Influence of Traditional Business Practice on Firm Boundaries – Evidence from the Japanese Automotive and Steel Industries

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Abstract: The formation of supply chains in the extant literature has been based on the presupposition that individual companies in the network accumulate added value only on those products for which they are responsible, and they complete each sequential transaction with in-house quality assurance. This paper discusses a unique type of inter-firm relationship, which is based on a traditional business practice known as “Performance Guarantee,” in the Japanese automotive and steel industry. Such formations have not been discussed in the scholarly literature of supply chain management. In this system, multiple suppliers jointly bear the responsibility for product quality. It seems that this cooperation was built by a historical development between two industries, by a chain reaction of joint product development and quality assurance, as well as by specific manufacturing management systems in the supply chain. Exploring the background of this inter-firm cooperation, observed in major Japanese industries, is meaningful because it adds a new perspective to conventional research regarding firm boundaries and its supply chain management.

Keywords: supply chain, firm boundary, performance guarantee, inter-firm cooperation

Introduction

The term supply chain management was born in the 1980s and is now defined by the Council of Supply Chain Management Professionals (CSCMP) as follows:

“Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies.” (Council of Supply Chain Management Professionals, 2016).

The researches of supply chain management became active in the 1990s and among those studies, several definitions of supply chains have been made. Christopher (1992) proposed that a supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer.

Mentzer, et al (2001) described the supply chains and their management as follows:

“We draw a definite distinction between supply chains as phenomena that exist in business and the management of those supply chains. The former is simply something that exists (often also referred to as distribution channels), while the latter requires overt management efforts by the organizations within the supply chain.”

This paper analyzes the structure of the cooperation, as in CSCMP’s definition, and upstream and
downstream linkages by companies’ management efforts, as in the paper of Christopher (1992) and Mentzer et al. (2001). The analysis was conducted from the perspective of firm boundaries, inter-firm relations, quality assurance, and technical background.

**Literature review**

Previous studies that focused on inter-firm relations include inter-organizational relationships (Thompson, 1967), buyer-supplier relations beyond formal contract (Cusumano & Takeishi, 1991; Kawabata, 1995), the hierarchical structure among suppliers (Nishiguchi, 1994), the problem-solving activity between sites (von Hippel, 1994), trust between suppliers and customers (Sako & Helper, 1998), the advantage of Keiretsu Alliance (Dyer, 1996), and complexity in the supply base (Choi & Krause, 2006). The business formations in these studies were based on the presupposition that individual companies completed each sequential transaction including quality assurance. The traditional transaction patterns in supply chains are shown in Figure 1. In the case of Pattern 1, products run vertically from raw materials to final products in the supply chain. In the case of Pattern 2, each of intermediate product of A and B is assembled by C, and C supplies the assembled product to D as a final product. In these conventional transactions, the sub-system (A, B, and C) to supply parts for products is shown by Nishiguchi (1994).

![Figure 1. Conventional Transaction Patterns](image)

This conventional business pattern, discussed in previous studies shows that upstream product suppliers accumulate added value for final product suppliers (Tier 1). Tier 1 suppliers ensure the quality of the product according to its specifications. These studies did not discuss the optimal combination of companies in the supply chain, from the perspective of quality assurance. On the other hand, in previous studies from the perspective of quality assurance, the traditional business practice, called Problem Solving or Performance Guarantee, was discussed for direct trade between steel and automobile manufacturers, as in Sei (1990) and Kawabata (1995). This form of transaction fully guarantees quality satisfying the automobile manufacturers beyond the specifications of the product. This traditional quality assurance system has not been discussed in the supply chain management studies. Therefore, in the case of supply
chain from steel product as raw materials to automobile parts, this paper tries to verify whether the transaction pattern will be the same as conventional type of transaction (as Figure 1) or not, in terms of quality assurance.

**Research Method**

Based on the above-mentioned research question, this paper conducts research and analysis by studying of the valve springs. The reasons for the choice of valve springs are as follows. First, valve springs are used as steel products for auto parts, and an extremely high quality level is required, as the auto parts tolerates expansion and contraction by one billion times for an extended period of time. Therefore, it is expected to be able to observe a typical quality assurance system as a high function product. Second, more than 90 percent of these products are domestically produced, which proves the strength of Japanese manufacturers. Third, valve springs are processed through supply chain formation. Therefore, a typical steel materials supply chain formation is analyzed. Figure 2 shows the production process of valve springs and their supply chain, as seen in Yoshihara (2011).

