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# Interfirm Relationships in the Japanese Machine Tool Industry, 1910s-1980s: Market and Organizational Principles

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**Abstract**

Machine tools are called as “mother machines” as they contribute to producing various kinds of machines that enable many manufacturing industries to develop. In fact, Japanese machine tool products support the growth and strong competitiveness of many manufacturing industries in Japan. Consequently, interfirm relationships between machine tool makers and their customers are worthy of examining. Many scholars emphasize that Japan’s interfirm relationships are illustrated by “obligational contractual relationships”, primarily reflecting the organizational principle. Nevertheless, it seems highly likely that the market and organizational principles are closely intertwined in interfirm relationships of Japan. This article focuses on how market principle and organizational principle worked and were intertwined in the interfirm relationships of Japan’s machine tool industry. The analysis of this article demonstrates that even within the same period, the two principles are intertwined, not in a uniform manner but in diverse ways, and the manner in which the two have been intertwined has exhibited some continuity yet also constantly changes. Consequently, it is difficult to find unique Japanese elements in the interfirm relationships, which points to the possibility that Japanese uniqueness has been overemphasized at the expense of recognizing commonalities between different countries.

**Keywords:** Interfirm relationship, Japanese machine tool industry, NC machine tools, Market principle, Organizational principle

## Introduction

The purpose of this article is to examine the dynamics of interfirm relationships in the Japanese machine tool industry from the early twentieth century to the 1980s, focusing on intertwining between market and organizational principles.

Machine tools are called as “mother machines” as they contribute to producing many kinds of machines that enable many manufacturing industries to develop in turn.[1] Hence, interfirm relationships between machine tool companies and their customers have greatly contributed to the

[1] Using metalworking, machine tools make many kinds of parts that are assembled for a tremendous variety of machines and other products. For this reason, they are often called the “mother machine” and they are considered to be one of the most important capital goods. It is said that the technology level of machine tools in a country determines the working accuracy and the level of that country’s machine and manufacturing industries (Rosenberg, 1976: 1); Sawai (2013: 1); Chuma (2002: 277).

growth and expansion of the manufacturing industries. In fact, Japanese machine tools products support the growth and strong competitiveness of various kinds of manufacturing industries of Japan.

At the same time, the Japanese machine tool industry succeeded in attaining top rank within the world market even though it had a late start. It achieved its world rank based on its high production output between 1982 and 2009. Although China overtook Japan in the world market in 2009, even since then, Japanese machine tools have maintained a high level of quality and technological capability.

Nevertheless, in the initial phase of Japanese machine tool industry, imports were a significant threat to Japanese machine tool makers and it was not until the 1960s that the industry became substantially self-sufficient. As for the customers of Japanese machine tools, interfirm relationships with foreign suppliers as well as domestic suppliers were important for a longer time, and as for the Japanese machine tool firms, competitive pressure from foreign rivals had a sustaining effect. Moreover, in the prewar, there were the important characteristics of the multilayer structure in the Japanese machine tool market although the structure changed in the postwar.

Furthermore, SMEs (small and medium-sized enterprises) in manufacturing industries actively introduced the NC machine tools since the 1960s. Japanese manufacturers concentrated on developing small, easily programmable, general-purpose machines catering to small-scale, flexible operations. Hence, interfirm relationships between small customers as well as between big companies were important in Japanese machine tool market. It partly illustrates the "Japanese specialty" in the interfirm relationships. In the meanwhile, machine merchants engaged in transactions of machine tools and merchants intervened actively with the transaction of machine tools. This intervention by merchants is very popular in the transaction of intermediate products in Japan. In the sense, it also represents the "Japanese specialty" in the interfirm relationships.

Many scholars emphasize that Japan's interfirm relationships are illustrated by "obligational contractual relationships", primarily reflecting the organizational principle while those of most Western advanced countries are represented by "arm's length contractual relationships", which are highly susceptible to market principle.

Nevertheless, it goes without saying that not all transactions in Japan are based on long-term and continual contracts. In other words, interfirm relationships in Japan follow the market principle as well as the organizational principle.[2] Moreover, it seems highly likely that both principles are closely intertwined in interfirm relationships. In fact, in interfirm relationship of Japanese machine tool industry, the organizational principle and the market principle coexist and are interrelated as will be analyzed. Therefore, in this article, I focus on how two principles worked and had been intertwined in the history of the Japanese machine tool industry.

There are splendid studies on Japanese machine tool industry such as Sawai(1981);

[2] In this article I uses the concept of the organizational principle in a rather broad sense. That is, I define the organizational principle as that which is used by economic actors in order to control the market mechanism intentionally and actively.

Sawai(2013); Sawai(2015); Chokki(1963); Chokki(1978); Friedman(1988); Yoshida(1986); Chuma(2002) and so on. However, most of them don't analyze transaction of machine tools. Even though some of them partly examine the interfirm relationships, they don't focus on market and organizational principles.

With regard to research data, I have conducted many interviews with key people in the machine tool industry, which has enabled me to access information that cannot be acquired from published materials, including previous studies. In addition, I also use the documents that were published.

## 1. Interfirm Relationships in the Prewar Period

### 1.1 The Overview of the Development of the Machine Tool Industry in Prewar Japan

(1) Supply side

Machine tool production in Japan began after the Meiji Restoration of 1868. However, it was not until WWI that the Japanese machine tool industry started to develop in earnest. In WWI when it became difficult to import machine tools, domestic production of machine tools increased. Not only Naval and Army arsenals but also civil manufacturing companies such as shipbuilding firms sharply increased orders for Japanese machine tools.[3] As a result, more than 70 percent of total demand was met by Japanese machine tool companies from 1916 to 1918 (see Table 1).[4] Production of machine tools in 1918 increased 12-fold in terms of volume compared to that in 1915. Even for several years after WWI, the industry continued to be booming (Table 1). [5]

Nonetheless, primarily due to the end of the war and the conclusion of the Washington Treaty in 1922, the Japanese machine industry suffered a serious blow as a result of the economic recession that followed. The long slump of the industry continued until the recovery from the Great Depression. The decrease in machine tool production was severe during this period. The dire situation threatened the very existence of the industry.

From 1932, the production of machine tools drastically increased (Table 1) because, in the 1930s, Japanese customers of machine tools increased their purchases of domestic products as well as imports.[6] The profit gained through machine tool production in 1933 increased rapidly. For example, by 1937, it was more than 18 million Yen, which is about 13 times as much as it was in1931. On the basis of volume, Japanese machine tool production increased from merely 10,000 in 1935 to 67,000 by the late 1930s.

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[3] Fujita (2008: 51). Indeed, it was similar to the situation regarding the Japanese steel market in the same period.

[4] Because of the short supply of machine tools, Shibaura Engineering Works began in-house production of machine tools when it expanded its factory site during 1916 and 1917. It is very similar to a few Japanese shipbuilding companies who started in-house production of steel for ships in WWI.

[5] Chokki (1963: 78, 110). Chokki insists that the period during WWI is the first development era of Japan's machine industry, and the 1930s, especially the era from 1933, is its second development era (Chokki, 1963: 153).

[6] Nagao (2002: 43, 45, 69, 74-5, 81, 117).

