Discussion Paper Series No.134

The Origins of New Industries: The Case of the Mobile Internet

Jeffrey L. Funk   Kobe University

February   2003

The Origins of New Industries: The Case of the Mobile Internet

By

Jeffrey L. Funk

Associate Professor, Kobe University

Research Institute for Economics and Business Administration

2-1 Rokkodai, Nada, Kobe 657 Japan

Telephone and Facsimile: 81 (078) 803-7009

funk@rieb.kobe-u.ac.jp

From April 1:

Professor, Hitotsubashi University

Institute of Innovation Research

2-1 Naka, Kunitachi, Tokyo 186-8603 Japan

The Origins of New Industries: The case of the mobile Internet

Abstract

This paper describes a model of new industry formation that is based on evolutionary theories of technical change. It represents the origins of new network industries as the interaction between multiple technological trajectories that are specific to a particular technology or broadly defined technological regime. The speed with which these multiple trajectories cause industry formation depends on their effective application to the most economical applications; this process occurs through the interaction between design hierarchies and market concepts. Growth in these initial applications causes sub-trajectories or sub-regimes, where competition in the new industry initially takes place, to emerge from the main trajectories. The model is applied to the mobile Internet, an industry that has just started to grow particularly in Japan and Korea.

Keywords: origins, industry, technology, trajectory, design, hierarchy, market, competition, cooperation, disruptive, mobile, Internet

1. Introduction

In spite of the recognized importance of new industries[1], there are few models (Van de Ven and Garud, 1989) that describe the origins and early evolution of new industries. Instead, the origin of new industries is typically considered as an exogenous variable in other models. For example, the product life cycle theory assumes new industries are formed through the emergence of technological discontinuities. It then attempts to explain such variables as the frequency of product versus process innovations, the number of new entrants, the amount of product variety, and the emergence of dominant designs and their effect on competition (Abernathy & Utterback, 1978, Tushman & Anderson, 1986). Further, recent research suggests that the product life cycle does not effectively explain many of these (Klepper, 1996; Klepper and Simons, 2000) and other variables (Frenken et al, 1999; Windrum et al, 1998).

This paper proposes a model for the origins of new industries. The model only addresses new industries that offer products and services, which were previously not technologically feasible. Examples include the telegraph, telephone, automobile, radio, television, computer, semiconductor, consumer electronic, and mobile phone industries. On the other hand, the model is not concerned with industries that emerge or grow primarily through changes in demographics or increasing incomes.

The model draws heavily on evolutionary theories of technical change. It represents the origins of new network industries as the interaction between multiple technological trajectories (Dosi, 1982) that are specific to a particular technology or broadly defined technological regime (Nelson & Winter, 1982). The speed with which

---

[1] There is an extensive literature on the importance of new industries. Schumpeter (1942) is usually credited with being the first with his concept of creative destruction.

these multiple trajectories cause industry formation depends on their effective application to the most economical applications; this process occurs through the interaction between design hierarchies and market concepts (Clark, 1985). Growth in these initial applications causes sub-trajectories, where competition in the new industry initially takes place, to emerge from the main trajectories. The emergence of modular designs (Baldwin and Clark, 2000) or dominant designs, facilitate the emergence of these sub-trajectories. Network effects, increasing returns, first-mover advantages, and irreversibility play important roles in this initial competition.

This paper also applies this model to the mobile Internet a new industry that is growing rapidly in Japan and Korea and is just starting to grow in Europe, other parts of Asia, and to some extent in the US. This paper defines the mobile Internet as access to Internet-based contents using a mobile phone and thus does not include laptops, PDAs, and SMS (short messaging services) for mobile phones. The market for mobile Internet services (1.02 trillion Yen), contents (100 Billion Yen), and shopping (30-40 Billion Yen) exceeded 1.1 trillion Yen or eight billion US$ in 2002 in Japan and the Korean market is estimated to be about 20% of this[2]. The application of the model to the mobile Internet is based on interviews with over 100 participants in the Japanese market.

2. Proposed Model

Figure 1 summarizes the proposed model. New network industries are formed by the interaction between multiple technological trajectories where progress in a single trajectory occurs through improvements in the trade-offs between relevant technological

[2] Source: mobile service revenues are from firm publications and other data is from the authors research

variables (Dosi, 1982). Technological trajectories are similar to Sahal's (1985) concept of innovation avenues and he argues that the combination of multiple innovation avenues is the source of many industries. Technological trajectories can be represented by the change in component performance or the distribution of available performance in the component (e.g., as a function of price) and both of these measures could be for new components or the installed base of components. For example, the relevant trajectories for the formation of the Internet could be defined as terminals (PCs, PDAs, or phones), digital content, software, and network (e.g., speeds) performance[3].

2.1 Interaction between design hierarchies and market concepts

The initial rate of industry growth depends on identifying and serving an initial set of applications. These initial applications are defined by the interaction between design hierarchies and market concepts (Clark, 1985) where every design problem begins with an effort to achieve fitness between form (solution) and context (definition of problem). The form includes the basic functional parameters of the product and the context includes the economic and social environment. In the latter, the way technology is socially constructed (Bijker, 1987) has a large effect on when and where these first applications emerge.

