Remaining Small: the common and distinctive characteristics of ‘Specialised Suppliers’ in Japan

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Abstract

Small and medium enterprises (SMEs) employ a large portion of the workforce in almost every country. Also, SMEs are considered the important actors for innovation.

There are many studies on innovative Japanese SMEs. However, the majority of these studies are case studies introducing the story of developing innovative products. Recently several academics tried to identify common characteristics among these innovative SMEs in Japan. The author of the current research also noticed several common characteristics among innovative Japanese manufactures which did not clearly state in the previous studies. Moreover, the author was curious about why these small innovative companies tend to remain small even they had an opportunity to grow.

These innovative Japanese manufacturers provide unique inputs, products or processing services to client companies to solve their problems. This characteristic is identical to a characteristic of Specialised Suppliers in Pavitt's taxonomy (Pavitt, 1984). Pavitt also pointed out that Specialised Suppliers were relatively small. Thus, the author believed these innovative small companies in Japan were categorised as Specialised Suppliers.

Although Pavitt's paper on his taxonomy was referred to more than 2.6 thousand in the Web of Science database and nearly 10,000 times in Google Scholar, surprisingly, a few studies examined the nature of Specialised Suppliers. In other words, most studies dealt with Pavitt's taxonomy as if it was proven. Although Pavitt statistically identified common characteristics among four categories of Supplier Dominated, Scale Intensive, Specialised Suppliers, and Science Based companies, it seems the taxonomy did not explain why common characteristics exist sufficiently.

The current research attempted to find the underlying reasons of common characteristics among Specialised Suppliers and examine the border of the category. And most of all, this research tried to answer why they prefer remaining small. The findings imply a rational strategy for remaining small as a Specialised Supplier.

Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institutes of learning.

Copyright Statement

1. Introduction

Small and medium enterprises (SMEs) employ a large portion of the workforce in almost every country. This has been pointed out by academics (e.g. Lefebvre et al., 1996, Lefebvre and Lefebvre, 1998) and official documents in many countries, including Japan. In Japan, the official documents such as the White Paper on Small and Medium Enterprises in Japan (Agency, 2018) published by the Small and Medium Enterprise Agency under the Ministry of Economy, Trade and Industry of Japan emphasised the importance of SMEs for employment.

The definition of SMEs differs across cultures and countries. In Japan, SMEs are defined according to the "Small and Medium-sized Enterprise Basic Act[1]" of the government. A characteristic of the Japanese categorisation of SMEs is the combined ways it defines them in terms of capitalisation, number of employees and industrial sector. (Table 1-1)

Table 1-1 Definition of SMEs in Japan

Industry	SMEs (meet one or more of the following conditions)		Small enterprises included among SMEs on the left
	Capital	Number of regular employees	Number of regular employees
Manufacturing, construction, transport, other industries (excluding 2-4)*	Up to JPY 300 million	Up to 300 people	Up to 20 people
Wholesale	Up to JPY 100 million	Up to 100 people	Up to 5 people
Services*	Up to JPY 50 million	Up to 100 people	Up to 5 people
Retail	Up to JPY 50 million	Up to 50 people	Up to 5 people

Note: The following industries are separately stipulated based on government ordinance related to SME legislation, as shown below.
[SMEs]
Manufacturing: Rubber product manufacturing industry: Up to ¥300 million in capital or up to 900 regular employees
Services: Software industry and information service industry: Up to ¥300 million in capital or up to 300 regular employees
Hotel industry: Up to ¥50 million in capital or up to 200 regular employees
[Small enterprises]
Services: Accommodation industry and amusement industry: Up to 20 regular employees
Source: White Paper on Small and Medium Enterprises in Japan 2020 (Japanese version) The translations above follow the official translation in the White Paper English version of 2018.

According to the White Paper on Small and Medium Enterprises (Japanese version) in Japan published in 2021, Japanese SMEs in the secondary and tertiary sectors[2] employed

[1] Act No. 154 of 1963, Japan
[2] The Japanese industrial classification divides industries in three categories as seem in many countries. A distinctive

32,201,032 people accounting for 68.8 % of the total 46,789,995 employees in 2016. Regarding the number of companies, excluding those SMEs belonging to the primary sector, there were 3,578,176 SMEs that accounted for 99.7% of the total 3,589,333 companies of all sizes in 2016. However, concerning added value, SMEs in the secondary and tertiary sectors generated 135,110 billion Japanese yen, about 52.9% of the total added value of 255,644 billion Japanese yen in 2015. As the data shows, SMEs play an essential role in the society and economy of Japan in terms of employment (and the numbers of enterprises), though they generate less added value. Since employment creates a basis for social stability, SMEs are critical actors in society.

SMEs are also considered important actors for innovation. The U.S. Small Business Administration researched the number of innovations created by large and small firms in the USA in 1982. Table1-2 shows the results.

Table 1-2 Number of Innovations by Large and Small Firms in the Most Innovative Industries.1982*

Industry	Total Innovations	Small Firm Innovations	Large Firm Innovations
Electronic computer equipment	395	227	158
Process control instruments	165	93	68
Radio and T.V. communication equipment	157	72	83
Pharmaceutical preparations	133	13	120
Electronic components	128	73	54
Engineering and scientific instruments	126	83	43
Semiconductors	122	29	91
Plastics products	107	82	22
Photographic equipment	88	9	79
Office machinery	77	10	67

Note: Large and small firm innovations do not always sum to total innovations because several innovations could not be classified according to firm size.
Small firms are the firms with fewer than 500 employees in this data.
Source: (Administration, 1996, Table 5.1, pp142)

The above data shows that small firms outperform larger firms in innovation in several industrial areas. However, it should be noted that the nature of innovation might be

difference in the categorization is that the mining industry is categorised into the secondary industry while some countries categorised it into the primary industrial sector. However, since Japan is not a country with rich mining resources and a company which survived in this sector is normally a large company, the majority of the SMEs in the secondary industrial sector is most likely in the manufacturing companies.

different in large firms and small ones (Acs and Audretsch, 1988).

Although SMEs are important actors in our economy and society, they often face long-time survival difficulties. Regarding the opening and dissolution of SMEs in the agency reports, the number of SMEs decreased by about 830 thousand between 2012 and 2016 (Agency, 2020). It means that about 21.5% of SMEs in 2012, about 3,860 thousand had disappeared in 2016[3](Agency, 2020).

Despite harsh reality, some SMEs continue business for a long time. Those long-term surviving SMEs include some manufacturing companies. Considering these long-term surviving manufacturing SMEs, the author of the current research observed some peculiarities among them.

The long-term surviving manufacturing SMEs compete in the markets where larger competitors exist instead of so-called niche markets where larger ones are rarely present. A large company can operate on a large scale and enjoy economies of scale: i.e., the larger the production volume, the lower the per-unit cost. A large company can spread its research and development costs and investments in equipment into many products. Also, it can have a strong buying power over various suppliers and get favourable business conditions. Therefore, it seems harder for SMEs to compete in the same market as larger competitors than in a niche market where a few large companies are.

A simple solution for increasing competitiveness in such a market with large companies is probably to be larger. However, some manufacturing SMEs seem to prefer remaining on a small scale even though they have had opportunities to grow to be larger companies. Some of them even live longer than 30 years while remaining small-scale.

There are several studies about these long-term surviving Japanese SME manufacturers by academia, government agencies, and journalists in Japan. There are two main strands in these works: one focused on the longevity of companies, the other focused on the excellence

[3] Since 460 thousand new SMEs started their business between 2012 and 2016, in total, about 270 thousand companies disappeared.

of SMEs' products and services.

Regarding the SMEs studies in Japan, there are several strands. The first strand focuses on longevity or companies' long lives. Increasingly many people write articles and books about long-established companies nowadays.

The TOKYO SHOKO RESEARCH, LTD (TSR) reveals as of 2017 that 303,069 companies have been in existence for more than 100 years in Japan. The oldest company was the KONGO-GUMI, a construction company specialising in traditional Japanese wooden shrines and temples, and was established in 578 A.D. TSR further reported that manufacturers were the most prominent groups of 8,751 companies, accounting for 26.4% of long-established companies (RESEARCH, 2016). Many people study these long-established companies, usually focusing on longevity reasons (e.g. Shimizu, 2011, Shimizu, 1999, Ryuzo, 2004). These studies, however, tend not to distinguish the industrial sectors of those companies; some studies even discuss both a traditional confectionery producer and a construction company together.

A traditional confectionary producer can survive long based on loyal regional customers and little need for significant investments. It can rely on traditional craftsmanship and be profitable in small scale operations. Thus, a traditional confectionery producer can easily live long if it has some popular products for customers. In many cases, children eat such traditional confectionery with their parents, and grandchildren eat the same confectionery with their parents who have eaten it from their childhood. In such a way, small traditional confectionery shops survive for a long time.

On the other hand, a construction company like *KONGO-GUMI* survived for a long time specialising in traditional wooden architecture like Japanese shrines and temples. Such construction companies were sponsored and worked under a large shrine or temple in the past. Historically these shrines or temples lost their influence in society and have economically decreased, too. With a decrease in these shrines or temples in society, many of these construction companies needed to be independent and get work by themselves. Subsequently, the number of these construction companies decreased vastly. Although the

market became small, the number of companies with fine craftsmanship decreased more. Thus, some construction companies still survived, maintaining historic religious buildings and building a small number of newly built shrines and temples.

Considering such differences between a traditional confectionery producer and a construction company in terms of the different nature of their markets, it seems that discussing these two categories together in a paper is questionable.

Regarding the second strand, most research follows a case studies approach. These works typically introduce the success stories of each company. Some articles or books introduce several SMEs in an article or a book (e.g. Sakamoto, 2012a, Sakamoto, 2012b, Komeda, 2013, Seibi-do, 2012, Kataoka and Hashimoto, 1996, Kamijo, 2012, Goda, 2010, Kogyo, 2014b, Hashimoto and Kataoka, 2000, Sakamoto, 2008), while other studies introduce one company only (e.g. Wakabayashi, 2011). The stories are mainly about product developments and corporate strategies and tend to be more about manufacturers than services.

For example, Wakabayashi's work (2011) introduced a company called "Hardlock Industry Co., Ltd.", which developed never loosen metal nuts used for aeroplanes, automobiles, and skyscrapers. His book introduces a story about the product development of the Hardlock Nuts based on an interview with the CEO (and the inventor of the product) of the company. This book shows a typical approach in the second strand.

The third strand studies appeared only recently. They try to identify the commonalities in management practices among innovative long-established SME manufacturers. For example, Kurosaki (2015, 2003) and Seki (1999, 2005, 2012) pointed out that the accumulated skills of blue-collar workers were essential for differentiation in product development. Similar discussions were raised in other countries.

One of them was the study of Hosoya on the company group he called "Global Niche Top (GNT) companies" (Hosoya, 2011, 2013a, 2014). Hosoya analyses the common characteristics among highly competitive SMEs in Japan influenced by the work of Simon

called “Hidden Champion” (2009). In this book, Simon identified the common characteristics of German firms with the top share in the world niche market. Hosoya was influenced by this work[4] and tried to identify common characteristics in 31 competitive small manufacturing firms through interviews. Then based on the findings derived from these interviews, Hosoya conducted a questionnaire survey (663 answers out of 2,000) on SMEs holding the top share in a particular niche market(s) with products or highly-specific processing services, which he called (Global) Niche Top (GNT) companies (Hosoya, 2013b). Finally, Hosoya published a book (2014) in which he consolidated his previous works and described the common characteristics of these Niche Tops (N.T.s) as below:

- Having extremely high abilities in innovation by holding original core technology;
- Adopting a user-oriented product development process;
- Establishing a good reputation among potential users;
- Trying to utilise internal resources to the maximum while at the same time remaining open to the use of external technology;
- Maintaining established networks with large suppliers, outsourcing SMEs, universities, etc.;
- And understanding the importance of inter-business cooperation for product development.

Hosoya was, at the time of publishing his first book in 2014, an internal research officer at the Ministry of Economy, Trade and Industry of Japan. The Ministry tried to promote the idea of GNT in promoting SMEs in Japan. Most likely partially influenced by this governmental policy, several studies followed this trend of identifying commonalities among competitive SME manufacturers (e.g.Namba, 2014, Shimoda and Yabuki, 2016, Namba et al., 2013). These studies discussed some commonalities, though they did not reveal the reason behind them.

Before Hosoya published his studies, I also realised that some innovative SME manufacturers studied as separate case studies seemed to share common characteristics.

[4] He personally confirmed the influence of Simon’s work to the author of the current research.

When Hosoya published his first comprehensive paper on GNT in 2013 (Hosoya, 2013c), followed by his first book (Hosoya, 2014), the characteristics he pointed out seemed both agreeable and questionable to some extent. Holding core technology and trying to utilise internal resources to the maximum are the agreeable points. However, the innovative SME manufacturers I noticed are neither actively using external technology nor maintaining established networks with large suppliers and universities. The innovative SME manufacturers that I noticed are relatively independently developed their innovations and keep some distance from large suppliers and universities, though their customers include large companies. Also, Hosoya did not adequately explain why his sample companies share common characteristics.

It seemed more important to notice that the innovative SME manufacturers I identified are developed and provided specialised products or manufacturing services to resolve customers' problems and helped produce distinguished products. In other words, these SME manufacturers develop and provide to customers technology solutions that larger companies could not or probably do not do due to various reasons.

Moreover, there seemed one peculiarity commonly observed among them. These innovative SME manufacturers seemed to prefer remaining small-scale even though they had an opportunity to grow. Since there are potentially unfavourable conditions for competition caused by the small size of a company, as explained above, if they preferred remaining small, there might be good reasons or strategies behind this.

If a group of companies could develop each specialised product or manufacturing service while remaining small, there might be unique ways to overcome their scale disadvantages. If a company is small, the resource the company can use for their innovation is usually limited. In the case of a small traditional confectionery producer, it does not seriously matter since it does not need significant resources to produce and sell its products to regional customers. A traditional Japanese rice wine producer can also survive with some loyal customers. However, suppose a small company is a manufacturing company that develops and provides unique inputs to larger customer companies and works in a market where larger competitors exist. In that case, the small scale might be a significant disadvantage. A

small manufacturing company often faces difficulties hiring qualified human resources, such as university graduate engineers, because the company's salary is much lower than large companies. Small companies often cannot acquire expensive state-of-the-art technologies. It also has difficulties investing large amounts of money in research and development activities. Therefore, if a manufacturing company prefers remaining small even though it had opportunities to grow, there may be rational reasons for its choice.

The current research began by exploring various factors associated with innovations and the reasons for remaining small-scale in competitive SME manufacturers. At the later stage, my supervisor, Dr Bruce Tether, pointed out the similarity between my research subject and "Specialised Suppliers" of Pavitt's innovation taxonomy. It seems that the taxonomy proposed similar common characteristics I found among the innovative SME manufacturers in Japan. In other words, some of the SME manufacturers I considered innovative seemed to fit the category of Specialised Suppliers of Pavitt's taxonomy.

There are several common characteristics that the author of the current research identified among innovative SME manufacturers in Japan:

- To develop and provide innovative products or unique manufacturing services to customers for problem-solving;
- To compete with often much larger companies, by the quality and performance of their products or services instead of product prices or service charges;
- To maintain independence from customers or other companies (not an affiliate of others);
- And to prefer remaining small-scale, even they had opportunities for growth.

Since Pavitt proposed the taxonomy based on statistical analyses, he did not state if Specialised Suppliers "prefer remaining small", though he pointed out they were relatively small (Pavitt, 1984). However, except for the question, the common characteristics that I noticed among innovative SME manufacturers in Japan generally fit his taxonomy. Moreover, his taxonomy shows several factors when exploring those innovative SME manufacturers. Thus, it might be helpful to use Pavitt's taxonomy as a framework for investigating innovative SME manufacturers in Japan.

Because of the nature of his study, statistical analysis as an attempt at creating an innovation taxonomy, Pavitt did not mention the reasons behind the sets of characteristics of Specialised Suppliers. Moreover, how a small company can be a Specialised Supplier remains in question. Although numerous studies refer to Pavitt's taxonomy study, very few of them explored the nature of Specialised Suppliers, such as the essential condition to be a Specialised Supplier.

Therefore, the current research will attempt to identify the reasons for the sets of common characteristics that Specialised Suppliers show by using innovative SME manufacturers in Japan as samples. For this purpose, the current research tests the sample companies' fit to Pavitt's taxonomy and discusses the Specialised Suppliers' category border. Then the current research explores and attempts to identify the reasons behind the common characteristics that the companies investigated in the current research share.

If the current research could identify the reasons behind the sets of characteristics of Specialised Suppliers and how to be identified as one of them, the result would be valuable to SME manufacturers in being more competitive.

2. Literature Review

As described in the previous chapter, the current research explores the fundamental nature of Specialised Suppliers using innovative SME manufacturers in Japan as examples. Therefore, it is necessary to identify what the characteristics of Specialised Suppliers in Pavitt's taxonomy are before testing if the companies investigated in the current research are Specialised Suppliers or not.

Then the current research explores the reasons why some common characteristics exist among Specialised Suppliers. If Specialised Suppliers are the companies that can develop and produce innovative inputs for other companies, they probably are in a better competitive position than ordinary SMEs in the market. Moreover, their innovative products most likely generate better profits differentiating their quality and functionality from ordinary products. Thus, if there is a solid way to be a Specialised Supplier, SMEs can have another choice to be stronger.

Pavitt's taxonomy is one of the best-known taxonomies in management study. As of 17th of July 2021, the study has been cited 2,622 times in the Web of Science database and nearly 10,000 cited in Google Scholar. The study is a classic study published in 1984. However, it is still used and referred to in other studies and has kept its value in modern society. For example, a recent study by Dosi, Riccio, and Virgillito (Dosi et al., 2021) analysed the process of deindustrialization using the four categories of Pavitt's taxonomy: Supplier Dominated, Scale Intensive, Specialised Suppliers, and Science Based. Thus, it seems that Pavitt's taxonomy is still considered valid.

Also, as I stated in the previous chapter, some of the common characteristics among innovative SME manufacturers in Japan that I had identified appear to fit one of the proposed categories of Pavitt's taxonomy: Specialised Suppliers.

Although Pavitt was not the first academic to create an industrial taxonomy, he tried to develop a taxonomy about the production of technology and innovation reflecting sectoral diversity. He used data from about 2,000 significant innovations in the U.K. between 1945-

79. The data was collected by academics[5] based at the Science Policy Research Unit (SPRU) at the University of Sussex, UK. In this process, independent experts in different industrial sectors identified innovations in 11 sectoral categories at the two-digit level and 26 categories at the three- and four-digit level of the UK Standard Industrial Classification (SIC), which accounted for more than half the output of manufacturing sectors in the U.K. (Pavitt, 1984).

Pavitt analysed the data in terms of (1) the source of technology used in a sector, (2) the institutional sources and the nature of technology produced in a sector, and (3) the characteristics of innovative firms such as size and principle activities. Based on his analyses, Pavitt proposed a three-part taxonomy of innovative firms: "supplier dominated", "production intensive", and "science-based". Furthermore, he divided the second category, "production intensive", into two sub-categories of "scale intensive" and "specialised suppliers".

Although there are some limitations due to the nature of the data, such as half of the coverage in manufacturing sectors and some over-representation of innovations in mechanical engineering, Pavitt's study pioneered a way of showing multiple ways of innovating within organisational settings. This study pointed out common characteristics in institutional arrangements associated with developing innovations and reflecting sectoral differences.

Pavitt analysed institutional sources of knowledge inputs for innovation. The most important information sources are asked of each innovative company. Three groups were identified based on where these companies get essential information for their innovation: 1) in-house or within their companies, 2) other companies of either/ both customers or/ and suppliers, and 3) public institutions such as higher education and governmental research institutions. In Pavitt's study, technical inputs mean technical knowledge and innovative products used in the customers' production process, like manufacturing machinery for automobile productions.

[5] J. Townsend, F. Henwood, G. Thomas, K. Pavitt and S. Wyatt

According to where innovation was produced and used, innovation was divided into process innovation and product innovation. Process innovation was defined as the innovation being used in the sector of its production, while product innovation was defined as the one being used in a different sector.

In addition, the type of users, whether performance-sensitive or price-sensitive customers, were analysed considering the nature of each category, together with the method of appropriating benefits from the innovation, such as secrecy and technical patents. Finally, the typical core sectors and size of innovative companies representing each category were analysed. Table 2-1 summarises the taxonomy (Pavitt, 1984).

Table 2-1 Pavitt's Taxonomy

Sectoral technological trajectories: Determinants, directions and measured characteristics

Category of firm		Typical core sectors	Determinants of technological trajectories: Sources of technology	Determinants of technological trajectories: Type of user	Determinants of technological trajectories: Means of appropriation	Technological trajectories	Measured characteristics: Source of process technology	Measured characteristics: Relative balance between product and process innovation	Measured characteristics: Relative size of innovating firms	Measured characteristics: Intensity and direction of technological diversification
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Supplier dominated		Agriculture; housing; private services traditional manufacture	Suppliers Research extension services; big users	Price sensitive	Non-technical (e.g. trademarks, marketing, advertising, aesthetic design)	Cost-cutting	Suppliers	Process	Small	Low vertical
Production intensive	Scale intensive	Bulk materials (steel, glass); assembly (consumer durables & autos)	PE suppliers: R&D	Price sensitive	Process secrecy and know-how; technical lags; patents; dynamic learning economies;	Cost-cutting (product design)	In-house: suppliers	Process	Large	High vertical
	Specialised suppliers	Machinery; instruments	Design and development users	Performance sensitive	design know-how; knowledge of users; patents	Product design	In house: customers	Product	Small	Low concentric
Science based		Electronics/ electrical; chemicals	R&D Public science; PE	Mixed	R&D know-how; patents; process secrecy and know-how; dynamic learning economies	Mixed	In-house: suppliers	Mixed	Large	Low vertical / High concentric

[a] PE = Production Engineering Department.

Source: (Pavitt, 1984, p354)

Pavitt identified that: "(t)he other important sources of process innovations in production-intensive firms are the relative [sic] small and specialised firms that supply them with equipment and instrumentation, and with whom they have a close and complementary relationship." (Pavitt, 1984, p359). He categorised this group as "Specialised Suppliers". Below are the characteristics of Specialised Suppliers as identified by Pavitt (Pavitt, 1984, pp354-362):

- Although they produce a relatively high proportion of their own process technology, the focus of their innovation activities is more on product innovations for use in other sectors;
- Typical core sectors belonging to Specialised Suppliers are "machinery" and "instruments". Pavitt also mentioned the possibility of other industries such as electronics as being categorised as Specialised Suppliers;
- Their source of technology is "design and development users";
- They are performance-sensitive rather than price-sensitive;
- The means of appropriation are "design know-how", "knowledge of users", and "patents";
- Their technological trajectories are "product design" while the way for another sub-category of "Production Intensive" is "cost-cutting (and product design)";
- The source of process technology is either "in house" or "customers";
- They are more oriented to "product innovation" than "process innovation";
- The size of firms is "relatively small";
- And the intensity and direction of technological diversification are "low" and "concentric".

Pavitt (1984) also considered interrelationships or "main technological linkages" among these Specialised Suppliers and the other categorised groups, as shown in Figure 2-1[6].

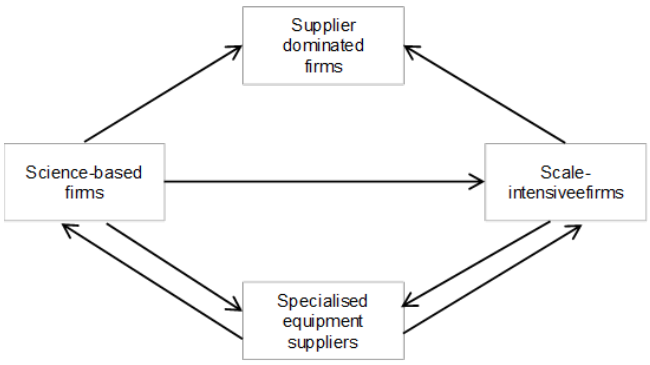

Fig. 2-1 The Main Technological Linkage amongst Different Categories of Firm
Source: Drawn by the author based on Pavitt's original figure (Pavitt, 1984)

[6] Pavitt categorised scale-intensive and specialised (equipment) suppliers as two different sub-categories within the production-intensive sector. Therefore, it might be necessary to draw a different arrow from the box of Specialised equipment suppliers to the box of Supplier dominated firms in this chart.

In contrast to Specialised Suppliers, Pavitt considered that "Supplier dominated companies get most of their technology from production intensive and science-based companies (e.g., power tools and transport equipment from the former; consumer electronics and plastics from the latter). Science-based companies also transfer technology to production intensive companies (e.g., the use of plastics and electronics in the automobile industry). Moreover, as we have seen, science-based and production intensive companies both receive and give technology to Specialised Suppliers of production equipment (Pavitt, 1984)."

Concerning the interrelationships between Specialised Suppliers and their users, Pavitt said that "large users provide operating experience, testing facilities and even design and development resources for specialised equipment suppliers" (Pavitt, 1984). Specialised Suppliers, in return, provide "specialised knowledge and experience as a result of designing and building equipment for a variety of users, often spread across a number of industries" (Pavitt, 1984, p359).

Pavitt listed up machinery and instruments as typical industrial sectors as Specialised Suppliers in his 1984 paper. Later in 1988, Robson, Townsend and Pavitt (Robson et al., 1988) added speciality chemicals and software to this list. This second paper enlarged the idea of specialised inputs from tangible products like machinery to intangible products like software. It probably means they noticed a possibility of various intangible inputs from Specialised Suppliers. In other words, if a company provides a unique solution to its customer's production process, the company could be a Specialised Supplier. If we employed this definition, finding a Specialised Supplier in other industrial sectors is possible. In this sense, it might have some meaning to test various innovative SME manufacturers from other industrial sectors to the four categories listed by Pavitt to determine whether they are Specialised Suppliers in the current research.

The possibility of finding Specialised Suppliers in several industrial sectors not listed by Pavitt et al. generates a question of the essential condition to be a Specialised Supplier. Although Pavitt's taxonomy explains there is/ are significant statistical tendencies in the interrelationships between the ways of producing innovations and organisational arrangements, it does not show the border between four categories. Since Pavitt divided industries into only four categories, each category is likely to include various sub-categories. Considering there are many different industrial sectors in the economy, and the number of industrial sectors has increased over time, whether all these sub-categories share the same characteristics is questionable.

Moreover, Pavitt's taxonomy did not answer important questions of the current research: Why do Specialised Suppliers share these common characteristics? How can a company be a Specialised Supplier, especially while remaining small-scale?

Pavitt also considered the question of why Specialised Suppliers remain small-scale.

> This is puzzling given that, as Rosenberg has pointed out, common skills, techniques, and know-how underlie all mechanical engineering products, just as they do in chemical-based and electrical/electronic-based firms. Why, then, have firms in these science-based sectors typically diversified and grown big based on their accumulated skills, whereas those in mechanical and instrument engineering typically have not? (Pavitt, 1984, p364).

