

Unrealistic Concept of Disruptive Technology in "The Innovator's Dilemma" by Christensen

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1. Introduction

Christensen's famous Book "The Innovator's Dilemma" was published¹⁾ in 1997 and was chosen as the best business book of 1997 as well as the best business 'How-To' book of 1997, where many pages were dedicated to the HDD industry to certify his model for the downsizing of HDD to be a disruptive technology to destroy the great firms.

Recently, I had a chance to look back the history²⁾ of the HDD industry for a recent quarter century and pointed out questions on his descriptions in the Book, especially regarding to the HDD industry³⁾.

It could be a good timing to verify the events at the downsizing and its meaning, now that the last production of 1.8"HDD was finished in 2014 and the downsizing is virtually over in the industry, history of which is said to be fast according to the Book.

Christensen stated in the Book : "But the value of understanding this history is that out of its complexity emerge a few stunningly simple and consistent factors that have repeatedly determined the success and failure of industry's best firms. Simply put, when the best firms succeeded, they did so because they listened responsively to their customers and invested aggressively in the technology, products, and manufacturing capabilities that satisfied their customers' next generation needs. But, paradoxically, when the best firms subsequently failed, it was for the same reasons
— . . ."

2. Christensen Model

According to Christensen, a disruptive technological change to make the performance lower would occur when it exceeds the high-end market demand by the entrant company. The performance is improved gradually by the progress due to the sustaining technologies aiming the high-end market. The existing company, which listened to their customers' needs, would tend to adhere the existing technology and fail. A schematic diagram is shown in Fig.1. Even when the performance does not exceed the high-end market needs, the entrant can enter into the lowest ranking value network at first and then will go up higher ranking value network by improving the performance if the entrant's progression speed is higher than the great firm's one as is shown by a heavy line in Fig.1 added by me.

