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DISCUSSION PAPER SERIES

No. 512

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June, 2019

東京大学ものづくり経営研究センター
Manufacturing Management Research Center (MMRC)

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BUILDING NEW FACTORIES FOR HIGHER RESILIENCE: THE CASE OF EPSON ATMIX[1]

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[1] This discussion paper is a reprint of the content, but not the formatting, of chapter 6 "Building New Factories for Higher Resilience: The Case of EPSON ATMIX" in Fujimoto, T. and D. A. Heller (ed.) (2018) Industries and Disasters: Building Robust and Competitive Supply Chains. Hauppauge, NY: Nova Science Publishers, pp.147-166. ISBN: 978-1-53612-905-2, Based on the Agreement Between the authors and NOVA science publishers.

* Corresponding Author: mukai@tcue.ac.jp. Note: This article is based on Mukai, Fujimoto and Park (2017).

Abstract

This paper presents a case where Epson Atmix responded to the Tohoku Earthquake in 2011 in two steps. First, the company engaged in a six-week recovery of its damaged production site, which produced fine metal powder used in automotive engine turbochargers and other products. Next, the company determined that market volume was sufficient to justify building a second plant, which it located in a less disaster-prone area nearby. The company used the process of building the second plant as an opportunity to make explicit design information that had previously been largely tacit. In doing so, the company created a real-world example of a virtual dual supply system.

Keywords

Business continuity plan, BCP, Tohoku earthquake, Concentration, Portability, Resilience

1. INTRODUCTION

Manufacturing firms today need to build their resilience by preparing for supply chain disruptions caused by natural disasters; they must also improve competitiveness in their supply chains in order to withstand global competition. Manufacturing is defined here as managing and processing flows of value-carrying design information to the customers (Clark and Fujimoto 1991, Fujimoto 1999, 2007). Recent studies argue that information visibility or an information sharing system is important for supply chain management (Goswami, Engel and Krcmar 2013, Klueber and O'Keefe 2013). This means that manufacturing firms can improve their competitiveness by smoothing the flow of design information. Supply chain risk management should also include an information-flow view (Tang and Musa 2011), but such an approach has seldom been presented in the literature. According to recent research conducted from the perspective of the flow of design information, firms can achieve resilience by securing the option to restore essential design information either at the point of disruption or on an alternate production line. This approach is called virtual dual sourcing (Fujimoto 2012, Fujimoto and Park 2014).

This article examines how a Japanese firm responded to a supply chain failure caused by a natural disaster and details the processes and problems associated with building virtual dual sourcing in relation to the product/process architecture of the concerned product.

As open-system organizations face environmental uncertainty, they try to reduce uncertainty in the early stages, while simultaneously building information-processing capabilities to deal with future uncertainties (Lawrence and Lorsch 1967, Galbraith 1973). An organization's central value-creating process (e.g., its "technical core") can be described as a technological production function between input and output that is not only a matter of tools, machines and other hardware, but one that is also concerned with task procedures, worker skills, and other software matters (Thompson 1967). Therefore, the concept of "technical core" includes supply chain management and is aimed at ensuring stability to achieve higher efficiency. Consequently, an organization facing environmental uncertainty tries to insulate its technical core from the environment by setting up boundary-spanning units that act as buffers between the stable core and the fluctuating environment. Modern manufacturing firms and industries tend to operate based on this core-boundary view of organizations and business continuity plans (BCPs) are used to protect from sudden natural disasters and other business disruptions (Harney 2004).

At the same time, we can understand manufacturing as the creation and transmission of value-carrying design information between customers and internal processes, including product development, design engineering, purchasing, production, distribution, and sales of both goods and services (Clark and Fujimoto 1991, Fujimoto 1999, 2007), as opposed to the narrow definition of manufacturing that sees it simply as transforming physical materials. According to our broader view, the supply chain is a system for protecting the technical core from environmental influences, since it facilitates effective flows of information, products, and money between firms and toward customers to ensure value creation and delivery (Lambert and Cooper 2000, Youn et al. 2012).