The research methods for valve springs are as follows:

- A literature survey investigates the market conditions of valve springs, their manufacturing process and inter-firm transactions.
- An Espacenet Patent Search looks at the patent publications for valve spring or high strength spring, and looks at their applicants of steel manufacturers, secondary processors and valve spring manufacturers.
- Interviews with key personnel involved in the valve spring supply chain are shown in Table 1.

**Table 1. Record of Interviews**

<table>
<thead>
<tr>
<th>Interview Period</th>
<th>Interviewee's Organization</th>
<th>Interviewee's Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>year</td>
<td>month</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>8</td>
<td>Mr. X</td>
</tr>
<tr>
<td>2014</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>2</td>
<td>Mr. Y</td>
</tr>
<tr>
<td>2014</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
Results

Current Supply Chain Formation of Valve Springs

Figure 3 shows inter-firm transactions in Japan for the valve spring supply chain from raw materials to automobile manufacturing. Only two steel manufacturers produce steel wire for valve springs, indicating a strong oligopoly. Five secondary processors produce oil-tempered wire through heat-treatment processes on steel wire. The secondary processors are subsidiaries or close business partners of the steel manufacturers. Looking at the supply chain from steel wire to valve spring manufacturing in Figure 3, the number of companies and their trade partners are limited, implying a very stable oligopoly, which has been kept more than twenty years in Japan. While no companies overwhelmingly dominate the oil-tempered wire and valve spring market, it is clear that they have very high switching costs.

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Notes: Names of Companies
Nippon-S: NIPPON STEEL & SUMITOMO METAL CORPORATION
Kobe-S: Kobe Steel, Ltd.
Shinko-W: Shinko Wire Co., Ltd.
Sugita-W: SUGITA WIRE, LTD.
NSSG-W: Nippon Steel & Sumikin SG Wire Co., Ltd.
(SEI-S Wire: Sumitomo (SEI) Steel Wire Corp.
Suncall: SUNCALL CORPORATION
Togo: TOGO SEISAKUSYO CORPORATION
Chuo-S: Chuo Spring Co., Ltd.
NHK-S: NHK Spring Co., Ltd.
Murata-S: Murata Spring Co., Ltd.

Toyota: Toyota Motor Corporation
Daihatsu: Daihatsu Motor Co., Ltd.
Mazda: Mazda Motor Corporation
Honda: Honda Motor Co., Ltd.
Suzuki: SUZUKI MOTOR CORPORATION
Nissan: NISSAN MOTOR CO., LTD.
Subaru: Subaru Corporation
(MMC: MITSUBISHI MOTORS CORPORATION
Isuzu: Isuzu Motors Ltd.
Hino: Hino Motors, Ltd.
UD Trucks: UD Trucks Corporation
Mitsubishi Fuso: Mitsubishi Fuso Truck and Bus Corporation

Figure 3. Supply Chain of Valve Springs in Japan
Observed Cooperative Relationships among Suppliers

While the investigation of the mechanism of quality assurance for valve springs has progressed, several areas of cooperation were observed among supply chain companies in Figure 3. The first one is the joint development of valve springs. In patent publications regarding valve spring inventions, twenty-five are for the development of a valve spring corresponding to the light-weight automobiles, as shown in Table 2. Following the introduction of oil-tempered wire manufacturing technology in Japan in the 1980s, valve spring manufacturers developed a new type of product for light-weight vehicles or small-sized engines, reflecting global environmental initiatives. Twenty-five inventions related to the above can be identified in the patent publications. Out of these twenty-five publications, twenty have indicated the inventions as patent claim or product conditions in the examples in three areas: steel manufacturing, secondary processing, and valve spring manufacturing, as included in the scope of patent applications (shown in Table 2). The results show that it is difficult for one company alone, in one area, to develop new valve springs.

