PRELIMINARY THOUGHTS ON THE RELATIONSHIP BETWEEN KNOWLEDGE CREATION AND OBSOLESCENCE IN AN INFORMATION-BASED ECONOMY

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1 ABSTRACT

The new electronics technologies are propelling a transformation in value creation from being based on physical work to being based on knowledge. While the economy thus created is based on innovation, its corollary is an acceleration in obsolescence. Some products such as personal computers are now on a three-month product cycle, demonstrating that even as value is being created more quickly, it also being destroyed more quickly. In the case of software, the quintessential product of the Information Economy, obsolescence is also extremely rapid. Information and knowledge creation have already become the central pivot in capitalist economies and this is like to continue and even become more prevalent. Current descriptions of the economy emphasis its roots in information and/or knowledge, to this we might add that the economy is obsolescence-based.

2 INTRODUCTION

Two significant tendencies are apparent in the contemporary economy. The first tendency is a shortening of product development cycles

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The author thanks Charles Edquist, Kristian Kreiner, and the participants of seminars at the Copenhagen Business School and Linkoping University for helpful comments; also James Curry, Raghu Garud, W. Richard Goe, Jack Kloppenburg, Nicos Mouratides, and Urs von Burg for their comments. The author thanks the Alfred P. Sloan Foundation and the Matsushita International Foundation for research funding.

and an accelerated introduction of new products. The second, and obviously related, tendency is the rapidity of product obsolescence. At the heart of these two tendencies is the growing centrality of knowledge-creation and innovation in the value-creation process. Increasingly, products are laden with knowledge and design resulting from the exercise of human creativity. The value assigned to purely physical components and inputs is dropping, while the value generated by human knowledge and creativity is increasing. These developments are most clearly manifested in the electronics-related industries, such as personal computers, software, and data communications, but are not confined to these traditional high-technology sectors. The growing importance of knowledge, design, and creativity is apparent in nearly every industry and bringing a related acceleration of obsolescence, especially as the digitalization of formerly analog activities takes place.

Obsolescence is fundamental to capitalism and has always plagued firms competing for business, but recently an important fundamental shift in the pace of obsolescence has occurred. An overriding fact of the contemporary economy is that the value and even usability of many commodities has become increasingly transient. A fundamental root cause of this dramatic speeding in product change has been the introduction of electronics and especially semiconductors. For example, a seemingly endless stream of new personal computers, cellular phones, and other electronics items is being introduced. Each new introduction seems to have greater functionality for roughly the equivalent price of its predecessor, but concomitantly the value of previous models drops dramatically.

This essay points out the relationship between the acceleration of knowledge-creation and the increasing rapidity of obsolescence. The first section lays out the conceptual premises of the argument. The second section examines the producer's goods industry because of its central role in manufacturing. Until recently, producer's goods such as factory automation were considered "durable" goods; however, more recently, they also have been swept up into the cycle of rapid obsolescence. The third section describes the dynamics of obsolescence in the personal computer (PC) industry. The PC is a particularly interesting product because it is a modular system and different parts of the module are subject to different rates of change. The fourth section examines what can be considered the quintessential knowledge creation industry, computer software. In software, product physicality is rendered almost nil, while the knowledge component is nearly total. Thus, even though software is essentially indestructible, rapid change is the norm. The fifth section speculates on the applicability of the knowledge-obsolescence linkage to the transmutation of computer networks into the Internet. The concluding discussion recapitulates the points made earlier and discusses some implications.

3 KNOWLEDGE CREATION AND OBSOLESCENCE

The importance of knowledge creation in what many have termed the "Information Age" is explicitly stated by many scholars (Fransman, 1994; Nonaka, Takeuchi, 1995; Leonard-Barton 1995). Admittedly, information and knowledge are difficult to define, but it is necessary to adopt at least a provisional definition. Here, I accept Fransman (1994, p. 716-717)

> *"Information... refers to states of the world and state-contingent consequences. Information refers inherently to a closed set of data. However, knowledge is essentially open-ended. Knowledge is always in a process of becoming, extending beyond itself."*

So, for example, Zuboff (1988) points out today's automated machinery creates information constantly, yet it is the work of human beings to transform this into knowledge. Or, put more properly, only human beings can transform information into knowledge. Without human intervention, information per se has no value[2].

Commodity production is dependent upon both intellectual components and physical components. The relative balance between the physical value-added and the mental value-added is shifting inexorably toward the mental side, based on the creation of new knowledge. Innovations come in a variety of forms: the conscious management of continuous improvements on the factory floor, as pioneered by Japanese industry, or the development of a new model of an existing product (Kenney, Florida, 1993; Fruin 1996). More powerfully, new knowledge can bring about the development of an entirely new product category such as the Chrysler Minivan. But, perhaps, the most powerful new knowledge is expressed in creative **ideas** such as new methods of organizing entire sectors of production or even industries. An example would be the changes in distribution implemented by Walmart. Finally, the most powerful, Schumpeterian innovations can create entirely new fields for value creation – such as the process now occurring with the Internet. Each of these sets of actions depends on human beings taking new ideas or knowledge to the marketplace, where they may make previous products, processes, or organizations (or a combination of these) obsolete.

