

# **Information Society and informationization in the Electronic Age**

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# Information Society and informationization in the Electronic Age

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## 1. Introduction

In 2000, in his capacity as Japan's last prime minister of the twentieth century, Yoshiro Mori stated that his government was strongly committed to redressing Japan's underdeveloped information technology (IT) and in the coming years develop IT to a level comparable with the United States. Behind this desire was the theory from the prime minister's IT Strategy Council, which was organized and met just prior to the extraordinary session of the Diet. Consequently, the 2001 New Year media coverage of the millennium was abuzz with articles on IT.

There is little doubt that the development and expansion of IT has had a far reaching effect on the economy and economic organizations. However, the future path of the development of IT and its impact have yet to be determined.

One aspect of information society—the development and expansion of IT—is what used to be called “informationization.” This takes the form of an explosive increase in the volume of information, the acceleration of the economy and globalization. (Okuno 1999).

Another aspect in the development of IT is the digitalization of both products and services. Through the digitalization of data it is now possible to produce near-perfect reproductions at virtually no cost. Previously, reproduction was expensive and the quality was generally low. The progress in IT which made it possible to reproduce information digitally have also been responsible for drawing out the public good-like characteristics of information. Because of this, even though *ex post* it would be useful to be able to provide the product or service at no cost, from a hypothetical, *ex ante* perspective, it would be impossible to recoup the initial investment necessary to develop the product in the first place, which in turn, takes away much of the incentive to develop new products. Thus, there is a conflict between *ex ante* incentive and *ex post* efficiencies.

Finally, “the completion of coordination through digital programming” which, in spite of the authors' belief that it is a key concept of IT has, surprisingly, been left out of previous examinations of informationization. The degree of progress made in data transmission technology has markedly reduced coordination costs by streamlining the coordination of people, things and organizations with digital programs, and at the same time made coordination more accurate. As a result, systems and mechanisms that were previously customized in detail by machine or people are now coordinated quite simply

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<sup>1</sup> In writing this article we have received valuable feedback from the members of the “Informationisation Research Group” including Ikeda Shinobu, and Masahiko Aoki, head of the Research Institute of Economy (RIETI), Trade and Industry. Hiroshi Izumida, from RIETI, kindly discussed Section 3 with us at great length and substantially edited the text. We are very grateful to all concerned but take full responsibility for the content of this article.

and in a standardized fashion. As a result of these changes, the level of freedom between the coordinated components has been increased and a degree of coordination which was previously impossible made possible. As a consequence, on the one hand, it is now possible to separate “coordination between parts and unnecessary elements” and on the other hand, to bundle together, using digital programs the “coordination of parts and elements that are intimately related”—both measures were previously unattainable when coordination was managed by machine or humans. In this way, developments in IT have led to previously bundled parts and elements being unbundled and subsequently rebundled in a more natural configuration. In the background to this, are the issues raised by the economic theory of coordination and open (or closed) architecture that has attempted to put this theory into practice. The final part of this paper will consider how the issues raised by modular and open architecture (utilizing this kind of coordination) have influenced not only assets and services, but also organizations and industry.

In this paper, we examine and analyze the economic implications of the “IT revolution,” in reference to these three points.

## **2. The meaning of informationization<sup>2</sup>**

### **2.1 The explosion and increasing asymmetric information of data**

In Okuno (1999), “informationization” was identified as the explosive increase in the volume of information resulting from the dramatic reduction in data management and transmission costs. In reality, a significant reduction in transaction costs and value-added production costs was noticeable, especially in information industries. Internet banking is a prime example of this. If the hypothetical cost of a single in-bank transaction is 100 points (on a 1–100 scale), internet banking costs for exactly the same transaction are little more than one tenth of this at 12—considerably cheaper than telephone banking which costs 50 points.<sup>3</sup> Online share trading via the internet, in addition to the fact that it is now possible to utilize “stock exchange information services” previously only available to stock brokers, has brought about a sizeable drop in transaction fees. However, a characteristic of the “commodity of information” is the fact that added-value is only determined by discriminatory means. An increase in the supply of information does not necessarily mean that an increase in data equates an increase in value. In fact, the opposite is true—a dramatic increase in information of divergent values.

There is little that can be done in response to the increase in the volume of data passing through society as each individual exists in a “boundedly-rational” state in which there is a limit to their powers of recognition, which in turn, restricts the amount of information it is possible to process. Furthermore, people do not have the ability or mechanisms (including corporate organizations) to manage the diversity of data in circulation. In fact, the amount of information that individuals and individual

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<sup>2</sup> In this paper we emphasize the expansion in the volume of information but there are other aspects to informationisation. Please refer to Ikeo (2001).

<sup>3</sup> Booz’Allen & Hamilton <http://www.bah.com/press/jbankstudy.html> Booz’Allen estimates that the establishment of a specialized Internet requires only US\$1–2 million, which is substantially lower than branch-based banking. In addition, while ordinary banks’ running costs account for 50–60 percent of revenues, the running costs for internet banking is estimated at 15–20 percent of revenues. Cost per transaction is estimated at \$1.08 for a branch, \$0.54 for telephone and \$0.28 for PC and \$0.13 for the internet.

organizations will actually be able to process will decrease as the volume of data—in all its diversity and different flavors—in circulation increases. As informationization increases, the “omnipresence of information” and the degree of asymmetric information will escalate rapidly resulting in the increased need for a means for coping with the omnipresence and asymmetry of information.

At the outset, the image of informationization was that it would be more efficient with advances in information transmission and collective information and the establishment of the principle of “one item one value.” However, in the real world, electronic transactions have not necessarily increased uniformity of values. For example, in the internet auction market place, there have been numerous cases of items equal in value being won at wildly fluctuating prices. This loss of an economic subject with sufficient information to judge value is the end result of information becoming omnipresent and asymmetrical—informationization has brought “one item many values” into existence. Responses to the asymmetrical information will be made at an individual, enterprise, market and national level.

Consider, for example, the sale of books on the internet. In the sale of books, the high degree of efficiency in referencing and the low cost of transactions on the internet, make it far more cost-effective than sales at existing bookshops. However, it is difficult to envisage a world where internet book sales replace traditional book shops completely. This is because the sale of books (and any economic activity) is always accompanied by a “moral hazard.” Internet transactions are rife with potentials for fraud: that is, despite the transaction and payment by credit cards, the delivery of product cannot be guaranteed. In online shopping, the purchaser’s degree of trust of the internet retailer is crucial but with the asymmetric information this is not as simple as might be. It is much easier to trust a familiar shop than to trust a faceless operator on the internet. For this very reason, many people still—and will most likely continue to do so in the future—prefer to buy books from their local bookshop rather than from an online retailer who supplies the same books at much cheaper prices.

In many cases, book retailers in cyber space have come up with a solution for the asymmetric information. Well-established online retailers are using their position as widely known businesses to generate trust. Online book retailing majors such as Amazon.com are blessed with brand power, generated by both their sheer size and newsworthiness, that enables them to achieve this. If Amazon.com were ever to come close to collapse this would be reported by the mainstream media. As long as there is no such news one can relax and continue to shop at Amazon.com. As customers feel safe purchasing from Amazon.com the company has secured ultra-goodwill (goodwill that exceeds everyday goodwill). Therefore, retailers that sell by brand know that if they act in a morally irresponsible manner it will ultimately mean the loss of any ultra-goodwill they had already established or were likely to earn in the future. This puts the purchaser at ease as the internet retailers are unlikely to do anything that will adversely affect their business by tarnishing the brand.