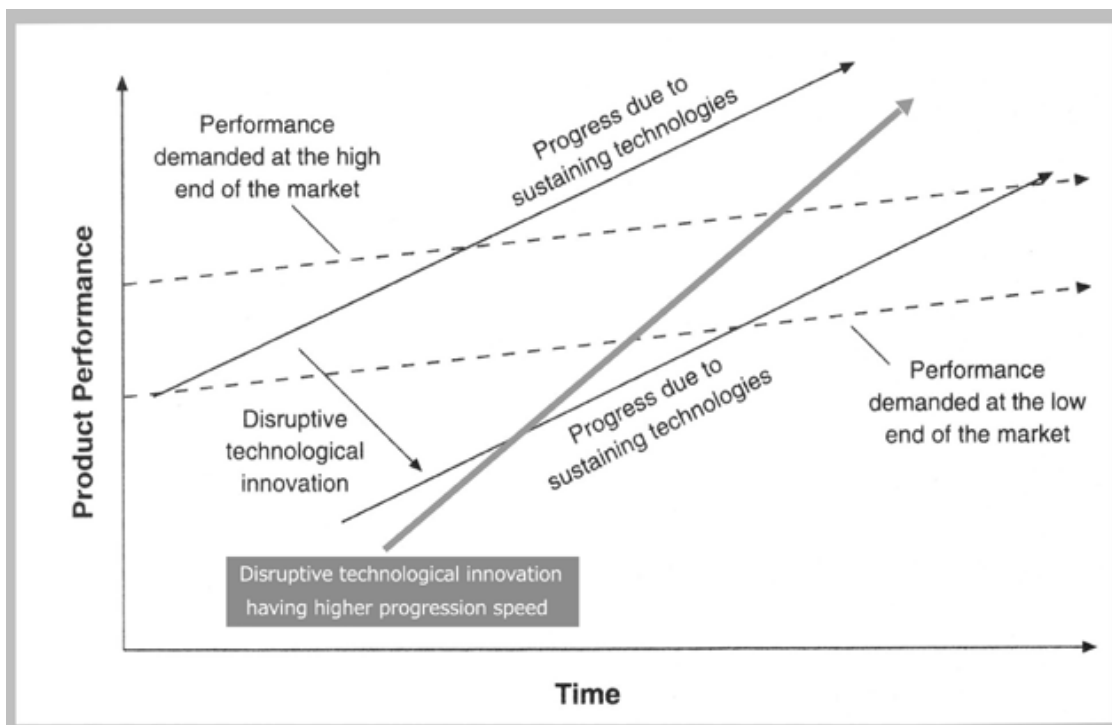


Fig.1 The Impact of Sustaining and Disruptive Technological Change

3. Characteristics of Disruptive Technology of Downsizing

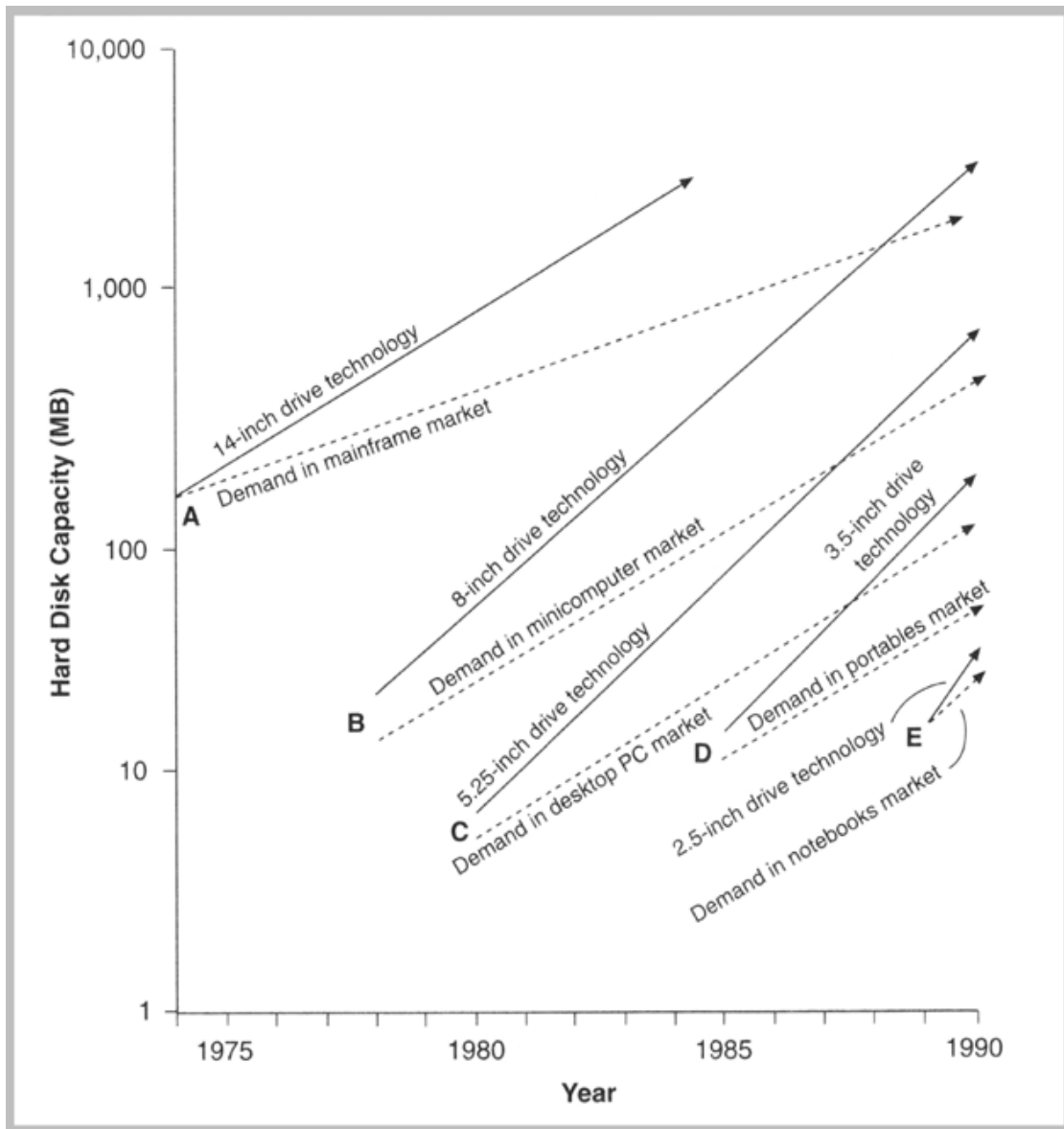


Fig.2 Trajectories of Capacity Demand vs HDD Capacity

According to Christensen, the downsizing of HDD occurred and the capacity increased due to the sustaining technologies as is shown in Fig.2.

