft with their the operating system and office applications offerings, both of which have strong network effects has virtually dominated the software rent space.

5.1.1. Research questions

In the face of migrating innovation rents, what are the alternative rent appropriation models available for firms? Several of these products exhibit network effects accompanied by dominant designs and standards, what is the role of standards to ensure the capture of innovation rents? Microsoft is an excellent example of a firm that has used network effects and standards effectively (e.g., with the innovation rents? Microsoft is an excellent example of a firm that has used network effects and standards effectively (e.g., with the Windows operating systems and its various office applications software) to continue to capture innovation rents. However, because typically only one of several designs emerges dominant with one dominant “winner-take-all standards”, firms which do not own the dominant design and associated standards have to develop alternative strategies to appropriate rents. Our review of the evidence suggests that marketing plays an important role for these firms to capture rents including through branding, distribution channels and customer relationship management capabilities. How can firms develop brands (e.g., Intel’s ingredient branding strategy), channels (e.g., Dell’s direct distribution model) and customer relationships (e.g., Amazon’s customer relationship strategies) to create pockets of innovation rents in the ever-shifting value chains, and then seek to appropriate these rents?

An alternative important way to build and appropriate innovation rents in the face of emerging technologies may be the provision of services. Services are an important way to build customer relationships, induce loyalty and obtain higher margins as is evident in IBM’s successful transition to a service provider from a hardware provider. In addition, if the firm’s core product is “service provision,” then the firm does not have an investment in and is not committed to any given emerging technology, but can transition across shifting value chains arising from invading emerging technologies. Indeed, such a model of service provision is being actively pursued by several other firms looking to consolidate their customer relationships, and profit margins. From an organizational innovation perspective, interesting questions include: How can firms transition to a hybrid goods–service paradigm with a view to capture innovation rents in a shifting value chain? How can firms achieve and maintain competitive advantage in services, which are easily imitable by competitors?

5.2. Digitization of goods

Digitization techniques have rendered analog signals (e.g., voice, pictures) transmitted by telephones, movies and music, similar to digital signals generated by personal computers, thus enabling the same infrastructure to accommodate manipulation, transmission of voice, audio, video and data (Collis, Bane, & Bradley, 1997, p. 161), i.e. the widespread digitization of information. The importance of the digital revolution is that it crucially changes the generation, access and availability of information in time and place, and the cost of that information to producers and consumers of information. Information can be now made available in any form and at any time the consumer desires it, rather than when it is convenient for the producer to distribute it.

Digitized information exhibits what has been called the “first-copy” problem (Shapiro & Varian, 1999). Specifically, once the first copy of the information has been produced, additional copies cost essentially nothing. In other words, while information is very costly to produce, it is cheap to reproduce (whether by the producer or by the consumers). The dominant component of the fixed costs of producing information is sunk costs. The variable costs of digitized products are low so that the costs of producing an additional copy do not increase, even if thousands of copies are made. Moreover, there are no natural limits to the production of additional copies of information: if you can produce one copy, you can produce a million copies, at the same unit cost, without any additional material resources for the additional copies.

5.2.1. Research questions

The low–unit costs of digitized goods offer many opportunities for innovation. Digitized goods are by nature, experience goods, i.e. their quality cannot be ascertained until the consumers have experienced the good. In other words, sampling the digitized good may be critical to the adoption and subsequent success of the digitized good. Interesting research questions in this area include what types of sampling design mechanisms (e.g., sampling a portion of the good, sampling the entire good for a given time period) is most likely to ensure consumer adoption, and higher price realizations for the firm?

Further, in a situation of sunk fixed costs and very low marginal costs, excessive price competition is commonplace among purveyors of digitized goods. Witness for example, the excessive price competition characterizing the digital downloading market where various players including Apple’s Itunes, Amazon and Wal-Mart are offering music at 99c for a song. In such a situation, an important question for companies is how they can add value to the digitized good, to both distinguish themselves for competition and hope to achieve superior prices for their offerings. Interesting research questions include exploring the role of additional complementary/bundled offerings and personalization of the digitized goods (and their prices) to achieve product differentiation. In particular, given that the fixed costs of producing a digitized good is high, and the costs of producing copies of the digitized good are low, and the costs of making small changes in the digitized good are low, an alternative approach would be to
produce versions of the digitized good tailored to the needs of different customers. A full line of digitized goods will maximize the total value of the information provided, enabling the realization of superior values, by serving different customers with different willingness to pay. In addition, these approaches can provide the company with the much-needed margins in a competitive market with declining margins.