The role that brand and reputation play here is not new, but the increasingly asymmetric information and the limitations imposed on legislative enforcement due to globalization, (which is elaborated on below), has made the importance ascribed to brand and reputation even greater than before. Let us take a closer look at this in more theoretical terms. In general for economic organizations, be they individual or corporations, there are very good reasons for maintaining brand and reputation that has

been established through past activities. Even when information has become asymmetrical, market dynamics such as these create the incentive for the seller to supply high quality products and thereby maintain their reputation. This also assists the market to run smoothly.

At present, we could assume that businesses with a good reputation sell products of high quality.<sup>4</sup> These businesses increase patronage through their good reputation and consistent product quality. They sell at a price higher than cost and earn ultra-goodwill.<sup>5</sup> If they were to sell an inferior product or service to some of their customers this would be communicated to the rest of their customer base through the media and other means. This would severely damage trust in the company and would mean losing the reputation built up over the years and the ultra-goodwill earned by maintaining consistency of product and reputation. In order to prevent the loss of this ultra-goodwill, businesses have good reason to try and continue to provide products and services of high quality and, by doing this, continue to maintain their good reputation.

The concepts of “reputation” and “brand” are virtually interchangeable. In the current situation where the volume of information is enormous and looms omnipresent, internationally prominent and familiar brands can use their position to boost consumer-confidence in their product. In other words, the “economies of brand.” The reputation of a brand, by giving customers and users the level of quality they have come to expect, secures ultra-goodwill—rent—for the company. It is characteristic of informationization that as brand-recognition increases, so does the pace of market-penetration.

The problem is that this kind of brand power and the ultra-goodwill garnered by it disappears with changes in product generations. There is also a good chance that it will be snatched by a new brand. This could mean less incentive to maintain a brand as with the acceleration in information and lifecycles of products become shorter, the degree of ultra-goodwill achieved through brand power decreases. This point is examined in greater detail in section 2.3.

The various problems resulting from the increased asymmetric information are likely to force changes in the structure of economic organizations. As also argued in Ikee, (2001) the reduction in information costs will result in a greater burden for economic organizations which should stimulates further change in these organizations. Asymmetric information existed before and it is fair to say that the actual choice of “business organization” as a transaction form itself is one method of dealing with it. This is because transactions that take place outside a business organization (market and reciprocal/relative transactions) must be conducted in a contractual form and the fulfillment of the contract needs to be secured by the state through the courts. However, for example, in the case of a key piece of information which is unverifiable, (something that a third party such as the courts could not possibly know), it would be preferable to bring the transaction participants into the organization and conduct the said transaction under direction than to have contractual transactions take place outside the organization.

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<sup>4</sup> However, these goods are judged to be “experience goods.” Experience goods are goods whose nature cannot be ascertained until the item is purchased and consumed—a cursory examination does not reveal what the item is. Nevertheless, it is possible to find out about the goods from other people. It is unfortunate but if one considers that within every transaction lurks a potential “moral hazard,” it may be better to consider every transaction as an “experience good.”

<sup>5</sup> Refer to Shapiro (1983).

In this way, if there is a problem, either with verification or from the asymmetric information, with proper documentation, it will be possible to solve it in-house. In many cases, this will be a more effective solution.

Where information has become asymmetrical, efficiency in the distribution of resources depends largely on the type of legislative framework put in place by the government. The product liability act is one example of this. Say, for example, that a product purchased by a consumer caused an accident. In this case, it is clear that differences will emerge based on the distribution of gain as to whether the burden of proof—that the cause of the accident was from the product in question—lies with the purchaser (the potential victim), or with the business (manufacturer, the potential perpetrator). In addition, with information being largely asymmetrical, the manner in which proof is provided raises important issues as to the efficiency of resource distribution.

In more detail, if the construction of the product in question is simple and if it is easy to explain what type of product it is (low level of data asymmetry) and either the manufacturer or consumer took on the responsibility of providing proof, the costs incurred in establishing a causal relationship (or lack of) would not be significant. In contrast, if the manner in which the product is constructed is complicated and a high degree of specialized knowledge is required to understand its inner workings (higher level of data asymmetry) and the burden of proof lies with the consumer, a considerable amount of money would be required to establish the existence (or absence) of a causal relationship between the product and the accident. For the manufacturer, however, a small additional outlay would be sufficient to establish any causal relationship (or absence of one) as much of the specialized knowledge required should have already been accumulated when the product was developed. Given this, and the fact that at present a large number of consumer products are very complicated and require a significant degree of specialist knowledge to understand how they function, it seems only natural that a public liability law should place the burden of proof on the side of the manufacturer in product related accident cases.<sup>6</sup>

In this way, the role fulfilled by the government and the state following the explosive increase in the amount of information and the asymmetric information are undergoing changes. The role of the government and the state is also changing due to the globalization of information. It is this point that we will now examine.

## **2.2 Globalization of information**

Okuno (1999) gloomily pointed out that informationization leads to internationalization and globalization. The expansion of the internet and the dramatic drop in the cost of international calls has made it possible, even for people at the ends of the earth, to exchange emails, shop or just enjoy a conversation at very little cost. This kind of internationalization and globalization has greatly expanded potential target markets. As a result, by being able to sell billions of copies of a product, as with Microsoft Windows, it is possible to create goodwill on a massive scale based on a huge volume of sales.

Globalization, internationalization and the breakdown of the barriers of international borders have made it possible to develop, manufacture and sell products right across the world. Previously, states were responsible for deciding on contractual

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<sup>6</sup> The reasons behind this are examined in Section 3.

protocols (legal system and contract law) and ownership rights. By having the police and the judiciary (provided by the state) enforce the law, the state was able to manage economic activity. In other words, the state provided the “public good” of “market infrastructure” to ensure that economic activity—including production and transactions—was conducted in a safe and sound manner. Now, with individual organizations formulating their own protocols to enable them to organize contracts and transactions over the internet, and through the trust built up over numerous repeat-transactions and ultra-goodwill coming from brand power, economic activity is currently at the stage where it is transgressing national boundaries. The need for an economic infrastructure provided by the state is gradually disappearing.

Recent insights in “economics of politics” suggest that the reason the state is a state is because the causes of those who want to bring it down and those who aim to prevent this from happening are in balance.<sup>7</sup> The cause of those who want to dissolve the state is motivated by a variety of factors including religious and language differences, as well as division based upon regional cultural differences or discrepancies in the distribution of wealth. Examples of this include the regional and racial separatist movements in Kosovo or Quebec that aim to dissolve and divide the nation. However, the state is the producer of public goods. The provision of public goods such as security, disaster prevention, maintenance of roads and ports, is accompanied by “large scale economic ness.” This has been sufficient incentive to preserve large states intact and keep regional and racial autonomy movements in check.