In order to verify the characteristics of the disruptive technology of the downsizing, the information of the commercial shipments is necessary as is shown in Fig.3.

From the meaning of a word "disruptive" , the shipment of HDD of the original

form-factor must become significantly smaller than that of HDD of the smaller new form-factor. A corresponding figure in the Book shall be introduced in Fig.4.

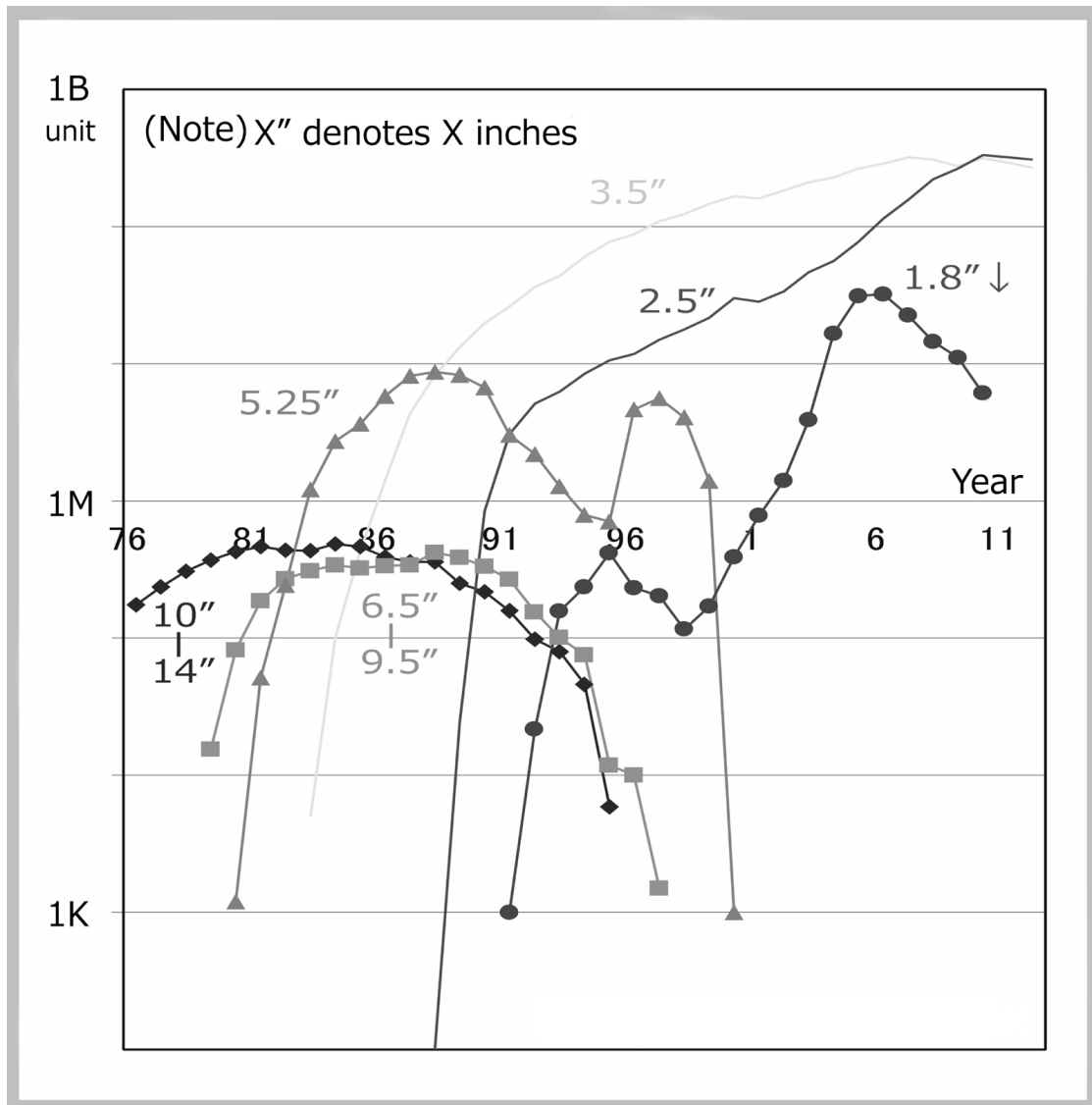


Fig.3 Unit of HDD shipment for 35 years according to form-factor

The Form-factors fit for the above criteria were 5.25" and 3.5". The downsizing of 2.5" to 1.8" should not be the