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Strategic Reconfiguration of Transactions in the Japanese Manufacturing Industry: A Case Study of Quantifying the Processing Designed by a Supplier

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Abstract

This study investigates the reconfiguration of transactions that occurred due to criteria and measurement devices designed by a supplier in the Japanese manufacturing industry[1]. Assemblers played a significant role in the development of this industry by providing financial and technical support. Other industry participants also contributed to this development. Previous research mainly focused on transactions between assemblers and suppliers with the assembler-led control mechanism. In contrast, this study focuses on transactions with multiple types of companies, such as assembler, supplier, material manufacturer, and tool distributor, and investigates changes of control mechanism. The proposed framework is grounded in the sociology of markets and the new institutionalism of organization studies, and it addresses calculative devices as a control mechanism of transactions involving diverse interests. The case study describes how Yamamoto Metal Technos Co. Ltd., a typical secondary supplier, quantified cutting processing based on its own technology achieved through considerable business experiences, for making better negotiations with assemblers. Once the newly designed criteria and measurement devices worked as calculative devices that withdrew companies' interests had piled up under assembler-led transactions, reconfiguration of transactions began based on those interests. This study's results suggest that the design of calculative devices is critical in strategic reconfiguration for attaining advantageous and important positions in transactions.

Keywords
Reconfiguration, calculative device, calculative agency, rules of thumb, quantify

(1) Introduction

In the past, in the context of transactions between assemblers and suppliers in the Japanese manufacturing industry, the assemblers primarily gave orders to the suppliers and provided funds

[1] This study focuses specifically on the transactions occurring in the automobile and electric appliances sectors in the Japanese manufacturing industry.

and technology to them. In contrast, suppliers focused on the subcontracting business. By the late 1980s, this assembler-led mechanism featured traits such as “commission as a bundle,” “lump-sum subcontract,” “effective competition among a few suppliers,” and “a long-term and stable continuous transaction” (Fujimoto, 2001). It also enabled cost reduction and quality improvement and became the most efficient transaction-control mechanism until changes in the Japanese manufacturing industry’s social, economic, and technical conditions in the 2000s.

After these changes, we could observe new transaction styles appear and developed new theoretical viewpoints to analyze those transactions, such as globalization in the Japanese manufacturing industry due to overseas relocation of the production base (e.g., Shimokawa, 2002, 2004; Sei, 2016), the concept of modular architecture (e.g., Baldwin and Clark, 2000; Sako, 2003) and the concept of networks loosely connecting independent companies (e.g., Fujimoto et al., 1998; Seki, 2011). Related studies carefully examined new transactions in detail, through the assembler-led control mechanism. Some studies focused on suppliers which sought to develop their own technology or goods to survive. Seki (2011) described supplier effort that does not depend on assemblers as "autonomy" and introduced such cases in his book. The studies focused on suppliers; however, they mainly used the same viewpoint or framework as in other studies (e.g., Ueda, 2006; Seki, 2011). That is, the previous studies have mainly focused on the transactions with assembler-led control mechanism even though there exists a greater number of new transaction styles with diverse interests than before. For example, assemblers, material manufacturers, machine tool manufacturers, and wholesalers have recently begun to negotiate and directly conduct transactions with suppliers. However, little attempt has been made to understand these new and alternative control mechanisms of diverse interests, which were not observed in previous transactions[2].

In contrast, this study focuses on diverse interests and transactions with multiple types of companies, such as supplier, assembler, material manufacturer, and tool distributor, and investigates changes caused by a supplier’s actions to make advantageous negotiations to receive stable orders from assemblers. The advent of new transaction styles can also lead to newer control mechanisms. Rather than focusing only on the assembler-led control mechanism, studies need to explore the control mechanisms targeted toward transactional relationships in which multiple interests are intertwined. This implies that there is still scope for building a strong ground to

[2] For more details of the reviews of previous studies on the historical and theoretical considerations of the assembler-led control mechanism, see Uenishi (2016, 2017).

study new events that did not occur under the assembler-led control mechanism of transactions and examine how suppliers can design a control mechanism strategically.