**Table 1 Production, import, export, domestic demand and dependency on import of machine tools, 1915–44 (thousand Yen, %)**

| Year | Production | Import | Export | Domestic demand | Dependency on import |
|---|---|---|---|---|---|
| 1915 | 1,480 | 900 | 264 | 2,116 | 42.6 |
| 1916 | 8,300 | 1,800 | 1,255 | 8,845 | 20.3 |
| 1917 | 12,000 | 3,452 | 835 | 14,617 | 23.6 |
| 1918 | 18,000 | 6,640 | 1,191 | 23,449 | 28.4 |
| 1919 | 14,500 | 10,560 | 963 | 24,097 | 43.9 |
| 1920 | 11,900 | 13,441 | 989 | 24,352 | 55.2 |
| 1921 | 9,429 | 10,976 | 389 | 20,016 | 55.0 |
| 1922 | 7,315 | 6,521 | 441 | 13,395 | 52.3 |
| 1923 | 4,710 | 3,808 | 233 | 8,285 | 45.9 |
| 1924 | 8,907 | 7,747 | 602 | 16,052 | 48.4 |
| 1925 | 6,392 | 5,744 | 276 | 11,860 | 48.4 |
| 1926 | 7,045 | 3,012 | 282 | 9,775 | 30.7 |
| 1930 | 4,430 | 4,840 | 235 | 9,035 | 53.6 |
| 1931 | 3,940 | 3,070 | 185 | 6,825 | 45.0 |
| 1932 | 8,200 | 5,810 | 325 | 13,685 | 42.5 |
| 1933 | 10,618 | 11,339 | 280 | 21,677 | 52.3 |
| 1934 | 16,547 | 14,485 | 425 | 30,607 | 47.3 |
| 1935 | 18,751 | 9,998 | 390 | 28,359 | 35.3 |
| 1936 | 30,868 | 15,385 | 1,245 | 45,008 | 34.2 |
| 1937 | 50,199 | 40,968 | 1,628 | 89,539 | 45.8 |
| 1938 | 204,085 | 91,738 | 3,640 | 292,183 | 31.4 |
| 1939 | 274,597 | 157,166 | 11,094 | 420,669 | 37.4 |
| 1940 | 312,479 | 78,500 | 13,470 | 377,509 | 20.8 |
| 1941 | 318,167 | 26,140 | 10,360 | 333,947 | 7.8 |
| 1942 | 427,036 | 16,230 | 10,935 | 432,331 | 3.8 |
| 1943 | 602,913 | 8,040 | 11,030 | 599,923 | 1.3 |
| 1944 | 723,069 | 3,990 | 4,030 | 723,029 | 0.6 |

Source: Ministry of Agriculture and Commerce (1921); Toyo Keizai Shimposha (1950: 390); Chokki (1963: 77, 103, 109).

At the same time, as Table 1 shows, Japan continued to import many machine tools throughout the prewar period. In Japanese formal trade statistics, imports of lathes[7] appear for the first time in 1896. Except for the periods during WWI and WWII, the dependency rate of imports to machine tools demand was high. Even the increase of tariffs in 1926 did not greatly influence the number of imported machine tools. In the 1930s, market demand continued to rely heavily on imports.[8] It shows that through prewar Japan, interfirm relationships between Japanese machine tool customers and foreign suppliers was important amidst the severe competition that ensued between the Japanese and importing machine tool companies.

[7] A Lathe is the machine tool which usually rotates the work piece on their axis to manipulate the metal in various ways such as through cutting, sanding, knurling, drilling, or deforming, facing or turning. It is the most popular kind of machine tool.

[8] This was different from the Japanese steel industry that had already achieved self-sufficiency in the 1930s.

(2) Demand side and multilayer market structure

In Japan, during WWI, the demand of machine tools increased explosively although there was some demand for them before the war. In particular, civil arms factories led the increase in demand for machine tools in Japan. Subsequently, the shipbuilding, motor, and industrial machine industries expanded their orders for machine tools. In addition, the Navy ordered machine tool firms to establish a fleet of eight battleships and eight battlecruisers. Even after the end of the war, the demand increase continued until 1921 because the industries continued to order and the plan to increase armaments stimulated machine tool production.

Although demand was low in the 1920s, in the 1930s demand in the machine tool industry experienced a rapid upturn and economic expansion regained momentum around 1932. Manufacturing orders to machine tool firms again increased rapidly from the early 1930s. In particular, along with the outbreak of the Manchurian Incident in September 1931 and the Shanghai Incident in January 1932, munitions plants related to military production increased orders for machine tools. Through the 1930s, the Army and Navy made requests to civil firms that produced munitions and armaments-related products such as military aircraft, ships and automobiles, which expanded production. As a result, orders to machine tool firms increased sharply. Furthermore, the demand for machine tools was prompted by the demand for other manufactured products such as textile machines, motor and electric machines and bicycles. In particular, many lathes and milling machines[9], primary types of tool machines, were installed by textile machine and electric machine companies.

The value of machine tool orders expanded from 6.83 million Yen in 1931 to 89.54 million Yen in 1937. The number of installed machine tools increased from 10,000 in 1935 to 67,000 in 1938. For instance, top Japanese aircraft manufacturers, including Nakajima Aircraft, aircraft factories of Ishikawajima, Mitsubishi Heavy Industry and Kawasaki Shipbuilding Ltd, had 1800 machine tools in total prior to 1935, but the number of tools increased to 2264 in May 1935.

Machine tools in prewar Japan were bought by an extremely diverse range of customers from military arsenals to small machine makers so that the machine tool market in the period had a four-layer structure that formed a pyramid. Such a structure was formed after the Russo-Japanese War and became standard in the 1920s.

The first layer, the top of the market structure, was composed of electric machines and aircraft companies that partly delivered to the Army. In this layer, the machine tools to be bought were high end and large sized. The second layer of the market consisted of demands by the military arsenals, the Ministry of Railways, shipbuilding companies and general machine companies. The third layer included machine tools to be manufactured for automobiles, bicycles and textiles. This layer of the market was composed of small-scale customers that could not or did not have to buy expensive

[9] A milling machine, often called a mill, is a machine tool which uses rotary cutters to remove material from a work piece advancing in a direction at an angle with the axis of the tool. It is also one of the most commonly used processes in industry and machine shops. After the advent of computer numerical control (CNC), milling machines evolved into machining centers, often called MCs.

machine tools imported and manufactured by large and mid-sized Japanese machine tool makers. Finally, at the lowest layer of the structure, there was the second-hand machine tool market.

The four-layered structure of the market continued throughout prewar Japan and created inflexible barriers between the market layers. The sale of each machine tool firm was limited to the specific layer of the market. Therefore, this multilayered market shows a kind of the organizational principle. On the other hand, under the multilayer market, competition within each market layer was fierce, which illustrates the working of the market principle, as will be analyzed later. Consequently, the multilayer market structure represents the intertwining between the market and organizational principles. Hence, I examine how two principles were intertwined each other in the interfirm relationships of each market layer.

### 1.2. Interfirm Relationship in the First Layer Market

(1) Market principle: competition among merchants for sales of imported machine tools

Imported machine tools dominated the first layer market. During the Russo-Japanese War, especially, in 1905, boring machines, gear cutting[10] machines and milling machines were heavily imported. After that, the boring machines, gear cutting machines and milling machines continued to be highly dependent on imports. In the 1930s, imports of automatic lathes and drill presses[11] increased sharply. In particular, many special-purpose machines used for military arsenals were imported during this period.[12]

With regard to imported machine tools, trading companies played an important part in their presence in the late Meiji period, roughly around the 1900s. Whereas foreign trading companies played a significant role in importing products to Japanese civil companies, so did Japanese trading companies in importing machine tools for use in military arsenals. US, British and German trading companies competed to import machine tools to Japanese civil companies. Takada Co. and Okura-gumi were the leading trading companies that imported machine tools requested by military arsenals. Although Mitsui & Co. engaged in the trading of machine tools, it was overshadowed by those two trading companies. Mitsubishi Trading Co. emerged later as a sales agency of foreign machine tools and did not appear until the early 1930s.

However, Mitsubishi and Mitsui began aggressive expansion into the import business of machine tools from the mid-1930s. In particular, they actively increased imports in response to orders made by major customers such as aircraft, automobile and electric machine companies. Some of these customers grew rapidly in the interwar period and some of them imported through

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[10] In machining, boring is the process of enlarging a hole that has already been drilled, by means of a single-point cutting tool. Boring machines are used to achieve greater accuracy in the diameter of a hole, and can be used to cut a tapered hole. Gear cutting is any machining process for creating a gear. The most common gear-cutting processes include hobbing, broaching, milling and grinding. Such cutting operations may occur either after or instead of forming processes such as forging, extruding, investment casting or sand casting.