In his arguments, mechanical and instrumental engineering are considered typical industrial sectors for being Specialised Suppliers. Thus, this statement could be rewritten to ask why Specialised Suppliers have not grown larger while Science-based firms choose to grow larger.

Pavitt attempted to explain the reasons for this puzzle. He suggested that explanations lie in differences in technology sources, user's requirements and appropriability between sectors. He also mentioned the possibility of small firms becoming larger in a sector experiencing a "paradigm shift" or scale barriers stopping new entrants from joining the sector.

However, these explanations are seemingly not sufficient enough to answer the puzzle of remaining small. It might be that if a group of innovative SME manufacturers chose to remain small scale, there are probably good, or rational, reasons for this choice. Although Pavitt tried to answer the question, there are probably no concrete or at least reasonably agreeable answers yet.

Robson, Townsend and Pavitt (Robson et al., 1988) further explored Pavitt's 1984 taxonomy by using data on 4,000 significant innovations and innovative companies in the U.K. from 1945-1983; a more comprehensive database than the one used in the first study. In this study, the idea of Specialised Suppliers was expanded:

- Specialised inputs are machinery, instruments, speciality chemicals, and software;
- The main focus is product innovation;
- The main sources of technology are the firm's design office and the customers' production engineering and systems activities;
- The main threat of entry is from technologically dynamic firms in these user sectors or small firms spun off from them;

- The number of significant innovations is highest in science-based firms and Specialised Suppliers. In Specialised Suppliers, this is caused by the "continuous pressures to improve production efficiency in user sectors";
- Specialised Suppliers focus on product innovation because they sell their products to customers who use them for their production processes;
- Innovative Specialised Suppliers are relatively small scale because technological barriers to entry are low;
- The characteristics of Specialised Suppliers are shown in mechanical engineering, instruments, and rubber and plastic products industries;
- The non-metallic materials industry shows the key characteristics of Specialised Suppliers. There is a strong stream of product innovations from small firms;
- And, the directions of important technological activities of Specialised Suppliers are "horizontal (i.e., in related product markets) or downstream (i.e., in user sectors)".

In this study, Robson, Townsend, and Pavitt added two new industrial sectors as Specialised Suppliers, and, as pointed out before, they added intangible inputs of software. They claim that a driven force of developing innovation is from continuous customer pressure. Also, they pointed out the characteristics of Specialised Suppliers are also found in rubber and plastic products industries.

Moreover, they tried to answer the remaining question of the small scale of Specialised Suppliers. They claimed Specialised Suppliers are relatively small because the technological barriers to penetrate the market are low. However, their answer does not satisfactorily explain the initial question of why Specialised Suppliers remain small while science-based companies tend to grow. Also, if technological barriers for the specific market entry are low, the market competition would be severe and not many small companies would survive. In addition, it seems there might be a contradiction in their answer. If technological barriers are low and many small companies can produce products or services that their customers need to improve production processes, "special inputs" might not be unique or the ones that improve customers' competitiveness with competitors. Thus, there might be different reasons for the initial question.

To summarise, the taxonomy of innovation-oriented organisations developed by Keith Pavitt and initially published in 1984 has been and continues to be highly influential in innovation studies and, to a lesser extent, industrial economics. Pavitt remarkably used a mixture of his intuition, prior understanding of industries based on his experience, and pattern recognition to develop his taxonomy. In the first paper (Pavitt, 1984), there is a marked absence of formal statistical testing. There is more formal statistical analysis in the second and co-authored paper (Robson et al., 1988), but this is still limited compared to modern

standards. Nonetheless, Pavitt's taxonomy and the classification of "Specialised Suppliers" has stood the test of time. The taxonomy is still used, referenced and appreciated in modern researches. Key characteristics of Specialised Suppliers are discussed in detail above, including a strong reliance on user-producer interactions and design, rather than R&D, as a core source of knowledge for innovation.

However, the taxonomy is not without its limitations or immune to criticism. In particular, one question that Pavitt and colleagues did not adequately resolve was why Specialised Suppliers tend to remain small, while Science-based firms often grow large. This is a question that I will seek to address in this thesis.

After Pavitt's pioneering studies developing the innovation taxonomy, many studies referred to it, mostly in uncritical ways. Some researchers have attempted to apply Pavitt's taxonomy to other country or industry contexts.

For example, Souitaris applied Pavitt's taxonomy empirically on a sample of 105 Greek companies, accounting for almost 3% of all listed manufacturing firms in the ICAP annual directory of 1997 (Souitaris et al., 2000, Souitaris, 2002). Using a snowballing sampling technique[7], Souitaris interviewed these 105 manufacturers, of which fifteen companies were categorised as Specialised Suppliers mainly from machinery and engineering sectors.

Soutaris confirmed the innovation rate was higher in Specialised Suppliers and Science-Based among Greek industries, and Specialised Suppliers focused on product innovation rather than process innovation. Furthermore, he found that innovation was associated with a high growth rate and employee training and incentives. According to him, Specialised Suppliers rely on their employees' initiative and talent, and thus the presence of a project champion, engineers' and managers' training and incentives are essential. In addition, Soutaris found that Specialised Suppliers search for technology ideas using a database and co-operation with universities and research institutes (Souitaris, 2002). Although a dependency on specialised human resources for innovation and usages of open databases might be understandable, cooperation with universities and research institutions is questionable. Not many research institutes would be happy to cooperate with SMEs of no special abilities.

His research was an adaptation of Pavitt methodology of statistical analyses into Greek industries, which is much smaller in sampling. Thus, although the results of his study

[7] Souitaris claimed that a snowballing sampling technique generated the same effect to a random selection technique due to the complex personal networks in Greek management culture.

showed similar tendencies to Pavitt's study, it only proved that the Greek industries might have similarities with UK industries. Therefore, although his findings of associations between innovation with growth, employees' abilities, and motivations are understandable, they might not be unique or findings.

Anantana, Enkawa, and Suzuki explored New Product Development (NPD) efficiency in 396 companies from fourteen Japanese manufacturing industries (Anantana et al., 2008). According to the authors of this research, it was the first attempt to apply Pavitt's model to Japanese manufacturing.

These researchers categorised 396 firms from 14 Japanese manufacturing industries into four groups of "supplier-dominated", "scale-intensive", "science-based", and "Specialised Suppliers", considering the source and direction of technologies. In this context, they defined the Specialised Suppliers as those in which " technological accumulation takes place through the design, [the] building of specialised inputs that will be provided to [the] next customer" (Anantana et al., 2008, pp767).

Table 2-2 Industrial Classification of the Study by Anantana et al.

Industry	Number of samples	Supplier-dominated	Scale-intensive	Science -based	Specialised suppliers
1 Construction	58		●		
2-1 Processed Food	4	●			
2-2 Beverage and Liquor	0	●			
3 Cloth and Apparel	7	●			
4-1 Wood and Furniture	12	●			
4-2 Paper and Pulp	7	●			
4-3 Printing	4	●			
5-1 Pharmaceutical	8			●	
5-2 Chemistry for General Use	19			●	
5-3 Chemistry for Business Use and Material	79				●
6 Iron-Steel and Nonferrous Metal	47	●			
7-1 Machinery and Appliances for General Use	26			●	
7-2 Machinery and Appliances for Business Use	57				●
8-1 Electrical Machinery and Appliances for General Use	36			●	
8-2 Electrical Machinery and Appliances for Business Use	68				●
9 Information Communication	15			●	
10-1 Automobile and Motorcycle	16		●		
10-2 Ship and Other Transportation	11		●		
11-1 Precision Machinery and Appliances for General Use	10			●	
11-2 Precision Machinery and Appliances for Business Use	40				●
12-1 Electronic Part and Devices for Auto Industry	22			●	
12-2 Electronic Part and Devices for Others	26			●	
13-1 Machinery Part for Auto Industry	27				●
13-2 Machinery Part for Others	12				●
14 Software	14				●
Total	625	81	85	162	297

Source Anantana, Enkawa, and Suzuki, 2008

Anantana et al. employed the New Product Development Scorecard (NPDSC) to gather and analyse data for this research. As a result, they also reconfirmed that NPD efficiency is

significantly higher in Science-Based and Specialised Suppliers. They also found that customers' and market's needs showed the most substantial positive impact on development efficiency for Specialised Suppliers. Also, the primary technological source was generated from specific customer requirements, and Specialised Suppliers were forced to develop and enhance their technological ability to improve production efficiency in customers' firms (Anantana et al., 2008).

Anantana et al. concluded that:

> Meanwhile, because technology for [the] specialised suppliers group are[sic] generated from customer requirements, thus firms in this group should put the importance on grasping needs of customers and markets and try to make the relationship with them to sectors (Anantana et al., 2008,pp773).

As this statement showed, Anantana et al. emphasised the importance of a specific customer's requirements as a driving force to develop new technological abilities in Specialised Suppliers. However, the study did not discuss where Specialised Suppliers acquire technological inputs and how Specialised Suppliers develop technological ability.

Also basing his study on the Pavitt taxonomy, Freel (2003) investigated sectoral patterns of small firm innovation in the UK, including networking and geographical proximity, using a sample of 597 small and medium-sized manufacturing firms. He found that except for Science-Based firms, innovators seem to be larger than non-innovators. Also, he suggests firm age appears to have no impact on innovativeness. Innovation-related cooperation with customers has positively associated with product innovation, while cooperation with suppliers, competitors or universities does not link with product innovation.

In a later related study, Freel (2005) pointed out the importance of internal resources as complements to external resources. He investigated patterns of association between firm-level innovativeness and various indicators of skill requirements and training activity by using a sample of 1,345 'Northern British' SMEs. His key finding was the importance of intermediate 'technical' skills rather than higher-level 'technology' for product innovation.

Another study of note is Lee's (1996) exploration of the role of the user firms in machine tool industries, which Pavitt categorised as one of the typical sectors for Specialised Suppliers, and which Lee used as a framing concept for this qualitative study. Lee concluded that machine tool users make a critical contribution in developing the machine tool industry by investing in machine tool firms, direct involvement in developing and commercialising tools, and generating demand for machine tools. He also pointed out that mutual learning

through continuous user-supplier interactions underlies a wide variety of innovative activities. Also, the research emphasised the importance of users' interaction for innovations in Specialised Suppliers.

In summary, the studies reviewed above are examples of other researchers applying Pavitt's taxonomy in different contexts – Greece, Japan, the UK and the Machine Tool industries. These studies applied Pavitt's ideas uncritically; they accepted the taxonomy and its classification (particularly of Specialised Suppliers) as a given. However, these studies can be considered to have added to knowledge by, for example, emphasising the importance of employees' skills and human capital as a source of innovation and demonstrating the importance of design and user-producer interaction for the development of innovation. Unfortunately, none of these studies addressed the question as to why Specialised Suppliers tend to remain small.

Other studies went further and tried to revise the original taxonomy or develop a new taxonomy. Among these studies, De Jong and Marsili (de Jong and Marsili, 2006) considered that taxonomies created based on empirical studies of innovation activities were mainly dealt with large firms. Instead, they focused on innovation patterns in small and micro firms using a new survey of 1,234 innovative small[8] and micro firms in The Netherlands. Their analysis was at the firm level instead of the sector level, and they found that there was "a more diverse pattern of innovation of small firms than in Pavitt's" (de Jong and Marsili, 2006).

De Jong and Marsili identified four categories of small innovative firms, "science-based", "specialised suppliers", "supplier-dominated", and "resource-intensive" instead of the two, "supplier-dominated" and "Specialised Suppliers" in Pavitt's taxonomy. In addition, they used some new variables for building a new taxonomy. The variables they used are shown in Table 2-3 (de Jong and Marsili, 2006).

As the table shows, they added variables on "Innovative input", "Managerial attitude", "Innovation planning", and "External orientation". Because of these additions, their studies added some detail to the characteristics of Specialised Suppliers. They summarised their findings on Specialised Suppliers as below (de Jong and Marsili, 2006):

[8] Below 100 employees in Italian classification

Table 2-3 Variable Used to Develop the Taxonomy of Firms by De Jong and Marsili

Dimension	Variable	Description and response code[a]
Innovative output	Product innovation	Mean score of two items (de Jong and Marsili) 1. Firm introduced any product new to the firm in the past 3 years (yes/no) 2. Firm introduced any product new to the industry in the past 3 years (yes/no) Process innovation Firm implemented at least one new work process in the past 3 years (yes/no)
Innovative input processes	Innovation budget	Firm reserved an annual budget (money) to implement new products or (yes/no)
	Innovation capacity	Firm reserved capacity (Mortimer) to implement new products or processes (yes/no) Innovation specialists Firm employed people who were occupied with innovation in their daily work, e.g., specialised staff members, new product developers, etc. (yes/no)
Sources of innovation	Suppliers	Firm innovates when suppliers propose new applications (5-point Likert scale) Customers Firm innovates when customers express new desires/ needs (5-point Likert scale)
	Scientific development	Firm innovates to commercialise universities/knowledge institutes' new technologies or findings (5-point Likert scale)
Managerial attitude	Innovative orientation	Mean score of three items (Cronbach's alpha = 0.67) 1. It is worth to spend my time on innovation (5-point Likert scale) 2. Innovation enables my firm to better serve its customers (5-point Likert scale) 3. Innovation is needed to keep up with our competitors (5-point Likert scale)
Innovation planning milestones	Documented plans	Firm had a documented plan describing renewal ambitions, targets and (yes/no)
External orientation problem in	Consultation of external sources	Number of sources consulted for information or advice on any business the past 3 years (e.g., suppliers, colleague firms, commercial consultants, sector organisations). Measure based on respondents' indication of consulted parties (min = 0, max = 6 sources or more)
	Inter-firm cooperation develop	Firm formally cooperated with other firms or institutes to initiate or renewal activities based on a formal agreement (yes/no)

[a] *Note*: Dichotomous responses are coded as 'yes' = 1 and 'no' = 0. Responses on a 5-point Likert scale are coded as 'totally agree' = 5, 'agree' = 4, 'neither agree nor disagree' = 3, 'disagree' = 2 and 'totally disagree' = 1. Some of the variables ('managerial attitude' and 'product innovation') are constructed by summing up the responses to different statements in response to our survey. Cronbach's alpha is also reported.
Source copied the table prepared by de Jong and Marsili (de Jong and Marsili, 2006pp219 Table 2)

Innovativeness among the Specialised Supplier firms is fairly high. It is almost at the highest level (comparable to science-based firms) in product innovation, while it is lowest in process innovation, implying a distinctive prevalence of product over process innovations. The innovation process among Specialised Supplier firms is based on a more diffused use of specialised labour in preference to financial and time resources. These firms are customer-driven, and they heavily rely on understanding customers' needs as a source of their innovations. This cluster ranks lowest in the use of other sources of innovation, that is, suppliers and scientific development. This finding is also consistent with the low degree of "openness" in the Specialised Supplier firms: the number of sources they consult is the lowest (about two), although they frequently participate in formal collaboration (likely with

their customers) (de Jong and Marsili, 2006, pp223).

> The specialised supplier firms show a commitment to product innovation and close relationships with their customers. For these firms, it is not surprising that speed to the market is important; indeed, the number of firms that consider themselves as first movers is just below the maximum value (33% versus 24% average) (de Jong and Marsili, 2006, pp224).

As described above, de Jong and Marsili confirmed several characteristics of Specialised Suppliers in Pavitt's taxonomy: focus on product innovation, closeness to outside resources for innovation, reliance on the customers' needs for innovation, frequency of formal collaboration with customers (de Jong and Marsili, 2006). In addition, de Jong and Marsili also found that the innovation process of Specialised Suppliers was based on "a more diffused use of specialised labour" and that "speed to the market is important" (de Jong and Marsili, 2006).

Another study that sought to extend and refine the Pavitt taxonomy was undertaken by Castellacci (2008), who tried to develop a new sectoral taxonomy combining manufacturing and service sectors. Castellacci used the data from the Fourth Community Innovation Survey (CIS4, 2002-2004). The study focuses on two main characteristics: provider and/or recipients of advanced products, services and knowledge, and the dominant innovative trajectory in the sector. As a result, Castellacci proposed four sectoral patterns of innovation covering both manufacturing and service industries as below (Castellacci, 2008):

- Personal Goods and Services: Supplier-Dominated Goods and Supplier-Dominated Services;
- Mass Production Goods: Scale -Intensive and Science-Based:
- Infrastructural Services: Physical Infrastructure and Network Infrastructure;
- And, advanced knowledge providers: Specialised Suppliers and Knowledge-Intensive Business Services.

In addition to the inclusion of services industries, Castellacci explored the lower level of industrial classifications and categorised them into the four categories of their new taxonomy. An interesting point of their proposal is that they include so-called professional service industries into Specialised Suppliers, such as Real Estate, Legal and Accounting, Management Consultancy, Architectural and Engineering etc. Also, they re-categorised some industrial sectors that Pavitt predicted as Specialised Suppliers into different categories. For example, they categorised rubber and plastic manufacturing as Scale and Information Intensive, while Pavitt predicted it was categorised in Specialised Suppliers.

Bogliacino and Pianta also proposed a revised taxonomy covering manufacturing using the Third and Fourth Community Innovation Survey (CIS3 and CIS4). They proposed four categories: Science-Based, Specialised Suppliers, Scale and Information Intensive, and Supplier Dominated (Bogliacino and Pianta, 2010). Bogliacino and Pianta later explore their new taxonomy, including ICT activities as a key to identify commonality and diversifications in innovations. (Bogliacino and Pianta, 2016). Below is their revised taxonomy:

- Science-Based
  - Manufacture of chemicals and chemical products
  - Manufacture of basic pharmaceutical products and pharmaceutical prep.
  - Manufacture of computer, electronic and optical products
  - Telecommunications
  - Computer programming, consultancy and related activities
  - Scientific research and development

- Specialised Suppliers
  - Manufacture of electrical equipment
  - Manufacture of machinery and equipment n.e.c.
  - Manufacture of other transport equipment
  - Repair and installation of machinery and equipment
  - Real estate activities
  - Legal and accounting activities
  - Management consultancy activities
  - Architectural and engineering activities; technical testing and analysis
  - Advertising and market research
  - Other professional, scientific and technical activities
  - Rental and leasing activities
  - Office administrative, office support and other business support activities

- Scale and Information Intensive
  - Manufacture of paper and paper products
  - Printing and reproduction of recorded media
  - Manufacture of coke and refined petroleum products
  - Manufacture of rubber and plastic products
  - Manufacture of other non-metallic mineral products
  - Manufacture of basic metals
  - Manufacture of motor vehicles, trailers and semi-trailers
  - Publishing activities
  - Audio-visual activities

- Broadcasting activities
- Information service activities
- Financial service activities, except insurance and pension funding
- Insurance, reinsurance and pension funding, except compulsory social security
- Activities auxiliary to financial services and insurance activities

- Suppliers Dominated
  - Manufacture of food products
  - Manufacture of beverages
  - Manufacture of tobacco products
  - Manufacture of textiles
  - Manufacture of apparel
  - Manufacture of leather and related products
  - Manufacture of wood and cork, except furniture
  - Manufacture of fabricated metal products, except machinery and equipment
  - Manufacture of furniture
  - Other manufacturing
  - Wholesale and retail trade and repair of motor vehicles and motorcycles
  - Wholesale trade, except motor vehicles and motorcycles
  - Retail trade, except motor vehicles and motorcycles
  - Land transport and transport via pipelines
  - Water transport
  - Air transport
  - Warehousing and support activities for transportation
  - Postal and courier activities
  - Accommodation and food service activities
  - Veterinary activities
  - Employment activities
  - Travel agency, tour operator reservation service and related activities
  - Security and investigation activities
- Services to buildings and landscape activities

Another study of note is Sterlacchini's (1999), who analysed the roles of innovative activities in small non-research and development-intensive industries in Italy. He interviewed 143 small Italian manufacturing firms and found that 104 were sub-contractors, which worked on the decentralised process from other companies in the same industry. The remaining 39 firms were the independent firms producing final products. Although he considered that most of his sample firms belonged to supplier dominated industries, some industries belonged to Specialised Suppliers.

Following Pavitt, Sterlacchini categorised firms in "Clothing" (57 firms), "Knitwear" (25), "Wood and Furniture" (20), "Footwear" (16), and "Plastic Products" (15) as being "supplier dominated", while firm making "Dies" (10 firms) were classed as Specialised Suppliers. He confirmed that acquisitions of innovative capital goods such as CAD-CAM and computer programmable machines take the largest share in total innovation costs and dominate scale-intensive and supplier dominated industries. On the other hand, design, engineering, and pre-production development expenditures are "relatively" higher for Specialised Suppliers.

Table 2-4 Means and Standard Deviations (in brackets) of Innovation Input Indicators by Industry

	INVSAL (1994–1996)	DEPRSAL (1994–1996)	AUTOM (1996)
Clothing	1.7 (3.5)	0.1 (0.4)	61.3 (15.7)
Knitwear	13.8 (20.0)	0.6 (1.6)	64.1 (14.9)
Wood and furniture	5.5 (8.4)	1.1 (2.1)	64.4 (15.7)
Footwear	4.0 (5.0)	0.7 (2.5)	64.8 (22.0)
Plastic products	10.5 (13.9)	0.6 (1.1)	72.7 (14.5)
Dies	7.2 (4.3)	2.8 (1.8)	75.5 (10.0)
Total	5.9 (11.2)	0.6 (1.6)	64.8 (16.3)

Note: INVSAL and DEPRSAL are expressed as percentages of innovation costs (due, respectively, to the acquisition of innovative machinery and the activities of design, engineering and trial production) on firm sales. AUTOM is a qualitative variable whose value, for each firm, ranges from 50 (maximum distance from the 'technological frontier' of the industry) to 100 (the firm lies on the 'technological frontier')
Source: (Sterlacchini, 1999)

Sterlacchini revealed several ways to produce innovative inputs to customers without research and development, such as innovative capital goods and design activities and engineering and pre-production developments. He claimed these activities were undertaken by firms in 'Supplier Dominated' industries, at least as frequently as Specialised Suppliers. Therefore, firms in Supplier Dominated industries, such as clothing, knitwear, wood, furniture etc., do not merely rely on supplied and acquired goods but generate added value by design and other activities. Sterlacchini's study implies the boundary between 'Specialised Suppliers' and 'Supplier Dominated' industries may be much less clear than Pavitt suggested. This point should be explored in the current research.

In contrast to the studies reviewed above, which sought to refine and extend the Pavitt taxonomy, De Marchi, Napolitano, and Tacchini (De Marchi et al., 1996) used the Central Statistical Office of Italy (ISTAT) and the National Research Council of Italy (CNR) survey on technological innovation in Italian manufacturing companies conducted in 1987 to test the predictive power of the original taxonomy. Their study included 6,839 innovative companies by combining the survey data of two national research institutes above and another survey on investments conducted in 1985. Their approach was to change qualitative descriptions of Pavitt's taxonomy into quantitative analyses. Their results

showed the predictive power of Pavitt's model to be low and highlighted the extreme variability of innovative behaviour at the company level (De Marchi et al., 1996). However, the study leaves a question of the way of transforming qualitative descriptions into quantitative figures. De Marchi et al. also mentioned their intention was not the true interpretation of Pavitt's taxonomy.

> We are not interested in providing the <true> interpretation of Pavitt's taxonomy, but only in borrowing Pavitt's approach and some of its fundamental concepts and predictions to conceive a quantitative model of a firm's innovative behaviour (De Marchi et al., 1996, p19).

Although De Marchi et al.'s attempts are interesting and probably variabilities of innovative behaviour at the company level exist, their analyses do not actually test Pavitt's taxonomy itself. At least, Pavitt identified certain statistical tendencies in the interrelationship between technological trajectory and industrial sectors and did not deny the possibilities of company-level differences.

In summary, as outlined above, several studies have attempted to extend and refine Pavitt's taxonomy, using a variety of methods but most commonly using more comprehensive data and sophisticated statistical techniques. In essence, however, these studies are similar to Pavitt's pioneering study in motivation in that they are seeking to identify types of innovators which share common characteristics.

It is notable that all of these studies retained the category of Specialised Supplier, although the industrial sector and sub-sectors understood to be Specialised Suppliers has varied. However, all three studies have left unanswered the question of why Specialised Suppliers tend to be and remain relatively small businesses.

In short, to summarise this chapter as a whole, I started by reviewing the Pavitt taxonomy, which has become a seminal study in understanding different approaches to innovation by different types of companies. The taxonomy has been very widely cited and remains influential to this day. Subsequently, various studies have applied the Pavitt taxonomy or investigated types of innovators, such as Specialised Suppliers. Other studies have sought to extend, refine and test the taxonomy.

Considering there are large numbers of studies using Pavitt's taxonomy, it is thus interesting that very few studies have explored the nature or essential conditions for being Specialised Suppliers. Also, the reviewed studies have not sufficiently answered the question of why Specialised Suppliers shared common characteristics in innovation trajectory.

Understanding underlying reasons for the common characteristics is presumably essential to being a Specialised Supplier. Moreover, knowledge of these common characteristics would provide valuable information to a company that hopes to compete in a Specialised Supplier market. Finally, it should be noted that none of the studies reviewed above addressed the question of why Specialised Suppliers remain relatively small businesses.

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3. Purpose of the Research

A certain number of SME manufacturers in Japan provide innovative products to larger customer companies to sort out their problems or improve their production performances. There is a curiosity among them. These innovative SME manufacturers seem to prefer remaining small even though they had opportunities to grow.

Pavitt created an innovation taxonomy (Pavitt, 1984) in which he categorised industrial sectors into four categories based on the different innovation trajectories. In his taxonomy, one of the four categories is called Specialised Suppliers. In Pavitt's propositions, Specialised Suppliers provide innovative inputs to their customer companies. Since innovative SME manufacturers in Japan show similar characteristics to Specialised Suppliers, these Japanese companies might be categorised as Specialised Suppliers. Pavitt even mentioned that Specialised Suppliers are relatively small companies.

After Pavitt's seminal research, many academics employed this taxonomy as a framework for their works. They attempted to apply Pavitt's taxonomy to other contexts of different countries or particular industries. Several others attempted to test the validity of the taxonomy. Finally, other groups tried to extend Pavitt's taxonomy or create a new one using more comprehensive data sets with additional variables. However, interestingly a few tried to explore the underlying reasons of common characteristics of each technological trajectory that appeared in Pavitt's taxonomy.

These characteristics are identified based on statistical analyses and thus represent existing commonalities among the companies categorised in each category. However, the statistical significance does not explain why these characteristics are commonly shared in a group. However, if some common characteristics existed, there might be rational reasons, both positive and negative, behind them.

Surprisingly only a few studies examined how and why these common characteristics existed. In particular, studies of Specialised Suppliers were not sufficiently tested to understand the fundamental nature of the category.