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2 This is analogous to oil that has no value if it cannot be pumped out and transformed into something useful.

A product's value and its pace of technical change are increasingly dictated by the knowledge embedded within the product[3]. For example, the old-fashioned broom is certainly the result of human knowledge and creativity; yet there is little change or innovation in the broom industry, because little new knowledge is embodied in it. When one purchases a broom, the main costs in the product (not including distribution and retail markup) are its physical components and the very routine production labor needed to assemble them. Likely, the broom purchased today will, if unused, have nearly the same value in the year 2000. The case of the broom can be thus summarized: little knowledge input, little profitability, and little obsolescence.

Semiconductors are a stark contrast[4]. Semiconductors sold today will, by the year 2000, have lost more than 50 percent of their value. Some will no longer be available, having been replaced by improved products with greater functionality. The value of the knowledge embedded in those semiconductors will have disappeared (even if they have never been used). Interestingly, while if used the broom relatively quickly wears out, semiconductors or software can be used repeatedly with almost no wear, that is, they are very resistant to physical degradation. And yet, because of the speed of new product development, semiconductors are transient, here today and gone tomorrow (for an excellent discussion of this see Hutcheson, Hutcheson 1996). In contrast to brooms, the semiconductor soon becomes worthless, even though it still works.

With knowledge in its various manifestations as the increasing arbiter of value, innovation (*i.e.*, new knowledge creation) has become the key to success in the global marketplace (Nonaka, Takeuchi, 1995). Emphasis on innovation means that product life-development cycles are decreasing in length[5]. Businesses have little choice but to innovate or risk being outflanked. Hewlett Packard (HP) has responded to this increased pressure by acceler-

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3 Arthur (1996) uses the word "congealed", instead of embodied or embedded. It is curious to note that Marx used the same word "congealed" when he talked about the value present in a product.

4 According to an article in **Electronic News** (1996, p. 1), *"The life span of an IC made by a big player is short. There's only about 18 months to four years while a firm like Motorola ramps up production, places a circuit in a system and manufactures the circuit at volumes high enough to keep it profitable"*.

5 In a provocative article, Bayus (1994) argues that product life-cycles are not getting shorter, rather the increased speed may be due to increasing rapidity of product development cycles and thus the release of more products into the marketplace. So, what appears to be shorter product cycles may not be correct, that is, a product "lives" as long, but is relegated to lower price markets etc. Thus, the life cycles are roughly the same.

ating product cycles. The President of HP observed that during the 1980s, 70 percent of HP's orders came from products less than three years old, but in the 1990s *"that changed to be products less than two years old. The lifetime of a product simply [is getting] shorter and shorter"* (Platt, 1993). For each company initial competitive success provides only an advantaged position from which to reenter the competition.

The distinction between a commodity's physicality and its embedded knowledge is, of course, artificial, for these are but two perspectives on a commodity's fundamental unity. Even the most disembodied product, computer software, to be transmitted and used requires the physical flow of electrons, magnetic impulses or photons of light on a CD-ROM. Thus, though the software's physicality is minimal, it still exists – for human knowledge and creativity must be transmitted and actualized in the physical world or, put differently, embodied in a medium.

Today's rapidity of change, based on the centrality of knowledge and creativity, has led Drucker (1993) to argue that we are entering a postcapitalist society. There can be little doubt that aspects of these changes pose fundamental problems for capitalist economies and firms, including the difficulty of earning sufficient returns on invested capital before it depreciates entirely and problems of enforcing private property rights in easily copiable intellectual property. However, it seems unlikely that these are insurmountable problems for capitalism – we are merely entering a new phase.

4 PRODUCER GOODS

Producers' goods are often highly complicated and expensive machines. Traditionally, these machines had quite long life expectancies and were considered durable assets. The knowledge of how to create value with these machines was located in the machinists who operated the machines and in their physical configuration. Thirty years ago, these machines were freestanding and used little or no electronics. Change was rather slow and confined to better tools and other gradual improvements. Clearly, the knowledge embedded in the machines was increasing, but at a rather slow rate. This pace began to change as semiconductors were applied to machines in the 1970s (for a discussion of this process, see Noble, 1984).

