1.2.2 Types of innovation

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Abstract

Broadly speaking, large companies appear to have a greater chance of gaining an advantage in capturing the fruits of innovation compared to startups. However, innovation can prompt a shift between startups and incumbent large companies. Why would an incumbent market leader, which should have a dominant market position, lose their position? Below, I examine the "characteristics of change" brought about by innovation and the causes behind the shifts in leading companies, focusing on: (1) the magnitude and continuity of change; (2) impact on existing capabilities, knowledge, and resources; (3) the level of change in product systems; (4) the relationship with users; and (5) structural changes in industries as a whole.

1 The magnitude and continuity of change: Incremental and disruptive innovation

In order to discern whether change works in favor of incumbents or new entrants, it is necessary to focus on the characteristics of the changes produced by innovation. The question is whether the changes brought about by innovation are incremental and continuous or disruptive and discontinuous. In general, when innovation brings about incremental and continuous change, it tends to favor incumbent firms, whereas when innovation brings about disruptive and discontinuous change, it tends to favor emerging new entrants. In terms of patterns of innovation, in the ascending stage of the S-curve of technological progress or the fluid and transitional stages of the Abernathy model, the information, knowledge, and experience accumulated up to that point are useful for innovation in terms of both product and production technology, and incumbent companies that are ahead of the curve can gain an advantage. In the stage premised on a dominant design—in which the necessary elemental technologies and the basic concept of the product have

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been established—the company will seek to specialize in a series of operations such as technology development, production, and sales by hiring, training, and efficiently organizing the necessary engineers and staff ahead of other companies. As such, specialization through the thorough division of labor and the pursuit of efficiency is the key component of competition. There is not necessarily a lot of room for new entrants to come in and take on this challenge.

However, innovation does not always lead to incremental and continuous change. The pursuit of efficiency will eventually reach its limits, providing an opportunity for discontinuous and disruptive innovation to emerge. In other words, this is a phase of transition from one technological system (S-curve) to another (S-curve). This kind of change is sometimes called a "paradigm shift" or "dematurity." During this phase, past know-how and knowledge accumulated up to this point are useless, and it becomes necessary to hire engineers with different specialties to those hired in the past. It is also necessary to rethink the organizational structure and assumptions about regions and customers. Middle managers and executives with a proven track record in traditional technology areas may also resist change. Rather than making risky investments in immature new technologies, it is natural for human beings to want to think of scenarios that will drive out new technologies by investing in more reliable existing technologies.

Incumbents are placed in a particularly difficult position when the introduction of new products and services erodes the revenue of existing cash-cow businesses. Indeed, even if they have the same opportunity to realize the same innovation, and even if they share similar assessments of its potential, its expected benefits will vary from company to company. If a company is engaged in a business that directly competes with a new product or service, the expected profit will be smaller to the extent that the profit of the existing business is eroded—that is, the so-called cannibalization of existing business by new business. In contrast, startups—which start from scratch—have nothing to lose, so their expected profits are higher.[2]

If a product is technologically innovative but does not compete with existing products on the market, incumbent companies stand on equal footing with startups. However, where existing products or businesses are replaced, the incentive to focus on new products and services is reduced. Indeed, as they are making steady profits from their existing business, they tend to be stricter in their assessment of risky new products. Accumulated past knowledge—a strength in incremental innovation—becomes chains from the past in disruptive innovation.[3]

There are a number of reasons why accumulated strengths can turn into hindrances, such as distorted perceptions of environmental changes at the individual and organizational levels (i.e., cognitive bias), and individual and organizational ties. Consequently, incumbent companies are hesitant and resistant to new technologies, resulting in their falling behind emerging companies and losing their prominent positions in the market. Some companies underestimate new technology and focus on improving old technology. Even if you focus on both new and old technologies, a two-pronged strategy may disperse management resources,

2 Chandy and Tellis (1998)
3 Leonard-Barton (1992)

resulting in neither being successful. This was exemplified by the many silver halide film manufacturers that failed to take appropriate measures to respond to the trend of digitalization.[4]

Nonetheless, when we talk about "discontinuous" innovation, to what extent is it actually "discontinuous"? Whether something is discontinuous or not is relative to the market environment and the individual company facing the change. Will the leading roles in discontinuous innovation always change? Is the cannibalization between existing and new businesses the only reason why incumbent companies are reluctant to respond to the new products appearing under their nose? Are there changes in the leading roles in seemingly continuous innovation? As explored below, the relationship between innovation and the rise and fall of companies is not always simply a matter of gradual and continuous innovation being an advantage for incumbent companies, and disruptive and discontinuous innovation being an advantage for emerging companies. This point is worth discussing further.