Since the innovative SME manufacturers that the author of the current research identifies seem to be categorised as Specialised Suppliers, exploring reasons of common characteristics would also shed light on the fundamental nature of Specialised Suppliers. The reasons should include an answer to why they prefer remaining small. Also, the current research could give some tips for SMEs to be strong companies while remaining small.

As explained above, previous studies on those innovative SMEs in Japan, potentially categorised as Specialised Suppliers, tended to introduce each company and its innovative products. The majority were not concerned about whether or not there were common characteristics among the companies they studied, probably because they assumed each company was unique. However, as Pavitt proved, if we focus on the similarities instead of differences among companies, we might find a different insight into understanding these companies' nature. If there is a set of common characteristics among a group of companies, there most likely are the rational reasons, or possibly strategic choices, behind them. Thus, understanding the reasons would give us a different understanding of the companies.

It should be pointed out that there might be a tendency to emphasise differences in SMEs' cases. On the contrary, it seems that many studies seek to identify standard management practices among large companies. Each company is unique in corporate history, industrial (sub-) category, size, and other factors. They have different human resources, machinery, and technology. However, even if there were great diversities in the appearance of each company, there could be some commonalities among, at least, successful companies. If some companies can fairly compete and survive in a specific market, they find suitable ways to do it, which might lead to shared characteristics.

Thus, the current research aims to find management commonalities among innovative Japanese SME manufacturers presumably categorised as Specialised Suppliers. Pavitt's innovation taxonomy is used as a checklist of items to explore in the current research. For example, the balance between product innovation and process innovation will be examined. Pavitt predicted, and other academics statistically reinforced, the preposition of Specialised Suppliers focus on product innovations. The current research will check each item on the sample companies if the statement is true.

Moreover, the current research explores the reasons behind the common characteristics stated in Pavitt's taxonomy. In this way, the current research would test if the sample companies fit the taxonomy and could be considered as Specialised Suppliers or not. The current research also attempts to understand the reason behind the characteristics, which will clarify Specialised Suppliers' fundamental nature.

There are two possible contributions of the current research to the body of academic knowledge and SME manufacturers.

The current research findings will provide some detailed insights into each common characteristic of Specialised Suppliers. For example, how they foster product innovation.

A series of realities in each item would possibly clarify the fundamental conditions of being a Specialised Supplier.

Second, if the current research can identify reasons behind Specialised Suppliers' specific innovation trajectories and institutional settings, the findings will show other SME manufacturers an alternative way of being competitive while remaining small-scale. In other words, the research would clarify the way how an SME manufacturer can be a Specialised Supplier.

4. Methodology

4.1. Research Framework

The current research attempts to test the proposed characteristics of Specialised Suppliers as outlined in Pavitt's innovation taxonomy. Pavitt (1984) explained "Specialised Supplier" as follows：

> Specialised suppliers. Firm-specific technological advantage is based on the capacity to improve the performance of specialised inputs (machines, instrumentation, materials, software) into complex and interdependent production systems. The main focus is product innovation, and the main sources of technology are the firm's [engineering] design office and the production engineering and systems activities of customers. The main threat of entry is from technologically dynamic firms in their user sectors or from small firms spun off from them (Pavitt et al., 1989).

The current research focuses on some innovative Japanese SME manufacturers that generally fit this statement.

Pavitt developed the taxonomy of innovative manufacturers based on extensive statistical analyses. The current research employs a different approach to Pavitt. The research tests his taxonomy by looking at the "nature" of proposed characteristics. In other words, instead of checking statistical commonalities of Specialised Suppliers, the current research attempts to explore the reasons behind the characteristics and how these Specialised Suppliers make innovations possible.

For an SME manufacturer, it is important to understand why Specialised Suppliers have common characteristics and how they could be innovative solution providers. The current research will explore the nature and story of each company's innovations and check commonalities with the supposed characteristics of the Specialised Suppliers with careful focus on the reasons behind them.

The current research will start testing proposed characteristics on some innovative Japanese SME manufacturers, categorised as Specialised Suppliers.

4.2. Research Subject

The current research follows Pavitt's taxonomy for selecting research items. In addition, several research criteria have been added or modified from Pavitt's taxonomy to discuss the boundary characteristics of Specialised Suppliers.

The fundamental criterion for selecting sample companies is providing an innovative technological solution(s) to customers. This criterion is consistent with Pavitt's taxonomy.

The second criterion is companies categorised as SMEs in Japan. Pavitt's taxonomy also indicated Specialised Suppliers are relatively small companies.

The third criterion is companies that maintain independence. For example, developing specialised products may differ between a purely independent and an affiliate of a larger company. Thus, the current research focuses on independent companies, excluding affiliates or companies holding close economic connections with large companies.

The fourth criterion concerns industrial sectors. The current research covers broader industrial sectors than the sectors identified as "typical core sectors" for Specialised Suppliers in Pavitt's taxonomy. For example, Pavitt categorised machinery as a typical core industrial sector for Specialise Suppliers, but he categorised textiles as Supplier Dominated. However, since some companies have similar characteristics to Specialised Suppliers in the textile industry in Japan, the current research includes them for testing. These textile companies developed unique products creating innovative solutions for customers. Therefore, including such companies would help consider the borders of Specialised Suppliers, too.

The fifth criterion is Japanese SME manufacturers. Although Specialised Suppliers could include service industries, and some previous studies included service industries such as management consultancy into Specialised Suppliers, the current research shall stick to manufacturers. There are two practical reasons for this selection. First, considering the limited research resources, especially time and money, I would like to avoid unnecessary complexities. The inclusion of service sectors would certainly increase complexities. The current research faced a few challenges in identifying the shared characteristics among innovative SMEs and exploring the underlying reasons. There is not much literature in this field. Thus, I would like to keep this research simple to explore deeper within the research limitations. Second, information on the innovative SME service industries is limited compared to manufacturing companies in Japan. There might be policy influences on the situation. The Japanese government traditionally put more significant policy weight on

manufacturing, partially influenced by Japanese traditional craftsmanship. As a result, many governmental institutions, including local governments and many regional media, published directories on innovative SME manufacturers. Unfortunately, these directories usually do not include many service industries. Thus, it is not easy to find good samples in service industries compared to manufacturing industries.

The sixth criterion is the location of sample companies. The current research selected companies located within accessible distances from Tokyo, considering the limited time and budget. With this limitation, the author of the research tried to select companies in different prefectures to minimize the potential influences of the location, like regional manufacturing culture.

4.3. Selection of Research Samples

It is challenging to select qualified samples in a limited time frame for research. At the same time, it is crucial to minimise biases in selecting sample firms.

A snowballing approach, for example, is an effective way to get interviewees introduced by the previous interviewee. However, it might limit the samples within inner circles based on business relationships.

Using academic and journalistic published materials is another way to find sample companies for the current research. However, there are some problems with Japanese published materials. Both academics and journalists tend to select similar companies for their works probably because some companies look more appealing than others to readers. Also, some CEOs told the author that they did not like to meet academics and journalists because they had had some bad experiences. For example, a CEO told me that he had never met a journalist who published a book introducing his company.

Therefore, the current research selects a series of SME directories as a basis of company selections published by the Small and Medium Enterprise Agency, a specialised governmental agency under the Ministry of Economy, Trade and Industry of Japan. The directories are named "*Ashita-no Nihon-wo sasaeru genki-na monotukuri kigyo 300-sya* (300 Energetic Manufacturers for Sustaining Japanese Future) (Agency, 2006, 2007, 2008, 2009)" (hereinafter called the directories)[9].

In preparing the directories, SME candidates were listed up by officers working in several governmental organisations: METI regional offices; Organization for Small and Medium

[9] The name of directories had changed slightly each year but purpose and content are similar.

Enterprises and Regional Innovation, Shoko Chukin Bank (a special purpose bank established by governmental law), and Japan Finance Corporation for Small and Medium Enterprise (a financial institution owned by the Japanese government). The final selection of companies listed in the directories was made by a special committee headed by a notable university professor specialising in innovation study.

These directories introduce firms and their innovative products/ manufacturing services with or without patents. As Thomä and Bizer pointed out (Thomä and Bizer, 2013), many SMEs do not use the patent system to appropriate their innovations. Thus, it is considered better to use directories, including SMEs holding patented and non-patented innovative products.

The directory was first published in 2006 and has continued every year. Each directory introduces 300 SME manufacturers on a one-firm per one-page basis. However, from 2009 the directory changed its format, and the 300 SME manufacturers were divided into two groups: 1) 150 companies supporting Japanese innovation and 2) 150 companies with some "shining" products/ processing services.

From over 900 SME manufacturers listed in the directories between 2006 and 2009, innovative SMEs, which seems to fit the Specialised Suppliers' category, were selected as candidates for the current research. The narrowing down of candidate companies was based on the time constraint of the researcher, and thus only companies in Tokyo and the surrounding ten prefectures were chosen. Finally, 52 innovative SME manufacturers in Tokyo and ten surrounding prefectures were selected as candidates for the current research.

4.4. Profiles of Companies Investigated in the Current Research and Their Innovation Stories

The current research firstly studied fifteen innovative SME manufacturers and rejected three companies. The remaining twelve companies provide innovative products or processing services to other companies as inputs, while the three rejected companies produce innovative final products. One of the rejected companies, a company named Komy, produced flat-faced convex plastic mirrors being used in the overhead compartment of aeroplanes. The company has an almost 100% share in this product area. The mirror makes checking remaining or suspicious goods in the compartments by cabin attendants easier. The product adds value to the airlines' services and safety in this sense. However, the product is not built in the manufacturing process of other products, and thus the current research excluded Komy from the analyses. Other twelve companies fit the proposed characteristics of Specialised Suppliers by Pavitt (Pavitt, 1984, Pavitt et al., 1989), though some features of

these companies are different from the propositions.

The profiles of twelve companies are summarised in Table4-1, followed by a brief introduction and the innovative stories of each company.

Table 4-1 Profile of Companies Investigated

	Name of the Company	Prefecture	Established	No. of Employees	Sector	Products/ Services	Customers / Customer Industrial Sector
1	Art	Gunma	1982	15	Dyeing and coating fabrics	Specialist dyeing and coating/ processing services of fabric. Extraction and provision of sericin (silk protein from cocoons).	Textile companies for dyeing and coating Cosmetics and textiles for sericin coating
2	CERARICA NODA Co., Ltd.	Kanagawa	1956	20	Chemical (natural wax)	Natural wax and wax powder.	Chemical, cosmetics, foods.
3	EGURO Co., Ltd.	Nagano	1937	180	Machinery	Precision machine tools (precision lathes, CNC precision lathes and machining centres)	Manufacturers that need to produce high-precision mechanical parts such as cameras, medical instruments and automobile industries
4	Fuji Lace	Gunma	1963	20	Textile (lace weaving)	Fire-resistant lace curtains, Japanese paper window shades, washable paper bedclothes, special fabrics for the space industry, and clothes with sensor functions	Textile, research institutes
5	Ishikawa Wire Netting Co., Ltd.	Tokyo	1949	35	Metal manufacturing	Metallic mesh and punching metals for automobiles, electric goods, architecture, industrial machinery, and art decorations	Electrics goods, electronics, construction, other manufacturers (using filters)
6	MASUKO SANGYO Co., Ltd.	Saitama	1804	25	Machinery	Ultra-fine friction grinders, ultra-precise cutting machines, hyperfine micronizers	Food, chemical, cosmetics, and others (almost 50% world market share in grinding machines).
7	Mitsumi MFG. Co., Ltd.	Tokyo	1958	28	Machinery	Oil-less vacuum pumps.	Any industries using vacuum pumps, including machinery, the space industry, automobile industries, and research institutions
8	Firm-X (name undisclosed)	Tokyo	1963	15	Machinery	Diamond-cutting machines, safe-glass cutting machines, diamond saws	All manufacturing, including machinery, the space industry, automobile industries, and research institutions
9	Saito Seisakusho Co., Ltd.	Tokyo	1934	59	Machinery parts	Solid carbide drills and end mills.	Heavy industries, automobile industry, shipbuilding, precision mechanical industry
10	San-M Package Co., Ltd	Shizuoka	1967	150	Paper manufacturing	Non-woven fabric medical and industrial masks.	Pharmaceutical (hold almost 100% share in Japan, 30% in Europe and 50% in Australia as OEM for medical masks)[10]
11	TAKANO Co., Ltd.	Gunma	1967	120	Machinery	Oil Sticks, custom-made oil-free moulds, and die parts.	Metal moulds, machinery, other manufacturers
12	TANOI MFG. CO., Ltd.	Tokyo	1905	161	Machinery parts	Seamless taflets, burr-less taflets, multitaps, multi-spiral taps, IT taflets	All types of manufacturers.

[10] The market share might decreased after many companies started produce non-woven fibre masks for the COVID-19.

Art

Art was established in 1982 and is located in *Kiryu* City in Gunma Prefecture. Silk-related industries flourished in Kiryu City and surrounding areas in the past. The Kiryu area was one of Japan's largest three silk-related industrial areas and had many silk-related industries like weaving, dyeing, coating, and textiles. Unfortunately, the industries have experienced some decline due to the development of synthetic materials and cheap imported products from newly developing economies. However, there are still many silk-related industries in the area, and several unique companies exist there. Art is one of the companies providing unique solutions to its customers.

Art is a small manufacturer with just 15 employees as of August 2017. Its primary business is to provide textile companies' dyeing and coating processing services. The company specialises in a heat-dyeing and chemical coating process for chemical-based threads.

Art has two innovative technologies. The first is being the only provider in Japan of specialised treatment services for producing extreme heat/ cold insulations used in the space industry. Without the company's heat dyeing and coating technologies, its customers could not develop unique clothes durable to extreme heat and cold in space. Therefore, Art could be categorised as a Specialised Supplier providing unique and innovative processing services to customers to develop unique cloth for the space industry.

The company developed the technology through trial and error, though it acquired the essential treatment technologies from external industrial research institutions. The CEO emphasises the importance of technological applications. He said that he developed a unique way of applying the basic technologies to specific materials used in the space industry, which is difficult to coat, through trial and error. This company has a tiny laboratory space in the corner of its factory, where it carried out experiments on chemicals used for dyeing and coating.

The other technology developed by this company is a unique process to extract "sericin", a type of silk protein, from silk cocoons. There are two types of proteins in silks: fibroin and sericin. Fibroin is the main component of thin silkworm thread, while sericin covers the surface of each silkworm thread and works as a glue to make thin silkworm threads into a cocoon. Historically, the cocoon had been discarded after people extracted their silk threads. Together with an Industrial Research Institute[11] in the prefecture, Art developed a new technology for extracting

[11] The Industrial Research Institute is a governmental organisation under the Ministry of Economy Trade and Industry. The ministry locates one industrial research institute to each prefecture in Japan so that the institute supports industrial development in

sericin from the cocoons. Until the company developed its unique technology, sericin was extracted from cocoons using chemicals, which were neutralised after the extraction[12]. Art developed another cheaper and safer way for extraction.

Moreover, the company also developed various ways of using extracted sericins to coat various threads. Art can coat cheaper threads such as cotton with the sericin so that the product holds the beneficial nature of allergy-free silks. Art provides this technological solution to other manufacturers who can lower allergy-free silk-touch cotton towels costs. The company also develops technologies for allergy-free cosmetics and soaps. Several larger chemical companies use this technology by paying Art. Thus, in this case, without Art's innovative technologies of extracting sericins from cocoons and coating them to various materials, many customers could not develop their innovative products.

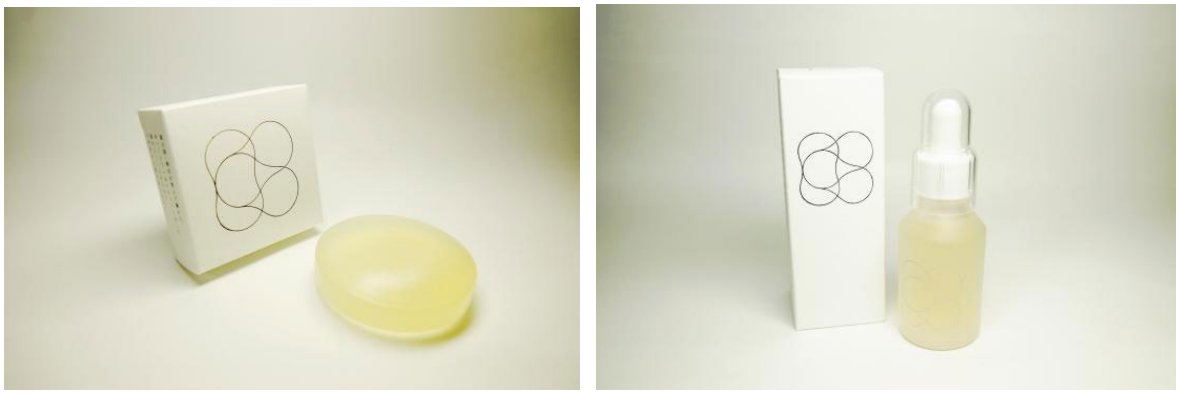

Figure 4-1 Allergy-free Soap Products Using Sericins.
Source: http://img21.shop-pro.jp/PA01340/197/product/107852087.jpg

CERARICA NODA

CERARICA NODA was established in 1956[13]. The company produces various natural wax products from five types of raw materials extracted from living plants and insects. Nowadays, petroleum-based artificial waxes are widely used in society because they are cheaper than natural waxes and are believed to maintain more stable product quality and price. The petroleum-based waxes, however, include health risk ingredients. According to the CEO of CERARICA NODA, natural waxes have opposite characteristics, such as them being difficult to maintain stable quality and price, though with lower health risks. Many wax companies produce both petroleum-based and natural waxes. However, CERARICA NODA only produces natural waxes.

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the area.

[12] There is another much larger company, which has nearly 6,000 employees, holding a different sericins extracting technology in Japan. This company developed sericin extracting technology earlier than Art. Art developed a completely different technology for extracting sericins later and in a much smaller scale and with little equipment. The two companies' industrial patents do not violate each other.

[13] The history of wax production dates back to 1832 when an ancestor of the current chairman started its natural wax businesses.

The company processes these natural waxes in different shapes, from fine powder to large pellets, and different qualities suitable to the different requirements of each customer. The company's natural wax products are used in the food industry as a gum base, glossy ingredients for chocolates, and separators in food production processes. Customers in the cosmetics industry use its natural wax products for lipsticks, foundation powders, eyeliners, and face creams. Their products are also used for medicines, glossings and waterproofing for textiles, writing materials, toners for printing and photocopying machines, recording media like CD-ROMs, DVDs, Blue Ray Disks, and waxes for furniture and architecture. Usage in cosmetics and medicines implies the high quality of CERARICA NODA's products.

The innovativeness of this company is to develop many uses of natural waxes. For example, this company is the first company that developed ink toners for compact desk-top photocopying machines. When Xerox's large business photo-copying machine dominated the market, the development of the natural wax-based toner made it a Japanese office machine supplier possible to develop portable and even personalised photo-copying machines.

This company also developed the technology for using natural waxes in coatings for CD-ROMs, DVDs, and Blue Ray Disks. In addition, the company also developed and provided health safe wax coatings for foods, medicines, and floor waxes. In other words, CERARICA NODA explores and expands natural wax versatilities.

Since the natural wax materials produced by CERARICA NODA can be used for many different products, their customers are varied in both size and industry. The customers include large and international office machine suppliers, cosmetics producers, and the food and chemical industry. These customers approach CERARICA NODA to develop their new products using natural waxes.

There are two notable characteristics of this company. First, CERARICA NODA produces a wide range of natural wax materials, while other natural wax producers typically specialise in one particular type of raw wax material. CERARICA NODA established a worldwide supply chain network to stabilise its diversified natural wax supplies, including developing countries.

Second, the company produces high quality and high purity natural waxes using old-fashioned production equipment rather than modern machinery that its competitors use. Generally, companies invest in modern production equipment to increase competitiveness in the wax producing industry. However, at CERARICA NODA, the company can hold a competitive position in the wax market without installing modern production equipment.

EGURO

EGURO, based in *Okaya* City in *Nagano* Prefecture, was established in 1937. This company manufactures high precision metal machine tools. Okaya City is where many precision engineering companies such as EPSON are located. It is believed that this area's water purity and low and stable temperatures attract the precision industries. Pure water is necessary to clean precision and electronics industries in their production processes. In addition, the low and stable temperature make expansion and contraction of the materials less likely to happen.

The main strength of EGURO can be found in the extremely high precision of its machine tools. Their products are famous for their perfect flatness and circles. It is reported that by using EGURO's machine tools, customers, which include large automobile companies and camera manufacturers, do not need to undertake additional finishing processes on surfaces after they have used EGURO's machines. EGURO'S machine tools are used for producing many products, such as camera zoom lenses, which require high precision processing for smooth movements.

Figure 4-2 CNC Machining Tool SANAX-10

Source: EGURO Webpage http://www.eguro.co.jp/products/01.html

In the past, each machining tool in the factory was connected to a rotating metal rod driven by a large engine. The system is called the "line shaft system" (figure 4-3). Because of this system, it wasn't easy to re-arrange production lines. The founder of EGURO invented a compact independent machining tool, which was driven by a compact motor. Using this innovative portable machining tool, manufacturers have the freedom of designing and arranging production lines in their factories.

Figure 4-3 Line Shaft System (an example)

Source: Nikkei Inc.
https://www.nikkei.com/news/image-article/?R_FLG=0&ad=DSXBZO53549080030420130000001&ng=DGXZZO53549190T00C13A4000000&z=20130403

An interesting characteristic of the company is the way it pursues higher precision. Many machine tool manufacturers typically try to increase process precision by relying on computer-controlled appliances such as FANAC. EGURO also installed such appliances for their machine tools, and then it achieved further precision by improving the flatness and the true circle of their machining tools' parts by craftmanship. The skilled workers working in EGURO create higher flatnesses and circles using traditional hand tools. (See Figure 4-4)

Figure 4-4 Creating Flatness by Traditional Hand Tool

Source: http://www.eguro.co.jp/innovation/index7.html

The company tries to pass this traditional craftsmanship to the younger generation.

Fuji Lace

Fuji Lace was established in 1963 in *Kiryu* City, *Gunma* Prefecture, where the silk industries prospered. The company provides lace weaving processing services.

The lace weaving industry has a unique characteristic among various industries. Most weaving companies worldwide use the standard weaving machines manufactured by only one German

manufacturer called *KARL MAYER,* an almost monopolistic hold in the weaving industry. Also, raw materials are often provided by larger companies. Especially artificial threads are produced and provided by large chemical companies.

It is easy to predict that material innovations often come from large chemical companies, and process innovations are typically derived from manufacturing machine producers in this industrial structure. However, Pavitt also pointed out that "[t]he main exception is textiles, which is heavily dependent on innovations from other sectors" (Pavitt, 1984, pp349). Therefore, the textile industry is categorised as Supplier Dominated.

In the case of Fuji Lace, there are different situations. Although the company buys raw materials from large chemical companies and weaving machinery from KARL MAYER, Fuji Lace developed innovative lace products based on their ideas and technologies.

This company was the first company to develop flame-retardant lace curtains. These flame-retardant curtains use a synthetic thread developed by one of the largest chemical companies in Japan. However, it is not the material alone that created the flame-retardant curtains. A specific weaving technology or pattern that Fuji Lace developed is a key in producing flame-retardant curtains. The curtain was the first innovative product of this company.

Since then, the company has continued to develop textiles with unique functions. Synthetic lace materials, which are highly durable to extreme heat and cold, can be used in the space industry, is another example. The company also developed washable Japanese paper clothes. Fuji Lace's CEO researched Japanese paper (or "*washi*") production extensively and developed a unique method of producing washable Japanese paper clothes.

This company is currently working on developing bed sheet fabrics with various sensors in cooperation with a university. This material is designed to be used in medical institutions to monitor patients' conditions while in bed.

Ishikawa Wire Netting

Ishikawa Wire Netting was established in 1922 in *Arakawa* Ward, Tokyo's traditional downtown area, where many SMEs are located. This company specialises in producing metal wire and mesh materials. The company produces various products such as metal mesh parts for automobile ventilation, metal filters for industrial air conditioning, headcovers for microphones, and metal nets for fryers. It even produces a small tea filter net. The company uses various metal wires and threads made of stainless steel, copper, brass, aluminium, and titanium to produce these items.

The customers of Ishikawa Wire Netting include automobile, electronics and industrial machinery industries. In addition, the company produces metal covers for professional-grade microphones for large audio-visual manufacturers such as SONY.

According to the CEO, the strength of this company is the ability to produce and provide various high precision wire netting and metal works with exceptional low-cost and artistic value. It also provides various technological solutions for wire netting to customers.

Ishikawa has developed some original products, including picture/ photo patterned metal mesh plates for architectural decorations. In 2014, the company developed an ultra-thin metal mesh *origami*[14] paper named "*ORIAMI*".

Figure 4-5 Crane Origami by "*ORIAMI*"
Source: https://oriami.jp/admin/wp-content/themes/oriami/images/top/slide01.jpg

An interesting characteristic of this company is that it provides various wire netting products specifically designed to each customer's needs by attaching internally developed jigs to standard machine tools easily acquired on the market.

MASUKO SANGYO

MASUKO SANGYO is an old company dating back to 1804 when it was set up as a metal casting company. The father of the current CEO developed a grinding machine in 1965 and transformed the company into a grinding machine specialist that makes various materials into micro-particles and powders.

The current CEO also has developed another cutting machine producing micro-particles and micro-powders. Thus, MASUKO SANGYO has two main product lines: a grinding machine using industrial (or artificial) grinding stones and micro-cutting machines. Both of its product lines are innovative in many senses.

The grinding machine is the only grinding machine using grinding stones that can be used in the

[14] Origami is the traditional Japanese paper foldingart.

food processing industry. Industrial grinding stones are typically produced by bonding hard particles of various materials into disk shapes. Due to this production process, there are usually tiny pores in industrial grinding stones. This nature creates two problems. The first problem is the limitation in the size of ground particles and powders, and the second is that the machine cannot be used for food processing.

Making the gap between two grinding stones smaller is necessary to produce smaller particles and powders. However, the smaller the gap, the higher the friction heat generated by the two grinding stones. Thus, the heat made the industrial grinding stone crack; it was difficult to make tiny particles with grinding stone type grinders.

Since tiny particles of materials remain in the pores of the grinding stones after production, which can become a breeding ground for bacteria, it was believed that the grinding stone type grinders were not suitable for the food processing industry.

It took a long year of trial and error, but finally, the founder of MASUKO SANGYO found a unique way to produce non-porous industrial grinding stones. These non-porous grinding stones are significantly tougher and more durable than traditional industrial grinding stones with pores. Therefore, MASUKO SANGYO can produce grinding machines that can make micro-particles without worrying about cracking due to friction heat. Also, since the non-porous grinding stones can maintain a high level of sanitation, these grinding machines can be used in the food processing and cosmetics industries.

