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Benefits and Costs of Closed Innovation Strategy: Analysis of Samsung's Galaxy Note 7 Explosion and Withdrawal Scandal

Jinhyo Joseph Yun [1,*], JeongHwan Jeon [2,*], KyungBae Park [3] and Xiaofei Zhao [1]

[1] Department of Open Innovation, Open Innovation Academy of SOItmC, Convergence Research Center for Future Automotive Technology, Daegu 42988, Korea; qiaoke@dgist.ac.kr
[2] Department of Industrial & Systems Engineering/ERI, Gyeongsang National University, JinJu 52828, Korea
[3] Department of Business Administration, Sangji University, Wonju 26339, Korea; kbpark@sangji.ac.kr
* Correspondence: jhyun@dgist.ac.kr (J.J.Y.); jhjeon@gnu.ac.kr (J.J.)

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Abstract: The Samsung Galaxy Note 7 has been withdrawn from the market after a number of the devices exploded after its launch in 2016. Our research seeks to answer three questions and proceeds as follows. Did the closed innovation of Samsung trigger the Galaxy Note 7 withdrawal? If so What are the costs and benefits of Samsung's closed innovation? From among the qualitative inquiry methods, this study used case study research. From this research, we isolated three important implications. The first is the benefit and cost of Samsung Electronics' closed innovation strategy. The second is the internal impact of the Galaxy Note 7 explosions on Samsung Electronics. The third is that success in open innovation strategies requires a great investment to produce strong effects.

Keywords: Samsung Galaxy Note 7 explosion; closed innovation; benefits of closed innovation; cost of closed innovation; not invented here syndrome

1. Introduction

Samsung Electronics is one of the leading electronics companies in the world, with the largest market share in terms of sales. From the wide array of smartphones it has manufactured, only the Samsung Galaxy Note 7 has been withdrawn from the market after certain devices exploded after launch in 2016. In the past, smartphone manufacturers, such as Samsung, Apple, and Blackberry, have faced diverse scandals such as smartphone explosions after launch; however, cases in which a specific smartphone was been withdrawn from the market because of such explosions are rare. Given the novelty and impact of this case of the Samsung Galaxy Note 7, this study aims to analyze the reason behind the withdrawal of this device in relation to its explosion, the withdrawal process, and the impact of the incident in depth.

1.1. Research Questions

Did the closed innovation of the Samsung Galaxy Note 7 trigger the withdrawal?
What are the costs and benefits of Samsung's closed innovation, if then?

We deduced this research question from the news concerning the Galaxy Note 7 from a discursive analysis of world newspapers.

This study was conducted to find the answers to the above two questions. First, it focused not on the physical cause of the explosion, but on the cause that led to the incident in terms of business administration. Through the analysis, we may understand the technical innovation strategy of Samsung smartphones in detail.

1.2. Research Method

From among the qualitative inquiry methods, this study used case study research. Case study research is "defined as a qualitative approach in which the investigator explores a real-life, contemporary bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information (e.g., observations, interviews, audiovisual material, and documents and reports), and reports a case description and case themes" [1]. The case target of this study is the explosion of the Samsung Galaxy Note 7. First, this study analyzed articles from Korean and overseas newspapers, such as the Financial Times, for the period of 26 August to 16 November 2016. The keywords used were "Galaxy Note 7 explosion." Second, we contacted Korean newspaper reporters who had written articles related to the scandal, as well as employees of Samsung Electronics, both former and current, by e-mail, and a few persons were interviewed for the purpose of receiving more in-depth information. For the interviews, a questionnaire was distributed on 12 May 2017. Interview details are described in Table 1. We interviewed two newspaper reporters through e-mail. In addition, we interviewed five Samsung electronics employees, among which four are currently working, and one is retired. Among Samsung employees, two additional people were interviewed. Lastly, we interviewed two specialists about Samsung Electronics through email, and followed up with a second interview.

Table 1. Schedules and targets of in-depth interviews.

Target	Interview Schedule	Channel
C, Newspaper reporter	12 May 2017	E-mail
J, Newspaper reporter	15 May 2017	E-mail
L from Samsung Electronics	15 May 2017	E-mail + interview
J, a specialist of business strategy	16 May 2017	E-mail + interview
C from Samsung Electronics	17 May 2017	E-mail
C from Samsung Electronics	17 May 2017	E-mail + interview
J from Samsung Electronics	15 May 2017	E-mail
J from Ex-Samsung Electronics	15 May 2017	E-mail
P, a specialist of business strategy	19 May 2017	E-mail + interview

It is not common to use a qualitative analysis to answer any scandal. Frankly, the qualitative approach was our only to analyze the Galaxy Note 7 explosion, even though there are some clear limitations that require further clarification, especially without the support of Samsung. We expect this research to be the starting point of the study on Samsung's open innovation strategy.

The semi-structured interview questionnaire is described in Appendix A. Because of the complex requirements involved in interviewing, such as contacting and interviewing participants to generate data, and analyzing that data to obtain observations and new knowledge, this process takes a significant amount of time and requires a lot of money [2]. Third, this study analyzed books and research papers that described the process of technology innovation and development at Samsung, which became the background of the development of the Samsung Galaxy Note 7, and identified information on the causes and related information about the explosions. This was undertaken because understanding the strategies and history of technology innovation and development of Samsung itself is vital to identifying the essence of the explosion and to developing an in-depth description and analysis of this case. We required five step answers to each question, and looked to the deeper meaning in the email answers from interview questions found in Appendix A.

Our limits were the interviewees. When we sent e-mail, we added an interview agreement requirement. Therefore, by additional interviewing, we had the chance to analyze this case in detail. The research questionnaire is not for quantitate analyses but for qualitative research. Therefore, the adding of interviews and the e-mail semi-structured questionnaire could not have any research problem.

2. Literature Review and Research Framework

2.1. Literature Review

Nowadays, as new economic pressures on innovation are forming, the research and development costs of new products are rising, and product life cycles are being shortened [3]. To counter these trends, there is a need for companies to come up with innovative ideas to introduce their business models; in this process, internal product development makes use of outside resources while inside intellectual property is managed externally [4].

Fundamentally, new products are created by linking capabilities related to technologies and customers [5]. In the case of service innovation in product-centric firms, managers can use business models as tools to visualize changes, which should increase internal transparency, understanding, awareness of service opportunities, and necessary alterations to their models [6]. Managers of new product and process development projects thus face a paradox: how to take advantage of core capabilities without being hampered by their dysfunctional flip-side [7]. So, exploration and exploitation alliances are required in the biotechnology pharmacy industry [8].

Even though an open approach to innovation presents the opportunity for firms to come up with product features that would have been difficult to plan out under concrete closed integration, when partner companies set different goals, open innovation also restricts the group's ability to finalize the product's technological trajectory [9]. Thus, both discovery and divergence are treated as benefits and costs of open innovation.

Open innovation concepts have proven themselves as relevant to both "high-technology" companies, such as Lucent, 3Com, IBM, Intel, and Millennium Pharmaceuticals, and those who do not belong to this group yet adopted the concept early on [10]. According to them, key success factors of inbound open innovation include the provision of a top-down direction and encouragement of practices of open innovation; allocating responsibility for success; network-building in important areas; and the proper alignment of criteria and rewards to motivate success, be they in an open or closed environment.