Abernathy and Clark's (1985) model of technological development provides us with a partial framework for understanding the challenges of firm's identifying and serving these initial applications. In their model, innovations can strengthen or overturn existing technical or market linkages. Innovations that overturn existing technical

[3] For example, data on the performance of digital devices can be found in (Woodal, 2000) and data on the diffusion of digital devices can be found in (Lohr, 2002).

linkages destroy existing capabilities (Tushman and Anderson, 1986, Henderson and Clark, 1990) and thus require new capabilities that are often difficult for incumbents to develop. Innovations that overturn existing market linkages require new marketing or distribution systems that may also be difficult for incumbents to develop. One type of innovation that overturns existing market linkages is a disruptive technology (Christensen, 1997). Disruptive technologies improve some aspects of product performance while sacrificing others, thus making the new technologies appropriate for a new set of customers. It is important to recognize that customers must actually use the product in order to generate information about the requirements of the context (Arrow, 1974).

Innovations that do not overturn existing technical or market linkages will favor regions[4] with the capabilities in the old technology. The relevant capabilities might be found in the suppliers or the users (von Hippel, 1988) of the new technology. For example, two reasons for US dominance of the digital computer market (i.e., mainframe computer) was its strength in the analog computer market and in the applications for both types of computers including the scientific and military markets (van den Ende, Kemp, 1999). Similarly, early dominance of the television industry by US firms can be explained by their strength in the radio industry (Klepper & Simons, 2000).

On the other hand, the more interesting case is when innovations overturn existing technical and/or market linkages since these innovations may not favor regions that are the leaders in the old technology. Instead these types of innovations will likely favor regions that have firms or other institutions (Lynn et al, 1997) with the appropriate

[4] Regions can be part of a single country (e.g., Silicon Valley), a single country, or contain multiple countries (e.g., Europe).

capabilities in the supply and use of the new technology and/or have firms that focus on the relevant customers. Of course, even if the region does not have such incumbent firms, it may succeed through institutions that support the formation of new firms as long as there are low barriers to entry in the supply and/or use of the new technology. Silicon Valley is the best example of such a region (Kenney and von Burg, 2000; von Burg and Kenney, 2000; Cohen & Fields, 2000).

Whether the innovation overturns or does not overturn existing linkages, the social construction of technology (Bijker, 1987) suggests that other factors will also influence the ability of the region to identify and serve the initial applications. These include the region's demand characteristics (Rosenberg, 1982; Porter, 1990, Mowery and Rosenberg, 1998), the establishment of relevant standards, licenses, and regulations (David, 1986; Funk, 2001; Hughes, 1983; Shapiro and Varian, 1999), and the regions division of labor (BRIE, 2001; Tether, 2002) including the interactions between firms (Van de Ven and Garud, 1989)

Path dependency will play an important role in determining the above factors, including those related to incumbents, the formation of new firms, and the social construction of technology. Firms will develop capabilities and focus on customers in an evolutionary manner where local search and adaptation predominate (Holbrook et al, 2000). Similarly, demand characteristics and institutions that support the creation of new firms and standards, entry barriers, and other government policies will also be created in an evolutionary manner (Mowery and Rosenberg, 1996).

In any case, the region that first identifies and serves the most economical applications will be rewarded with first mover advantages (Klepper, 1996; Mowery and Rosenberg, 1996, Mueller, 1997) in that it will begin developing capabilities in the new technology. The extent of its advantage will depend on the similarities in standards (Funk, 2001), the degree of network effects, increasing returns (Arthur, 1989, Liebowitz, 2001) and irreversibility all of which have been found to play a strong role in network industries. As the industry grows, the existence of network effects will increase customer value while increasing returns will reduce supplier costs. On the other hand, firms in less successful regions may find it difficult to develop new capabilities or focus on different customers, which may radically slow regional growth particularly if there are no new entrants. Local search, incremental adaptation, and coordination problems may even lead to irreversibility thus preventing the industry from emerging until long after it has emerged in other regions (David, 1986; Oechssler, 1997).

2.2 Technological sub-trajectories and expansion of applications

Clark's (1985) model of design hierarchies and market concepts tells us something about how competition in the industry will evolve in the region that first identifies and serves the most economical applications. In his model, the logic of problem solving and the formation of concepts that underlie choice in the marketplace impose a hierarchical structure on the evolution of technology (Nelson & Winter, 1982). On the one hand, as alternative product forms compete at consecutively more detailed levels problem solving becomes more interdependent and incremental. These incremental improvements enhance and extend the underlying technology and thus reinforce the design at higher levels in the hierarchy; these reinforcements are often characterized in terms of a dominant design (Abernathy and Utterback, 1978). On the other hand, movements up the hierarchy are associated with departures from existing approaches and are sometimes called “dematuration” (Clark, 1985)[5].