2 Impacts on existing capabilities, knowledge, and resources: Reinforcing and destructive

2.1 Reinforce or destroy existing capacity

In exploring the impact of innovation on competition, a key consideration is the perspective of how the changes brought about by innovation change a firm's existing capabilities. Tushman and Anderson took three industries—namely, the airline, cement, and minicomputer industries—to see how "discontinuous" technological advances impacted corporate competition.[5] They found that in some cases, incumbent companies led innovation and continued their business as a result, while in other cases, new entrants led innovation and many incumbent companies exited. This suggests that even discontinuous technological innovation, often described as "extraordinary" technological progress, can have very different impacts on firms' existing capabilities. In the former case, past know-how remained effective; in the latter case, it was no longer useful. Tushman and Anderson referred to the former as "competence-enhancing innovation" and the latter as "competence-destroying innovation."

Let us review the cement industry they examined. There have been three discontinuous innovations since the start of cement production in the US in 1872. First, the introduction of rotary kilns, which used powdered charcoal, in the 1890s saved on labor and stabilized quality. Second, the introduction of the long kiln (patented by Edison) in the 1900s increased economic efficiency. Third, very large kilns with computerized process control were introduced in the 1960s. Each of these innovations resulted in a dramatic increase in production efficiency.

The first of these innovations rendered previous know-how concerning the use of human labor to burn wood to make cement obsolete, and was thus a capability-disrupting innovation. Accordingly, it was mostly new companies that were actively involved in the introduction of rotary kilns, resulting in many new

4 Tripsas and Gavetti (2000)
5 Tushman and Anderson (1986)

companies entering the cement industry. In contrast, the latter two innovations were sustaining insofar as they used coal-fired rotary kilns, and were thus capacity-building innovations. As a result, incumbent companies led the adoption, new entrants did not increase, and no significant changes occurred on the industry map.

What is clear from these examples is that even if an innovation is at first glance discontinuous by an order of magnitude, its impact on competition will differ depending on the extent to which the underlying technology is a continuation of existing technology.

2.2 Transformational power

In examining the impact of innovation on competition, we must pay attention to more than just the impact on existing capabilities from a technological perspective. It is also necessary to focus on its relationships with customers and markets, which is precisely what Abernathy and Clark do.[6] They examine how innovation affects a company's existing management resources, skills, and knowledge, which they call transilience. In terms of both technology (i.e., the form of products, production, and operations) and markets (i.e., the relationship with markets and customers), innovation is classified into four types based on whether the transformative power of innovation is disruptive (i.e., existing resources lose value) or conservative (i.e., value is retained).

1. An example is the Ford Model T, a disruptive innovation developed by Ford that was disruptive in terms of both the market and technology. In addition to being groundbreaking in terms of the product and production technology, this innovation opened up a new market, namely, the mass market. Mass production implies the establishment of mass production at the same time as the creation of a mass market.
2. An example is the Model A developed by Ford, a company that was conservative in terms of technology but disruptive in terms of market innovation. Introduced in 1926 as the first new model since the Model T, the Model A was intended to create a market for a mid-sized car for the growing urban family segment.
3. Conservative in terms of market, but disruptive in terms of technology. An example was the enclosed steel chassis introduced in 1921. The enclosed chassis, which replaced the open wooden chassis, changed the design of automobiles significantly, shifting the focus of competition to convenience, comfort, and performance, and changing the production system from one that relied on the skilled labor of wooden chassis manufacturers to one that relied on late-stage molding by machines.
4. Although conservative in terms of market and similarly conservative and low-profile in terms of technology, its cumulative impact was far from small. For example, the price of the Model T dropped from USD 1,200 in 1908 to USD 290 in 1926, due to the contribution of minor

6 Abernathy and Clark (1985)

> improvements in various areas such as casting, welding, assembly, and alternative materials, which produced remarkable productivity gains. In terms of product technology, improvements in reliability and performance were also built up.