This study investigates how suppliers can strategically change the transaction-control mechanism to their advantage by considering diverse interests and reconfiguring the transactions. In other words, there was an opportunity to see the appearance of the supplier-led control mechanism of transactions rather than the assembler-led control mechanism. Specifically, this study discusses how suppliers can develop and design new criteria and measurement device as transaction-control mechanisms and take advantage in transactions. To discuss it, this study used the case of Yamamoto Metal Technos Co. Ltd. (Yamamoto Metal, henceforth). This company is a typical secondary supplier for metal cutting processing. It receives blueprints and orders from assemblers and processes the orders through basic techniques. However, it expanded its business, more than typical suppliers usually do, by developing the criteria and measurement devices designed with quantified processing data; this can help in the construction of a more efficient method of processing and solve problems that occurred under the previous transaction-control mechanism.

(2) Theoretical framework: Reconfiguration through designing rules and tools

This section proposes a framework to develop a transaction-control mechanism that represents, demonstrates, and configures diverse interests. As mentioned above, different transaction styles have begun to appear in Japanese companies. Direct negotiations with suppliers have begun to appear with assemblers, material manufacturers, machine tool manufacturers, and wholesalers. This stream is counter-current compared to the previous control mechanism. Previous studies mainly focused on the assembler-led and supplier-follow control mechanism of transactions. They did not pay much attention to the control of diverse interests, even though the marketplace is a place for various companies having different interests. To understand the transaction-control mechanism of diverse interests like the marketplace, the concepts of tools and rules in the study of the sociology of markets would help. The sociology of markets investigates the mechanism of market formation by describing how problems that arise due to conflicts of interests are addressed and how relationships are formed (Fligstein and Dauter, 2007). Callon (2004) investigated tools and rules that may serve as calculative devices and act as an anchor in adjusting conflicts of interests and relationship formation.

In Callon's discussion, economic activities are described as calculative processes involving non-human elements, such as technologies and artifacts. A calculation is not innately performed as assumed in economics but becomes possible when "distributed calculative agency" (Callon and Muniesa, 2005, p. 1237), which we can find in every actor, is associated with each other. This association is handled by calculative devices that provide logic and consistency for calculations, such as double-entry bookkeeping and calculators (Callon and Muniesa, 2005). In other words, distributed calculative agency (henceforth, calculative agency) becomes visible through calculative devices that appear as tools and rules and makes association possible; it creates relationships that involve both non-humans and humans. This socio-technical arrangement or formation with non-humans and humans is called a configuration (Callon, 2004; Callon and Muniesa, 2005). In other words, a configuration is collected and associated with calculative agencies and "what they want, think or feel depends on the configuration of their socio-technical environment" (Callon, 2004, p. 4).

Therefore, the key to configuration is the calculative device; depending on the calculative device design, it will control how calculative agencies are formed and influence configurations. Callon (2004) points out that "We must be aware that when designing ICTs, what is at stake is the type of human agency, of human being we want to develop" (p. 9). At the same time, Callon (2004) also notes that discussion on the desirable design configuration is insufficient; therefore, various configurations will be formed and experimented upon in the future. This means that configurations will keep changing because the calculative agency is not an internal attribute but rather a relational effect formed by a configuration. The calculative agencies change as the configuration varies (Ueno and Tsuchibashi, 2006, p. 236). While calculative agencies and configurations continue to change, designing calculative devices means participating in the shaping of new calculative agencies or reconfiguring existing ones; it does not only mean responding to demands or satisfying needs (Callon, 2004, p. 9).

This raises the question of the direction in which a calculative device is being designed without concrete calculative agencies and configuration. In Callon (2004), it was considered that various rules and tools support the calculation as devices and focus was on the devices for formalization. It has not much explained why others include those calculative devices for calculation and the direction of designing them. Why formalization is important has been explained by the new institutionalism in organization studies, developed based on Max Weber's modernization theory (1920). According to the theory, rationality represents an ultimate value used as a reference in the search for appropriateness of behaviors (e.g., Clegg, 2005; Lounsbury and Carberry, 2005), and the ultimate modern value is formal rationality, indicating the technical rationality of an instrumental process (e.g., Kanno, 1971). Therefore, being efficient or following efficiency is taken-for-granted in the modern times; behaviors can be justified as technically rational by following efficiency and others with different interests can be convinced through displaying the efficiency of behavior.

