A Business Strategy in the Lithium-Ion Battery Industry

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Abstract--**Recently, modularization has progressed, particularly in the electronics industry and is receiving considerable attention. This development of modularization can be explained using the business architecture concept. Based on architecture-based strategies that add some perspectives from organizational capability and the ability development environment to this concept, many industrial studies have been developed from automobile and electronics industries. This strategic idea includes the perspective of "analytical strategies" in strategic management. However, it may be recognized that actual business operations include activities that relate to the "process", and this strategic idea includes less perspective of "process", to be utilized to develop a business strategy from the analytical result. In this paper, citing the lithium-ion battery industry as an example, architecture-based strategies was reconsidered from the strategic management perspective and their relationship was identified. Moreover, a strategic approach that also includes a process perspective was proposed from the result and its validity was examined by making a concrete proposal of a business strategy for Japanese lithium-ion battery manufacturers.**

I. INTRODUCTION

Since the beginning of 2000's, the market share for lithium-ion battery (LIB) manufacturers in Japan, which had previously led the world, has continued to decline year by year. Particularly the progress of Korean or Chinese LIB manufacturers has been remarkable these several years [7, 16]. This phenomenon has been observed in the electronics industry from the 1990s and considerable research in the field of architectural theory has been performed to clarify the cause [18, 21, 22, 23, 31]. According to this research, one major reason is the switch in product and process architecture from the integral type to the modular type, and the fact that newly emerging countries are rapidly catching up.

Here, the product and process architecture is one of the key subsystems that constitutes business architecture, which is prescribed by patterns of the state of interaction among the active elements of a system, which constitute a business process [8]. Fujimoto has been developing his research on competitiveness, profitability and strategy for companies; focusing on a manufacturing industry and using an analytical frame that includes product and process architecture and "organizational capability" [9, 10, 11]. Shintaku et al. added, furthermore, "ability development environment" (industrial geography) perspective [23]. As this paper uses this analytical frame for our proposal on analysis and strategy for part of the manufacturing industry or LIB, this term is consistently referred to as "architecture-based strategies" in the sense that our strategies are based on the analytical frame.

In our research, the LIB industry was specifically analyzed based on architecture-based strategies and revealed why the market share of Japanese LIB manufacturers has declined share year by year since 2000, while South Korean and Chinese LIB manufacturers have, in contrast, advanced [29, 30]. Next task is to propose specific strategies for Japanese LIB manufacturers based on our research result.

The procedure to plan a strategy with architecture-based strategies involves identifying the architecture, identifying the organizational capability of each company taking the "ability development environment" (industrial geography) perspective into consideration, considering compatibility with the company's organizational capability and considering the architectural positioning that the company should adopt [9, 10, 11]. However, even if the strategic architectural positioning that the company should adopt becomes clear, there is a lack of clear guidance on "how to" adopt the position specifically.

The reason for this limitation would lie in the fact that the analytical frame, along with the concept of the product and process architecture and organizational capabilities in architecture-based strategies, has been logically developed by considering both "emphasizing organizational capabilities" (resources) and "emphasizing the attractiveness of an environment" (positioning), which have been considered two main streams in strategic management [9, 10, 11]. These two strategic management theories focus on "causes" for their analysis and are categorized into "analytical strategies" that define a specific goal and make plans to be accomplished it beforehand. In such theories, there is no focus on "process" or "how to accomplish".

On the other hand, strategic management has also strategies which are categorized in terms of "process-oriented strategies" that focus on the analytical "process". Aoshima et al. classified these "analytical strategies" and "process-oriented strategies" into four approaches of strategic management, namely a classification to identify the factors to achieve the goal (source of profit) is in the company or outside, and another classification to identify whether the analysis focuses on "factors" or "process" [2]. This idea includes the idea of the process element which is less focused on by architecture-based strategies.

Here again, by reviewing previous research results based on architecture-based strategies [18, 21, 22, 23, 31], it may be recognized that actual business operations include activities that relate to the "process". In other words, it is probable that "process"-related business operations could be identified by reanalyzing the analytical result obtained through architecture-based strategies by consulting four approaches of strategic management. Moreover, if the "process-oriented perspective" is also considered for a company's strategic planning, a company may be able to create more specific,

clearer and effective strategies. That is the authors' perspective.

Therefore, in this paper, citing the LIB industry as an example, architecture-based strategies is reconsidered from the strategic management perspective and their relationship is identified. Further, based on this result, a composite strategic approach that also includes a process perspective is proposed. This approach considers four approaches of strategic management for architecture-based strategies. Finally, validity of the proposed approach is examined by making a concrete proposal of a business strategy for Japanese LIB manufacturers.

II. OVERVIEW OF BUSINESS ARCHITECTURE AND TWO STRATEGIC THEORIES

This Chapter covers the basic concept of business architecture, architecture-based strategies based on the concept, and an overview of strategic management.

A. Business architecture

Business architecture is "properties described by mutual-dependence relationship patterns among the components" of a system comprising business processes that cover product and service development, production, and sales. Architectural properties can be understood via dual perspectives of modularization and openness, while product and process architecture can be considered a major subsystem of business architecture [8]. The terms standardization and modularization proliferate in various industries such as computers and household electrical appliances, and attract considerable public attention. Almost all such discussions must be considered architecture-related, particularly to product architecture [3, 4, 13, 20].

Any system involves mutual-dependencies among components, the level of which dictates a system complexity. Modularization is a strategy to reduce such complexity, which can be accomplished by "system hierarchizing and interface integration" and the "formulation of interface rules". The higher the level of hierarchizing, integration, and interface rules, the higher the level of modularization (modular type), and the opposite results in a higher level of integral (integral type) [1, 8].