The initial applications, which are determined through the interaction between design hierarchies and market concepts, cause sub-trajectories to emerge from the main trajectories and these sub-trajectories represent interactions between the design hierarchies. The relationship between main and sub-trajectories can be seen as a conceptual application of Leontief's (1986) input-output analysis, applied at a micro-level in the economy. Leontief's models represent an economy as a combination of industries where each industry uses goods and services to produce outputs. In the proposed model, the main trajectories represent inputs of ideas and concepts that are used to construct the new industry while the sub-trajectories represent outputs and measures of technical performance for the industry.

The relationship between main and sub-trajectories is also similar to the relationship between Sahal's (1985) concepts of generic and industry specific innovation avenues (Sahal, 1985). Sahal considered (presumably in the early 1980s) the evolution of microelectronics to be a generic innovation avenue while the proposed model defines specific types of microelectronics as either sub- or main trajectories. Specific types of microelectronics begin as sub-trajectories in strategic battles for the creation of standards and platform leadership and some of these sub-trajectories become main trajectories.

---

[5] It is likely that network products differ from the products that have been used to develop and test Clark's model (1985); the latter includes automobiles, semiconductors (Clark, 1985), insulin, and switching equipment (Durand, 1992). Network products comprise an open system of interdependent components and thus contain multiple design hierarchies. It is likely that the interactions *between* these hierarchies particularly at lower levels in each hierarchy can have a larger effect on the evolution of the industry than the distinction between movements up and down a single hierarchy.

For example, the interaction between one component of PC computer hardware (the microprocessor) and another of PC computer software (the operating system) caused the emergence of two significant sub-trajectories that became the focus of competition for platform leadership in the PC industry in the 1980s (Gawer & Cusumano, 2002). The victory of the Wintel standard has caused both operating system and microprocessor performance to become main technological trajectories in the information technology industry and their technological regimes include many types of electronic products (Freeman and Soete, 1997). In applications that have very different requirements from the PC, sub-trajectories are emerging that represent significantly different designs; one will be discussed shortly in the discussion of the mobile Internet.

The PC and other examples suggest that there will be synergistic effect between the sub-trajectories and the product or system's modularity. Many network innovations like the digital computer (Baldwin and Clark, 2000) only become network products as firms create modular designs where multiple firms can provide various components or modules in an open-system configuration. In some cases, the sub-trajectories define the performance of these modules while in other cases the addition of modules (Baldwin and Clark, 2000) causes the emergence of new sub-trajectories.

In most cases, technological evolution along these sub-trajectories will expand the application space and in turn influence the main technological trajectories. In the long run, the total application space for the technological regimes will be determined by both the technological trajectories and the ability of suppliers and users of the technology to adapt it to specific applications. This raises the possibility that a lagging region may catch up and pass the region where the industry originally emerged because of early maturation in the leading region.

3. The Mobile Internet

Mobile phone services were started in the US, Japan, Europe and other leading industrialized countries in the early 1980s and they all experienced similar growth patterns. Each country began with business users who were in their 30s and 40s and gradually expanded such that in countries with penetration rates greater than 60% most people between the ages of 15 and 65 own phones. As implied by the penetration rates shown in Table 1, mobile phones first diffused to young people in Scandinavia followed by Korea, the rest of Europe, Japan, and the US. The service providers in these countries began introducing mobile Internet service in 1999.

3.1 Initial Strategies

Japanese and Korean firms initially introduced different strategies than the US and European firms with respect to the mobile Internet. U.S. and European service providers initially focused on business users and thus complex business applications in the mobile Internet[6] while Japanese and Korean firms introduced consumer-based services. A key part of the consumer-based services was and still is micro-payment services where the service providers collect content charges from the users and pass about 90% of them onto the content providers. Micro-payment services are much more important for consumer-oriented services like entertainment and news than for business services like financial, travel, and shopping that use a transaction-based business model.

These different strategies partly reflect two historical differences and their effect on cognitive representations (Tripsas and Gavetti, 2000) and local search and adaptation

---

[6] For example, see (JP Morgan, 2000).

(Raff, 2000; Holbrook et al, 2000). First, First, unlike Europe and the US, Japan and Korea introduced national licenses and did not adopt GSM, the global standard for mobile phones. This caused roaming services, which are primarily used by business users, to emerge as a critical source of profitability in Europe and the US and not in Japan and Korea. Further, corporate users represent a much larger percent of users in the US and Europe than in Japan[7].

Second, Japanese and Korean service providers introduced much higher activation commissions than the US and European mobile phone service providers as early as 1994. These higher activation commissions enabled manufacturers to introduce much more expensive technologies into the Japanese (and in the Korean) than in the European and US phones for the same prices to the final customer. It also caused both the Japanese and Korean phone market to basically collapse into one rather inexpensive price segment, which emphasizes weight and size. On the other hand, the European and US phone markets contained multiple price segments where the manufacturers made their profits in the high-end phones, which were sold to business users[8].

Further, the standard setting bodies that were created to set standards for the mobile Internet in the US and Europe reinforced the emphasis on business users. The most important mobile Internet standard in the West is WAP or Wireless Application Protocol. Nokia, Motorola, and Ericsson created the WAP forum in June 1997 and by mid-1998 most of the world's leading phone manufacturers, service providers, and other mobile-related firms had joined the forum. Although the main purpose of the forum was to create the markup languages and key protocols needed to define contents and

---

[7] Interviews with Nokia, Deutsche Telecom, and others.
[8] For a more detailed discussion, see (Funk, 2001).

transmission methods, content development and business models also became important topics of discussion in these conferences.