Each of the four types of innovation has a different impact on competition. The most dramatic is the first type, which is a disruptive transformational force both technologically and commercially, but the remaining types also have varying impacts on competition. For example, the advent of the enclosed chassis put small automakers that relied on wooden body manufacturers in a difficult position. In the 1930s, Chrysler created disruptive technological innovations in carburetors, body design, and transmissions to increase its market share. Both of these are representative of the third type of innovation, which is disruptive in terms of technology and conservative in terms of market. Japanese companies have been good at the fourth type of innovation, which is conservative in terms of both technology and the market. It is well known that Japanese companies have increased their market share through this type of innovation.[7] The issue is that different types of innovation bring about varying degrees of change in the external environment and different levels of change, and different management approaches and considerations are required to deal with the ensuing changes.

3 Different hierarchical changes: Parts and connections

In some cases, innovations that are seemingly gentle, unobtrusive, and an extension of existing technological accumulation can put incumbent companies in a difficult position. These are cases that cannot necessarily be explained within the framework described so far. For example, the US company Xerox, which had taken the lead in the development of xerography and dominated the photocopier business, was unable to cope with the Japanese attack on small photocopiers, and RCA, which had licensed its technology to Sony for a long time, was unable to bring to market a product that could compete with Sony's small transistor radios.

Accordingly, Henderson and Clark focused on the hierarchy of change that innovation brings.[8] Defining a product as a product system consisting of subsystems that could be called components (i.e., elemental technologies and parts), they note that the changes brought about by innovation comprise two types of change: changes that occur at the individual component and elemental technology level, and changes in the way those components and elemental technologies are put together to create a product. More specifically, changes that occur at the component level are called "modular innovation," while changes that occur at the level of how things are connected are called "architectural innovation."

In many cases, it is when the way in which components and elemental technologies are combined changes that incumbent companies struggle to respond to seemingly continuous innovations, even though there is no significant change at the individual component or elemental technology level. In this respect,

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7 Cusumano (1988)

8 Henderson and Clark (1990)

the authors cite the example of innovation in photolithographic equipment, a type of equipment used to manufacture semiconductors. The first generation of such equipment was a type called "contact exposure," in which the mask and wafer were directly attached to each other and exposed to light. Casper, an American company, was one of the major manufacturers of this generation. However, due to problems of contamination and scratches, a second generation, the proximity contact method, in which the image of the mask is projected onto the wafer, was introduced. In response to this generational shift, Casper entered the proximity exposure market, but without success, lost its leading position to Canon and other companies, and withdrew from the industry.

There was little difference in the elemental technology of the two generations. In fact, the majority of proximity-type units also had the option to be used with the contact process. For this reason, Casper regarded the Canon proximity model as nothing more than an imitation of its own product. However, in reality, there were fundamental differences between the two generations in terms of the relationship between the components and the way in which they were put together to form a product. Simply put, as the proximity type is non-contact, accurate positioning of the mask is required, and the key lies in putting the relevant parts together to achieve accuracy. However, Casper, which was unable to shift from shipping contact-type units, was unable to recognize the location of the problem itself and could not improve the accuracy of the structure and systems of technology development that had been built premised on the contact method. Although Casper received complaints from users of the proximity-type equipment, the company was locked into thinking of things as an extension of its experience with the contact exposure process. As with complaints made about the first generation, issues were ultimately treated as being on the user's side and not as issues with the devices themselves.

A change in a specific part can trigger a change in the way the whole is connected. For instance, when jet engines were introduced on aircrafts, this was not just a change in the source of propulsion. Indeed, the adoption of jet engines forced a review of the entire structure of aircraft. Boeing, which increased its market share, is said to have successfully tackled this problem. Even if parts change, as in jet engines, they may still be easy to recognize. When the only change is in the way the parts are connected, as with the proximity exposure technique, it is even more difficult to recognize, and consequently review the organization and development process accordingly.