Openness is the concept of "the degree of information required for system development, improvement and maintenance to be shared or accepted in a social setting". Openness indicates that such extent is expanding, while closed indicates the opposite [8].

Those two perspectives are mutually independent and it is possible, for instance that only modularization is enabled and no openness toward external. Also, there is another concept other than those two perspectives in systems, namely "hierarchy" [5, 20, 24, 25]. An architecture could have different types in various system hierarchy and the openness varies depending on a layer to be opened.

B. Architecture-based strategies

As mentioned in Chapter I, Fujimoto et al. develop a strategy based on three key concepts, namely adding "organizational capability" and "ability development environment" (industrial geography) to the product and process architecture concept [9, 10, 11, 23]. In this paper, we refer to this as "architecture-based strategies".

There are two types of product architecture, namely the modular-type, which requires less reconciliation with other elements due to its quasi-one-to-one relationship between functional and structural sub-modules in a product, and the integral type, which requires reconciliation with other elements due to its many-to-many relationship. A similar classification can be applied to process architecture by mapping product structures and production processes.

Similarly, openness for architectures, namely whether an architecture is open or closed, can be classified by examining whether the interface design rules are used within a company or widely used as an industry-wide standard [9, 10, 11]. Therefore, the characteristics of a kind of architecture can be simply classified into "four basic types" using a 2 by 2 matrix, with modular/integral as one axis and open/closed as another. Practically, there is no "open - integral type", because the integral type belongs to a closed type due to its closed basic design. Therefore, the end result of the product architecture classification reveals "three basic types" in combination [9, 10, 11].

Also, from a system hierarchy perspective, there are four combination of architecture; based on the relationship between the product architecture in-house (inside) and the product architecture for end-user products (outside). As selecting any one of such architectural combinations affects profitability, Fujimoto refers to this as "architectural positioning strategy". Similarly, another strategy, to learn through best practice for in-house weak architecture and strengthen strong architecture is referred to as "dual strategies in architecture" [9, 10, 11].

Next, "organizational capability" referred to in this paper are based on the concept cited by Fujimoto as the "organizational capability of manufacturing", which indicates the organizational capability revealed at the point of product development or production. In concrete terms, it is the ability of the whole organization to engage in the process of creation, transfer, and transmission of design information which appeals to a customer, correctly (with high quality), efficiently (at low cost), and rapidly (with a short lead time) rather than competitors [10, 11, 23]. In this strategy, such architecture is considered compatible with the organizational capability of manufacturing, an integral type of manufacturing at which Japanese companies traditionally excel.

Further, Shintaku et al. mentioned the "ability development environment" which acquires organizational capability. This "ability development environment" includes factors that play key roles in establishing in-house organizational capability among national companies, and

differs among major global regions. As it is significantly affected by each country's unique market environment, systems, culture and history, it prioritizes in-house organizational capability and "adaptability" with the nation or region [23]. The environment underpinning such ability is also referred to as "industrial geography", from this perspective.

C. Strategic management

Strategic management has a long history, and there are two major streams of "emphasizing capabilities of organization" (resources) and "emphasizing the attractiveness of an environment" (positioning). The "emphasizing capabilities of organization" is also referred to as the "organizational capability party", while in the US, it is known as a "resource-based view" [12, 26, 27]. Meanwhile, "emphasizing the attractiveness of an environment" (positioning) is also referred to as "positioning party" and represented by M. Porter [19]. These two strategic management theories focus on "causes" for their analysis and are categorized into "analytical strategies" that define a specific goal and make plans to be accomplished it beforehand. The architecture-based strategies explained in Section II-B were logically developed by considering those two strategic management theories [9, 10, 11].

On the other hand, strategic management has also strategies which are categorized in terms of "process-oriented strategies" that focus on the analytical "process" [15].

Aoshima et al. treated "analytical strategies" and "process-oriented strategies" as competitive strategies and classified them into four approaches of strategic management. Based on two classifications to identify factors behind the source of profit (achieving of goals) "inside" (in-house) or "outside", and another classification to identify whether the analysis focuses on "factors" or "process", as shown in Fig. 1, it is classified into positioning, resource (resource-based view: RBV), game and learning approaches [2].

The positioning approach determines competitive factors for an enterprise externally and emphasizes the importance of positioning itself in an advantageous environment for its goals.

The resource approach is also known as a resource-based view and seeks to define where differences in company performance originate with respect to the management resources of each company.

The game approach also determines the source of profit externally, like the positioning approach, but instead of setting a company against an advantageous environment, emphasizes the creation of said advantageous environment by its own actions. It has been developed by referring to part of the game theory idea [2] as well as the notions of the "stakeholder approach" [6] and "organizational relationship theory" [28], which implemented the concept of stakeholders to strategic management.

The learning approach also encompasses a unique management resource that is beneficial in terms of profit for a company as the resource approach, as well as the process itself, which accumulates invisible assets such as knowledge and information.

In this paper, our analysis has been performed based on the four approaches of strategic management. More importantly, "you should use multiple and well-balanced 'conceptual lenses' to develop your strategic scenario", as referred in [2]. In other words, the four approaches could be integrated and the authors' idea would also follow suit.

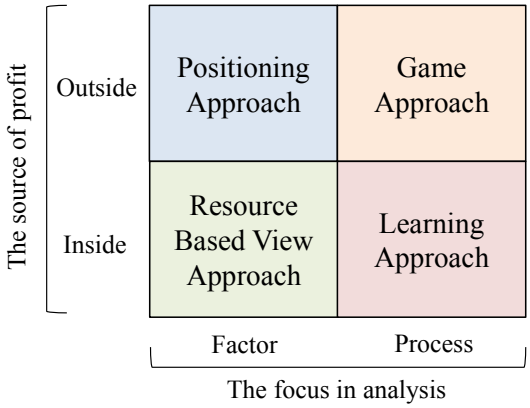


Fig. 1 Four approaches of strategic management [2]

III. LIB OVERVIEW

In this Chapter, the overview of the lithium-ion battery (LIB), which is the target of our analysis, is described.