These historical differences are part of but not the only reason why Japanese and Korean firms initially focused on consumer-based rather than business services. NTT DoCoMo, which the other Japanese and Korean service providers basically copied, created a separate organization and hired outsiders with Internet and consumer experience to create the i-mode service. In addition to the micro-payment service for its official sites, they also made Internet mail services and a method of accessing so-called unofficial sites with the input of a URL or bookmark (Matsunaga, 2000). Most incumbents that have succeeded in disruptive technologies like the mobile Internet[9] have created separate organizations (Christensen, 1997).

3.2. Interaction between design hierarchies and market concepts

The first key interaction between design hierarchies and market concepts was between young people and entertainment. The high mobility and ample free time of young people lead to their high use of the mobile Internet. Young people are major consumers of games and horoscopes and the downloading of ringing tones and screen savers is similar to their emphasis on personalizing clothing, hair, makeup, and handbags. It appears that fashion conscious young people who place a strong emphasis on personalizing their appearance are the biggest users of the mobile Internet in Japan.

Positive feedback played a strong role in the growth of i-mode. The success of

[9] The mobile Internet is a disruptive technology when compared to the PC Internet because it offers greater performance on some dimensions (portability) and lower performance on other dimensions (smaller screens, keyboards, and processing and memory capability). Further, at the current rate of improvement in processing speeds, mobile phones will have the same level as PCs in about 10 years.

entertainment contents in particular screen savers caused the number of entertainment content providers to rise from 9% of the total i-mode content providers to more than 50% by September 1999. And the increase in the number of these entertainment content providers naturally led to a rise in the number of i-mode subscribers, which caused more entertainment-related firms to apply to become i-mode content providers. Further, the increasing number of content providers and subscribers also caused the manufacturers to introduce phones with better ringing tone functions and color displays at the end of 1999 and early 2000.

The second and third interactions between design hierarchies and market concepts reflect user learning. The second interaction was between the popularity of mail, entertainment contents, and phones with internal cameras. This interaction is one more example of how digital technology is bringing down the production costs of contents if we define contents in a liberal manner. Mail can be considered an expression of creativity and mobile mail has spawned an entire sub-culture including the use of "thumbs" and icons that serve as abbreviations (Brooke, 2002). Users like to add screen savers, ringing tones, URLs (including ones for their own home pages), photos, and beginning in early 2002 5-second videos taken with an internal camera.

The third key interaction between products and user needs is between mail and portals. User learning drove a movement in traffic from official to unofficial sites in NTT DoCoMo's i-mode service. While the official sites are presented in menu form much like PC Internet portals, with unofficial sites the users physically input a URL or access the site through a saved bookmark or URL in a mail message, portal site, or search engine. The growth in traffic to unofficial sites was facilitated by the growth in mail since it was easy to include URLs in the mail messages. There was also a synergistic effect between the number of portals and search engines for unofficial sites and the traffic to the unofficial sites.

NTT DoCoMo's competitors, KDDI and J-Phone began to become part of this phenomenon in early 2000. The success of i-mode forced KDDI and J-Phone to solve many of the same problems such as lack of content and long connection times (Sigurdson, 2001) that were not solved by European and US firms. In fact, KDDI was also using WAP and like its Korean counterparts solved the problems associated with WAP that were not solved in Europe and the US. KDDI introduced WAP in April 1999 and three Korean operators introduced WAP at later dates in 1999. KDDI introduced packet services in December 1999 and micro-payment services in April 2000. J-Phone introduced its mobile Internet services including micro-payment services and a quasi-packet system in December 1999. The micro-payment and packet services solved the problems of content and long connection times respectively.

A major reason why KDDI and J-Phone solved these problems and the US and European service providers did not solve them is because the success of i-mode provided evidence that investments in mobile Internet technology could pay off. The success of entertainment contents and the positive feedback that these successful contents created between contents, users, and phones provided this evidence. Evidence of a successful mobile Internet did not emerge in the European and US markets because the service providers did not introduce micro-payment systems, which were a prerequisite for entertainment contents like screen savers, horoscopes, and ringing tones and instead focused on business contents like financial, travel, and shopping services that do not require micro-payment services.

Interestingly, SMS (short-message services) has done much better than WAP in

Europe, Asia, and most recently in the US. SMS is basically a form of proprietary mail, which became popular in the late 1990s, about the time that mobile phones had become popular with young people. Further, Further, the SMS services accidentally contained an easy way to do revenue sharing between service and content providers. This has caused a number of third parties to offer specialized SMS services that include discount coupons, surveys, ringing tones, and screen savers some of which are integrated with other media like television programs. The success of these SMS services has caused positive feedback to emerge between services, phones, and contents; these firms are now implementing multiple media message services or MMS[10]. Unfortunately, SMS is very limited technology when compared to the mobile Internet and European and US service providers may not introduce mobile Internet services for fear of cannibalizing their SMS revenues.