There are several advantages to utilizing open innovation in risk-laden activities, such as the pioneering of new technologies or business opportunities, deferred financial costs, early exits that translate to reduce downward losses, and delayed exits in the case of spin-off ventures [11]. However, according to them, innovative firms must develop new capabilities and methods to discover the full "real option" potential of open innovation practices.

In the process of the transformation of consumer electronics, open innovation has industrial dynamics. It should be noted that other categories of companies, such as small suppliers of components, modules, and end-user products in high-end markets, as well as manufacturers and assemblers of components and systems, also play significant roles in the innovative enhancement of such electronics [12].

What changes should a company expect in its organizational structure and management system when it shifts from closed to open innovation? According to a study in which four Italian firms operating in mature, asset-intensive industries adopted open innovation, operating in mature, asset-intensive industries was described, the journey from closed to open innovation involves four main dimensions of a company's organization; i.e., inter-organizational networks, organizational structures, evaluation processes, and knowledge management systems [13].

In the developmental changes in the semiconductor (DRAM technology) field, Samsung Electronics followed a spiral process model of technological innovation in which there are four steps [14]:

a. Entrance of foreign companies into the Korean market and their refusal to transfer their technologies to Samsung, initiating its indigenous technological innovation capabilities (ITICs);
b. Samsung started technological innovation capabilities (TICs) by means of the reverse engineering of imported foreign technologies and by transfer of technology;

c. Samsung improved technological innovation (TI) by means of an adaptive technological innovation strategy and, finally;
d. Samsung developed the capability of establishing its own ITICs, becoming one of the leading companies in the world and competing alongside firms from advanced countries in the global market.

Innovation is a result of multiple combinations, such as the dynamic combination between exploitation and exploration, the open combination between absorption and distribution, the vertical combination between upstream and downstream, the functional combination between intensive and extensive, and the multiple combination between synergic and sporadic [15]. According to this, in the innovation activities for Samsung's code-division multiple access (CDMA) digital phone development, a strong vertical combination gave the company a competitive advantage over its rivals.

However, in the case of smartphone apps, in contrast to Apple, who employed a closed strategy for quality control of the platform and to ensure customer loyalty, Samsung employed the platform strategy of "openness," which allowed the free entry of participants and the "sharing" of created value. This is considered a vital and an excellent platform environment [16].

According to McAfee and Brynjolfsson, the world is at a turning point at which the effects of digital technologies can only be shown through automation and the creation of "unprecedented things [17]". There is nothing new about digital technologies with computer hardware, software, and networks at their core. But after the third revolution, they are transforming the economy as they become more complex and integrated [18].

The fourth industrial revolution is based on physical technology breakthroughs such as autonomous vehicles, 3-D printing, advanced robotics, and new materials in addition to digital breakthroughs such as the Internet of Things (IOT), radio frequency identification (RFID), Bitcoin, and several digital–based biological innovations, which are diffusing much faster and more widely than previous so-called revolutions [18]. With the arrival of the fourth industrial revolution, there have been several effects on business: (1) customer expectations are shifting; (2) products are being enhanced by data, thus improving asset productivity; (3) new partnerships are being formed as companies learn the importance of new forms of collaboration; and (4) operating models are being transformed into new digital models [18]. This revolution is reshaping human reality, including the areas of business and economy, involving the following:

1. Hyperhistory, which is the situation of individual and social well-being dependent on information communication technologies (ICTs);
2. ICTs as interpreting and creating technologies;
3. ICTs as technologies of the self;
4. Enhancing, augmenting, and reengineering technologies;
5. The self-constitutive value of privacy;
6. Shifting and decreasing intelligence with the stupidly smart;
7. ICT-friendly environment; and
8. The emergence of a political multi-agent system (MAS) [19].

In other words, with the acceleration of the fourth industrial revolution, which can also be called the second information technology (IT) revolution, in which ICT spreads to all industries, companies are actively making attempts to form creative and new connections and combinations between technology and market, beyond their current boundaries, in almost all industries, including mature and asset-intensive industries and high-tech industries [13].

2.2. Research Framework

The research framework of this research shows the research agenda, research frame, and changes to the research target in this research. That is to say, in the 4th industrial revolution, the costs of closed

innovation increased with the decrease of the benefits of closed innovation. We will analyze the Galax Note 7 explosion in the context of the changing of costs and benefits of closed innovation and open innovation in Figure 1. As shown in Figure 1, this study focused on the aspect of the rapidly changing cost and revenue structures of cases of closed and open innovation as the fourth industrial revolution accelerates. That is to say, the framework of this study was to analyze the cause of the Galaxy Note 7 explosion, a part of the Samsung smartphone business, which part of the business used a closed innovation strategy under an open innovation–dominant paradigm, and the process of handling the incident, from two aspects. First, we analyzed the changes in revenue and cost of Samsung's closed innovation policy according to the paradigm shift from the closed innovation–dominant paradigm to the open innovation–dominant paradigm. That is, we compared A and A+ in Figure 1. Second, we analyzed Samsung's closed innovation under the open innovation–dominant paradigm by comparing it with the open innovation strategy of other companies such as Apple. That is, we compared A+ and B+ in Figure 1.

