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Intellectual Property Strategy Required for Startups from Joining in a New Business Ecosystem to Growing as Large Companies: A Case Study of Tesla

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Abstract

This article conducts a case study of Tesla's intellectual property (IP) strategy to clarify the IP strategy required for startups from joining in a new business ecosystem to growing as large companies. As a result, it was clarified that to establish new businesses quickly, it may be effective for startups with limited own resources to focus on patents for not only core areas developed on their own but also the interface between core and outsourcing areas to collaborate with companies that have a substantial patent portfolio in outsourcing areas and open the interfaces to diffuse their core technologies. In the process of growing into large companies, startups are exposed to stiff competition as competitors try to catch up. Therefore, it is necessary to increase their capability, formulate added value through in-house research and development and design in the outsourcing areas, and apply for patents to increase its competitive advantage. It was further indicated that a pledge of non-exercise of patent rights may be an effective option to avoid being sued for patent infringement. This study is unique in identifying effective IP strategies for startups in terms of outsourcing, diffusion of their technologies, increasing their capability and avoiding patent infringement lawsuits.
Keywords: Startup, IP Strategy, Interface, Pledged Patent, EV

1 Introduction

Global warming is increasing the demand for electric vehicles (EVs). In approximately 2020, many countries have announced plans to ban the future sale of gasoline, diesel, and other internal combustion engine vehicles and transition to zero-emission vehicles. EV sales are now accelerating in the world's major automotive markets, especially in China, Europe, and the United States [1][2]. In the past, traditional automakers that focused on gasoline and diesel vehicles built long-term competitive advantages by strengthening the coordination of technologies such as engine control. However, they have been exposed to changes such as modularization and international division of labor because of the shift to EVs [3]. At the same time, the coordination of technologies, which was a source of competitive advantage, will no longer work, and the cost of joining in the EV industry for startups that have no experience in manufacturing automobiles has decreased [4]. In the future, the power balance in the global automobile industry will significantly change.

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In this situation, Tesla, which had no experience in car manufacturing, joined the EV industry and continues to release new EV models with great impact. In particular, the Roadster was released in 2008 as the first mass-produced EV. It is equipped with batteries, which are one of the core components and were not manufactured by Tesla but outsourced [5], and the body, such as the chassis, was jointly manufactured with Lotus [6]. Tesla's EV can be positioned as the EV emerged due to the change in production such as modularization and an international division of labor.

In 2010, a well-known car designer with a proven track record in Mazda North America was employed by Tesla to strengthen the design, and Tesla released Model S, a luxury sedan, Model X, a crossover SUV in 2015; Model 3, a compact sedan in 2017; and Model Y, a crossover SUV in 2020 [7][8]. From July to September 2022, Tesla's consolidated net profit surpassed those of Toyota, with a net profit per vehicle of 1.32 million yen, which is eight times that of Toyota [9]. Tesla is now the leading innovator in the EV industry.

Tesla also impacted the intellectual property (IP) strategy. In June 2014, Tesla pledged that "All Our Patent Are Belong To You" (In this study, we refer to such patents as "pledged patents") [10]. Regarding the purpose of the pledge, the annual report states, "We made this pledge in order to encourage the advancement of a common, rapidly-evolving platform for electric vehicles, thereby benefiting ourselves, other companies making electric vehicles, and the world." [11] This pledge raised various discussions. For example, there were negative evaluations that it was nothing more than a "PR move" and that no competitor would use Tesla's technology because the definition of "good faith" as a condition for using a pledged patent is ambiguous. However, as an effective evaluation, it led Toyota to license approximately 5,700 fuel cell technology patents free of charge until 2020, implying that Tesla's announcement also affected the IP strategies of traditional automobile manufacturers [12].

However, there is no guarantee that Tesla's rapid progress in the EV industry will continue. Chinese company BYD is already chasing Tesla in the EV sales race [13][14], and even Toyota, which has adopted an all-directional strategy that is not limited to EVs plans to sell 1.5 million EVs annually by 2026 [15]. Tesla will face competition from conventional automakers soon.

Regarding Tesla's IP strategy, the patent strategy may provide a very instructive example of a startup establishing a new business quickly and maintaining a competitive advantage while being exposed to being caught up by traditional automakers. As noted above, Tesla pledged that "All Our Patent Are Belong To You" and subsequently explained in its most recent annual report that "We have also adopted a patent policy in which we irrevocably pledged that we will not initiate a lawsuit against any party for infringing our patents through activity relating to electric vehicles or related equipment for so long as such party is acting in good faith." [11]. Therefore, the pledge in 2014 is still valid today. However, it is stated on Tesla's website that "Tesla Patents" means all patents owned now or in the future by Tesla (other than a patent owned jointly with a third party or any patent that Tesla later acquires that comes with an encumbrance that prevents it from being subject to this Pledge) [16]. This means that not all of Tesla's patents are pledged patents. Furthermore, it should not be ignored that patent applications are now continuing after the pledge. In fact, the list of pledged patents published on the Tesla website [17] does not include all patents as of October 31, 2022, approximately 280 US patents were not released as pledged patents. Thus, Tesla still has an underlying strategy of both open and closed areas through patent applications and owns patents to maintain its competitive advantage. Moreover, Tesla may be redesigning open and closed areas by making some patent as pledged patent.

In addition, while traditional automakers have much experience in filing many patent applications and have already filed many patent applications in the field of EVs, Tesla keeps filing a relatively small number of them [18]. Although Tesla may be targeting specific technology areas and filing minimal patent applications, it will inevitably be exposed to competition from traditional automakers in the future, which may necessitate a change in its IP strategy.