[11] The drill press is a fixed style of drill that may be mounted on a stand or bolted to the floor or workbench. Drill presses are often used for miscellaneous workshop tasks such as sanding, honing and polishing, other than drilling holes.

[12] Kikai Gakkaishi (1937, 40(237), p. 19).

foreign trading companies. Data shows that trading companies competed fiercely to acquire more large customers as well as increasing the number of imported goods. Therefore, we can say that in the process of importing machine tools, the market principle worked in the way of competition among trading companies.

(2) Organizational principle

With regard to the supply structure of machine tools, Japanese machine tool firms were limited to catering for a clientele in their designated market layer, as previously noted.

The customers of the top layer of the market structure, such as the Navy and the factories related to the military, mainly demanded high-end and large-sized machines. They continued to buy mostly imported machine tools because Japanese machine tools were at the time still inferior to imports in terms of efficiency, precision and durability.[13] According to Table 2, the average price of imported machine tools was much higher than that of domestic machine tools through the 1930s. In fact, it was not rare for Japanese machine tool firms to imitate superior foreign machine tools even in the 1930s.[14]

**Table 2 Average price of machine tools in Japan, 1930–37 (Yen per unit)**

| Year | Domestic production | Import | Domestic demand |
|---|---|---|---|
| 1930 | 1,969 | 9,680 | 3,435 |
| 1931 | 1,876 | 10,233 | 2,967 |
| 1932 | 2,733 | 12,911 | 4,110 |
| 1933 | 1,889 | 9,946 | 3,280 |
| 1934 | 2,136 | 9,042 | 3,345 |
| 1935 | 1,865 | 8,297 | 2,567 |
| 1936 | 1,902 | 5,111 | 2,423 |
| 1937 | 2,293 | 6,698 | 3,281 |

Source: Toyo Keizai Shimposha (1950: 300); Sawai (1981: 35).

Consequently, Japanese machine tool suppliers gradually became separated from this first layer market. In the sense that competition between foreign machine tool makers and Japanese makers was almost blocked, the organizational principle worked strongly in this layer market and the market and organizational principles were intertwined.

[13] Katsuda (1918: 29, 33–4). Based on examining the history of the US machine tool industry, Nathan Rosenberg insisted on “technological convergence”(Rosenberg(1963)). Namely, the US machine tool industry endeavored to solve the problem caused among users so that new technology and new products from the industry could be introduced by a wider range of users. However, considering the multilayer structure of Japanese machine tools in the prewar period, it would have been very difficult to realize Rosenberg’s proposal in the Japanese machine tool industry.

[14] Nagao (2002: 118).

### 1.3 Interfirm Relationship in the Second Layer Market

(1) Market principle

In the second layer of the market, domestic and foreign machine tool firms competed fiercely to expand sales to large customers. In specific, soon after WWI ended, there was a sharp increase in imported, high price precision machine tools within the second layer market with which the Japanese machine tool companies had to compete against foreign companies as well as rivals of Japan. Due to this severe competition, the price of machine tools decreased in this layer.[15] This intense competition demonstrates that the market principle worked in this layer market.

(2) Organizational principle

Because this layer market was a considerable size and the level that customers requested was high in terms of technology, it was almost impossible for small machine tool firms to succeed at this layer. As a result, a few large companies, the so-called "top five machine tool firms": Ikegai Co., Okuma Machinery Works, Karatsu Iron Works Co., Niigata Engineering Co. and Tokyo Gas Electric Engineering Co. dominated this market layer,[16] while they competed with imports as described above. This oligopolistic structure of Japanese machine tool industry represents the organizational principle.

Moreover, large customers, including the Naval arsenal and the Army arsenal, ordered and continued to purchase from a few specific large machine tool companies. Transactions were made between only specific suppliers and specific customers. As a result, large Japanese machine tool companies mainly engaged in build-to-order manufacturing for specific customers. As such, relationships with specific customers were close and there was a great deal of cooperation between machine tool firms and their customers. This also illustrates the organizational principle in interfirm relationship.

Consequently, they closely cooperated continuously with specific customers while machine tool firms also competed with each other and imports. Therefore, we can say that the organizational principle intertwined with the market principle in this second layer market.

### 1.4. Interfirm Relationship in the Third and Fourth Layer Markets

(1) Market principle

In the third and fourth layer market, small machine tool makers, their small customers and small merchants continued to be the main players throughout the prewar period.

Apart from the period of the Depression, the new entry of small companies, including startups, continued in these layer markets. Small customers did not care about poor quality and demanded lower prices for general-purpose machines. Therefore, it was not so difficult for small companies to enter this layer of the market. With regard to the supplier, the cost of entry to the market was so

[15] Kimura (1992: 9).

[16] Sawai (1981: 39; 2013: 10; 2015: 91, 94); MITI (1970: 454–7). Increase in orders to Japanese machine tool companies during WWI contributed to their remarkable growth.

low that the number of small machine tool firms that manufactured low-price[17] and second-hand machine tools continued to increase.

It was in the WWI period that small companies actively entered this market layer, due to the increase in demand for machine tools. Before the war, they had engaged in various industries. Some of them manufactured miscellaneous machines and others engaged in maintenance and processing work of second-hand machines. Some companies had manufactured parts and attachments of machines via subcontracting. Small firms had a market share of 46 percent of the Japanese machine tool production in 1919. These frequent and increasing new entries represent the working of the market principle.

Some of these companies accomplished the rapid growth in the 1930s. Because the demand for machine tools at all layers of the market exploded in the 1930s, supply shortages and delivery delays became a serious issue. Large machine tool makers would not cover the increasing demand from small customers. As a result, there was a wide range of business opportunities for small machine tool firms. Consequently, many of the small machine tool firms grew rapidly.[18] By the frequent appearance of new firms and the growth of existing small companies, the production rate for factories with fewer than 30 employees tended to be higher through the 1930s.[19]

In the meanwhile, the small merchants of machine tools dealt in machine tools that were manufactured by small machine tool firms, including second-hand machines, and sold them primarily to small customers. Most of the merchants were small and were concentrated in several specific regions. The “tanimachi” in Osaka and “san no hashi” in Tokyo were famous as the agglomeration districts of small machine merchants.

Small machine tool firms depended heavily on these small merchants for the sales of machine tools.[20] Due to the fluctuation of the economy, the bargaining power between them frequently changed, and conflicts of interest occasionally occurred between small makers and small merchants. These frequent changes in bargaining power and occasional occurrences of conflicts of interest show that the market principle worked in the relationship between them.

In sum, the frequent and increasing entry of small firms and the conflicts of interest between small makers and small merchants show that the market principle was robust in these layer markets.

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[17] For example, the price of lathes made by small companies was only about 31 percent of that of lathes made by large and mid-sized firms at the end of the 1910s. With regard to drilling machines and milling machines, the prices of products made by small firms were only 28 percent and 17 percent of those products made by large and mid-sized firms respectively.

[18] Sawai (1981: 43). In the 1930s, they were no longer “small” companies. The proportion of these “mid-sized” firms to the total machine tool production rose considerably in terms of volume. This resulted in the emergence of the “mid-sizing” phenomenon.

[19] Sawai (2015: 47, 94, 152).

[20] In contrast, large machine tool firms sold their products directly to customers as a rule. This was one way they differed from the large steel firms, who almost always sold their products via merchants. However, in general, machine tool makers were strongly technology-oriented so that they did not pay much attention to marketing (Chokki, 1978: 195). And, the distribution system of machine tools was changed in the postwar period(Institute for Economic Research for Osaka City University, 1955: 382).