These grinding stones and machines widened the possibilities of developing various foods and drinks using nano-size materials. Currently, the machines of this company are the only grinding machines in the world that can produce cellulose micro-fibre as grinding stone type grinders.

Figure 4-6 An Example of MASUKO SNGYO's Grinding Machine

Source: www.masuko.com/company/pdf/MKZA10.pdf

The second product line is micro-cutting machines. This machine uses a high-speed rotating cutter to cut materials into small tips and particles. The machine requires high precision and toughness to endure high-speed rotating mechanisms. As a result, only two companies, one in the USA and MASUKO SANGYO, can produce such machines. Nevertheless, MASUKO SANGYO succeeded in developing the technology completely internally to produce its rotating cutting machines.

Figure 4-7 Core of Rotating Cutting Machine

Source: www.masuko.com/company/pdf/mkcm5.pdf

Regarding manufacturing arrangements, MASUKO SANGYO produces non-porous grinding stones internally while it sub-contracts the production of other machine parts. MASUKO SANGYO carefully divides parts between several sub-contractors so that they cannot get the whole picture of its technology. The final assembly and adjustments are made in the MASUKO SANGYO factory.

Mitsumi MFG

Established in 1956, Mitsumi MFG is located on the periphery of Tokyo's metropolitan area, where many SME manufacturers are traditionally located. This company was the first Japanese company to develop an "oil-free" rotary vacuum pump in 1960.

Since vacuum pumps create vacuums using rotating parts (rotors) in a casing, oil lubrication between rotors and casings is required. However, lubrication creates dirty smears on the pump parts and materials handled by the pumps. This characteristic made vacuum pumps difficult to use in certain circumstances.

Mitsumi MFG is the company that developed an oil-free vacuum pump for handling banknotes in automated telling machines (ATMs). At that time, typical vacuum pumps were too large to install in ATMs, and they required oil lubrication and regular maintenance. Mitsumi MFG developed a small oil-free vacuum pump that did not require frequent maintenance. Without this innovation, it is likely ATMs would not be as widespread as they are today.

Since then, the company has specialised in "made to order" oil-free vacuum pumps. Customers

come to this company when they need specific vacuum pumps, especially after other pump manufacturers failed or were unwilling to develop vacuum pumps according to customers' requirements.

Figure 4-8 MSV-200-GV Oil-Free Vacuum Pump

Source: A Mitsumi MFG leaflet

Mitsumi MFG's oil-free vacuum pumps are used in the space station. Although the details are confidential, it seems likely that considering the harsh environment of space, the reliability and maintenance-free features of Mitsumi MFG's oil-free vacuum pumps are second to none.

The company designs all vacuum pumps internally and manufactures the core parts such as rotors in their factories and some outsourced parts.

Firm-X (name undisclosed)

Firm-X was founded in 1963 in the downtown area of Tokyo by the father of the current chairman as a manufacturer of cloth sewing machines. The founder developed cloth cutting machines used in apparel industries where the machines cut patterns from plain clothes.

One day, a person visited his company and asked for a human wig-making sewing machine. Coincidentally, he had read a newspaper article based on an interview with a famous Japanese hairdresser who had succeeded in Paris. In the article, the hairdresser forecasts increased demand for ladies wigs due to the increased number of working females likely wanting to change hairstyles for different occasions. Therefore, although his company did not produce a wig-making sewing machine at that time, he replied he was working on the development. In about two years, he had struggled with the development and finally developed a wig-making sewing machine, which he sold to Korea (a major wig exporter at the time) and subsequently to 48 countries worldwide. At that time, Firm-X became a large company producing and exporting about 4,000 wig-making sewing machines per month. Then after his father passed away, the current chairman, the eldest

brother, divided the company into three to split the company equally among the siblings. Since then, the company has remained small scale.

A technological turning point was when the company chairman developed a diamond-cutting machine after his inheritance. This cutting machine is a type of bandsaw that uses a looped metal band for the cutting material. The diamond-cutting machine uses a metal-band blade on which artificial diamond powder is bonded. Thus, the chairman developed the technology of diamond powder bonding. Although other machining tool manufacturers tried to imitate his machine and produce similar diamond bandsaws, this company's machines have two distinct technological advantages. First, they can cut even hardened ceramic tiles, and second, they can cut any materials without cracking. For instance, the diamond-cutting machine can cut a lightbulb in half without smashing it.

Figure 4-9 A Cut Sample

Source: undisclosed

The chairman later developed a unique cutting machine for hardened window glass sashes, in which reinforced steel wires are sandwiched inside two panes of glass. Such a steel sash is essential for crime prevention and is often installed in big cities buildings and houses. However, this hardened glass makes rescue operations difficult in the case of natural disasters. After many tragedies during the Great Hanshin-Awaji Earthquake in 1995 when many people were locked inside buildings, the chairman developed this machine.

Saito Seisakusho

Saito Seisakusho was founded in the peripheral area of Tokyo in 1934. The company has its headquarters and a small factory there, while the main factory is in Miyagi Prefecture.

Saito Seisakusho produces outstanding “micro” drill bits and end mills for industrial machine tools. The father of the current CEO developed these drill bits and end mills alone. The company’s product line-up includes an extra-fine 0.02mm diameter drill bit and a 0.05mm diameter end mill.

It is possible to curve English characters onto a 0.5mm propelling pencil lead by using this micro drill bit.

Figure 4-10 Examples of Micro Drill Bit and End Mill

Source: https://www.atom21.co.jp/en/en_products.html

Saito Seisakusho's drill bits and end mills are used in manufacturing processes where users cannot use electrical discharge machining tools when producing small holes or cutting plates. Electronic parts manufacturing is such an example. Electronic companies cannot make electronic hardware parts such as computer substrates smaller without using the fine drill bits from the company.

Many competitors have tried to imitate such fine drill bits and end mills but to no avail. Competitors cannot achieve the outstanding precision and durability of Saito Seisakusho's products, which can be used for long hours in mass-production lines.

The interesting thing is that, according to the current CEO, Saito Seisakusho produces these fine products using standard CNC machine tools available on the world market and which other companies could also acquire. According to the CEO, the company modifies some parts of the acquired machine tools, though these details remain confidential.

San-M Package

The father of the current CEO[15] established this company in 1967 as a package printing company in a rural area of Shizuoka Prefecture. Since Shizuoka Prefecture is famous for the quality and richness of pure waters streamed down from Mt. Fuji, there are many paper-related industries. San-M Package started its business as a printing services provider to product-packaging companies. Later San-M Package chose to specialise in printing on non-woven fibre materials, which are not ideal for printing due to their uneven surface.

San-M Package developed the technology of applying ultrasonic welding technology to bond non-woven fibre materials. The company's founder bought an ultrasonic welding machine produced by a large manufacturer without any particular purposes. However, the current CEO found a way

[15] As of the interview in September 2017. As of June 2021, he is the chairman and his son is the CEO of San-M Package.

of applying the technology to non-woven fibre materials.

Nowadays, the company mainly produces non-woven fibre (medical) masks using ultrasonic welding technology. This company has a nearly 100% market share of non-woven fibre masks as an original equipment manufacturer (OEM) to large medical products manufacturers. Since its customers export their medical masks to the world market, this company holds a high market share in the world (medical) mask market. It is estimated that the mask products of the San-M Package hold about 40% share of the medical masks market in the EU and 30-35% in Australia.[16]

Figure 4-11 Non-Woven Fibre Masks

Source: https://www.san-m.co.jp/product
Accessed 5th of June 2021

Unlike typical OEM companies, customers of SAN-M Package, mainly well-known medical suppliers, do not provide both product and process technologies to San-M Package. Instead, these customers come to explain the concept of their new product, and San-M Package designs whole manufacturing processes suitable to each. In addition, San-M Package sometimes advises modifying product specifications to customers since the company has better knowledge about non-woven fibre materials. San-M Package's factory is highly automated and kept confidential.

[16] This was the situation before the New Corona virus spread. Since the non-woven fibre mask manufacturers were multiplied partially because of governmental policy, market shares are likely to have changed. However, it is likely that as an OEM company, San-M Package still keeps a certain market share at present. At least, the company shows good business performance as of June 2021.

TAKANO

TAKANO was established in 1967 and is currently located in an industrial park in Gunma Prefecture. The company produces high-precision metal moulds and parts for machine tools and provides oil-free solutions to other manufacturers.

An oil-free technology is a technology to make manufacturing processes maintenance-free by using solid oil embedded into the surface of machine parts. The oil-free technology improves efficiency in manufacturing processes and contributes to the more extended durability of manufacturing machines. Generally, large manufacturers develop and produce oil-free parts either internally or via subsidiaries. A large company like Toyota, for example, has a special section for preparing oil-free parts within their factories. However, since developing and producing oil-free parts is costly, substantial demand is necessary to justify the investment. Thus, developing and producing oil-free parts are difficult for SMEs.

TAKANO developed an oil-free technology that enables SMEs to prepare oil-free parts in small volumes and at a low cost. The company developed a solid oil stick, where users can quickly introduce an oil-free solution to their manufacturing process by themselves. Figure 5-10 shows an example. The user drilled small holes and embedded TAKANO's product named the "Oil-Stick" into the surface of metal parts to make it oil-free.

Figure 4-12 Oil-Free Technology by "Oil-Stick"

Source: http://www.kk-takano.co.jp/wp-content/uploads/2015/11/case06.png
Accessed 6th of June 2021

TAKANO compounded a special solid oil for the Oil-Stick internally. The company also developed a special Oil-Stick for the food industry. Traditional solid oils used for the oil-free parts are not safe for the foods. Thus, it was difficult for the food industry to introduce oil-free technology, even if the food companies wanted to do so. Therefore, TAKANO developed a unique oil that is compounded, making it safe for the food industry.

TANOI MFG

TANOI MFG was established in 1923 by the father of the current chairman and was the first company to succeed in the production of screw taps and thread cutting dies in Japan. A screw tap is a tool for producing a screw hole, and a thread cutting die is a tool for producing screws. Until that time, screw taps and thread cutting dies were imported from western nations, mainly the USA and the UK.

Figure 4-13 Examples of Screw Tap (left) and Thread Cutting Die (right)

Source: Left http://www.tanoi-mfg.co.jp/cutting/index.html
Right https://www.monotaro.com/monotaroMain.py
Accessed 5th of June 2021

This company now provides screw taps, thread cutting dies, and other related tools with one of the highest precisions and durability in the world. Manufacturers usually need to finish processing by smoothening surfaces and surrounding holes of processed materials after screw taps or thread cutting dies. As a natural part of the screw taps and thread cutting dies process, metal or material burrs appear on the processed materials. TANOI MFG developed screw taps and thread cutting dies, which do not require this finishing process thanks to its tools' precision and unique shape. Since the many holes and screws required in assembled products, this technology significantly reduces manufacturing steps.

TANOI MFG further developed a uniquely shaped tool called the “Multi-Tap”, which can drill a hole and create a thread ridge simultaneously, combining two processes into one. Together with the non-finishing precision of TANOI MFG’s tools, this innovative tool helps increase productivity significantly.

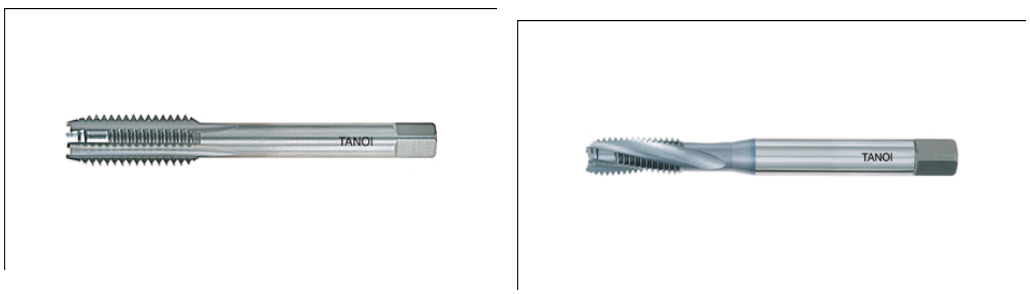

Figure 4-14 Multi-tap TC-MLT (left) and Multi-Spiral Tap MTL-SP (right)

Source: http://www.tanoi-mfg.co.jp/cutting/mlt.html
Accessed 6th of June 2021

TANOI MFG developed another innovative tool called “SCUTDRILL”, the only tool that can make a hole in Carbon Fibre-Reinforced Plastics (CFRP) without requiring a finishing process. Hardened CFRP is a lightweight and durable material increasingly used for many industrial products such as automobiles and aeroplanes. However, the hardness of CFRP makes it difficult to manufacture. The SCUTDRILL quickly makes a hole in CFRP and is reportedly eight times more durable than traditional drill bits. Thus, the tool created the possibility of increasing productivity in these industries.

Figure 4-15 SCUTDRILL

Source: http://www1.odn.ne.jp/m-suguremono/product/11th/images/miyagitanoi.jpg
Accessed 6th of June 2021

As a company investigated in the current research, TANOI MFG has an exceptional feature. Although the company is categorised as an SME by the Japanese governmental definition, it was once a large company. When this company developed Japan-made screw taps and thread cutting dies in the 1950s, its products were more precise, durable, and cheaper than imported tools. TANOI MFG grew quickly and became a large company with two factories at 40,000 ㎡. The company faced some managerial problems and became small to its current size of around 150 employees. Since then, TANOI MFG has remained small-scale.

4.5. Approach to Selected Companies

The open data of 52 pre-selected manufacturing SMEs, including two companies visited during the pilot stage of this research, were gathered from Internet sources, including corporate websites and related internet articles. In addition, published information such as books, academic and journalistic articles, and audio-visual materials was also gathered. Finally, the gathered data was formed into a matrix together with the data from the directories.

As the first contact, e-mails were sent to 15 companies in March 2015. This e-mail included an interview request to the CEO of each company, a brief explanation of the research, and the reason for selecting their companies as research samples.

In Japan, the personal e-mail addresses of CEOs are not available publicly. Consequently, e-mails were sent to either representative addresses or sales contacts of each company. Unfortunately, the response rate to the e-mails was very poor. Only a very few companies replied, and only one CEO agreed to accept an interview request.

After visiting the one CEO who accepted an interview, some reasons for refusals were revealed. In some cases, similar to western societies (Goldstein, 2002), gatekeepers block access from unknown sources. However, possible and more important reasons for the refusals were that many CEOs did not like to work with university (and governmental) researchers. These CEOs told me that many academics (and journalists) visited their companies to satisfy their own interests without considering CEOs' feelings and precious time.

Based on this realisation, the strategy to approach CEOs was modified. Instead of e-mails, handwritten letters were sent to the CEO of each candidate company by using a formal white envelope used for personal correspondence. Furthermore, CEOs' names and corporate addresses were handwritten carefully instead of using a computer printer. As a result, employees of the companies would be less likely to open the envelopes, which might be personal correspondence. Thus, these letters were more likely to reach the CEO's secretary. In addition, a handwritten letter to each CEO with their name was enclosed with a separate typed explanation of the current research.

More importantly[17], the letter explains the researcher's belief in SMEs' importance and as a potential contribution of the current research to SME manufacturers in society. The letter also

[17] This assumption was confirmed later at the interviews with some CEOs, who told the author of the current research they had decided to meet me since they also believe in the importance of the research for SME manufacturers.

asked each CEO to share their time if they would find a potential value in the current research. Therefore, even when the secretary opened the letter, they needed to ask for the value judgement of the CEO. The letter did not ask for a reply but stated the researcher would contact them to ask whether or not they would accept an interview.

The letters were sent to the 25 candidate companies in this second approach. A week later, the researcher attempted telephone contact with each CEO. The contact time was precisely set between 10:00-11:00 and 13:30-15:00, when business is likely to be less busy.

As a result of this modified approach, by the end of March 2017, founders/ CEOs of the 13 companies were interviewed.

It should be noted that although the letter asked to share about an hour for an interview, most of all, CEOs agreed to share a much longer time for the interview, sometimes more than 3 hours. In addition, some of them said they had decided to cooperate with the current research because they understood the potential value of the research for SME manufacturers, including them.

After several interviews and once mutual trust was established between interviewees and the researcher, the reason why many CEOs of SME manufacturers were reluctant to cooperate with researchers was found. The CEOs did not have a good impression of academics and journalists. They said most universities worked only for large firms, and their research findings were not suitable or beneficial to SMEs. Other CEOS said that researchers came to their companies just for their academic interests and not for the company. For example, a CEO shared a story with the researcher that a journalist who specialised in SMEs published a book including their company without visiting nor contacting them.

4.6. Interview research

The current research employs a case study method based on interviews to explore the current circumstances of management decisions among Specialised Suppliers in Japan. As Yin (2013) says, “the more that your questions seek to explain some present circumstance (e.g., “how” or “why” some social phenomenon works), the more that case study research will be relevant.”

Since the characteristics of innovative and problem-solving Japanese SME manufacturers are understudied, it is necessary to explore each company in detail to understand them. Thus, the current research employed a case study method (Yin, 2013). To explore the fundamental factors of Japanese Specialised Suppliers, the flexibility of the interview as a data collection method is suitable for situations where the researcher needs to explore characteristics that are not revealed

explicitly. One-to-one direct interviews can allow unconscious factors of management to be revealed.

At the same time, the current research seeks to test known common characteristics proposed in Pavitt's taxonomy and find additional characteristics. A semi-structured interview approach seems suitable to examine known characteristics and find unexpected information. Using semi-structured interviews, the author can test the fit of each company investigated in the current research to Specialised Suppliers in Pavitt's taxonomy. The author might also get an unexpected reality from the interviewees.

The factors or management aspects included in the questions were prepared based on the previous literature about Specialised Suppliers and innovative Japanese SME manufacturers (Appendix 1). In addition, another checklist was prepared for each unique company based on any available information concerning the research sample companies, including Internet articles, central or regional governmental websites for introducing innovative regional companies, and published books and business magazines.

The main subjects for interviews were founders or CEOs of the research sample companies, who presumably knew their companies the best. More importantly, as management practices in SMEs are not often institutionalised, a founder/ CEO can be the only one who can see the whole picture of the company. In many instances, they also take a leading role in product development (Goldstein, 2002).

Interviews were conducted flexibly, with the researcher listening to what the interviewee wanted to talk about most of the time to gain the interviewee's trust. SME presidents are typically not talkative to outsiders. One well-known innovative firm president also told the author that researchers often had come to ask questions about what the researchers wanted to know rather than what the president wanted to discuss. Gaining the trust of CEOs is highly important before exploring research subjects.

It is necessary to establish a reliable procedure to avoid subjective interpretations of interviews and generate data validity (Berry, 2002). In this sense, the way of asking questions influences interviewees and thus answers. The author tried to avoid asking questions one by one at each interview, following the interview checklist. Instead, the author encouraged each interviewee to speak as they preferred to establish mutual trust. As IC recorder was prepared but only used when interviewees agreed to its usage. The researcher brought some confectionary as a gift to respect Japanese customs when visiting other people. The degree of any corporate disclosures was

checked. Some companies refused to disclose companies' names since it could harm their businesses.

After each interview, a detailed interview memorandum was prepared in Japanese with the addition of some unspoken words/ sentences within parentheses. This is because of the linguistic characteristics of the Japanese language, which tend to drop sentence subject and objects, and expect reading between the lines of speakers, especially in the words of people in a higher position.

As a result, exactly recorded transcripts cannot easily be understood or analysed. To avoid misunderstandings and clarify the interviewees' meaning, an interview memorandum with some additional sentences and words in parentheses was prepared. These memorandums were sent with a handwritten letter to the interviewees to confirm contents, including the researcher's interpretations of what they said. By replaying these "conversations" with interviewees, the meanings of words became more precise. Then, the current research could explore deeper into the management practices and the ways of thinking of the CEOs.

The researcher also asked for an opportunity to conduct a second interview to confirm the contents of the memorandum and potentially interview other individuals in the company. Interviews with multiple people are intended for two reasons. One was for the triangulation of data. Another is based on the consideration of tendencies in SMEs. In SMEs, top management considers corporate management deeply every day without noticing the depth of their considerations. Thus, it is challenging to reveal such wisdom in only one interview.

For the analyses, the author first tests a fit of Pavitt's taxonomy to the sample companies, then the border of the taxonomy concerning Specialised Suppliers will be discussed. Also, possible reasons behind the existence of these commonalities are analysed to conclude the current research.

5. Findings

This chapter analyses the findings of the current research.

Then, the findings are compared to the proposed characteristics of Specialised Suppliers in Pavitt's taxonomy (Pavitt, 1984, Pavitt et al., 1989) to test the accuracy of the predictions and analyse the border of their definitions.

5.1. Data Gathered

In total, fifteen innovative SME manufacturers were visited and interviewed. Subsequently, three companies were excluded from the analysis since they mainly produced consumer products instead of special inputs to customer companies.

Data was gathered from semi-structured interviews as well as published materials and Internet websites. Table 5-1 summarises the gathered data.

Table 5-1 Data Gathered from Companies Investigated

	Name of the Company[18]	Length of Interview (and factory visit)	Printed Materials	Audio & Video Materials	Internet Webpage	Other Products Gathered
1	Art	− CEO 30min − CEO 90min +Factory visit 30min	− Corporate brochure	− Recording of FM radio programme 20min	− Corporate webpage http://www.art-silk.jp/index.html	− A soap produced using sericin
2	CERARICA NODA Co., Ltd.	− CEO 115min − CEO 149min +Factory visit 30min − Sub-group-leader of procurement 60min	− Corporate brochure − A chapter of the research report by a governmental bank		− Corporate webpage https://ceraricanoda.com/	
3	EGURO Co., Ltd.	− CEO 60min +Factory visit 30min − CEO 70min − Vice-chairman 70min	− Product catalogue − Product leaflets	− 2 MPEG videos about products total 14sec − 1 flv. video by web magazine 2min27sec	− Corporate webpage http://www.eguro.co.jp/index.html	
4	Fuji Lace	− CEO 150min+Factory visit 30min − CEO 230min − Director 50min+Factory visit 30min		− 1 MPEG video 1min34sec	− Corporate webpage https://clothing-store-1191.business.site/ − An article on the Kiryu City webpage https://www.city.kiryu.lg.jp/sangyou/guide/gyoshu/seni/1002432.html	− A washable Japanese paper pillow cover
5	Ishikawa Wire Netting Co., Ltd.	− CEO 30min − Factory visit 30min (introduced by a staff member)	− Corporate brochure	− 7 MPEG videos about their technology by company total 21min44sec	− Corporate webpage https://ishikawa-kanaami.com/ − An article by MITI webpage − An article by the Tokyo City gov.t	− Participated in a CEO's presentation at a study group 40 min and a handout
6	MASUKO SANGYO Co., Ltd.	− CEO 125min − CEO 100min +Factory visit 30min − Production Manager 125min	− Product leaflets		− Corporate webpage http://www.masuko.com/index.html	
7	Mitsumi MFG. Co., Ltd.	− CEO 60min − +Factory visit 10 min	− Product leaflets − A chapter of the book about innovative SMEs (Gonoi, 2000)	− 1 MPEG video about the company and technology by Tokyo City government 17min42sec	− Corporate webpage https://www.mitsuvac-tokyo.com/ − An article on the webpage of a TV programme − An article from Nikkei webpage	
8	Firm-X (name undisclosed)	− Chairman 240min − Machine demonstration 10 min	− A chapter of the book (cannot disclose)	− 8 Mpeg videos by TV programs on company and technology (total 88min)	− Corporate webpage (cannot disclose)	
9	Saito Seisakusho Co., Ltd.	− CEO 120min	− Products catalogue − A chapter of the book (Kogyo, 2014a)		− Corporate webpage https://www.atom21.co.jp/index.html	
10	San-M Package Co., Ltd	− CEO 75min − CEO 90min − Director 55min	− A chapter of the book	− 1 video of corporate introduction (only being allowed to watch at the company) about 20min	− Corporate webpage https://www.san-m.co.jp/	− A sample of non-woven fabric mask
11	TAKANO Co., Ltd.	− CEO 15min +Factory visit 30 min − CEO 100min	− Product catalogue	− 1 MPEG video of corporate introduction 22min41sec	− Corporate webpage http://www.kk-takano.co.jp/	
12	TANOI MFG. CO., Ltd.	− Chairman 85min − Chairman 60min − Director of Engineering 110min (incl. factory visit 30min)	− Product catalogue − Brochure of the founder story prepared by the company	− 5 MPEG videos about the products total 7min38sec		

Note: Prepared by the author

[18] The English name of each company is described as shown on the corporate business card or English webpage including the choice of capital letter and lower case letter.

5.2. Are They Specialised Suppliers?

This section examines if the companies investigated in the current research fit the described characteristics of Specialised Suppliers. The current research gathered data following items of Pavitt's taxonomy. Therefore, this section first explains the findings for each item on the companies investigated and discusses their fit to Specialised Suppliers' characteristics. Then, the boundaries of Specialised Suppliers will be discussed where data was available.

The common characteristics identified by statistical analyses means that they have statistical significance in the population. In this sense, proposed common characteristics of Pavitt and other studies followed (e.g. Pavitt, 1984, Sterlacchini, 1999, Freel, 2003, de Jong and Marsili, 2006, Robson et al., 1988) represent the most significant features for each item.

However, characteristics with statistical significance do not automatically mean all Specialised Suppliers shared all the proposed characteristics. For instance, some items are common to all the companies investigated, and others are possibly not. Therefore, the current research will check the essentially shared characteristics for consideration of the border of Specialised Suppliers. Considering the sample size, the analysis of the border remains just an implication, though.

Also, the statistical analysis does not clarify why the common characteristics exist. However, the underlying reasons are the critical importance of SMEs becoming Specialised Suppliers and being competitive.

However, these reasons are not easily observed from the outsider nor revealed in figures. Thus, the author of the current research believes that what interviewees, including CEOs, founders, and managers, said are valuable data to understand the nature of common characteristics.

Based on these considerations, the current research considers both the words and the interviewees' ways of explanation being the critical data. Thus, although a semi-structured interview checklist was prepared before each interview based on the information gathered from public data such as the Internet and published materials, the author prioritised what the interviewee wanted to talk about rather than checking the interview items one by one.

In the current research, detailed interview memorandums leaving nuances of conversations were prepared and sent to interviewees for their review. These carefully examined interview records showing the interviewees' words are precisely the critical data for the current research. As a result, some parts of this chapter on the current research findings

become rather descriptive.

The main items and characteristics of Specialised Suppliers in the taxonomy, which Pavitt first proposed and later expanded by Pavitt, Robinson, and Townsend, are summarised below (Pavitt, 1984, Pavitt et al., 1989). This chapter compares the findings from the companies investigated and these characteristics.

1) Industrial Sector

   Typical core sectors for Specialised Suppliers are machinery, mechanical engineering, instruments, speciality chemicals, software, rubber, plastic products, non-metallic materials, and (possibly[19]) electronics.