In particular, a new business ecosystem is being formed that includes an unspecified number of transaction entities, including existing automobile-related companies and battery-related electric and chemical companies in EV industry. As mentioned above, modularization and international division of labor are progressing in the EV industry. Therefore, it is important for establishing a competitive advantage to design the core areas developed in-house and the outsourced areas. In the EV business ecosystem, there is a possibility that Tesla has designed an "open area" where one of the core parts such as batteries are not developed by Tesla but outsourced [5][6] and a "closed area" where minimal patents protect core areas to build a competitive advantage for its business. Furthermore, Tesla might have attempted to redesign an "open area" by releasing some of its patents as pledged patents and a "closed area" where patents are not released as pledged patents.

Furthermore, along with the design of a "closed area" based on patents, the design of an "open area" through international standardization is also important for the growth of companies. Some EV charging technologies have already been standardized. Currently, there exist CHAdeMO (Japan), CCS (Europe), GB/T (China), and NACS (North American Charging Standard, which standardizes Tesla's charging connector and charging port) [19]. Tesla also provides adapters that enable the charging of its EVs from all standardized charging stations [20][21]. Via Licensing Alliance, a patent pool management company, publishes a list of essential patents related to standardized charging technology and licensors of these patents [22][23]. The licensors comprise GE Hybrid Technologies, LLC, LG Energy Solution, Ltd., LG Innotek Co., Ltd., Mitsubishi Electric Corporation, Mitsubishi Heavy Industries, Ltd., Robert Bosch GmbH, Siemens AG and Sun Patent Trust. What IP strategy did Tesla adopt in the presence of essential patents owned by major electronics companies?

Tesla's IP strategies may represent the approach needed for startups from joining in a new business ecosystem such as the EV industry to growing as large companies. Therefore, this study analyzes the IP strategies required for startups, from joining in a new business ecosystem that includes an unspecified number of transaction entities from different industries as modularization and international division of labor progress to growing as large companies.

This paper is organized as follows. Section 2 reviews research on EV and battery manufacturers' patent strategies, patent application statistics for batteries, and so on. Section 3 presents the research method. Section 4 analyzes Tesla's IP strategy. Section 5 summarizes IP strategies required for startups from joining in a new business ecosystem to growing as large companies. Finally, Section 6 provides a conclusion.

2 Literature Review

Chen et al. explained the architecture of Tesla's EVs, comprising battery pack, electric motor, power electronics, charging infrastructure, body, and chassis, and analyzed how these components have changed in terms of modularization and integration, from outsourcing and in-house

production in the evolution from Roadster to Model S [3]. However, regarding the patent strategy, their relationship with these architectures is unclear and it is not pointed that not all of Tesla's patents are pledged patents. This study clarifies the relationship between these architectural components and patents, as well as between pledged patents and other types of patents.

Lang et al. pointed out that one area that plays an important role in EV modularization is the battery pack, which acts as an interface between the patented platform and the module [24]. However, in terms of the patent strategy, Lang et al. only mentioned that the platform has been patented but did not explain which patents related to the platform exists, e.g., the patent of the interface.

Park et al. described a collaboration between EV companies and battery manufacturers [18]. Regarding the number of battery and charging patents among EV companies, Toyota has more than Volkswagen and Tesla, but Tesla has the highest number of EV sales. Among battery manufacturers, Panasonic and LG Chem are outstanding, but the Chinese company CATL has the highest number of sales, implying that technical superiority through patents does not necessarily lead to business success. Furthermore, while Toyota is strengthening patent filing for all-solid-state batteries, which are attracting attention as next-generation batteries, CATL is focusing on LiFePO4, which is inexpensive and easy to mass produce. It is hypothesized that Tesla maintains its competitive advantage by using cheap CATL batteries. This is considered a competitive advantage of Tesla by positioning batteries as an open area in the modularization and international division of labor of EVs and outsourcing batteries at low cost. However, the relationship between the competitive advantage resulting from outsourcing and Tesla's patents has not been explained. Although Park et al. focused on the number of battery and charging patents, they positioned them as a single technological unit and did not distinguish between battery and charging technology patents. Therefore, they did not analyze how IP strategies were designed from a micro perspective.

According to battery patent statistics from 2000 to 2018 compiled by the European Patent Office and the International Energy Agency [25], Japan and South Korea are leading the battery technology competition, and 7 of the top 10 patent applicants are Japanese companies. Panasonic and SONY, which are among the top 10 companies, have been long-term leaders in this field, but others have increased their patent applications for lithium-ion batteries for EVs. In recent years, LG Electronics, Toyota, Nissan, and Bosch have rapidly increased patent applications for automotive batteries. Furthermore, since 2011, battery pack patents for automobiles have continued to increase because battery packs have different structures depending on their uses, and battery research has shifted from basic research to commercialization activities. These patent statistics indicate quantitative trends in patent applications and demonstrate the macro trends of some large companies. However, Tesla is not ranked in the top 10 companies in the above statistics due to its small number of patents, and it is unclear whether Tesla is following the same trend as the large companies. This study not only conducts a quantitative evaluation of Tesla's patents but also a detailed analysis of the scope of rights to analyze the quality of its patent strategy with a low number of patent applications.