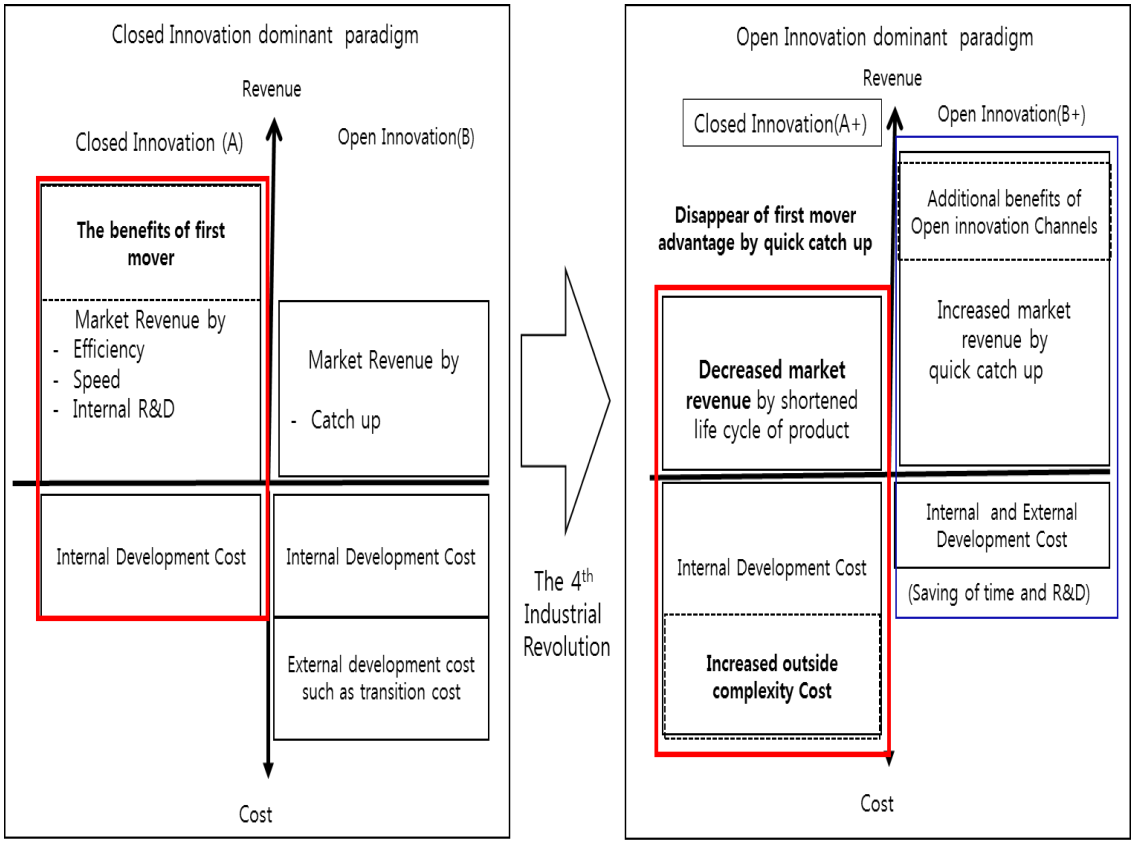

Figure 1. Research framework. Source: Authors' elaboration.

3. In advance Analysis

3.1. Global Status of Samsung Smartphone Business

In terms of global supply status of lithium-ion batteries, which are used for smartphones, Samsung SDI ranked first, accounting for 23%; Panasonic was in second place, with 21%, followed by LG Chem (15%), Amperex Technology (10%), and Sony (about 8%); these figures are for 2015. This indicates that Samsung is achieving the world's largest production of smartphone batteries. The global market share of Samsung smartphones has rapidly increased over the past 10 years, as shown in Figure 2, from 1.8% in 2007 to 32.3% in 2013, at which time Samsung developed the world's first 5-inch

large-screen smartphone, and on to 22.1% in 2016. Recently, however, Samsung's market share has slightly decreased because of the rise of Xiaomi, Vivo, Oppo, and Huawei.

According to an experiment conducted by the German branch of Samsung Electronics, in terms of battery capacity and time of smartphones, LG Electronics's G5 sustained 2800 mAh for 6 h, 31 min, and 49 s; the Huawei P9 had a value of 3000 mAh for 6 h, 51 min, and 43 s; Sony Xperia X had a value of 2620 mAh for 7 h, 15 min, and 35 s; HTC 10 had a value of 3000 mHa for 8 h and 3 s; Apple iPhone 6S had a value of 1715 mAh for 8 h, 13 min, and 57 s; Samsung Galaxy S7 Edge had a value of 3600 mAh for 10 h, 30 min, and 14 s; and Samsung Galaxy S7 had a value of 3000 mAh for 10 h, 59 min, and 11 s. In other words, with regard to the total usage time for each smartphone battery, Samsung ranked first. However, in terms of the total use time for a smartphone battery against the battery capacity, the battery efficiency of Samsung smartphones was relatively low. In fact, to improve battery efficiency, Samsung Electronics has made efforts to reduce smartphone battery size by using more compact components. The ratio of the battery size in the Galaxy Note 3 was 21.0% in September 2013; that of the Galaxy Note 4 was 21.2% in October 2014; that of the Galaxy Note 5 was 20.4% in August 2015; that of the Galaxy S7 Edge was 22.7% in March 2016; and that of the Galaxy Note 7 was 19.4% in August 2016. Samsung Electronics has made intensive efforts to increase the smartphone battery time and capacity alongside decreasing the battery size over the past two to three years.

In 2015, smartphones, that is, mobile devices, accounted for about 50% of all sales of Samsung Electronics. Its mobile devices formed 44.6% of this total; non-mobile computers were 1.3%; device solutions—semiconductors/memory cards—were 21.1%; display panels—LCD and OLED panels— were 12.2%; visual display business—digital TV—were 13.0%; and other consumer electronics—printers, air conditioners, and refrigerators—were 7.8% among the sales of Samsung Electronics. The ratio of the sales of smartphones at Samsung Electronics has rapidly increased.

3.2. Overview of Samsung Galaxy Note 7 Explosion

As the combination of various components of a product, its size and range, and its development speed significantly grow, the possibility of an unexpected mutant, which is a risk, in a product system increases (Table 2); it is believed that this risk exists for all such complex products [20]. Crises faced by companies are related to either their corporate systems or to their products, and involve technical factors and managerial factors such as organizational structure, human factors, organizational culture, and the philosophy of top executives [21].

Table 2. Development of the Samsung Galaxy Note 7 explosion.

Time (2016)	Date	Development
August	2	Samsung Electronics first released the Galaxy Note 7 at an event in New York.
	19	Samsung Electronics officially launched the Galaxy Note 7 in Korea and the US.
	24	A user on a Korean Internet community board showed a photo of a burned Galaxy Note 7.
	29	A video showing a burned Galaxy Note 7 was uploaded on YouTube.
September	31	Samsung Electronics suspended the supply of the Galaxy Note 7 to Korean mobile service providers.
October	1	The Korean Agency for Technology and Standards requested a report on the results of the investigation into the explosion by Samsung Electronics.
	2	Samsung Electronics officially announced that a battery fault had caused the explosion and decided to stop selling the smartphone and to make replacements.
	8	The Federal Aviation Administration recommended now allowing the Galaxy Note 7 on airplanes.
	9	The Consumer Product Safety Commission (CPSC) recommended users stop using the Galaxy Note 7. Samsung Electronics instructed Korean and American customers to stop using the Galaxy Note 7.
	10	The Ministry of Land, Infrastructure and Transport recommended users stop using the Galaxy Note 7 on airplanes and stop placing the devices in cabin baggage.
	15	CPSC decided to officially recall the Galaxy Note 7.
	19	Korean mobile service providers started to replace the Galaxy Note 7 with a new one in all stores across the nation.

Table 2. *Cont.*

Time (2016)	Date	Development
November	1	Samsung Electronics started to sell the new Galaxy Note 7.
	5	A Galaxy Note 7 smartphone burned on board an airplane at Louisville International Airport, Kentucky, United States.The Korea Testing Laboratory announced that the cause of the incident was "external impact."
	6	CPSC started to reinvestigate the Galaxy Note 7 explosion.
	10	AT&T and T-Mobile suspended replacement of the Galaxy Note 7.Samsung Electronics temporarily suspended the production of the Galaxy Note 7.
	11	Samsung Electronics announced it would suspend selling and replacing Galaxy Note 7 units around the world. (Discontinued)

Source: [22].

The characteristic of the development of this incident was that the risk and impact of the incident dramatically expanded and likely became uncontrollable when the Korean Agency for Technology and Standards, the Consumer Product Safety Commission, and Samsung Electronics interactively handled this problem. When Samsung Electronics responded to this issue, it did not interact with its customers because its focus was on interacting with the risk management organizations of the U.S.A. and Korea. Thus, the risk of this incident dramatically increased, leading to the discontinuation of the smartphone unit.