Since the end of the cold war, however, security—the largest public good provided by the state—has become less important. As noted above, the state now plays a lesser role in the provision of another previously important public good, economic infrastructure. This suggests a breakdown in the above-mentioned balance that has secured the position of the state and an intensification of regional and racial separatist movements. In turn, this lends a legitimacy to the claim that “economic globalization will bring about the localization of the state.”

If this is the case, it is possible to imagine the power of the state, at least in an economic role, gradually decreasing. Businesses seeking cheaper labor and reduced tax burden will become multinationals or *mukokuseki*—ambivalent nationality. Production and commerce will transcend national barriers in all respects—not just in business-to-business transactions (B2B) but also in business to consumer (B2C), customer-to-customer (C2C) and peer-to-peer (P2P) transactions as well—and continue to internationalize.<sup>8</sup>

As emphasized a number of times above, as the advent of informationization intensifies the degree of asymmetric information, it follows that the asymmetric information between the government and its citizens will increase too. In order to put in place the necessary conditions (that is, public goods measures to deal with a market collapse) for the appropriate distribution of resources, and in order to manage and maintain the competitive environment, the volume of data required by the government will increase exponentially. There is a limit, however, to the government’s ability to collect and manage this data.

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<sup>7</sup> For example refer to Persson and Tabellini (2000).

<sup>8</sup> ‘Peer to peer’ is a method of direct communication between two terminals without being routed through a server.

As a result of the increase in volume and diversity of information, depending on the situation, the government should delegate certain responsibilities to the public as well as process information in a decentralized manner and decentralize the decision-making process. To achieve this it will be necessary to mobilize citizens' groups, such as nongovernmental organizations (NGOs), to implement government policy.<sup>9</sup>

### **2.3 Economic acceleration.**

In addition to the increased volume of information and globalization, the third consequence of informationization is the "speed economy."

Just as countries are established on the balance of unity and discord, the volume of data that can be used will be determined by a balance of its value and the cost of collection and management. On the one hand, there is merit in collecting data over and above this amount if the expected added value (on average) is greater than the cost of collection and management. On the other hand, if the forecast additional value is less than the additional costs involved there is obviously no point in collecting it. In fact, it would be prudent to pare back data collection and management activities in order to conserve capital. The explosion of data from informationization has further enlarged the vast reservoir of information available to the public and businesses, hence increasing the cost of data collection. At the same time, the emergence of computers and the internet has significantly decreased data collection and management costs. Thus, previously uneconomical data can now be used effectively. Two extreme examples of this are the niche markets of online auctions and pet accessories. Even though these kinds of products or services only provide a small portion of the total added value, developments in information transmission technology mean that the marginal cost involved in finding niche or fringe markets is now considerably lower than before. As the data management costs required to evaluate and analyze these markets has plummeted, the number of businesses developing niche markets in order to build up genuine ultra-goodwill has increased considerably.

In contrast, numerous businesses are familiar with the mass market where high competition makes it virtually impossible to earn ultra-goodwill. In many cases, more profit can be generated if businesses develop a large number of niche markets, garner a lot of ultra-goodwill while active in those smaller markets, and then expand from there. This will speed up the tempo of the development of niche markets. Furthermore, using their home pages, people on the internet express themselves in a variety of new ways: As new information emerges, the changes in an economic society intensifies and the pace at which new niche markets emerge escalates. This in turn speeds up the search for new niche markets.

Such a process could mean that over time, the whole economy, not just the internet, could turn into "dog years." That is, a speed equivalent to the illusion of a person's lifetime compressed into about ten years—a dog's life span (in terms of speed, a compression of seven times). It is often said that we are now at a watershed as we move from the twentieth century's "economy of scale" into the twenty-first century's "speed economy."

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<sup>9</sup> We think that it is probably a fairly natural progression to give the responsibility for providing some sort of public asset to a volunteer group. More specifically, it is important that a "sense of values" is considered as part of an effective relationship. If this is done



This acceleration of the economy will foster anxiety over whether product lifecycles will be shortened, as brand power and business reputations, and the ultra-goodwill earned from it, are replaced by a new brand and reputation. The reputation of an existing business represented by brand power, is built up by the business's activities over time. It is established through reputation accumulated through advertising activity, existing product range and technological expertise. In a pre-information society, factors such as brand and reputation, factory facilities, technology and product range, and the company with the upper hand on the stock front—"first mover's advantage"—all had a role to play. It was also easy for a leading company to avoid being surpassed by competitors (second movers), as long as it was briefed well on the nature of the competitor's business and future strategy. In such a situation, the first mover's efforts not to be surpassed by frequently defending itself against its competitors' actions, will have meant that its position was secure.<sup>10</sup>

In contrast, in the current climate, weighed down by immense quantity of data, it is often difficult to even identify the position of the followers. By the time a company becomes aware of a competitor's position, it is often too late as they have already been overtaken. Today's society is characterized by a "second movers' advantage" as the first movers' weak points can be easily identified and exploited by the second mover. Therefore, it is likely that industry leaders in each of the various product and service areas will change with each change in generation.

This turn of events can actually be seen as providing an incentive for existing, successful businesses to surrender their position as market leader. When adopting new technologies and developing new products, it is impossible to guarantee that existing brand power will be strong enough to carry over to the new product. It may even destroy the existing brand image altogether. As a result, in supplying a new product or developing new markets businesses cannot help but be passive. It is difficult for existing businesses with brand power to respond adequately to economic acceleration and there is considerable risk that their position will be lost to either new products or new businesses.

With the development of informationization and the information society, the more the economy accelerates, brands will change with the changing generation of products and the rent (goodwill) on which brand power is based, will have its life cut short. To put it another way, because the effective life span of ultra-goodwill—an essential element in maintaining a brand economy—is so short, it has to be of the highest standard. In much the same way that Bill Gates has had a rapid rise to reach the status of the world's richest person. The emergence of the internet, through email and home pages, is providing a new platform—quite different to any that existed previously—for self-assertion as well as a new economic and social incentive. Up until now people were able to realize their goals in one of three ways: to earn a lot of money and be "rich;" to enter politics, sports or entertainment arena and become a "star;" or achieve self-fulfillment in the area of social welfare and charity work or in a trade. The emergence of the internet has made it possible to satisfy one's own set of values, create a popular reputation on the internet by self-advertising and self-promotion and become a

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<sup>10</sup> In the context of industry organization theory this the phenomenon of 'preemption.' For detail refer to Tirole (1988).

net “star.”<sup>11</sup> It seems natural at this point in time, to interpret activities undertaken not in pursuit of financial gain, such as the development of Linux and the activities of non-political or NGOs, as behavior seeking to satisfy one’s own set of values or to establish a popular reputation. We predict a global increase in various social activities based on similar not-for-profit motives in the future information society.