Wen et al. pointed out that IBM's strategy of not asserting relevant patents against the Open Source Software (OSS) community in mid-2000 eliminated the "thicket of patents" problem faced by startups and encouraged their participation in the OSS community, which later influenced the establishment of the Ecopatent Commons by IBM, SONY, and others in 2008 and the Tesla's pledge in 2014 [26]. However, as the "thicket of patents" is an issue, such a strategy of non-exercise of rights increases the probability of protection for companies participating in the

community when a large company that owns many patents takes the lead. If a company with few patents such as Tesla pledges that it will not enforce its rights, it is doubtful how effective it will be in resolving the patent thicket problem.

Furthermore, some prior studies have explained that the intention of patent openness is the expectation of outbound open innovation, which aims to create and acquire value through the diffusion of technology to the outside world. For example, Enkel et al. pointed out that to make a profit by multiplying technology, ideas are brought to the market, IPs are sold, and the ideas are transferred to the external environment [27]. Further, patents may be opened in the hope that others will take advantage of patents that are not used by the company [28]. Are Tesla's pledged patents also expected to be an outbound open innovation? However, it is also pointed out that anyone who implements Tesla's pledged patents automatically gives Tesla the right to implement their patents, furthermore, because Tesla has already acquired major patents for EVs, when major automakers enter the EV market in the future, they will need to license Tesla's patents [29]. Therefore, this study analyzed whether Tesla's pledged patents promoted outbound open innovation or whether they had some other aim.

3 Research Methods

3.1 Target of Analysis

This study focused on US patents because most of Tesla's pledged patents were filed in the US. In addition, as the filing dates of Tesla's pledged patents are from 2006 to 2015, its pledged patents and other patents filed during this period were analyzed. Next, for batteries (an outsourcing area) and solar power generation (an area of business expansion through corporate acquisitions), the patents filed after 2016 were also analyzed.

3.2 Classification/Extraction of Relationship

Within the scope of the above target, this study independently analyzed the scope of Tesla's patents in detail, rather than macro-classifying them according to the International Patent Classification. Then, the EV components and the interface, that is, the boundary between these components, were categorized with a clear distinction between the components and the interface, which is more detailed than in previous studies. This classification makes it possible to analyze the details of Tesla's IP strategy that have not been clarified by previous studies, such as the relationship between outsourcing areas (open areas), in-house development areas (closed areas), the boundary between open and closed areas, and international standardization trends. In addition, as mentioned above, in line with its hiring of a prominent designer [8], it is quite possible that Tesla has strengthened its IP strategy through design patents, so patents and design patents were put in the same category and the relationship between both rights were analyzed.

If there is a citing/cited relationship between multiple patents, then they include at least a partial technology or design relationship. Therefore, in this study, when patents cite certain patents, we consider that they have a relationship of improved patents over certain patents. Next, we organize the relationship between the pledged patents and other patents.

3.3 Extraction of Relationship of Other Companies

The EV industry is built as a new business ecosystem that includes an unspecified number of transaction entities, existing automobile-related companies, and battery-related electric and chemical companies in different industries. Therefore, to confirm whether the business areas of Tesla and other companies in the EV industry overlap or not, we analyzed the citation relationship between Tesla's patents and the patents of other companies. In addition, to confirm whether Tesla's pledged patents promoted innovation such as improved inventions by other companies, we compared the number of citations of Tesla's pledged patents with that of its other patents.

4 Analysis of Tesla's IP Strategy

4.1 Scope of Patents

Table 1 presents the results of the classification based on the scope of rights of patents applied from 2006 to 2015. Due to space limitations, only the analysis results for batteries, charging technologies, and solar power generation are presented.

Table 1: Number of Tesla's Pledged and Unpledged Patents

(Filing Year: 2006–2015)

Classification		Registered Patents		Registered Design Patents	
		Pledged Patents: 237	Unpledged Patents: 47	Pledged Design Patents: 11	Unpledged Design Patents: 8
Battery	Characterized by the Battery Control (ex.Thermal Control)	34	1		
	Characterized by the Structure of the Battery Pack	52	2		
	Characterized by the Battery Control (Others)	8			
	Combined Use of the Metal-Air Battery	7			
	Combined Use of the Engine	3			
	Method of Replacing the Battery Pack		2		
	Refining Method of NMP Used in Battery Manufacturing Process		1		
Charging	Control/System (Fast Charging)	4	1		
	Control/System (Charging of the Metal-Air Battery)	5			
	Control/System (Optimizing the Charging Environment)	8			
	Control/System (Selection of Charging Method)	15			
	Control/System (Prevention of Battery Deterioration)	6	2		
	Control/System (Power Distribution for Multiple Charging Ports)	2			
	Control/System (Using AC Power)	2			
	Control/System (Others)	2	1		
	Connector	4		2	
	The Door of Charging Port	5			
	Adapter		1		
	Charging Stand (Public)			2	
	Charging Stand (Private)				1
Solar Power Generation			16		

52 pledged patents for the structure of the battery pack were confirmed; however, there was no patent for the battery itself. In recent years, patents for battery packs have increased more than for battery cells [25]. In this trend, as mentioned above, Toyota, an automobile set maker, has also filed a patent application for all-solid-state batteries [18]. However, Tesla may have a unique reason as a startup for focusing on the battery pack rather than the battery itself.

Regarding the charging technology, Tesla has obtained a wide range of patent rights, including fast charging, selection of charging method, and prevention of battery deterioration, and four pledged patents and two design patents have been identified for the charging connector, which is the interface between the charging technology and an EV's charging port. In addition, one unpledged patent right was identified for an adapter that allows the connection of different standard charging connectors to an EV's charging port. Further, 16 unpledged patent rights were identified for solar power generation. However, four were filed by Tesla on its own, and 12 resulted from the acquisition of SolarCity.