3. 3 The emergence of sub-trajectories and more sophisticated applications

Growth in the initial applications discussed in the last section has caused sub-trajectories, where competition in the Japanese market currently takes place, to emerge from the main trajectories of phones, networks, contents, and software (See Table 2). Some of these sub-trajectories will quickly fizzle out as customer needs are quickly satisfied.

For example, although it is possible to download ringing tones that have more than 40 polyphonic tones, most industry people believe that further increases add little value and competition in these contents is changing to voice- and vocal-based ringing tones where network speeds are a more relevant trajectory. Similarly, although some phones

---

[10] For example, Vodafone started Vodafone Live in late 2002.

can display more than 250,000 different colors, it is likely that this number will not increase much in the future. Further, although camera phones now contain more than 300,000 pixels, two million pixels will provide quality that is equivalent to what is found in traditional photographs and enable camera phones to read and process finely printed URLs, mail addresses, and bar codes.

However, other sub-trajectories will represent key areas of competition in the mobile Internet for years to come. These sub-trajectories will increase the number of applications for the mobile Internet (see Table 3) and at some point in the far-off future probably cause the mobile Internet to represent a larger market than the PC Internet. For example, the display size of Japanese phones had reached 2.2 inches (diagonal) and is increasing by about 5% a year. This trend is expected to continue and perhaps accelerate as new displays that are as thin as paper and can be rolled and folded are introduced.

More immediate effects are expected from increases in processing power, memory, and network speeds particularly because they will enable greater client side processing. The client-side processing that is currently having the largest impact on the Japanese and Korean mobile Internet is Java. Programming languages like Java enable users to download a program or Java applet once and then to either utilize the program independently of the network (e.g., with games) or utilize the program in conjunction with data that is subsequently downloaded from the network. Alternatively, the Java program could be pre-loaded in the phone thus eliminating the need for downloading the program at all.

The use of Java can reduce downloading time and costs, improve the user interface, and reduce content development costs. Downloading times and costs can be reduced by either pre-loading the program in the phone or by users downloading it once. In the case of downloading a program, it becomes economical to do so when the user plans to download an equivalent amount of data to do the same task. Although games were initially the most popular content for Java programs, it is expected that most Japanese entertainment contents and most contents in general will be written in Java or a similar programming language by the end of 2003 and 2005 respectively.

3.4 Processing speed, memory and network speeds

The major limitation for Java and similar programming languages are the processing and memory capabilities of phones and network speeds. The processors and memory chips are very different from those used in PCs due to greater restrictions on power consumption in mobile phones. Limited performance in these areas meant that the first Java phones (released in January 2001) could only download a Java program (called a Java applet) of up to 10 kilobytes and save between five and thirty of these full size i-applets depending on the manufacturer. Since then manufacturers have released phones that can download and process larger i-applets by increasing phone performance.

The increased processing and memory capabilities reflect Moore's Law. Every year microprocessors become faster and memory sizes become larger. And this will continue to occur. For example, the microprocessors in phones released in 2002 have clock speeds of about 50 MHz as opposed to clock speeds in PDAs and PCs of 400 MHz and 2.2 GHz respectively. It is expected that these speeds will continue to double every 18 months just as PC speeds have done for many years (See Figure 2).

Memory is currently an even larger bottleneck than processing speed for a movement of all contents to Java. Even if only 10% of the more than 3000 sites on the official NTT DoCoMo decided to offer their contents in Java as opposed to c-HTML, users would still only be able to download a small percentage of these programs. This issue along with the desire to save ringing tones, photos, and videos is causing phone manufacturers to offer external memory (e.g., Sony's memory stick) in much the same way that PC manufacturers did this in the form of smaller hard disks in the early 1980s. Another way to overcome these memory limitations is for content providers to use a specific set of standard Java programs.

It is also possible that new forms of user interfaces that make up for the small display and keyboards of mobile phones will emerge. Single word voice recognition systems have been available for several years and it appears that user resistance to making voice commands is a bigger bottleneck than actual technical problems. This suggests that much more interesting interfaces will emerge such as holograms and full voice recognition as processing speeds increase and outstrip the needs of Java and other needs.

Faster network speeds are also necessary to download larger i-applis along with higher resolution photos, vocal ringing tones (i.e., music), video, and other applications. 3G services, which have been introduced in Japan and are being introduced all over the world, are expected to have the capability to download between 384 and two megabits per second. Further, some firms, for example, Qualcomm, expect data charges to fall as low as $0.022 per megabyte. If data charges were to fall as low as $0.022 per megabyte, a three-minute MP3 file could be delivered for as little as $0.07 and a two-minute, medium resolution video clip could be delivered for a cost of about $0.13. In comparison, NTT DoCoMo's i-mode service currently charges almost $20 per megabyte of data or 1000 times the future cost projected by Qualcomm (Qualcomm, 2002).

We can also expect other forms of networks to play an important role in the mobile Internet. For example, it is possible to download data from WLANs and exchange data between devices with Bluetooth and various infrared technologies. Higher processing speeds in phones will be needed to work with these networks. Phones with infrared functions are already being used in Japan to connect phones with cash registers and control televisions and karaoke machines. Many Japanese firms are also implementing systems that utilize various forms of infrared technologies so that phones can be used as point cards, tickets, and money.