LIBs are rechargeable batteries that can be repeatedly used. In recharging stage, lithium emits electrons toward the cathode and ionized then it moves to anode. In discharge stage, the ionized lithium emits electrons to anode and return to the cathode. These mechanisms are the operating principles as a rechargeable battery.

Major features that lithium batteries must have are voltage, capacity, maximum current, life and safety. The (single) cell of a lithium-ion battery comprises four major components, namely the cathode, anode, separator and electrolyte. Other components include current collector that collects electrons from the cathode and anode, safety mechanism for preventing over heat and explosion and a casing.

Two important components among them are cathode and anode, which impact on capacity, performance and safety for lithium-ion batteries, while a major material used for the cathode is lithium cobalt oxide ($LiCoO_2$). To increase energy density and safety, other cathode materials have also been continuously used, Lithium Nickelate ($LiNiO_2$), which uses nickel or manganese in place of cobalt, Lithium Manganese ($LiMn_2O_4$), other oxides known as ternary system ($LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$), or Lithium Iron Phosphate ($LiFePO_4$). Conversely, typical anode materials include graphite-based carbon (C) materials and silicon (Si) based materials under development.

There are three major shapes of lithium-ion battery cells

distributed in the consumer product market. The cylindrical type is denoted as "diameter x length"; typical subtypes of which include 14500, 16650, 17500, 18500 and 18650. Recently, 18650 (18mm x 65mm) has typically become the industry standard, while square and lamination types are common in customized product and have more variety and higher flexibility than the cylindrical type. In recent years, the growing demand for smartphones and tablet PCs has increased the ratio of the lamination type [7]. In other words, the shape of lithium-ion batteries is evolving alongside final customer products, from cylindrical to square and then lamination shapes respectively.

Fig. 2 shows the internal structure of a lithium-ion battery cell, taking the cylindrical shape as an example. As is clear, the structure involves the cathode and anode applied to the current collector while sandwiched by separators and the electrolyte filling in the space between the materials. The capacity primarily depends on the selected cathode and anode materials and other factors, while the thickness of the cathode and anode materials applied to the current collector and number of wire turns, are also relevant.

When the cells are completed as a finished product, they are usually consolidated with a protection circuit to form a package. For automobile application, multiple packages are bunched together to form a module and then a certain number of modules are piled up to get a required voltage and capacity.

Besides the consumer application, other applications such as Plug-in Hybrid Electrical Vehicle (PHEV), Electrical Vehicle (EV) and Energy Storage System (ESS) for large scale power are expected to contribute further market expansion in the future.

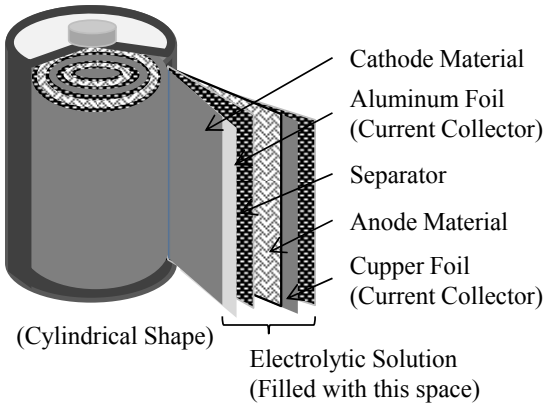


Fig. 2 A structure of lithium-ion battery cell (cylindrical shape) [29]

IV. RELATIONSHIP ANALYSIS OF TWO STRATEGIC THEORIES

In this Chapter, the relationship between architecture-based strategies and strategic management is analyzed by using the result of our previous research on consumer LIB.

A. Analysis results using the analytical frame of architecture-based strategies

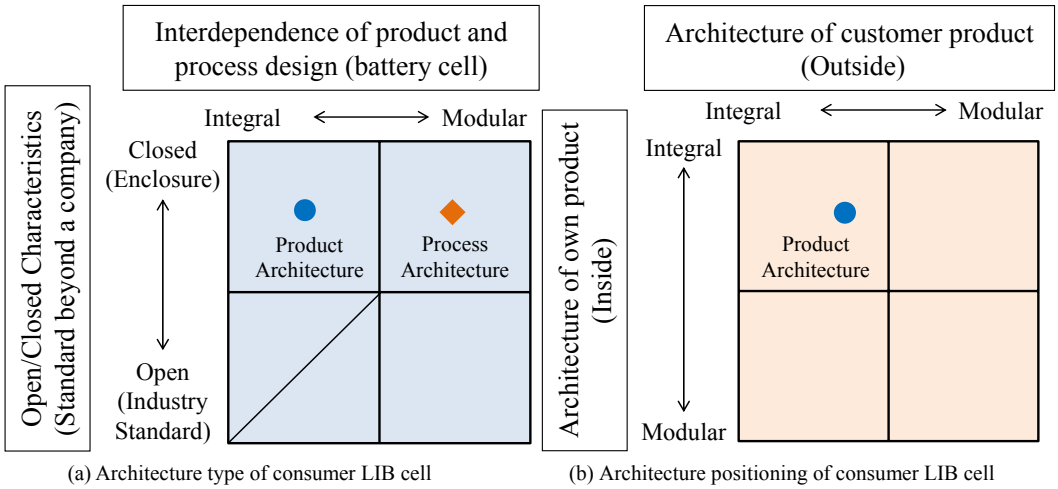
The result of our previous research on consumer LIB cell architecture were as follows;

- Product architecture: Closed integral
- Process architecture: Closed modular

Also, as for the product architecture, there is certain positions to which the "architectural positioning strategy" under the concept of the layering with end-user products, and it includes;

- Inside integral and outside semi-integral positioning

as our conclusion [29]. Fig. 3 shows these representations.