It was the linkage of electronics with machinery that transformed the economics of owning manufacturing machines. Suppliers are now improving the electronics portion (the brains) of machines so rapidly that newer models are significantly more productive than previous ones. For example, John McDermott, vice president of Rockwell Automation's Standard

Drive Business, has described the changes in the industrial motor starter business, which until the recent application of semiconductors had changed only very slowly for nearly 100 years:

> *As the technology changes faster, the life cycle of our products drops... Both features and cost are impacted so greatly by technology that if you don't have a new product within four years, you're not competitive... If you have a three-year development window and four-year product life cycle, you're in tough shape* (Bassack, 1996, p. 30).

The point is that many even quite mundane businesses are now gripped by accelerating change.

Machining is becoming an extension of the electronics and software industry with its exceedingly rapid rate of change (Yamazaki, 1994). The machining center is a large piece of machinery containing many components and materials, all of which are embodiments of human knowledge. For example, there are extremely sophisticated bearings capable of preventing the cutting tool from slowing down from 15,000 rpm when it goes from air to cutting metal (Lee, 1996). However, the key to the acceleration of change in the machining industry has been the application of electronics to machine tools or what the Japanese call **mechatronics.** Integrated circuitry and software are becoming ever more significant value-added components for machine tools. For example, at Mori Seiki, one of the largest machine tool builders in the world, the value of the software and electronics in the machines has increased from 20 percent of the total value to a current 30 percent (Mori, 1996).

The ability to process more information allows the use of more sensors to gather data, which in turn permits the operation of the machine at higher speeds. And, curiously, at higher speeds tools are more efficient and accurate. The important point here is that the software and the computer controller are the most knowledge-intensive components (but, emphatically not the only components that have significant amounts of embodied knowledge) of the machine tool. It is thus quite natural for the software and computer controller to be the components that become obsolete most rapidly.

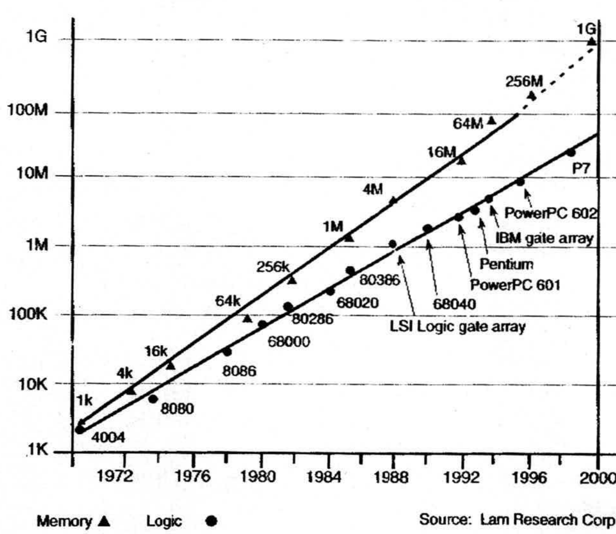
The acceleration of changes means that these machines, costing $250,000 or more, have moved from being capital assets to being only tools rapidly becoming obsolete (Yamazaki, 1995). The typical machine tool produced by Mori Seiki and used by Toyota is replaced every ten years by a new machine of comparable cost that can replace two or three machines of the previous generation. This is a change for a traditional industry such as machine tools. Today, at Mori Seiki 50 percent of its sales comes from products less than two years old and 80 percent from products less than five years old (Mori, 1996). And, of course, the old machine is sold in the secondhand market for a 10 percent of its original cost.

Rapid change is not confined to traditional machining industries. It has become pervasive throughout business. For example, a similar automation trajectory is underway in printed circuit board (PCB) component insertion (Mody *et al.*, 1995). Component insertion machines have been developed that reduce the role of human insertion. The new insertion machines are so fast that the actual robotic inserter is merely a blur as it inserts components fed to it from a tape reel. Yet, the rapidity of improvement in insertion machines and the shrinking size of the components means that the machines quickly become obsolete and lose value (Kawai, 1992).

The producers' goods sector with the most serious obsolescence problem is semiconductor equipment. Here, for the current generation of microprocessors or DRAMs, the capital investment for a new fully-outfitted fabrication facility is approximately $1 billion, and the factory will be largely obsolete in four years (though it does have residual value for producing less sophisticated and hence less profitable products). Because semiconductors are evolving so quickly (see Figure 1), a new generation of equipment is already far into development when the current generation is introduced.

Figure 1

NUMBER OF TRANSISTORS PER CHIP



Obsolescence of production equipment is becoming an ever greater cost to business. Profits must be made quickly before the equipment in the factory has lost its value, in the current environment of "speed-based" competition. The introduction of electronics has made machines more productive, but simultaneously, due to accelerating technological change, productive life of machinery is decreasing. Factories are under extraordinary pressure to operate constantly, because physical depreciation no longer bears any relationship to obsolescence. Whereas previously there was a link between the two, now that linkage is broken. Intensifying competition forces all companies to accelerate the introduction of new capital equipment.