2) Relative Balance between Product Innovation and Process Innovation

   Specialised Suppliers focus on product innovations because they sell their products to customers who use them for their production processes. Specialised Suppliers are innovative because they receive continuous pressure from users to improve product efficiency.

3) Source of Technology

   Specialised Suppliers' main sources of product technologies are the firm's design office (in-house) and the customers' product and system engineering. In contrast, the primary sources of process technologies are either in-house or (often large) customer companies.

4) Type of Users

   The users of Specialised Suppliers are performance-sensitive rather than price-sensitive.

5) Means of Appropriation

   The means of appropriation are product design know-how, knowledge of users, and patents.

6) Size of Company

   The size of Specialised Suppliers is relatively small. One reason for this smallness

[19] Pavitt, Robinson, and Townsend said "possibly" in their paper.

considered by Pavitt is low technological barriers to entry into the sector. Technologically dynamic firms in their user sectors or small firms spun off from them easily enter the market and are the main threat to the Specialised Suppliers.

It should be noted that the current research has some limitations to these fitting tests. One of them is the difficulty in identifying customers of the companies investigated. It seems that SMEs sometimes tend not to disclose all their customers' names because of nondisclosure agreements. Other times, they probably want to stay neutral between competing customers. Thus, the current research could not gather data on one item of Pavitt's taxonomy, "intensity and direction of technological diversification".

5.2.1. Industrial Sector

Based on the statistical analysis of previous studies, Pavitt et al. considered that Specialised Suppliers typically belong to the industrial sectors of machinery, mechanical engineering, instruments, speciality chemicals, software, rubber, plastic products, non-metallic materials, and (possibly) electronics. In these industrial sectors, companies develop and improve specialised inputs for their customers (Pavitt, 1984, Robson et al., 1988).

Firstly, the industrial sector where each sample company belongs is checked. Table 5-2 shows the summary of findings.

Table 5-2 Industrial Sector

	Name of the Company	Fit to the Taxonomy	Industrial Sector to which the Company Belongs	Category in Pavitt'sTaxonomy
1	Art	No	Textile (dyeing and coating)	Supplier Dominated
2	CERARICA NODA Co., Ltd.	No	Natural wax	Supplier Dominated
3	EGURO Co., Ltd.	Yes	Machinery/ Instrument	Specialised Supplier
4	Fuji Lace	No	Textile (lace weaving)	Supplier Dominated
5	Ishikawa Wire Netting Co., Ltd	Yes	Metal manufacturing	Specialised Supplier
6	MASUKO SANGYO CO., Ltd.	Yes	Machinery/ Instrument	Specialised Supplier
7	Mitsumi MFG. Co., Ltd.	Yes	Machinery/ Instrument	Specialised Supplier
8	Firm-X	Yes	Machinery/ Instrument	Specialised Supplier
9	Saito Seisakusho Co., Ltd.	Yes	Machinery/ Instrument	Specialised Supplier
10	San-M Package Co., Ltd	No	Paper manufacturing	Supplier Dominated
11	TAKANO Co., Ltd.	Yes	Machinery/ Instrument	Specialised Supplier
12	TANOI MFG. CO., Ltd.	Yes	Machinery/ Instrument	Specialised Supplier

Source: Prepared by the author of the current research

Table 5-2 shows that two-thirds (8 out of 12) of the companies (EGURO, Ishikawa Wire Netting, MASUKO SANGYO, Mitsumi MFG, Firm-X Saito Seisakusho, TAKANO, and TANOI MFG) produce machinery, instruments, and metal parts. These industrial sectors are considered typical industrial sectors where Specialised Suppliers were found in Pavitt's taxonomy.

The other four companies belong to different industrial sectors from where Pavitt considered Specialised Suppliers typically belonged. There are two possibilities. Some of these companies are not considered Specialised Suppliers, or the industrial boundary of Specialised Suppliers is wider than Pavitt thought. The latter case includes likely possibilities of changing the boundaries of industries influenced by technological changes over the years. Therefore, it is necessary to examine the companies categorised in different industrial sectors.

Art is a specialist for high-temperature dyeing and coating on synthetic fibres and also succeeded in extracting sericin, a type of protein, from silk cocoons based on its know-how in high-temperature dyeing and coating processes. The company is categorised in a textile industry, which was categorised in Supplier Dominated in Pavitt's taxonomy. Pavitt assumed that the general chemical industry develops and processes innovation in the textile industry (Pavitt, 1984, p349). In other words, most process innovations come from suppliers (Pavitt, 1984, p343). Therefore, the textile industry was categorised as Supplier Dominated instead of Specialised Suppliers.

In the case of Art, it is a different story. First, the company acquired standard machinery and chemicals, the same machinery and chemicals as other dyeing and coating companies. However, Art developed a specific high-temperature dyeing and coating method for synthetic fibres. As a result, it became the only producer of extreme heat resistant synthetic fibre materials used for the space industry. Thus, it was not a particular chemical provided by a supplier but the specific way of compounding and applying chemicals to the synthetic fibres that made it possible for Art to treat the materials. In other words, Art found a specific solution without relying on the provided technologies. It should also be noted that Art developed the method on its standard production line.

Art could be categorised as a Specialised Supplier considering it develops and provides a specific solution to customers who need extreme heat resistant synthetic fibre coatings. This company is a possible example of companies showing an essential characteristic of Specialised Suppliers but working in different industrial sectors of Supplier Dominated in Pavitt' taxonomy. In other words, although the company provides unique solutions to other

companies as inputs, it belongs to the textile industry that was considered a typical Supplier Dominated industry.

Art also developed a new process of extracting sericin from silk cocoons and found a way of providing an allergy-free coating on other than silk fabrics. The company found the sericin extracting process using a dyeing machine acquired from the open market, like extreme heat-resistant coating technology. In other words, the company produces innovative products by developing unique process technology using aged standard dyeing and coating machines. The CEO of Art said he developed the sericin extracting process technology based on the company's accumulated knowledge and know-how on high-heat dyeing and coating. He did not modify the machines.

Fuji Lace is a specialist in weaving laces categorised in the textile industry, like Art. The company developed multiple innovative lace products. For example, Fuji Lace was the first company that developed fireproof lace curtain materials and the sole provider of synthetic lace materials for the space industry. A large chemical company developed a synthetic thread that is highly durable to fire. However, no company could weave the thread properly into cloth. Fuji Lace is the first company that could develop the way of weaving the synthetic thread into a fire-proof curtain. Considering the company develops and provides specific solutions, weaving technology to customers to produce innovative products, Fuji Lace may also be categorised as a Specialised Supplier, like Art. These two companies in the textile industry, Art and Fuji Lace, could be considered Specialised Suppliers since they provided unique solutions to products of other companies.

There is also an interesting similarity between these two textile companies. They both developed innovative process technology to provide solutions by using standard machinery. Regarding Fuji Lace, the company found a way of weaving various materials into required specifications using de-facto standard weaving machines. In the weaving industry, almost all companies worldwide use the weaving machines of KARL MAYER, a German manufacturer[20]. Thus, most manufacturers produce (almost) the same products using the same machinery. However, Fuji Lace found an innovative way of weaving materials into clothes with the required functions using KARL MAYER machines. According to the CEO of Fuji Lace, the way of weaving differentiates the function of the laces. The CEO achieved innovation by modifying the standard machines of KARL MAYER independently.

Fuji Lace also developed technologies for weaving new functional fabrics used for the space

[20] https://www.karlmayer.com/en/

industry, weaving washable Japanese paper-based fabric, and weaving metal sensor functions into bedclothes. According to the CEO of Fuji Lace, they deeply know the nature of threads, including how thread changes in response to the changes in temperature and humidity, and have developed the know-how to control this. The CEO also said they could design various functional clothes production processes based on the accumulated knowledge of threads and the lace weaving process. In addition, he said that different weaving patterns create different functions. The CEO of Art also said he knew a lot about the dyeing and coating process and materials.

Pavitt said that

> A relatively large proportion of innovations in mechanical and instrument engineering and textiles are produced by firms with their principal activities elsewhere (32.1, 54.6 and 36.3 percent[21] respectively), whilst column 1 shows that firms with their principal activities in mechanical and instrument engineering and in[sic] textiles produce a relatively small proportion of innovations in other sectors (16.0, 19.8 and 24.7 percent respectively) (Pavitt, 1984, p352).

Regarding the textile industry, since most of all weavers use the KARL MAYER machines, innovations might come from either the textile machinery company (KARL MAYER) or material suppliers. The case of the fire-durable synthetic thread shows a typical condition of Supplier Dominated industry in Pavitt's taxonomy. It might mean although Pavitt's taxonomy was nearly 40 years old, the primary industrial structures are not vastly changed: the textile industry heavily relies on machinery and material suppliers.

However, considering the two companies described above, Art and Fuji Lace, they took different ways in developing innovative solutions. These two companies use standard machines and materials and develop new ways of producing their innovative products. Therefore, it seems that although a value of Pavitt's taxonomy, showing there are similar sets of organizational arrangements in innovations in each industry, there are exceptions and those exceptions questioned the fundamental condition for being Specialised Suppliers. In the cases of Art and Fuji Lace, two companies seem to be categorised as both Supplier Dominated and Specialised Suppliers. Thus, this finding suggests that Pavitt's taxonomy is not a "taxonomy", a hierarchical system exactly classifying something empirically. Instead, Pavitt's taxonomy is a typology that individually created a conceptual classification when

[21] sic

referred to the arguments in organizational sciences (e.g. Rich, 1992). This point could be explored further in other research.

Even though Pavitt's taxonomy is, in reality, a typology, its usefulness has not changed. As stated above, the taxonomy has still been used effectively in recent research. Moreover, for the current research, Pavitt's taxonomy is the only one that well fits the common characteristics of the group of innovative SME manufacturers in Japan. Thus, the current research still follows several items of Pavitt's taxonomy to explore the companies investigated.

CERARICA NODA produces natural wax products in traditional manufacturing, categorised as Supplier Dominated in Pavitt's taxonomy. As described above, CERARICA NODA produces natural wax products or, more precisely, various shapes and qualities of purified natural waxes without using artificial chemicals. Customers can produce their unique and high-quality products using waxes produced by CERARICA NODA. Without CERARICA NODA, customers could not develop portable photocopiers, CD-ROMs and DVDs. Regarding the portable photocopier development, CERARICA NODA developed and provides wax powders for special toners for portable desktop photocopiers. Although the company specialises in natural waxes instead of artificial ones, it is necessary to deeply understand the nature of natural waxes and their chemical reactions to produce high-quality products. According to the CEO of the CERARICA NODA, even the same type of natural wax is potentially different depending on the various conditions of its origins like temperature and soils.

CERARICA NODA has a similar characteristic to the two textile companies described above. The company produces high-quality and a variety of products using traditional and standard facilities. These companies developed unique process technologies in-house based on their accumulated know-how and knowledge, especially in their raw materials, to develop innovative products. These companies are most likely categorised as traditional industries where companies are supposed to acquire process technologies from suppliers in Pavitt's taxonomy. In this sense, the company is probably categorised as Supplier Dominated in Pavitt's taxonomy. However, instead of getting technologies from suppliers, these companies develop their unique process technologies in-house as other Specialised Suppliers are supposed to do. It probably means there is a possibility of defining Specialised Suppliers not by an industrial sector but by how they behave, in this case, the way of developing process technology.

The CEO of CERARICA NODA said that his company had accumulated in-depth

knowledge about the nature of natural waxes and the methods of dealing with them. The CEO said that knowledge of natural raw materials, possibly called process technology, is more critical for producing high-quality natural wax products than modern technologies.

CERARICA NODA even recently bought an old factory with an old coal-fired melting furnace, which dated back to 1931, and the company intends to use it to produce its high-quality waxes. This action is far from the tendency of other wax producers. Most wax producers stopped natural wax production and moved to petrochemical wax production by introducing state-of-the-art technologies. It is considered cheaper and easier to produce artificial petrochemical waxes maintaining the same qualities and specifications. And, to move to artificial wax production, some of these wax producers are transformed into chemical companies categorised as Science-Based in Pavitt's taxonomy, where the latest technologies and knowledge are the key.

There is an interesting issue in CERARICA NODA. Like Science-Based companies, CERARICA NODA acquired modern high-tech research equipment and employed five graduate school graduates with scientific backgrounds. However, the company mainly uses this equipment to test and understand the nature and quality of natural waxes. The company chairman explained that these employees researched the nature of natural waxes and checked their products' qualities. Understanding the nature of materials is similarly considered important at Art and Fuji Lace. Therefore, their feature could be a key to being a Specialised Supplier in typically Supplier Dominated industries.

San-M Package produces masks using raw materials (non-woven fabric) provided by its customers, often seen in the textile industry, where the customers provide raw materials. As Pavitt stated, innovations often come from suppliers in the textile industry because creating new materials is the key factor for innovation. The non-woven fabric itself could be considered an innovation. It requires unique chemical treatment processes and thus is usually the product of large chemical companies that melt resins, produce artificial threads, make them into webs, and finally into fabrics.

Process technology often comes from suppliers or weaving machine manufacturers in the textile industry. Although non-woven fabrics do not require a weaving process but a welding process, San-M Package bought an ultrasonic welding machine developed by a machinery company from the market. Therefore, core process technology, and ultrasonic welding technology, came from machinery suppliers. The company, thus, is probably categorised as Supplier Dominated in Pavitt's taxonomy.

However, the innovation of San-M Package is that the company developed a unique method of applying ultra-sonic welding technology to non-woven fabrics. According to the CEO, the company developed a way to apply an ultrasonic welding machine to non-woven fabric mask production. All non-woven fabric mask producers, including San-M Package, sewed non-woven fabric parts together into masks until San-M Package succeeded in developing its process technology. When sewing non-woven fabrics, thread holes remain in the mask products. The application of ultrasonic welding technology to the non-woven fabric masks dramatically increases the products' hygiene specifications.

It should be noted that San-M Package did not manufacture a modified ultrasonic welding machine. Instead, the company found how to apply ultrasonic welding technology to non-woven fibres and asked a small local machinery company to develop the machine. Eventually, San-M Package built up the fully automated production lines using modified ultrasonic welding machines and originally developed jigs.

One of the significant contributions of Pavitt's taxonomy is that it simplified and found the typical technological trajectory or patterns in each industrial sector based on statistical analysis. For example, in the textile industry, significant changes mainly came from the changes in materials such as artificial thread, and process technology relies on weaving machine suppliers.

However, the findings of the current research show some different patterns. For example, some companies investigated in the current research might be categorised into two categories in Pavitt's taxonomy. These companies investigated in the current research could be considered as both Supplier Dominated and Specialised Suppliers. In other words, although there are typical industrial sectors often categorised in one of the four categories of Supplier Dominated, Scale Intensive, Specialised Suppliers, and Science-Based in Pavitt's taxonomy, belonging to these industrial sectors is not a necessary condition to fit one of the four categories. It seems more important to focus on the character of developing and providing unique solutions to other companies to be a Specialised Supplier.

5.2.2. Relative Balance between Product Innovation and Process Innovation

This section discusses whether or not the companies investigated in the current research prioritize product innovation or process innovation. Then the section explores the nature of innovation and how the companies achieve it.

Pavitt, Robson, and Townsend (Pavitt, 1984, Robson et al., 1988) considered that customers seek solutions or improve their production process and pressure Specialised Suppliers to

develop innovative products. In other words, customers need to have special inputs from Specialised Suppliers. Therefore, in the previous studies (Pavitt, 1984, Robson et al., 1988), Specialised Suppliers are considered to focus on product innovation rather than process innovation. Customers' requirements of having special inputs for improving and sorting out their production pressures Specialised Suppliers to develop innovative products.

Firstly, it is necessary to clarify the meanings of "product innovation" and "process innovation". The Oslo Manual 2018, a widely-used manual for measuring innovations, defines product innovation and process innovation as follows:

> A[sic] product innovation is a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market.
>
> A business process innovation is a new or improved business process for one or more business functions that differ significantly from the firm's previous business processes and have been brought into use by the firm (OECD, 2018, p21)[22].

A company would compete with others with different products or services based on product innovation. On the other hand, in process innovation, a company would compete with other companies by increased quality and cost reductions.

The companies investigated generally focused on product developments based on the requests from customers as Pavitt et al. predicted as Specialised Suppliers should do (Pavitt, 1984, Robson et al., 1988). The results of the research are shown in Table 5-3.

However, the current research found one slight difference from the prediction. In addition to responding to customers' requests, some companies investigated developed new products intentionally and autonomously. These companies developed their innovative products more intentionally and without receiving customers' requests. They often anticipated the potential needs of customers and developed new technologies intentionally. Even though, interestingly, both groups shared the same attitude towards challenging orders.

[22] The Oslo Manual 2018 reduces the categories of innovation from four (product, process, organisational and marketing) to two (product and business process) to avoid ambiguity. The current research follows their practice.

Table 5-3. Relative Balance between Product Innovation and Process Innovation

Name of the Company	Fit to the Taxonomy	Product or Process Innovation	reasons for developing innovations
Art	Yes	Product innovation based on process innovation	Requests from others/ Own initiative
CERARICA NODA Co., Ltd.	Yes	Product innovation	Requests from others/ Own initiative
EGURO Co., Ltd.	Yes	Product innovation	Requests from others
Fuji Lace	Yes	Product innovation based on process innovation	Requests from others
Ishikawa Wire Netting Co., Ltd	Yes	Product innovation	Requests from others/ Own initiative
MASUKO SANGYO CO., Ltd.	Yes	Product innovation	Requests from others
Mitsumi MFG. Co., Ltd.	Yes	Product innovation	Requests from others
Firm-X	Yes	Product innovation	Requests from others/ Own initiative
Saito Seisakusho Co., Ltd.	Yes	Product innovation	Requests from others
San-M Package Co., Ltd	Yes	Product innovation based on process innovation	Requests from others/ Own initiative
TAKANO Co., Ltd.	Yes	Product innovation	Requests from others/ Own initiative
TANOI MFG. CO., Ltd.	Yes	Product innovation based on process innovation	Requests from others/ Own initiative

Source: Prepared by the author of the current research

Art developed its special dyeing and coating technology for high-temperature durable textiles internally. The company CEO said he preferred taking challenging orders in their heat dyeing and coating processing services field. According to him, if the company always accepted challenging orders, existing and potential customers would come to his company whenever they had such orders, which competitors often did not accept. In this way, Art can accumulate unique technological experience, avoid cost competition, and establish its reputation.

When Art developed the new method of extracting sericin from silk cocoons, the project was started as a collaboration of textile companies in the neighbouring area and the (Japanese government) Industrial Research Institute of the prefecture[23]. A technical officer of the Institute initiated the project to develop a new usage of silk cocoons to revitalise the textile industry and reduce waste. As a result, Art is the only company that succeeded in developing sericin extracting technology.

After developing the unique way of extracting sericin from cocoons, the CEO of Art tried to

[23] Industrial Research Institutes are governmental research and industrial testing organizations established by the Japanese government or the prefectural government. These organizations are closely connected to the central government especially to Ministry of Economy Trade and Industry.

find its usages. First, he considered producing silk-touch cotton clothes by using sericin coating. His idea was to add a silk-like feeling to cheaper materials. He produced sericin coated ladies' underwear and asked his employees to test them. One of the employees reported to him that her allergic reactions ceased after using the samples. The CEO of Art started to examine the effect by asking for scientific testing from external research institutions. Then, he confirmed the effect of lowering allergic reactions from the sericin and started to develop a way to use sericins for people who suffered from various allergies. Currently, the company provides the sericin technology to other companies that apply it to towels, soaps and cosmetics companies.

CERARICA NODA produces a variety of natural wax products based on its requests from customers. In addition, the company autonomously researched the nature of natural waxes and found new possibilities in natural wax usage and made proposals to customers. For example, the company's current CEO found the new idea of using natural waxes for CD-ROMS, DVDs, and portable photocopiers (as special toner). Therefore, the CEO approached customers to develop the new products by using the products of CERARICA NODA.

In EGURO, the chairman said the company accepted any orders from any customers, as long as the order was calculated as profitable. The company is relatively passive among the companies investigated in the current research.

In the case of Fuji Lace, customers visit the company when they have specific and complicated orders, which other companies could not accept. In addition, public organisations such as the Industrial Research Institute of the prefecture often consulted with the company. Such public institutes often work as middle agents connecting a private company to another private company. And thus, these institutes came to consult Fuji Lace when they received requests from enquiring companies capable of new product development.

As described above, the former CEO of MASUKO SANGYO, the father of the current CEO, developed his first non-porous artificial grinding stones based on the requests of a university professor. The current CEO developed the company's second main product line of cutting machines in response to customer requests. Such rotating cutting machines are challenging to manufacture, and only one American company produced such machines at that time. Japanese customers of the cutting machines had problems repairing their machines because they needed to send the machine to the USA and waited several weeks for its return. They consulted MASUKO SANGYO and asked if MASUKO SANGYO could produce the same type of machines in Japan. The CEO of MASUKO SANGYO accepted their requests and had attempted to develop such cutting machines over several years, and finally became the

second company producing high-speed rotating cutting machines in the world. In other words, MASUKO SANGYO challenged itself in response to the needs of Japanese industries.

Mitsumi MFG is famous for its technological superiority in oil-free vacuum pumps. The company's CEO said he would accept any requests as long as the requests were not suspicious. The company has never given up developing requested vacuum pumps once an order has been accepted. Customers came to Mitsumi MFG to order vacuum pumps with complicated specifications that other companies could not accept. The CEO of Mitsumi MFG said he would be motivated in developing challenging to make products, especially when the product would benefit society.

San-M Package produces medical-grade masks receiving specific orders from multiple customers. As an OEM manufacturer, the company produces non-woven fibre masks with various specifications. In the sense of materialising customer requests into products, the company is a solution provider and could be positioned at the border of Specialised Suppliers. The company could be transformed into another type of Specialised Supplier, machinery producer when the company developed the applied technology of ultrasonic welding machines to non-woven fabrics. The difference is that instead of selling the machine as one of its products, the company became an OEM manufacturer selling its manufacturing services to customers. Nowadays, instead of developing new products receiving customer pressure, the company advises customers to materialise customers' ideas into actual products. Customers even ask San-M Package to send their salespeople to their business negotiations since San-M Package's staff are more knowledgeable than customers on the nature of non-woven fabric productions. Although the CEO of San-M Package says its technology is the one that can be imitated easily, and thus the company never shows production lines in its factory to customers[24], the company has proven its superiority in process technology under the current COVID-19 situation. After the outbreak of COVID-19, the Japanese government asked several large manufacturers to produce non-woven fibre medical masks. SHARP, one of the largest electronics companies with extensive cleanroom facilities, accepted the request and started producing the mask. The company established new automated production lines in its cleanrooms and provided non-woven fibre materials. However, the SHARP product package contained several defective masks; two to three masks were melted together in a package.

TANOI MFG started to produce taflets, screw taps, and thread cutting dies when Japanese

[24] The company prepared a promotion video and shows the video to customers. When the author of the current research watched the video, the camera angles are well considered and the details of the production lines are vague.

companies imported them from other companies. In this sense, the company started its business in response to the potential needs of Japanese manufacturers. Since then, the company has produced these screw taps and cutting dies, receiving orders from other companies. According to the company chairman, the company tries to provide better solutions to customers. He said some complex orders could not generate profits but became precious opportunities for developing new technologies. In addition, the company pursues increasing processing speed, making multiple functions into one product, and making tools into tiny sizes. Examples of the products achieving two different manufacturing processes are seamless taflets, burr-less taflets, multitaps, and multi-spiral taps. As such, TANOI MFG started to respond to the potential need of Japanese manufacturers, improved and developed its technologies in response to customers' needs, and nowadays, the company has developed innovative tools through its initiatives.

As explained above, most of the companies investigated in the current research started developing their innovative products based on customer requests. Thus, they indeed received pressures from customers to develop innovative products or solutions for customers as Pavitt's et al. predicted (Pavitt, 1984, Robson et al., 1988). However, some of the companies investigated moved to the next stage of developing new innovative products through their initiatives. One interesting common characteristic is that the companies investigated, possibly categorised as Specialised Suppliers in Japan, prefer taking challenging orders. In this way, the companies can develop new technologies and accumulate know-how that other competitors do not have.

5.2.3. Source of Technology

Pavitt (1984) analysed the "sectoral sources of technology used in a sector" and considered that each category had particular sources of product and process technologies. He said research and development laboratories and production engineering departments were the prime internal sources of technology, and suppliers, users, and governmental research institutes were the external sources of technology (Pavitt, 1984).

Pavitt, Robson, and Townsend (Pavitt et al., 1989, p 85) said Specialised Suppliers mainly focused on product innovation, and the main sources of technology for the innovation were the "firm's design office" (in-house) and the "production engineering and system activities of customers" (external). This consideration reflects their understanding of the relationships between Specialised Suppliers and their customers. In their view, Specialised Suppliers provided innovative inputs, such as equipment and instrumentation, used for process innovations of their customers. Their often larger customers, in return, provide

"operating experiences", "testing facilities", and even "design and development resources" to the Specialised Suppliers. Pavitt said these relationships were "close and complementary" (Pavitt, 1984).

As described in the previous section, all the companies investigated in the current research focus on product innovation, which fit the predictions in Pavitt's taxonomy. Also, all the companies investigated in the current research provide unique inputs, including innovative processing services, to customers as Specialised Suppliers as also were predicted to be. Therefore, this section moves to examine where these companies acquire technology inputs for their innovation.

Table 5-4 summarises the organisational settings for product development activities in the companies investigated and the ways of developing innovative products.

Table 5-4 Organisational Setting for Technological Developments

	Name of the Company	Number of Employees	Existence of Design Office	Number and Qualification of Staff in the Office	People in Charge of Technological Development
1	Art	15	No		CEO (technical high school)
2	CERARICA NODA Co., Ltd.	20	Yes: research and quality control office (RQC)	Five graduate students (science majors)	CEO (science university), RQC, technological sales
3	EGURO Co., Ltd.	180	Yes: design office	20 university engineering graduates and other majors	CEO, design office, production departments
4	Fuji Lace	20	No		CEO (commercial high school)
5	Ishikawa Wire Netting Co., Ltd.	35	No		CEO
6	MASUKO SANGYO Co., Ltd.	25	Yes: technology staff in the production department	Four high school graduates (not engineering)	CEO, technology staff
7	Mitsumi MFG. Co., Ltd.	28	No		CEO (engineering university)
8	Firm-X (undisclosed)	15	No		CEO (junior high school)
9	Saito Seisakusho Co., Ltd.	59	Yes: development/ planning staff in the sales department	One or two (not confirmed)	(not confirmed)
10	San-M Package Co., Ltd	150	Yes: research and development, design and development (D&D)	One university, three high schools	CEO, research and development
11	TAKANO Co., Ltd.	120	Yes: development	One engineering university	CEO, development department
12	TANOI MFG. Co., Ltd.	161	Yes: development and design	Five engineering high schools and above	CEO, D and D, technological sales

Source: Prepared by the author of the current research

Firstly, considering the internal source of technology, as far as an organizational setting is concerned, the companies investigated do not fit the prediction of Pavitt et al.

