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The Mechanisms for Business Ecosystem Members to Capture Part of a Business Ecosystem's Joint Created Value

Haruo Awano * and Masaharu Tsujimoto

Department of Innovation Science, Tokyo Institute of Technology, Tokyo 108-0023, Japan; tsujimoto.m.ac@m.titech.ac.jp
* Correspondence: awanohaha@yahoo.co.jp

Abstract: Research into business ecosystems has rarely examined the success of business ecosystem members. Business ecosystem leaders tend to focus on their own success rather than carefully monitoring the success of business ecosystem members, and each member must find a mechanism to capture part of the business ecosystem's joint created value. This study examines the mechanisms by which business ecosystem members capture part of a business ecosystem's joint created value in the cases of linear tape open (LTO) ecosystems and how these mechanisms contribute to the sustainability of a business ecosystem. A case study was conducted with a review of both the author's experience with Sony and third-party resources. We confirm the results by panel data analysis. We identified three mechanisms. First, a business ecosystem member can establish a new business ecosystem on their own through newly created complementary innovation. Essentially, a business ecosystem member can become a business ecosystem leader in a new business ecosystem. Second, a business ecosystem member gains market shares from technology leadership, the experience of mass production, and collaboration with the business ecosystem leader. Third, a business ecosystem member who creates complementary innovations can obtain patent royalties. These mechanisms help business ecosystem members stay within business ecosystems and contribute to its success and sustainability.

Keywords: business ecosystem; sustainability; value; profit; market share; complementor; panel data; statistical analysis; linear tape open

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1. Introduction

A business ecosystem is important for various businesses, such as electric vehicles, the Internet of things (IoT), storage products, and so on. The success of a business ecosystem depends on the actions of self-interested actors that join the network; thus, getting members to join a business ecosystem requires an understanding of what motivates these potential members, especially how participation relates to achieving their particular goals [1]. While the members of a business ecosystem will generally work to advance the overall ecosystem's success, their self-interest is a higher priority [1]. Business ecosystem leaders, as well, tend to focus on their own success rather than carefully monitoring the success of business ecosystem members [2]. Each business ecosystem member needs to find a mechanism to capture a part of the value beyond what is contributed to the business ecosystem's joint value creation [1,3]. Research on business ecosystems has rarely examined the success of business ecosystem members [1,4].

The sustainability of a business ecosystem is also important for both business ecosystem leaders and members. How one makes a sustainable business is a challenge faced by many business ecosystems [5].

These previous insights inspired this research, which focuses on the following questions: What mechanisms allow business ecosystem members to capture part of the business ecosystem's joint created value? How do these mechanisms contribute to the sustainability

of a business ecosystem? This paper intends to contribute to the current literature by complementing previous research.

The International Business Machines Corp (IBM), Hewlett-Packard (HP), and Quantum (formerly Seagate) created business ecosystems for a new open format of linear tape open (LTO) technology in 2000 by making use of standardizations and succeeded in expanding the market for LTO drives. Media manufacturers, such as Fujifilm, Sony, Hitachi Maxell, and others, obtained a license and manufactured and sold their LTO media as complementary business ecosystem members. The LTO format share increased from 12% in 2001 to 77% in 2008 in the backup market of midrange and low-end servers [6]. LTO has become the major standard in the industry, and its capacity has increased through extensive research and development (R&D) to create new generations related to multiple business ecosystems. Since 2000, LTO has now continued for more than 20 and has established a sustainable position as a storage format. It has been studied how royalties from the media manufacturers of business ecosystem members contribute significantly to the profits of IBM, HP, and Quantum's business ecosystem leaders [7,8].

In this research, we aimed to study how LTO media manufacturers capture value from the business ecosystem as business ecosystem members while they devote themselves to complementary innovations. We also aim to examine how the mechanisms of capturing shared value contribute to the business ecosystem's sustainability. We studied cases of LTO business ecosystems related to the seven generations of LTO format.

This paper is organized as follows: Section 2 introduces the related literature. Section 3 describes the research methods used. Sections 4 and 5 are devoted to studying LTO business ecosystems cases and analyzing the mechanisms for business ecosystem members to capture part of the business ecosystem's joint created value. Section 6 discusses the empirical findings and offers some practical and theoretical implications and limitations. Section 7 concludes the paper.

2. Literature Review

2.1. Business Ecosystem

The "business ecosystem" is an economic community supported by a foundation of interacting organizations and individuals—the organisms of the business world. The economic community produces goods and services of value to customers, who are themselves members of the ecosystem [9,10]. The member organisms also include suppliers, lead producers, competitors, and other stakeholders [9]. A business ecosystem leader is valued by the community because their functioning enables business ecosystem members to move toward shared visions that align their investments and find mutually supportive roles [10]. The generic schema of a business ecosystem consists of the supplier, focal firm, complementor, and customer, as shown in Figure 1 [11]. A customer may need to bundle offers alongside the focal actor's product to utilize it. Such offers are bundled downstream by the customer, and these are referred to as complements [11]. It has been studied that hub firms orchestrate network activities to ensure the creation and extraction of value without the need for hierarchical authority [12].

The characteristics of the ecosystem concept were described by clarifying the business model theory [13]. Previous studies have shown four research streams concerning ecosystems. For example, researchers using the business ecosystem perspective concentrate on the business context and set value capture and/or value creation as central variables [14]. The purpose of research in this stream of a business ecosystem is to reveal the dynamics and patterns of ecosystems and organizational behavior [14]. A wider view of the ecosystem's business process is needed to take account of the social perspectives as well as the human/non-human dimension [15]. Keystone organizations play a crucial role in business ecosystems. Fundamentally, they aim to improve the overall health of their business ecosystem by providing a stable and predictable set of common assets [16]. A keystone species has a disproportionately large effect on its environment relative to its abundance [17,18].

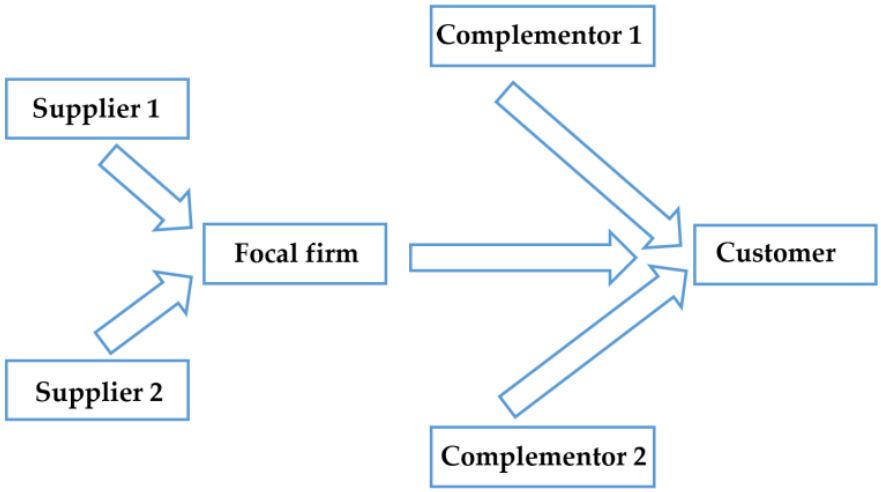

Figure 1. Generic scheme of an ecosystem. Source: [11].