3.3. Technical Cause of Samsung Galaxy Note 7 Explosion

At the time, Samsung Electronics explained that the explosion of the Galaxy Note 7 was caused by "a slight problem that occurred during the battery cell manufacturing process". Overall, according to the related article description and the interview with the person concerned, among the two channels supplying smartphone batteries to Samsung Electronics, China ATL and Samsung SDI, there was a problem in the batteries supplied by Samsung SDI. As shown in Figure 2, normal batteries should meet the two conditions supplied by ATL. First, the negative pole should be short so that it does not to arrive at the round end. Second, the edge should be nearly a right angle. However, the Samsung SDI batteries did not meet these two conditions and short-circuited, leading to the eventual explosion. First, the negative pole arrived at the round end; second, the edge was too smooth.

As can be seen in Figure 3, when a 3500 mAh battery with a size almost identical to the 3600 mAh battery of the Galaxy S7 was inserted into a space that is significantly smaller than that of Galaxy S7, the battery short-circuited.

4. Change of Benefits and Cost of Closed Innovation in Paradigm Shift

4.1. Tradition of Samsung's Innovation: Closed Innovation in a Closed Innovation–Dominant Paradigm (A)

Byung-Chul Lee, the founder of the Samsung Group, said that all businesses have their own risks, and yet some businesses are indeed riskier than others. Thus, he stressed that related risks should be eliminated one by one in any kind of plan, which proved to be one of his entrepreneurial gifts [23]. With this, he also suggested that the manageable innovation promotion of closed innovation is the innovative spirit of Samsung, saying that "The duty of an entrepreneur is to do business that no one does or can do" [23]. For this purpose, he founded the Samsung Electronics Industry Co., Ltd. in January 1969, a time when Korea did not have any technological foundation. Despite his thoughts on closed innovation, however, he established open innovation based on technology accumulation as his corporate vision. As a contributor to a newspaper, he mentioned, "The electronics industry can have extensive joint development of new fields and technologies only when it systemizes and mutually assists domestic companies." He then clarified the development direction of the industry, saying it should be based on its own technology development accumulation. After that, Samsung worked with advanced technology companies until the 1970s, creating companies like Samsung–Sanyo Electronics (renamed Samsung Electro-Mechanics), Samsung NEC (renamed Samsung Electronic

Tubes), and Samsung Corning. Samsung also focused on securing its own technologies for a short period. The efficient introduction and absorption of technologies and capital, an aggressively competitive internal system, and improvement-focused technology development were stressed in the main electronic businesses of the company.

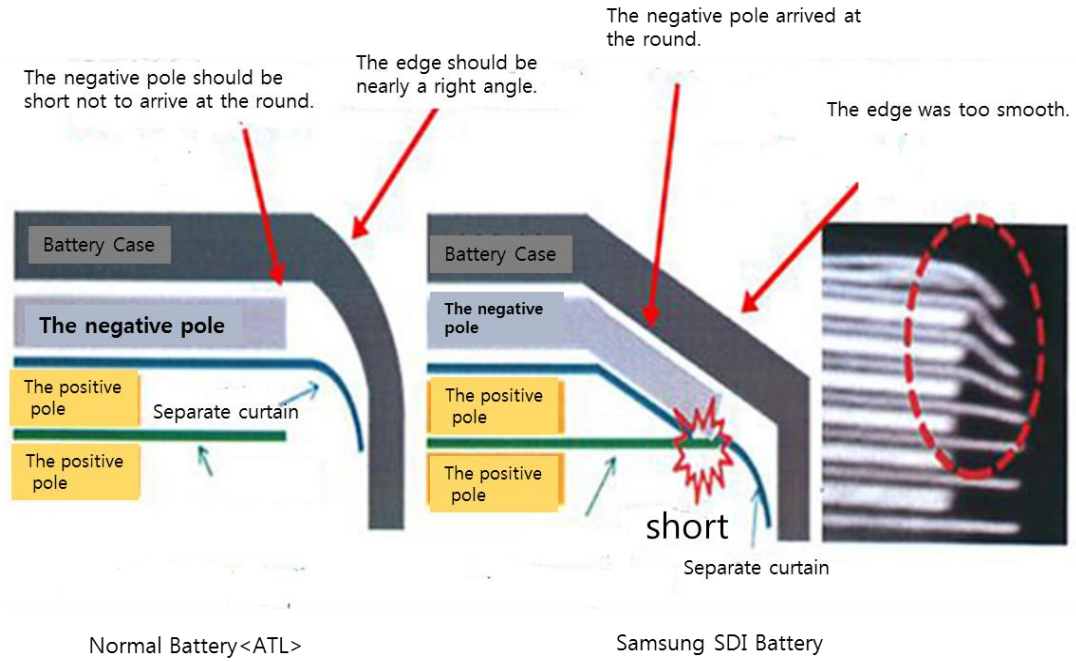

Figure 2. Conceptual diagram of the technical cause of the Galaxy Note 7 explosion. Sources: [24,25].

Figure 3. Comparison between batteries of Galaxy Note 7 and Galaxy S7. Source: Ohmynews, 2 September 2016.

In its aim for development, Samsung aggressively and boldly invested in the semiconductor field, attempting to acquire a first-mover advantage [26–28]. The innovation of the Samsung semiconductor, with its diverse strategies such as rapid, aggressive, and massive investment, mass production system establishment, fast achievement of goals, and various process innovation, technology selection,

and intensification and diversification to reduce production costs, formed an archetype of the closed innovation strategy of the closed innovation–dominant paradigm [29]. Samsung Electronics formulated a strategy of securing first-mover advantage through massive investment and research and development (R & D) and maintaining their position in the semiconductor field. More concretely, to maintain and develop the advantage of leaders in the semiconductor sector, Samsung promoted speed management based on a strict internal control system, a diversified structure that can carry out all matters in the company, synergy between internal organizations, and a combination of internal R & D and production that allowed internal R & D to directly lead its own production. This allowed Samsung to realize a strong closed innovation strategy.

Samsung's way of management is called the "Samsung-Style Paradox Management," which presents the closed innovation strategy in the closed innovation–dominant paradigm with the following paradoxes: (1) Become a large and prompt organization with an emphasis on both status and execution; (2) Observe horizontal and vertical diversification and specialization; and (3) Mix and match the strengths of American and Japanese management styles [30]. These three core success factors, called paradox management, emphasized prompt decision-making and execution, synergy through convergence, and evolutionary change, are in congruence with the core success factors of closed innovation in the closed innovation–dominant paradigm. With this, Samsung-Style Paradox Management includes the following: (1) Fusion of leadership for East to meet West, (2) Perpetual crisis and contingency planning, and (3) Speed for the survival of the fastest [16]. The strong points of closed innovation under the closed innovation–dominant paradigm are identical to the key factors of Samsung's paradox management, such as the massive R & D investment and fast speed needed to maximize the first-mover advantage, the leading of marketization of faster R & D performance through internally diversified recombination, and continuous evolution through internal R & D and internal fusion.

The Frankfurt Declaration by Kun-Hee Lee in 1993, which was a "new management declaration," was the climax of the closed innovation strategy in the closed innovation–dominant paradigm. There, Lee stressed essential innovation such as quality rather than quantity and love for customers and human beings rather than instant and superficial improvement [30]. Leading the market through internal investment in R & D and rapid response to customer requirements, and by meeting customer expectations quickly, was the direction Lee wanted to pursue.