Rapid product obsolescence also creates new managerial dilemmas. For example, dies and molds are crucial tools for making plastic and metal parts. Currently, a well-made die or mold can be used for a million, ten million, or even one hundred million strokes or shots. However, shortened product life-cycles mean that some production runs have become as short as 100,000 strokes or shots. When the run is completed, the dies and molds are scrap – the knowledge embedded in them no longer has any value. They cannot be adjusted for use in the new model nor are they likely to be sold to another manufacturer.

Short production runs also pose a dilemma for manufacturing engineers. To keep costs under control, they must use lower-cost dies and molds so that they can bring the per unit cost down. The difficulty is purchasing dies and molds that produce the same level of quality while used, but have a shorter production life. While it is relatively easy to build them out of shoddier materials and with less care, this decreases quality, which is unacceptable. These managerial dilemmas impel manufacturers to pose questions about what quality means to the customer, to increase value engineering, and to search for innovative solutions.

As a result of increasingly rapid innovation, contemporary manufacturing must plan for obsolescence. Historically, industrial equipment became obsolete in a matter of decades; now the rapidity of change, especially in electronics, can affect even newly delivered capital goods, which often are nearly obsolete when they are delivered. Previously such rapid change applied only to consumer items like fashion goods, but many producer goods are now affected.

The integration of electronics into production machinery has accelerated technological change, while decreasing a machine's productive life. In effect, even for the rather traditional industries such as machine tools, time has become one of the central facts of the competitive environment. This goes far beyond the traditional advertising slogans, "new and improved", that was simply repackaging the old product in a new brighter package. This environment is placing pressure on managers to operate factories continuously, the cost of idle factories has become even more crushing.

5 PERSONAL COMPUTERS

Innovations in electronics are incessant and viewed over time are dramatic. For example, in Winchester hard disk drives the areal density of information storage is increasing at 50 percent per year. Six years ago 40-megabyte hard drives were standard; now, 540-megabyte hard drives are considered small. Semiconductor memory capacity doubles even more rapidly, every eighteen months. However, prices per chip or disk drive remain roughly constant. Thus, price per bit of information is decreasing exponentially, and consumers can purchase ever more powerful information systems at a roughly constant price.

But not all parts of PC are experiencing such rapid evolution. For example, monitors are evolving, but much more slowly, even though new programs such as Windows 95, 3-D graphics, desktop publishing, and CAD-CAM applications are driving a move to larger monitors. Still, the monitor industry is evolving more slowly. This slower evolution is directly related to its physical aspects and its connection to the physical needs of users as an interface device.

The PC industry is the quintessential example of the acceleration of innovation coupled with rapid price declines. The PC is becoming a perishable item. This phenomenon has compelled final assemblers to move closer to their customers, because the value of key components, especially the microprocessors, DRAMs and disk drives, declines so rapidly that long transit periods can dramatically undermine profitability through the devaluation of the various components. To cope, computer assemblers are reorganizing their global production networks to maximize proximity to customers.

Three factors have interacted to complicate calculations regarding where to assemble personal computers. The first factor is the rapidity with which microprocessors and other key components lose value, thus encouraging companies to assemble PCS close to the final customer. The second factor is the increasing automation of processes such as printed circuit board assembly; inexpensive labor costs are not as important, because capital investment has become an ever greater part of total costs. The third factor is the ever-increasing volatility of the market. Response times must be shortened. A mistaken purchasing decision can result in multimillion dollar losses in a rapidly depreciating inventory.

The rapidity of price declines in computers has created a situation in which personal computer producers often cannot assemble and sell the systems before some components decrease in value. Five years ago, personal computer motherboards were often assembled in then low-wage Asian countries such as Taiwan. The completed boards were shipped to the U.S. Recently, because MPUs decline in cost so rapidly, companies altered their production. They still assemble the motherboard in Asia which consists of more slowly evolving components, but now they insert the MPU in the U.S. just before shipment to the customer. Even, more recently, because of increasing automation, the obsolescence of even more traditional components, and the rapidly changing marketplace, some firms are beginning to build the entire motherboard in the U.S. The reason is that the evolution of other components such as BIOS chips, graphics chips etc. is also quickening. In the two to three weeks it takes to ship the a completed PC to the U.S. from Asia the MPU and the hard disk drive may already have lost 5 percent of its value. As a result it is less expensive to do assembly closer to the customer[6].

For integrated circuitry the major component in its value is its design, not the physicality of the chip. This is not to say, that chip production is merely a repetitive activity generating little value. Much value can be created in production, because the "software" must be rendered into the physical material – a process that requires enormous ingenuity, knowledge, and skill. But, the key value-adding activity in semiconductor production is located in two places: chip design and in the semiconductor equipment. The product life-cycle for semiconductor design software is now six months. After six months the software may be completely without value, the workstations on which the software is run only slightly less transient, having two-year life expectancies.