Table 2: Patent Publications for the Development of Valve Springs Corresponding to Light Weight Vehicles

<table>
<thead>
<tr>
<th>PA No</th>
<th>Company Name of Applicants</th>
<th>Publication No.</th>
<th>Year of Publication</th>
<th>Patent Claim</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Chuo-S</td>
<td>JPH04187756</td>
<td>1992</td>
<td>steel wire manufacturing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2 Chuo-S</td>
<td>JPH11246943</td>
<td>1999</td>
<td>secondary processing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3 Chuo-S</td>
<td>JPH11246914</td>
<td>1999</td>
<td>steel wire manufacturing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4 Chuo-S</td>
<td>JPH11246941</td>
<td>1999</td>
<td>secondary processing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5 Chuo-S</td>
<td>JP2001009725</td>
<td>2001</td>
<td>steel wire manufacturing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>6 Chuo-S</td>
<td>JP2003160034</td>
<td>2003</td>
<td>secondary processing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>7 Chuo-S</td>
<td>JP2004323912</td>
<td>2004</td>
<td>steel wire manufacturing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>8 Chuo-S</td>
<td>JP2012036418</td>
<td>2012</td>
<td>secondary processing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>9 NHK-S</td>
<td>JPH09112614</td>
<td>1997</td>
<td>valve spring manufacturing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>10 NHK-S</td>
<td>JP2005195183</td>
<td>2005</td>
<td>steel wire manufacturing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>11 NHK-S</td>
<td>JP2011219851</td>
<td>2011</td>
<td>secondary processing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>12 NHK-S</td>
<td>JP2013036067</td>
<td>2013</td>
<td>steel wire manufacturing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>15 Nippon-S, Suzuki-M, Toyota</td>
<td>JPH08153513</td>
<td>1996</td>
<td>secondary processing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>17 Kobe-S, Shinko-W, NHK-S</td>
<td>JP2004351968</td>
<td>2004</td>
<td>secondary processing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>18 Togo</td>
<td>JPH07214216</td>
<td>1995</td>
<td>steel wire manufacturing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>19 Togo</td>
<td>JP2003193197</td>
<td>2003</td>
<td>secondary processing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>22 Kobe-S, Shinko-W, NHK-S,</td>
<td>JP2012077367</td>
<td>2012</td>
<td>secondary processing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>23 Chuo-S, Toyota</td>
<td>JP2003105497</td>
<td>2003</td>
<td>steel wire manufacturing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>24 Nippon-S</td>
<td>JPH0217421</td>
<td>1990</td>
<td>secondary processing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>25 Toyota</td>
<td>JPH07145714</td>
<td>1995</td>
<td>steel wire manufacturing</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25</td>
</tr>
</tbody>
</table>
Therefore, it is clear that cooperation among the three areas above is essential for development of valve springs. In addition, while no company alone holds all the high technology, collaborating companies involved in these three areas could maintain a high technology level.

The second cooperation phenomenon is the cooperation in the approval process by the automobile manufacturers. It has been generally known that the suppliers must obtain automobile manufacturers’ approval for their production process before they start delivering new products under agreed specifications between final suppliers and automobile manufacturers. In the case of valve springs, a basic agreement was signed between valve spring and automobile manufacturers for each type of engine model with the contract renewal remaining in place for each vehicle’s model change. As a preliminary stage for this basic agreement or contract renewal, it is necessary for all the suppliers involved in new valve spring products to get the automobile manufacturers’ approval for the production process. For the valve springs’ authorization procedure, the required approval is for the integrated production process from raw materials to finished products. Since the contract is renewed for each type of valve spring, this integrated approval is implemented for each type of valve spring, according to interviews, shown in Table 1. Once the approval is issued, valve springs can be manufactured and can continue to be supplied during the validity period of the contract. In this integrated approval system, close inter-firm cooperation among the suppliers of steel wire, secondary processing and valve springs is observed.