4.2. Samsung under a New Environment: Closed Innovation in the Open Innovation–Dominant Paradigm (A+)

Samsung is a dominant company in home appliances like TVs and washing machines, but it is its smartphones that have made Samsung a household name like Walt Disney and Toyota Motors [31]. The Samsung smartphone business embraced Android, the open-access operating system (OS) of Google, in 2009, but its first smartphone did not attract much attention from the public. Despite this, however, in 2010 Samsung introduced the Samsung Galaxy S line and launched various smartphone models with bigger screens, ranging from 2.8-inch to 5-inch units; these screens were different from those of other smartphones. This method of manufacturing devices with similar functions yet of different sizes to identify which would do well in the market is an uncommon practice given its high cost [31]. But it was made possible because Samsung promoted the closed innovation strategy, which involved a vertical integration production structure in which its display, memory, processors, and other high-tech parts were internally produced and assembled. While Apple produced a minimum number of smartphone models with a unique design, Samsung rapidly produced smartphones with all kinds of designs, watched the market's response to all of them, and modified the products. In other words, Apple achieved the vertical integration of the smartphone OS, but Samsung achieved the vertical integration of hardware and, through extensive closed innovation, identified the product that customers wanted and then rapidly produced it.

Since its first launch of the Galaxy smartphone series in 2010, Samsung has seen customer demand for large-screen smartphones. As shown in Figure 4, Samsung's global market share was 19% in 2011,

30.4% in 2012, and 32.3% in 2013, ranking first in terms of the total production of smartphones in the world. However, the highest market share of Samsung smartphones was achieved through a typical closed innovation strategy. In other words, Samsung itself produced its main smartphone parts and innovated them as much as it could, in addition to producing smartphones with various types and structures and finding and meeting customer demand and expectations.

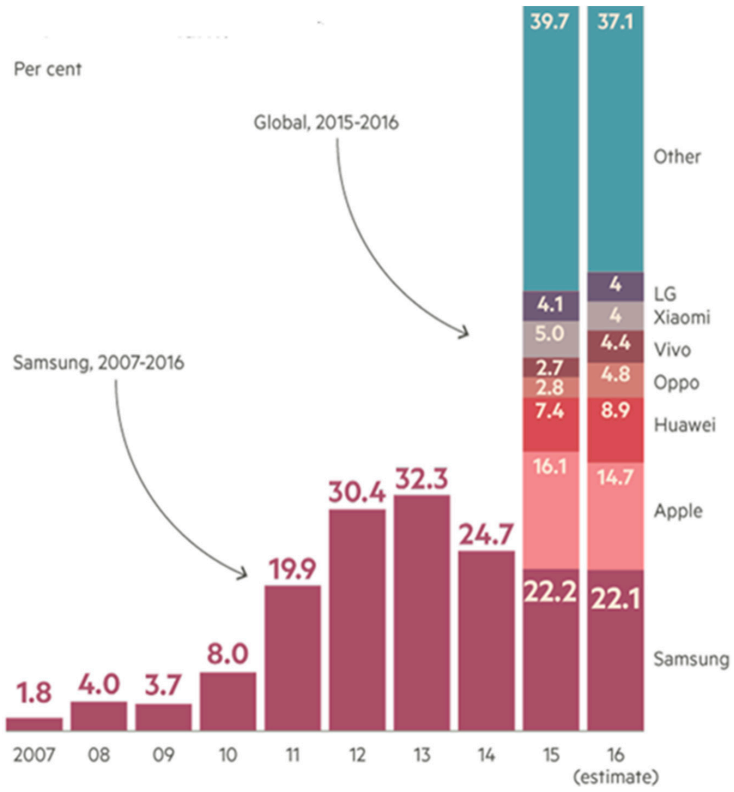

Figure 4. Smartphone market share of Samsung from 2007 to 2016. Source: Financial Times (10 November 2016), and Strategy Analytics.

However, we need to pay attention to the shift of the smartphone business environment from the closed innovation–dominant paradigm to the open innovation–dominant paradigm. Thus, the global market share of Samsung smartphones rapidly dropped from 32.3% in 2013 to 22.1% in 2016. During Samsung's downturn, Chinese smartphone manufacturers, such as Xiaomi, Vivo, Oppo, and Huawei, grew. The benefits of the first-mover in the market, acquired through the development of various product lines together and massive investment, was lost in a very short period. Since then, new product competitors have grown exponentially and extended their market share. As of May 2017, Chinese smartphones accounted for about 20% of the European market.

The reason that Samsung enjoyed the advantages of being a global leader in the memory semiconductor and display fields, and ranked first in the global market through the use of the closed innovation strategy, is that this strategy matched the closed innovation–dominant paradigm of the industry. Since that time, however, the reason that Samsung's smartphone business has faced a significant decrease in its global market share of over 10% in the three years after it achieved global top smartphone market share, is that Samsung's closed innovation strategy did not match with the open innovation–dominant paradigm of the smartphone industry.

4.3. Risk Surging by Closed Innovation Strategy and Management of Samsung Electronics

The main risk of closed innovation under the open innovation–dominant paradigm, in terms of management, is that the first-mover advantage has a shorter product life cycle. As a prime example,

Samsung Electronics experienced a rapid reduction in its global market share from 32.3% in 2013 to 20.1% in 2016—a short period of three years. Samsung promoted the traditional closed innovation strategy, in which it developed new and diverse smartphones and launched them quickly in the market. This speed-focused management strategy, however, eventually led to the major oversight that led to the Samsung Galaxy Note 7 explosion.

According to interviews and articles, it can be assumed that the development of numerous sizes of batteries by Samsung SDI, shortly after the internal built-in battery was adopted, caused a battery pack design fault that stemmed from problems of management.

Samsung verified the quality of its smartphones through a fast process; this efficiency of the closed innovation process, such as internal development, use, and verification, however, increased the possibility of product uncertainties or incidents.

To maximize the efficiency and speed of more diverse smartphones rapidly, Samsung Electronics and Samsung reorganized their decision-making structure into an efficiency-based hierarchical structure, rather than a horizontal creativity-centered structure. During the process, the smartphone and smartphone battery production departments and sectors did not engage in horizontal and active discussions, and the unilateral and hierarchical culture increased the uncertainty in the development of new and diverse product lines.

5. Benefits and Costs of Closed Innovation Strategy

5.1. Evidence of Closed Innovation Strategy by Samsung

Samsung Electronics pursued the closed innovation strategy. It has released many smartphone models within a short cycle, and by surveying the customers' responses to them, improved the units. The strategy was used in the Galaxy S and Galaxy Note series, which are Samsung's main mobile devices. According to Appendix B, 10 phones under the Samsung Galaxy S series were released from 2010 to 2016. In addition, according to Appendix C, 8 phones under the Samsung Galaxy Note series were launched from September 2011 to 2016. In other words, from 2010 to 2016, Samsung Electronics released 18 smartphones only in the Galaxy S and Galaxy Note series. On average Samsung has launched a new smartphone model every 4.7 months since 2010. It should be noted as well that Samsung also released low-end models during the same period. In contrast, Apple launched just 10 smartphones, namely the iPhone, iPhone 3G, iPhone 3GS, iPhone 4, iPhone 4S, iPhone 5, iPhone 5S, iPhone 6, iPhone 6S, and iPhone 7, over the past 10 years since its first iPhone was released in 2007.