4.2 Analysis of Battery-Related Patents

(1) Why does Tesla not own the patents of the battery itself?

Tesla had been outsourcing batteries since its founding [5], but in June 2014, in collaboration with Panasonic, it started to build the Gigafactory to manufacture batteries and other products in-house [30], which means it shifted from outsourcing to in-house production. Although it now engages in in-house production, Panasonic and Tesla have separate floors in the Gigafactory, and the battery cells manufactured by Panasonic are handed over to Tesla [30]. Thus, at this point, Tesla was still not engaged in self-development and was heavily dependent on Panasonic, but owning its own battery production plant would have enabled it to procure large quantities of batteries from Panasonic.

For reference, as of 2018, more than 6,000 battery-related patents had already been filed in major countries, Samsung, Panasonic, and LG Electronics were the top three companies in terms of number of patents granted for cell-level development from 2000 to 2018, while Toyota ranked 4th, Nissan 9th, GM 12th, and Ford 14th for automotive set makers [25].

How does this relate to Tesla's IP strategy? In general, when a large number of patents are filed in a given technical field, it is difficult to avoid practicing many patents owned by competitors. Therefore, it may be necessary to enter into a cross-licensing agreement. As a result, companies may be forced to license their own high-value technologies to competitors in exchange for licenses to their competitors' technologies. Regarding the licensing of a large number of patents, in recent years, the criteria for calculating the licensing of standard-essential patents (SEPs) for information and communication technologies has become problematic, especially for multi-component products such as automobiles, and the possibility that the calculation may be based on the final product, the automobile, cannot be denied [31]. If a similar situation were to occur with EV battery technology, Tesla, as a set manufacturer, would be at risk of being required to pay a large licensing fee for the battery technology. When Tesla was in the growth stage, it was not willing to actively develop battery technology and apply for many battery technology patents. It decided that it would be better to procure batteries from a company that owned high-level battery technology and thus partnered with Panasonic, which has the world's leading number of battery technology patents. This alliance strengthened their battery patent portfolio and enabled them to fully rely on Panasonic for cross-licensing agreements with other battery-related companies.

(2) Why Does a Competitor Acquire the Patent Rights of the Battery Itself?

We will examine the IP strategy of one of its competitors, Toyota. Toyota ranks fourth in terms of patents for lithium-ion batteries, behind Samsung, Panasonic, and LG Electronics [25]. In addition, Toyota is strengthening its patent filings for all-solid-state batteries, which are attracting

attention as next-generation batteries [18]. With many auto manufacturers using lithium-ion batteries in their EVs and Tesla potentially dominating the EV industry with its fast charging technology, Toyota may aim to weaken the competitive advantage of Tesla's fast charging technology by using all-solid-state batteries in its EVs, which can be charged more quickly than lithium-ion batteries and are expected to increase driving range.

In October 2023, Toyota announced a partnership with Idemitsu Kosan in the field of all-solid-state batteries [32]. Toyota plans to use all-solid-state batteries based on sulfide solid electrolytes supplied by Idemitsu Kosan in its EVs. In other words, Toyota's all-solid-state batteries are not entirely self-developed, but its reliance on other companies is limited.

For Tesla, which does not have its own battery technology, increasing its reliance on Panasonic was an efficient strategy for establishing its business quickly as a startup. Further, as mentioned above, there could have been an IP strategy advantage in avoiding cross-licensing issues. However, the battery remains a competitive area as it is a factor that significantly affects the performance and price of EVs. To enter that development race, the cost of R&D as well as the cost of IP strategies would have been higher, so it was possible only for a large company like Toyota to enter the race, which may have been difficult for Tesla, which was still in the process of growing.

(3) Why Did Tesla Focus on Patent Applications for the Battery Pack?

The battery pack is the interface between the EV body and the battery; thus, naturally, more patents for EV battery packs will be filed for batteries. However, if the battery is completely outsourced, as in Tesla's case, there may be another reason to focus on patent applications for the battery pack. Within the EV industry business ecosystem, the business domains of all trading entities are not necessarily clearly separated. Boundaries between trading entities, i.e., different business domains of companies, may overlap. The top three patent holders for battery packs are LG Electronics, Panasonic, and Samsung [25]. In addition, as presented in Table 2, 9 of Tesla's 52 pledged patents on the structure of battery packs cite patents by Panasonic, a well-known battery manufacturer, while 6 patents are cited by Panasonic. Other battery manufacturers were also identified as having a citing/cited relationship. Thus, the business areas of Tesla and battery manufacturers overlap in the field of battery packs. As various battery manufacturers may be candidates for negotiations regarding outsourcing batteries, there is a risk that some battery manufacturers will demand that Tesla purchase not only batteries but also other related technologies in combination. Thus, various interventions in their business areas can occur, increasing transaction costs. To avoid this risk, it would be effective to obtain a number of patents on the battery pack—the interface between the car body and the battery—to form a barrier to entry into Tesla's business area and create favorable conditions to proceed with the contract.