The third one is cooperation in quality assurance, called the Performance Guarantee. The business practice of quality assurance, called the Problem Solving (Sei, 1990) or Performance Guarantee (Kawabata, 1995) appeared in previous studies in the context of the direct trade between steel and automobile manufacturers. Based on the above previous studies, this paper redefines Performance Guarantee as a concept in which suppliers take full responsibility for product quality to satisfy customers. The previous studies show two kinds of business practices involving Performance Guarantee. One is that specifications include unrealistic items. This business practice assures the quality which is required by the automobile manufacturers, even though it is essentially infeasible or impossible to confirm for each product. For example, according to Sei (1990), there is a requirement that products should not have any scratches, which cannot be perfectly achieved in actual deliveries. Therefore, this requested specification, is unrealistic for day to day operations. Even though product specification includes some items which suppliers are notable to implement, suppliers agree to assure the full quality, including the requirements noted above. This quality assurance system is a traditional business practice of Performance Guarantee. Another business practice is the suppliers’ guarantee to solve problems after the delivery of products, called Problem Solving by Sei (1990). This guarantee states that in the event that the automobile manufacturers find any problems, the automobile manufacturers place the responsibility on suppliers, entrusting them to trace the cause of the problems and to solve them. According to Kawabata (1995), Performance Guarantee is the concept that suppliers take full responsibility for quality assurance, including the items not written in the specifications, in order to fully satisfy the automobile manufacturers. That is to say, supplier should not cause any quality problems at all upon delivery of the product (Sei, 1990). Therefore, in any case of occurrence of product problems after delivery, suppliers try to find causes and solutions with full responsibility. Performance Guarantee, a unique business practice, has been discussed in previous studies as a quality assurance system in the direct trade between steel and automobile manufacturers. According to interviews, this traditional business practice has also been applied in the supply chain for valve springs, including steel manufacturers, secondary processors and valve spring manufacturers. In other words, the Performance Guarantee in cases when valve spring problems were found by an automobile manufacturer, shows the formation of inter-firm cooperation among the above three parties of suppliers to find a solution to the problem and to jointly bear the responsibility for quality assurance. This is the traditional business practice of Performance Guarantee, and the third inter-firm cooperation phenomenon observed in the valve spring supply chain.

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Discussion

As obtained from the survey, in the valve spring supply chain with a limited number of companies and trading relationships, three kinds of suppliers’ vertical inter-firm cooperation were observed as follows;

- joint development of products is performed among limited suppliers
- before starting delivery of new product, cooperation among suppliers involved in the production is built during the manufacturing process approval by the automobile manufacturers
- limited cooperating suppliers build up a quality assurance system, a Performance Guarantee

The background of the above results will be explored and discussed below.

Historical Reasons

It is considered that the historical background of steel wire processing caused vertical cooperation among suppliers. In Japan, historically, imported piano wire from Sweden had been used as raw materials for high-functional uses, such as valve springs. According to Ochiai (2013), mass production technology of piano wire was first established in Japan in 1941, with increased valve spring demand for military aircraft. Ochiai (2013) reported that only a few steel wire manufacturers were asked by the military organization to produce piano wire domestically. Since that time, steel manufacturers and secondary processors started cooperating for domestic piano wire production. For example, at the beginning of the 1940s, secondary processors emerged in the valve spring supply chain, including the establishment of Suzuki Metal Industry Co., Ltd., a predecessor of current Nippon Steel and Sumikin SG Wire Co., Ltd.; Sanko Senzai Kogyo, a predecessor of current SUNCALL CORPORATION; and Nippon Tessen Kohsaku, a predecessor of current Shinko Wire Co., Ltd., which was taken over by Kobe Steel, Ltd. In other words, the base of cooperation between steel manufacturers and secondary processors dates back to the 1940s. On the other hand, valve spring products, using imported piano wire, had already been produced for automobiles in the 1930s, according to Japan Spring Manufacturers Association (2012). Thus, since the 1940s, when domestic piano wire production increased to mass production level, valve spring manufacturers gradually began to use domestic piano wire. Under this situation, it is considered that steel manufacturers, secondary processors and valve spring manufacturers began to construct the integrated vertical supply chain. While oil tempered wire replaced piano wire in the 1980s, it is considered that the foundation of the current supply chain as shown in Figure 3 had been formed. The valve spring supply chain has a long history and only a limited number of suppliers accumulated the production know-how over many years. This historical background is an important key factor for the current inter-firm cooperation between limited partners.