### **3. The meaning of digitalization**

#### **3.1 What is digitalization (digital assets)**

The information transmission revolution began when LSI and computers, the technologies that manage digital information, were married with communication and began to be used on a much wider scale. It is true that people operated machines made from pendulums and spring notches that displayed data digitally and were familiar with methods of digital calculation such as the abacus. However, a number of problems were encountered in trying to employ these machines effectively. First of all, parts were required in both quantity and quality and because it was necessary to make the pendulums and springs one at a time, it was a very expensive process. For example, it was possible to make a digital watch using a combination of springs, cogs and notches but it was very expensive and with each attempt to manufacture a watch of higher quality the cost also escalated. This was because springs, cogs and notches are “objects” and in order to improve the accuracy of the watch it was necessary to manufacture more accurate parts which was inevitably expensive.

Analog signals, on the other hand, can be transmitted, (either wired or unwired), be recorded onto a tape and by subsequently copying this tape, it can be provided as a product or service. This method does have drawbacks, however. While the cost of the recording and copying medium—analogue tapes—are cheap (in comparison to material objects, additional production is possible at a fraction of the cost) but being analog, each time it is copied the quality diminishes. In other words, “data” in the analog age was not completely separated from its medium, and as maintaining data quality was an expensive exercise, it ended up being nearly as expensive as the above-mentioned material objects.

In contrast, consider software such as word processors, spreadsheets and digitalized music. This software is written as digital data and stored on media such as floppy disks or compact discs (CD) and are in fact unbundled from their storage media. Thus, production costs are extremely low and even if the data is copied there is minimal or no loss in quality. This characteristic of being completely unbundled from its storage media will be referred to below as “immateriality.”

The basic software (operating system, or OS) provides the essential interface between the computer and user making it possible for people to use application software and get used to computers very quickly and easily. In this sense, unlike past tools and machines, these new implements are intangible or digital and not physical “things.” The phenomenon that makes it possible to “unbundle” data from its storage media will be referred to as “digitalisation” and the products produced, “digital products.”<sup>12</sup>

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<sup>11</sup> Refer to Okuno-Fujiwara, Suzuki and Watanabe (2001).

<sup>12</sup> If one considers the “digital technology” in this paper as “technology which has made reproduction very easy as it expresses the original information by 1s and 0s, completely abandoning recreation, it records having discarded some of the data” it is easier to understand.

Among “digital products” are the software—free ware and share ware—that can be downloaded from the internet for free (or at a small cost). Beginning with the well-known open source OS, Linux, freeware and shareware software can be downloaded from the internet completely free of charge (other than the cost of connection) negating even the need to purchase storage media such as floppy disks or CDs. In this way, IT, in the sense of the expansion of the internet and the spread of computers, has made the cost of digital products zero. The special characteristics of digital products are examined below.

### **3.2 The public good characteristic of digital products.**

Digital products are objects of extreme contrast. They are extremely expensive to develop yet they cost virtually nothing to copy and can be copied without any loss of quality.<sup>13</sup> This progress in digital and digital reproduction technology, coupled with the increasing asymmetric information, makes it very unlikely that an individual who copies a digital product, whether for use or for sale, without the right to do so, will be caught. In short, digitalization is causing a great deal of problems for the system of intellectual property rights (patents, copyright and trademark rights) that has been a cornerstone of the market economy of the twentieth century. (Hayashi 2001).

Before delving further, it is useful to have a concise definition of the two representative intellectual property right concepts of copyright and patents. In modern society, individual rights, such as the right of ownership, were established by the state. Furthermore, the state also provides its citizens with incentives to respect the rights of others by taking punitive action against those who infringe upon the rights of others. From this legislative intervention grew the trade in rights which are traded in market economies in the same manner as any other marketable commodity; through the market, the right is transferred and the appropriate amount paid.

There are a number of products and services, however, that cannot be easily transferred in such a marketplace. Because of the high cost of consumption and exclusive rights, public infrastructure such as roads, national security, the environment and pollution, are the type of assets or services which are not subject to similar incentives. As neo-classical economics clearly points out, the purchase and sale of such products and services would cause inefficiencies in the distribution of resources, ultimately resulting in market failure.

On the other hand, for market mechanisms to work effectively, the market-share of market participants should be small enough to be virtually negligible. In other words, monopolistic businesses with enormous market share should not exist. If this kind of businesses did exist, it would begin to use its monopolistic power causing, once again, inefficiencies in the distribution of resources. In neo-classical economics, this is referred to as a noncompetitive market. “If all product and service markets are completely competitive with no market failures, the distribution of resources, brought about by the balance of market mechanisms, will be efficient” is the first theorem of welfare economics’ and the most emphasized aspect of neo-classical economics.

There is a serious problem with the production of digital “information” related to the two problems outlined above. The financial investment in the production of

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<sup>13</sup> Jiro Kokuryo makes this point stating that digitalization “has exposed the true nature of the commodity of information.”

information—activities such as composition, writing and invention—more specifically, in the act that realizes it (the invention of something important or the composition of a socially important work of literature or music) is non-recoverable.

Furthermore, if a digital product can be freely copied by anybody, its post-production and usage costs are close to zero (or even zero). From the *ex post* perspective, once the item has been invented or the composition completed, the fact that the people and businesses that experience a genuine sense of value from ownership or use are allowed to use this information free of charge (and to reproduce free of charge) increases efficiencies within society.

If, in order to ensure efficient post-production distribution, digital products were assigned a value of zero, there would be no financial incentive to invent or compose as even the production of socially beneficial information (invention or composition) would not be rewarded. As a result, in the digital market economy, there is longer a financial incentive to produce any kind of information (the “digital product”). From a *ex ante* pre-production perspective, in order to ensure goodwill as an incentive to produce information, a high retrospective value is desirable but from an *ex post* standpoint a zero value is preferable as money has already been spent in the production of the information leading to “a lack of adjustment between the *ex ante* and *ex post* situations.” Due to this lack of adjustment, even under the “analog market economy,” in regard to the production of information, the “first best” solution cannot be realized: The system of intellectual property rights such as patent rights and copyright has been formulated as the next “second best” solution.

From another perspective, when information is unbundled from “things” and examined from an *ex post* perspective, it is very close in nature to that of “public goods.” This is because information shares non-rivalness—a special characteristic of public goods. By this, even if used by many people at once the “congestion cost” is low and the degree of “deterioration in quality” is also low. Information also shares another characteristic with public goods, the “impossibility of preventing consumption.” This is because it is very difficult to prevent a piece of information shared with one person from being passed on to other people. In other words, because the “costs of preventing the resale of information” are high, the moment (the ownership and usage rights of) information is passed to another person, it is extremely difficult to prevent this information from being spread across society.

Before the progress in digitalization, this type of public good characteristic of information had not been very pronounced. This is because mediums, such as books and records, were necessary for the transmission of information. Also, as the mediums used in transmission are “objects,” this has resulted in congestion—the cost of people consuming information simultaneously. Secondly, the limitations of analog reproduction technology, such as tape recorders and photocopiers, meant that each time a copy was made quality suffered. From this point too, grew the impossibility of excluding consumption. This is because if a printed item or piece of music is copied only once it retains great value but the more it is copied the more the value drops. Thirdly, if the volume of information is not very large and the asymmetric information is limited, it is relatively easy to catch a retailer who illegally copies and resells data you have produced and using intellectual property rights it is possible to protect one’s exclusive right to this data.