It was studied that every business ecosystem develops in four distinct stages: birth, expansion, leadership, and self-renewal/death [9]. The life cycle provides scholars with a valid framework through which to analyze the evolution of major businesses [19]. Business ecosystems grow and decline not only because of the technological product lifecycle but also because of the lifecycle of the ecosystems themselves [20]. Since video game hardware is a technological system, a hardware platform loses its superiority or edge when new technology or hardware is introduced. However, since the adoption of a platform is dependent on both complementors and consumers, the ecosystem's growth and decline do not always depend on the technological superiority of the platform [20–22].

Business ecosystem leaders holding leadership roles may change over time [9,10]. Certain complementors that contribute to symbiotic co-existence within a platform ecosystem could merge as keystone firms/companies in the same business ecosystem [20]. These complementors could contribute to the sustainability of platform-based markets and facilitate the co-existence of multiple platform ecosystems [20].

2.2. Sustainability

The sustainability of a business ecosystem is an important issue for a business ecosystem leader and business ecosystem members. How one makes a sustainable business out of a profusion of ideas and overwhelming richness of possibilities is the challenge faced by business ecosystems [8]. Companies in a business ecosystem are under a constant threat of competition and commoditization. The only way they can sustain themselves is by aggressively improving their contributions to the business ecosystem [8]. Companies can improve their contribution through differentiation; by differentiating themselves from their competitors by being unique at something that customers find valuable [23]. The stability of differentiation, however, depends on its continued perceived value to customers [23]. When a product has several generations, the new technology for each generation can be differentiated. The performance of each new technology generation is, therefore, superior to that offered by the old technology [24]. Sustainability is reached in this way, as each generation is sustaining [25] in that they are developed to meet the needs of the company's existing customers, who are demanding improved performance at a low cost [24]. The success of a business ecosystem depends on self-interested actors, such as business ecosystem members and a business ecosystem leader [1]. Even an innovative and technologically superior business ecosystem cannot be sustained if the business ecosystem members of complementors that are responsible for the development and provision of goods are not successful [20]. To ensure sustainable evolution, the business ecosystem leader needs to attract and retain high-quality business ecosystem members innovators [26]. The effective strategy of a business ecosystem leader is twofold: First, they must create value within

the business ecosystem. Then, they must share the value with business ecosystem members [16]. By sharing the value, a business ecosystem leader may continue to expand its own healthy business ecosystem and allow it to thrive in a sustainable way [16]. The business ecosystem leader who fails to do so will find itself perhaps temporarily enriched but ultimately abandoned [16].

2.3. Standardization

Compatibility standards are a set of rules for the design of new products. These rules facilitate coordination between independently designed products or components by establishing a common interface to govern their interactions [27]. There are several types of standards, such as the de jure, consortium, and de facto standards. A de jure standard is a standard determined by public organizations, such as the International Standard Organization (ISO) [28] and European Computer Manufacturers Association (ECMA) [29]. A consortium standard is a standard that consortium members establish collaboratively to promote a new product. A de facto standard is a standard that has been adopted by the market as the outcome of conflicts between differing standards. The trend for standardization in the information technology (IT) industry has changed from a previous model where powerful companies created de facto standards to today's consensus-based model, where industry forums or consortiums are involved in standardizations [30].

3. Research Methods

One purpose of this study is to clarify what the mechanisms are for business ecosystem members to capture part of the business ecosystem's joint created value. The other purpose is to examine how these mechanisms contribute to the sustainability of a business ecosystem. This paper intends to contribute to the current literature by complementing previous research.

3.1. Data

We used both primary and secondary data sources for this study. One of the authors is experienced in the areas of strategic planning, R&D, marketing, production, business alliances, and new product and technology planning of storage media with Sony, including LTO media. This author worked for Sony Japan and Sony USA for more than 30 years as a general manager, engineer, and in-house attorney.

The cases of LTO business ecosystems were studied in conjunction with a review of third-party resources. Published materials available from research companies, published scientific papers, press releases issued by the related companies, information on the LTO websites, and information on the homepages of IBM, HP, and Quantum were studied to gather objective and quantitative data. Published materials available from research companies are 2003–2010 Fuji Chimera Research Institute Inc. market reports, the 2011 Techno Systems Research Co. Ltd. market report, the 2018 Japan Data Storage Forum Report, and the scientific journal "Synthesiology" published in 2017. Market data for which no published figures were available for a certain period were extrapolated and confirmed with practitioners. Information regarding license conditions was gathered from published materials related to patent infringement litigation.

We searched every issue of IEEE Transactions on Magnetics from 2002 to 2016 for articles relating to magnetic tape technology. IEEE Transactions on Magnetics is a leading industry journal in the field of magnetic storage technology. Using this source, we counted published articles that addressed technical research as a proxy for the general level of technology owned by a company. We used keywords, such as "tape" and "magnetic," to guide the article search. We used the article title to find articles related to magnetic tape technology. If there was insufficient information available in the title, we read the abstract and the conclusion to ascertain if the article addressed the magnetic tape technology.

3.2. Variables

The definitions of the variables used for our analysis are summarized in Table 1 and detailed below.

Table 1. Variable descriptions.

Variables	Description
Objective variable	
Media market share	Firm's market share in a given year
Explanatory variables	
Technology leadership	The variable takes a value of one during generations if the firm succeeded in developing the core technology and in the first introduction of the product that adopted that technology into the market
Collaboration with business ecosystem leader	The variable collaboration with business ecosystem leader is defined asthe variable, which takes a value of one during a collaboration if a firm and a business ecosystem leader collaborated for some years and succeeded in the joint development of a new technology
Experience of mass production	The valuable takes a value of one if the firm had an experience of mass-producing the media of a linear tape, such as DLT, before the start of production of LTO media
General level of technology	The sum of the articles that discussed the research of tape media in a given year
Control variable	
Generation	We control for generation level effects using the generation dummy for each generation of LTO

3.2.1. Objective Variable

Our objective variable, media market share, is a firm's market share in a given year. A market report published by a research company usually uses market share as a measure of firm success [11].

3.2.2. Explanatory Variables

To assess the effects of technology leadership on firm performance, we construct the variable technology leadership of categorical data. The variable takes a value of one during generations if the firm succeeded in developing the core technology and in the first introduction of the product that adopted that technology into the market. There were two major core innovations, such as metal double layers tape and barium ferrite (BaFe) tape. These core innovations are complementary innovations of media manufacturers, who serve as complementors in the business ecosystem. We define the variable technology leadership no. 1 and the variable technology leadership no. 2 for these core innovations.

A business ecosystem leader is valued by the community because their functioning enables business ecosystem members to move toward shared visions that align their investments and to find mutually supportive roles [10]. It is, therefore, important for business ecosystem members to work closely with a business ecosystem leader. We define the variable collaboration with a business ecosystem leader that takes the value of one during a collaboration if a firm and a business ecosystem leader collaborated for some years and succeed in the joint development of new technology.