disruptive technology though Christensen defined it as disruptive one, 1.8"HDD scarcely affecting the shipment of 2.5"HDD. There were only two candidates of the disruptive technology after 5.25", from which form-factor PC use has emerged and the tough competition has begun.

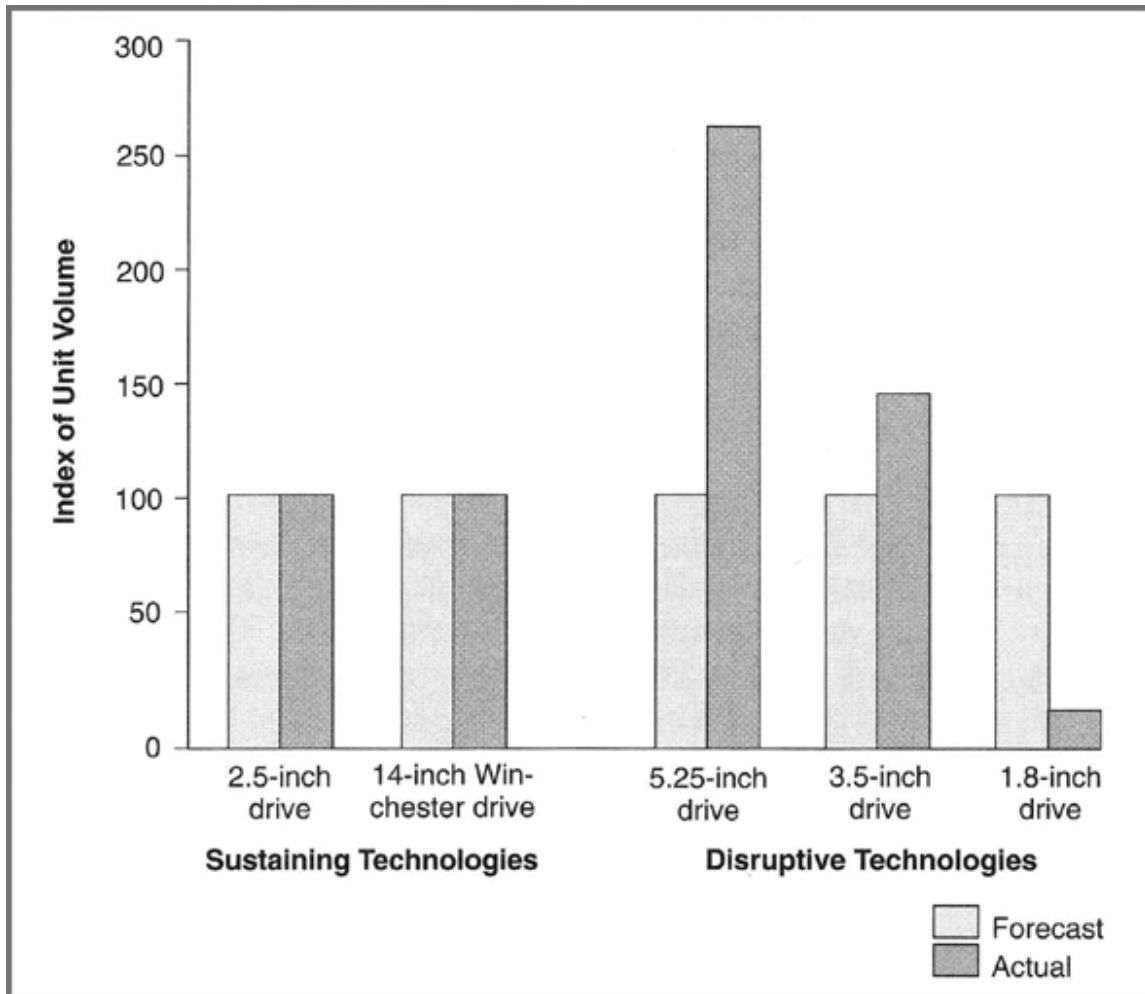


Fig.4 Differences between Forecasts and actual Shipments for 4 years

Christensen used the forecast of Disk Trend Report for the judgment of the downsizing to be sustaining or disruptive. It was not reasonable to rely on someone's forecast, which is essentially subjective, for the judgment which is to be objective.