The structure of organizations involved in product development (i.e., how teams are divided and how they cooperate) and processes (i.e., information flow and problem-solving procedures) are created on the basis of how certain parts are connected and assembled. This is not easy to change. The more successful companies of the previous generation are created on assumptions about how certain parts are connected and assembled, making it more likely that their former strengths will be exposed as weaknesses when those assumptions have to be revised. The impact of an innovative change should not only prompt us to focus on its magnitude, continuity, and relationship with existing technologies and markets, but also on the hierarchy of change—that is, on identifying what level of the product system the change occurs.

4 Changes in the value chain: Customer relationships

As Abernathy and Clark point out, in order to examine the competitive impact of innovation, it is important to pay attention to changes in both the market and technology. In tracing the history of technological innovation and the rise and fall of companies in the American hard disk drive industry, Christensen focused on the importance of customer relationships.[9]

In the hard disk industry, incumbent companies had no problem handling innovations that were extensions of traditional axes of performance-evaluation, regardless of whether it was a capability-disrupting change or a change in the way components were connected. This was because the primary users remained the same, whatever the nature of the innovation. If key users recognize that new technologies are important and demand them, incumbent companies will work frantically to address them. This is a very natural process.

However, this is not the case where the axes of evaluation for performance demanded by customers differ and the value of the product is not recognized by existing major customers. For example, when 5.25-inch drives were proposed during the heyday of 8-inch disk drives in the early 1980s, the latter's advantage was only its size and weight. Although small and light, these drives were far inferior to 8-inch drives in terms of storage capacity, access type, and cost per megabyte. Minicomputer manufacturers, who were the main users of 8-inch drives, thus found 5.25-inch drives unattractive, resulting in existing hard disk drive manufacturers having no reason to focus on 5.25-inch drives. Even if company engineers were interested in 5.25-inch drives, upper management meetings prioritized resource investment in 8-inch drives for mainstream customers.

Meanwhile, new entrants in the 5.25-inch drive market approached fledgling PC makers in search of new customers. For desktop PCs, the small form factor and light weight of 5.25 inch drives was highly valuable, thus creating a market for 5.25 inch drives. Subsequent accumulation of technology surrounding 5.25-inch drives made it possible to expand their capacity, eventually surpassing 8-inch hard disk drives. Leading 8-inch drive manufacturers, who had focused solely on minicomputer manufacturers, were late to the party, and lost their leading roles to 5.25-inch drive manufacturers as a result. Similar changes in leading roles took place in the shift from 14-inch to 8-inch drives, and from 5.25-inch to 3.5-inch drives.

It is not unusual for a new technology to start in a small market. When transistors first appeared, it was thought that their use would be limited to a handful of applications because they faced greater limitations compared to vacuum tubes in terms of frequency, power, heat resistance, and price. Jet engines were similarly limited to military aircrafts, and many companies believed that propellers would endure as the mainstay of commercial aircrafts. Even when the telephone first appeared, companies that provided telephone services saw it as a technology with limited applications and markets. It was thought that the main customers of long-distance communication services would be offices that exchanged information in writing, and that it would only be a handful of rich eccentrics engaging in the poor-quality calls.

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9 Christenson (1997)

If a new technology is aimed solely at a limited number of applications, there will be no major problems. However, when the technology advances in a way that was not initially anticipated, it will eventually expand its applications and market, eventually eroding the existing market. When this happens, companies that underestimated and delayed their response will be caught flat-footed.[10] This is precisely Christensen's point. Listening to your existing key customers is a pitfall. Of course, existing key customers are important because they provide the day-to-day revenues that support day-to-day business. However, there is no guarantee that existing key customers will remain key customers forever. While you must listen to your existing key customers, you also need listen to those who may become key customers in the future. As such, it is important to have an attitude that is attenuated to customers' needs and which asks where customers with cutting-edge needs are to be found.

This paper is a summary of Chapter 3 of Hitotsubashi University's Institute of Innovation Research (2017), please refer to this book for further detail.

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10 Rosenberg (1995)

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