(2) Organizational principle

On the other hand, small machine tool firms in these layer markets had cooperative relationship with small machine merchants in various ways. For instance, the merchants not only mediated in the negotiations with small customers of machine tools, but they also lent money to the small machine tool firms and arranged materials for manufacturing on occasions, like wholesale and subcontracting systems.[21] This illustrates how the organizational principle, which intertwined with the market principle, functioned strongly in interfirm relationships between Japanese small merchants and small manufacturers of machine tools.

Furthermore, the close ties between small machine makers and small merchants with low price of the products blocked the entries of large Japanese machine makers and foreign machine tool companies to these layer markets, consequently, functioned as a kind of non-tariff barrier to them. It demonstrates that the working of the organizational principle in these layer market.

## 2. Interfirm Relationships in Postwar Period

### 2.1 New Intertwining between the Market and Organizational Principles in the Postwar

In the postwar of Japan, the multilayer market structure of machine tools changed drastically. For instance, contrast to the prewar period, there were mostly no demand of machine tool by the Naval arsenal, the Army arsenal and the Army, and the degree of dependence on imports of machine tools also decreased rapidly since the 1960s. Competition among Japanese machine tool makers spread beyond market layers, differing from the prewar period.

As a result, in the interfirm relationships of the Japanese machine tool industry in the postwar period, there were many phenomena that demonstrate the new intertwining of the market principle and the organizational principle although the continuity between the period existed.

(1) Market principle

The composition of demand for machine tools in the postwar period largely changed compared with that of the prewar period. As previously noted, the arsenals of the Navy and Army purchased high-level machine tools before the war. Nevertheless, after the war there was almost no demand from the arsenals. Japanese machine tools were bought by so-called “civil” customers.[22] Therefore, we can say that the four -layer market structure was almost collapsed.

Throughout the 1950s, the main user industries of machine tools were concentrated in the “civil” machine industries. The so-called “four machine industries”, general machinery, transport equipment, electrical machinery and precision machinery industry constituted about 70 percent of the demand for machine tools.[23] In 1952 and 1953, of the “civil” customers, the biggest market for

[21] Sawai (1981: 47).
[22] Sawai (2013: 361); Chokki (1963: 196; 1978: 201).
[23] Chokki (1963: 194, 199; 1978: 78); Institute for Economic Research of Osaka City University (1955: 292); Sawai (1990: 149; 2013: 360).

machine tools was in the transport equipment industries, such as railway vehicles and automobiles, although there was great variety of "civil" customers. In particular, the automobile industry was very active in introducing new machine tools. In the late 1950s, Japanese automobile companies all introduced transfer machines for the mass production of engine parts.[24]

Although there were almost no imports from 1946 to 1948, imports of machine tools restarted in 1949 and since then they kept increasing through the 1950s. Machine tool customers whose precision processing technologies were out of date attempted to catch up by introducing advanced imported machines after imports restarted. Throughout the 1950s, the state-of-the-art machine tools were imported was a continuation of the prewar period,[25] and foreign firms accounted for between 30 and 50 percent of the market (see Table 3). The degree of dependence on imports of machine tools was as high as that of the prewar period as well. For example, according to a survey by MITI in 1952, the automobile industry was the largest industry ordering imported machines. In addition, industries of electric power, medical machines, optical machines, bearings, communications equipment and watch manufacturing were the primary customers of imported machines.

In the prewar period, the highest layer of demand was met by only imported machine tools, as shown earlier. However, as the four-layer market structure was collapsed in the postwar, as noted earlier, Japanese machine tool makers competed more fiercely against foreign companies in domestic market.

Furthermore, in contrast to the prewar period, competition spread beyond layers. For instance, competition among machine tool firms across each demand layer became intense under the recession of 1965.[26] To survive the recession of 1965, even large machine tool firms began to enter the low-price machine market. As a result, they competed with small machine tool firms in this market segment.[27] In particular, the price war for the small customers intensified and discount rates of 60 percent of the normal price were not uncommon. To expand sales to small customers whose financial position was weaker, the machine tool firms actively increased selling by installments.[28]

Again, new entries to the industry intensified the competition across each demand layer. In the 1950s and the 1960s, employees of large and old machine tool firms became newly engaged in establishing a number of local machine tool startups. Maintenance companies, subcontractors of machine tool manufacturing, rough shape materials for casting, other machines and parts manufacturers also became new entrants into the machine tool business. [29]

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[24] Morino (1995: 38–9, 43); Chokki (1978: 85).
[25] Nagao (2002: vii); Chokki (1978: 84).
[26] Sawai (1990: 163).
[27] Sawai (2013: 387).
[28] Chokki (1978: 224–6); Sawai (1990: 163).
[29] Institute for Economic Research of Osaka City University (1955: 99–100); Chokki (1963: 238–40).

**Table 3　Production, trade and demand of Japanese machine tools (million Yen, %)**

| Year | Production | Export | Import | Domestic demand | Degree of dependence on import | Export ratio |
|---|---|---|---|---|---|---|
| 1945 | 130 | 0.1 | 0.04 | – | 0.1 | 0.1 |
| 1946 | 106 | 0 | – | 106 | – | 0 |
| 1947 | 172 | 1 | – | 149 | – | 0.6 |
| 1948 | 500 | 1 | – | 499 | – | 5.2 |
| 1949 | 771 | 51 | 42 | 862 | 4.9 | 6.6 |
| 1950 | 537 | 214 | 133 | 452 | 29.4 | 39.9 |
| 1951 | 1,066 | 286 | 134 | 930 | 14.4 | 26.8 |
| 1952 | 1,707 | 352 | 848 | 2,203 | 38.5 | 20.6 |
| 1953 | 3,738 | 411 | 2,254 | 5,319 | 42.4 | 11 |
| 1954 | 5,385 | 549 | 5,229 | 10,066 | 51.9 | 10.2 |
| 1955 | 3,680 | 715 | 4,042 | 7,007 | 57.7 | 19.4 |
| 1956 | 7,174 | 527 | 2,523 | 9,170 | 27.5 | 7.3 |
| 1957 | 15,549 | 724 | 12,201 | 27,026 | 45.1 | 4.7 |
| 1958 | 21,113 | 479 | 13,777 | 34,411 | 40.0 | 2.3 |
| 1959 | 24,318 | 497 | 10,449 | 34,270 | 30.5 | 2.0 |
| 1960 | 45,169 | 1,624 | 19,701 | 63,246 | 31.1 | 3.6 |
| 1961 | 81,882 | 2,434 | 38,899 | 118,347 | 32.9 | 3.0 |
| 1962 | 100,892 | 2,587 | 47,581 | 145,886 | 32.6 | 2.6 |
| 1963 | 95,132 | 4,295 | 22,796 | 113,633 | 20.1 | 4.5 |
| 1964 | 90,906 | 6,509 | 21,319 | 105,716 | 20.2 | 7.2 |
| 1965 | 70,349 | 8,943 | 13,963 | 75,369 | 18.5 | 12.7 |
| 1966 | 76,453 | 14,611 | 7,586 | 69,428 | 10.9 | 19.1 |
| 1967 | 126,041 | 17,642 | 12,839 | 121,238 | 10.6 | 14.0 |
| 1968 | 175,986 | 18,584 | 34,176 | 191,578 | 17.8 | 10.6 |
| 1969 | 239,988 | 21,742 | 34,485 | 252,731 | 13.6 | 9.1 |
| 1970 | 312,349 | 24,088 | 44,162 | 332,423 | 11.3 | 7.7 |
| 1971 | 264,405 | 28,044 | 39,762 | 276,123 | 14.4 | 10.6 |
| 1972 | 205,180 | 27,408 | 22,366 | 200,138 | 11.2 | 13.4 |
| 1973 | 305,223 | 35,237 | 21,332 | 291,318 | 7.3 | 11.5 |
| 1974 | 358,610 | 57,664 | 37,211 | 338,157 | 11.0 | 16.1 |
| 1975 | 230,739 | 61,611 | 21,575 | 190,703 | 11.3 | 26.7 |
| 1976 | 228,604 | 76,073 | 13,687 | 166,218 | 8.3 | 33.3 |
| 1977 | 312,844 | 115,493 | 15,720 | 213,071 | 7.4 | 36.9 |
| 1978 | 365,525 | 162,138 | 19,638 | 223,025 | 8.8 | 44.4 |
| 1979 | 484,132 | 206,643 | 26,214 | 303,703 | 8.6 | 42.7 |
| 1980 | 682,102 | 269,577 | 38,221 | 450,746 | 8.5 | 39.5 |

Source:Kikai Sinko Kyokai Keizai Kenkyujo (1985: 38); MITI, *Yearbook of Current Production Statistics*.