However, there is one thing that must be remembered. Even though our behavior can technically justify and determine, formal rationality quantifies values as well. Each society's unique values qualify through relativization; as a result, formal rationality unavoidably embraces these various unique values (Kanno, 1971; Clegg and Lounsbury, 2009). It means that when we observe and follow the efficiency in numbers, quantified unique values are implied in those numbers. Therefore, companies trying to be more efficient is taken for granted. At the same time, being efficient can bring conflicts between companies because formal rationality embraced a variety of distinct values, and the contradiction between them manifests as a conflict (Meyer and Rowan, 1977).

Here I would like to emphasize that this framework does not focus on the efficiency itself. Efficiency is just a modern ultimate value that shows better or worse in numbers and every company justifies their actions by referring to it. However, efficiency can be different for every company. Efficiency can be different for assembler and supplier because they have different interests and unique values. All efficiency can be shown in numbers and when that happens, those unique values and interests would be hidden in numbers. A Calculative device is just a device that hides those interests or unique values in a black box and shows formal rationality like efficiency in numbers.

Considering the above discussion, a theoretical framework that is as follows, will be used to analyze the control mechanism and reconfiguration of transactions in this study. A company forms its calculative agency using existing calculative devices and configuration. By archiving its calculative agency, the company can design a new calculative device that displays the more efficient ways of other companies. Therefore, the calculative device designed by one company will be used in other companies' calculations, and they will depend on it. Simultaneously, the other companies will also attach the unique value of their company, which is implied, in those devices through the design. When companies begin to calculate their actions based on these new devices, the existing control mechanism of transactions changes to the new calculative devices and the transactions start to reconfigure.

In the next section, these research steps, archiving the calculative agency through existing calculative devices and configuration, designing calculative devices such as tools and rules, other companies depending on those devices and the initiation of reconfiguration of transactions, are described empirically using the case study of Yamamoto Metal. In the case study, data were collected mainly via semi-structured interviews with the president of Yamamoto Metal between 2008 and 2016 and additional interviews conducted on the material manufacturer, tool manufacturer, and cutting oil manufacturer who had transactions with the company, in 2010; further information was added from internal documents and company websites.

(3) Case Study: Design of calculative devices and reconfiguration of transactions[3]

1. Calculative agency of Yamamoto Metal

Yamamoto Metal has been in the metal cutting processing business as a secondary supplier in Osaka since 1965. Today, the company also operates a measurement and assessment service for processing. At the time of its founding, the company experienced instability of transactions as it catered to the assemblers' demands, such as extremely short deadlines and seasonally changing volume of orders. These demands brought the company to a situation wherein there were terms with no orders, a mismatch between volumes of orders and the number of machines to use. To solve the instability and these problems, Yamamoto Metal tried the typical method-increasing the volume of orders received from specific customers, at first. However, this created more imbalance in the availability of machines. The machines needed for those orders alone were in operation while the other machines were unused. Playing along with the assembler-led control mechanism destabilized its business even at that time.

To find a solution to this problem, Yamamoto Metal started analyzing the processing system using the knowledge of management engineering of its president. As a result of the analysis, the company found that the current method of operation was not worth the cost and the cause of destabilization was the way of receiving orders. Therefore, Yamamoto Metal changed its approach from increasing specific orders received from specific customers, mostly relying on their relational skills and specializing in specific processing, to increasing various orders from different customers. As a result, the company began diversifying the orders received from a broad range of customers. Even when the volume of orders was small, machines could operate in a balanced way by coordinating the same processing of orders, and a stable production system was developed. Additionally, this change enabled Yamamoto Metal to accumulate large and diverse processing data that could not have been obtained if the company was specializing in specific orders received from specific customers.