(a) Architecture type of consumer LIB cell (b) Architecture positioning of consumer LIB cell

Fig. 3 Architecture of consumer LIB cell [29]

Further, the architecture was analyzed by adding the analytical axis of the "product architecture <=> process architecture" to the conventional analytical axes of the "integral <=> modular" and the "open <=> closed" for the product architecture. The above was proposed based on the idea that a product and process architectures for any product are not always the same and each should be treated as own analytical axis to identify the characteristics of products or industries. The analysis was made for identifying the factors of the rapid growth and success of Korean and Chinese LIB manufacturers by adding the newly proposed analytical axis to the three key concepts of architecture-based strategies stated in section II-B [30]. This result is shown in Table.1.

The above success factors reduced from architecture-based strategies indicate that the success types are different but there are two commonalities as follows.

- Talent and technologies are acquired externally to cope with the integral-type product architecture in which Korean and Chinese manufacturers have not been strong.
- A manufacturing strategy which exploits affinity with their own strength of modular-type process architecture and the organizational ability of its company efficiently as well as capitalizing on the ability development environment in industrial geography.

Based on architecture-based strategies, in conclusion, Korean and Chinese LIB manufacturers had implemented two strategies, namely obtaining organizational capability conforming to the integral type of product architecture, which is their weak side, and using modular-type process architecture, their strength.

Here, care must be taken to ensure that the dual architectural strategies are realized in the product and process architecture within the same product. This result was revealed by deriving new analytical axes from clearly separated product and process architectures.

As stated above, architecture-based strategies can enable analysis centering on compatibility between architectural characteristics and organizational capability and spawn conclusions focusing on architectural positioning. This shows less emphasis on the perspective of "how to" or process-oriented approach.

B. Reanalysis of success factors in view of strategic management

The next aspect involved reanalyzing the success factors derived from the above architecture-based strategies from strategic management perspective to determine the success factors that could be validated from a "process" perspective. This result is shown in Table 2.

This analytical result shows that Korean and Chinese LIB manufacturers' success factors include "process" factors. Acquiring talent from outside has an immediate effect on strengthening in-house human resources as well as a positive side-effect of weakening a competitor's organizational capability when triggering a brain drain of talent away from

TABLE 1. SUCCESS TYPES AND SUCCESS FACTORS CLASSIFIED BY ARCHITECTURE-BASED STRATEGIES [30].

Success type		**Vertical-Integration Type (South Korea Type)**	**Vertical-Specialization Type (China Type)**
Representative		Samsung SDI, LG Chem	BYD, BAK, ATL, Lishen
Product Architecture	**Organizational Ability**	- Cooperation with the excelled market strategy in which the set operation division in company (group) - High performance and high quality without made in Japan and inferiority targeted at from the start - Continuous research and development activities corresponding to market change	- Existence of the founder with the battery technology and knowledge, or cooperators who supply battery technology at the time of foundation - Research and development activities prioritiing performance and safety from the start - Activity involving overseas institutional customer acquisition
		- Acquisition of talented people and technology from the outside and catch-up	
	Industrial Geography	- Practically exploiting domestic industrial preferential treatment policy	- Existence of the huge domestic market and a cultural background (OEM/EMS Market, Shanzai Market)
Process Architecture	**Organizational Ability**	- A low-cost strategy which exploits the affinity with modular-type process architecture - Acquisition of talented people and technology from the outside and catch-up - Increase efficiency of a manufacturing process - In-house production of manufacturing equipment and components - Bold investment by powerful top-down leadership	- Capability to secure investment power - A low-cost manufacturing strategy, exploiting manufacturing equipment devices and cheap personnel expenses - Outsourcing, automation, in-house production of manufacturing equipment - Acquisition of talented people and technology from the outside and catch-up
	Industrial Geography	- The benefit of low Won exchange rates - The benefit of low domestic power rates - Practical exploiting domestic industrial preferential treatment policy - Selection of the producing district according to the market characteristic	- Existence of a domestic supply environment for low-cost material - Existence of an environment for the domestic acquisition of cheap labour power - Existence of a huge domestic production plant for application products (OEM/EMS)

the company. This indicates that this strategy includes some elements of the game approach. Other activities that can be considered part of the game approach, which transforms an external environment advantageously, include partnerships with other companies and the usage of EMS. Catching up and in-house production can be considered to include some elements of the learning approach because they involve acquiring capabilities. In other words, with architecture-based strategies in mind, Korean and Chinese LIB manufacturers utilized dual architectural strategies; namely further strengthening their modular-type process architecture and adapting themselves to the integral type of product architecture. Conversely, viewing from strategic management perspective, they adopted an integrated strategic approach by exploiting those four approaches of strategic management.

C. Strategic approach utilization comparison

Based on the result of Section IV-B, by reviewing the result obtained in view of architecture-based strategies with strategic management, it was identified that Korean and Chinese LIB manufacturers utilized the "integrated strategic approach" taking advantage of four strategic approaches. However, the weighting for each of the four approaches was uneven. In case of Korean and Chinese LIB manufacturers, as shown in Fig. 4, weighting factors are high in the order of (1) positioning approach, (2) resource approach, (3) game approach and (4) learning approach. Both countries have the same weighting factors for the four approaches of strategic management, however specific contents of those strategies are different.