At the same time, competition among Japanese machine tool firms was intense. For instance, large machine tool firms competed for technology imports from advanced countries. As the agreements to import technology limited the regions they could export to, consequently competition among Japanese machine tool firms that made these import agreements became more intense in the domestic product market.[30]

In conclusion, competition across the demand layer including the new entrants to the industry

[30] Chokki (1978: 222).

was an example of the market principle working.

(2) Organizational principle

On the other hand, the degree of dependence on imports of machine tools tended to decrease in the postwar according to Table 3. Instead, the rate of Japanese production of all amounts of machine tools substantially increased.

In addition, apart from the Korean War period, 1950 to 1953, the export ratio was also very low (see Table 3). In the 1950s the export of Japanese machine tools was limited to Asian countries, Korea, Taiwan and the Philippines[31] and the export ratio of machine tools was only from 2 to 5 percent from 1957 to 1963. The export ratio of machine tools was mainly determined by economic fluctuation. For example, whereas the ratio rose sharply in 1965 and 1966 because of the depression (see Table 3),[32] it fell again after 1967 owing to the Japanese economic boom. This shows that in the Japanese machine tool market, exports acted like a buffer in response to economic fluctuation. That is, domestic demand was the independent variable and export was the dependent variable. As for sales of Japanese machine tools, Japanese customers were more important than foreign customers in this period.

In short, the ratio of exports as well as imports to domestic production was so low during the 1960s and the early 1970s, although domestic machine tools and imports competed intensely in the 1950s. Therefore, it is highly probable that interfirm relationship, especially cooperation between Japanese machine tool firms and Japanese companies became important.

In fact, there was already a great deal of cooperation between suppliers and customers of machine tools, especially in the transaction of special-purpose machine tool.

There are two different types of machine tools: special purpose and general purpose. Special-purpose machine tools are customized for a few specific customers, whereas general-purpose machine tools are standardized for many customers. The former are expensive, high end and tend to have a long delivery time, whereas the latter are relatively cheap, low end and tend to have a short delivery time. Therefore the former are primarily for large customers. More importantly, the former are products that are close to the organizational principle as they need close cooperation with specific customers.

Indeed, in introducing the transfer machines as a special-purpose machine tool, Japanese automobile companies cooperated with machine tool firms. Automobile firms planned the concept of transfer machines based on their own specification, and then drew up blueprints of machines with engineers from the machine tool firms. The machine tool firms then manufactured the machines. For example, Toyota Motor Corporation and Nissan Motor Corporation asked Toyota Kohki and Kiryu Machine Manufacturing respectively to manufacture special machine tools

[31] Morino (1995: 138).

[32] The boom in the US economy in 1965 and 1966 also contributed to the increase in exports of Japanese machine tools (Chokki, 1978: 205).

exclusively for them.[33] In the transaction between Japanese machine tool firms and their large customers, the organizational principle functioned in ways of cooperation.

The organizational principle also worked in the industrial organization of Japanese machine tool in this period. Typically, many market segments were oligopolistic and were substantially concentrated by a few firms. According to the survey on 18 kinds of machine tools by JMTBA (Japan Machine Tool Builders' Association)[34] in 1961, for 10 months from January 1961 to October 1961, in all the market segments, the top two firms had more than 50 percent of the market share and the top firms in each segment accounted for about a third of domestic production. For example, the top firms accounted for 72.5 percent of the turret lathes market and 92.2 percent of the roll grinding machines[35] market respectively. Radial drilling machines, boring machines and bed type milling machines were also very concentrated market segments.[36] Such an oligopoly in each market segment demonstrates the organizational principle.

In addition, we can observe that large machine tool firms intentionally segregated their main markets so as to lessen competition. For example, there were very few market segments where the top five machine tool firms and other large machine tool firms engaged in other machine businesses competed, except for knee type horizontal and vertical milling machines, special-purpose machine tools and shaping machines.[37] This intentional segregation between machine tool companies is an illustration of the organizational principle.

Moreover, there were attempts by machine tool cartels and the government to solve the problems caused by manufacturing various kinds of machine tools in this industry even though they finally were not successful. These attempts illustrate the organizational principle. For example, JMTBA first attempted to institute a production restraint program in 1957 and the members of JMTBA wanted to reduce competition by promoting specialized production and limiting entry into the market. Their first step was taken in August 1957, when a "production field discussion committee" was set up as one of the special standing bodies of the cartel. Along with the recession in the machine tool industry after 1963, in November 1964 a new pact was approved as the Agreement Concerning Concentrated Production (*Shuchu Seisan ni Kansuru Moshiawase*), which aimed to enhance the growth of member firms to the "appropriate scale" by reducing price and product competition through specialization. This scheme was called "product field regulation" (*Seisan Bunya Taisei*).[38] In the scheme, 10 groups became established from December 1965 to

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[33] Chokki (1978: 88).

[34] The JMTBA was established at the end of 1951 (Nagao, 2002: vii).

[35] The grinding machine, often referred to as a grinder, is a machine tool used for grinding. It is a type of machine that uses an abrasive wheel as its cutting tool. Each grain on the wheel's surface cuts a small chip from the work piece via shear deformation. Grinding is used to finish work pieces that must show high surface quality and high accuracy of shape and dimension.

[36] Chokki (1963: 226; 1978: 144).

[37] Chokki (1963: 241).

[38] Friedman (1988: 96–9); Nihon Kosaku Kikai Kogyokai (1972: 489–500).

May 1966.[39] Each group tried to collaborate with the member firms in areas such as co-development, information exchange, joint implementation of PR, issuance of common pamphlet, co-attendance at exhibitions and so on.[40]

### 2.2 Interfirm Relationship in the NC Period, 1970s and 1980s

The introduction of numerically controlled (NC) appliances in the 1970s drastically changed the machine tool industry.

The first oil crisis that began in 1973 changed the relative prices for factors of production. In particular, there was a dramatic rise in the price of natural resources for fuel, the price of products whose production consumed large amounts of oil and, in turn, wages. In response to this change in the relative price system, Japanese manufacturing firms actively introduced microelectronic machines and microelectronic technology from the late 1970s. This was symbolized by Factory Automation, the so-called "FA" of the manufacturing industries. In the process of FA, a number of NC machine tools were introduced in Japan.[41] It is highly likely that the introduction of NC machine tool strongly influenced the interfirm relationship between machine tool makers and customers.

(1) Market principle

New entrants to the industry continued in the 1970s and the early 1980s so that the number of machine tool producers increased. In particular, growth in the number of firms producing NC lathes, machining centers(MC) and NC mills was remarkable. The number of NC lathe producers rose from 10 to 37 firms, the number of NC mill makers from 10 to 25, and the number of machining center specialists from 14 to 45 companies. The number of JMTBA members increased from 23 in 1965 to 49 firms in 1975.[42] As a result, machine tool market became more competitive. For example, concentration ratio in the machine tools market fell overall in the 1970s and the early 1980s, although the ratio in the market generally was low. Concentration in the automatic lathe, NC lathe and MC fell strikingly.[43]

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[39] Chokki (1978: 147); Sawai (1990: 159, 161). This grouping was closely related to the third "Act on Temporary Measures for the Promotion of Machine Industry". See Odaka and Matsushima (2013) and Sawai (2015: 112–3) on the Act and its results.