Table 2: The Number of Citations of Tesla's Patents (Result of Survey [33])

Characterized by the Structure of the Battery Pack: 52		Characterized by the Battery Control (ex.Thermal Control) : 34		Charging Connector: 4	
Citation of Panasonic: 9	Cited by Panasonic: 6	Citation of Panasonic: 7	Cited by Panasonic: 3	Citation of Mitsubishi Motors: 1	Cited by GM: 1
Citation of CATL: 0	Cited by CATL: 4	Citation of CATL: 0	Cited by CATL: 4		
Citation of LG: 2	Cited by LG: 9	Citation of LG: 0	Cited by LG: 5	Citation of Ford, GM, Volkswagen, BMW, AUDI, Hyundai, Toyota, Nissan: 0	Cited by Ford, Volkswagen, BMW, AUDI, Hyundai, Toyota, Nissan, Mitsubishi Motors: 0
Citation of Samsung: 9	Cited by Samsung: 18	Citation of Samsung: 2	Cited by Samsung: 15		

In addition, 34 pledged patents related to battery thermal control were identified, as presented in Table 2. Battery temperature affects charging efficiency and battery life, which in turn affects EV quality. Further, 7 of the 34 patents cited Panasonic's patents and 3 were cited by Panasonic.

Other battery manufacturers have similar relationships. Thus, thermal control of batteries may overlap business areas and battery packs. These cited relationships indicate that to efficiently obtain patents, the interface of the outsourcing area must not only be viewed as structural, such as battery packs, but also as thermal control of batteries.

4.3 Analysis of the Charging-Related Patents

(1) Relationship between Tesla's Patents and Essential Patents Managed by Via Licensing Alliance for Charging Technology

The essential patents related to standardized charging technology managed by Via Licensing Alliance related to EV charging include 35 US patents [23]. The study analyzed the citation relationship between these essential patents and Tesla's US charging patents and found that only one essential patent, the Bosch patent, was cited in Tesla's pledged patents. This indicates a weak technical relationship between these essential patents and Tesla's pledged patents. As presented in Table 1, Tesla's pledged patents on EV charging are categorized as fast charging, selection of charging method, etc. However, 35 essential patents were found to be related to authentication and billing methods when charging.

Therefore, what does a weak technical relationship mean? The standardized technology is a result of collaboration, but many of the licensors of essential patents are large companies with long experiences of patent filings. As noted in the annual report, despite Tesla's encouragement of the development of a common platform for EVs [11], it did not aim to make its own EV charging-related patents into essential patents together with larger companies. Tesla may have aimed to build a competitive advantage by improving the performance of its own charging technology, such as fast charging technology, and may have aimed to create a de facto standard. Thus, the patent pledge may have strengthened the promotion of the de facto standard and aimed to form a platform based on its technology.

(2) Charging Connector

In contrast to the battery pack, only four pledged patents and two design patents for the interface between the charging technology and an EV's charging port were identified (see Table 1). Moreover, as presented in Table 2, only one of the four Tesla pledged patents cited a patent from Mitsubishi Motors, a traditional automaker, and only one was cited by GM.

The reason for this small number of charging connector patents and weak citation relationships may be that EV charging technology was unified under different regional standards and did not become an area of competition.

(3) Relationship between Tesla's Charging Technology and Charging Connector

Next, the relationship between charging technology and charging connectors is analyzed. For Tesla to gain a competitive advantage in EV charging technology, it needs to develop and promote the diffusion of high-level charging technology. One way to achieve this is to expand the use of its EVs, but another effective way is to enable non-Tesla EVs to be charged with its charging technology. However, because charging connector standards differ from region to region, some strategy is needed to promote the diffusion of Tesla's EV charging technology.

Regarding this strategy, as presented Section 4.1, Tesla has made all patents related to charging connectors pledged patents. In addition, in 2022, Tesla published technical specifications and computer-aided design files for its charging connector [21]. Thus, the charging connector is positioned as a completely open area, and if this charging connector becomes widely used, it can be expected that other EV set makers will adopt EV charging ports that correspond to this connector's specifications. Similarly, Tesla has positioned most of its patents for the charging technology as pledged patents, so it expects other companies to join the charging business by leveraging the charging technology it has developed.

Then, why is a charging adapter that allows charging with different standard charging connectors unpledged patent? In 2021, Elon Musk said on Twitter (now renamed "X"), "We're making our Supercharger network open to other EVs later this year" [34]. A senior White House official appears to have urged automakers, including Tesla, to open their charging systems to other EVs; however, while Tesla's charging system is capable of fast charging, the charging systems of other automakers are slow charging [35]. Therefore, in the near future, Tesla's fast charging technology can be a differentiating factor. However, even if its charging technology is opened up to other companies, it is necessary to match charging connectors and ports with different standards in each region or use a charging adapter between the charging connectors and ports.

Tesla has pledged patents for much of its charging technology and charging connectors, but the charging adapter is not a pledged patent and therefore the charging adapter patent is enforceable. Thus, making it possible to exclusively implement the connection of Tesla's charging connector to the charging port of other companies' EVs and allowing an injunction against charging EVs with different charging port standards using charging technology developed by a competitor may prioritize the spread of Tesla's charging technology.

Thus, Tesla aims to expand the use of its charging technology through its differentiating technology, charging technology, and charging connectors and adapters, which are the interface between charging technology and EVs. Meanwhile, Toyota is stepping up patent filings for all-solid-state batteries, which are attracting attention as next-generation batteries. As all-solid-state batteries can be charged at higher pressures than lithium-ion batteries, implying that they can be charged quickly without relying on Tesla's charging technology, Tesla needs to develop a strategy to have some competitive advantage in the battery itself.

4.4 Analysis of the Patent for Solar Power Generation

As noted above, 16 patents for solar power generation were identified, of which four were filed by Tesla on its own and 12 were from the acquisition of SolarCity. In 2016, Tesla acquired SolarCity, a large solar power company in the US, to link its battery storage business to its solar power business [36].