4. Discussion

This paper presents a model of new industry formation. It represents the origins of new network industries as the interaction between multiple technological trajectories that are specific to a particular technology or broadly defined technological regime. The initial applications emerge through interactions between design hierarchies and market concepts where the social construction of technology takes place. Growth in the initial applications causes sub-trajectories or regimes, where competition in the market initially occurs, to emerge from the main trajectories.

This model enables us to more fully open the “black box” of technology development[11] and address a number of economic and managerial questions that cannot be addressed with existing models like the product life cycle model. One set of relevant questions is: 1) Why did industry A evolve faster than industry B; and 2) Why did industry A start first in region C while industry B started in industry D? We can address

[11] I am borrowing the term from (Rosenberg, 1982)

these questions by analyzing the relevant trajectories and determining both the rates and reasons for the rates at which initial applications emerged and grew in various regions and industries. While it is possible that macro-economic factors influence the main technological trajectories, it is very likely that the effective integration of them to form new industries is a function of factors that are stressed in evolutionary theories of economics and the social construction of technology.

This paper uses the mobile Internet to demonstrate the role of the main technological trajectories, initial applications, and sub-trajectories. The initial applications caused sub-trajectories like color resolution, camera resolution, Java, and processor speeds to emerge. These trajectories are now expanding the number and sophistication of the applications and provide additional stimulus to these sub-trajectories.

This model can also be used to address managerial questions about growth and competition in various industry segments. For example, 1) Why did certain divisions of labor emerge in industry A and not in industry B; 2) How fast will the market for a certain sub-trajectory grow given a certain rate of improvement; and 3) Why did certain firms win in these industry segments? We can address these issues by analyzing the technological sub-trajectories, the emergence of modularity, the relationships between the sub-trajectories and modularity, and the institutional factors surrounding the sub-trajectories and modularity. For example, the sub-trajectories can be used to analyze platform strategies. In the case of the mobile Internet it appears that the evolution of Java may determine the platform winners in the mobile Internet, an outcome that is very different from the conventional wisdom.

Future research should also attempt to mathematically simulate industry formation.

It should be relatively easy to represent the main and sub-trajectories in a simulation model. The identification and serving of the initial application is more problematic but recent models of disruptive technologies may provide sufficient analytical capability (Adner, 2002). These models can be used to simulate and perhaps even predict the growth of a new industry where the application space could be modeled as a function of the main and sub-trajectories. We can represent the evolution of incumbent capabilities, the formation of new firms, and other institutional responses by a chain of discrete Markov processes where the probability function in one state is a function of past states (David, 2001). Such a model would enable us to further open the "black box" of technology development and address a much more detailed set of questions about past, existing and even future industries.

5. References

Abernathy, W. & J. Utterback (1978), "Patterns of Innovation in Technology, Technology Review 80 (July) 40-47.

Abernathy, W. and K. Clark (1985), "Innovation: Mapping the Winds of Creative Destruction," Research Policy, 14, p. 3-22.

Adner, R. (2002). "When Are Technologies Disruptive? A Demand-Based View of the Emergence of Competition," Strategic Management Journal, Vol. 23, No. 8., pp. 667-688.

Arrow KJ (1974). The Limits of Organization, NY: Norton.

Arthur, B (1989). Increasing Returns and Path Dependence in the Economy, Ann Arbor: University of Michigan Press, 1994.

Baldwin, C. and K. Clark (2000). Design Rules, Boston: MIT press.

Bijker, W., T. Hughes, and T. Pinch (Ed) (1987): The Social Construction of Technological Systems, MIT Press.

BRIE (2001). Tracking a Transformation: E-Commerce and the Terms of Competition in Industries: the BRIE-IGCC E-Conomy Project, Washington DC: Brookings.

Brooke, J. (2002). New York Times, "Youth Let Their Thumbs Do the Talking in Japan, " April 30, 2002, p. 14.

Christensen, C. (1997), The Innovator's Dilemma, Boston: Harvard Business School Press.

Clark, K. (1985), "The Interaction of Design Hierarchies and market Concepts in Technological Evolution," Research Policy (14), 235-251.

Cohen, S. and G. Fields (2000), "Social Capital and Capital Gains: An Examination of Social Capital in Silicon Valley," in Understanding Silicon Valley: The Anatomy of an Entrepreneurial Region, Kenney, M. (ed).

Credit Suisse First Boston (CSFB, 2002), "European Wireless Telecommunication Services," October 4, 2002.

CTIA (2002), Roaming Service Revenues, Cellular Telephone Industry Association, http://www.wow-com.com/industry/stats/surveys/

David, P. (2001). "Path dependence, its critics, and the quest for "historical economics," in Evolution and Path Dependence in Economic Ideas: Past and Present, P. Garrouste and S. Ioannides (Editors).

David, P. (1986). "Historical Economics in the Long Run: Some Implications of Path-Dependence." In Historical Analysis in Economics, G. D. Snooks (ed), London: Routledge.