This experience led Yamamoto Metal to search and build a full-fledged system to measure processing and collect various data. For example, the company had small-scale factories that were not suited for mass production. One of the factories turned into a factory specialized for stainless steel processing that could not be processed together with iron. Another factory turned into a factory specialized for same-order spans. Other small factories also specialized by taking advantage of their small size, measuring various processes, and collecting more various data.

[3] For further details and the extended version of this case study, see Uenishi (2017).

More varied data were collected, Yamamoto Metal was able to analyze the processing and find problems and solutions by using those data. It allowed Yamamoto Metal to exhibit more efficient ways of processing to its clients in order to solve their problems. This assessment service began to attract companies that struggled with various issues under assembler-led control mechanism of transactions.

Yamamoto Metal formed its calculative agency, the measurement and data accumulation techniques based on its production system, while struggling with the prevailing issues under assembler-led transactions. The company noticed how its calculative agency helped make processing more efficient and, in turn, how it could solve the problems that occurred in assembler-led transactions. This means that the impact of its calculative agency was not limited just to assemblers, but also other companies involved in processing, such as material manufacturers, machine tool manufacturers, and cutting oil manufacturers. These companies also recognized that the rules of thumb, such as "see the processing with the blade of the tool" and "best measurements should be taken here," could not solve problems anymore and they needed to measure and quantify processing. Each company made local optimizations, and the differences caused by them were complemented by the rules of thumb. However, the gap between theoretical numbers in simulations and actual numbers in the processing have widened as the performance of materials and machines improved. Filling this gap with the rules of thumb became an increasingly difficult task, but no one had an alternative solution. This gave Yamamoto Metal an opportunity to present a way to fill the gap and solve the problems. Accordingly, the company designed criteria (rules) and measurement devices (tools) by using its calculative agency.

2. Criteria designed as rules

The gap starts from the company closest to the origin of processing. That is, a material manufacturer is the first target to design rules and tools. For Yamamoto Metal, it could create an environment of less competition with other suppliers because if the material manufacturer would depend on its data and technology and use them to produce new raw material, Yamamoto Metal was the only supplier that knew how to process it with best effort. For the material manufacturer, the data that Yamamoto Metal had already collected from various materials processing operations were needed desperately. Material manufacturer used to receive material drawings developed by assembler from processing supplier and then developed and manufactured materials according to the drawings. However, material manufacturer recently received fewer material drawings and developed and manufactured material through direct consultations with processing supplier via processing drawings. In addition, the assembler demanded shorter R&D period and cost reduction, owing to which the material manufacturer began to face the challenge of developing high-quality, high-performance materials under such difficult conditions.

Sumikei Techno Co. (Sumikei Techno, henceforth) was a material manufacturer facing such a challenge; it mainly developed, manufactured, and sold over 300 different types of aluminum extrusion materials and processed components of different qualities. The company often received inquiries on the materials and processing methods that suited certain materials from both processing suppliers and assemblers, and began receiving more complaints about cracks in the material. This was the case for "Material X," which had been developed as a new product in 2006. The cause of cracks was the use of an inappropriate processing method. Material X was developed to avoid the use of lead, which is essential for the formation of alloys, after introducing a regulation to reduce the use of lead due to environmental issues. Tin was employed instead of lead, and a relatively more environment-friendly material like Material X was developed. Still, the cutting ability and strength of the material were inferior compared to those of a lead alloy. Therefore, a processing method suited to Material X was required, but processing suppliers handled Material X using a conventional processing method and this caused cracks in the material. To avoid the formation of cracks, the processing method had to be revised to accommodate the characteristics of tin, whose melting point is lower than that of lead. However, the biggest issue was that neither processing suppliers, or Sumikei Techno knew the appropriate processing method for Material X. Processing suppliers had no prior experience with this new material, and Sumikei Techno was neither specialized in assessing materials in the processing stage, nor presented the right conditions for processing. None of the material manufacturers in Japan owned a technical team that could assess the processing stage, and the cracks that occurred upon processing lead-free materials became common. To solve the problem of cracks, Sumikei Techno began looking for a company able to assess processing and develop a method suited for Material X. Research laboratories of material manufacturers could only assess the material itself, while processing suppliers only had rules of thumb to prevent cracking. Still, the method could not be translated into data or transformed into a general processing method. Searching for this partner company was difficult and took approximately two years.