Disasters cause drastic and unpredictable environmental changes that make probability estimations difficult (Knight 1921). Supply chain failures caused by disasters are unpredictable destructions of technical cores that temporarily shut down parts of the design flow to customers. As such, they give rise to unusual situations for at least two reasons: (1) the technical cores, which are normally stabilizing factors, become sources of economic uncertainty, and (2) the buffers in the boundary-spanning units, which normally insulate the technical cores from uncertainties in the supply chain, now protect the whole chain's functionality from the precariousness of the technical cores. A natural disaster is a rarer source of supply chain disruption than other accidents, but it can occur anywhere and anytime—thus, all companies must prepare for it, while they must also improve productivity for competition. Natural disasters bring to the fore the problem of balancing supply chain effectiveness and resilience. That is why this paper focuses on supply chain disruptions caused by a natural disaster.

An organization that has just faced a supply chain failure due to a major natural disaster is caught in a dilemma between a desire for greater robustness and a need for sustained competitiveness. It will be inclined to focus entirely on robustness, by building up buffer stocks or setting up a back-up production line, to prevent disruptions caused by future disasters. However, since firms face competition every day, they must continue to improve the efficiency of their technical cores and their competitiveness. Balancing this trade-off between robustness and competitiveness has become increasingly critical for most companies.

In recent years, the above trade-off has posed severe challenges to firms. Even as they have become more vulnerable to natural disasters due to globalization, the same phenomenon has created a more competitive environment. Organizations can no longer afford to focus too much on supply chain robustness, since doing so would cause more damage to their probability of survival—as a result of the ensuing low competitive performance—than the impact of any disaster. As stated in Fujimoto (2012), natural disasters are extremely rare, but global competition is a fact of everyday life.

In general, many discussions of BCPs suggest that firms should prepare for supply chain failures by building up buffer stocks or setting up back-up production lines for greater resilience. However, this is not feasible in all situations. For example, companies manufacturing products with integral architecture (Ulrich 1995) find it difficult to establish back-up production lines because of asset specificity (Williamson 1985).

The aim of this article is to examine a critical step in "virtual dual sourcing" as a new approach to supply chain disruptions by analyzing the lessons from EPSON ATMIX, a supplier of high-performing metal powder that was severely affected by the Great East Japan Earthquake (Tohoku Earthquake) of 2011. EPSON ATMIX makes special-purpose products that are highly customized in their design and production process. This implies that multiple sourcing and substitution with other products or processes is difficult. When supply chains of such products are disrupted, substitution is more difficult than for standardized goods, because standardizing designs or making designs more flexible is not usually allowed by customer or market needs. Moreover, establishing other back-up production lines is not feasible in terms of competitiveness. This paper examines how a firm making highly specialized products can fulfill its orders in disrupted situation by focusing on the case of EPSON ATMIX. As our conclusion, we suggest the concept of virtual dual sourcing as a general measure for responding to supply chain risks.

2. Literature Review

2.1. Supply Chain Risks

Unpredictable events impact on supply chains in terms of parts shortages, the need for changes to product design, manufacturing stoppages and logistics breakdowns (Braunscheidel and Suresh 2009, Duncan et al. 2011, Nishiguchi and Beaudet 1998, Thun and Hoenig 2011, Sheffi 2005, Whitney, Luo, and Heller 2014). There are two kinds of risks for supply chains: daily operational uncertainty with respect to quality, cost, and delivery, and disruptions owing to natural disasters or unexpected incidents (Kleindorfer and Saad 2005, Van Wassenhove 2006, Oke and Gopalakrishnan 2009, Gupta et al. 2016). This article focuses on the latter kind of risk.

In the literature on supply chain risks, typical risk management measures include carrying buffer inventories (Song and Zipkin 1996, Tomlin 2006), diversifying suppliers (Dada et al. 2007, Tomlin 2009) and strengthening customer–supplier relations (Krause 1997, Handfield et al. 2000, Liker and Choi 2004, Krause et al. 2007), which are concrete methods.