As table 5-4 shows, five out of the twelve companies investigated do not have an independent design office (or even a design section). Instead, in these companies (Art, Fuji Lace,

Ishikawa Wire Netting, Mitsumi MFG, and Firm-X), the CEOs are the ones who are personally in charge of both product and development.

The other seven companies have design offices or similar functional sections, though six out of these remaining seven companies have less than five people in that section. EGURO is the only exception among the companies investigated, where 20 people are assigned to its design section.

A simple assumption might be that the existence of an independent design office depends on the size of a company. When a company is small-scale, it is naturally difficult to spare and specialise limited human resources to a specific function such as a design section. It is often observed that separation of design sections occurred after a company had become larger in scale. However, there are no apparent causal relationships between a design section's existence (or non-existence) and company size regarding the companies investigated. Also, there is no clear relationship between the number of qualified design staff and the sizes of companies.

EGURO has 180 employees. The company has a design office with 20 university engineering graduates. However, companies with more than 100 employees (San-M Package, TAKANO, TANOI MFG.) have different organizational settings. For example, San-M Package has only four people in its development section, where one university graduate and three high school graduates work. Likewise, TAKANO has only one engineering university graduate working in its development department, even though it employs 120 people. TANOI MFG employs 161 people, one of the largest companies investigated in the current research. However, the company assigned only five staff to its development and design office, though all five of these people graduated from engineering high schools or above.

On the other hand, some smaller companies assigned a larger number of people to their design sections. For example, MASUKO SANGYO employs 25 people, assigning four technical staff in the production department. These four staff members are not university graduates but graduates of non-engineering high schools. CERARICA NODA assigns five science-major master’s graduates to its research and quality control office, though it has only 20 employees.

Thus, as far as the companies investigated in the current research are concerned, the size of companies and qualifications and numbers of assigned staff to the product design and development function are not strongly correlated.

There might be two reasons behind the situation. The first reason is the significant difficulty in recruiting qualified staff for SME manufacturers. Highly qualified university and graduate school graduates can find a position in a much larger company. Two CEOs (TAKANO and MASUKO SANGYO) expressed difficulties hiring qualified staff because they could not offer competitive salaries and attractive corporate benefits. The CEO of MASUKO SANGYO also said that it was easier to hire mid-career people who had trained within larger companies because it was hard to provide sufficient and costly training to new graduates as an SME manufacturer different from traditional large Japanese companies. Thus, some of the organizational arrangements and the number of qualified staff found in the current research may not be the companies' intention. Furthermore, a CEO said that even if the company could hire a mid-career engineering university graduate, such a person often would not stay in the company for a long time

The second reason is a tendency often found in innovative Japanese SME manufacturers. The founders, who are sometimes the current CEO and in other cases are the former CEO, are the ones who developed their innovative products in eleven companies investigated in the current research (Art, CERARICA NODA, Fuji Lace, Ishikawa Wire Netting, MASUKO SANGYO, Mitsumi MFG, Firm-X, Saito Seisakusho, San-M Package, and TANOI MFG) developed their first innovative products without any design or development sections. In such companies, the CEOs are generally in charge of product development in the infancy of the companies. These founders later tried to transfer their development functions into organizational settings. However, sometimes they succeeded, and other times failed.

The company that assigned multiple people to its product development section had its reason. For example, in CERARICA NODA, the company needs to explore and examine the nature of natural waxes to produce high-quality products continuously since the qualities and natures of natural waxes are not always the same. EGURO, for another example, worked closely with its customers to develop customised machine tools that fit each customer's specific requirement. Therefore, the company needed 20 people working together.

TAKANO has a more centralised setting for product development. The company has several sales branches over Japan, and people working at each branch regularly visit its customers to provide after-sales technical support, parts sales, and to get new orders. The new orders and requirements of customers are gathered at the headquarters, and the CEO and one staff assigned to product development work together on order. Because of the organizational setting, TAKANO does not need much staff in its product development section.

There is no typical organisational setting among the companies investigated differently from what Pavitt, Robson, and Townsend (Robson et al., 1988) predicted. In addition, people who do not have engineering or science educational backgrounds are sometimes in charge of product development in these Japanese companies.

A possible answer to the different institutional setting from the prediction in Pavitt's taxonomy is the difference in the education system and labour market structure between western countries and Japan. A job-specific recruitment system is not applied to university or high school graduates in many cases in Japan. Instead, companies recruit new graduates mainly in April and train them internally through in-house training and a job rotation system. As a result, there is no clear division of labour in typical Japanese companies, especially in SMEs, except in particular functions such as chemical research. On the other hand, the highly specialised education system and a more evident division of labour in western countries require an apparent organizational setting of product development sections, like a design office. This issue could be better explored in other research opportunities.

Concerning the external source of technology, Pavitt, Robson, and Townsend (Pavitt et al., 1989, p85) considered "production engineering and system activities of customers" external technological sources. They said the often larger customers allowed Specialised Suppliers to use their production lines to develop and test specialised inputs. In addition, they said that the customers sometimes even provide support to Specialised Suppliers in developing innovative products.

The current research findings show slightly different situations. It seems only EGURO and TAKANO are the companies that fit this prediction well. The CEO of EGURO said the company works closely with the factory engineers of its customers. The company sends its engineers to customers' factories to install and adjust its machine tools to the customers' requirements. In addition, EGURO regularly visits customers to check its machine tools. TAKANO makes its salespeople in regional offices visit its customers regularly to follow up on its products, metal parts, and metal moulds. Through regular visits to each customer, the company gathers ideas for improving its products. However, these two companies did not say if they had received support from large customer companies.

There are contrary examples that appeared in the findings. The CEO of Mitsumi MFG said that he would intentionally avoid support offers, either financially or practically, from customers. He said that once the company receives support from customers, the customer might put some restrictions on the products of Mitsumi MFG in sales or technical licenses. Thus, the company has tried to avoid any support from customers. Mitsumi MFG had once

faced financial difficulties after a customer found a defect in its pump. As a result, Mitsumi MFG borrowed money from a bank, declining financial support from that customer.

The case of Mitsumi MFG might be an extreme example. However, the companies investigated in the current research generally tried to maintain neutral positions among their customers. The findings revealed one of the reasons for keeping neutral positions. The CEO of EGURO explained that the company works with both large companies and SMEs. When EGURO developed a new machine for a large customer, it usually generated a profit since the large customers need many of the same machines. However, when EGURO developed a new machine for a small company, it was hard to profit from that business alone. Thus, EGURO tries to sell similar machines to other companies in the same industry to secure its profits. Therefore, for a small company, it is better to be neutral among various customers keeping the possibility to sell their refined products freely.

A surprising finding of the current research is about the external sources of technologies. Although Pavitt, Robinson, and Townsend (1989) considered that Specialised Suppliers acquire technology from "the production engineering and system activities of customers", the companies investigated do not often get technologies from outside their companies. Furthermore, none of the companies investigated said they had experiences in acquiring technologies from their customers.

On the contrary, some of these companies (CERARICA NODA, Fuji Lace, MASUKO SANGYO, and TANOI MFG) even provide technical consultations to their customers. For example, as described before, CERARICA NODA found new ideas using natural waxes and brought them to large manufacturers. Likewise, Fuji Lace provides consultations to the factories of several of the largest chemical companies in Japan, which provide artificial threads to Fuji Lace. As such, they are different from the predictions of the previous studies.

EGURO, a machine tools manufacturer, shows a very close pattern to the prediction in Pavitt's taxonomy. The company closely works with its larger customers, and they develop new machinery together. However, even in this case, the one that develops new technology is not the production engineering department of the large customer but EGURO, though those large customers allowed EGURO to install its machinery into their factory lines for testing as Pavitt' taxonomy predicted.

When the current research explored the external source of technologies more, it found different situations in their past. The companies investigated acquired technologies from external organizations when they had developed their first innovative products. For

example, Art, MASUKO SANGYO and TAKANO sought technical advice on product developments from external research institutions. Also, Art, CERARICA NODA, and TANOI MFG have experiences in collaborative research with a university to develop their core technologies.

Nowadays, their relationships with external research institutions have changed from those in the past. After developing their first innovations, the companies have deepened those technologies through practical applications of such technologies. Then, after several years, these companies established technological advantages even to their often larger customers. In this stage, the relationship with customers and external research institutes became more equal-like partnerships. What these companies still need is testing fields of their products in their often larger customers' factories.

After reaching that stage, they work less often with research institutions and use those institutions only when the companies need highly scientific tests; for example, CERARICA NODA asked for genetic analysis of natural waxes from a university.

The findings of the current research do not well fit the prediction of Pavitt's taxonomy. Although the companies investigated acquired the essential technologies from external sources, typically public research institutes or higher education facilities, they continued developing technologies independently after establishing core technology. From that stage, sources of internal and external technologies are different from predictions of previous studies, at least among the companies investigated. It might mean sources of technologies are not the necessary conditions of being Specialised Suppliers. In other words, there are various ways to acquire and develop technologies for innovations.

5.2.4. Type of Users

All companies investigated target performance-sensitive customers that seek specific solutions from these companies investigated. When closely observed, there are probably three types of performance sensitivity that these companies investigated to attract customers.

The first type is that these companies investigated provide products with far better performance than competitors. In other words, their products outperform competitors. As a result, customers prefer to purchase the companies' products even if those products are often more expensive than competitors' products.

The story of Firm-X is probably an excellent example of such a product and an exciting example of how these companies can attract performance-sensitive customers rather than

price-sensitive ones.

As described above, a diamond-cutting machine of Firm-X is a type of bandsaw machine. Bandsaw machines are not complicated and are produced by many manufacturers, including SMEs and large machining tool companies. Some of these manufacturers produce (they called) diamond-cutting machines, too. Even a university lecturer established a company producing similar diamond-cutting machines after visiting Firm-X. It implies the diamond-cutting machines of Firm-X look simple enough to imitate easily.

When a Japanese national research institute sought a bandsaw for their research expedition, Firm-X and the imitator of Firm-X remained on the shortlist. After some consideration, the research institute bought the diamond-cutting machines from the imitator since the company offered significantly lower prices than Firm-X. The chairman of Firm-X never decreased the prices of his machines and never complained to the imitator, a former university lecturer who studied Firm-X. Firm-X's chairman says he had absolute confidence in the performance of his diamond-cutting saw, and thus he did not decrease the price offer nor complain to the imitator.

After two years, the same research institute came to Firm-X and bought its diamond-cutting machine. A research officer of the research institute told the chairman that there had been many problems with the other company's machine. Then, they realised the value of the Firm-X machines. Therefore, after two fiscal years, as soon as a new budget was secured, the institution returned to Firm-X to purchase its diamond-cutting machine. They said they would like to buy three machines; one for daily research activity and two for backups since they work in remote land under harsh weather conditions, and it would be difficult in returning to Japan soon.

Firm-X's chairman, surprisingly, withdrew the order of three diamond-cutting machines. Instead, the CEO offered the institute the sale of one machine and kept a precise copy of the machine in his office to examine the problem when a customer faced one and contacted him. In reality, no serious problems happened with the diamond-cutting machine for the next two years.

One researcher of this institute was so impressed by the machine of Firm-X. At an international research conference, the institute introduced Firm-X's machine as a part of its members' research presentations, though the chairman of Firm-X did not ask for it. The institute researcher said they could finish their research project in two years rather than the expected 10-years by using the diamond-cutting machines of Firm-X.

After the conference, several research institutions of foreign nations came to buy the diamond-cutting machines from Firm-X. But, again, surprisingly, the chairman of Firm-X did not sell his machines to them. Instead, he told these new (and potential) customers to borrow the machine from the Japanese institute whenever necessary. The chairman is confident in the durability of his machines. He believes his machine will not break even if several research institutes share one machine and use it more frequently and for some time. Naturally, then, such a story increased the reputation of Firm-X and its machines.

The story implies that performance-sensitive users choose Firm-X. At the same time, Firm-X intentionally let potential performance-sensitive customers realise the value of Firm-X's products. Moreover, considering the lifecycle cost, the machine of Firm-X might be cheaper.

The cutting machines of Firm-X are much more expensive than similar machines since the chairman included all the development costs in the retail price. The chairman of Firm-X never intended to get into price wars. In other words, the company intentionally targets performance-sensitive and neglects cost-conscious customers. However, if the machine over-performs competitors' machines and achieves extreme durability, the total life cycle costs become cheaper. In this sense, the customers of Firm-X are both performance-sensitive and cost-sensitive.

A similar situation is found in Saito Seisakusho. The company produces micro drill bits. Except for its finest micro drill bit of 0.05mm, micro drill bits can be manufactured easily using modern CNC machining tools. Many competitors produce micro drill bits using CNC machines through cheap labour and sell them much cheaper than Saito Seisakusho. The prices of Saito Seisakusho's drill bits are almost ten times those of competitors' products. Even so, loyal customers purchase drill bits from Saito Seisakusho regularly. According to Saito Seisakusho, its products overperformed competitors' products in precision and durability, together with extensive product line-ups. Manufacturers prefer quality and durability because of the cost of stopping production lines frequently to change broken drill bits and the reproduction cost of defective products caused by lower precision drill bits. Customers of Saito Seisakusho are also not only performance-sensitive but also cost-sensitive ones.

TANOI MFG's high precision screw taps do not need additional finishing work. Thus, even if they are more expensive than competitors' products, customers purchasing TANOI's products may reduce total production costs: another example that high-performance products can decrease costs.

The second type of performance sensitivity is to seek “only one” product. For example, Art is the only company that can coat and dye special polymers for artificial clothes. It also developed a unique method of extracting sericins from cocoons. Fuji Lace is also the only producer of lace materials used in the space industry. Several companies investigated the current research (Art, Fuji Lace, Ishikawa Wire Netting, MASUKO SANGYO, Saito Seisakusho, TANOI MFG) produce “only one” product.

The third type is that a company provides a one-stop service in a particular product area. Customers come to these companies investigated since they can find a solution and do not need to search around. For example, CERARICA NODA produces significantly wide varieties of natural waxes in various forms. The company is the only company that deals with five different types of natural waxes. Therefore, customers can find the most suitable wax for their designed products by visiting CERARICA NODA.

Such product coverage is typically seen among the companies investigated in the current research. For other examples, Ishikawa Wire Netting deals with a wide variety of wire nettings. Saito Seisakusho produces more than 6,000 drill bit items in various sizes. MASUKO SANGYO has more than 200 varieties of non-porous grinding stones. Customers can find a unique solution for their needs by only visiting one company.

The current research findings show that these three types of performance sensitiveness are not exclusive. Table 5-5 shows the situation.

Table 5-5 Three Types of Performance and the Companies Investigated

	Name of the Company	Outperformance	Sole provider	One-stop
1	Art	Dyeing and coating	Sericin extraction	
2	CERARICA NODA CO., Ltd.	Fine (and stable) qualities	Extreme fine natural wax powders	All five natural waxes
3	EGURO	Higher precisions in machine tools		Various machine tools
4	Fuji Lace	High performance in lace weaving technologies	Unique clothes for the space industry	A variety of lace weaving knowledge
5	Ishikawa Wire Netting		Steel wire paper for Origami	All types of wire nettings
6	MASUKO SANGYO	Griding machines/ cutting machines which other companies cannot produce	Non-porous grinding stones/ cutting machines	200 non-porous grinding stones
7	Mitsumi MFG	Oil-free Vacuum pumps which other companies could not manufacture		Provide any solutions in oil-free vacuum pumps
8	Firm-X	Diamond-cutting machines of extreme performance	Hardened steel sash cutting machines	
9	Saito Seisakusho	Ultra-fine micro drill bits	Ultra-fine micro drill bits	6,000 (micro) drill bit items
10	San-M Package		Non-fibre mask production services	More than 1,000 types of mask item production
11	TAKANO CO., Ltd.		Oil-free parts for the food industry	
12	TANOI MFG	High precision screw taps and thread cutting dies	Screw taps and thread cutting dies used for CNCF	Wide varieties of screw taps and thread cutting dies

Source: Prepared by the author of the current research

5.2.5. Means of Appropriation

Pavitt said that "secrecy, process know-how and lengthy technical lags are not available to the same extent as a means of appropriating technology" for Specialized Suppliers as the large producers do. Also, he said the large producers use patent protection to protect imitations (Pavitt, 1984, p359). Therefore, as a means of technological appropriation, Specialized Suppliers largely depend on "firm-specific skills reflected in continuous improvements in product design and product reliability, and in the ability to respond sensitively and quickly to user's needs" (Pavitt, 1984, p359)[25].

The findings of the current research generally fit these predictions. Table 5-6 shows the summary of three areas of appropriation.

25 It should be noted that Pavitt also listed up patents on the summary table (Pavitt 1984, p354, table 5 Sectoral Technological Trajectories)

Table 5-6: Ways of Technological Appropriation

	Name of the Company	Specific Skills	Response to Users' needs	Patent
1	Art	Yes	Yes	Yes (occasionally)
2	CERARICA NODA CO., Ltd.	Yes	Yes	Yes (stopped using it)
3	EGURO	Yes	Yes	Yes (occasionally)
4	Fuji Lace	Yes	Yes	Yes (occasionally)
5	Ishikawa Wire Netting	Yes	Yes	No
6	MASUKO SANGYO	Yes	Yes	Yes (stopped using it)
7	Mitsumi MFG	Yes	Yes	Yes (stopped using it)
8	Firm-X	Yes	Yes	Yes (stopped using it)
9	Saito Seisakusho	Yes	Yes	Yes (details unclear)
10	San-M Package	Yes	Yes	Yes (stopped using it)
11	TAKANO CO., Ltd.	Yes	Yes	No
12	TANOI MFG	Yes	Yes	Yes

Source: Prepared by the author

All the companies investigated hold specific skills and produce innovative products or provide innovative processing services. For example, Art holds special heat dyeing and coating technologies. Based on this knowledge, the company developed a sericin extracting method. CERARICA NODA has a deep and comprehensive knowledge of natural waxes. EGURO has a way of producing extreme precision in machine tool production. Fuji Lace is a specialist in lace weaving and holds a deep knowledge of the nature of various kinds of threads and weaving patterns. As such, each company has a unique area of knowledge and skills.

The findings of the current research show that all the companies investigated work closely with customers. Also, they made continuous efforts to respond to the various needs of customers. For example, some companies investigated assigned people to follow up on customers regularly, like TAKANO, which has ten sales branches, and 20 people regularly visit customers to follow up on their needs.

EGURO also regularly visits customers' factories to check the conditions of their machine tools. According to the chairman of EGURO, the company works with customers closely until they can develop the exact machine tools they want. Also, he says the company helps customers re-adjust or even modify EGURO's machines when they have changed their products. Since a large machining tool manufacturer likely never follows up with the machines once sold to customers without additional contracts, this time-consuming and kind support differentiates EGURO from them.

Other companies like MASUKO SANGYO, Firm-X, Saito Seisakusho, and TANOI MFG sell spare parts regularly and keep in touch with their customers. TAKANO even sends its employees to help and participate in its customers' socializing activities, like parties and sports events for customers' employees. The CEO of TAKANO says it is better to have face-to-face relationships with customers since it has a better chance of getting orders when the price is the same as competitors. The large competitors sell their products through trading companies so that they can minimize their tasks. However, people often prefer to place orders to the people they know well. Also, the CEO of TAKANO added that the company occasionally gets weak signals of potential orders and needs

through these strong human ties with customers. TANOI MFG also sends its people the company calls “Doctor Sales” to customers regularly to follow up on its parts’ performance. The chairman of TANOI MFG says the small company has an advantage of entering inside customers’ factories. Large companies usually allow small companies to walk into their factories though they never allow large competitors to do the same. Also, he says that being able to walk into customers’ factories is proof of established trust with customers.

These findings suggest that the companies intentionally followed up on their customers and established closer relationships. As a result, these companies get rich information on customers’ needs and potential ideas for new product developments through tight customer relationships. On the other hand, large companies usually avoid close and ‘toiled’ follow up activities, seeking efficiency in their activities. Thus, a small company might have a better chance of getting into customers’ factories and getting rich information.

Another way of responding to customers’ needs is that the companies investigated in the current research prepare various products. Large companies tend to narrow down their product line-ups to improve their productivity and efficiency in their operations. However, these small companies investigated prepare a wide variety of products, even though customers occasionally purchase some.

Saito Seisakusho produces more than 6,000 items of drill bits. The CEO of Saito Seisakusho explains its strategy using an analogy. He says a large menswear retailer prepares only several sizes of suits. As a result, their suits are ‘wearable’ to most customers, but not the bespoke size for each customer. Saito Seisakusho prepares a large variety of products so that each customer can find just what they want. The company also sells its drill bits starting at only one piece to customers. TAKANO produces mould parts. Concerning mould parts, although large standard parts suppliers can produce custom parts, they do not prefer to do this, especially if an order is for a small lot. Large mould parts suppliers sell many standardized parts by mail order to minimize their sales costs. As a result, one customer needs to order custom parts from other companies separately. For large companies, narrowing down product line-ups means efficient operations and minimizing the risk of dead stock. Usually, large companies do not want to take small lot orders. TAKANO takes a different approach and provides both standard and custom mould parts. It also provides oil-free parts in a small lot and self-oil-free solutions to customers. MASUKO SANGYO prepares more than 200 different grinding stones. Thus, each customer can find a suitable combination of grinding stones.

It seems that to produce a wide variety of products, some of which might be purchased quite rarely, is costly and requires a lot of labour. In other words, such a choice reduces operational efficiency in a company, and thus large companies usually avoid doing this. However, if a company has confidence in the product quality and performance and can sell those at higher prices, preparing a wide variety of products could be a strategy to differentiate the company, a strategy for Specialized Suppliers.

Concerning patents as a means of technological appropriation, only one company (TANOI MFG) usually registered its innovations into the patent system. The other three companies (Art, EGURO, and Fuji Lace) registered their innovations only when developing them with other public or private organisations, and these counterparts wanted to register. The remaining six companies (CERARICA NODA, MASUKO SANGYO, Mitsumi MFG, Firm-X, San-M Package, and TAKANO) used the patent system before but stopped using it. Saito Seisakusho uses patent systems, but its details are not evident in the current research. There is no information concerning the patents of Ishikawa Wire Netting in its primary products areas. Therefore, the usages of the patent system seem not as predicted by Pavitt et al. Instead, the majority of the companies investigated show reluctance to use the patent system. They consider the industrial patent system an inadequate way of appropriation technology because several problems exist in Japan's current industrial patent system.

TANOI MFG registered many innovations into the patent system. However, the company even faced the problems of registration. After the company registered its innovation into the system, one Chinese company started producing imitations of TANOI MFG's standard items and sold them at lower prices. TANOI MFG did not find it serious since this Chinese company could not imitate TANOI MFG's unique tools, even looking at the patent documents. The chairman of TANOI MFG says if competitors imitate TANOI MFG's products looking at the patent documents and that the imitators' products are superior in quality to TANOI MFG, he would accept it. These words of the chairman imply his confidence in the company's technological superiority. In other words, TANOI MFG is confident that competitors could never be able to copy their innovation only by looking at the patent documents and thus usually registered their innovations.

It seems other companies generally do not actively register their innovations. For example, three companies registered innovations developed with partners only. Art registered the patent for its sericin extracting technology which the company developed with a governmental research institute. EGURO and Fuji Lace registered when their development partners wanted to register.

Some other companies stopped using the patent system once or a few times. For example, CERARICA NODA registered. However, today, the CEO considers it better not to register industrial patents since they require yearly maintenance fees and can protect innovations only for 15 years. MASUKO SANGYO, another example, registered its first non-porous grinding stone in the industrial patent system. However, the patent system did not allow the company to register as a non-porous grinding stone but required detailed substances. It means that the company needed to open all chemical compositions of each non-porous grinding stone. Thus, the company stopped using the system to conceal its innovation. Most likely because the company experienced that difficulty in the patent system, the CEO took a different approach for the second innovative product of the company, high-speed rotating cutting machines. He sub-contracted more than 2,500 pieces of the cutting head parts separately to different independent manufacturers so that these sub-contractors could not understand the whole picture of the machine. Mitsumi MFG and Firm-X also said that they prefer not to use the patent system since it reveals their innovations to the public. San-

M Package also stopped using the system. When the company obtained industrial patents for the world's first ultrasonic welding machines for non-fibre fabrics, other companies imitated the machines after looking at the industrial patent. Since then, San-M Package has never registered its innovations in the industrial patent system.

TAKANO developed oil-free solutions, and special oil can be used for the food industry. The unique oil has a chemical formula. Pavitt (Pavitt, 1984, p362) claims that a patent is a vital method for the fine chemical industry to appropriate technologies. The findings of the current research show a contradictory answer. According to TAKANO, one industrial patent cannot cover all chemical technology. Under the current industrial patent system, competitors can change the chemical composition slightly and apply for new patents.

As explained above, the companies investigated in the current research prefer not to use the patent system to appropriate their technologies. These companies believe the patent system does not effectively protect their innovations from competitors.

Instead, the current research found one alternative way to protect innovations among the small manufacturers investigated. Mitsumi MFG and TAKANO said they prefer using the public record system instead of patents. The public record system does not automatically reveal its contents to the public. However, when a large company claims TAKANO's, for example, technologies as their innovation, it can prove the company registered it before. Therefore, even if it is difficult to win a lawsuit with large companies, TAKANO still can continue producing and selling these products.

To sum up the ways of appropriating technologies, the SME manufacturers probably categorised as Specialised Suppliers rely on specific skills for continuous improvement in products and quick and continuous response to their customers as Pavitt predicted (Pavitt, 1984). Also, these companies did not actively use the patent system, though large companies do. All these issues suit the predictions of Pavitt.

However, the current research also found different situations. Although Pavitt considered secrecy, process know-how, and lengthy technical lags are not applicable to Specialised Suppliers, the findings show that the companies investigated employ secrecy to protect their technologies and produce innovative products by internally modifying process technologies. Also, it seems the patent system is not sufficient for all SMEs to defend their innovations from competitors, significantly larger companies.

Therefore, the companies investigated in the current research, which are likely categorised as Specialised Suppliers, have broader ways of technology appropriation than the prediction of Pavitt.

5.2.6. Size of Company

Pavitt (1984) says Specialized Suppliers are "relative[sic] small and specialized companies that supply them with equipment and instrumentation and with whom they have a close and

complementary relationship."

As previously noted, the companies investigated are selected from SME categories in Japan. In this sense, all the companies investigated fit the prediction of Pavitt's taxonomy.

However, two groups are identified: companies always remaining small scale, and companies remaining small scale nowadays though once experienced large scale.