We measure a firm's experience of mass production of a linear tape, such as LTO, that takes a value of one if the firm had an experience of mass-producing the media of a linear tape, such as digital linear tape (DLT), before the start of production of LTO media. Here, the DLT was developed by the Digital Equipment Corporation (DEC) in 1984. Then, the DLT format was purchased, and the DLT tape drive was manufactured by Quantum.

We define the variable, general level of technology, as the sum of the articles that discussed the research on tape media in a given year.

3.2.3. Control Variables

We control for generation level effects by using the generation dummy for each generation of LTO.

3.2.4. Statistical Analysis

We use panel data for our empirical analysis to ensure the results of our qualitative study regarding the factors for obtaining a market share. To select a proper method for the panel data analysis, we tested three methods: the pooled ordinary least squares (OLS) model, the fixed-effects model, and the random-effects model using an F-test (used to compare between the pooled OLS model and the fixed-effects model), and a Hausman test (to compare between the fixed-effects model and the random-effects model). We confirmed that the random-effects model was the most appropriate. We decided to use the random-effects model for our analysis. We estimate the following equation:

$$ms_{it} = \beta_0 + \beta_1 TL1_{it} + \beta_2 TL2_{it} + \beta_3 CO_{it} + \beta_4 EM_{it} + \beta_5 GLT_{it} + \beta_6 L1 + \beta_7 L2 + \beta_8 L3 + \beta_9 L4 + \beta_{10} L5 + \beta_{11} L6 + \alpha_i + \varepsilon_{it}, \quad (1)$$

where ms_{it} is firm i's market share in year t; $TL1_{it}$ and $TL2_{it}$ are the explanatory variables of technology leadership no. 1 and no. 2, respectively; CO_{it} is the explanatory variable of collaboration with the business ecosystem leader; EM_{it} is the explanatory variable of experience of mass production; GLT_{it} is the explanatory variable of the general level of technology; L1, L2, L3, L4, L5, and L6 are the generation dummies for each generation of LTO; α_i is the unobserved heterogeneity for a firm; and ε_{it} is the error term.

4. The Business of LTO (Linear Tape Open)

4.1. Standardization of LTO Format and Its Licensing

A new open format of LTO was created by IBM, HP, and Quantum (formerly Seagate) in 2000, which has become the industry standard after beating the competition with DLT, digital data storage (DDS), and others. Here, the digital audio tape (DAT) called digital data storage (DDS) was defined by Sony and HP in 1989. The IBM, HP, and Quantum initially relied on the scheme of international standardization (ISO/IEC, ECMA website) [28,29,31] to create the open format of the LTO. They have been using consortium standardizations since the second generation of LTO. LTO adopts an open licensing policy, which enables any company to obtain a license to manufacture and sell LTO drives and media.

IBM, HP and Quantum set up a licensing administrator for their patent pool and jointly licensed the intellectual property rights, including the LTO trademark with a copy of the format specification, through this licensing administrator [32]. Here, a patent pool is a useful scheme organized among companies that own complementary essential patents to license essential patents. The LTO drives and LTO media manufacturers of business ecosystem members pay royalties through this licensing administrator.

4.2. Opening the Migration of LTO by Business Ecosystem Leaders

The business ecosystem leaders of IBM, HP, and Quantum have revealed the migration of the LTO format, as shown in Table 2. According to technical studies of the specification, the high capacity of LTO6 needed high recording density and required new advanced technology in place of the metal technology used in the previous LTO format generations one to five. Complementor media manufacturers were expected to develop the new technology accordingly to realize LTO6.

Table 2. The linear tape open (LTO) roadmap, Source: LTO website [33].

LTO	Capacity	Transfer Rate
Generation 1 (2000)	200 GB	Up to 30 MB/s
Generation 2 (2002)	400 GB	Up to 60~70 MB/s
Generation 3 (2005)	800 GB	Up to 160 MB/s
Generation 4 (2007)	1.6 TB	Up to 240 MB/s
Generation 5 (2010)	3 TB	Up to 280 MB/s
Generation 6 (2010)	6.25 TB	Up to 400 MB/s
Generation 7 (2015)	15 TB	Up to 750 MB/s
Generation 8 (2017)	32 TB	Up to 1180 MB/s
Generation 9	62.5 TB	Up to 1770 MB/s

A functional schema of an LTO business ecosystem and is shown in Figure 2. Media manufacturers supply LTO media to customers, who then buy LTO drives. Business ecosystem leaders drive manufacturers and complementor media manufacturers, thus collaborated to create a new generation of LTO 6.

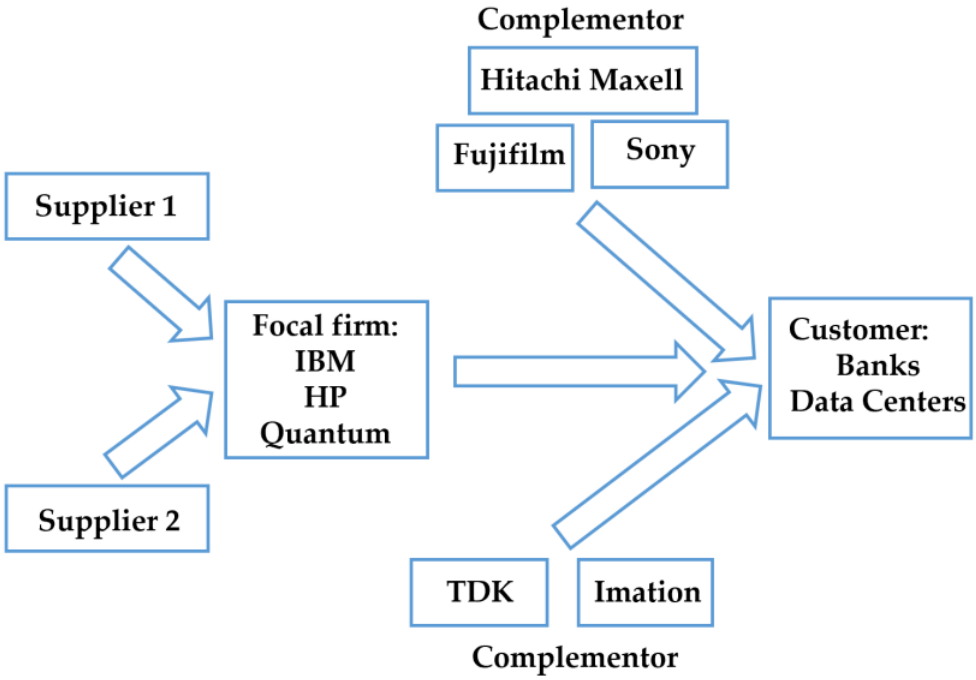

Figure 2. The scheme of a business ecosystem of LTO.

4.3. Business of LTO Media

Five media companies manufacture LTO media, as shown in Figure 3. Fuji film had the largest market share, and Hitachi Maxell, TDK, and Sony had a market share of 13%–22%. Imation had the smallest market share of around 9% in 2009.