The Chain Reaction of Co-development and Quality Assurance

Inter-firm cooperation by suppliers also might be caused by a chain reaction starting with the joint development of products, as in Table 2. It is considered that suppliers in three areas involved in new product development discovered new manufacturing know-how and shared it. When developed products are delivered to automobile manufacturers, production process approval by the automobile manufacturer is required, as explained above. Because approval is issued for the integrated production process from raw materials to finished products, suppliers in the three areas are expected to work together to obtain approval from automobile manufacturers. When an automobile manufacturer finds a product problem after delivery, the three suppliers build a cooperative structure to trace the cause of the problem and to solve it, using accumulated knowledge from the joint development stage. Only these three suppliers, involved in the product’s development, are capable of finding a solution. Thus, joint development of products forms a linkage in the approval process and quality assurance responsibilities by the three parties of suppliers. It is clear that these suppliers fulfill one part of business cycle from the product development to the quality assurance as a chain reaction, keeping the same cooperation pattern by the three parties.
Production Management System of High-Functional Materials

As with valve springs, high-functional materials are processed in cold temperatures and are widely used in automotive parts. According to Akaishi & Hiraga (2011), the surface of oil-tempered wire used in valve springs, should be kept close to defect-free for further processing by the valve spring manufacturer. Therefore, a secondary processor plays a very important role in the supply chain and are required to have a high level of know-how to implement the requested quality of oil-tempered wire as above. It is necessary for secondary processors to finely control quality management in order to achieve the optimal state of material organization. Since quality management is based on accumulated data and experience, it is very difficult for engineers to learn quality management know-how in a short period of time (Akaishi & Hiraga, 2011). Because specific know-how, utilizing a huge data base, is required in secondary processing, which is located in the center of the supply chain, it is quite natural that the cooperative relationships are built between suppliers in three areas.

A New Type of Supply Chain Model

With regards to the valve spring, a new type of supply chain was observed as inter-firm cooperation from the viewpoint of quality assurance. Here, multiple immobilized suppliers jointly carry out product development and build a quality assurance system called Performance Guarantee to bear the responsibility for product quality. This phenomenon shows that there is a boundary for quality assurance, which is different from the boundary of an individual company, as shown Pattern 3 in Figure 4.

Actual contracts include individual sales and purchase agreements toward downstream from upstream of the process, however, there are no partnership or alliance agreements, for example in A, B, and C in Figure 4. Therefore, in the case of Problem Solving of Performance Guarantee, as a first step, the automobile manufacturer indicates the problem to the valve spring manufacturer. However, the valve spring manufacturer cannot solve the problem independently because delivered products were jointly developed with the steel manufacturer and secondary processor. After the first step, information flows upstream to the secondary processor and steel manufacturer, sequentially. Then inter-firm cooperation between the three is constructed to investigate the cause of the problem and to solve it, using the quality assurance formation, Problem Solving, in the system of Performance Guarantee. It is considered that this new type of supply chain model for quality assurance has been the base of the cooperative inter-firm relationships built by a historical development between two industries, by a chain reaction of joint product development and quality assurance, and also by specific manufacturing management systems for high-functional materials.

This phenomenon is considered to be observed also in other steel products’ supply chains, such as those of piston rings, bolts, nuts, steel chains, bearings and so on. These products manufacturers might have long histories of inter-firm trading, deal with high-functional materials that go through secondary processing under finely controlled quality.
management and that are further processed in the circumstance of cold temperature as the case of valve springs.