Regarding the relationship between corporate acquisitions and IP, when Google could not keep up with the development of its patent portfolio during its startup stage and was at risk of facing patent infringement lawsuits, it enhanced its patent network by acquiring Motorola [37][38]and then signing a cross-license agreement with Samsung [39]. Does this apply equally to Tesla? Solar panels are a technology area in which numerous patent applications have been filed. In countries where solar panel research and development (R&D) started early, such as Japan and the US, old patents on solar panels are gradually expiring [40]. Although a report indicates that the efficiency of solar panels is gradually improving [41], there are some types of solar panels

that have not been significantly improved their efficiency for a long period. Therefore, the acquisition of SolarCity might have not necessarily aimed at developing a patent network for photovoltaics.

4.5 Analysis of the Patents for Battery and Solar Power Generation since 2016

Both the battery and solar power generation technologies are outsourcing areas, and an IP strategy focused on interfaces was implemented for batteries. However, no outstanding IP strategy was identified for solar power generation in the analysis up to 2015. Therefore, to understand whether any changes have occurred in Tesla's IP strategy in the process of its growth into a large company, we analyzed battery- and solar power-related patents that have been filed since 2016 (see Table 3).

Table 3: The Number of Tesla's Patents (Battery and Solar Power)

	Filing Year			
	2006 - 2015		2016 -	
	Registered Patents	Registered Design Patents	Registered Patents	Registered Design Patents
Characterized by the Battery Control (ex.Thermal Control)	35		6	
Characterized by the Structure of the Battery Pack	54		6	
Battery Components (Electrolyte, Electrode)			11	
Appearance of the Battery Pack				3
Solar Power Generation (ex.Lamination, Roof Mounting Structure)	16		30	
Appearance of Solar Panels			11	3

(1) Battery-Related Patents

The number of patents for the interfaces, battery packs, and temperature control decreased, where 11 new patents for dry electrodes, a component of the battery, were identified. This indicates that Tesla, which had been heavily dependent on Panasonic for outsourcing batteries, decided to develop the battery itself in-house. Dry electrode is one of the components that is expected to reduce the cost and shorten the process of lithium-ion battery manufacturing. To rapidly establish the EV market during the startup period when Tesla had scarce resources, it outsourced areas it lacked the capability and designed its IP strategy as described above. However, as competitors began to attack with EVs cheaper than Tesla's and batteries affected the price of EVs, Tesla needed to change the battery from being maintained as an outsourcing or open area to a closed area that would ensure competitive advantage and to obtain the patents for the batteries.

(2) Solar Power Generation-Related Patents

Despite a long period of R&D of solar panels, several types of solar panels have not improved much in terms of power generation efficiency, so there may have been no reason for Tesla to develop technology to further improve the efficiency of power generation. As if to confirm this, after the acquisition of SolarCity, Tesla obtained 11 patents for technologies that improved the color of solar panels, as well as three design patents related to their external shape (see Table 3). Tesla is in the business of supplying electricity derived from renewable energy sources to its customers' homes and EVs [36], and as solar panels, which are the source of electricity, have

become technologically commoditized, Tesla may be trying to create new value through design to attract customers for its homes and EVs. This is an effective IP strategy in which a startup adds new value with low cost in terms of design to a technology that has been invested in by large companies for a long period, for which numerous patent applications have been filed, and has eventually become commoditized.

4.6 Relationship between Pledged and Other Patents

(1) Pattern of Open and Closed Strategy

Figure 1 depicts the transition in the number of pledged patents and other patents. As a whole, patents with old filing dates were released as pledged patents, but some patents with old filing dates have not been released as pledged patents. As described in Section 3.2, we analyzed the relationship between these patents using the citation relationships and found the following three patterns.

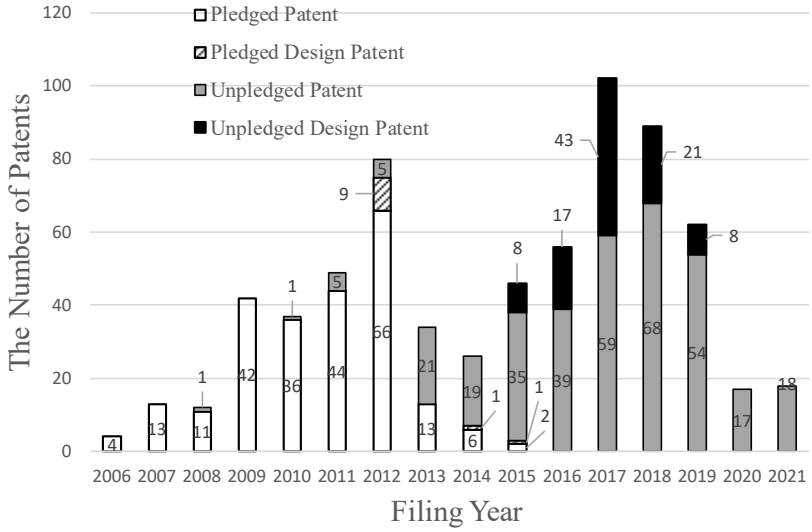

Figure 1: Number of Tesla's Patents

Pattern 1: Pledged patents and improved patents are also pledged patents (full open-type). The set of patents under this pattern is completely open, so there are no particular barriers to the implementation and improvement by other companies.

Pattern 2: Pledged patents, but improved patents are not pledged patents (from open to closed type). Although there is no particular barrier to the implementation of patents under this pattern by other companies, caution should be exercised as improvements made by other companies may coincidentally overlap with the scope of Tesla's unpledged patents.

Pattern 3: Unpledged patents and improved patents are also unpledged patents (full closed type). However, it is obvious that if other companies implement these patents under this pattern, it will be an infringement of rights.