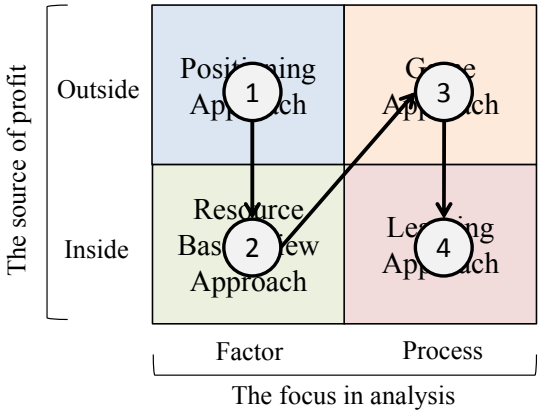


Fig4 Priority of four strategic approaches taken by Korea and Chinese LIB manufacturers

On the other hand, Japanese LIB manufacturers have higher organizational ability than Korean and Chinese LIB manufacturers due to their goals to develop higher performance and quality by implementing reconciliation and high level technology and high quality manufacturing technology. Also, they continue developing by aiming to create higher performance and quality for automobile and industrial applications. From this perspective, weighting factors for the use of the approaches by Japanese LIB manufacturers can be considered, as shown in Fig. 5, high in

TABLE 2. SUCCESS TYPES AND FACTORS CLASSIFIED IN TERMS OF FOUR APPROACHES OF STRATEGIC MANAGEMENT

Success type	Vertical-Integration Type (South Korea Type)	Vertical-Specialization Type (China Type)
Representative Manufacture	Samsung SDI, LG Chem	BYD, BAK, ATL, Lishen
Positioning Approach	- Aiming to develop products with similar performance and safety as well as outperforming Japanese products on price - Selling to major external customers as well as internal business divisions (affiliated companies)	- Aiming to deliver cheaper products with performance and safety accepted by the proper market - Major customers are external, namely European and large domestic customers
	- Key target markets include notebook PC and cellphone markets - Mass production and selling to countries targeting both industrially advanced nations and newly emerging countries	
Resource Based View Approach	- Investment utilizing funding resources of vertical-integration and financial groups - Utilizing some advantageous aspects of the domestic environment such as currency, power rates and preferential industrial treatment policy	- Utilizing lower labor costs nationally - Utilizing in-house resources where cheaper domestic materials are obtained
	- Acquiring talent from outside - Introducing manufacturing equipment and technology from outside (Japan)	
Game Approach	- Acquiring talent from outside, particularly Japanese competitors - Open collaboration with manufacturing equipment makers and component suppliers - Leveraging excellent market strategies to establish a market for internal business divisions in emerging countries	- A vertically specialized ecosystem, leveraging EMS and activities to obtain major European customers
Learning Approach	- To be competitive in terms of technological and organizational ability - Streamlining the performance of manufacturing equipment - Enabling the in-house production of manufacturing equipment and components	

the order of (1) resource approach, (2) learning approach, (3) positioning approach and (4) game approach. In other words, their strategy focuses primarily on the resource and learning approaches, weighting "internal" so to speak, rather than "external" or the positioning and game approaches. It is consistent with what Japanese enterprises are usually commented as facing inward in general.

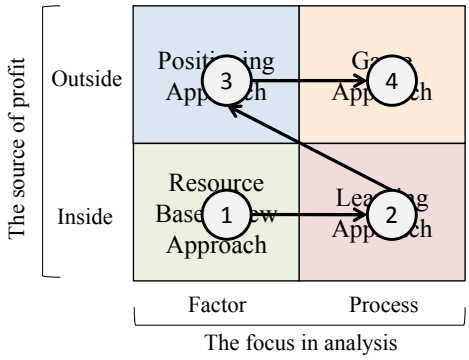


Fig. 5 Priority of four strategic approaches taken by Japanese LIB manufacturers

V. CONSIDERATION OF THE ANALYTICAL RESULT

A. Viewpoint of the analysis

In Chapter IV, the analytical results based on architecture-based strategies for the LIB industry was reanalyzed from the four approaches of strategic management. This can also be thought of as analyzing the same subject from a different perspective and can be illustrated conceptually, as shown in Fig. 6.

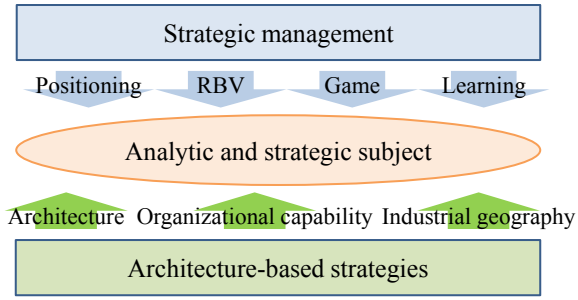


Fig. 6 Concept chart of analysis viewed from two strategic approaches

Consequently, when the target is reanalyzed by changing the perspective from the architecture-based strategies to the approach of strategic management, the elements that can be categorized in the four strategic approaches are identified. Indeed, as the perspective used by architecture-based strategies does not take the "process" into account, the analysis does not indicate any items categorized into a "process". Even the "ability development environment" (industrial geography), that could include the process element because of its potential path dependency, is not indicated. However, when you analyze a subject, items that relate to the "process" accompanying the architecture or organizational capability may be identified by changing perspective. As seen in the LIB case, the four strategic approaches are deemed to be adopted in an actual environment in companies and utilized in an integrated fashion. Overall, then, the "process"-oriented perspective might be necessary on occasions such as strategic planning cases using architecture-based strategies. In other words, it is suggested that one effective approach could be to consider strategies from the perspective of four approaches of strategic management while exploiting the analytical result of architecture-based strategies. However, while the four strategic approaches are integrated, rather than equally adopted, the four approaches are weighted unevenly, as seen in the LIB case.