4.4. The Development of a New Tape Technology in Order for Media Manufacturers to Realize LTO 6

Media manufacturers as business ecosystem members of complementors were expected to develop a new technology that realizes LTO6. A detailed description of the actions of complementors and business ecosystem leaders in the case of LTO6 is described below.

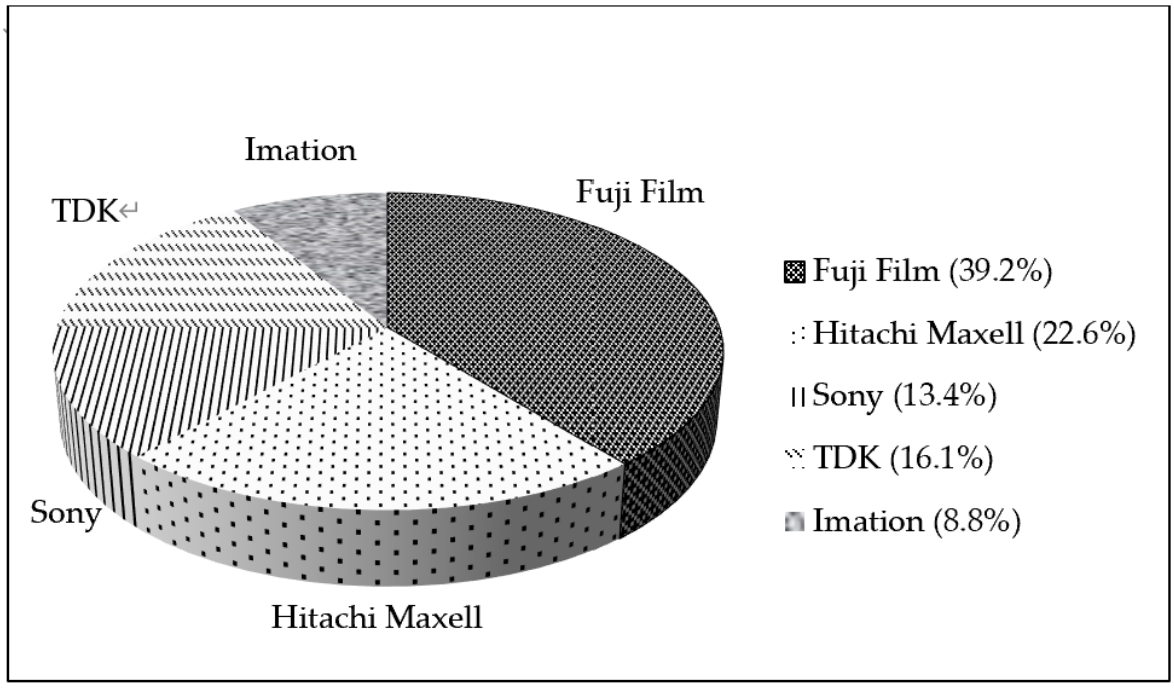

Figure 3. Media market share for LTO format in 2009. Source: [34].

4.4.1. The Development of BaFe Media by Fujifilm as a Business Ecosystem Member

Fujifilm devoted itself to developing BaFe media to realize the density required for the LTO6 format [35]. Here, BaFe media consists of small-sized BaFe particles that enable higher recording density and result in high-capacity storage media. Table 3 shows the history of developing BaFe tape by Fujifilm. Fujifilm started joint research with IBM for BaFe in 2004. It was eight years before Fujifilm succeeded in commercializing the tape for LTO6 in 2012. This joint research seemed to accelerate developing BaFe tape because the performance of the developed BaFe tape could be practically evaluated by IBM, the drive company. Moreover, Fujifilm solved the material problem that the BaFe particles were easy to aggregate. IBM then developed new signal processing technology, the so-called data-dependent noise predictive maximum-likelihood (DD-NPML) detection mechanism. This could compensate for the distortion of the reproducing signal, which had a negative effect on the performance of BaFe tape [35].

Fujifilm was able to provide samples of BaFe tape to drive companies other than IBM in 2007, and as a result, Fujifilm was able to obtain evaluation results for various types of drive formats. These evaluation results seemed to help Fujifilm develop the technology of BaFe tape, and this was finally employed as the tape for Oracle's T10000 and for IBM 3592 in 2011. Furthermore, Fujifilm succeeded in the commercialization of BaFe tape for LTO6 in 2012.

In summary, the business ecosystem leaders of IBM created incentives for joint research, allowing Fujifilm to invest eight years in creating complementary innovations, such as the BaFe tape. Hence, Fujifilm succeeded in the R&D of BaFe tape as its own differential technology through joint research with the business ecosystem leaders of IBM and ultimately contributed to the business ecosystem of LTO6.

4.4.2. The Development of Vapor Deposition Media by Sony as a Business Ecosystem Member

Vapor deposition (VD) is a method that can be used to produce thin films to realize high-density recording for storage media. The most common VD processes are sputtering and evaporation. Sony developed and commercialized vapor deposition tape as an 8 mm videotape to realize longer-duration video recording. Sony also commercialized vapor

deposition tape as a data storage tape for applying high-capacity storage. Sony has devoted itself to developing new technology for vapor deposition tape, which can be used for the LTO format.

Table 3. History of developing BaFe tape by Fujifilm. Source: [35].

Step	Year	Events
First step	1992	BaFe tape research started by three researchers.
Second step	2004	Started joint research with IBM on recording density demonstration for BaFe tape.
	2006	Succeeded in technical demonstration of areal recording density of 6.7 Gb/square inch (volume 8 TB equivalent) for BaFe tape jointly with IBM [36]. Hitachi Maxell, Ltd. proposed iron nitride tape. Sony proposed metal evaporated tape and discussion about post-metal tape began in the tape industry.
Third and fourth steps	2007	Started providing samples and presentations of BaFe tape to various tape drive system companies.
	2010	Succeeded in technical demonstration of areal recording density of 29.5 Gb/square inch (volume 35 TB equivalent) for BaFe tape jointly with IBM [37].
	2011	Employed as the tape for Oracle's (SUN at that time) T10000 third-generation system (volume 5 TB). This was the first successful commercialization of BaFe tape. Succeeded in commercialization as the tape for the IBM 3592 fourth-generation system (volume 4 TB).
	2012	Succeeded in commercialization as the tape for LTO6 (volume 2.5 TB). As a result, BaFe tape was employed in all three major tape storage systems.
	2013	Succeeded in technical demonstration of areal recording density of 85.9 Gb/square inch (volume 154 TB equivalent) for BaFe tape jointly with IBM [38].
	2014	Succeeded in commercialization as the tape for IBM's 3592 fifth-generation system (volume 10 TB). Succeeded in technical demonstration of areal recording density of 123 Gb/square inch (volume 220 TB equivalent) for BaFe tape jointly with IBM [39].
	2015	Succeeded in commercialization as the tape for LTO7 (volume 6 TB).