(2) Relationship between the Scope of Patents and Three Patterns of Open and Closed Strategies

Table 4 presents the relationship between the scope of rights and the three open and closed strategy patterns. Due to space limitations, we present the results of the analysis for batteries, charging technologies, and solar power generation, as in Table 1.

Here, focusing on the charging connector, all the patents belong only to Pattern 1, and these are completely open areas. Charging connectors are intended for active diffusion. However, as Patterns 1 and 2 are mixed in most areas, other companies have no particular barriers to implementing them within the scope of their pledged patents but will need to be extremely careful when improving them.

Table 4: Relationship between Three Patterns of Open and Closed Strategy and Tesla's Patents

Classification		Registered Patents			Registered Design Patents		
		Pattern 1: 116	Pattern 2: 121	Pattern 3: 47	Pattern 1: 8	Pattern 2: 3	Pattern 3: 8
Battery	Characterized by the Battery Control (ex.Thermal Control)	13	21	1			
	Characterized by the Structure of the Battery Pack	23	29	2			
	Characterized by the Battery Control (Others)	6	2				
	Combined Use of the Metal-Air Battery		7				
	Combined Use of the Engine	3					
	Method of Replacing the Battery Pack			2			
	Refining Method of NMP Used in Battery Manufacturing Process			1			
Charging	Control/System (Fast Charging)	2	2	1			
	Control/System (Charging of the Metal-Air Battery)		5				
	Control/System (Optimizing the Charging Environment)	3	5				
	Control/System (Selection of Charging Method)	8	7				
	Control/System (Prevention of Battery Deterioration)	2	4	2			
	Control/System (Power Distribution for Multiple Charging Ports)	2					
	Control/System (Using AC Power)	1	1				
	Control/System (Others)	2		1			
	Connector	4			2		
	The Door of Charging Port	5					
	Adapter			1			
	Charging Stand (Public)				2		
	Charging Stand (Private)						1
Solar Power Generation				16			

(3) Response of Other Companies

Tesla constructed the Gigafactory in partnership with Panasonic and acquired SolarCity to form a partnership in the energy storage and solar power generation businesses. Such efforts are called inbound open innovation, a form of open innovation that aims to create value by introducing technology, knowledge, etc. from outside. Conversely, providing technology, knowledge, etc. to external parties is called outbound open innovation. Does Tesla expect outbound open innovation through pledged patents? Based on the analysis in Section 4.3(3), it appears that charging technology and charging connectors are expected to be outbound open innovation, but other factors are unclear.

If outbound open innovation had been promoted, the citations of Tesla's pledged patents would have increased. The number of citations received is effective as an indicator of the importance of patents [42]. From another perspective, outbound open innovation may involve opening patents that are unused to the company in the hope that they will be used externally [28].

We compared the number of citations of Tesla's patents to analyze whether its pledge was aimed at promoting outbound innovation. Table 5 presents the average number of citations for pledged and other patents. No significant differences were identified between them. Thus, Tesla may not have promoted the improvement of pledged patents by other companies.

Table 5: The Average Number of Citations of Tesla's Patents

Filing Year	Pledged Patents		Unpledged Patents	
	The Number of Patents	The Average of the Citation	The Number of Patents	The Average of the Citation
2006	4	38.8		
2007	13	140.0		
2008	11	27.1	1	8.0
2009	42	33.6		
2010	36	30.3	1	5.0
2011	44	26.3	5	31.0
2012	66	17.4	5	12.4
2013	13	10.0	21	13.3
2014	6	19.0	19	9.7
2015	2	6.0	35	8.1

(4) The Possibility of the Defensive Termination

From the analysis of Section 4.6(3), we could not find a specific relationship between Tesla's pledge and outbound open innovation. Therefore, we analyzed the issue from a different perspective.

At first glance, Tesla's pledge that "All Our Patent Are Belong To You" makes it appear as if its patents have been granted a nonexclusive license to an unspecified number of companies. Tesla explained that "Tesla irrevocably pledges that it will not initiate a lawsuit against any party for infringing a Tesla Patent through activity relating to electric vehicles or related equipment for so long as such party is acting in good faith." Regarding this explanation, it is pointed out that anyone who practices Tesla's pledged patent automatically grants Tesla the right to practice that person's patent [29]. Thus, the original contract is obviously a potential non-exercise of rights as it goes beyond the mere interpretation of a nonexclusive license.

By the way, regarding non-exercise of rights, it is known that "Eco-Patent Commons" was established in 2008, pledging non-exercise of environment-related patent rights. The Eco-Patent Commons defines for defensive termination of this non-exercise of rights, which means that if a company sues a patent infringement action against a right holder who has released a patent, the non-exercise of rights against that company can be terminated [43]. Therefore, Tesla's pledge is intended for defensive termination. Although Tesla's pledge might be partly aimed at promoting outbound open innovation, as in the case of the charging connector, the overall goal may have

been to defend against patent infringement lawsuits. Although Tesla has fewer patents than other automakers [18], the pledge reduced the risk of patent infringement lawsuits.