At that time, Yamamoto Metal was not just measuring the processing and collecting data but also began analyzing data accumulated through its production system at its own technical development center, a rare facility for supplier, and providing consulting services such as assessing processing, analyzing processing data, and identifying processing conditions suited to materials. Customers for its services were assemblers and companies with problems with assembler-led transactions. Yamamoto Metal assessed their processing, provided proposals for solving problems, and proposed more efficient processing conditions. Sumikei

Techno initiated a business partnership with Yamamoto Metal in May 2008.

The first step in solving the problem of cracks was to measure the machinability of Material X. Machinability is a criterion of material that shows the ease of grinding during processing by cutting. Machinability used to be covered by rules of thumbs; however, Material X utilized tin instead of lead, and its machinability was reduced under the conventional processing method, such that it could no longer be covered by the rules of thumb. Therefore, Yamamoto Metal measured the machinability of Material X under various conditions and analyzed the differences in the degree of machinability compared to conventional materials and conditions that could guarantee a satisfactory outcome. As a result, Yamamoto Metal successfully showed the cause of the cracking and proposed suitable processing conditions for Material X. In other words, Yamamoto Metal defined a new set of conditions for processing, rather than changing the processing method itself, by focusing on machinability.

Machinability was covered by the rules of thumb until now; however, it could now be measured, assessed, and showed in numbers. Companies could now desire and request a greater production of Material X, rather than just reducing its cracking. The improved process needed a setup for machinability and other conditions, and Yamamoto Metal could provide these services to those companies. This led Yamamoto Metal to work on more measurement criteria to assess a variety of processing conditions. In particular, metal fatigue is another important criterion for processing, which was found to be another primary cause of cracks in Material X; it was also covered by the rules of thumb. If the metal is fatigued, its strength declines and, by continuing the processing, the metal eventually fails to bear the stress, and cracks arise. Machinability is a crucial attribute, but it fails to pursue its original purpose if quality issues such as cracking occur as a result of pursuing a greater machinability. The treatment of metal fatigue requires simultaneously addressing the machinability and the cause of cracking.

3. Measurement devices designed as tools

Through a business partnership with Sumikei Techno, Yamamoto Metal began to design measurement devices to utilize the accumulated processing data beyond just measuring and assessing, with criteria such as machinability and metal fatigue. Material X was measured using machines and tools owned by Yamamoto Metal and assessed by combining these results with the accumulated processing data. To assess more various processes and set up suitable processing conditions, an enormous amount of processing data regarding the machinability and metal fatigue of materials and the tools for processing are required. Accordingly, Yamamoto Metal needed to design a measurement device that was suitable to its processing technology for collecting the data on various objects. In 2007, Yamamoto Metal designed its proprietary measurement device for machinability, “MULTI INTELLIGENCE®.”

At the same time, a measurement device for metal fatigue (called fatigue testing machine), which was equally important, was designed. The alternative to existing testing machines was produced based on either the rules of thumb or theoretical figures. These machines also were too expensive to purchase only for testing metal fatigue for Yamamoto Metal, and therefore, the company outsourced this task without purchasing the machine. However, Yamamoto Metal could not obtain and offer an accurate assessment by combining machinability measures with outsourced measurements of metal fatigue using different techniques. This affected the extent of processing consulting provided to clients using the processing data and technologies. In 2008, Yamamoto Metal began developing a proprietary fatigue testing machine and designed “GIGA QUAD®,” a quadruple-type rotating bending fatigue testing machine.

These measurement devices were specially designed to accumulate processing data along with the processing technology of Yamamoto Metal. The company was now able to collect a large amount of more accurate data and assess both machinability and metal fatigue by using the devices; therefore, combining them was not a problem. There were companies that individually measured machinability and metal fatigue in the past; however, no company had ever succeeded in measuring machinability and metal fatigue, assessing processing, and proposing more efficient methods in the same package by utilizing their own processing technology.