Sony issued press releases regarding developing vapor deposition tape in 2014 and 2017. Sony announced that it developed magnetic tape technology with the world's highest areal recording density of 148Gb/in2 in 2014 [40,41]. Sony announced that it developed, in collaboration with IBM, magnetic tape storage technology with the industry's highest recording areal density of 201Gb/in2 in 2017 [42–44]. Sony, one of the business ecosystem members, and IBM, one of the business ecosystem leaders, collaborated and succeeded in achieving the industry's highest recording areal density. They published a collaborative paper regarding this achievement in 2017. IBM, as the business ecosystem leader, supported Sony in developing advanced technology related to vapor deposition tape. It seems that IBM created incentives for Sony to invest in creating complementary innovations. Sony could thus develop its own differential technology and contribute to the LTO business ecosystem.

4.4.3. The Development of Iron Nitride Media by Hitachi Maxell as a Business Ecosystem Member

Hitachi Maxell planned to develop iron nitride media to achieve the high-density storage required for future media, such as LTO6 [6,35,45]. Here, iron nitride particles can maintain superior magnetic properties, even when the size of the particles decreases. Iron nitride media could be one of the candidates to realize high-density recording for storage media. Hitachi Maxell thought the most effective way to reduce media noise was to decrease the diameter of the magnetic particles. Moreover, Hitachi Maxell developed very fine iron nitride particles and named these particles nanocomposite advanced particles ("Nano CAP") [45,46].

5. Results: The Mechanisms to Capture Part of a Business Ecosystem's Joint Created Value by Business Ecosystem Members

5.1. One Mechanism for Business Ecosystem Members to Capture Part of a Business Ecosystem's Joint Created Value

As shown in Table 3 and Figure 4, the BaFe tape Fujifilm developed was also employed as the tape of T10000 drives (Product B) of Oracle and as the tape of the fourth and fifth generations of IBM3592 drives (Product C). Fujifilm sold their products of tape media to customers, such as banks and data centers. These customers purchased LTO drives or Oracle T1000 drives, or 3592 drives.

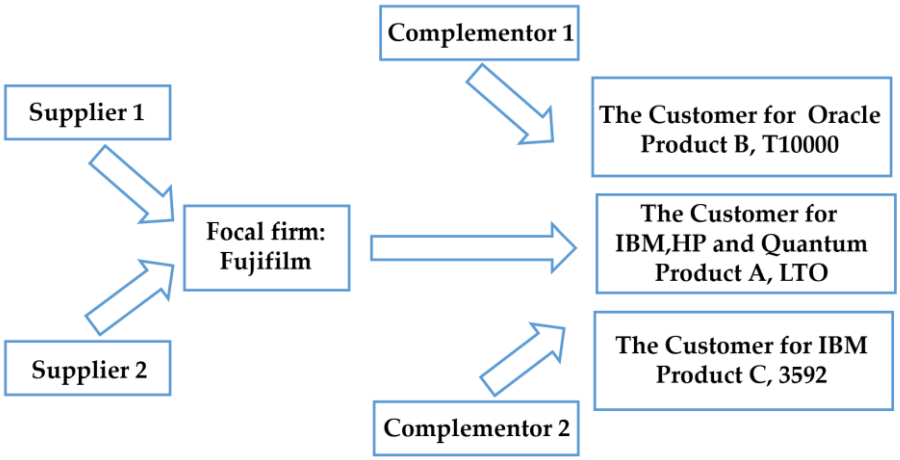

Figure 4. A new business ecosystem was established by Fujifilm.

Fujifilm established a business ecosystem as the business ecosystem leader through the "core" technology of BaFe tape. On the other hand, Fujifilm was the complementor for the business ecosystem of LTO 6, as shown in Figure 2. Fujifilm obtained profits not only from the LTO media business but also from both the T10000 and IBM3592 media businesses. This is one mechanism for a business ecosystem member to capture part of the business ecosystem's joint created value. A business ecosystem member can essentially establish a new business ecosystem through its own core technology created in collaboration with a business ecosystem leader. Thus, a business ecosystem member of a complementor can become a business ecosystem leader in a new business ecosystem. This can be an incentive for a business ecosystem member of a complementor to devote itself to developing and investing in creating complementary innovations for core technology.

If no business ecosystem members have succeeded in developing a core technology that will realize a product of a new generation, the business ecosystem cannot be sustained from that generation. The sustainability of a business ecosystem of LTO, therefore, depends on the success of developing a core technology by media manufactures of business ecosystem members.

5.2. The Second Mechanism for Business Ecosystem Members to Capture Part of a Business Ecosystem's Joint Created Value

5.2.1. Analyzing Market Share

The market share is regularly used as a measure of firm success [11]. A high market share means there is a large sales amount for a product. We used the market share of business ecosystem members to measure how much business ecosystem members capture part of the business ecosystem's joint created value. The more market share business ecosystem members obtain, the more jointly created value is captured. Detailed information regarding the market share is summarized in Table 4 for the case of the LTO media business. Regarding articles discussing tape media research, Fujifilm published one article in 2007, three articles in 2010, three articles in 2011, one article in 2013, one article in 2014, one article in 2015 and one article in 2016. Sony published one article in 2002, two articles in 2005, one article in 2006 and two articles in 2014 regarding articles discussing tape media research. Hitachi Maxell published two articles in 2005 and one article in 2006 as articles discussing tape media research. Fujifilm, Sony and Hitachi Maxell had a general level of technology in these years.

Table 4. Market share of LTO media manufacturers. Source: [34,47].

Year	Fujifilm	Sony	Hitachi Maxell	TDK	Imation
2002	56.4	0	36.4	2.2	3.3
2003	52.9	0	35.3	6.7	5.07
2004	41.7	3.95	33.3	11.2	6.83
2005	37.1	7.9	30.7	15.7	8.6
2006	36.2	8.7	29.6	16.8	8.7
2007	37.9	8.5	28.6	16.1	8.9
2008	38.6	11	25.6	16.1	8.85
2009	39.2	13.4	22.6	16.1	8.8
2010	39.7	13.2	22.2	16.2	8.5
2011	44.1	16.1	19	13	7.1
2012	48.5	19.1	15.9	9.72	5.66
2013	52.8	22	12.7	6.48	4.2
2014	57.2	24	9.52	3.24	2.82
2015	61.6	27.9	6.35	0	1.4
2016	66	30.8	3.2	0	0

Fujifilm has kept a high market share from 36% to 66% for 15 years. Fujifilm demonstrated technological leadership, as it was the first company to succeed in the commercial introduction of both metal double-layer tape and BaFe tape. The double-layer tape was adopted as the core technology of LTO from the first generation to the fifth generation. BaFe tape was adopted as the core technology of LTO from the sixth generation. Fujifilm collaborated for eight years from 2004 to 2012 with the business ecosystem leader IBM to develop the BaFe tape. Fujifilm had an experience of mass-producing the media of a linear tape, such as DLT, before the start of production of LTO media. Technology leadership, collaboration with the business ecosystem leader, and experience of mass production are most likely the main factors that allowed Fujifilm to succeed in the LTO media business and to maintain a high market share.