Under this situation, Samsung Electronics enjoyed first-mover advantage for large-screen smartphones when the Galaxy S3 (a 4.8-inch phone) in 2012 and the Galaxy S4 (5.0-inch phone) in 2013 drew much attention from customers in the global market. However, Samsung's leading position rapidly shrank in just two to three years because of Apple's iPhone 6 series, released in 2014, and Chinese smartphone manufacturers' production of large-screen devices.

While Samsung Electronics was quickly developing and releasing new devices, no one can deny that the process complexity increased. Since the company first adopted a built-in battery in 2015, the battery pack design, the battery operating time, and the battery capacity have been sources of high uncertainty. Because the company has implemented various functions for smartphones over short periods of time, such as increasing the battery operating time and capacity and decreasing the battery volume, related uncertainties have increased.

5.2. Benefits of Closed Innovation Strategy by Samsung Electronics

Samsung achieved the top share in the global smartphone market through its "excellent research and development capacity and well-accumulated innovative workforces." In fact, though, the company was passive about M&As with other companies, except for the Harman case. By strengthening its internal capacity, Samsung has made efforts to improve unification of its systems from parts to finished products. With continuous investment in R & D and differentiation from other companies in

terms of performance and quality, Samsung Electronics successfully launched the Galaxy series and explored new smartphone fields, like the Galaxy Note. In addition, it continued to develop product differentiation such as edge screen, iris recognition, and Bixby AI. While pursuing the traditional closed innovation strategy, Samsung Electronics successfully accumulated amazing technical capabilities, such as excellent manufacturing capacity and its own procurement capability, unmatched by other competitors, through vertical integration in the hardware sector, allowing the company to produce internally completed products. "One genius can feed millions of others"—this management philosophy of Kun-Hee Lee already stresses the management strategy of Samsung, which focuses on internal capacity. In fact, current and former employees of Samsung Electronics, as well as reporters and experts, all mentioned that the main success factor of Samsung smartphones was "Samsung Electronics's internal R & D and internal innovation capacity accumulation."

In terms of the existence and contribution of open innovation when Samsung Electronics obtained its high global market share, current employees, reporters, and experts had different opinions. In addition, they thought the contribution was not high according to interviews. However, the recent movements of Samsung Electronics, such as the acquisition of LoopPay of the US, which became Samsung Pay, through use of massive internal reserves, and that of Harman, a top global acoustic apparatus company, have shown the use of a new open innovation strategy.

5.3. Costs of Closed Innovation Strategy by Samsung Electronics

It was said that the cause of the Galaxy Note 7 battery explosion in terms of management was "internal research and development and innovation capability accumulation." This was cemented by the results obtained from this study's in-depth interviews with current and former employees of Samsung Electronics, reporters, and experts. For example, as Samsung Electronics continuously received its smartphone batteries from Samsung SDI, its own efforts to improve the quality of batteries through the diversification of its battery suppliers became insufficient. Samsung Electronics itself pointed out that the supplier in Samsung Group had to meet fixed deadlines and that there was not enough time to fully verify the batteries. In addition, an opinion that its long corporate culture of command and discipline had been accumulated through a long closed innovation process, leading to the battery explosion, was suggested several times. There was another opinion that the incident was caused by the internal way of operating the overall value chain including R & D in Samsung Electronics. If there are different opinions in an organization, they should be clearly expressed and handled. However, that process was considered as having low efficiency and appeared to be rejected. In other words, the high efficiency of Samsung's management system is the actual cause of its products being more exposed to risk factors or uncertainties.

The interviewees also agreed that the explosion was not caused by the result of the "externally excellent R & D performance and innovation capacity acquisition process"; that is, in terms of management, they all thought the explosion was not related to the open innovation strategy at all.

5.4. Where Should Samsung Electronics Go?—The Future of Samsung's Smartphone Innovation Strategy

Members and nonmembers of Samsung all agreed that the company needed to continuously and actively obtain innovation capacity from "the outside" and continue to have the top innovation capacity globally. In particular, the current department heads of Samsung Electronics, who directly witnessed the acquisition of Harman, highly agreed with this opinion. Strictly speaking, the current employees of Samsung Electronics who were there at the time of the scandal and the successful acquisition of Harman and Viv Labs strongly recommended the open innovation strategy as the future development strategy of Samsung Electronics. With the acquisition of Harman, the company itself experienced the possibility of launching a new business and the usefulness of technology acquisition. It is necessary for Samsung Electronics to watch the technologies and markets of global startups and aggressively and initially invest in companies in order to create new business in the future. A former department head of Samsung Electronics who did not experience the success of open innovation

suggested promoting both closed and open innovation. In particular, in the case of the software sector, even though Samsung Electronics has exerted much effort to develop internal capacity, this effort has clear limits in acquiring technologies over a short period. Recently, Samsung's active M&A actions are in the same vein. However, as Samsung Electronics does not have high open innovation capacity like that of Google and Apple, it is suggested that maximizing the acquisition of open innovation capacities by actively seeking to cooperate with venture companies or small- and medium-size companies around the world with advanced technologies should be the core project for the company. Achieving the mass production of a new business over a short period by a big business like Samsung Electronics through an M&A or partnership with a start-up or SME is the way to overcome the growth limits of capitalism as described in Schumpeterian Dynamics of Open Innovation (Yun, 2015).

6. Discussion and Conclusion

6.1. Discussion

Innovation Paradigm Shift from CI into OI in the 4th Industrial Revolution

As the 4th industrial revolution proceeds, the paradigm of innovation is changing from closed innovation to open innovation. The 4th industrial revolution means higher technology innovation acceleration by smart IT. As in the (Appendix C) causal loop model, in the 4th industrial revolution, bigger open innovation will be motivated continuously. But in higher technology innovation, smaller closed innovation will be motivated continuously. If the technology innovation acceleration decreases, open innovation will decrease continuously, and closed innovation will increase continuously. This is to say, this causal loop model is dynamicly reversible, in contrast to Senge's Success to the Successful [32].

In this model, there are two reinforcing loops, they are as follows. One is the open innovation-reinforcing loop (Table 3). The other is the closed innovation-reinforcing loop. Like the Samsung the Galax Note 7 exposition, the reinforcing loop of closed innovation can motivate another Samsung Galaxy Note 7 exposition.

Table 3. 2 Reinforcing Loops in the causal model of the 4th industrial revolution.