4. Initiation of the reconfiguration via newly designed criteria and measurement devices

As a result of the criteria and measurement devices designed, the configuration of transactions at Yamamoto Metal began to change. Assembler and material manufacturer which had never conducted transactions with the company before began to inquire about its business. Assembler always looked for suppliers that enabled higher cost reduction; this could be offered by the business that used Yamamoto Metal’s devices. In addition, the partnership between Sumikei Techno and Yamamoto Metal could provide material development and guarantee processing with no cracking problem to assemblers, all in a bundle. GIGA QUAD® could also provide quality assurance regarding the material to assemblers.

Since processing could be visualized in numbers only with those devices, it became a black box and invisible to the client. Therefore, the companies that employed the devices must also use assessing and consulting services and continue using the devices and services to accumulate their data for more accurate analysis. By providing better processing and more efficient transaction using the devices and services, no one would be concerned about the fact they always needed to use the devices and services. For example, companies that used Material X needed to ask Yamamoto Metal to set up the processing conditions, based on the assessment of their processing. Requests for this assessment increased as the number of companies that used Material X was augmented. This was based on a practice unique to Yamamoto Metal, which searched for suitable processing methods and tools every time the material changed. As a result, Yamamoto Metal could receive orders using its own technology; this helped the company to solve its prior problem of instability in orders by replacing the assembler-led control mechanism of transactions.

Since Yamamoto Metal succeeded in designing criteria and measurement devices, the measurement and assessment of machinability that had been working since 2007 became a full-fledged machinability assessment testing procedure in 2010 and was formalized as a business in 2015. The measurement and assessment of metal fatigue started with R&D activities in 2008 and became a business in 2014. In 2016, the transactions between Yamamoto Metal and UACJ (formerly Sumikei Techno) were still carried out through the criteria and measurement devices. In addition, Yamamoto Metal won contracts to test a new material developed for an automobile manufacturer as commissioned research.

These measurement and assessment services are not restricted to testing materials. From materials and tools to cutting oil, everything associated with cutting processing could be subject to measurements and assessments. If the cutting tools and cutting oil optimal for processing could also be developed alongside materials, the materials could be sold in combination with the processing method, tools, and oils, as a complete package. Therefore, all the items at a processing site could be replaced with those included in the processing technology solutions of Yamamoto Metal. Thus, Yamamoto Metal approached the cutting tool and cutting oil manufacturers for potential joint development.

However, this joint development did not materialize because of conflicting interests. Yamamoto Metal aimed to design tools with a high cutting ability to accommodate the processing technology, while the tool manufacturer wanted to design tools with a high level of cutting ability and durability. Another reason for the mismatch of interests was that the criteria and measurement devices presented the durability of the cutting tools as numerical data. A number summarized the use of tools, but this indicator could become ambiguous when the material changed. In comparison, the number shown by the measurement devices was a compatibility index between various materials and cutting tools, which means that these numbers represented the performance of the tools for users. Revealing the performance of the tools would increase the number of competitors, which was something that tool manufacturers wanted to avoid. Likewise, the cutting oil manufacturer also wanted to avoid an increase in competition.

The assessment of cutting tools and

cutting oil was requested by client companies requiring processing conditions that matched the production site. However, as mentioned above, it was difficult to jointly develop cutting tools and cutting oils because the interests of companies did not match. Therefore, Yamamoto Metal decided to enhance its business and service based on the criteria and measurement devices designed instead of starting new joint developments.

(4) Discussion: Strategic reconfiguration via designed calculative devices

This section discusses what can be learned from the case study of Yamamoto Metal and helps see the beginning of the reconfiguration of transactions by establishing newly designed calculative devices from three perspectives. First, the calculative agency can be obtained under existing configuration of transactions and embodies newly designed calculative devices. As mentioned above, Yamamoto Metal was struggling with demands of assemblers. However, the company made progressive changes in its production system while responding to the demands of assemblers and developed measurement techniques and data accumulation using its production system as its calculative agency. Using its calculative agency, Yamamoto Metal solved not just its own problems, but also those of other companies which were a result of a similar assembler-led control mechanism as Yamamoto Metal. Solving problems had successfully satisfied assemblers' demands. The calculative agency that Yamamoto Metal archived provided stability to the company and solved problems caused by assembler-led control mechanism.