Sony entered the LTO media market in 2004, four years behind its competitors. In contrast, Sony did not have the technology leadership and experience of mass production. On the other hand, Sony steadily increased its market share since 2011 when it co-developed with the business ecosystem leader IBM, and in 2016, it gained a second market share of 30% after Fujifilm. The LTO license administrator organized by the business ecosystem leaders announced that Fujifilm and Sony had completed interchange testing for LTO7 [48,49]. Media manufacturers, such as Fujifilm and Sony, needed to cooperate closely with drive manufacturers of business ecosystem leaders to complete interchange tests. There was a close collaboration between Sony and the business ecosystem leaders. As a result, Sony

could successfully introduce LTO7 media to the market. Collaboration with the business ecosystem leader is likely an important factor that allowed Sony to obtain high market shares and to succeed in the business of LTO media.

Hitachi Maxell supplied DLT tape to Quantum before it produced LTO tape, and the company had experience producing linear tape before supplying LTO tape. Hitachi Maxell kept a relatively high market share from 22% to 36% from 2002 to 2010. They have independently developed iron nitride tape for LTO6 without collaborating with a business ecosystem leader, but in the end, their technology was not adopted for LTO6. Hitachi Maxell did not have either technology leadership no.1 or technology leadership no.2. Hitachi Maxell published papers in IEEE Transaction and showed that despite its high level of general technology, it could not recover its market share.

TDK maintained a market share of around 16% from 2005 to 2010 and could not increase its market share any further. Imation was a US company and had kept its market share around 8% to 9% from 2005 to 2010. It also could not increase its market share any further. TDK and Imation did not have either technology leadership no.1 or technology leadership no. 2. They did not publish articles discussing tape media research. They did not collaborate with a business ecosystem leader. They had no experience of mass-producing the media of a linear tape before the start of production of LTO media.

In the case of these companies, we study the market share and key factors, such as technology leadership, the general level of technology, collaboration with business ecosystem leaders, and experience of mass production. Technology leadership, the general level of technology, and experience of mass production are the technology factors and collaboration with business ecosystem leaders is the business factor. We found the following three results.

(1) Technology leadership, the experience of mass production, and collaboration with business ecosystem leaders contribute to obtaining a high market share;
(2) Collaboration with business ecosystem leaders helps business ecosystem members gain market shares even if they do not have experience of mass production and technology leadership;
(3) The general level of technology cannot recover the market share alone.

It is interesting that business factors, such as collaboration with business ecosystem leaders, are key factors that contribute to the mechanisms for business ecosystem members to capture part of the business ecosystem's joint created value.

5.2.2. Results of Statistical Analysis

We quantitatively confirm the results of the above (1) and (3) derived from the qualitative analysis explained in Section 5.2.1 Three explanatory variables were chosen among technology leadership no.1, technology leadership no.2, the general level of technology, collaboration with business ecosystem leaders, and the experience of mass production for each analysis. This is because there are only five media manufacturing firms for the panel data statistical analysis. The number of manufacturers needs to be larger than one plus the number of explanatory variables for the multiple regression model [50].

Model 1 is our baseline model where technology leadership no.2, collaboration with business ecosystem leaders and experience of mass production are chosen as the explanatory variables. The results of the panel data analysis using the random-effects model for model 1 are shown in Table 5.

The Pr (probability) values for TL2, CO, and EM are much less than 0.05. Therefore, TL2, CO, and EM have statistically significant effects on market share. We can confirm that technology leadership no2, collaboration with business ecosystem leaders, and experience of mass production contribute to the market share. These explanatory variables thus benefit market share.

Model 2 has chosen technology leadership no. 1, technology leadership no. 2, and collaboration with business ecosystem leaders as the explanatory variables. The results of panel data analysis using the random-effects model for model 2 are shown in Table 6.

The Pr value for TL1 is less than 0.05. Therefore, TL1 has a statistically significant effect on market share. We confirm that technology leadership no. 1, in addition to technology leadership no. 2, and collaboration with the business ecosystem leaders also contribute to the market share.

Table 5. Coefficient estimates from the random-effects model for model 1.

	Estimate	z-value	Pr (>|Z|))
(Intercept)	3.2862	0.8602	0.38967
TL2	20.36828	4.6376	3.53E-06
CO	14.54898	5.0972	3.45E-07
EM	17.05137	6.0143	1.81E-09
L1	9.55325	1.9023	0.05714
L2	8.13335	1.8726	0.06112
L3	6.98345	1.621	0.10502
L4	7.00012	1.7183	0.08575
L5	3.55104	0.8867	0.37525
L6	−0.51933	−0.131	0.89574

R-squared: 0.69397, adjusted R-squared: 0.651.

Table 6. Coefficient estimates from the random-effects model for model 2.

	Estimate	z-value	Pr (>|Z|))
(Intercept)	8.23152	1.5251	0.127225
TL1	20.65477	2.0969	3.60E-02
TL2	38.58524	3.7879	1.52E-04
CO	10.12857	2.7845	5.36E-03
L1	7.29752	1.4433	0.148934
L2	6.31967	1.4507	0.146875
L3	5.61181	1.3112	0.189781
L4	5.62848	1.3886	0.164963
L5	2.9313	0.7443	0.456697
L6	−0.51933	−0.1337	0.893656

R-squared: 0.36469, adjusted R-squared: 0.27673.

Model 3 has chosen technology leadership no. 2, collaboration with business ecosystem leaders, and the general level of technology as the explanatory variables. The results of the panel data analysis using the random-effects model for model 3 are shown in Table 7. The Pr value for GLT is more than 0.05. Therefore, GLT does not have a statistically significant effect on market share. We confirm that the general level of technology does not contribute to market share. It is confirmed that technology development, which is carried out simply for the purpose of developing in-house technology without collaboration with business ecosystem leaders, does not benefit the expansion of market share.

Table 7. Coefficient estimates from the random-effects model for model 3.

	Estimate	z-value	Pr (>|Z|))
(Intercept)	7.5674	1.6308	0.10294
TL2	24.0382	4.4076	1.05E-05
CO	18.0316	5.1933	2.00E-07
GLT	2.0617	1.2579	2.08E-01
L1	11.6803	1.8862	0.05926
L2	10.3245	1.9335	0.05318
L3	7.5893	1.405	0.16003
L4	8.7055	1.7359	0.08258
L5	3.8602	0.7771	0.4371
L6	−1.2066	−0.2452	0.80633

R-squared: 0.53596, adjusted R-squared: 0.47171.

From the panel data statistical analysis using model 1, model 2, and model 3, we quantitatively confirm that technology leadership, collaboration with business ecosystem leaders, and the experience of mass production contribute to obtaining a high market share. We also confirm that the general level of technology does not benefit market share. In other words, the general level of technology cannot recover the market share. We quantitatively confirm the results of the above (1) and (3) derived from the qualitative analysis explained in Section 5.2.1

5.3. Other Mechanisms for Business Ecosystem Members to Capture Part of a Business Ecosystem's Joint Created Value

It is important that a business ecosystem leader creates economic incentives for business ecosystem members of complementors to invest in creating complementary innovations and to keep doing so over time. The schema of an LTO business ecosystem is shown in Figure 2. Drive manufacturers of business ecosystem leaders and media manufacturers of business ecosystem members collaborated to create a new generation of LTO 6.