More recent studies have focused on temporary rather than permanent diversification (Sheffi 2005). This strategy is called contingent rerouting (Tomlin 2006) or back-up supply. However, these studies consider alternative sourcing only as a temporary measure in case of supply chain failures. They also assume that alternatives are identified and contracted before any specific disruption and that the necessary capacity is on standby reserve. Moreover, Nishiguchi and Beaudet (1998) argues that Japanese "institutionalized mechanisms," such as supplier associations and *keiretsu* (informal business groups), foster trust building and capability sharing among firms, and this enables temporary diversification of multiple suppliers.

However, not all firms can choose temporary diversification. For example, Aisin temporarily diversified suppliers but Riken did not (Whitney, Luo, and Heller 2014). Contingent rerouting is only available when there is an additional provider with volume flexibility; that is, additional capacity that is capable of absorbing volume that was displaced by a disruption (Tomlin 2006). There may be other factors that constrain temporary sourcing diversification, such as product design and production processes. It is likely that the more specialized an item or activity is, the lower the availability of temporary providers becomes. The design and nature of products—such as product complexity, uniqueness (Lamming et al. 2000), and customization versus standardization (Asanuma 1989)—are crucial variables around which the supply chain is created. Whitney, Luo, and Heller (2014) argues that the asset specificity dictated by the manufacturing methods and processes of a disrupted item or process constrains the range of responses to supply chain disasters.

Adding more buffer inventories or copying production lines is not practical from the point of view of daily competition (Fujimoto and Park 2014). Whether permanent or temporary, implementing diversification of sourcing depends on product and process architecture. Thus, although diversification of sourcing for products with integral product/process architecture is difficult, companies must still be able to respond to supply chain disruptions. Simultaneously, a company, plant or site must survive in daily competition, which means that it cannot invest too much time and effort in preparing for supply chain disruptions.

2.2. Design Information and Virtual Dual Sourcing

According to recent studies, information visibility is important for supply chain management (Goswami, et al. 2013, Klueber and O'Keefe 2013). Therefore, mitigating supply chain disruptions requires taking information flows into consideration (Braunscheidel and Suresh 2009; Fujimoto 2012). Moreover, in order to understand how daily operational productivity and preparations for such risks are balanced, we need to examine the impact of a disaster and the response of a firm's supply chain starting from a design-based view of manufacturing and supply chains.

The supply chain of a given product-as-artifact can be reinterpreted as a chain of value-carrying design information that is carried through Thompson's technical-core processes (Thompson 1967) or Penrose's "productive resources" (Penrose 1959), each of which is a combination of design information and its medium. Thus, the supply chain of a given product involves multiple firms that specialize in a part of the design-information processing and collaborate with other firms in creating the stream of value-carrying design information.

The key to manufacturing management, in this broad sense, is creating good designs that satisfy and attract the customers, transforming them into products, and delivering said products to the customers through "good flows," or accurate, quick, efficient and flexible flows of design information. Supply chain management, as a part of this process, is seen as effective inter-firm coordination of the entire design-information flow for a given tradable artifact or product (Fujimoto 2012, Park, Hong, and Roh 2013, Fujimoto and Park 2014).

By combining various measures, it is possible to build a supply chain that is both competitive and robust, which is a pressing need in relatively high-wage countries in this era of global competition. Exactly which measures need to be taken should be determined after considering various factors, such as urgency, target recovery lead times, the size and growth of the domestic market, the severity of global competition, the value of inventory and equipment, and the possibility that products and technology will become obsolete.

Based on this design information view, we can more clearly understand how information technology (IT) can provide effective support in responding to supply chain disruptions. IT infrastructure is required to meet information needs in all stages of crisis management (Park, Hong, and Roh 2013). IT systems, such as collaborative electronic database infrastructures, play an important role in continuity of operations planning (Duncan et al. 2011, Schackow, Palmer, and Epperly 2008).