[40] The grouping policy had major limitations and was not successful. The basic difficulty was the fact that the members of each group did not produce sufficiently similar machinery to allow consolidation to obtain scale economies. The major groups were composed of firms that did not compete with one another or that had product lines so dissimilar as to make integration impossible. Furthermore, interfirm distrust was the primary obstacle and member firms adamantly opposed any arrangement that would reduce corporate independence. Negotiations about group affiliation were also complicated because companies could not readily determine which group was best for them. Another major difficulty was that a large number of firms were never involved in any group at all(Friedman (1988: 99, 100–101, 242)). As a result, the machine tool cartels, the "groups", were totally ineffective when it came to the increase in demand for machine tools in the late 1960s. Rather, the number of firms involved in each kind of machine tool increased (Sawai (2013: 364; 2015: 113)).

[41] Kim (2003: 19).

[42] Sawai (2015: 114).

[43] Friedman (1988: 108–12); Chokki (1978: 144–5).

Severe competition in the machine tools market was clearly apparent in the change in market share occupied by machine tool companies. Older leading firms experienced dramatic drops in their shares of overall production between 1968 and 1983. Instead, new firms – independently and without the assistance of older companies – entered the market and began to displace the previous leaders. For example, five of the top ten firms in 1956 were not in the top ten in 1983, and by the 1980s new firms had become dominant in the machine tool industry, especially in NC machine tools. According to Table 4, in both the NC lathe and MC markets, which were the dominant type of NC machine tools in terms of production amount, Yamazaki[44], Okuma and Mori Seiki occupied the top three positions in 1985. Moreover, these three firms had the top shares in total machine tools in the same year (see Table 4). However, in 1975, a decade earlier, neither the market share nor ranking of the three companies were high. In short, during a decade when introduction of NC machine tools advanced rapidly, the three companies' positions in the NC machine tool market rose rapidly.

In particular, Yamazaki and Mori Seiki made a great breakthrough. Whereas Yamazaki was not conspicuous in the machine tool market until the 1960s, it actively developed NC machine tools. For instance, the company established an R&D Team for NC lathes in 1964 and a Technology Development Center in 1966. In addition, in 1970, it concluded a technology alliance agreement with two US machine tool firms that had advanced technologies in large NC lathes and MC. As a result, it developed on average about ten kinds of machine tools per year in the early 1970s, and dramatically increased its sales of NC machine tools. Mori Seiki was an outsider in the JMTBA until 1983 only after trade friction prompted it to adopt an emergency export control program in order to appease the US. Thus, Mori Seiki, as outsiders, could produce and price as they pleased so that it became one of the largest manufacturers in the MC and NC lathe market.[45] Instead, the old and traditional top machine tool makers such as Ikegai, Hitachi Seiki, Toshiba Machine and Toyota Khoki lost their dominant position in the machine tools market (see Table 4). that machine tool market became more competitive and market share by firms changed sharply demonstrates that the market principle was in force.

[44] Yamazaki was established in 1919 and began to manufacture machine tools in 1932, starting to sell high-speed and precise lathes all over Japan in 1958.

[45] Friedman (1988: 98).

**Table 4　Market share by machine tool firms (%)**

| | 1975 | | 1980 | | 1985 | |
|---|---|---|---|---|---|---|
| | Name of firm | Market share | Name of firm | Market share | Name of firm | Market share |
| Machine tools | Toshiba Machine | 7.1 | Yamazaki Mazak | 7.2 | Yamazaki Mazak | 7.6 |
| | Yamazaki Mazak | 4.5 | Okuma Machinery Works | 6.7 | Okuma Machinery Works | 6.8 |
| | Hitachi Seiki | 4.4 | Mori Seiki | 5.2 | Mori Seiki | 5.4 |
| | Toyota Kohki | 4.3 | Toyota Kohki | 4.8 | Makino Milling Machine | 4.8 |
| | Makino Milling Machine | 3.9 | Hitachi Seiki | 4.6 | Mitsubishi Heavy Industries | 4.3 |
| | Okuma Machinery Works | 3.5 | Toshiba Machine | 4.6 | Hitachi Seiki | 3.9 |
| | Ikegai Co. | 3.1 | Makino Milling Machine | 3.7 | Toyota Kohki | 3.5 |
| | Mori Seiki | 2.4 | OKK | 3.3 | Toshiba Machine | 3.4 |
| | OKK | 1.5 | Ikegai Co. | 2.9 | OKK | 2.7 |
| NC lathe | Ikegai Co. | 18.9 | Mori Seiki | 21.0 | Okuma Machinery Works | 15.9 |
| | Okuma Machinery Works | 10.7 | Okuma Machinery Works | 11.0 | Mori Seiki | 14.2 |
| | Yamazaki Mazak | 9.2 | Ikegai Co. | 9.7 | Yamazaki Mazak | 12.5 |
| | Hitachi Seiki | 8.7 | Yamazaki Mazak | 6.8 | Hitachi Seiki | 6.9 |
| | Toshiba Machine | 7.1 | Hitachi Seiki | 6.0 | Miyano | 5.3 |
| Machining center | Hitachi Seiki | 13.2 | Mitsu Seiki | 11.2 | Yamazaki Mazak | 8.2 |
| | OKK | 9.9 | OKK | 10.0 | Okuma Machinery Works | 7.3 |
| | Makino Milling Machine | 9.1 | Okuma Machinery Works | 9.3 | Mori Seiki | 6.8 |
| | Yasda | 8.3 | Yamazaki Mazak | 8.9 | Makino Milling Machine | 5.7 |
| | Yamazaki Mazak | 2.5 | Hitachi Seiki | 7.6 | Mitsu Seiki | 5.6 |

Source: Nihon Kosaku Kikai Kogyokai (Kosaku Kikai Tokei Yoran, each year); Kikai Sinko Kyokai Keizai Kenkyujo (1983); Miura (1986: 13); Sawai (1990: 187); Sawai (2013: 390).

Along with the increase of NC machine tools, the proportion of small customers in the domestic machine tool market rose remarkably. According to Table 5, while in 1970 the demand by small users accounted for 28 percent of the domestic shipment of NC machine tools,[46] it comprised more than half of the total domestic shipment in 1973 for the first time and reached 65 percent in 1978. Furthermore, growth across the decade was almost entirely attributable to the expansion in sales to small enterprises. Throughout the 1970s to the early 1990s, the proportion of small customers in the total demand of machine tools continued to be roughly 60 percent in Japan.[47]

[46] In 1967, 83 percent of NC machine tools were sold to large customers.

[47] *Denshi Kogyo Nenkan* (1985: 420); Mori (1982: 110); Kawamura (1997: 108); Yoshida (1986: 232).