Dosi, G., (1982). "A suggested interpretation of the determinants and directions of technical change," Research Policy 11, pp. 147-162.

Freeman, C. and L. Soete (1997). The Economics of Industrial Innovation, MIT Press, 1997.

Frenken, K., P. Saviotti, and M. Trommetter (1999). "Variety and niche creation in aircraft, helicopters, motorcycles and microcomputers," Research policy 28, pp. 469-488.

Funk, J. (2001). Global Competition Between and Within Standards: the case of mobile phones, London: Palgrave.

Gawer, A. and M. Cusumano (2002). Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation, Boston: Harvard Business School Press.

Henderson, R. and K. Clark (1990). "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms," Administrative Science Quarterly, 35 (1990), pp. 9-30.

Holbrook, D., W. Cohen, D. Hounshell, and S. Klepper (2000), "The nature, sources, and consequences of firm differences in the early history of the semiconductor industry, Strategic Management Journal, Vol 21, pp. 1017-1041.

Hughes, T., (1983). Networks of Power, Baltimore: John Hopkins

Kenney M. and U. von Burg (Institutions and Economies: Creating Silicon Valley, in Understanding Silicon Valley: The Anatomy of an Entrepreneurial Region, Kenney, M. (ed), Stanford University Press, 2000.

Klepper, S. (1996). "Entry, exit, growth, and innovation over the product life cycle," American Economic Review, vol. 86, no. 3.

Klepper, S. and K. Simons (2000). "Dominance by birthright: entry of prior radio producers and competitive ramifications in the US television receiver industry," Strategic Management Journal, 21:997-1016.

Leontief, W. (1986). Input-Output Economics, Oxford University Press.

Liebowitz, S. (2002), Re-Thinking the Network Economy: The Ture Forces that Drive the Digtial Marketplace, Amacom.

Lohr, Steve (2002). "Technology Climate Is Gloomy, but Its Future Still Seems Bright," NY Times, July 29, 2002. http://www.nytimes.com/2002/07/29/technology/29POKE.html)

Lynn, L., N. Reddy, and J. Aram (1997). "Linking technology and institutions: The innovation communities," J. Eng. Technol. Manage. Vol. 14, pp. 129-145.

Matsunaga, Mari (2000). I-mo-do jiken (The i-mode Event), Tokyo: Kadokawa Shoten.

Mobile Communication International (2000 –2002), London: Informa Telecoms and Technology Group.

Mowery, David and Nathan Rosenberg (1998), Paths of Innovation, NY: Cambridge University Press.

Mueller, D. (1997). "First-mover advantages and path dependence, International Journal of Industrial Organization, Volume 15, Issue 6, Pages 827-850.

Nelson, Richard (1996). The sources of economic growth, Cambridge Mass.: Harvard University Press.

Nelson, R, Winter S (1982). An Evolutionary Theory of the Firm, Cambridge, MA: Harvard University Press.

Oechssler, J. (1997). "Decentralization and the coordination problem," Journal of Economic Behavior and Organization, Vol. 32, pp. 119 – 135.

Porter, M. (1990). The Competitive Advantage of Nations, NY: Free Press.

Qualcomm (2000), "The Economics of Mobile Wireless Data," http://www.qualcomm.com/about/downloads.html

Raff, D. (2000), "Superstores and the evolution of firm capabilities in American bookselling," Strategic Management Journal, Vol. 21, pp. 1043-1059.

Rosenberg, Nathan (1982), Inside the black box: Technology and Economics, NY: Cambridge University Press.

Rosenberg, Nathan (1994), Exploring the black box, NY: Cambridge University Press.

Sahal, D., (1985). "Technological guideposts and innovation avenues," Research Policy, 14, pp. 61-82.

Schumpeter, J. (1942). Capitalism, Socialism, and Democracy, NY: Harper & Row.

Shapiro, C. and H. Varian (1999), Information Rules, Harvard Business School Press.

Sigurdson, J. (2001). "WAP OFF – Origin, Failure, and Future," Prepared for the Japanese-European Technology Studies, The University of Edinborough.

Tether, B. (2002). "Who co-operates for innovation, and why. An empirical analysis," Research Policy 31, pp. 947-967.

Tripsas, M. and G. Gavetti (2000), "Capabilities, Cognition, and Inertia: Evidence from Digital Imaging, Strategic Management Journal, Vol. 21, pp. 1147 – 1161.

Tushman, M. & P. Anderson (1986), "Technological Discontinuities and Organizational Environment," Administrative Science Quarterly, vol. 31, 439-456.

USIC (2000). "State of the Internet 2000," United States Internet Council & ITTA Inc., http//usic.wslogic.com/intro.html

Van den Ende and R. Kemp (1999). "Technological transformations in history: how the computer regime grew out of existing computing regimes," Research Policy 28, 833-851.

Van de Ven, A. and R. Garud (1989). "A framework for understanding the emergence of new industries," Research on Technological Innovation, Management and Policy, vol. 4, pages 195-225.

Von Burg, U. and M. Kenney, "Venture capital and the birth of the local area networking industry," Research Policy, pp. 1135 – 1155.