Recently, especially after the Tohoku Earthquake, researchers have placed emphasis on the "virtual dual sourcing" strategy from the perspective of the design-information flow of manufacturing, or *monozukuri* (Fujimoto 2012, Park, Hong, and Roh 2013, Fujimoto and Park 2014). Virtual dual sourcing is defined as keeping supply at a satisfactory level for the market without regularly maintaining two or more similar production lines and other equipment. A firm can keep different production lines for different products during ordinary times and duplicate the design information of the affected products only when a crisis strikes, so that only during a crisis does the firm operate a second line for the product as if the product had dual lines; this is virtual dual sourcing (Fujimoto and Park 2014). However, the process by which virtual dual sourcing may be implemented has received little attention. This article analyzes said process of implementing virtual dual sourcing by examining the case of EPSON ATMIX.

3. Research Methods

Manufacturing firms recovering from supply chain disruptions should improve their robustness against future disasters only after securing and strengthening their international competitiveness. This is not always easy because, in the aftermath of a catastrophe, the human mind tends to become dominated by a "disaster mentality" rather than "competition logic." To examine how Japanese firms responded to natural disasters such as the Tohoku Earthquake, we made extensive site visits to many companies in major Japanese export industries (such as automotive, electronics, chemicals, etc.) Firms were carefully selected based on two criteria: (1) they had suffered major disaster-related damage, and (2) their senior executives were willing to share their experiences and allowed the research team to visit the sites. The research team focused on learning about how these firms reconstructed the stock of critical design information (e.g., stamping dies, tools, programs, processes, photo masks, etc.) in the damaged processes (e.g., the technical cores) at the disrupted sites or at alternative locations.

After careful assessment, we selected the case of EPSON ATMIX, which is a major manufacturer of special-purpose metal powder for turbocharger parts for automobile engines and other products. Following the Tohoku Earthquake, its production line was stopped for about a month and a half and was fully recovered only after six months.

EPSON ATMIX makes specialized materials and parts for specific goods. Such materials and parts are produced through specialized processes, that is, integral processes (Ulrich 1995) with tacit know-how, so their design information is difficult to transfer. However, the implementation of a BCP is still needed in a case such as this one. We will analyze EPSON ATMIX's response to an unexpected disruption of the supply chain in which it is embedded and explain the process by which virtual dual sourcing is built.

The central task of this research was to identify the weak links in the supply chain and examine how the firm being investigated focuses its preparatory and preventive efforts on cultivating effective response to future disasters. Based on actual events and behaviors in Japanese manufacturing industries, we adopted four criteria to evaluate the weak links in a supply chain, namely supply concentration, supplier visibility, design information substitutability, and design information portability (Fujimoto and Park 2014). Our research team used extensive semi-structured interviews to inquire about these four criteria. EPSON ATMIX's top manager at the site and the heads of the related business departments at were chosen as interviewees because of their extensive knowledge about the overall information flows at the concerned sites.

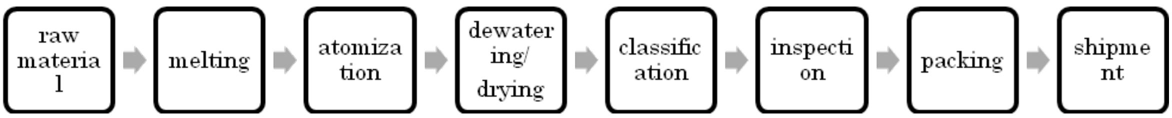
4. Case Study

4.1. EPSON ATMIX

EPSON ATMIX was established as a fully-owned subsidiary of Seiko Epson Corporation in 1999. EPSON ATMIX develops and supplies high-performing metal powder that is made using a unique atomization technology. This fine micron-sized powder is used in automotive, medical, electronic, and IT devices. Recently, it has been adopted in the variable stator vane of turbocharged engines, which is frequently used by producers of automobiles. The metal powder is also employed in dental goods, the demand for which has been growing greatly. Indeed, fine and high-quality metal powder is needed to achieve the overall quality of the final product. The powder is developed in close collaboration with customers and is customized to each customer's needs. In addition, manufacturers of metal power do not explicitly reveal the types and quantities of materials that they use. For all the above reasons, this fine metal powder is difficult to substitute.