Calculative devices designed by Yamamoto Metal was embodied the calculative agency of Yamamoto Metal, as mentioned above, and made rules of thumb visible in numbers. Rules of thumb supported efficient processing and transactions in many ways for a long time. However, the invisibility of rules of thumb also created many problems because there were many different companies that had different interests in the process of manufacturing. To make the rules of thumb visible to solve problems, companies needed rules and tools such as criteria and measurement devices to quantify processing. Criteria and measurement devices enabled Yamamoto Metal to propose processing settings that suited the material properties and ensured the quality of materials and resulted in improving the production system. That is, criteria are the rules that clarify what should be visible as the data, while measurement devices are the tools for collecting data followed by criteria, and a larger volume of accurate data can be collected by criteria and devices that only one company could collect previously. The companies that purchased the measurement devices eventually collected the data by using them. Yamamoto Metal just needed to collect the data from those companies for free through providing their assessment and consulting services.

Second, the designed calculative devices triggered the reconfiguration of the existing transactions by making the latter align with them. Material manufacturer acquired the ability to sell directly instead of operating through wholesaler and began working on developing higher-quality materials by using the criteria and measurement devices. A distribution company used the criteria and measurement devices to assess equipment performance and display numeric results on their catalogs. Price was the only metric used to choose the equipment for client companies; however, the distribution company could now provide equipment performance as another metric for the selection of equipment. Additionally, the distribution company had worked on a database of equipment performance and planned to demonstrate this database to client companies. Machine tool manufacturers began collecting processing data by attaching measurement devices to their machine tools. This allowed them to develop machine tools to meet more client companies' needs by using the data collected. In this way, the criteria and measurement devices designed by Yamamoto Metal were gradually arranged in the existing configuration and triggered reconfiguration of transactions.

Third, the designed calculative devices showed a possibility of becoming pivotal in the future control mechanism and continuing reconfiguration of the manufacturing industry. MULTI INTELLIGENCE® did not sell much since the formalization of the business in 2015, but the main target of this device was Yamamoto Metal client companies, especially the research laboratories of assemblers and material manufacturers. Research laboratories conducted many measurements and analyses needed in product development and manufacturing, and MULTI INTELLIGENCE® connected these laboratories and Yamamoto Metal.

For example, several measurements were needed when an automobile manufacturer attempted to use a new material or a new processing technology for a new product. [4] The company performed assessment tests before establishing the technology for manufacturing the product. To do so, the research laboratory of the manufacturer would ask Yamamoto Metal for help in measuring, assessing, and accumulating data, carried out using MULTI INTELLIGENCE®; thus, it was employed to measure and assess the machinability in the research laboratory of the automobile manufacturer. The research laboratory collected the data obtained by MULTI INTELLIGENCE® and purchased the data (under the same conditions) from Yamamoto Metal, allowing it to reduce the time required for R&D as well as the time to respond to problems. New materials and processing

[4] The case of an automobile manufacturer was presented as an example of how an assembler's research laboratory functions, but the same applies to other companies who aim to shorten the R&D phase and the accuracy of equipment can also be improved by using MULTI INTELLIGENCE®, like medical equipment manufacturers.

technologies, including hybrids, electric vehicles, and fueled vehicles, are often applied in unknown fields such as next-generation vehicles. In these fields, accumulated data are scarce and valuable. Therefore, there is a high chance that Yamamoto Metal and MULTI INTELLIGENCE® would collaborate for new products, and after that, other companies would have to purchase and use MULTI INTELLIGENCE® with data from Yamamoto Metal if they wanted to use those materials or technology.