B. Proposal of a new strategic approach

Through the discussion described above, this section covers the integrated approach in strategic management.

Taking the weighting into consideration, the number of combination in the integrated approach based on the four strategic approaches can be calculated using the permutation formula in mathematics, i.e. ${}_nP_r = n! / (n-r)!$, then

${}_4P_4 = 4! / (4-4)! = 4\times3\times2\times1/ 1 = 24$ patterns (1)

Here, $n! = n \cdot (n-1) \cdot \ldots 2 \cdot 1$: n factorial, $0!=1$

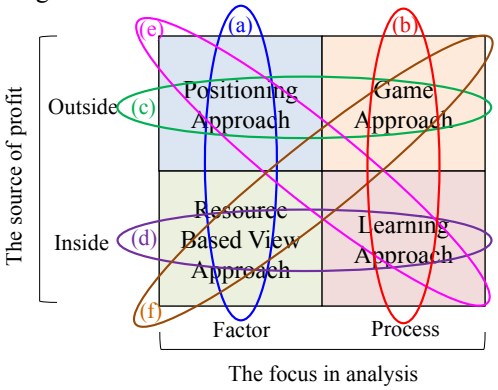
However, as it is too many and complex to include the consideration of all four strategic approaches with weighting to develop a strategy, we propose selecting two key strategic approaches with no weighting considered in the initial strategic planning. Under this simplification, the following two approaches will be treated equally.

- Positioning approach => resource approach
- Resource approach => positioning approach

This idea, selecting two strategic approaches with no weighting considered, or we call "composite approach", has the number of combination of ${}_nC_r = {}_nP_r /r! = n!/(n-r)!r!$, then

${}_4C_2 = 4\times3/2=6$ patterns (2)

The combination using these two strategic approaches is shown in Fig. 7.



(a) Positioning x Resource approach
(b) Game x Learning approach
(c) Positioning x Game approach
(d) Resource x Learning approach
(e) Positioning x Learning approach
(f) Resource x Game approach

Fig. 7 Composite approach in strategic management

Although there are six strategic approaches in this "composite approach", the same idea can be applied as the dual strategies in architecture, and strong approaches can be strengthened and a best practice should be used for weak approaches. Here, the idea of using a best practice for weak approaches is used for further strategic planning.

Based on the result, in Section IV-C, the approach seemingly weak but most favorable for Japanese LIB manufacturers is the third, namely Positioning x Game approach. This is an (Outside) - (Outside) type approach, enclosed in Red frame, whereby a profitable position is sought and an advantageous external environment self-procured to allow the individual entity to occupy the position.

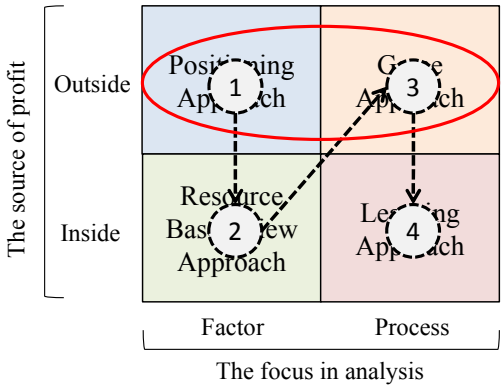


Fig. 8 A favorable strategic approach for Japanese LIB manufacturers

One of the strategies which are devised from this approach for Japanese LIB manufacturers includes;

- To select a target market or a business domain from architectural perspective (a positioning approach) and
- To produce a change with the partnering companies involved to occupy a profitable architectural field (a game approach).

VI. SAMPLE STRATEGIC PLANNING FOR JAPANESE LIB MANUFACTURERS

In this Chapter, we attempt to create some strategic proposals to Japanese LIB manufacturers adopting the idea on the strategic approach considered in chapter V, followed by consideration on their effectiveness.

A. Strategic planning using the positioning approach

First consideration is the positioning approach.

LIB manufacturers' expected market in future is automobile LIB market for EV and PHEV applications. In order to search the most ideal position among them, Fig. 9-(A) shows the flow of the entire automobile LIB business, from materials to finished products and Fig.9-(B) shows division of roles of each manufacturer in LIB industry. The most LIB manufacturers have processes from components to battery cells or battery packs that include protective circuit as their business domain. Automobile LIBs require higher level of performance such as the energy density as well as safety requirements compared than the consumer LIB. Also, they are required to add new technologies or features for EV and PHEV applications, because accurate reports for charging status and aging level are required. As a result, the importance of housing for components such as the four key components and battery modules and the technologies to monitor and control battery status has become increasingly important and the added values for those areas have been boosted. In other words, the ideal portion is, as shown in Fig. 9-(B), the upper stream region from materials to the four key components that are becoming important and battery modules and their control technologies in the region close to lower stream. These regions are considered to have higher integral trend from architecture-based perspective.

This indicates that one could try to advance into the lower business field where battery modules and their control technologies are merchandise. However, the entry barriers of this domain are high because this domain is led by automobile manufacturers and the LIB manufacturers have not been engaged independently as they focused on consumer oriented applications in their business. In actual fact, in Japan, there are some cases where automobile manufacturers established joint ventures with battery manufacturers. This way could be one of the strategies that Japanese LIB manufacturers can take, but they may not be able to lead the business, seemingly, this is not an ideal one.