Put simply, until the advent of digitalization, information was no more than a partial public good, and even if not completely, it did still function adequately in the market as a tradable commodity.

The emergence of an intangible digital technology, however, has brought information as a digital product closer to being a pure public good and made market-based transactions of data that much more difficult. First, data can be downloaded from the internet and stored without needing storage media such as CDs or floppy disks. Even if storage media are required they can be purchased very cheaply. Second, through the internet and email, it is possible to exchange information quickly and cheaply to the point where near simultaneous access to information for a large number of people has become possible. Congestion costs have also been reduced significantly and the use of intangible digital technology has virtually eliminated losses in data quality. Third, the increase in the asymmetric information from the IT revolution has made it increasingly difficult for the “developer or the owner of the rights to the data” with the copyright or patent to chase unauthorized copies (and collect royalties) as well as making “the cost of preventing the resale of data” prohibitively expensive.

### **3.3 The transaction mode for digital products**

What are problems from the “current exposure of the true nature of information as a public good?” and what changes will this bring to the economic society? Before looking into these questions, it is necessary to examine in greater detail how “information” (product or service) has traditionally been dealt with in a market economy. At present, the central elements in the protection of information are:

- copyright law: in the case of thoughts or emotions expressed creatively, including computer software;
- patent rights: for the invention of production methods, amongst other things.

More detail is available from Hayashi (2001) but a brief introduction of the problems he identifies is listed below.

An explanation of the most important differences between copyright and patents (within the context of this argument) is given. Both copyright and patent rights protect information, as the “product of human spirituality or creativity,” but the following differences in their nature can be identified.

In the case of patents, the inventor applies to the authorities for a patent and if the following conditions are met is granted the exclusive right to profit from that information and manage it as they see fit: the invention is recognized as having a potential commercial use; it is unique; and on the condition that a product outline is made public.<sup>14</sup> Accordingly, the use of an existing patent without the consent of its owner is illegal and may be subject to a civil compensation claim and if a complaint is filed, a penalty may also be imposed. Under the patent system all kinds of inventions and ideas are made public making it easy to have the content of the invention acknowledged and find out the specifics of the patent holder. Thus, by securing the consent of the patent owner (usually through a financial agreement) it is possible for

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<sup>14</sup> Patent Law, Article 2, Page 1.

someone else to provide a derivative service that is the practical application of the invention or idea.

In contrast, in the case of copyright, there is no application procedure or evaluation. Copyright is established as the composition is created. Thus, there is no public disclosure, nor is an outline of the content of the composition required unless the holder of copyright chooses to voluntarily register it. Even if the holder of the copyright does register their work the application process does not require anywhere near the same degree of detail as a patent application.

For example, if computer software was protected under the patent system and not copyright, the patent information would be easily accessible to others and would provide, we believe, a mechanism for people other than just the software developer to easily recognize the type of derivative software which could be developed.

It will involve a fair amount of detail, but some of the problems associated with the public disclosure of software development information should be considered. At present, the source code (development information written in programming language) is not open, but from a standpoint of economic benefit to society as a whole, the developer's rights should be protected through public disclosure of development information of computer programs, including software. This allows anybody who pays an appropriate amount to the developer to use the developed idea fostering competition amongst derivative ideas. For example, if the source code for a particular OS were to be made public it would be possible to quickly produce compatible word processing and spreadsheet software. This would stimulate further development-competition in the application market which can only be beneficial to consumers.<sup>15</sup>

Now, to focus on the increasing number of digital products from the development in IT. Intangible digital products and services are very expensive to produce initially but, once they have been produced, they can be replayed, reproduced and transmitted at virtually no cost. Digital products, in comparison to non-digital products, have a "pure" public good quality. In comparison to pure public goods such as national security, which is of equal benefit to all the nation's citizens as a whole, however, for most digital products, in the manner in which they are produced and used, the potential for a considerable conflict of interest to arise exists. Accordingly, the state would not be able to solve the problem by stepping in to provide these assets. Even the possibility of realizing the second best solution, even though it appears to be more realistic, has been put in doubt. The viability of a number of solutions are examined below.

The first possibility is to protect data by making it technologically impossible to copy. This means returning data to its ordinary status as a private asset by technologically preventing the digitalization of data. It is possible to make duplicating music CDs and some software CDs technologically very difficult but, this is not a cheap process. This solution would only be viable for programs and data as the value of both of

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<sup>15</sup> In the case of Microsoft Windows, information for the development of applications is basically made public in the form of API (Application Programming Interface) but as their source code has not been disclosed it is said that there are hidden functions that only Microsoft knows about. Because of this, if a company that was not involved in developing the OS developed application software, the product would not be able to maintain competitiveness and the monopolistic power of the developer of the OS would become greater still. As mentioned previously, the monopolistic power of OS software developers must guarantee to a certain degree an increase in before the fact incentive but if the source code is not disclosed, the unpleasant ramifications of an ex post facto monopoly would be incredible.

these exceed the protection cost. Furthermore, with improvements in technology on a daily basis, demand will be grow for protection technology to develop.

The second possibility is to take advantage of the asymmetric information. In short, if one reveals fresh information—completely “unknown” at the time of its formulation—to a small number of people, it will take time for it to become common knowledge. That is, the greater the degree of asymmetric information, the longer the lag before it becomes common knowledge. When a digital commodity (knowledge equates profit) becomes common knowledge it loses value. However, while it remains the exclusive knowledge of a privileged few, it is still valuable and if it is sold to a limited number of people for a limited amount of time, it may be possible to recoup production costs. It is a similar to today’s newspaper having a comparatively high value but old newspapers are worth no more than the old paper they are written on.

The third possibility is the application of digital copyright proposed by Hayashi (2001).

The fourth possibility is to seek a solution that does not rely on market mechanisms. Linux is an example of an “organization” where a large number of people with good intentions get together and cooperate to provide free software that they developed without any financial reward. This kind of voluntary or non-commercial activity is a phenomenon that economic theory cannot yet systematically explain. One possible explanation is that this kind of activity is motivated by possible after-the-fact recognition and reputation. It is hard to believe, however, that Linux or any other NPO or NGO activities are based on this kind of motive.

Another possible explanation is that the basis for these activities is a set of values. In short, value is subjective and this may be the motive for some people to construct a “digital product that will only be for other people.” Additionally, due to the fact that these people are united by IT, the possibility remains that the formulation of digital products will move forward. Even if people who do not share the same value take a free ride on the digital product which is developed, or even if a single condition such as a guilty conscience from taking a free ride is fulfilled, it is possible to show that there is a possibility of beginning this kind of production activity.

With the development of IT, the factors that will determine how digital commodities are produced and exchanged will probably be the nature of the actual product (or service) itself and historical accident. In other words, it is impossible to forecast the resolution of these issues.

## **4. The completion of coordination using digital programs**

### **4.1 Coordination and economic organization**

The widespread diffusion of digital products, and the emergence of electronic digital data management technology that followed, have revolutionized existing technology in two ways. The first is that, in comparison to traditional digital management technology, the new digital programs are much faster, more accurate and operate at a lower cost. The second, and more important point is that, as all these digital programs do is enumerate the collected digital signals, the above-mentioned data management function is applied to the actual digital signals. Even if data was digitalized in existing production machines, the mechanism for controlling it remained mechanical. The characteristic feature of digital computers is that the actual operational procedure is by a digital signal. By using a digital data management system and a digital network, the spatial limitations and time

constraints of the existing system are overcome, and the number of coordinating personnel required is greatly reduced. This will be termed the “completion of coordination through digital programs.”