At the downsizing to 3.5", Rodime, to 2.5", Prairie Technologies and Conner Peripherals, to 1.8" of the first wave, Integral Peripherals, Ministor and Maxtor failed. Conner and Maxtor could not be regarded as the entrants at that time frame already. In 1991, a great firm HP started 1.3"HDD project and failed lacking the profitable market.

In the second half of the 1990s, Seagate has successfully developed a high-end HDD of 3"/2.5" in 3.5" enclosure to improve access time by achieving 10k/15k rpm.

Quantum succeeded for a certain period upsizing to 5.25" to increase recording capacity(see the second wen of 5.25" in Fig.3).

The second wen of 1.8"below HDD also tells us that the market needs is the key even for the downsizing of HDD.

Toshiba succeeded in ramping up 1.8"HDD business and continued for 15 years(see the second wen of 1.8" in Fig.3). IBM developed 1"HDD(microdrive) aiming high capacity market of the compact flash memory. The recording capacity of HDD was increasing 100% every year at that time frame, which was little bit higher than that of the flash memory, owing mainly IBM to introduce MR technology to the head one. The increasing speed of the recording density, however, became lower and 1.8" below HDD lost the superiority against NAND flash memory over time and reached the end of life. Therefore NAND flash memory could be defined as a partial disruptive technology of HDD. By the way, 2.5"HDD is considered to have a longer product life as the NAND flash memory is also losing the speed of recording density increase. Any way, there could occur many unpredictable happenings during so long time.

By the above verification, it has turned out, I think, that the downsizing of HDD is not appropriate for the Christensen model at least for the latest quarter century. Then how was it about 1980's or before?

4. Meaning of Downsizing of HDD

According to Christensen, innovation of the head technology is shown in Fig.5

which is defined as the sustaining technology to increase sensitivity.

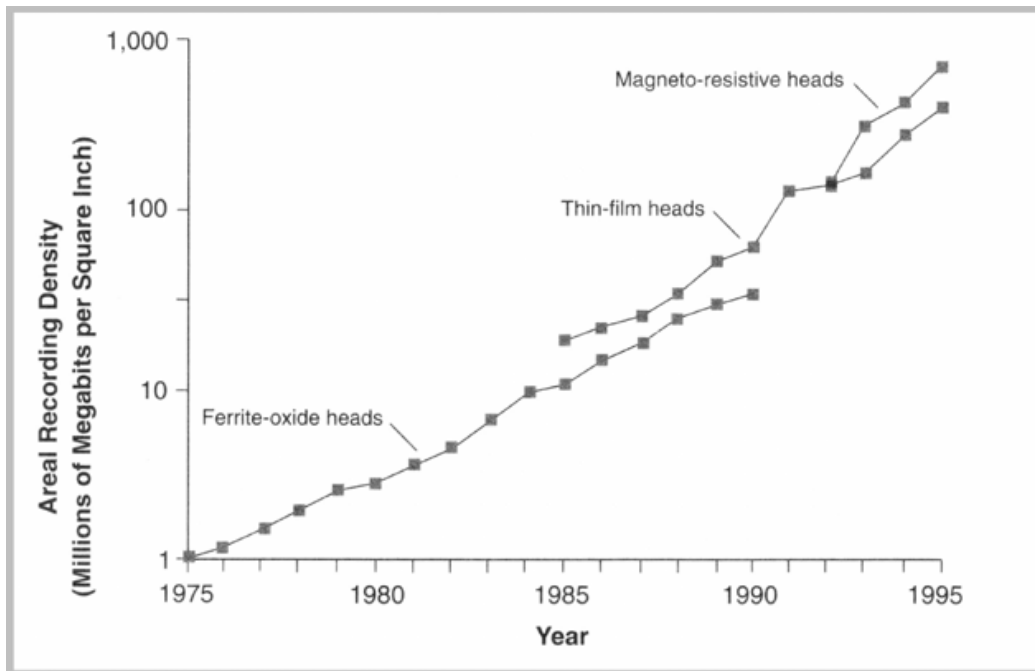


Fig.5 Progress of Head Technology

The improvement of the recording density can be attained with the conjoint progress of related components and coding method. Among them, head and disk have very close mutual dependence. For the disk, smaller magnetic particle size is required to make a bit size smaller with closer head flying height.