MULTI INTELLIGENCE® did not simply measure machinability; it played a significant role in creating a new blueprint for identifying the interests of other companies and reconstructing such interests. To be able to identify varied interests, Yamamoto Metal needed to find and solve more companies' problems which would become possible through the collection of a variety of accurate data. MULTI INTELLIGENCE® managed to be sold as a result of other companies' needs or interests to help Yamamoto Metal in deciding the direction of upgrading the device. More the problems that MULTI INTELLIGENCE® could solve, more the number of companies would use it. Then those companies would provide data to Yamamoto Metal. As such, Yamamoto Metal continues to design and enhance the measurement devices to understand other companies' interests by receiving orders of processing, ensuring that the measurement devices are used in the product development stage, and providing measurement and assessment solution services.

As more and more companies use the measurement devices, the transactions will get reconfigured around Yamamoto Metal. Being a part of the development stage of assemblers and the academic stage may have more effect of the reconfiguration. As the components in the rules of thumb have become measurable by the criteria and measurement devices, the need for composite measurements and assessment is being highlighted in academic conferences, such that the difference between simulations and actual measurements has become evident. In other words, the criteria and measurement devices visualized processing as actual values, which, in turn, formed the basis for reconfiguring transactions among diverse stakeholders. At the same time, it also meant that the criteria and measurement devices that Yamamoto Metal had strategically designed provided actual measurements in a manner that aligned with the processing carried on by the company.

As shown in the case of Yamamoto Metal, the design and arrangement of new calculative devices in the existing configuration is critical to reconfigure transactions strategically. Once new calculative devices become essential for controlling transactions, replacing or at least changing the assembler-led control mechanism, companies need to include calculative devices in their transactions. As discussed, the criteria and measurement devices designed by Yamamoto Metal influenced the reconfigurations of transactions among various types of companies. Developing these devices and offering services using them enabled a supplier like Yamamoto Metal to take advantage of the transactions that used to trigger a complete reconfiguration of transactions controlled with the rules and tools designed by assemblers. Therefore, Yamamoto Metal considers the total package for the measurement and assessment of the entire manufacturing process by including the designed criteria and measurement devices in the existing transactions.

(5) Concluding remarks

This study described the potential reconfiguration of transactions by arranging calculative devices designed by a supplier into existing transactions. In the case of Yamamoto Metal, the criteria and measurement devices were designed as calculative devices while considering other companies' problems or interests. The calculative devices were designed via a calculative agency, measuring processing and accumulating data, while solving Yamamoto Metal's own problems and responding to the demands of assemblers. This allowed the company to show others how calculative devices can make their processing more efficient and solve their problems. Ensuring that processing and transactions are efficient is more important than following the assembler-led control mechanism, which was considered as the ideal method in the past. As a result, reconfigurations of transactions began by arranging these devices as a control mechanism for transactions instead of assembler-led control mechanisms.

Furthermore, the criteria and measurement devices showed different patterns of reconfiguration. These criteria became the point of reference for corporate activities. For example, Yamamoto Metal's measurement and assessment solution service formulated new criteria based on the processing data. As explained before, Yamamoto Metal defined a criterion that served as a point of reference for the purchase of tools on behalf of distribution company that sought to differentiate by means other than price. In addition, measurement devices not only performed measurements but also collected data. For example, MULTI INTELLIGENCE® was designed to be attached to a machine tool, as explained before. In this way, companies could easily measure processing by simply attaching the device to their machine tools, while Yamamoto Metal could collect a large amount of data to use them for its business.

Even a typical secondary supplier can have a chance to analyze other companies' interest and design calculative devices that can become a possible control mechanism of transactions for the whole industry. It does not require advanced technology, but a calculative agency archived in the existing configurations to design calculative devices in order to process other companies' interests and make them depend on its calculative devices. However, this study is limited to the case of Yamamoto Metal and its client companies during a certain time period. It is necessary to study various calculative agencies and their calculative devices and reconfigurations to analyze the pattern or category of calculative devices to arrive at more specific conclusions. Furthermore, continuing the observations will provide an overall perspective on reconfiguration and its effect over the whole industry. However, as discussed, the framework for investigating transaction-control mechanisms from the perspective of calculative devices has yielded enough evidence, making it possible to apply the study's results to other transactions or industry reconfigurations.

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