The powder examined in this case is produced in Hachinohe, Aomori Prefecture. EPSON ATMIX started off in 1999 with only one plant, but established another plant ("Kita Inter Plant") in 2013. The first plant is located next to Hachinohe port, whereas the new plant is in the interior uplands of Hachinohe.

EPSON ATMIX uses an atomization process to produce fine metal powder (Figure 1). The powder consists of steel, nickel, chromium, cobalt, silicon, etc., and almost all the materials are sourced from nearby companies within Japan. Indeed, Hachinohe has historically been associated with the metals industry. The characteristics of this production technology are that it allows high-yield mass production of fine powder of less than 10 micrometers, super-fine powder of 2–3 micrometers, and spherical/low-oxygen-content powder. Although there are other companies that produce this powder, currently only EPSON ATMIX has the technology to mass produce it for global customers.



Source: http://www.atmix.co.jp/en/e_powder_atomization.html.

Figure 1 Production process.

The key to this production process, called "Atmix water atomization," is the atomizer. The materials are melted, mixed and then poured through a tundish. At the same time, high-pressure water is sprayed onto them from an atomizer (nozzle), producing the fine metal powder.

The 2011 Tohoku Earthquake and ensuing tsunami severely damaged the atomizer in the plant near the Hachinohe port. Operations had to be halted for about a month and a half. Recovery was supported by the Epson Group, which provided the services of 100 people for three months. Customers, such as automobile manufacturers, were also unable to substitute the product with other materials. Substitutive production by other companies was not available, since the expertise for the operations is highly tacit and unique. As a result, the supply chain was severely disrupted.

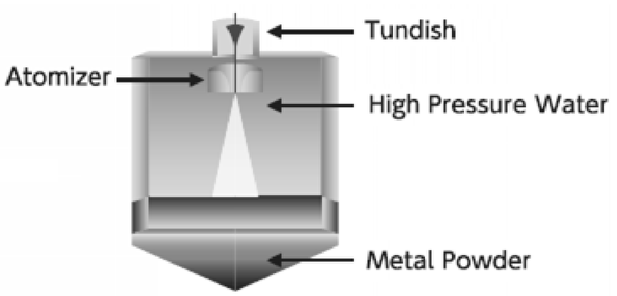
After evaluating the disruptions caused by the Tohoku Earthquake, EPSON ATMIX decided to build a new production facility. The company deemed that the volume of market demand justified the investment. Although the new plant adopted the same technology used in the original plant, the scope of operations was broader, ranging from melting and atomization to dewatering and drying. This broader range of operations allowed for more stabilized temperatures and continuous operations than could be carried out at the original plant. Today, the original plant produces much smaller batch sizes, whereas the new plant regularly produces larger batch sizes.

Naturally, this metal powder is so fine that it is invisible to the human eye, and it is difficult to continually ensure the appropriate setting conditions. Therefore, the technology and operation methods require the fine-tuning abilities of highly skilled operators as well as tacit knowledge. Before the second plant was constructed, experienced workers managed this process technology with their tacit expertise. However, when the new plant was established, they tried to make visible their own expertise under certain parameters in order to build new standards that would satisfy future customers. These parameters—for example, atomization, water pressure, electricity consumption, water tank level, and so on—could be monitored through an IT system in the new plant.

This visualization of parameters contributed to the portability of design information. Although there were some differences in operating methods between the two plants, if something happened in one plant, key parameters could easily be transferred to the other plant. The visualization of parameters also contributed to the recovery of the damaged line after the 2011 Tohoku Earthquake and helped the firms fulfill its supply obligations.

4.2. Case Analysis

Table 1 provides the results of the case analysis. First, EPSON ATMIX has no rivals because of its unique technology. It buys materials from nearby suppliers within Japan. EPSON ATMIX’s fine metal powder is customized for final products. The manufacture of this fine metal powder calls for the use of a unique production technology, atomization, which relies on specialized process equipment. Therefore, design information for this product is not amenable to production substitution.