**Table 5　Share of NC machine tool sales by size of customer firms (%)**

| Year | To big customers | To small customers | To firms with fewer than 30 employees | Others |
|---|---|---|---|---|
| 1970 | 70.1 | 27.7 | – | 2.2 |
| 1971 | 63.7 | 32.0 | – | 4.3 |
| 1972 | 54.4 | 40.5 | – | 5.1 |
| 1973 | 46.9 | 50.8 | – | 2.3 |
| 1974 | 46.9 | 47.4 | – | 5.7 |
| 1975 | 37.6 | 52.0 | – | 10.4 |
| 1976 | 42.7 | 55.5 | – | 1.8 |
| 1977 | 47.8 | 49.8 | – | 2.4 |
| 1978 | 33.4 | 64.4 | – | 2.2 |
| 1979 | 37.9 | 61.1 | – | 1.0 |
| 1980 | 34.9 | 64.4 | – | 0.7 |
| 1981 | 37.0 | 61.7 | 26.1 | 1.3 |
| 1982 | 40.1 | 59.3 | 26.7 | 0.6 |
| 1983 | 40.0 | 58.7 | 24.8 | 1.3 |
| 1984 | 40.6 | 58.3 | 23.4 | 1.1 |
| 1985 | 41.2 | 57.6 | 24.5 | 1.2 |
| 1986 | 43.6 | 53.7 | 24.5 | 2.7 |
| 1987 | 39.4 | 58.9 | 28.3 | 1.7 |
| 1988 | 38.6 | 59.8 | 29.4 | 1.6 |
| 1989 | 39.3 | 59.3 | 26.6 | 1.4 |
| 1990 | 41.7 | 57.6 | 24.8 | 0.7 |
| 1991 | 43.6 | 55.7 | 22.6 | 0.7 |
| 1992 | 45.7 | 53.5 | 22.0 | 0.8 |
| 1993 | 44.1 | 54.7 | 18.2 | 1.2 |
| 1994 | 42.4 | 56.3 | 21.5 | 1.3 |
| 1995 | 39.8 | 58.8 | 23.2 | 1.4 |

Note: Others" include sales to government and public organizations.
Source: Suchi Seigyo Kosaku Kikai Seisan Jisseki To Chosa (each year); Morino (1995: 69).

These small customers introduced general-purpose machine tools that were relatively cheap.[48] The Japanese NC machine tool firms succeeded as manufacturers of general-purpose machine tools for smaller customers, in contrast to US machine tool firms that continued to concentrate on expensive, special-purpose machine tools.

Indeed, the main reason why emerging firms such as Yamazaki and Mori Seiki were able to gain prominence by defeating old established machine tool makers, as shown earlier, was that demand by small customers increased sharply. This dramatic change in the main players in the Japanese machine tool industry represents the market principle as the change was similar to that

[48] Kawamura (1997); Fujita (2008: 66). From the beginning of the machine tool industry, each company specialized in special-purpose or general-purpose machine tools Fujita (2008: 34). However, because it was very difficult to be profitable when only trading in special-purpose machines, special-purpose machine tool firms also became involved in the general-purpose machine tool business. In addition, the elemental technologies of these two kinds of machine tools were not very different, and as a result they were transferable to each other Harada (1996); Fujita (2008: 37). The fact that the special-purpose machine tools were close to the organizational principle and general-purpose machine tools were close to the market principle and that they coexisted and were transferable to each other illustrates that the organizational principle was intertwined with the market principle. These phenomena are very similar to the IC industry where custom chips are produced for specific customers and standard chips are supplied to many unspecified customers. See Kim(2012) and Kim(2015) chapter 2.

occurring as a result of competition among firms in the free market.

This phenomenon implies that Japanese machine tool firms had much "flexibility" and "openness" in their interfirm relationships with severe competition because they tried to respond more to small customers, and as a result, to more varied requests. It represents the market principle.

(2) Organizational principle

At the same time, Japanese machine tool makers cooperated with the NC machine tools customers. With the rapid introduction of NC machine tools, machine tool producers cooperated closely with customers. In general, because machine tools tended to be developed only based on requests by customers, it was very important for the machine tool makers to cooperate with their customers.[49]

The most important NC machine tool customers were automobile and automotive parts companies. Transport equipment, including automobile and auto parts companies, occupied 35 percent of demand of machine tools in total in 1987.[50] For example, between 1991 and 2004, the "automobile and parts" companies were the machine tool industry's largest customers.[51] In the 1990s, if orders from the automobile companies and auto parts companies are taken together with general machinery and electrical machinery, these industries accounted for about 60 percent of the domestic demand for machine tools.[52]

The most important region in the production of Japan's automobile industry is the Aichi Prefecture and its vicinity and the prefecture overtook the Kanagawa Prefecture in 1981 and became the number one prefecture in terms of machine tool demand, due to the remarkable introduction of NC machine tools. There was also a significant amount of production of machine tools in the Aichi Prefecture.[53] Because of this, I conducted interviews with machine tool makers and their customers in the Aichi Prefecture and its vicinity[54] to examine the cooperation between them in the 1970s and 1980s. We can tell from the interviews that there was a great deal of cooperation between machine tool firms and customers in the development and sales of NC machine tools. When Nabeya, a customer of NC machine tools, bought them from Hitachi Seiki for the first time, there was an information exchange with Hitachi Seiki's engineers to ensure the smooth set-up of the machine. Moreover, Hitachi Seiki's engineers stayed for two weeks in Nabeya to discuss the technical aspects regarding the introduction of machine tools.

When Howa Kogyo tried to sell NC machine tools to customers, there were complaints from customers on occasions, sometimes involving problems caused by mistakes in machine operation. In those cases, it took about two months from the delivery of the machines for full operation to

[49] Sawai (2013: 398).

[50] Morino (1995: 22–3); MITI Statistical Survey Department. *Kosaku Kikai Setsubi To Tokei Chosa Hokokusho,* 1st and 7th survey.

[51] Fujita (2008: 75).

[52] Chuma (2002: 276–7).

[53] Kim (2003: 23–4).

[54] Interview with the CEO of Howa Kogyo (21 August and 23 January 2002); interview with manager of Okamoto Nabeya Co. (14 February 2003); interview with marketing manager of Yamazaki Mazak (24 December 2002).

start. Meanwhile, Howa Kogyo's engineers stayed with the customers to exchange information. In general, customers frequently requested machine tool firms[55] to explain cutting conditions, jig installation and using conditions, and after that machine tool firms and customers often exchanged information.

From these facts, we can infer that there was cooperation between machine tool firms and small customers. This cooperation illustrates that the organization principle worked in the interfirm relationship in transactions of NC machine tools.

In this way, cooperation between suppliers and customers of machine tools intertwined with competition among machine tool firms. This shows another way that the organizational principle and the market principle intertwined in this period.

### 2.3 Interfirm Relationship between Machine Tool Firms and Backward Industries' Firms

(1) The case of complementary relationships between market and organizational principles

In interfirm relationship between machine tool firms and backward industries' firms, the organization principle worked complementarily with the market principle.

NC machine tools used NC devices, parts and materials. Some of them were in oligopolistic industries. For example, in the NC device market, FUNUC was dominant in terms of market share. In machine tools parts, a few Japanese parts firms such as NSK and THK were highly competitive and had large market shares in the world market.[56] As for meehanite metal, a kind of cast iron material, most machine tool manufacturers used Mitsui Meehanite Metal. In the sense that a few companies dominated specific market segments, the organization principle is demonstrated.

Since most machine tools firms used NC devices, parts and materials from a few specific companies, the parts and materials tended to be general purpose. As a result, the oligopolistic firms in backward industries facilitated the new entry of small companies to the machine tools industry.[57] Indeed, many small firms entered the NC machine tools industry as previously noted. This intensified competition, and on occasions there was fierce price competition in the machine tool market.[58] These phenomena demonstrate that the organizational principle accelerated the market principle. In sum, two principles were intertwined complementarily in that case.

Furthermore, firms that entered the machine tool industry cooperated with their backward industries' companies.[59] For example, OSG, a famous tool maker located in Shizuoka Prefecture, cooperated with machine tool firms to sell tools to them. Sometimes they carried out co-development of cutting tools. The salesmen of OSG also visited the machine tool firms regularly to gather technical information and supply machine tool firms with the latest information

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[55] Kim (2003: 24).

[56] Chuma (2002: 276, 278).

[57] Fujita (2008: 143, 165); Sawai (2013: 380).

[58] This severe price competition resulted in bankruptcies of old established machine tool firms and trade friction between US and Japan. See Hidaka and Kim (2005) on machine tool trade friction between USA and Japan and the Voluntary Restraint Agreement (VRA) of export of machine tools.