Computer aided design (CAD) applications are one example of this. CAD applications, utilizing powerful computers and a network, have made it possible to design products in the imaginary space provided by the computer. Using this kind of program it is possible, without constructing a model, to replicate the form of the actual item to the point that it is three-dimensional. As a result, it has become possible for a production development team to develop a car cheaply and quickly and at the same time: placate the management who are worried about cost; satisfy the wishes of the retail team whose primary concern is comfort; and satisfy the design team who pursue originality. In short, the development and spread of IT has not just replaced “things” but has begun to set up mechanisms in the realm of the imaginary: Through the use of digital products and programs, IT has enabled the completion of previously costly and time-consuming activities, quickly, accurately and with minimal human intervention. In addition, IT has meant that similar operations can be performed instantly and at minimal additional cost. In this way, the development of IT has not been limited to an increase in the share of the “digital” economy but has allowed room for completing electronically, essential coordination of economic activity. In order for readers to better understand this argument, it is necessary to take a closer look at the concept of “coordination.” A concept which, in spite of being central to any understanding of economic activity, has until recently been largely ignored.<sup>16</sup>

A very important element in economic activity, is that each economic subject simultaneously, by delivering the required item in the required amount at exactly the right time to the economic subject that needs it, fine tune their (or the economy as a whole’s) production and consumption for a smooth operation. This is what is meant by coordination of economic activity. If economic activity becomes uncoordinated, the production line stops, economic activity comes to a standstill and ultimately business failures (from an inability to produce) become more commonplace. In extreme cases, even with a surplus, there will be people on the street starving to death. The Toyota *kanban* system is a model coordination system that reduces stock levels, increases goodwill and is very finely tuned; the numerous different parts for the many types of different types of vehicle that Toyota produces, arrive at the correct factory in the correct quantity exactly when required.

There are three main methods of coordination.

The first method of coordination is a people-based system where colleagues instigate coordination through communication and planning. In rowing eights, the rhythm of the eight rowers is coordinated by the cox’s voice. A police officer controlling traffic at an intersection coordinates the passing vehicles so that traffic flows smoothly and they do not collide. It is the same for an organization. For example, an order at a bookshop causes the following two courses. One course is the act of ordering, purchasing, receiving and delivering. In detail, the employee in charge of operations informs the employee in charge of purchasing to order the book from the wholesaler. The ordering supervisor passes the book to the operations supervisor and finally the book ends up the hands of the person who ordered it. The other course of action is the

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<sup>16</sup> For a more detailed explanation, see Milgroom and Roberts.



financial element: The operations supervisor who took the order relays this to the accounts' manager. The accounts' manager adds the provisional retail price to the account of the person who ordered the book and adds a provisional payment amount to the supplier's account. When the wholesaler delivers the book, the payment is made to the wholesaler either in cash or by issuing a bill. At the same time as the book is delivered to the person who ordered it, an invoice is issued to the purchaser, payment is received either in the form of cash or check and the receipt of payment is completed. Once both series of actions have been completed and the in-house settlement of the transaction on the actual item and account levels is completed and the paperwork is done all elements are completed. The activities of the company employees (operations, purchasing and accounts supervisors) are coordinated by the orders from superiors and put into action by the employees.

The second method of coordination is a mechanism of coordination using a value system. If a person wants to buy a specific share on the share-market, they determine the price they willing to pay for that share and place a purchase order. On the other side of the transaction, the seller determines a base price at which they would sell and places a sell order. A transaction takes place when there are buyers and sellers at the same level. Under this system, the required number of the seller's (at a price below the established price) shares are delivered to the purchaser (at a price above the established price). Microeconomic theory—that trade takes place at a balanced price with an individual or company (supplier) who decides to sell providing the required amount of goods or services to an individual or company that requires them—shows that the market mechanism itself is a large coordination mechanism.

The third method of coordination is a system of coordination where people use machines and tools. For example, the powered loom that weaves textiles from thread, operates on the basis of the following mechanical coordination. First, after threading the vertical threads, at the same time as the even vertical threads are raised (opening up a narrow space between the odd and even vertical threads) a horizontal thread is passed from right to left. Next (the even vertical thread have bee returned to their original position) at the same time as the odd vertical threads are raised the horizontal thread is passed from left to right. By repeating this process over and over again a woven textile is produced. Most of the machines and tools used by people operate on this kind of coordination mechanism. They are not easy to control. For example, in the early powered looms, when the horizontal thread ran out, the loom operator would climb up and add a new thread allowing the loom to recommence operation. In short, in this kind of system, most of the coordination was left up to the machine but the last line of coordination was the responsibility of the human operator. In the same way, using a car engine as an example, if you make it work hard in severe heat it will overheat. To prevent a 100 percent overheating the incorporation of mechanical mechanisms such as a cooling system and a load reduction system, is necessary. But as the cost is prohibitive, the majority of cars do not have such mechanisms installed. Because of this, the final level of coordination is the responsibility of the car's human operator.

#### **4.2 Electrification of coordination**

With the progress in digital technology, the electrification of mechanical coordination and the electrification of much of the final level of coordination which used to be part of human responsibility, it is now possible to largely complete coordination with digital

programs. Coordination using digital programs and a digital network has made it possible to produce quickly, in large volumes and at a reduced cost. Furthermore it has overcome the previous constraint of space and made it functional.

The term modularization is used in various contexts including auto-manufacturing and computer software (amongst others). In Kokuryo (1998) it is defined as “a method that makes it possible, using a clearly defined interface, to divide a large overall system into subsystems with clearly defined mutual interdependency, and design this subsystem independently.” As will be discussed in the following section, modularization is closely tied to open architecture (an open design method that is not dependent on a particular product or business). This section, following Kokuryo’s distinction, will examine why modularization has advanced even in even in [not open] closed architecture (a closed design method where the said parts can only be used in the individual product or business).<sup>17</sup>

Modularization occurs even in closed architecture for two reasons: by designing the closely related product groups as a single package greatly reduces the cost of coordination between the parts; and as explained in detail in (2001) modularization is very useful for parts’ performance management (breakdown).

First, the second element is observed in detail. In a hypothetical example, a finished product, like a car, develops a problem. Given the fact that cars are assembled products, it is most likely that the problem has its origin in a particular part. If the cars were not modularized it would be necessary to check each part one by one in order to find out where the problem was. If everything went well it might be possible to locate the problem in the first part checked. If things go badly it might not be located until the last part was checked. Due to the number of checks that have to be performed the time-related cost is high. Also the financial and time-related costs of replacing the part and redoing the wiring are high.