Von Hippel, E. (1988): The sources of innovation, Oxford University Press.

Windrum, P. and C. Birchenhall (1998). "Is product life cycle theory a special case? Dominant designs and the emergence of market niches through co-evolutionary-learning," Sructural Cange and Economic Dynamics 9, pp. 109-134.

Figure 1. The Origins of New Industries

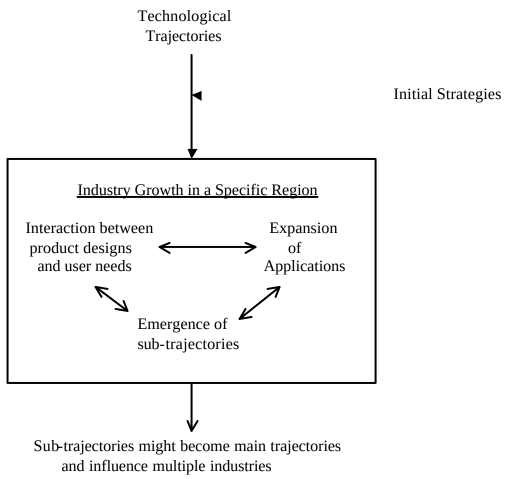
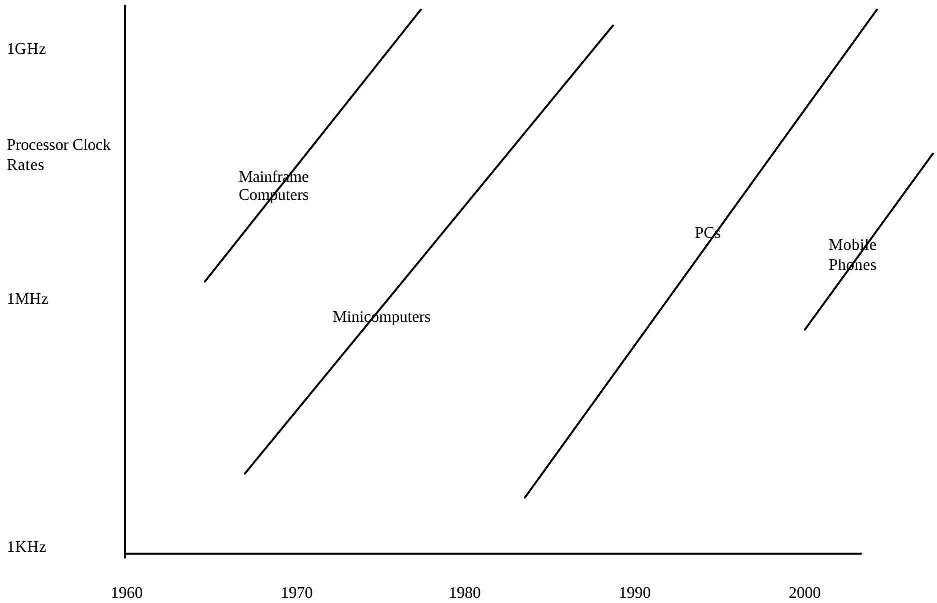


Figure 2. Four Generations of Computing Capabilities



Source: Manufacturers and author's analysis

Table 1. Selected Data About Mobile Phone Markets

Item		Japan	Korea	Scandinavia	U.S	Europe
Phone Penetration	1999	38%	50%	55%	29%	39%
	2001	53%	68%	76%	44%	79%
Digital Standard		PDC	Cdma One	GSM	CdmaOne, TDMA, GSM	GSM
Roaming Revenues		0%	0%	10%	11.4%	10%
Corporate Users		10%		30% - 40%		
Phone Subsidies		$250 - $350	$250 - $350	$70 - $160		$70 - $380
PC Internet Penetration (1999)		21%	27%	41%	42%	19%

Mobile phone penetration from (Mobile Communication International, 2000 -2002), roaming revenues from (CTIA, 2002; CSFB, 2002) and author's interviews, subsidies from interviews and (CSFB, 2002), and Internet penetration from (USIC, 2000).

Table 2. Sub-Trajectories and Their Effect on Applications

Sub-Trajectory	Current Level of Popular	Approximate Rate of Improvement	Examples of Short-Term Effect on Applications

	Phones		
Ringing tones	40 tones	Current level may be sufficient	Better ringing tones
Color resolution	250,000 colors	Current level may be sufficient	Better user interface
Camera resolution	300,000 pixels	May reach a sufficient level of two million by 2004	Shopping services in combination with magazines by reading URLs, etc.
Display size	2.2 inches (on the diagonal)	5% a year increase	Better user interface
Processing speeds	50 MHz	Doubles every 18 months	Larger i-applis and thus better user interface. Better infrared linkages with other devices. Faster GPS and thus better location-based services
Memory	1 MB internal 8 MB external for some phones	Doubles every 18 months. External memory standard on phones by 2004	Save more i-applis, photos, ringing tones, etc.
Network Speeds	384 kbps for some phones	>50% of phone with capability by the end of 2005	Faster and cheaper downloading of existing content plus i-applis, music, and video

Source: Manufacturers and authors analysis