Source: http://www.atmix.co.jp/en/e_powder_atomization.html.
Figure 2. Atomizer.

Table 1. Results of the case analysis

Consideration Elements	EPSON ATMIX

Product characteristics	Customized for final products.
Supply concentration	There are few rivals. Production process technology (e.g., atomization) is unique.
Suppliers' visibility by focal companies	Visibility is high.
Focal company's visibility by customers	Visibility is high.
Design information substitutability	Substitutability is low because of its production technology.
Design information portability	Portability was low as it was difficult to remove design information from equipment.
Method of recovery from supply chain disruptions	Recovery on the spot from the Tohoku Earthquake. After the Tohoku Earthquake, some key parameters were identified to build a new line.

Furthermore, at the time of the Tohoku Earthquake, the portability of this product was low, since it was difficult to detach design information from the equipment. Hence, EPSON ATMIX performed on-the-spot recovery after the 2011 disaster. Two years after the Tohoku Earthquake, the company built a new line. The recovery action identified key process parameters and these were visualized in the company's information systems. The identification of key parameters contributed to the full recovery of the line and simultaneously to making it possible to transfer design information to the production line in the new plant, that is, the building of a virtual dual sourcing system.

CONCLUSION

EPSON ATMIX employs specialized production processes for certain products. In other words, the company's production processes and product designs are characterized by integral architectures. BCPs and recovery actions of companies must consider the issue of design information portability. EPSON ATMIX solved this problem by visualizing key parameters when a new plant was built. The firm's solution was not limited to the physical product but also extended to design information measures that could deal with supply chain disruptions. The new plant of EPSON ATMIX is not simply a measure to provide a physical backup. If so, investments to build it would be an extremely costly BCP measure, probably leading to a strong, negative effect on competitiveness. However, building the new line with carefully identified key parameters has made it possible to strike a balance between competitiveness and effective BCP.

The main finding of this research is that visualizing design information of products is an essential step to achieve effective recovery from supply chain disruptions, even in the presence of limitations posed by integral product/process architecture. Balancing contingent activities and competitiveness is important for firms and building a system for "virtual dual sourcing" is one of the effective ways of implementing BCPs.

Existing studies suggest that IT systems play an important role in recovery from supply chain disruptions (Duncan et al. 2011, Schackow, Palmer, and Epperly 2008, Park, Hong, and Roh 2013). However, our case study shows that identifying critical points concerning design information is an extremely important aspect of information portability. Moreover, in the case of rather highly integral products/processes, key workers possessing tacit knowledge should be deployed to pursue the visualization of design information. If the product/process architecture is modular, visualizing design information for virtual dual sourcing is not as difficult. Yet, if the product/process architecture is integral, the visualization of design information for virtual dual sourcing is likely to be incomplete because it requires tacit knowledge for operations. Identifying and dispatching key individuals with tacit knowledge is an effective way to ensure recovery from supply chain disruptions.

This study only analyzes one case among many Japanese companies, which causes limitations with regards to generalizability. Nevertheless, there are many firms and sites making specialized or integral products or components around the world. Integral architecture usually requires tacit knowledge and careful design-information flow management. In addition, natural disasters can occur anywhere and at any moment. Therefore, companies under such circumstances could benefit from learning how to balance supply chain resilience and daily competitiveness, as shown in the case presented here, by using information flow oriented management.

The originality of this study lies in the fact that it explores supply chain risk and recovery starting from a design information view of manufacturing. Using a real-world example, we demonstrate the processes and challenges associated with building a virtual dual sourcing system, as well as how competitiveness is balanced with contingent activities. One practical implication from this study is the improvement of crisis management. Before building virtual dual sourcing or other effective measures to recover from supply chain disruptions, it is important to improve design information portability by identifying key factors and individuals. Nevertheless, we recognize the limitations of an approach relying on qualitative data. What remains unclear is to what extent visualizing design information and virtual dual sourcing are effective as general responses to supply chain disruptions for products with integral product/process architecture. Future studies can address this issue through further empirical analysis.

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