R1	
Open Innovation reinforcing loop	(R1) Advantage of Open Innovation and Internal Development → Relative Advantage of Open Innovation compared to Closed Innovation → Usage of Open Innovation (OI Usage) → Organizational Learning for OI Usage → Efficiency of OI Usage → Advantage of Open Innovation and Internal Development
R2	
Closed Innovation reinforcing loop	(R2) Advantage of Closed Innovation and External Acquisition → Relative Advantage of Open Innovation compared to Closed Innovation → Usage of Closed Innovation (CI Usage) → Organizational Learning for CI Usage → Efficiency of CI Usage → Advantage of Closed Innovation and External Acquisition

The choice between open innovation reinforcing loop, and closed innovation-reinforcing loop will be critical points of firms in the 4th industrial revolution from manufacturing to the service industry, or from Start-ups or SMEs to Big Business.

6.2. Conclusions

6.2.1. Let Us Minimize the Costs of Closed Innovation, and Move to an Open Innovation Strategy as Soon as Possible

The successful closed innovation strategy motivated the global top market share of Samsung smartphones. Samsung Electronics' internal R & D and technology accumulation allowed the rapid

development of newer and more diverse smartphones of Samsung than those of other smartphone manufacturers, the launching of those products in global markets, and the increasing of Samsung's market share around the world. However, this fast internal innovation process eventually led to the Galaxy Note 7 explosion.

6.2.2. The Motive Changing from Closed Innovation to Open Innovation; Galaxy Note 7 Explosion

The Galaxy Note 7 explosion is an opportunity to remove the Not-Invented-Here syndrome of the company by focusing on the closed innovation strategy [33,34]. This shows that current employees of Samsung Electronics agree with the necessity and possibility of applying an open innovation strategy for a short period. However, former employees of the company who only experienced success in closed innovation maintain their preference for the closed innovation strategy. Current employees who experienced the explosion look at the necessity and possibility of the open innovation strategy with high expectations.

6.2.3. Success in Open Innovation Strategy Requires Much Investment and Effects

Jeff Bezos, CEO and founder of Amazon, experienced a painful failure in many M&A that he initially invested in with the capital acquired by going public with his company. His experiences in failure and accumulation of open innovation capacity became a driving force of open innovation based technology innovation capacity accumulation and development [34]. The open innovation strategy involves high complexity and costs. The largest cost is internal resistance [35]. In addition to the Not-Invented-Here syndrome, internal resistance against destructive innovation that is beyond the existing products and services is the largest cost. Samsung Electronics has been successful in significantly reducing the largest cost generated by the closed innovation process of the smartphone business division caused by the Galaxy Note 7 explosion. Systematically combining the open innovation strategy with the Samsung smartphone business sector is vital for the future of Samsung Electronics as well as the smartphone business division. The process of systematically combining open innovation strategy and a company can be achieved by setting a business model as an important innovation target [36–38]. The internalization of the open innovation strategy in the Samsung Electronics system, above all, requires the strong support of the creative entrepreneurial spirit of its CEO [39]. Because of the Galaxy Note 7 battery explosion, whether Samsung Electronics CEO's active suggestion of the direction leads to the construction of an open business model platform at Samsung Electronics needs to be analyzed in the future.

6.3. Limitations and Future Plan

This study intensively analyzed the causes and impact of the smartphone battery explosion of Samsung Electronics, the company with the largest global market share, and the smartphone unit's withdrawal from the market, which was considered a novel case in terms of business strategy. For this, local and overseas news articles, previous research, and in-depth e-mail interviews with related experts were utilized.

Through the interviews with the current employees of Samsung Electronics for each section and the analysis of the internally diverse systems, R & D on the procedures, steps, and system of open innovation of Samsung Electronics is important for future study.

Frankly, we need to analyze the total innovation strategies, from manufacturing to the marketing of Samsung Smartphones, to evaluate the benefits and costs of closed innovation, and the costs and benefits of open innovation costs. In addition to this, the intensive additional analysis of the open innovation of the Samsung smartphone should be expanded to the Samsung digital TV, Samsung artificial intelligence department, and Samsung electric car department, because all of these are based on Google Android SW open innovation strategies. Samsung should be structured by all of the dynamic strategies of the open innovation approach in the 4th industrial revolution. Without the support of Samsung, this research has value because it is the first research based on the Samsung Smartphone's

open innovation strategy. Additional deep research on the Samsung Smartphone Department's open innovation dynamics is required and should be conducted with the Samsung Smartphone Department. We will consider other qualitative frameworks, such as a Delphi model of Samsung's open innovation framework, if we have the opportunity to research Samsung's open innovation with the support of Samsung. In addition, if we have the chance to research this with the support of Samsung, we will consider a content analysis through Nvivo.

Author Contributions: J.J.Y. did conceptualization, and wrote all this paper. J.J. arranged investigation, and validated this paper. K.P. did Causal-loop model, and visualized it. X.Z. did writing review and editing.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A.

Semi-Structured Questionnaire and Answers for in-Depth Interview about the Cause and Impact of the Samsung Galaxy S Note 7 Explosion and Withdrawal Scandal

1. Purpose of this research

Recently, the Samsung Galaxy S8 was released and is attracting much attention around the world. Given Samsung's status, we want to identify the cause and impact of the Galaxy Note 7 explosion in terms of management.

2. Use of research results

First, this research result will be presented by Professor JinHyo Joseph Yun, president of SOItmC, during his keynote speech in SOItmC 2017.

Second, this research result will be reviewed and published as an SOItmC 2017 special issue paper of JOItmC.

Third, this research result will be used as basic research data for management strategy consulting for Samsung and similar Korean and overseas companies.

3. Composition and answers of questions

There are four main items, each of which poses quantitative questions following a five-level Likert scale. An explanation (qualitative) behind the answers is necessary per item.

Second, an interviewee can answer each question for up to 3 min, and this entire questionnaire for 18–20 min.

Third, if you can have an in-depth interview individually, please answer the questions in this questionnaire and accept the in-depth interview request.

4. Interview

Please indicate to what extent you agree or disagree with each statement.

1) Samsung smartphones achieved the world's largest market share in a short period.

(1) The achievement was caused by its excellent research and development and its innovation capacity that has been well accumulated internally. (Excellence of internal resources) (Strongly agree 4, Agree 5)

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

<Please describe the cases or evidence.>

(2) The achievement was caused by the acquisition and internalization of globally excellent research and development performance and innovation capacity. (Use of external resources) (Disagree 6, Neutral 2, Agree1)

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

<Please describe cases or evidence.>

2) Unlike other battery explosion incidents of iPhones and other smartphones, the case of the Galaxy Note 7 had an enormous impact on Samsung Electronics.

(1) Samsung Electronics only focused on "internal" research development capacity accumulation and "internal" innovation capacity accumulation. (Agree 2, Strong 7)

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

<Please describe the cases or evidence.>

(2) The incident occurred during the process of "externally" acquiring excellent research and development performance and innovation capacity. (Disagree 5, Neutral 4)

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

<Please describe the cases or evidence.>

3) We would like to ask you about the impact of the Galaxy Note 7 explosion.

(1) The explosion incident will continuously have a negative impact on the future of the Samsung smartphone business because the negative image and customer perception of Samsung and its products have not been removed. (Disagree 3, Neutral 4, agree 2)

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

<Please describe the cases or evidence.>

(2) The explosion incident will give an opportunity for Samsung Electronics to strengthen the self-learning and countermeasure capability of its smartphone business and finally develop its business further. (Agree 7, Strong agree 2)

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

<Please describe the cases or evidence.>

4) We would like to ask you about the future strategy of the Samsung smartphone business.