The knowledge base for making integrated circuitry includes making and controlling explicitly physical materials at the atomic level. This means, once again, sophisticated production equipment with enormous amounts of human design skill embedded in it. This equipment is also increasingly software-intensive, as the equipment becomes more automated and removed from the shopfloor worker. There is a constant pressure to introduce equipment capable of operating more precisely at higher speeds, and this requires less human involvement.

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6 It is interesting to note that four to six weeks it takes to deliver a computer ordered from a mail order firm such as Dell or Northstar provides them with a significant competitive advantage because of the decrease in cost of components between the time it was ordered and when it is delivered.

Michael Dell, President of Dell Computers, has described the situation his company faces:

> *The equipment to build the machines is relatively indiscriminant. It doesn't care where it sits and time to market is really important. Labor is not a really important factor in the production of motherboards, particularly in high-end machines. If you're talking about low-end machines, which we don't participate in, you might have to build them in Taiwan to get the cost ratio. But then you have the question of, if you put it on a boat for 30 days and have the devaluation of materials, it's going to be much worse than if you built it close to the market* (Dell, 1996).

The rapidity of change and the corresponding devaluation of the commodity means that the transience of value has become a central feature for management.

Many have written about the computer as a very flexible machine. In a sense, the computer is neutral, in that its function is not totally circumscribed by its form. The broom, for example, can serve only a very limited number of functions. When something is highly materialized and thereby determined, it is difficult to change quickly. The more material, the more recalcitrant the object, and the more human labor must be invested into developing a new model. The PC, in contrast, can be an entertainment vehicle, a controller for machine tools, an information storage device, a switchboard router, a television receiver, or a word processor, spreadsheet, or database manager. In other words, it is not imprinted in necessarily deterministic ways. It has become a kind of universal receptacle, into which human creativity pour the software concretizations of various ideas[7].

The ambiguous nature of the computer also opens it to innovation, that is, by providing it with different software it is able to do new things. In this sense, much of the value created in the PC revolution comes from providing the PC with new sets of instructions (*i.e.*, software). Here the key is that the sets of instructions can be altered relatively quickly, as compared with more recalcitrant physical attributes[8]. The physical aspects of PCS are

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7 Babbage was perhaps the first economist to see this (Rosenberg, 1994).

8 The fashion industry has similar turnover cycles. In this industry product life-cycles are notoriously short. The value-added is clearly in the design (creativity), and that is devalued extremely quickly, as cheap copies are created.

not the determinants of value. MPU and disk drives lose market value, because they are the focus of so much innovation and new knowledge creation. A PC's value is directly related to its components that have the most knowledge embedded in them.

6 SOFTWARE AND VALUE CREATION

Software is only a set of encoded electronic instructions. Its lack of physicality gives software some characteristics of a service, while in other ways it resembles a commodity. Software (like musical recordings) need only be produced once; further reproduction is simple. Perhaps more than in any other commodity, the relative cost difference between production and reproduction is the greatest in software – in contrast to most other goods that require significant quantities of capital and labor to produce more units. Moreover, most other commodities (though not all, *e.g.*, recorded music and books) are "consumed" upon usage[9].

Software is basically a set of instructions that direct a machine to undertake a sequence of actions, or, put differently, a tool that can be loaded onto a computer to perform various activities such as processing words or numbers. Packaged software is a most unusual commodity in that its value is nearly entirely dephysicalized and embodied in its algorithms. The disk on which the software is transported is only a very small portion of its total value.

In contrast to a conventional machine, software has no physical components to wear out. In essence, software operates forever – except that it becomes obsolete. This contrasts with a that machine has a life expectancy in the sense of how many production cycles it can perform before wearing out. In other words, a machine has physical constraints. In contrast, software has virtually none. Software, in theory, is timeless. However, in the marketplace it has only a very limited life-expectancy, as it is soon replaced by a more functional upgrade. For example, Microsoft works on a one-year cycle for minor upgrades and a two-year cycle for major feature and architectural changes. Its operating systems are scheduled for major changes on a three to four-year cycle (Cusumano, Selby, 1985, p. 191).

9 Musical recording is fascinating because two tendencies have been at play in its technological evolution: The first tendency has been toward ever greater fidelity, e.g., from records to CD-ROMs. The second tendency has been toward increased ease of reproduction, e.g., records to cassette tapes and CD-ROMs. Moreover, with the move to digitalization reproduction is further eased. This is illustrated by JVC's recent decision to offer a CD-ROM recorder for $2,000. This means that soon consumers will be able to make their own CD-ROM copies.