Another option for the LIB manufacturers would be to focus on the four key component domain as shown as "Specialization" in Fig. 9-(C), and leave the battery assembly and afterward to other battery manufacturers. As the detail of the components and battery cells are shown in Fig. 10, this would involve them focusing on the series of processes from applying the cathode or anode to current collectors (aluminum or copper foil) to pressing and then rolling the same (Component). Actually, NEC Energy Device Ltd. delivers such rolls that are produced by applying a cathode to the aluminum foil of the current collector to AESC (Automotive Energy Supply Corporation) [17]. The proposal in this paper is to sell this rolled cathode material, not only to their affiliated battery manufacturers but also other battery manufacturers in China, Europe and America. If that happens, they could sell their products that are superior to competitors in terms of their performance and quality to broader market by confining their technologies and know-how on the cathode at the same time. Similarly, it could be possible to sell anode materials that are designed and manufactured along with the cathode materials. In other words, this can be explained whereby the LIB manufacturers strategically shift their business to the component manufacturing layer where higher integrality, hence higher profitability in terms of architectural perspective. It must be advantageous to have those two materials in hand in terms of product capacity variation and ensuring of safety because the combination of cathode and anode materials has significant impact on the battery capacity and safety. However, careful technical and profitability study must be performed to make sure if such a business deployment is feasible by exporting and delivering the rolled cathode materials because it could impact on safety.

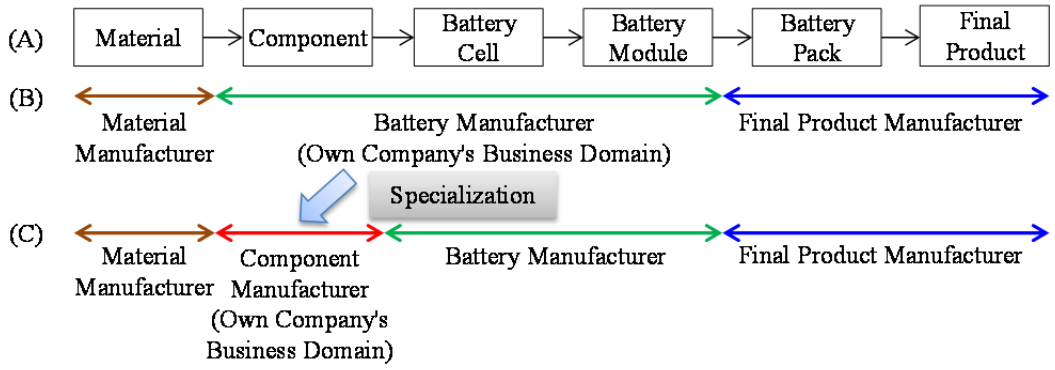


Fig.9 Business development flow of LIB product and division of roles of each manufacturer

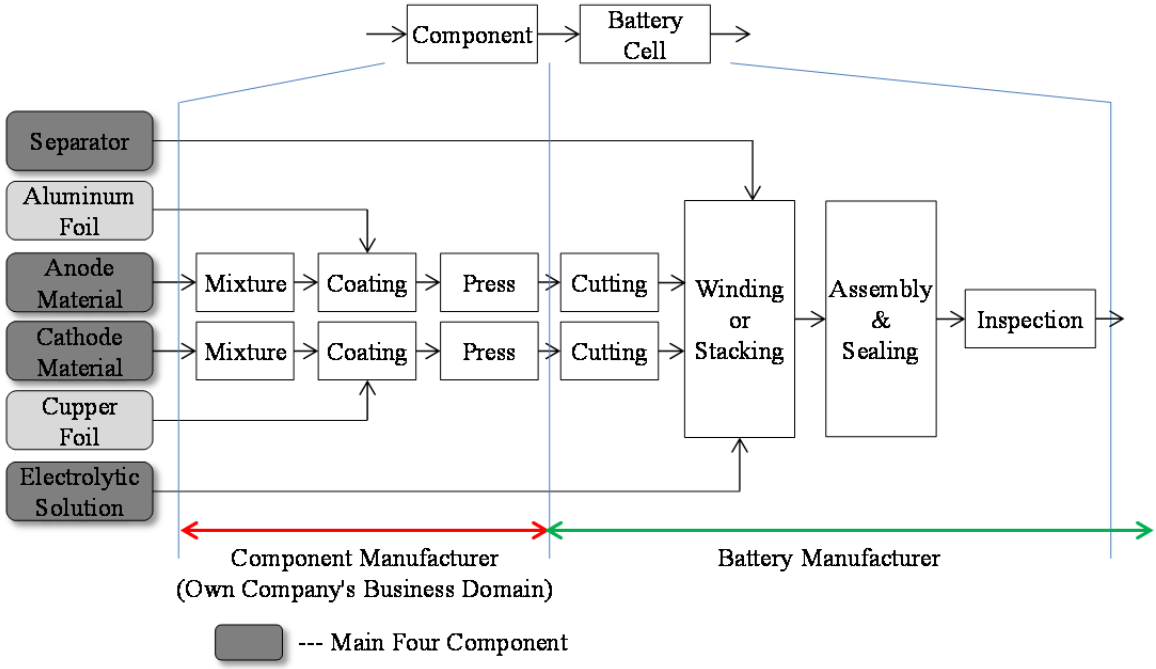


Fig.10 Production process of LIB

B. Strategic planning using the game approach

In Section IV-A, the business domain was selected in the discussion of the positioning approach. Next step is to consider the LIB architecture out of view of the game approach to position oneself on a profitable stage. In this step, it is important to consider from "process" perspective.