It was confirmed that the new transaction pattern as described above can be found in a certain range of supply chains for steel products. In the previous studies, Thompson (1967) proposed the reciprocal interdependency as one of the inter-organizational relationship caused by intensive technology. However, Thompson (1967) did not analyze how the relationship impacted industry boundaries or quality assurance systems. Sako & Helper (1998), Dyer (1996), and Choi & Krause (2006) discussed the relationships between buyers and sellers. Sako & Helper (1998) proposed the role of trust in the relationships, Dyer (1996) analyzed the influence of a product’s complexity on relations, and Choi & Krause (2006) noted how the complexity of the group of suppliers influenced the management of the focal company. However, they did not necessarily expand the discussion to the cooperation system among suppliers and firm boundaries with technology involvement as this paper does. Cusumano & Takeishi (1991) and Kawabata (1995) observed the unique business practice between suppliers and buyers in Japan, which often went beyond the scope of the transaction contracts. Especially Kawabata (1995), from the quality assurance point of view, explained this business practice as a term of Performance Guarantee. However, they did not address the cooperative behaviors of suppliers to realize this unique relationship as this paper does. von Hippel (1994) proposed "Sticky Information" and iterative problem-solving pattern between manufacturers and users, suggesting that during innovation-related problem-solving, technical information could be sticky and that when the solving required access to sticky information located at two or more sites, problem-solving activities would sometimes move iteratively among these sites. Additionally, von Hippel (1994) discussed that firms seeking to economize with respect to the transfer of sticky information would seek to align their organizational boundaries. It can be said that these views on interdependence and boundaries between organizations are very close to the main points of this paper. However, von Hippel (1994) did not discuss the scope of product supply responsibility based on the supply chain management point of view as this paper does. Apart from the preceding studies listed above, there are no papers discussing the supply chain and the firm boundaries from a perspective closer than this paper. Therefore, this paper adds to the literature on supply chains and firm boundaries by focusing on unique business practices and technology development.

Conclusion

This paper carried out an analysis of a supply chain focusing on the valve spring as an example of a high-functional product using steel wire as a raw material. As a result, strong vertical cooperation among suppliers was found in the supply chain. This inter-firm cooperative relationship has been built by three factors; the historical development of these industries, the chain reaction from co-development to quality assurance, and the production management system for processing high functional materials. It is important that the concept of quality assurance, called the Performance Guarantee is observed in supply chain formation. The Performance Guarantee in supply chain is a unique assurance system in which multiple immobilized suppliers jointly bear the responsibility for product quality. Previous studies have not shown this unique assurance system in supply chain formation.

The above research confirms new type of supply chain model, where related firms behave as one virtual company for product development, delivery approvals, and particularly for quality assurance. This provides firm boundaries, or boundaries of responsibility for product quality, which are different from the patterns of traditional supply chain formation. It is considered that this phenomenon represents one of the strengths of Japan's manufacturing industry. Since this unique guarantee regime has been observed for critical components that support the advanced automotive technology of Japan and has not been discussed in the previous literatures of supply chain management, it is considered a meaningful addition to previous studies.

Future research

This paper examines a structural quality assurance mechanism for high-functional material products within a supply chain. Giunipero & Eltantawy (2004)
illustrates the characteristics of a high-technology market as follows:

“High-technology markets are characterized by a rapid pace of technology change, which involves a high degree of uncertainty for buyers.” “Businesses developing high-technology product face higher risks of failure than other businesses because of greater competency demands and higher organization costs (Baker, 1995).” “The changing world events have had an impact on the supply chain environment.”

Since the valve springs discussed in this paper are high-functional material products, it is considered that high-technology must be involved in the manufacturing process, and that the technological capability would support the market value of the valve spring. Therefore, future research will reveal the reason why this new type of supply chain model for the high-functional materials products has existed for a long period of time under the higher risks of failure than other businesses, as Baker (1995) pointed out. And, by exploring the reason, the necessity of forming the new supply chain model described in this paper will be elucidated.

References


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Patent Publications in Table 2 (by Espacenet Search)

Patent publications organized according to the assigned PA number specific to this paper.

PA-1 Chuo Spring Co., Ltd. Production of High-Strength Carbonitrided Spring. JPH04187756, 1992-07-06.


PA-3 Chuo Spring Co., Ltd. High Strength Valve Spring and its Manufacture. JPH11246914, 1999-09-14.

PA-4 Chuo Spring Co., Ltd. High Strength Valve Spring and Manufacture. JPH11246941, 1999-09-14.

PA-5 Chuo Spring Co., Ltd. High-Strength Spring and Manufacture of the Same. JP2001009725, 2001-01-16.


PA-8 Chuo Spring Co., Ltd. High-Strength Spring and Method for Manufacturing the Same. JP2012036418, 2012-02-23.

PA-9 NHK Spring Co., Ltd. High Fatigue Strength Coil Spring with High Anti-Setting Property. JPH09112614, 1997-05-02.