Software is pure knowledge or creativity concretized in a medium. Often, it is not dependent upon the media for its operation, but other software is very dependent as, for example, a computer operating system. For example, application software can be delivered and used physically be it on CD-ROM, floppy disks, or the Internet. In contrast, the knowledge and creativity embedded in an automobile cannot be delivered using another set of physical media. The knowledge and capability embodied in the physical nature of the car entrap it. The car will suffer some obsolescence when a new car model is released, but the car's usability is little affected. In contrast, software products are usually replaced far more quickly, even though they operate forever.

The cost of software applications has also decreased dramatically. For example, word processing was first available as part of a dedicated system for about $7,000 to $10,000 per machine in the 1970s. It was also available from an extremely expensive mainframe or minicomputer terminal. In the mid 1980s a superior word processing system was available for approximately $500 on a PC costing approximately $5,000. In the 1990s word processing has been reduced to a function in a suite of productivity applications worth approximately $100 and operating on a $2,500 machine. Moreover, both the word processing software and the machine are far more capable or functional than they were previously. One observer believes the next step is that *"the word processor is likely to become a feature in the operating system with almost no explicit economic value* (McNamee, 1996, p. 76)".

The role of software is growing rapidly, both in the amount "software" embedded in commodities such as integrated circuits and firms producing and distributing software packages. Because it is easily copied and distributed, however it is difficult to ensure that software usage will be synonymous with ownership. Although the originating firm produced the program to secure profit, the user sees it merely as a use-value. The initial user can copy the software for another user at essentially zero cost, with no harm to the initial owner's use-values. Thus, the software program seller is constantly beset by the threat of copying.

Knowledge has thus been externalized and is copiable. With most products, copying is somewhat difficult because the product has tacit dimensions to its production that cannot be easily accessed – therefore, it is difficult to reproduce an exact copy. With software, reproduction is easily possible with the same equipment on which it is used, i.e., the PC. The machine using the tool can easily, almost effortlessly, make copies of its tools. Formerly, when one purchased a commodity, it was not so simple to reproduce because it had a physical form. And, reproduction of the physical required not only the same physical ingredients, but also required some of the tacit knowledge held by the workers. In software this is not true. Software can be reproduced by anyone. In effect, in software there is a breakdown in the tacit/explicit knowledge dichotomy.

It is in the software industry that the most purified form of mental labor is expressed. The physical aspect has been reduced to a minimum and may even be reduced further, if the current discussion of delivering software over the Internet actually comes to fruition. It may no longer be necessary to go to a store to purchase a CD-ROM; the software could be downloaded directly from the Internet to your computer. This is the goal of the current discussions of building an information appliance. Instead of an appliance dedicated to a certain function like a toaster connected to a power delivery network, the information appliance would be connected to an information delivery network. Software upgrades could be delivered directly to the end-user's computer as they become available – further accelerating the obsolescence of previous models.

7 THE INTERNET, KNOWLEDGE AND VALUE

The most interesting current development in the ongoing transformation of the global economy is the rapid growth of the Internet. The Internet is that vast unregulated, uncontrolled mass of information, images and opinions accessible to any computer owner with a connection to the network. The Internet is growing at an extremely rapid rate. Information that would have taken much time to find is now quickly available. What is curious is that much of it is not in the form of products – it is nearly costless for most users. Given the relative immaturity of the Internet, it is hard to draw any firm conclusions about its future, but some tentative observations are possible. Even though no one can be sure what the system will look when it is mature, businesses such as stock trading, bookstores and computer stores have already successfully gone on-line. Most interesting, are the relatively minimal startup costs. Investor and public relations offices have built elaborate web pages that provide much information, thereby saving staff time and making information more accessible.

The business model of the Internet software firms is unique. The most powerful Internet software companies, Netscape (Navigator) and Qualcomm (Eudora), provide their software free to users in an effort to capture market share (Lewis, 1996, p. 70). The "search engine" companies such as Yahoo! and Lycos also give their software and databases away. From the perspective of traditional economics, this practice seems foolhardy and even perverse, though recently some economists, such as Arthur (1995, 1996), have begun a rethinking of traditional economic concepts to encompass the value added from knowledge creation and the increasing returns in knowledge-intensive industries. The model of giving away software resembles the one adopted by network television when it decided to use advertising to solve the problem of how to charge viewers.