In contrast, if parts are arranged in a number of modules, locating the problem is quite simple. First, each module is checked to locate the problem. Once the affected module is located, each sub-module is checked until the affected sub-module can be identified. Within this sub-module it should be fairly easy to locate the damaged or faulty part. By using these steps, it is possible to reduce the number of checks required. Furthermore, by following the procedure for checking each module in this manner, even prior to identifying the damaged part, it is possible to return the car to its pre-damaged, finished product state by just changing over the affected module. To have the damage repaired in a very short period of time is very advantageous to both manufacturer and consumer.

The other merit of modularization is that the coordination between the parts performed by a digital program, in contrast to the mechanical coordination by cogs, is based on providing a greater degree of freedom in the placement relationships between the parts. For example, in the case of automobiles, various parts are used for control, running or air conditioning. It is very important to plan the coordination between the parts responsible for controlling these items. In the past, this was left to machines. If it required some fine tuning it could be easily adjusted by the driver (in the final instance) and the problem was solved. The development of information technology has made it possible to finalize nearly all the necessary coordination between the various parts using

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<sup>17</sup> Refer to section 4.1 of this paper.

a digital program. For example, there is little need for mutual coordination of the control and air conditioning product groupings. The greater degree of freedom between each part from electrification has allowed the closely related product groups (the control, running, air conditioning and lighting related) to be divided into different groupings and modularized (unbundled and rebundled) and the information that each product group in each module has is completed. Using this as a base and by finally coordinating electronically the total reported history of each module, it has been possible to dramatically reduce the necessity for human intervention. In a sense, electrification has greatly increased the degree of “the completion of coordination through electronic programs.” If the move towards trying out modularization even in the product groups that are only used in their own special vehicles is explained in this way it will probably gain greater acceptance.

For example, in the case of previous machine coordination, such as a car’s braking system, a large-scale system and strict customization is necessary to the point that if unnecessary items are not bundled coordination is very difficult. If people are given a leadership role in coordination, large scale and accurate coordination is difficult to achieve.

In contrast, coordination completed by a digital program, in comparison to an exclusively machine based coordination, allows a greater degree of freedom in how the parts are placed and coordinated. As a result, the parts are re-bundled—in coordination by digital program, all of the unnecessary parts are unbundled and only the parts necessary for coordination are bundled—the product becomes coordinated as a whole.

Modularization has moved beyond products to reach other areas too, such as production processes, group organization and transaction methods. One of the best examples is the previously mentioned CAD. Other examples are financial settlement and ordering systems. Using digital information, it is possible to achieve greater scope and more accuracy in financial settlements and orders. Systems such as supply chain management (SCM) and real time gross settlement (RTGS) are beginning to be adopted and are showing great improvements in efficiency.

Digitalized SCM is a computerized management system that covers every aspect of business activity from: customers; orders; material procurement; inventory management; to product dispatch. Coordination is improved by digitalization as excess stock is reduced and has the effect of reducing costs. The well known assembly and dispatch system at Dell Computers is a model example of this system but the mould was in fact cast by Toyota’s *kanban* system.

Nippon Steel Corporation, in order to substantially reduce production and retail costs, plans to introduce a system that will share production, retail and product tracking data with its major customers, the various auto-manufacturers. Through this system, which will be based on actual sales of vehicles, forecasts of demand and production plans, Nippon Steel will be able to manufacture and supply the right amount of material at the right time across its product range and thus reduce by half its automotive industry stockpile. The system developed in cooperation with Toyota was planned to be operational from the Summer of 2001 and similar systems with Honda and Nissan were also planned.<sup>18</sup> Instances of personal computer and general consumer goods

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<sup>18</sup> Through the provision of production information which had not previously been disclosed to other companies, they will pursue a reduction in consolidated costs. Morning edition of *Nihon Keizai Shimbun*, 26 December 2000.

manufacturers introducing digitalized SCM systems that are based on forecast demands for its own products and improve efficiencies in manufacturing, commerce and product flow, are steadily increasing.

The real time gross settlement (RTGS) system introduced by Bank of Japan toward the end of last year allows the immediate settlement of each transaction. Previously, the bank employed a designated time net settlement (DTNS) system whereby transactions made during a specified period of time were settled together. In contrast, it is foreseen that the merits of introducing the RTGS, which utilizes digital technology and a digital network, will be a reduction in transfer risk in addition to making it possible to avoid the accumulation of unsettled balances.<sup>19</sup>

It is forecast that the introduction of digital programs to complete coordination of organization and transactions will improve efficiencies in economic activity. Furthermore, digital means of coordination and information transmission serving as a medium, there will be a growth in the rebundling of product and organization and ultimately changes in the form of industry and economic organizations. This is examined in the following section.

## **5. Modularization and open architecture**

### **5.1 Informationization and product discrimination**

As set in the second section, in addition to the increase in the volume of information potentially available to businesses and individuals due to the explosion in data volumes resulting from informationization, the cost of collecting and managing data has become markedly cheaper due to the spread of information technology. Because of this, the ultra-goodwill generated through the development of niche markets—which up until now were economically unprofitable and only responsible for limited added value—has jumped following the reduction in costs for finding information and analyzing and evaluating it. Conversely, it has become increasingly difficult to create ultra-goodwill in the major markets that both businesses and consumers alike are very familiar with as product lifecycles have been shortened due to economic acceleration and overall participation has intensified. For businesses informationization has had the effect of limiting the opportunities for goodwill creation in the major markets but expanding the goodwill creation opportunities in niche markets and increasing added value brought about by product diversification.

These changes have not only compelled the advance of product discrimination for the development of niche markets but have also stimulated progress in product design and business forms (organizational architecture). Below we will examine first product design and in particular the response to product discrimination due to modular architecture. Product design and organizational architecture are closely inter-linked and it is thought that the influence of informationization will have an equalizing affect on both. The influence on product form will be the focus of the examination below but it will be relatively easy to expand the discussion to organizational forms.

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<sup>19</sup> For details refer to Bank of Japan, *Bank of International Settlements* (1997) “On the RTGS system G-10 Chuo ginko “Payments, Settlements System Committee” Report, “Real-Time Gross Settlements Systems,” <<http://www.bis.org>>.

In Fujimoto, (1998) architecture is considered on two axes. In this section while preserving this distinction we would like to add some observations from the perspective of economic theory.

These axes are the divisions of (1) modular architecture and (2) integral architecture. Integral architecture is a process whereby each part is designed and custom made so it will fit in with all of the product groups that make up the finished product. By assembling these product groups together we are left with the finished product. In production system terms, it is a construction where the finished product emerges through the parts being put together one by one.

In contrast, modular architecture is the various part groupings that make up the final product are divided into a number of clusters and the parts that make up each cluster are modularized as higher stage parts. In computers, for example, each of the modules or higher stage parts, such as CPU, I/O, hard drive and memory, are manufactured first. Needless to say that the CPU and hard drive are actually an assembly of lower stage parts and before the final product, the computer, is put together, the design method for constructing the mid range parts is none other than modular architecture.