[59] Shibata (2010: 342–3); Chuma (2002: 279–82).

on tools.[60] Tool makers, mold manufacturers and firms trading in materials for machine tools cooperated closely with each other and exchanged information.[61] This case also illustrates that the organizational principle worked in conjunction with the market principle.

(2) Intertwining between market and organizational principles in subcontracting system

The market principle and organizational principle intertwined in interfirm relationships between machine tool firms and subcontractors.

Machine tool companies ranked subcontractors by their performance. For example, Toyota Kohki ranked outsourcing factories based on the materials to be made by the inspection division and then gave warnings to the worst-performing 20 subcontractors.[62] This case illustrates that competition among subcontractors was utilized.

In addition, along with engaging in the management of subcontractors' price, product quality and delivery time,[63] machine tool companies exerted pressure on the subcontractors to reduce costs. For instance, in calculating the standard work time for setting the outsourcing price, machine tool firms calculated it based on severe criteria, and the outsourcing price per hour was less than that of in-house manufacturing.[64] In sum, in the subcontracting system, customers continued to exert pressure on suppliers to reduce costs, as a market mechanism.

Moreover, small subcontractors that were in a lower layer of the multilayer structure of the subcontracting system had fluid relationships with machine tool companies. That is, the degree of exclusiveness with specific subcontractors was very low.[65] In this way, the market principle worked in the subcontracting system of machine tool manufacturing.

Simultaneously, machine tool manufacturers used parts and materials companies as subcontractors, and in the subcontracting system the organizational principle worked. For example, the number of subcontractors tended to increase throughout the late 1950s and the 1960s. Not only large machine tool companies but also small companies established associations and cooperative societies among subcontractors.[66] According to a survey on the machine tool industry in 1973, machine tool companies outsourced 50 percent, 24–40 percent and 20–25 percent in terms of number of parts, standard operating time and manufacturing costs by subcontracting system respectively. [67] In particular, in the recession of 1965, machine tool companies decreased the number of subcontractors with which they transacted. As a result, the subcontractors which

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60 Interview with the CEO of OSG (27 January 2003); Kim (2003: 26).

61 Kim (2003: 25). It is said that wholesalers and merchants of tools and materials contributed to the information exchange (Kim, 2003: 26).

62 Sawai (1990: 181; 2013: 382).

63 Sawai (2013: 382).

64 Sawai (1990: 181–2; 2013: 382).

65 Chusho Kigyo Chosakyokai (1977: 1–2); Ishiro (1981).

66 Sawai (2013: 382; 1990: 182).

67 Kikai Sinko Kyokai Keizai Kenkyujo (1974: 185, 189). According to another survey in almost the same period, the amount paid to subcontractors accounted for roughly 30 percent of direct costs, which made up about 80 percent of manufacturing costs (Chokki, 1978: 140).

survived the recession came to depend on specific machine tool companies. Subcontractors that sold more than 60 percent of their total sales to specific large customers numbered 47.5 percent in 1962 and 55 percent in 1966.[68] Like these, machine tool firms strengthened the organization principle in managing subcontractors.

## Conclusion

In prewar Japan, machine tool production experienced two sudden spurts of growth, once during WWI and once again after the Great Depression based on the fluctuation in demand. Along with the growth, the Japanese machine tool market had a four-layer structure that formed a pyramid through the prewar period.

The four-layered structure of the market created barriers between the market layers. The sale of each machine tool firm was limited to the specific layer of the market. Therefore, this multilayered market shows a kind of the organizational principle. On the other hand, competition within each market layer was intense, which illustrates the working of the market principle. Consequently, the multilayer market structure in the prewar period represents the intertwining between the market and organizational principles.

The customers of the top layer of the market structure, such as the Navy and the factories related to the military, mainly demanded imported machine tools. In importing machine tools, Japanese trading companies played a significant role and the market principle worked in the way of competition among these trading companies.

In the second layer of the market, as large Japanese machine tool companies mainly engaged in build-to-order manufacturing, relationships with specific customers were close, which shows the isolated nature of the organizational principle. At the same time, they competed with each other to expand sales to large customers as well as competing with foreign machine tool firms. This also demonstrates the market principle.

The third and fourth layer of the market, which was composed of small customers, were dominated by only Japanese machine tool companies, especially small companies. The frequent and increasing entry of small firms and the conflicts of interest between small makers and small merchants show that the market principle was robust in these layer markets. On the other hand, small machine tool firms relied on merchants in various ways. For instance, the merchants not only mediated in the negotiations with small customers of machine tools, but they also lent money to the small machine tool firms and arranged materials for manufacturing on occasions. This illustrates that the organizational principle worked and how it was intertwined with the market principle.

As the four-layer market structure was collapsed in the postwar, Japanese machine tool makers competed more fiercely in domestic market. In particular, in contrast to the prewar period, frequent and increasing entries to the industry intensified the competition across each demand layer. In addition, the conflicts of interest between small makers and small merchants occurred on

[68] Chusho Kigyocho (1965).

occasion. They show that the market principle was robust in these layer markets.

On the other hand, the organization principle worked in the interfirm relationship of machine tool industry in the postwar period. The degree of dependence on imports of machine tools tended to decrease in the postwar. The industry became substantially self-sufficient. That is, interfirm relationships among Japanese companies became more important in this period. Consequently, there was a great deal of cooperation between Japanese suppliers and customers of machine tools. Besides, most market segments of machine tools were oligopolistic and machine tool firms intentionally segregated their main markets so as to lessen competition. There were attempts by machine tool cartels to solve the problems caused by manufacturing various kinds of machine tools as well. These illustrate the working of the organizational principle.

The introduction of NC machine tool since the 1970s strongly influenced the interfirm relationship between machine tool makers and customers. With regard to the market principle, new entrants to the industry continued in the 1970s and the 1980s especially, in the market segments of NC lathes, machining centers (MC) and NC mills so that competition became more intensely. Severe competition was clearly apparent in the change in market share occupied by machine tool companies. For example, older leading firms experienced dramatic drops in their shares of overall production between 1968 and 1983. Instead, new firms – independently and without the assistance of older companies – entered the market and began to displace the previous leaders.

The Japanese NC machine tool firms succeeded as manufacturers of general-purpose machine tools for smaller customers as small customers actively introduced general-purpose machine tools that were relatively cheap. The proportion of small customers in the domestic machine tool market rose remarkably. This phenomenon implies that Japanese machine tool firms had much “flexibility” and “openness” in their interfirm relationships with severe competition because they responded more actively to needs of various small customers. It represents the market principle.

Indeed, the main reason why emerging firms were able to gain more market shares by defeating old established machine tool makers was that the new firms responded to the sharply increasing demand by small customers much better than old established machine tools. This dramatic change in the main players in the Japanese machine tool industry represents the market principle as the change was similar to that occurring as a result of competition among firms in the free market.

At the same time, with the rapid introduction of NC machine tools, machine tool producers cooperated closely with customers. This cooperation illustrates that the organization principle worked in transactions of NC machine tools. In this way, cooperation between suppliers and customers of machine tools were intertwined with competition among machine tool firms. This shows a way that the organizational principle and market principle intertwined in this period. Furthermore, in interfirm relationship between machine tool firms and backward industries’ firms, the organization principle worked complementarily with the market principle.

According to the analysis of this article, even within the same period, the market principle and the organizational principle are intertwined, not in a uniform manner but in diverse ways, in the interfirm relationship of Japanese machine tool industry. More importantly, the manner in which

the market and organizational principles have been intertwined has exhibited big changes as well as some continuity through the history of interfirm relationship in Japanese machine tool industry. As a result, it is difficult to find uniquely Japanese and unchangeable elements, which points to the possibility that Japanese uniqueness has been overemphasized at the expense of recognizing commonalities between different countries.

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