Companies are giving the software because of the need to establish a market and capture market share. If their particular product becomes a standard, users might become customers for future upgrades or spin-off products. The business model is also interesting, according to an interview with Clark (1995, p. 70), the chairman and founder of Netscape, from the perspective of production and distribution costs:

> *The Internet is low-cost. We proved that by using the Internet to distribute our first product, and we were able to build a customer base of 10 million users in just about nine months. Our only expense was the engineering cost of making the program... So we see this potential for low-cost distribution of any kind of intellectual property – whether software, or pictures, or movies, or CDS, or anything that can be represented as bits.*

In this market space product evolution has been extremely rapid. For example, Netscape Communications, the main provider of Internet software, was established only in February 1993, but already by June 1996 was already issuing its third full upgrade of its Navigator software. Thus it was providing a new product yearly. This is also true of its Internet server software. Moreover, it has already made four acquisitions of other software companies, which is another way of developing and broadening its product line (Netscape Communications Company 1996).

It is not only the data communications industry software that is evolving extremely rapidly (von Burg, Kenney, 1995). Increasing numbers of users have brought the rapid expansion of data communications hardware as well. New switches, routers, data servers, algorithms, and software are needed. Switches installed two years ago are already overloaded and need to be replaced by those with higher capacity. System overload constantly forces users such as universities and firms to upgrade, or the performance of their networks degrades.

The rapidity of growth in the amount of data being communicated over networks is so powerful, and change occurs at so many levels, that even the most sophisticated companies find it difficult to keep up. As Figure 2 indicates, the biggest and most successful computer networking hardware company, Cisco Systems, purchases entire companies to secure access to new knowledge. Eric Benhamou, the president and CEO of 3Com Corporation, another major computer networking company, believes that:

> *If all [change] was fairly static, if the pace of change was relatively slow, you wouldn't have to buy companies to create this integration. You could rely on third-party integrators whose job is to take products from different companies and make them work together. The problem is that these networks grow and change so fast that even if you manage to freeze different vendors in one moment in time and get their products to interoperate well, two years downstream, each one of the products may have evolved in its own vector and the whole infrastructure is no longer coherent* (Benhamou, 1995, p. 46).

Figure 2

CISCO'S ACQUISITION, 1993-1996

DATE	COMPANY	PURCHASE PRICE ($SMILLIONS)
1996	Netsys	79
	Granite Systems	220
	Telebit	200
	Nashoba Network	100
	Stratacom	4000
	TGV Software	115
1995	Grand Junction	348
	Network Translation	N/A
	Combinet	114
	Internet Junction, Inc.	6
1994	Kalpana	204
	Newport Systems Solution	91
	Lightstream Corp.	120
1993	Crescendo Inc.	95

Source: Cisco System Inc. 1996.

In such a fast growing industry, companies can be formed to create certain pieces of knowledge-intensive (in this case, software-intensive) hardware; then that small startup is purchased by the larger company to secure control of the product:

> *" 'It's weird', said Joe Kennedy, co-founder of the five-month-old start-up Rapid City Communications, a development of gigabit intranet switches in Mountain View, California. 'What used to be two-and-one-half years for a start-up's business cycle is now being condensed to between six and nine months.' For instance, Rapid City accelerated its plans to hire a VP within the first six months of being in business. The company will announce its new VP at the end of the month"* (Bournellis, 1996, p. 1).

The speed of technological change in the computer networking applications area is not only changing so fast, but also it is expanding on so many dimensions that even firms in the center of its development cannot remain follow all its expansion paths.

Network applications are becoming increasingly data-intensive. As the material being transmitted changes from E-mail and data files to graphics and video with sound, the bandwidth demand is growing exponentially. Even while there is rapid improvement in communications hardware, there are improvements in software that can dramatically increase the hardware throughput. Though it is difficult to be sure of the exact outcome of these changes, there can be little doubt that the Internet is accelerating communication and opening new fields for human creativity.

8 DISCUSSION

This essay has argued that the increased knowledge embedded in commodities is strongly correlated with their tendency to become obsolete. In the contemporary economy, value is becoming increasingly transient. Accelerated obsolescence increases pressure on all economic agents to maximize the use of equipment and accelerate innovation to ensure maintenance of market share. In some industries, even as one generation is introduced, its successor is being prototyped for production, and the following generation's development project is being launched. Information processing and knowledge-creation are the twin forces driving value-creation in the global economy, both in consumer durables and in producer goods.

Knowledge creation/creativity, acceleration, and obsolescence are different aspects of the current competitive environment. In the foreseeable future there is little likelihood of a slowing this condition. Even companies with strong near-monopoly positions, such as Intel or Microsoft, cannot rest, or they will become victims rather than beneficiaries of the process. An example of what happens to those that hesitate is the fate of the Japanese DRAM producers, who eased up on investment during the last DRAM recession. The Korean firms, especially Samsung, who continued to invest, ended up being the enormously profitable leaders when the market recovered.