The majority of the companies investigated are categorised in the first group: Art, CERARICA NODA, EGURO, Fuji Lace, Ishikawa Wire Netting, MASUKO SANGYO, Mitsumi MFG, Saito Seisakusho, San-M, and TAKANO.

Firm-X was once a large company. When the company produced and exported 4,000 wig-making sewing machines per month, the company was much larger, with eight departments. Then, one day, an employee the chairman of the Firm-X trusted embezzled a large amount of corporate money and fled. Another time, the company faced fraud. After that, the chairman decided to separate the company into four small companies and share one by one with three younger brothers. Since then, he has kept his company on a small scale. Also, TANOI MFG was once a large tool manufacturer. Then, the company faced financial difficulties and became smaller. The company has remained small since that time. These findings imply the small scale of the companies is not a necessary condition for being a Specialised Supplier. TANOI MFG, for example, provided screw taps and cutting dies while the company was large, too. If the company provided such similar products, the company was a Specialised Supplier at that time, too.

However, TANOI MFG remains small after the company once became much smaller. Thus, there are probably good reasons for remaining small or preferring to remain small as Specialised Suppliers. This question will be answered in one of the following sections.

5.2.7. The Border of Specialised Suppliers

The previous section tested the fit of the companies investigated against the prediction concerning characteristics of Specialised Suppliers. Table 5-7 summarised the examinations.

Suppose we define Specialised Suppliers' fundamental characteristic as providing (innovative) inputs to other companies to improve quality and production efficiency. In that case, all the companies investigated in the current research are categorised as Specialised Suppliers.

However, as table 5-8 shows, some of the examined five characteristics of the companies investigated do not fit the predicted characteristics of Specialised Suppliers.

Regarding industrial sectors, four companies belonged to the industrial sectors considered typically in Supplier Dominated. All of these four companies show the characteristics of Specialised Suppliers, and thus, typical industrial sectors in four categories of Pavitt's taxonomy could be widened. Four companies investigated in the current research could be both Supplier Dominated and Specialised Suppliers since they all show characteristics of both categories. Art and Fuji Lace, for example, used standard machinery and modified them and found specific ways to use them to produce innovative products. Since they use de-facto standard machinery and provide raw materials, they are also categorised as Supplier Dominated.

Considering the findings, the balance between product development and process development seems too simple a separation. Furthermore, the current research found that some companies achieved product innovation, or producing innovative products, by modifying manufacturing processes, i.e., process innovation. Thus, this item is also not a necessary condition for being a Specialised Supplier.

Regarding technology sources, the companies investigated rely on internal design ability to develop product innovation, while they do not get technology from outside, except in the early stages of the companies' development. Although they need a testing field in their customer factories, they are the ones who develop and provide process technology.

Means of appropriation of technology are generally the same as the condition predicted with some broader interpretations. The companies investigated rely on their specialised skills and continuous product improvements working closely with customers. However, patents are not preferred technological appropriation methods, but they still prefer secrecy and technological advantages.

The size of companies is small. However, some companies investigated were once large, and small size is not an actual condition of being a Specialised Supplier though it seems they prefer to be.

To sum up, as far as the companies investigated in the current research are concerned, Specialised Suppliers are not sufficiently defined by industrial sectors, source of product and process technologies, and company's size. However, it seems Specialised Suppliers rely on internally developed unique skills to improve products and work closely with their customers. Moreover, probably, they prefer being small scale.

The following section attempts to explain the reasons behind these characteristics based on some current research findings.

Table 5-7 Fit to the Characteristics

	Name of the Company	Industrial Sector (Category in Pavitt's taxonomy judged by the industrial sector)	A balance between Product Innovation and Process Innovation	Source of Technology	Means of Appropriation	Size of Company
1	Art	Supplier Dominated	Product innovation based on process innovation	In-house: Trial and error by the CEO	Continuous improvement /quick responses/ technological lag	Small
2	CERARICA NODA CO., Ltd.	Supplier Dominated	Product innovation	In-house: accumulated knowledge in the organisation	Continuous improvement /quick responses/ technological lag	Small
3	EGURO Co Ltd.	Specialised Suppliers	Product innovation	In-house: design office	Continuous improvement /quick responses/ technological lag	Small
4	Fuji Lace	Supplier Dominated	Product innovation based on process innovation	In-house: Trial and error by the CEO	Continuous improvement /quick responses/ technological lag	Small
5	Ishikawa Wire Netting	Specialised Suppliers	Product innovation based on process innovation	In-house: Trial and error by the CEO	Continuous improvement /quick responses/ (N/A)	Small
6	MASUKO SANGYO	Specialised Suppliers	Product innovation	In-house: Trial and error by the CEO	Continuous improvement /quick responses/ technological lag	Small
7	Mitsumi MFG	Specialised Suppliers	Product innovation	In-house: Trial and error by the CEO	Continuous improvement /quick responses/ technological lag	Small
8	Firm-X	Specialised Suppliers	Product innovation	In-house: Trial and error by the CEO	Continuous improvement /quick responses/ technological lag	Large → Small
9	Saito Seisakusho Co Ltd.	Specialised Suppliers	Product innovation based on process innovation	In-house: Trial and error by the former CEO	Continuous improvement /quick responses/ technological lag	Small
10	San-M Package Co. Ltd.	Supplier Dominated	Product innovation based on process innovation	In-house: Trial and error by the CEO	Continuous improvement /quick responses/ technological lag	Small
11	TAKANO Co Ltd.	Specialised Suppliers	Product innovation	In-house: Trial and error by the CEO and staff	Continuous improvement /quick responses/ technological lag	Small
12	TANOI MFG	Specialised Suppliers	Product innovation based on process innovation	In-house: Trial and error by the CEO and some staff	Continuous improvement /quick responses/ technological lag	Large → Small

5.3. Additional Findings: Reasons Behind the Common Characteristics

As described above, Specialised Suppliers might not necessarily have exclusive concepts in other categories. However, necessary conditions probably still exist to be a Specialised Supplier.

Several characteristics remained common among the companies investigated:

- They provide unique and often innovative inputs to other companies so that these client companies can produce innovative products or improve manufacturing processes;
- They rely on internal knowledge and know-how to develop innovations (they do not mainly rely on external technologies provided by customers or suppliers);
- They accept orders of troublesome and laborious products, which are often those which cannot be produced or are refused by other competitors;
- They work closely with diversified customers;
- And, it seems they prefer remaining small even if they can be larger as a company and even as a Specialised Supplier.

If there is a set of shared characteristics among innovative SME manufacturers in Japan, there might be rational reasons behind it. Therefore, the current research attempts to explore some questions.

5.3.1. Development of Innovations

The first question is how these companies develop innovative products or processing services without acquiring technologies from outside. The answer that appeared in the current research is simple. Most of them spend considerable time developing their technology through trial and error.

The CEO of Art developed a unique technology of dyeing and coating to produce extreme heat resistant clothes. He also found a new method of extracting sericins from cocoons. He got advice from external research institutions, a Regional Research Institute of the prefecture, and universities to develop such technologies. However, the company did not get new technologies from them. According to the company's CEO, the main development process was through trial and error. He examines a combination of factors in coating and dyeing, such as air pressure, the temperature of dyeing solutions, machine rotation speeds, amounts of water, and varieties of chemicals. It took about ten years to develop a new sericin extraction method since many factors were interrelated.

This might fit what Pavitt, Robinson, and Townsend called “cumulative in development over

time" (Pavitt, Robson et al. 1989). They stated:

> The notion of cumulative and firm-specific technological trajectories has already entered management practice, especially in Japan, through the use of maps or graphs of technological improvement, including tree or "bonzai[sic] [26] " representations of the cumulative emergence of technological opportunities for specific firms (Pavitt, Robson et al. 1989, p 96).

The findings of the current research show cumulative ways in innovation activities among the companies investigated. The other companies investigated spent a long time developing their core technologies, sometimes even a decade.

The former CEO of MASUKO SANGYO, the father of the current CEO, developed the first artificial non-porous grinding stones in the world. A university lecturer visited his father and asked him to develop a grinding machine for food. However, it took more than ten years to produce the first non-porous grinding stone usable in the food industry. The current CEO remembered his father had repeatedly tried to produce the non-porous grinding stones devoting time and money to the extent that his family faced economic hardships.

The current CEO of MASUKO SANGYO also spent about fifteen years developing the second main product line of high-speed rotating cutting machines. About fifteen years ago, only one American company manufactured such cutting machines. So, when a MASUKO SANGYO customer asked the CEO to develop similar machines, he purchased that machine on the second-hand market, disassembled it into parts, examined it, and started developing the same type of machines by trial and error. According to the CEO, the head of the rotating cutting machine consists of more than 2,500 small parts. He visited a university, the National Institute of Advanced Industrial Science and Technology[27], and three famous brazing companies to ask how to assemble small parts into one. Nobody could answer the question. He then spent fifteen years developing his technologies for the machine. The story of MASUKO SANGYO is similar to the behaviours of SME owners. Kurosaki (2003) said that SME owners usually use various "personal networks". He also said that the SME owners contacted universities or research institutes only when they sought specific technical information (Kurosaki, 2003).

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[26] This word probably was the misunderstanding of "*bonsai* tree", which is the art of growing small trees into some images artificially. It seems Pavitt, Robinson, and Townsend intended to explain a tree diagram of *KAIZEN*, or continuous improvement activities started as a series of scientific process management techniques in the USA and established systematically in Japan.

[27] This is one of the largest public research organizations in Japan, focuses on the creation and practical realization of technologies useful to Japanese industry and society, and on "bridging" the gap between innovative technological seeds and commercialization. https://www.aist.go.jp/aist_e/about_aist/index.html

For another example, according to the current CEO of San-M Package, it took 2-3 years to develop the ultrasonic welding machine usable for non-woven fibres.

The companies investigated, innovative SME manufacturers, seem to develop their core innovations through trial and error. The CEO of TAKANO made an interesting statement on the cumulative way of developing innovation. According to him, not all companies could produce equally qualified products even using the same machines. He emphasized that it was crucial to understand how to reduce defects and improve productivity by utilising the machines through daily trial and error.

If these SME manufacturers develop their innovations by trial and error and spend a long time on development, the next and natural question is why? SME manufacturers have limited managerial resources compared to larger companies. Thus, why do they challenge themselves in developing innovations? Moreover, how could they share their limited resources on development activities?

The current research found an answer. These SMEs have no choice but to continue and finish development activities once they have started. A CEO (undisclosed) says SMEs could not afford to ruin invested resources, money, time, and other resources, and thus an SME needs to complete a product development once it has been started. It sounds like a sunk cost fallacy but probably means more for him. The CEO also said that if the company stopped product development activities halfway, it would be considered a failure. However, he continued that if the company continued until it succeeded, it became a success story. His words might be questioned in the economic sense. Spending additional money on a failed project halfway is wasting money. However, he probably meant that SMEs should be serious about starting product development activities. Also, more importantly, he has a strong determination for success spending his money for the development. In contrast, considering a large company, employee researchers might stop development efforts when the planned period finishes or the budget, which is not their private money but shareholders', is exhausted. Thus, some SMEs might be better at innovation than large companies since they continued until success.

From a different point of view, it is almost impossible to purchase costly state-of-the-art technologies for SMEs. The CEO of San-M Package said that 99% of SMEs should work practically within the technology they hold. He continued it was difficult to introduce expensive technology even if the company desired it. He shared his experience. Although he got an idea of using Charge Coupled Device (CCD) cameras for the automated final examination of production lines 20 years ago, he gave up the idea because one CCD camera

cost more than $1.6 million (USD). Today, all CCD cameras necessary to cover his factories cost just $8,000 (USD) in total, so his company could finally develop and introduce an automated CCD checking system as he had imagined before.

In other words, introducing state-of-the-art technologies is not usually an available choice for SMEs in developing innovations. Also, most likely, SMEs cannot invest a lot of money in scientific research, either. Therefore, SME manufacturers should find a way to develop innovative products by either modifying affordable technologies or developing new technologies by using their available resources. It seems these companies invest their time with solid determination for success.

5.3.2. Human Resource Development

Instead of introducing state-of-the-art technologies, the companies investigated tried to develop their human resources as an internal source of innovations.

As Penrose (1959) suggested, a company's growth is influenced by the effective usages of internal managerial resources such as human resources and time. In the case of a small company, available resources are often limited. Therefore, it is presumably more critical to effectively utilise limited resources to compete with other companies, develop innovation, and fundamentally survive.

Human resources are undoubtedly one of the most critical resources in a company of any size. It becomes much easier to develop innovation if a company has a technological genius. For example, there is the well-known story of Stephen Gary Wozniak. He designed and assembled the first Apple I and II computers alone. Apple Computer Inc. would undoubtedly not have become the technology giant today without him. However, that is an extreme example, and it usually is not easy for SMEs to recruit talented people.

The companies investigated in the current research also have difficulties recruiting qualified human resources from new school graduates and the mid-career labour market. This is because small companies generally pay less than large companies, and labour conditions are less desirable. CERARICA NODA, for example, currently hires young science-major graduates from graduate schools. However, the CEO said the company had struggled with hiring and keeping such trained staff in the past.

If it is difficult to hire highly qualified people, the companies need to improve the already hired people’s abilities to innovate. The current research found several interesting ways of education and training efforts in the companies investigated.

Some companies investigated, like MASUKO SANGYO, provide financial support and work hour flexibility so that employees can attend engineering schools or seminars. However, this is not a typical practice among the companies investigated.

The observations made by the current research found two shared practices in human resource development. The first practice is that top management, like chairpersons or CEOs, is the main staff training actor. The second is that training is not on technological knowledge but more fundamental abilities, such as open-mindedness and critical thinking.

There are several examples of direct participation of top management and focus on fundamentals. MASUKO SANGYO takes a different approach in fostering human resources. All employees need to participate in either product development or process development project activities. Every month, each project team submits a progress report. Every two months, each employee needs to report directly to the CEO. They discuss together for 30-40 minutes at that time. The CEO gives advice to each employee, and the progress is evaluated and reflected in their bonuses. In addition, the chairman of TANOI MFG visits the factory site and has 1-2 hours lunch meetings with 8-10 workers. In the meetings, they discuss product development.

5.3.3. Ideas of Innovation

However, it seems these SME manufacturers still need ideas for innovation before starting in trial and error. So, where do they find it?

The current research found several ways of getting innovative ideas. Firstly, as described above, some companies investigated work and follow-up closely with customers. So even after selling their products, they keep in touch with customers and get weak signals which lead to innovation. It is probably that a large company seeks operational efficiency and avoids troublesome projects. A large company usually wants to sell their products in large lots instead of a few pieces. The companies investigated in the current research, on the contrary, sell their product in single units to customers. Such tiresome activities give these small companies opportunities to get some inspiration for their next innovation.

Secondly, the companies investigated in the current research tend to work for different industrial sectors. The experiences of working with different industrial sectors allow them to deepen their knowledge of their product utilization. For example, the food and automobile industries require different specifications from Specialised Suppliers. Also, these small companies can easily walk into their large customers' factories since their large customers do not consider them to be a threat. Therefore, as long as these small Specialized

Suppliers are independent and keep a neutral position viz-à-viz customers, they have better chances of being close to the state-of-the-art technologies in the large companies' factories.

Moreover, the companies investigated accepted many challenging orders. Some companies even prefer them. This challenge would lead to other innovations if the company could overcome the difficulties. It might be that accepting challenging orders is a way to avoid cost competition and maintain a profit for the companies investigated.

The third and most interesting answer is observations on daily activities, which are not necessarily industrial activities. For example, the chairman of Firm-X found an idea for the core technology of a diamond-cutting machine from his childhood memory. He often observed craftsmen working in his father's small metal factory. These craftsmen used old rubber sandals to revitalize the surface of rotating files. Although the chairman did not clearly explain what it meant further, he stressed the importance of opening eyes to society and gathering information from various sources, from specialist magazines to TV entertainment programmes, newspapers, and commercial magazines. For the chairman of Firm-X, these wide ranges of information are the source of technology. According to the managing director, the CEO of Fuji Lace participates in various seminars (not only for specialists but also for general audiences), visits many museums, and visits many manufacturing sites whenever he has spare time.

Then, the next question might be, what underpinned their motivation for development over such a long time? Some companies investigated spent a considerably long time, actually years, to develop their innovations. Why could they continue their development? What underpinned their motivation for the long journey of innovation?

The current research found an unexpected answer. Social consciousness seems another factor underpinning motivation for innovation among the companies investigated. Some companies investigated clearly expressed a preference to develop products for society.

Art, for example, developed its new method of sericin extraction. The project started as a joint project with a governmental research institute and several textile companies in the neighbourhood. Several companies joined in the project. The cost for implementing the research was shared between all member companies and the institute. Within several years, all member companies except Art left the project one by one because they were tired of having no evidential achievement and wanted to stop their spending. The CEO of Art remained on the project alone since he thought the project was important for revitalisation in society. The CEO of Mitsumi MFG said he likes a challenging order, especially when it

might be useful for society.

One other extreme example was found in Firm-X. The CEO had tried to develop a new cutting machine that could cut fibre-reinforced glass. The idea was started as just a challenge for cutting materials which his existing machine could not cut. For several years, he did not succeed in developing the machine while spending a lot of money and time. Firm-X's managers, the CEO's family members, and even factory workers complained about his wasteful experiments and tried to stop them. The CEO of Firm-X was about to follow their request when the Great Hanshin-Awaji Earthquake happened. The CEO watched the tragedy of people locked up inside damaged buildings beyond reinforced windows on the TV news. Then, he changed his mind and made a plea to his company's workers, asking permission for a six-month extension of his experiment. The CEO told the author of the current research that he gave a deep bow to his workers at his factory. He succeeded in developing a fibre-reinforced glass window cutting machine soon after starting his re-experimentation. Although the company and the CEO received an honourable innovation award for the machine, this product is not profitable given its limited purposes. Nevertheless, the CEO is still proud of the machine.

5.3.4. Why Remain Small

The fourth, and my initial question, is why they prefer to remain small. Four reasons were identified.

The first reason is that the companies, primarily the CEO or the chairman, prefer small scale organizations because of manageability and the simple preference for face-to-face communication.

The second reason is the volume of their business: they cannot hire many or do not need many people. However, the third reason implies their strategic choice of remaining small-scale, which the author of the current research expected before starting the research. Finally, the fourth reason is entirely unexpected and surprising.

As for the first reason, some CEOs expressed their preferences for small-scale organizations. For example, the CEO of San-M Package believes it is essential for a company to create the condition where people within it are acquainted with one another for employees' motivation. The CEO of Fuji Lace also mentions that it is more difficult to communicate if a company becomes larger scale. The CEO of MASUKO SANGYO said he did not want to make the company larger but maintain its small size for employees to be acquainted with each other. He aimed to make his company a place where employees felt happy at work. He organizes

many socializing events such as a cherry blossom viewing party with his employees and customers and forms an amateur band with his employees. He sings his self-composed songs with others.

TAKANO's CEO says that a company would be challenging to navigate if it had more than 100 people. He even says he considers 50 people the maximum he could take care of human resource development. Concerning the second answer, the current research found that the CEO or the chairman is the main actor in developing human resources in many companies investigated. They directly try to educate and train employees, except for technical skills training on the factory site. In addition, the CEO and the chairman create or try to create institutional mechanisms for human resource development so that the top management can widen insights and deepen the considerations of employees.

The preference for a small-scale organization of the CEO or the chairman is also probably because of the significant difficulty in hiring qualified human resource personnel as candidates for future managers and training them inside their companies. The CEO of CERARICA NODA prefers around the 20-30 people scale for his company, whereby employees can be acquainted with each other. He shared his experience of the past. He says he had tried to discipline young people, for example, to wake up early in the morning. However, many young people resigned one by one. He says he learned the difficulties of fostering young people and changed his approach.

The second reason for being a small company is the volume of their business. For example, Art has hired only 15 people in total. The dyeing and coating company is located in Kiryu City, where the textile industry blossomed in the past. However, as international competition increased with Asian countries, the industry decreased its economic position, and many companies disappeared. Nevertheless, Art survived in specializing in heat dyeing and coating for synthetic fibres, which are difficult to process. The CEO says he wants to give jobs to young people and thus continues his factory, even if the dyeing and coating business sometimes runs a deficit. Since he developed new products by extracting sericins from cocoons, he can keep these 15 people in his company employed.

Although other companies investigated in the current research did not mention it, a balance between the number of jobs and employment or the scale of companies is the fundamental factor that defines the companies' size.

The third reason seems to be the strategic choice of companies. It is better to stay on a small scale to be competitive. The CEO of EGURO says it is better to remain small-scale to keep

working in a market where high precision is required and to maintain a close relationship with each customer. The CEO of Fuji Lace points out that a company needs to hire a lot more people to be a large company, which would make it more challenging for employees to communicate with each other, and the nature of the company would change. In other words, these companies investigated in the current research narrow down and focus on the specific market where each company can most effectively compete and stay profitable. When a company becomes larger, it needs to take bulky orders and enter price wars. Some CEOs says they do not want to take undesirable orders. It might also be that considering the attitudes toward receiving orders, the companies investigated intentionally narrow or even screen their target customers.

Finally, the fourth and last reason is entirely unexpected before interviewing. The CEO of Art mentioned the importance of giving jobs to young people. The CEO of Fuji Lace believes in the importance of forming an industrial cluster for regional society. Therefore, he does not accept all orders he receives but introduces other companies in the region capable of fulfilling those orders to help them survive. He says it is crucial in attracting potential customers into the area, for the regional economy, and thus for his company.

6. Conclusion

This chapter will attempt to predict a strategy underlying common characteristics among the companies investigated in the current research. In other words, I shall try to find rationality for a set of shared characteristics and especially for remaining small.

Pavitt' taxonomy and subsequent studies (Pavitt, 1984, Robson et al., 1988) show commonality statistically sufficient. The current research found the reasons why Specialised Suppliers show the commonalities. Also, the current research argues there is a possibility that Pavitt's taxonomy is not the taxonomy but a typology based on the example of companies that could be categorised both in Supplier Dominated and Specialised Suppliers as discussed in the previous chapter. These companies investigated developed innovative solutions by modifying standard machinery and found the combinations of factors in the production process to innovate. Thus, more important factors to be Specialised Suppliers are probably how a company focuses on achieving innovations. The following sections will discuss the points.

6.1. Specific Technology rather than Niche Market

It seems that the companies investigated prioritize "specific technology" rather than "niche market". As to markets or customers, they prefer to work in various industrial sectors. By working with different firms in different industries, these Specialised Suppliers in Japan can develop versatility in their products or services. They typically have core technology and have worked in diversifying their adaptations for different purposes.

They developed these core technologies basically through trial and error of prolonged struggles. Because they are SMEs, they have no respite in giving up on their chosen technologies and thus, they could succeed in developing competitive technologies. As a CEO pointed out, although large companies tend to stop their technological developments after a few years, and people in charge are changed every few years, SMEs cannot have the luxury of abandoning research and development once it has started. Additionally, they have few human resources allotted to these activities. As a result, an SME that started research and development needs to finish it to the end. In sample firms, they have spent a considerably long time, sometimes more than ten years, developing their core technologies on which they now rely. In other words, SME manufacturers can only spend time and ideas to develop innovations. Instead of acquiring state-of-the-art technologies, they try to modify standard machinery and find combinations of factors, such as temperature, processing time, combinations of ingredients and materials, to develop new "technology". To find the solution, they invest their most affordable resources, their own time, in development activities.

It seems that to sharpen and strengthen their developed core technologies, these Specialised Suppliers

prefer to work for different industries instead of focusing on a niche market. Some CEOs pointed out that each customer only knows technologies and know-how in one industry. Therefore, these Specialised Suppliers are in the position of understanding differences in technologies and know-how related to different industries. Based on this, they develop the versatility of their products or services.

6.2. Nature of their Knowledge

Considering the nature of their knowledge and know-how, these companies are more informed about materials and tools. They acquire their knowledge based on observations through their daily activities and trial and error. Even though some of these Specialised Suppliers in Japan have research and development sections or people in charge, their knowledge about materials is generally derived through their daily production activities.

For example, CERARICA NODA, a company specialising in natural waxes, has a high technology-equipped laboratory and hires people with master's degrees. However, they use this high-tech laboratory equipment to test and research the nature of natural waxes only. Interestingly, their production equipment is traditional and even looks outdated. However, CERARICA NODA can produce high-quality natural wax products since they deeply know the nature of natural waxes, based on their experiences over a long period. They said that the difficulties in natural wax production for each material is unique. Even different wax lots that came from the same plant are unique because they are natural.

Similar situations are found in other companies investigated. Even though they use high-tech equipment like CNC machines, all of them confirmed their strength is not derived from that. Some CEOs pointed out that they cannot differentiate their products from others if they use the same machinery. Thus, they typically modify the machines they purchased on the market based on their accumulated knowledge about the materials and the process technology they use. They do not try to get patents for their modifications to avoid imitations from competitors. Although I was allowed to visit their factories, I could not take pictures of some areas and sometimes could not go near specific areas in the factories because they had their modified machines.

Their knowledge of raw materials and how to handle them also makes it possible to develop and supply the most suitable products or services to each customer. They can propose the best products or services according to the requests from normally much larger customers. At MASUKO SANGYO, for example, a customer came to their company bringing materials they wanted to grind. The company offers a space where customers can test their machines and various grindstones by getting support from MASUKO's engineers. These engineers help the customers find the best combinations of machines and grindstones based on their knowledge of target raw materials, grindstones, grinding processes like rotation speeds, and the gaps of two grinding stones.

It seems that these Specialised Suppliers in Japan are not seeking higher technologies but investigating nature and know-how in materials and production processes. A few years ago.

CERARICA NODA bought an old boiler in Japan for natural wax production. The CEO believed there is more to explore in traditional production methods.

Lastly, it should be noted that it is not easy to say whether their knowledge is pragmatic or scientific. Although the company investigated develop innovations through trial and error, these companies also consider the reasons for their findings. In other words, they do not try without considerations. Thus, their way of developing innovations could be considered scientific without modern scientific equipment.

6.3. Being the Only Choice

These Specialised Suppliers are the last resort for various customers. Many customers came to these companies after finding that no other companies would accept their orders. These orders are typically and technologically complicated to fulfil. These Specialised Suppliers provide unique core technologies to these customers.

Probably, more importantly, it seems they have intended to be the last resort. When customers come to their companies, they can accept rather long delivery times or find solutions for their orders. Therefore, these Specialised Suppliers do not need to compete with competitors in price. However, it should be pointed out that although they do not need to compete in prices, they also narrow their market to the most challenging products or processing services that only limited customers require. Thus, these companies are profitable but not overly wealthy, though they have money to invest if necessary.

Many sample firms mentioned that they usually had not refused customers' orders. Instead, they said, they prefer technologically challenging orders. Probably because of this attitude, these Specialised Suppliers can establish their reputation, which will attract new customers who face difficulties finding solutions for their products. This seems to be the same situation as Hosoya pointed out about the Global Niche Top companies (GNT). GNT get new customers through reputations like "that company could provide solutions to your request" through people (Hosoya, 2017).