Fujifilm succeeded in the commercialization of BaFe tape for LTO6 through joint research with the business ecosystem leader of IBM. BaFe tape has been employed in the generations of both LTO 7 and LTO 8. This exemplifies an incentive for a complementor, such as Fujifilm, to devote itself to the development and investment in complementary innovation for core technology.

It is important for any media manufacturer to be able to manufacture and sell BaFe tape as LTO 6 media from the standpoint of standardization. Standard essential patents owned by Fujifilm related to the LTO format are licensed to other media manufacturers under nondiscriminatory standard terms and conditions [51]. Therefore, any media manufacturer can manufacture and sell LTO6 tape. Business ecosystem members, such as Fujifilm, which created complementary innovations for the business ecosystem, can continue to obtain royalties for their standard essential patents from the licensees of media manufactures of other business ecosystem members, as long as their patents are used for the format. This is an example of an incentive for a business ecosystem member to develop complementary innovations as a complementor and show another mechanism for a business ecosystem member to capture part of the business ecosystem's joint created value.

6. Discussion

In summary, we have found three mechanisms that allow business ecosystem members to capture part of a business ecosystem's joint created value. One mechanism is that a business ecosystem member can establish a new business ecosystem on its own through the newly created core technology of complementary innovation. A business ecosystem member can become a business ecosystem leader in a new business ecosystem. Another mechanism is that a business ecosystem member can obtain market share through technology leadership, collaborating with the business ecosystem leader, and the experience of mass production. The technology leadership that is driven by joint research and collaboration with a business ecosystem leader for future core technology and the experience of mass production contribute to obtaining the market share for a business ecosystem member. Another mechanism is that a business ecosystem member that creates complementary innovations obtains royalties by licensing its standard essential patents to other business ecosystem members.

This study contributes to the subsequent theory that each business ecosystem member must find mechanisms to capture part of the business ecosystem's joint created value beyond sole contributions [1,3]. Previous studies have investigated mechanisms that help to ensure value capture. One such mechanism is the joint legal agreements on the relative share of intellectual property rights (IPR) and other created intellectual properties among business ecosystem members and business ecosystem leaders [3]. Another mechanism is common commercial exclusivity practices as a means to ensure individual value capture for small and medium-sized enterprise (SME) partner(s) (e.g., time-limited commercial benefits and/or commercial benefits on certain geographical territories) [3]. It has been

reported that opening the common design specification, closing the differential technology, and leading both developing periodic new generations and their market development can be the mechanism for business ecosystem members to capture the profit for standardized media [52]. Research on business ecosystems has rarely examined the success of business ecosystem members apart from business ecosystem leaders [1,4]. This paper complements these previous studies by investigating business ecosystem members' mechanisms to capture part of the business ecosystem's joint created value.

It also has been studied that business ecosystem members of complementors earning low profits will either exit the business ecosystem or move to other business ecosystems [20–22]. These proposed three mechanisms for a business ecosystem member to capture part of the business ecosystem's joint created value help business ecosystem members to stay within the business ecosystem. These mechanisms also help business ecosystem members sustain their R&D over a long period. Therefore, these mechanisms contribute to the sustainability of the business ecosystem.

6.1. The Mechanism for a Business Ecosystem Member to Capture Part of a Business Ecosystem's Joint Created Value by Establishing a New Business Ecosystem as a Business Ecosystem Leader: The Case of the Blu-Ray Business

There is one distinguishing characteristic of the mechanism by which a business ecosystem member of a complementor establishes a new business ecosystem as a business ecosystem leader through its own newly created core technology. The business ecosystem member of a complementor can make a profit either from the original business ecosystem or from their new business ecosystem. The business ecosystem member of a complementor does not need to be too concerned with the profits obtained from either business ecosystem alone.

A business ecosystem leader's success often depends on the efforts of business ecosystem members in its environment [11]. Even an innovative and technologically superior business ecosystem cannot be sustained if the business ecosystem members of complementors that are responsible for the development and provision of goods are not successful [20]. The success of the newly created core technology of complementary innovation by a business ecosystem member contributes to the sustainability of the original business ecosystem.

The establishment of a business ecosystem by a business ecosystem member of a complementor, with its core technology, can be observed in the case of the Blu-ray business. Sony (Sony drive division), Panasonic, Pioneer, and ASUS sell Blu-ray drives to their general consumers, as shown in Figure 5. Blu-ray is a digital optical disc data storage format developed by the Blu-ray Disc Association [53], and this technology was commercialized in 2003. Sony media division, Panasonic, Mitsubishi Chemical, and Hitachi Maxell sell Blu-ray media as complementors to their general consumers. Blu-ray technology is the "core" for high-capacity optical storage. Sony's media division can manufacture and sell optical media for XDCAM and optical media for optical disc archives in addition to media for Blu-ray by making use of the core technology of Blu-ray media. Here, the XDCAM Camcorder is a professional product commercialized in 2003 for digital video recording using an optical disc [54,55]. Optical disc archive is a storage technology commercialized in 2013 for high capacity that uses removable cartridges that hold 12 optical discs [56].

Sony's media division of a complementor could establish a new business ecosystem as a business ecosystem leader through this "core" technology of Blu-ray, as shown in Figure 6. On the other hand, Sony's media division is a business ecosystem member of a complementor for the business ecosystem of Blu-ray, as shown in Figure 5. This is another case of the mechanism by which a business ecosystem member of a complementor can establish a new business ecosystem as a business ecosystem leader on its own through the newly created core technology of complementary innovation.

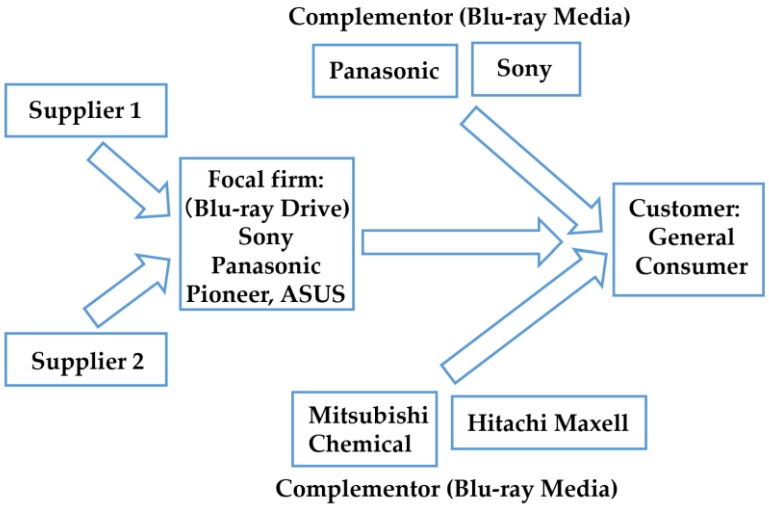

Figure 5. The scheme of a business ecosystem of Blu-ray drives and media.