The rapidity of change has dramatically altered the nature of value-creation. No longer is it possible to think of commodities as physical objects, for it is not their physicality that loses value, but rather the knowledge embedded in the commodity that is constantly being overtaken and depreciated in the marketplace. As we showed in the case of production equipment, rapid devaluation is occurring in many more industries. As the knowledge-based portion of the economy increases, previously stable sectors are drawn into the acceleration dynamic. Managers in monopolies or quasi-monopolies, such as Intel and Microsoft, have only limited leverage in managing product cycles. If they do make their own products obsolete, a competitor will do it for them.

Management faces an environment with two attributes: accelerating change and quickening obsolescence. For those in apparently more slowly changing parts of the economy, innovations such as the Internet may accelerate and transform their businesses (witness the case of the on-line bookstore, Amazon). For those in knowledge-intensive areas, such as software and electronics, the current environment is a harbinger of more change go come. In summation, management thus faces unique challenges, now company leaders must manage not only labor and capital, but knowledge and time.

9 REFERENCES

ARTHUR, W. B. *Increasing returns and path dependence in the economy*. Ann Arbor, MI : University of Michigan Press, 1994.

-----. Increasing returns and the new world of business. *Harvard Business Review*, p. 100-109, Jul./Aug. 1996.

BASSACK, G. Silicon invigorates industrial control. *Electronics Business Asia*, p. 29-30, Jul. [s. d.].

BENHAMOU, E. Interview. *Upside*, p. 38-51, Aug. 1995.

BOURNELLIS, C. Cisco's $220M gigabit ethernet move. *Electronic News*, v. 9, p. 1-10, Sep. 1996.

CLARK, J. The herring Interview. *Red Herring,* p. 70-74. Nov. 1995.

CUSUMANO, M., SELBY, R. *Microsoft Secrets*. New York : Free Press, 1995.

DELL, M. Interview. *Electronic Business Asia,* p. 49, Mar., 1996.

DRUCKER, P. *Post-capitalist Society*. New York, NY : HarperBusiness, 1993.

ELECTRONICS BUSINESS ASIA. Asia's Tigers battle for a share of the PCB pie, p. 52-54, Jan. 1996.

ELECTRONICS NEWS. Pitting the Davids against the semiconductor Goliaths. v. 23, p. 1, Sep. 1996.

FRANSMAN, M. Information, knowledge, vision and theories of the firm. *Industrial and Corporate Change*, v. 3, n. 3, p. 713-757, 1994.

FRUIN, M. *Knowledge Works*. New York : Oxford University Press, 1996.

HUTCHESON, G. D., HUTCHESON, J. Technology and economics in the semiconductor industry. *Scientific American*, p. 54-62, Jan. 1996.

KAWAI, M. General Manager, Circuits Manufacturing Technology Laboratory, Matsushita Electric Industrial Corporation. *Personal Interview,* v. 3, Dec. 1992.

KENNEY, M., FLORIDA, R. *Beyond Mass Production*. New York : Oxford University Press, 1993.

LEE, J. Status on research and production practices in industrial machinery and machine tools industry in Japan. *NSF Tokyo Office Report Memorandum,* v. 19, p. 96-101, Jan. 1996.

LEONARD-BARTON, D. *Well Springs of Knowledge*. Boston : Harvard Business School Press, 1995.

LEWIS, T. Surviving the software economy. *Upside*, p. 66-79, Mar. 1996.

McNAMEE, R. Fishing on the Internet sea. *Upside,* p. 74-81, Feb. 1996.

MODY, A. SURI, R., TATIKONDA, M. Kepping pace with change: international competition in printed circuit board assembly. *Industrial and Corporate Change,* v. 4, n. 3, p. 583-613, [s. d.].

MORI, M. Managing Director, Corporate Planning and Administration Department, Mori Seki Co., Ltd. *Personal Communication in Letter,* v. 18, jul. 1996.

NETSCAPE COMMUNICATIONS COMPANY. Corporate information package. 1996.

NOBLE, D. *Forces of production.* New York : Alfred A. Knopf, 1984.

NONAKA, I., TAKEUCHI, T. *The Knowledge-Creating Company.* New York : Oxford University Press, 1995.

PLATT, L. Experiences of a major player. *In:* IP, *LES Nouvelles,* p. 145-148, Dec. 1993.

ROSENBERG, N. *Exploring the black box.* New York : Cambridge University Press, 1994.

YAMAZAKI, K. *Personal communication,* v. 7, May. 1994. (Professor, Department of Mechanical Engineering, UC Davis).

VON BURG, U., KENNEY, M. Silicon valley and the creation of the computer networking industry. *Hitotsubashi Business Review,* v. 42, n. 4, p. 15-44, 1995. (in Japanese).

-----. *Personal communication,* v. 18, May. 1995. (Professor, Department of Mechanical Engineering, UC Davis).

ZUBOFF, S. *In the age of the new machine.* New York : Basic Books, 1988.