5 IP Strategy Required for Startups from Joining in a New Business Ecosystem to Growing as Large Companies

Based on the analysis in Section 4, Table 6 presents the IP strategies required for startups from joining in a new business ecosystem to growing as large companies. As explained in Section 4, Tesla was still in the growth phase when it first joined the EV business ecosystem. At that point, it had little incentive to actively conduct battery R&D and file many patents as there were already a large number of patents related to batteries. Therefore, Tesla may have decided that it would be better to outsource the battery business and collaborate with a major battery manufacturer with an extensive battery patent portfolio. In addition, when outsourcing the supply of batteries, various battery manufacturers may be subject to negotiation, increasing transaction costs due to bargaining tactics. Tesla may have applied for a number of patents related to the interface, the boundary between Tesla's in-house development area and the outsourcing area, in order to form barriers to prevent entry into its business area and create conditions for favorable negotiations.

However, Tesla will face stiff competition as competitors try to catch up with similar strategies. Further, the battery remains a competitive area as it is a factor that greatly influences the performance and price of EVs. Therefore, in the process of growing into a large company, Tesla needed not only to concentrate its patents on the interface with the outsourcing area but also to increase its capability, conduct its own R&D in the outsourcing area, and file patent applications to increase its competitive advantage.

The interface is not only a barrier to entry from other companies but also an important factor in the diffusion of their technology. Although some EV charging technologies are becoming standardized, Tesla did not cooperate in the essential patents related to standardized charging technology, which comprises patent rights holders from large companies. To secure a competitive advantage, Tesla has stepped up its patent filings to become the de facto standard for the fast charging technology that it has developed. In addition, while there are various standards for charging connectors in different regions, Tesla may have been trying to promote its fast charging technology by opening up the patents and design drawings of its charging connectors.

It is not practical for startups to file a large number of patent applications exhaustively in each technological field as they lack sufficient funds and human resources to file patent applications. As explained above, a patent filing strategy that focuses on the interface as the boundary between in-house developed and outsourcing areas or a strategy of opening up interface patents when different interfaces exist would be very effective. In addition, as in the case of solar power generation, where large companies have invested resources in the past and the technology has become commoditized, changing the mindset and adopting an IP strategy that focuses on design would be a very effective strategy for startups without accumulated technology to create a differentiating factor at an early stage.

A defensive IP strategy is also important because the process of growing from a startup to a large company increases the likelihood of becoming the target of patent infringement lawsuits. Tesla is particularly at risk because of having a small number of patents. The pledge "All Our

Patent Are Belong To You" may have been partially aimed at creating a platform for EVs starting from their own technology through patent openness. However, overall, it was intended as a defensive termination, i.e., to reduce the risk of patent infringement lawsuits being filed in exchange for allowing Tesla's patents to be enforced.

Table 6: IP Strategy Required for Startups from Joining in a New Business Ecosystem to Growing as Large Companies

	Background of Tesla's Strategy	Tesla's IP Strategy	Points of Reference for Startups
Early Period (Until 2015)	a. Tesla did not have sufficient resources and there were already numerous battery-related patents from large companies, therefore, Tesla outsourced the battery business. b. Standardization of the charging technology has progressed in various regions of the world. c. As Tesla expanded the scale of its EV business, the risk of the target of patent infringement lawsuits increased.	a. Tesla collaborated with a major battery manufacturer with an extensive battery patent portfolio and concentrated Tesla's patents on the battery packs. b. Tesla did not cooperate with other companies in the charging technology, but aimed at de facto standardization, and the patent for the charging connector, which is the interface for charging technology, was opened. c. In 2014 Tesla pledged non-exercise of Tesla's patents.	a. Concentrate patents on the interface between in-house developed areas and outsourcing areas due to the lack of patent application costs. b. Open interfaces to promote the company's technology. c. Consider the introduction of non-exercise of patent rights as one of the measures against patent infringement lawsuits.
Latter Period (From 2016)	d. Competitors joined the EV business and Tesla was exposed to price competition. There is an area for the cost reduction in batteries, which is an outsourcing area, and dry electrode technology is expected to reduce battery manufacturing costs. e. Tesla acquired SolarCity to combine Tesla's energy storage and solar power business. Some solar panel technology is already commoditized.	d. Tesla has filed patent applications for a dry electrode, which is one of the components of the battery to reduce battery manufacturing costs. e. Tesla has filed patent and design applications related to appearance to add value to solar panels.	d. Increase its own capability and commit its own resources where outsourcing areas still have an area for improvement. e. Add value by design to technologically mature elements.

6 Conclusion

This study clarified the IP strategy required for startups from joining in a new business ecosystem to growing as large companies through a case study of Tesla.

It is not practical for startups to file a large number of patent applications exhaustively in each technological field as they lack sufficient funds and human resources to file patent applications. To establish new businesses quickly, it may be effective for startups with limited own resources to focus on patent applications for not only core areas developed on their own but also the interface between the core and outsourcing areas. The strategy focusing on the interface plays an important role in collaboration with companies that have a substantial patent portfolio in outsourcing areas to prevent entry into business area of startups and create conditions for favorable negotiations. Further, it also plays an important role to diffuse their core technologies.

In addition, in the process of growing into large companies, startups are exposed to stiff competition as competitors try to catch up. Therefore, it is necessary to increase their capability, formulate added value through in-house R&D and design in outsourcing areas, and apply for patents to increase their competitive advantage. It was further indicated that even if a startup has a small

number of patents, a pledge of non-exercise of patent rights may be an effective option as a means of avoiding being sued for patent infringement.

This study suggests that the pledge of non-exercise of rights applied by Tesla in its EV business may have a dual aspect of promoting its technology and avoiding patent infringement lawsuits. Benchmarking should continue to determine the results the strategy of non-exercise of rights will produce in the future. In addition, as Tesla's CEO Elon Musk has been diversifying his business by acquiring major SNS companies and promoting SpaceX, a future research project is to analyze these businesses from a holistic perspective.

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