Fig.6 Example of Coating Type HDD

We can easily imagine how coating type HDD was a large-scale apparatus having

so small recording capacity. In order to make the head flying height lower, the vibration shall be controlled and disk surface shall be flattened. It is very hard to make magnetic oxide particles fine with milling process. Coating process of suspension has also issues based on aggregation. Sputtering process, which is fit for smaller disks, gives us fine magnetic particles on the disk surface, fine enough to achieve higher and higher recording density by the sustaining technological progress. Fine particle results to the excellent surface flatness. Therefore, the downsizing was inevitable for increasing recording density, then capacity and should be essentially regarded as the sustaining technology.

Fig.7 is an image of head flying height, which tells us how subtle and exquisite the foundation of HDD technology is.

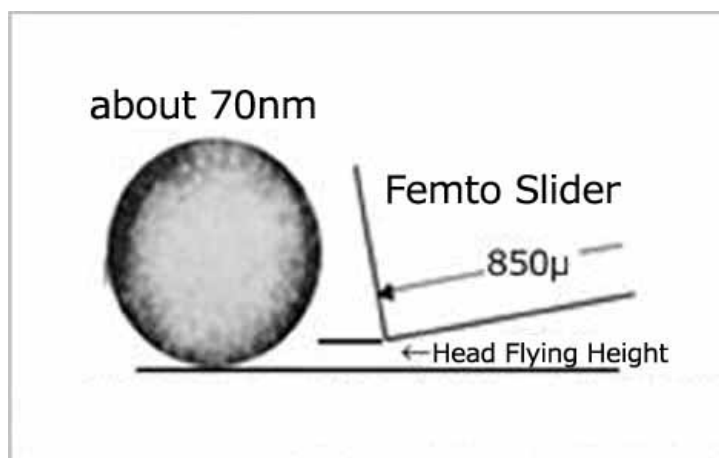


Fig.7 Image of Head Flying Height

According to the Book, "Generally disruptive innovations were technologically straightforward, consisting of off-the-shelf components put together in a product architecture that was often simpler than prior approaches." This was not the case in the HDD industry. There were no off-the-shelf components used in the key components for HDD. Especially when the coating disks changed to the sputtering

ones, technological crevasse should be large as well as when disks for MR heads were developed and when disks for vertical recording were introduced.

I have to insist again that the downsizing to a certain form-factor, say 3.5"~2.5", was inevitable and it was essentially the sustaining technology. Christensen recognized that the great firms were leader both for head and disk technologies and were standing by the downsizing. IBM's technological advantage maintained till the second half of '90's was symbolic. Such circumstances, however, was not reflected to the Christensen model.

5. Example of Established Technologies vs Disruptive Technologies

Table 1 is examples of the disruptive technologies by Christensen, which will transmit his image of the disruptive technology other than the downsizing of HDD.

Now let me introduce my comments on this table as follows:

Digital photography had fierce disruptive power to Silver halide photographic film. Fuji Film, however, had prepared countermeasures taking the situation into account. Customers' response must be different from those of the Christensen model.

It could not be regarded as an example of the Model that Kodak applied Chap.11 at 2012 because too much time has passed since the digital photography appeared.

Mobile telephony also affected to wireline telephony as well. But it was easy for the great firms like NTT to estimate the influences and NTT established NTT Docomo, a cellular phone company. Besides, disruptive power is partial in this case.

Packet-switched communications networks have caused a revolution in the communication net works and have had driving force to build today's IT society. It was 1965 when the theory was established. Effort to apply the invention has started

immediately in USA and Britain, the inventors' country. But who was able to imagine the today's IT world at that time. Generally speaking, revolutionary disruptive technologies need long term to penetrate, meanwhile we can have ideas for new businesses. Situation change might occur as is introduced in section 3.