In other words, these Specialised Suppliers will create a technological niche market for each company. This is because they are specialised in specific technological aspects. Then, they only accept orders which fit their technologies. Thus, what these Specialised Suppliers might be seeking is not multiplying production volumes but diversifying customers in different industries. As a result, they develop versatilities of their products or services and establish their unique position as a Specialised Supplier.

6.4. Maintaining Independence

Another common characteristic is their choice of being independent of other companies. The companies investigated in the current research do not want to be a part of other corporate groups,

under specific large companies, nor even controlled by investors.

Even for development, they prefer not to be financed by customers as far as possible. For example, in industries where metallic thread cutting dies are necessary for production, a customer often burdens the cost of preparing the thread cutting dies in their order. However, in the case of the companies investigated, they do not want to be supported. They said that if a customer financially supported them, they could not sell the product or services they developed to other customers. Thus, they prefer to self-finance.

Also, because their competitiveness is based on the broad and inter-industrial knowledge of customer needs, process technologies and production know-how of customers, they do not want to be under a specific company or industry. Instead, they prefer to freely accept orders from different industries and develop the versatilities of their products and services.

6.5. Building Close Relationships with Customers

Although these Specialised Suppliers prefer to be independent, they at the same time keep very close relationships with customers. The companies investigated in the current research have continuously made considerable efforts to follow up with customers. Large companies prefer to sell their products and tend to avoid burdens in aftersales care. However, these Specialised Suppliers in Japan try to keep in touch with customers. For example, these companies accept and help re-modify their machinery when customers change their products and thus need to re-design their factory lines. A CEO produced two more machines to create the same conditions as the machine he sold to faraway places. When the customer faced problems, he listened to the situation over the phone and recreated the problem at his factory to identify the solution(s). The company never charged the customers for these two additional machines.

Most of all, the companies investigated do similar follow-up activities though the styles are different. For example, one company regularly sent their staff to visit customers, and another sent all their employees to former customers to listen to their opinions. Although their styles of following-up are different, a shared understanding of them is similar. This close contact with customers is what they can do and what the more prominent competitors cannot. Furthermore, they can gather and acquire customers' potential needs and technological trends through these activities.

6.6. How to be a Specialised Supplier

It seems there is a rational strategy underlying the common characteristics among the companies investigated in the current research, probably categorised as Specialised Suppliers.

In other words, there might be a strategy to be a Specialised Supplier. The strategy found in the current research is as follows:

I. Firstly, they started with one product or processing technology as an SME manufacturer. (The situation is very much familiar to SMEs.)
II. The company found a specific technology and stuck to it.
    a. To deepen knowledge on a specific technology
    b. To deepen knowledge on nature of specific materials
III. The company accepts any challenging order which other companies might refuse
    a. To avoid cost competition
    b. To accumulate know-how
    c. To enjoy relative time allowance
IV. When the company succeeded in providing solutions to customers
    a. The company got a reputation
    b. The more challenging customers came
V. In this stage, the company needs to keep an independent and neutral position on all customers
    a. To avoid control from customers
    b. To enjoy easy access to large customers' factories
    c. To acquire broader knowledge by doing business with different industrial sectors
    d. Then, to develop versatility of their products or services.
VI. At the same time, the company needs to keep close relationships with customers
    a. To get weak signals for the next innovation needs
    b. To differentiate the company from large competitors who avoid inefficient operations by providing tiresome follow-ups
VII. Lastly and most importantly, remaining small
    a. To avoid undesirable cost competitions with bulky orders to pay salaries
    b. To maintain unharmed existence to large customers

It seems this set of choices underlies the common characteristics of Specialised Suppliers. Also, it should be noted that this series of choices or a way to be a Specialised Suppliers is not easy. Nevertheless, the companies investigated invest their most available resource, "time", to develop innovation with solid determination. In the cases of the companies investigated, these determinations are often underpinned by social consciousness. Therefore, it seems these companies choose the way to be proud of their innovations and their lives.

6.7. Lesson Learned: Practical Advice for Owner Managers of SMEs

Being, or becoming, a Specialised Supplier is one of the choices that SME manufacturers can make to survive while holding a better competitive position and earning good profits. This section provides some practical advice to owner-managers of manufacturing SMEs who aim to be Specialised Suppliers.

Table 6-1 Practical Lesson Learned

Area of Management	Recommended Tactics	Rationality Behind
Technology/Innovation	Focus on technologies that address users' needs instead of products or services	Specialised Suppliers provide special inputs that address customers' unsolved needs. The important thing to recognise is that these inputs are not 'a product' but 'a technological solution'. For example, a company investigated in the current research sells a grinding machine. However, what it is selling is not the machine but the technology to produce powders or cubicles according to customers' needs. Thus, choosing a process, for example, "cutting", "weaving", "grinding", and being a specialist in the chosen component technology, is the critical step to being/ becoming a Specialised Supplier. It is then necessary to explore that solution technology, including knowledge of the nature of raw materials.
	Find different usages of machinery to develop a suite of capabilities	Try to find different ways to operate your machinery apart from that detailed in technical manuals. Use machinery as "a tool" instead of just operating it. A set of minor modifications, such as temperature, machine rotation speed, processing time, will create different results. Develop such a set of technologies or capabilities.
Market	Do not seek a niche market but find a niche technological process	Some management textbooks recommend SMEs to find and compete in a niche market where larger competitors do not penetrate. However, such a market could be less profitable, and the market size might be small. Also, there is a risk of market extinction if a company focuses on a specific niche market. The Specialised Suppliers studied in the current research took a different approach. They choose one specific technological process necessary in productions in many different industries rather than in one market. In other words, if we consider standard market segmentation as vertical segmentation or industrial-wise segmentation, Specialised Suppliers take a horizontal, production process-wise approach to market segmentation. This approach enables them to have stronger resilience to changing market environments. Thus, finding a specific technological step that your company can focus on is one of the essential steps to being a Specialised Supplier.
Customer relationship	Take challenging orders after other competitors had declined	Many companies tend to avoid technologically complicated and time-consuming orders. In contrast, rise to the challenge and take such orders positively when you think the technology you need to develop will be adaptable to other orders in the future. Undertaking such orders

		will also deepen customer confidence and trust. Do not decline these orders due to short-term profit and operational efficiency considerations alone. Negotiate better prices and time-allowance for such orders, especially after other companies rejected them. Aim to be the solution provider for your customers.
	Be neutral to all customer	The strength as a Specialised Supplier relies on broader and inter-industrial knowledge and know-how. Thus, it is critical to keep a neutral position for all customers. Do not take capital investments and tied contracts from a particular company. Do not specialise in particular industries too. Different industries have different priorities and requirements in products or services. Studying and accumulating these differences will help your company develop new adaptations and versatilities of your products and services.
	Follow up with all customers for a long time even without good profit	Large companies will often not maintain after-sales services to achieve operational efficiency. However, as Specialised Suppliers, it is better to provide such services continuously even not particularly profitable. These activities are precious opportunities to acquire knowledge on the latest developments in each industrial area. Also, by continuously visiting customers, your company can find new business opportunities earlier than competitors.
Employee management	Do not seek university graduates but train young people in-house	It isn't easy to hire well-educated university graduates for an SME since they expect good salaries. However, since you do not need to have people with state-of-the-art technological knowledge, you do not need to hire university graduates to be a Specialised Supplier. The latest technological knowledge and scientific approach are essential for large companies since they deal with a complicated and wide variety of products. In the case of Specialised Suppliers, the technology employees need to comprehend is limited, and they can be trained in-house. More critical is to endure continuously exploring one technology deeper. While many people stop considering deeper when they believe they understand, employees of Specialised Suppliers need to seek a deeper understanding of all new aspects in the simple process continuously.
Size of your company	Remain small	If your company becomes larger, you need to take a larger volume of orders to support your company and employees. This leads to a focus on volume of activity and cost competition. It is better to keep the size of your company balanced to the specific demand where your company can differentiate its technological capabilities and products/ services relative to others and thereby enjoy adequate (but not high) profits. It is essential to remain a size that your customers do not need to fear. Keep the size of your company small enough so that your customers allow your people to access the customers' factory sites closely without being afraid of leaking technological knowledge.

7. Limitations and Further Research

This chapter explains the limitations of the current research and potential areas for further research.

The current study aims to explore the nature of Specialised Suppliers among Japanese SME manufacturers. This study started from observations on innovative Japanese SME manufacturers which appeared to have common characteristics. The author was interested in the peculiarity that these innovative manufacturers remain small even when they had opportunities to enlarge their companies. It is often considered that a company, especially a manufacturer, can benefit the most from the scale of the economy. Also, they can be more competitive when they have more resources invested in research and development activities.

Then, while considering the common characteristics shared among these small innovative companies, we, the author of the current research and the academic supervisor, noticed similarities between these companies and Specialised Suppliers, a category within Pavitt's taxonomy (Pavitt, 1984). Pavitt and Robson, and Townsend (Pavitt, 1984, Robson et al., 1988) created a taxonomy that shows institutional patterns for innovations based on the statistical analysis of the about 2,000 significant innovations in Britain. These studies are considered pioneering studies for innovation taxonomy and have been referred to some thousand times since appearing.

However, since these studies rely on statistical analysis, they do not explain why such common institutional arrangements are observed in each category. Therefore, the current study attempted to find the rationale behind these particular institutional settings in the taxonomy.

As a methodology, the current study employed the comparative case study approach intending to explore these innovative Japanese SME manufacturers' nature and found shared characteristics among them for testing the statistical results of Pavitt's taxonomy. However, although the research was conducted carefully, avoiding subjective interpretations of the data, it still has several limitations

Regarding the research approach in innovation study, Fujimoto (Fujimoto, 2019) argues what good innovation studies are. He categorised studies by the number of sample companies: using a large number of samples, a small number of samples, and a medium number of samples. He says in general, a hypothesis building type study tends to be conducted through a small number of case studies. In contrast, a hypothesis testing type study employs statistical analysis on a large number of samples. An example concerning

Japanese companies' former approach can be found in Dore's classic study on a Japanese company (2011). He has explored the Hitachi factory deeper and compared the characteristics of the Japanese factory with the British factory focusing on the labour relationships and so forth. Another classic example is the result of an extensive MIT research project, " The Machine That Changed the World" (Womack et al., 1990), which studied the TOYOTA production system and created the idea of lean production. The characteristic of such case studies is to explore a small number of sample companies deeper to generate a hypothesis.

On the other hand, studies using a large number of samples are usually based on statistical analysis and test hypotheses. In this sense, Pavitt's taxonomy study (1984) is a unique study that generated and statistically tested a hypothesis of innovation taxonomy at the same time. However, the study still has characteristics of the statistical approach where the commonalities are found and proved as a figure, but the reasons behind the results are unseen.

Fujimoto (2019) points out a tendency in management study in the USA where academics analysed large data sets available via the Internet or large databases. Fujimoto referred to "Successful Industrial Innovations" by Myers and Marqyus and the Project SAPPHO at SPRU and argues the strength of the approach using a medium number of case studies is doing statistical analysis based on the understandings o the interrelationships of existing factors derived from case studies. He argues it is essential to challenge the medium number study to find and prove a hypothesis (Fujimoto, 2019).

The current study's initial intention is close to Fujimoto's idea saying a medium number study, where I can prove the existence of common characteristics with the rational reasons behind it. However, with limitations of time and money, the current research could only approach twelve innovative Japanese SME manufacturers. Therefore, although I believe the current research found some interesting aspects of Specialised Suppliers, it might be possible to employ a large number of questionnaire surveys based on the ideas generated by the current research to clarify and confirm the current research findings.

In addition, the companies investigated in the current researches are the ones who accepted the author within their limited time. As a result, the companies investigated are varied from mechanical engineering, instrument production to OEM manufacturing. Although all of them have innovative inputs to their customers, and thus could be considered as Specialised Suppliers, as research samples, they are not purely from the typical industrial sectors for Specialised Suppliers which Pavitt proposed nor including sufficient numbers of companies belonging to different industrial sectors to test the border of the Specialised Suppliers

category.

Moreover, some companies merely shared one short time opportunity in the current research. Therefore, the data gathered is imbalanced among the companies investigated. On the other hand, the companies that provided rich data are probably specific companies who sympathise with the potential value of the current research to show an alternative way for SME manufacturers to be innovative and competitive, and even resilient companies, while remaining small scale.

Although the current research attempted to find the core condition for being a Specialised Supplier, the number and composition of the companies investigated indeed posed a limitation on the liability of the discussion.

Some more simple limitations are that the current research explored only Japanese companies within reachable areas from Tokyo. The limitations were derived from the location where the current research author lives. However, there are several areas in Japan where innovative companies exist, probably more significant than other areas. Therefore, it would be interesting to explore and compare these areas if there is a difference in developing innovations among SME manufacturers.

Also, the knowledge and understanding of the author may hinder the interpretation of the information provided through the interviews. As pointed out before in this thesis, almost all critical ideas are usually at the head of the management in SMEs. A researcher can merely get some of these ideas through the questions asked. Thus, the author's knowledge seriously influenced the findings of the current research.

Also, it might be a fascinating study if we could employ comparative case studies on Specialised Suppliers in different countries to identify the characteristics of Specialised Suppliers separately from the characteristics connected to industrial and cultural traditions of a country.

Appendix 1: Interview guide

1. Self-introduction
- DBA student and senior consultant of a company working for developing countries
- From whom (from where) I heard about the interviewee's company

2. Purpose of the research

3. How to conduct an interview
- Research as a public domain document
- Keeping confidentiality by anonymizing information (if desired)
- Contents of the interview are not open to other people, including seniors/colleagues in your company
- Contents of the interview will be written as a memorandum and feedback to you for confirmation delete information that you do not want to be recorded
- Time management (Schedule for today, schedule for feedback)
- Recording need agreement
- Any questions before starting the interview?

4. Interview Items

1.1. Attributes of the company

1.2. Interviewee
- Name
- Position
- Work experience (inside the company and, if possible, before joining the company. The latter is useful to know what kinds of comparative views the interviewee could have)

1.3. Questions (Prioritize interviewees to speak in their own ways/ structures and check items not covered later)
- New product development
  - Basic concept/ direction of product development
  - Source of idea
  - Decision making
  - Who is in charge?
- Marketing and promotion
- External networks
  - With whom: university/ governmental agency/ private company?
  - How to establish networks
- Source of competitiveness
- Size of company
  - Reasons for remaining small
  - Advantages and disadvantages of being small
- Others (if something comes up)

5. Closing
- Thank you
- Follow up: about when I will send a memorandum, if you want to contact me, etc.
- Asking the introduction of people, other companies, etc.
- Any questions?

References

ACS, Z. J. & AUDRETSCH, D. B. 1988. Innovation in Large and Small Firms - An Empirical-Analysis. *American Economic Review,* 78, 678-690.

ADMINISTRATION, U. S. S. B. 1996. The State of Small Business, A Report of The President 1996.

AGENCY, T. S. A. M. E. 2006. *Ashi ta no Nihon wo sasaeru genki na mono tukuri kigyo 300 sya (300 Enegetic manufacturers sustaining Japanese future),* Tokyo, Japan, Ministry of Economy, Trade and Industry.

AGENCY, T. S. A. M. E. 2007. *Ashi ta no Nihon wo sasaeru genki na mono tukuri kigyo 300 sya (300 Enegetic manufacturers sustaining Japanese future),* Tokyo, Japan, Ministry of Economy, Trade and Industry.

AGENCY, T. S. A. M. E. 2008. *Ashi ta no Nihon wo sasaeru genki na mono tukuri kigyo 300 sya (300 Enegetic manufacturers sustaining Japanese future),* Tokyo, Japan, Ministry of Economy, Trade and Industry.

AGENCY, T. S. A. M. E. 2009. *Ashi ta no Nihon wo sasaeru genki na mono tukuri kigyo 300 sya (300 Enegetic manufacturers sustaining Japanese future),* Tokyo, Japan, Ministry of Economy, Trade and Industry.

AGENCY, T. S. A. M. E. 2018. The White Paper on Small and Medium Enterpries in Japan 2018. Tokyo.

AGENCY, T. S. A. M. E. 2020. The White Paper on Small and Medium Enterprises in Japan 2019.

ANANTANA, T., ENKAWA, T. & SUZUKI, S. 2008. *New Product Development Efficiency and Firm's Financial Performance: Perspective of Technology Trajectories in Japanese Manufacturing,* Wuhan, Wuhan Univ Technology Press.

BERRY, J. M. 2002. Validity and Reliability Issues in Elite Interviewing. *Political Science and Politics,* 35, 679-682.

BOGLIACINO, F. & PIANTA, M. 2010. Innovation and Employment: a Reinvestigation using Revised Pavitt classes. *Research Policy,* 39, 799-809.

BOGLIACINO, F. & PIANTA, M. 2016. The Pavitt Taxonomy, revisited: patterns of innovation in manufacturing and services. *Economia Politica,* 33, 153-180.

CASTELLACCI, F. 2008. Technological paradigms, regimes and trajectories: Manufacturing and service industries in a new taxonomy of sectoral patterns of innovation. *Research Policy,* 37, 978-994.

DE JONG, J. P. J. & MARSILI, O. 2006. The fruit flies of innovations: A taxonomy of innovative small firms. *Research Policy,* 35, 213-229.

DE MARCHI, M., NAPOLITANO, G. & TACCINI, P. 1996. Testing a model of technological trajectories. *Research Policy,* 25, 13-23.

DORE, R. P. 2011. *British factory Japanese factory : the origins of national diversity in industrial relations*, Routledge.

DOSI, G., RICCIO, F. & VIRGILLITO, M. E. 2021. Varieties of deindustrialization and patterns of diversification: why microchips are not potato chips *. *Structural Change and Economic Dynamics,* 57, 182-202.

FREEL, M. S. 2003. Sectoral patterns of small firm innovation, networking and proximity. *Research Policy,* 32, 751-770.

FREEL, M. S. 2005. Patterns of innovation and skills in small firms. *Technovation,* 25, 123-134.

FUJIMOTO, T. 2019. Good Innovation Study - pioneering study and medium number study. *Soshiki Kagaku (organizational science)* 52**,** 30-37.

GODA, M. 2010. *Tuyoi Kigyo wa Hekotarenai (Strong Company Never Beatened),* Tokyo, Japan, Doyu-kan.

GOLDSTEIN, K. 2002. Getting in the Door: Sampling and Completing Elite Interviews. *Political Science and Politics,* 35**,** 669-672.

GONOI, H. 2000. *Nihon wo Sasaeru Genki na Chusyo Kigyo tachi (Vital SMEs that Support Japan),* Tokyo, Japan, Yell Publishier.

HASHIMOTO, H. & KATAOKA, N. 2000. *Zoku Sozo-teki Chusyo Kigyo (Sequel Creative Small and Medium Enterprises),* Tokyo, Japan, Nikkan Kogyo Newspaper Publishing.

HOSOYA, Y. 2011. *Nihon no Monodukuri: Grobal Niche Top Enterprises ni tuite no Kosatu* (Japanese Manufacturing: Considerations on the Global Niche-top Enterprises). *Sangyo Ritchi (Industrial Location).*

HOSOYA, Y. 2013a. Study on Global Niche-top Enterprises as Representatives of Excellent Small and Manufacturing Companies in Japan. *Discussion Paper of Research Institute of Economy, Trade & Industry (RIETI).*

HOSOYA, Y. 2013b. Study on Global Niche-top Enterprises as Representatives of Excellent Small and Medium Manufacturing Companies in Japan. *Discussion Papers.* Tokyo, Japan: The Research Institute of Economy, Trade and Industry.

HOSOYA, Y. 2013c. Study on Global Niche-top Enterprises as Representatives of Excellent Small and Medium Manufacturing Companies in Japan. *RIETI Discussion Papaers.*

HOSOYA, Y. 2014. *Global Niche Top Enterprises,* Tokyo, Japan, Hakuto Syobo.

HOSOYA, Y. 2017. *Chiki no Chikara wo Hikidasu Kigyo -Global Niche Top Kigyo ga Shimesu Mirai(A company that better utilise regional potentials-A Future created by Global Niche Enterprises),* Tokyo, Japan, Chikuma Syobo.

KAMIJO, M. 2012. *Tokyo no Chumoku no 20 sya (Noticable 20 Companies in Tokyo),* Tokyo, Japan, Diamond

KATAOKA, N. & HASHIMOTO, H. 1996. *Sozo-teki Chusyo Kigyo (Creative Small and Medium Enterprises),* Tokyo, Japan, Nikkan Kogyo Newspaper Publishing.

KOGYO, N. 2014a. *jidai-ni chosen-suru yuryo chuken/ chusyo seizogyo (Good middle and SMEs challenging to the next generation).*

KOGYO, N. 2014b. *Yuryo Chuken-Chusyo Seizogyo (Excellent Medium-Small Manufacturers).*

KOMEDA, M. 2013. *Osaka Chumoku no 20 sya (Noticable 20 Companies in Osaka),* Tokyo, Japan, Diamond Publishing.

KUROSAKI, M. 2003. *Sekai-wo Seishita Chusyo-Kigyo (SMEs which dominate the world market)* KODAN-sya.

KUROSAKI, M. 2015. *Sekai ni Kantaru Chusyo Kigyo (SMEs at the World Top Level),* Tokyo, Japan, Kodan-sya.

LEFEBVRE, E. & LEFEBVRE, L. A. 1998. Global strategic benchmarking, critical capabilities and performance of aerospace subcontractors. *Technovation,* 18**,** 223-234.

LEFEBVRE, L. A., LEFEBVRE, E. & HARVEY, J. 1996. Intangible assets as determinants of advanced

manufacturing technology adoption in SME's: Toward an evolutionary model. *Ieee Transactions on Engineering Management,* 43, 307-322.

MORTIMER, J. E. 1974. British Factory - Japanese Factory - Origins of Diversity in Industrial Relations - Dore, E,R. *Ergonomics,* 17, 552-554.

NAMBA, M. 2014. Growth Mechanism to the "Global Niche Leader": Comparison Study of Japanese and German Companies. *In:* KOCAOGLU, D. F., ANDERSON, T. R., DAIM, T. U., KOZANOGLU, D. C., NIWA, K. & PERMAN, G. (eds.) *2014 Portland International Conference on Management of Engineering & Technology.* New York: Ieee.

NAMBA, M., FUKUYA, M., SUZUKI, K., FUJIMOTO, T., OOTAKE, T., NAKAYAMA, H., MIYAKE, K. & HIRATA, M. 2013. *Grobal niche top kigyo no keiei sennryaku (Corporate Strategy of Global Nichi Top Enterprise).*

OECD 2018. *Oslo Manual 2018.*

PAVITT, K. 1984. Sectoral Patterns of Technical Change - Towards A Taxonomy and A Theory. *Research Policy,* 13, 343-373.

PAVITT, K., ROBSON, M. & TOWNSEND, J. 1989. Technological Accumulation, Diversification and Organization in UK companies, 1945-1983. *Management Science,* 35, 81-99.

PENROSE, E. 1959. *The Theory of the Growth of The Firm*, Oxford University Press.

RESEARCH, T. S. 2016. *Zen-koku "Sinise-kigyo" cho-sa (national "old company" research)* [Online]. Available: http://www.tsr-net.co.jp/news/analysis/20161202_01.html [Accessed August 14 2019].

RICH, P. 1992. The Organizational Taxonomy - Definition and Design. *Academy of Management Review,* 17, 758-781.

ROBSON, M., TOWNSEND, J. & PAVITT, K. 1988. Sectoral Patterns of Production and Use of Innovations in the UK - 1945-1983. *Research Policy,* 17, 1-14.

RYUZO, O. 2004. *kindai-ka katei ni okeru shinise kigyo no jigyo tenkai* (Business development of old companies in Japanese social modernisation). *Kansai University of International Studies,* 1, 55-65.

SAKAMOTO, K. 2008. *Nihon-de Ichiban Taisetu-ni Shitai Kaisya (The most worthy company in Japan)* Tokyo, Asa publishing company.

SAKAMOTO, K. 2012a. *Chiisakutemo Ichiban no Kaisya (Small but No1 Company),* Tokyo, Japan, Kodan-sya.

SAKAMOTO, K. 2012b. *Chisana Kaisya no Ookina Shigoto (Big Job in a Small Company),* Tokyo, Japan, Doyu-kan.

SEIBI-DO 2012. *Sekai-ichi no Mono wo Umidasu Nihon no Kaisya (Japanese Companies Producing World Number One Products),* Tokyo, Japan, Seibi-do Publishing.

SEKI, M. 1999. *"Shin Monodukuri kigyo ga Nihon wo Kaeru" (New Manufacturing firms change Japanese Society)*, KODAN-sya

SEKI, M. 2005. *"Nippon-no Monodukuri-Gaku - Chusyo-Kigyo kara Manabe!" (Japanese ways of manufacturing, Learn from SMEs)*, NIKKEI-BP publishing

SEKI, M. 2012. *Mituketa! Saiko no Keiei Senryaku (The Best Strategy Founded).*

SHIMIZU, T. 1999. *Sengo Nihon ni okeru kigyo no "Jyumyo"* (The "Longevity" of Firms in Postwar Japan). *Keiei shigaku (Japan Business History Review),* 34, 1-21.

SHIMIZU, T. 2011. *Kaisya ha nan-sai made ikirunoka? -kigyo no jyumyo no keiryo bunnseki-* (How long

company live? Quantitative analysis of corporate longevity). *Special Open Lecture for Highschool Students, Tokyo University.* Tokyo University.

SHIMODA, A. & YABUKI, T. 2016. Success Factors in Global Niche Top Companies Analysis of Free Description Data using Text Mining. *Proceedings 2016 5th Iiai International Congress on Advanced Applied Informatics Iiai-Aai 2016*, 828-833.

SOUITARIS, V. 2002. Technological trajectories as moderators of firm-level determinants of innovation. *Research Policy,* 31, 877-898.

SOUITARIS, V., IEEE & IEEE 2000. *Application of a sectoral taxonomy to explore contingencies in the theory of determinants of innovation,* New York, Ieee.

STERLACCHINI, A. 1999. Do innovative activities matter to small firms in non-R & D-intensive industries? An application to export performance. *Research Policy,* 28, 819-832.

THOMä, J. & BIZER, K. 2013. To protect or not to protect? Modes of appropriability in the small enterprise sector. *Research Policy,* 42, 35-49.

WAKABAYASHI, K. 2011. *Zettai Yurumanai Neji- Chisana Kaisya ga Sekai-ichi ni naru Houho (Never Loosed Nuts- The Way a Small Company Became No. 1 in the World),* TOkyo, Japan, Chuke Publishing.

WOMACK, J. P., JONES, D. T. & ROOS, D. 1990. *The Machine That Changed the World,* Macmillan/Rawson Associates,.

YIN, R. 2013. *Case Study Research Design and Methods 5 edition*, SAGE.