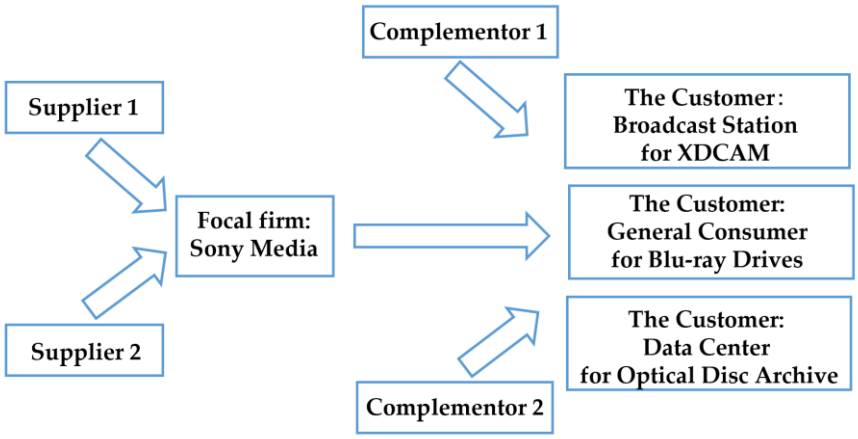

Figure 6. A new business ecosystem was established by Sony Media.

6.2. The Mechanism for Business Ecosystem Members to Capture Part of a Business Ecosystem's Joint Created Value by Obtaining the Market Share

We confirm that technology leadership, the experience of mass production, and collaboration with business ecosystem leaders contribute to obtaining the market share. Here, the technology leadership indicates that the firm succeeds in developing the core technology and in the first introduction of the product that adopts that technology into the market. To capture the returns from innovation, many firms strive to be technology leaders in their industry by first introducing new innovations to the market [11]. First-movers can gain advantages, such as earning economic profits through technology leadership [57]. This paper shows that obtaining a high market share by providing technology leadership can be the mechanism for business ecosystem members to capture part of the business ecosystem's joint created value.

The first-mover can obtain the experience of mass production before its competitors start their own mass production. A first-mover has the advantage derived from the "learning" or "experience" curve, where costs fall with cumulative output [57]. This allows first-movers to maintain leadership in the market share [57]. Firms that pursue sustainability first-mover strategies have gained competitive advantages in many industries [58]. Therefore, mass production experience makes a business ecosystem member gain the market share and capture part of the business ecosystem's joint created value.

A business ecosystem leader enables business ecosystem members to move toward shared visions that align their investments and find mutually supportive roles [10]. Complementary business ecosystem members develop and commercialize their products, which

are one of the main attraction points for customers [26]. To ensure sustainable evolution, the business ecosystem leader needs to attract and retain high-quality business ecosystem members innovators [26]. How to create a good business ecosystem and sustainable development is the main problem faced by business ecosystem leaders [59]. Therefore, collaboration with a business ecosystem leader for future technology allows a business ecosystem member to obtain supportive advice and not only help with future technology but also for the current technology and business. This is the reason why a business ecosystem member gains market share through collaboration with the business ecosystem leader. In other words, it is difficult for a business ecosystem member to gain market share on its own, even if it develops an advanced technology. Collaboration with a business ecosystem leader is essential. The development of technology alone is expected to increase its general level of technology. However, an increase in the general level of technology does not always benefit market share.

6.3. The Mechanism for a Business Ecosystem Member to Capture Part of a Business Ecosystem's Joint Created Value by Obtaining Royalties through Licensing the Standard Essential Patents Related to Its Complementary Innovations

Various strategies involving intellectual property rights in creating standards have been studied so far to understand how to profit from standardized products [27]. One of the strategies previously studied is licensing as a mechanism for profit [27]. This paper shows that obtaining royalties from other business ecosystem members through licensing standard essential patents related to complementary innovations can be the mechanism for a business ecosystem member to capture part of the business ecosystem's joint created value.

The licensing patent scheme makes it possible for other business ecosystem members to start manufacturing and selling products using complementary innovations. It is studied that the sustainability of technology (patents) licensing is related to industrial development and economic growth [60]. The licensing of standard essential patents makes other business ecosystem members sustain their R&D for a long time and stay within the business ecosystem. Therefore, licensing patents contributes to the sustainability of the business ecosystem.

6.4. Implications, Limitations and Future Research

This study offers several implications for managers and decision-makers, not only in theory. The findings should be helpful to managers and decision-makers in search of a way to make a profit when they join a business ecosystem as a complementor member.

Despite the value of our study results, there are also some limitations that should be taken into account. First, this study focused mainly on the business ecosystems related to seven generations of LTO business. We also studied the case of the Blu-ray business. Both businesses of LTO and Blu-ray are storage businesses. The results of this study are affected by the nature of products of the storage business. The business ecosystem leaders and the business ecosystem members of this study are both manufactures of hardware products. This study did not analyze software products. This paper may not accurately reflect the situation of software products, such as game software or complementary products of the video game business. Hence, future studies should focus on whether the results of our study are applicable to businesses other than those for storage products.

Second, the business ecosystem leaders and business ecosystem members of this study are large companies, such as IBM, HP, Fujifilm and Sony. It does not consider the case of SMEs whose R&D fund is limited. SMEs cannot usually spend enough R&D funds for complementary innovation. Future studies are recommended to investigate cases of SMEs.

Third, this study clarifies quantitively the mechanisms that allow business ecosystem members to capture part of the business ecosystem's joint created value. We study qualitatively how the mechanisms contribute to the sustainability of a business ecosystem. However, this study's achievement is limited due to a qualitative analysis of the sustainability of a business ecosystem. Future research could investigate quantitively how the mechanisms contributing to the sustainability of a business ecosystem.

7. Conclusions

A business ecosystem leader's success may depend upon the success of business ecosystem members [1]. Business ecosystem members are expected to contribute to the business ecosystem's joint value creation. At the same time, each business ecosystem member also needs to find mechanisms to capture that value and to succeed in its business [1]. However, research on business ecosystems has rarely examined business ecosystem members' success (e.g., [1,4]).

In this study, we addressed the following research questions: What are the mechanisms for business ecosystem members to capture part of the business ecosystem's joint created value? How do these mechanisms contribute to the sustainability of a business ecosystem? This paper examined the cases of business ecosystems related to the seven generations of LTO technology to complement previous theories.

We have identified three mechanisms. One mechanism is that a business ecosystem member can establish a new business ecosystem on its own through the newly created core technology of complementary innovations. A business ecosystem member can essentially become a business ecosystem leader in a new business ecosystem. The business ecosystem member does not need to be too concerned with the profit obtained from one business ecosystem alone. Another mechanism is that a business ecosystem member gains the market share through technology leadership, the experience of mass production, and collaboration with business ecosystem leaders. The other mechanism is that a business ecosystem member that creates complementary innovations can obtain royalties by licensing their standard essential patents to other business ecosystem members.

It is studied that business ecosystem members of complementors earning low profits will either exit the business ecosystem or move to other business ecosystems [20–22]. Therefore, these three mechanisms we have found help business ecosystem members to stay with the business ecosystem as complementors. These three mechanisms for business ecosystem members to capture part of the business ecosystem's joint created value contribute to the sustainability of the business ecosystem.

This paper complements previous theories by providing an additional three mechanisms for business ecosystem members to capture part of the business ecosystem's joint created value.

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