Table 1 Established Technologies vs Disruptive Technologies

Established Technology	Disruptive Technology
Silver halide photographic film	Digital photography
Wireline telephony	Mobile telephony
Circuit-switched telecommunications networks	Packet-switched communications networks
Notebook computers	Hand-held digital appliances
Desktop personal computers	Sony Playstation II, Internet appliances
Full-service stock brokerage	On-line stock brokerage
New York & NASDAQ stock exchanges	Electronic Communications Networks(ECNs)
Full-fee underwriting of new equity and debt issues	Dutch auctions of new equity and debt issues, conducted on the Internet
Credit decisions based upon the personal judgment of lending officers	Automated lending decisions based upon credit scoring systems
Bricks & mortar retailing	On-line retailing
Industrial materials distributors	Internet-based sites such as Chemdex and E-steel
Printed greeting cards	Free greeting cards, downloadable over the Internet
Electric utility companies	Distributed power generation(gas turbines, micro-turbines, fuel cells)
Graduate schools of management	Corporate universities and in-house management training programs
Classroom and campus-based instruction	Distance education, typically enabled by the Internet
Standard textbooks	Custom-assembled, modular digital textbooks
Offset printing	Digital printing
Manned fighter and bomber aircraft	Unmanned aircraft
Microsoft Windows operating system and applications software written in C++.	Internet Protocols (IP), and Java software protocols
Medical doctors	Nurse practitioners
General hospitals	Outpatient clinics and in-home patient care
Open surgery	Arthroscopic and endoscopic surgery
Cardiac bypass surgery	Angioplasty
Magnetic resonance imaging (MRI) and Computer Tomography (CT) Scanning	Ultrasound-initially floor-standing machines, ultimately portable machines

Hand-held digital appliances like tablet PCs are a partial disruptive technology of notebook computers as their function is limited.

There seems to be no exact example of Christensen model in the Table.

I will show you another questionable example other than the downsizing of HDD.

From the Book.

Christensen introduced minimill process as a disruptive technology of the established steel making one. The scenario is attractive for the entrants to start from products of the lowest value network and to run up to those of the highest value network eventually by the sustaining technological progress.

The minimill might be regarded as to have cost advantage to make crude steel where there are enough scrap sources. As far as refining process is concerned, however, the minimill process itself has no advantage comparing to the existing process. Besides, it has another big issues due to the characteristics of scrap. It is hard to remove metal constituents, especially more precious than iron, Ni, Cr from stainless steel, Zn, Sn from surface treated steel and Cu from steel-other metal composites.

In USA, more than 60% of steel products is provided by the minimill, while in Japan, about 20%. What is written in the Book on the minimill could be a good advice for the US steel manufacturers. But the minimill is merely a complementary process of the existing steel making ones, that can not be its disruptive technology essentially.

It shall not be an example of the Christensen model that Developing countries enter into low-end markets at first based on low price owing to currency depreciation, low labour cost and low infra cost and run up to high-end markets by the sustaining technological progress after getting such capability.

Effect of the long-term disruptive technologies shall be discussed as a different

item from the Christensen model.

6. Discussion

The concept of disruptive technology itself looks attractive, especially for the entrants and Christensen's explanation in the Book was so sophisticated and plausible at first glance that the Book might be welcome. But we have to recognize it is hard to find out the cases fit for the Christensen Model based on his definition of the disruptive technology. The proof of no examples is a kind of devil's proof.

There might be still many supporters of Christensen Model. They should show the examples based on his definition exactly because this kind of concept belongs to a category of management engineering and should be useful in the real business world.

Apart from the Christensen's Disruptive Technology, I will try to find out "blue birds" of the disruptive technology to destroy excellent companies paying attention to a key word "surprising" or "overlooking".

References

- 1) Clayton M. Christensen : "The Innovator's Dilemma" HBS Press(1997)
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- 3) Jiro Nishimura: "The Downsizing of HDD and the Disruptive Technology" Chemical Engineering of Japan 79(No.1) pp.85-88(2015) (A report written in Japanese)