One more axis used by Fujimoto is the distinction between open architecture and closed architecture. Open architecture is a design method (over and above business) where parts, irrespective of whether they are made by the same component manufacturer, are manufactured with a standardized interface to enable their use in a variety of different final products. In contrast, closed architecture is a design method where for each finished product different parts are manufactured, meaning each part is custom designed for the final product that it will be used in. In traditional Japanese auto-manufacturing, when each car is being designed (design in), a number of component manufacturers are invited to submit designs and the best designed products are “accepted” for use in that particular model. As we can see, this traditional Japanese manufacturing method is classic closed architecture. Closed integral systems (enclosed management central to which are its skilled laborers and subsidiaries) are a specialty of Japanese-style management with face-to-face communication as its central element, the importance of which will no doubt continue hereafter.

Fujimoto (2001) suggests that, depending on the product, different combinations of architecture are used as shown in the product groupings below. The open architecture product group shown below is the de jure or de facto standard, as, in some form or another, it has become the industry-standard product architecture.<sup>20</sup> In contrast, as Fujimoto and Kokuryo point out, closed architecture—a method for designing products unique to a particular company—or, more precisely, closed integral architecture, was a particular strength of Japan’s during the 1980s. Both also suggest that, from now onwards, open architecture and modularization will become increasingly important.

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<sup>20</sup> As stated above, “open architecture” does not necessarily mean that an industry standard has been established, but rather that the interface between the parts has been standardized and is defined as method of design that makes it possible to use products from different companies and still be able to connect them together.

	Closed architecture	Open architecture
Integral	Mainframe [computers]	
Module	Automobiles Notebook Computers	Desktop computers, automobiles

In section 3.5, the explanation that modularization was advanced even in a closed architecture due to the ease of checking for damaged parts and coordination between the parts was given. The issue that now remains is why modularization and open architecture have both developed at the same time. In the following section, the potential advantage of combining modularization and open architecture is examined.

### 5.2 Modularization and open architecture

The main premise of open modular architecture is the existence of a “standard interface” for connecting the modules. For example, so-called IBM compatible (or PC) desktop computers are made up of various components such as the CPU, OS, and hard drive. Each of the components are made in series: in the case of CPUs there are the Pentium III series of processors that come in speeds such one gig hertz, 933 megahertz, 700 megahertz and so on manufactured by Intel; the Celeron series of processors also from Intel; and series manufactured by other companies. In the case of operating systems, there are the Windows series and the various manifestations of Linux amongst others. In the case of the remaining components such as hard drives and monitors the competition is much more intense with a much wider array of manufacturers producing components of varying quality.

In the case of open module architecture, if the interface is actually standardized across different products and different companies, it is possible to interchange between different types of products from same company and different types of products from different companies. For example, it is easy to swap a 17 inch [CRT] monitor manufactured by company A for a 15 inch flat panel display manufactured by company B due to the standardization of interfaces. The desktop computer personal computer I had before I changed over to this new desktop, are certainly very similar products but they were in fact different.

As outlined in the previous section, the modularization of components is very beneficial to overall product coordination. The desktop computer is divided in to a number of parts, each part is modularized and coordinated inside. By having the machine output via the interface the information necessary to coordinate the whole thing from the completed module, able to coordinate the completed item as a collection of modules.

Furthermore, modularization based on open architecture is very cost-effective. For example, company A can only use a limited number of company X’s one gig hertz CPUs in the computers it assembles. But if company X’s CPU is used by companies B, C D and E—a large number of computer manufacturers (finished product)—this greatly increases the volume of production of company X’s CPUs. Due to standardized interfaces it is possible to use components from a variety of different companies, the production quantities of modularized components are huge making it possible to

achieve excellent economy of scale. This, in turn, keeps costs lower which is beneficial for consumers and business alike.

The acceleration in economic activity has effectively shortened the product lifecycles and trends—a very important issue for businesses to deal with. With integral architecture designed products, the process from design to manufacture changes completely with each new product produced, making the process of product development both expensive and slow, preventing any kind of rapid response. In contrast, with modular architecture, it is not necessary to completely reconstruct the whole product. By simply technologically revamping each module, it is possible to produce a revised product cheaply and quickly allowing rapid, cost-effective responses to economic acceleration.

### **5.3 Modularization and product discrimination**

When compared to integral architecture and closed modular architecture, open modular architecture has a clear advantage. That is, if various product groupings have been prepared for the individual modules, it is possible to build a variety of different finished products using various combinations of modules. Well-known examples of this are products assembled from hardware modules—such CPUs, RAM, hard drives and displays—and software modules—such as operating systems and other related software—under the so-called IBM compatible PC open standard (standardized interface).

In this kind of modularized product, the availability of a variety of different modules exponentially increases the variety of finished products. For example, if we have a finished product assembled using  $m$  number of modules and each of these modules have their own subcategory models— $n$ . In this case the variety of different finished products is represented by  $m \times n$ . That is, it is possible to make  $m \times n$  combinations of the finished using  $m \times n$  individual modules. Say, for example, we have 3 speeds of CPU—500mhz, 750mhz and 1ghz, and three different sizes of display—12 inch, 15 inch and 17 inch. For the sake of simplification, if we were to assemble a desktop computer using these 2 components, we would have a 500mhz with a 12 inch monitor as our base model and a 1ghz with 12 inch monitor as our speed-maximized-under-budgetary-constraints-model. All together we would be able to produce 3 squared giving us a total of nine different computers. Moreover, the total number of modules required to achieve this was only six.

What's more, if the interface is standardized in the industry and open to different businesses, a number of businesses will be involved in the manufacture of that module (for example, a 15" monitor) stimulating competition which will ultimately result in lower prices and improvements in quality. At the finished product end of the scale, competition will also intensify through manufacturers adding value and their own design to the basic configurations.

Modular architecturally designed products manufactured under this kind of open standard have the following advantages: (1) the product groups within modules can be coordinated in the most appropriate manner; (2) by outputting the summary information, the final product can be attained by the coordination of the modules, and therefore, the burden on the final stage of production can be reduced; (3) possible to reduce both time and labor when either repairing components or performing routine maintenance on each module; (4) when a component fails, prior to even identifying the part at fault, [the

problem can be remedied] by simply by exchanging the affected module improving the convenience factor for the consumer (5) that it is possible to build various products by simply changing the way in which the components are assembled; (6) competition between module manufacturers leading to cheaper prices and improved quality; (7) increase in competition between businesses that assemble the finished product through the assembly of modules.

Of course, there were still being products that are not suited to production based on open modular architecture. However, it is likely that the increase in the level of freedom of in coordination that has followed the development of digital technology and digital networks, will continue to popularize open modular architecture with all of the advantages that it brings.

## 6. Conclusion

In this paper, the influence that the development of IT has had on economic systems from three perspectives were examined: “informationization;” “digitalization;” and “the completion of coordination through electronic programs.” Though these trends are still full of uncertainty. As suggested in relation to NPO/NGO activities, the development of information technology may actually take its place in traditional economic activity. Furthermore, just as the future was unclear during the time of the second industrial revolution from the end of the nineteenth century to the beginning of the twentieth century, it is impossible to forecast the outcome of the current IT revolution—what has been dubbed as the third industrial revolution.

Although the current experiences are clearly different from past economic phenomena (in product, organizational and transaction form), this paper pointed out a number of these differences and observations as to why these phenomena are occurring. If these observations have been helpful to the reader, this is more than we could have hoped for.

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