Other interesting questions include: what are the optimal strategies for developing and pricing versions of digitized goods? What are the costs and benefits of using sequential and temporal versioning strategies (e.g., movies in theaters, movies on DVD’s, movies on pay-per-view and movies on cable channels) versus simultaneous versioning (e.g., online newspapers versus traditional newspapers)? How many versions should the firm offer to customers without increasing their costs of maintaining the various versions and creating customer confusion about which of the several versions in the market are suitable for them?

5.3. Shifting loci of innovation (to outside the firm)

For many years now, new product development executives have spoken about the perils of a “not invented here” syndrome which resulted in the rejection of superior innovation ideas when they were not generated within the firm. However, more recently, there is a growing shift in the locus of innovation from within the firm to outside the firm not just to other firms but also to customers.

There are several reasons for such a shift in the locus of innovation. As noted earlier, the relay race nature of the evolution of emerging technologies suggests that knowledge is created first in the small, de novo firms and is only gradually inducted into the larger, well-established firms. Moreover, the convergence in technologies suggests that knowledge domains in emerging technologies are interconnected, arising from a convergence of several distinct technologies located frequently across several firms, some of whom may be from different industries. The relay race evolution of technology and digital convergence suggest multiple loci of innovation outside the firm, and the opportunity for outsourcing innovation to others, both firms and customers (Nambisan & Sawhney, 2007).

With respect to customers, there is a growing idea of the democratization of innovation (Von Hippel, 2006) wherein the users of products and services, whether firms or individual consumers, are able to innovate for themselves. While the idea of user-centered innovation is not new (Von Hippel, 1988), it has been growing in leaps and bounds over the past decade with the emergence of technologies that facilitate information sharing and collaboration. Steadily improving quality of computer software and hardware, improved access to easy-to-use tools and components of innovation, and access to a steadily, richer innovation commons (areas where various partners including firms, customers and their suppliers can work together on innovations) combined with an increasing difficult regime of patent enforcement has fueled the growing role of customers in the innovation process.

In addition, with the growing prevalence of open-source development, where users are developing innovations and making them freely available to others, individual users do not have to necessarily develop everything they need on their own; they can benefit greatly from innovation developed and freely shared by others. In particular, an interesting aspect of user-led innovation is that users often freely reveal their innovations. This is especially typified in the “open-source” software development movement where project contributors would routinely and systematically freely reveal the computer code that they had developed at private expense. Such user-innovators often freely reveal their innovative efforts because it often the best or the only practical option available to them. Users who freely reveal what they have done often find that others then improve or suggest improvements to the innovation to the mutual benefit of all users of the product.

5.3.1. Research questions

Innovation by users tends to be widely distributed rather concentrated among a few very innovative users. Moreover, these users may not be motivated by financial rewards, but by other rewards including for example, enhancement of their reputation and increased diffusion of their idea. Hence, an important question for large, well-established firms used to the traditional models of innovation within the organization’s research and development departments is what models of community building and incentive mechanisms can be useful to nurture user-generated innovations and leverage these innovations for commercialization without disrupting the fragile ecosystem of the system of user-innovators.

Combined with other features of emerging technologies (e.g., relay race evolution of technologies convergence, revolution by application), the shifting locus of innovation portends changes for the organization of innovation within the new product development and/or research and development functions of firms. In the face of such changes, what collaborative mechanisms (e.g., consortiums, joint ventures, and partnerships) are likely to be more effective in leveraging the innovations outside the firm? What rent-sharing arrangements are likely to be more optimal not only from the perspective of short-term profits, but ensuring continued innovation within the partnership? Finally, an important issue is at what stage (e.g., idea, concept, prototype, or finished product) should the externally-generated innovation be imported into the firm? Each of these different stages of the innovation will have different risk and rent profiles for the various partners in the innovation process.

6. Conclusion

Emerging technologies are pervasively affecting the competitive dynamics, business models and consumer behavior across a wide range of industries including those not traditionally considered to be technology-intensive. Not surprisingly, therefore, managers have to cope with the threats and leverage the opportunities posed by these emerging technologies. Indeed, anecdotal evidence suggests that the challenges posed by the emerging technologies are overwhelming, frequently resulting in high product and firm failure rates.

From an academic perspective, I argue that the implications of the emerging technologies for organizational innovation research are significant. In this article, I identify several research questions that emerge from the emergent technologies in the area of organizational innovation. These research questions vary widely in terms of their scope and the potential methods that may be used to address them. I strongly encourage interested scholars to address these research questions. Insights generated from such a line of inquiry have the potential to broaden the canvas of marketing theory and provide valuable insights to managers who confront these onerous challenges on a daily basis.

References