As this would make the players to shift strategically to profitable electrode manufacturing, wider promotion toward Chinese and European battery manufacturers is an important factor. This requires an architecture flexible enough to cope with various end-user requests at lower prices. Such architecture that involves customizing own products for customer request is "inside integral and outside integral" architecture positioning strategy and impairs efficiency and profitability. One of the way to improve matters is to procure a certain variety of cathode and anode materials (in rolled form) and establish an environment where a certain combination of separators and electrolytes from other component manufacturers can be designated, to facilitate flexible handling of various customer requests. As shown in Fig. 11, this means that the LIB cell product architecture positioning is shifted from "inside integral and outside integral" positioning (indicated by "●") to the "inside modular and outside integral" positioning (indicated by "★"). The thing to note here is that this architecture positioning shift is the change in battery manufacturers' layer, own company's business domain is, on the other hand, shifted to more profitable layer and the product architecture of the component manufacturers who are specialized in Component preserve the closed integral architecture type as shown in Fig. 12. This corresponds to the fact that both approaches, modularization and integration, are made in different layers simultaneously [2].

To accomplish this, component manufactures must strive to improve unit sales by lateral expansion, as well as closely coordinating with separators and electrolyte manufacturers

who supply the other four key components. Furthermore, component manufactures may need to obtain finished goods manufacturers' consent by trying to convince them such advantages as securing the safety, lower cost and shorter delivery time, even if they are not his own customers. This may also involve collaboration with battery cell assembly manufacturers in terms of the delivery inspection. Other effective strategies are to occupy the material area where you can differentiate yourself as encouraging Chinese and Taiwanese battery assembly manufacturers at the same time. In any case, the idea of this compound approach is to encourage them to establish the external environment that is advantageous to themselves in view of the game approach so that they can shift to the position that is defined from the idea of the positioning approach. This idea could help us construct a new ecosystem as part of LIB business strategies.

Of course, this idea is subject to continuous research and development on the four key components that require reconciliation, at which Japanese LIB manufacturers excel, and there is also a need to engage in activities that enhance our organizational ability by performing repetitive learning.

C. Summary on strategic considerations

In summary, the strategies examined for Japanese LIB manufacturers in this Chapter are;

- Positioning approach perspective
  -- To focus on profitable components (electrodes) that have higher integrality in terms of architecture (shift to other layer)
  -- Leave the battery cell assembly to other battery manufactures and broaden the customer base by selling products widely to battery manufacturers in China and Europe.
- Game approach perspective
  -- Possess a series of electrode materials and shift the battery cell to product with modular-type architecture
  -- Aim cooperating and collaborating with cell assembly manufacturers and material suppliers
  -- Encourage finished goods manufacturers to support the new ecosystem construction.

Although this is not mentioned in the preceding paragraphs, promoting standardization of the interface with external world could also be a part of the effort of constructing the ecosystem, because the activity of leading such standardization involves the process-oriented element.

In this Chapter, by taking the idea of combining the approaches in strategic management with architecture-based strategies, some strategies that aiming at creating strategies for the Japanese LIB manufacturers are discussed. Based on the game approach, a more specific and clearer strategic direction is presented with the method proposed in this Chapter, as compared to conventional methods with a less process-oriented perspective. The strategic approach we proposed herein is considered effective against ESS LIB as well as automobile LIB.

VI. CONCLUSION

In this paper, it is shown that the relationship between two strategic theories, architecture-based strategies, which are based on the concept of architectural theory and strategic management, citing the LIB industry as an example. Comparing the result of our analysis using architectural-based strategies as a starting point, with approaches of strategic management, the need for a process perspective for architecture-based strategies is suggested. Further, based on this result, a composite strategic approach that considers four approaches of strategic management for architecture-based strategies was proposed and tried to propose business strategies for the Japanese LIB industry. Accordingly, the above study identified a specific and clear direction based on the process-oriented perspective, which does not fully take architecture-based strategies into account.

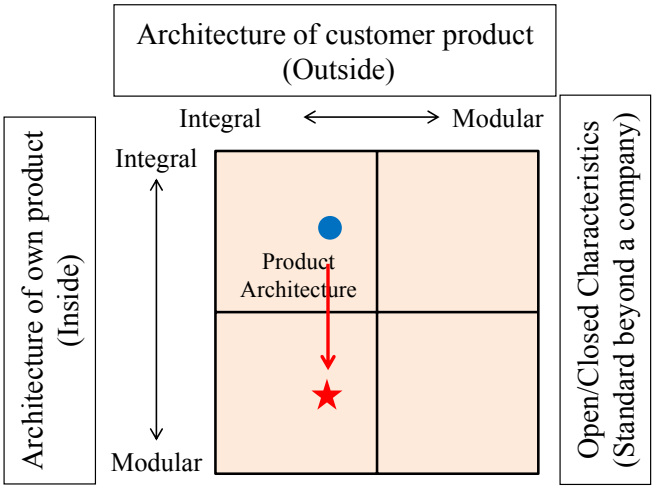


Fig. 11 Architectural positioning shift in LIB cell layer

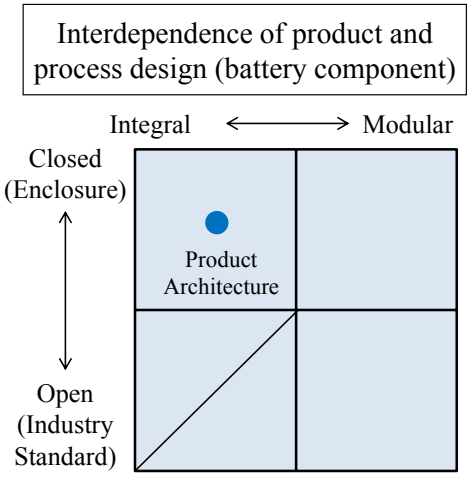


Fig.12 Architecture positioning in battery component layer

However, further discussion with battery manufacturers may be required concerning the feasibility and effectiveness of this proposed strategy. Also, certain other research tasks remain, like determining the applicability of these analytical results to other industries and the existence of patterns in other compound approaches taken in actual business activity.

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