(1) By continuously accumulating "internal" research and development capacity, Samsung is set to have the global top innovation capacity and lead the innovation of the global smartphone business. (Disagree 4, Neutral 3, agree 2)

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

<Please provide concrete suggestions.>

(2) By continuously acquiring innovation capacity actively and "externally," Samsung is set to continuously secure the global top innovation capacity. (Strongly agree 3, Agree 6)

a. Strongly disagree b. Disagree c. Neutral d. Agree e. Strongly agree

<Please provide concrete suggestions.>

Appendix B. Samsung Galaxy Note Series

Galaxy S Series	Galaxy S1	Galaxy S2	Galaxy S3	Galaxy S4	Galaxy S5	Galaxy S6			Galaxy S7	
						Galaxy S6	Galaxy S6 Edge	S6 Edge Plus	Galaxy S7	Galaxy S7 Edge
Issue data	Jun. 2010	Apr. 2011	Jun. 2012	Apr. 2013	Apr. 2014	Apr. 2015			Mar. 2016	
Display	4.0 inch	4.3 inch	4.8 inch	5.0 inch	5.1 inch	5.1 inch	5.1 inch dual covered	5.7 inch duel covered	5.1 inch	5.5 inch duel covered
Mobile AP	Exynos 3110	Exynos 4210	Snapdragon S4 Exynos 4412	Snapdragon 800 Exynos4412	Snapdragon 801 Exynos 5422	Exynos 7420	Exynos 7420	Exynos 7420	Exynos 8890 Snapdragon 820	Exynos 8890 Snapdragon 820
Camera	Front 0.3M Back 5M	Front 2M Back 8M	Front 1.9M Back 8M	Front 2M Back 13M	Front 2M Back 16M	Front 5M Back 16M	Front 5M Back 16M	Front 5M Back 16M	Front 5M Back 12M Dual pixel	Front 5M Back 12M Dual pixel
Inner memory	8, 16GB	16, 32 GB	16, 32, 64 GB	16,32,64 GB	32, 64 GB	32, 64 GB	32, 64, 128 GB	32 GB	32, 64 GB	32, 64, 128 GB
OS	Android 2.1	Android 2.3	Android 4.0	Android 4.2	Android 4.4	Android 5.0	Android 5.0	Android 5.1	Android 6.0	Android 6.0

Figure A1. The history of Samsung Galaxy Smartphone series. source: [40].

Galaxy Note Series	Galaxy Note 1	Galaxy Note 2	Galaxy Note 3	Galaxy Note 3 Neo	Galaxy Note 4	Galaxy Note 5	Galaxy Note 6	Galaxy Note 7
Issue data	Sep. 2011	Aug. 2012	Sep. 2013	Jan. 2014	Sep. 2014	Apr. 2015	Aug. 2015	Aug. 2016
Display	5.29 inch	5.55 inch	5.7 inch	5.5 inch	5.7 inch	5.1 inch	5.7 inch	5.7 inch
OS	Android 2.3	Android 4.2	Android 4.3	Android 4.4	Android 4.4	Android 4.4	Android 5.1	Android 6.0

Figure A2. The history of Samsung Galaxy Note Smartphone series. Source: [41].

Appendix C. Causal Loop Modeling of the Paradigm Shift from CI to OI in 4th Industrial Revolution

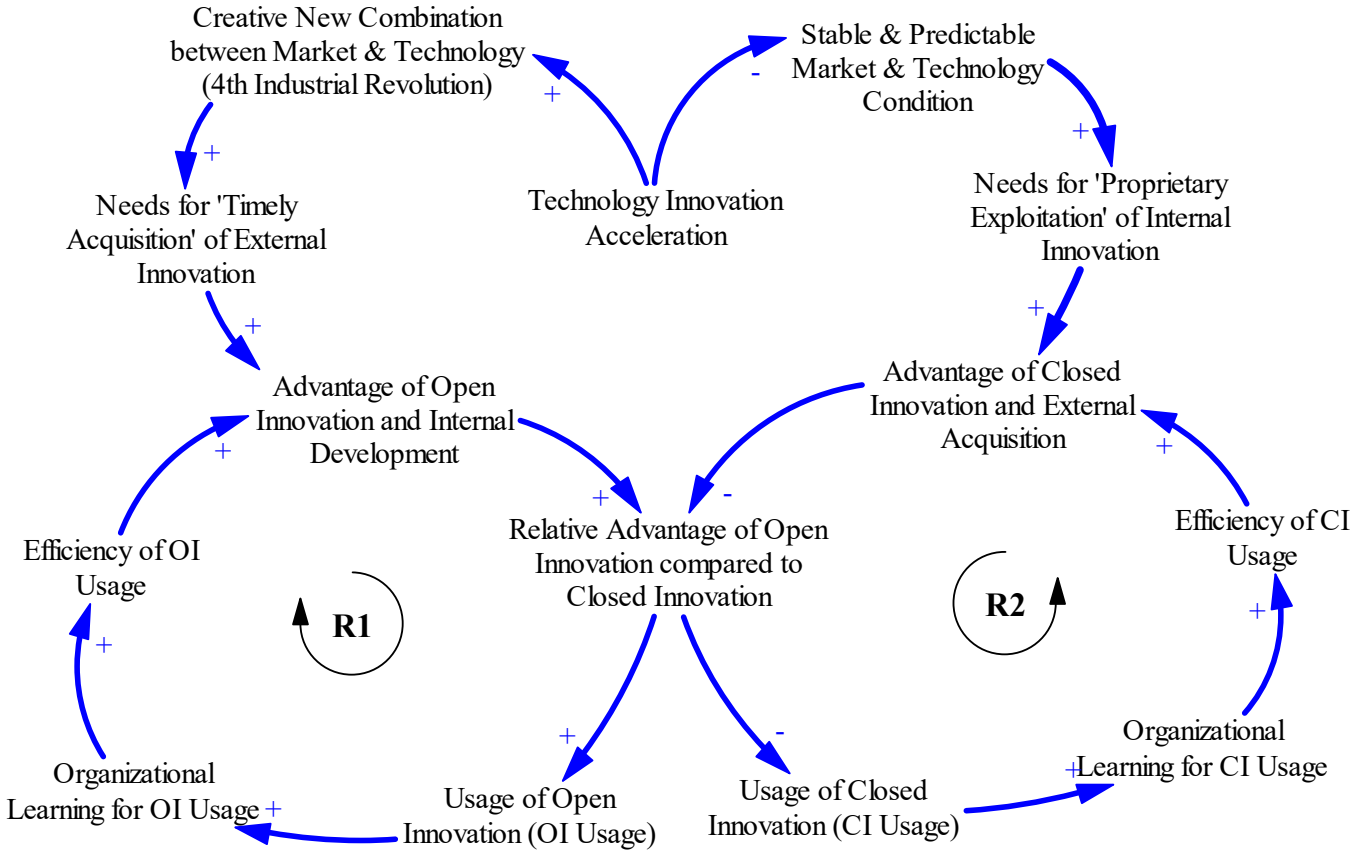

Figure A3. Causal loop model.

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