91-F-16

Production of the Japanese Wool Textile/Apparel Industry

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October 1991

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(draft, not edited)

September 12, 1991

Presented at the Conference on

"Wool in Japan: A Case Study of Adjustment of the Textile Industry"

held at Australian National University

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1. Introduction

The main purpose of this paper is to describe and analyze present situations and future prospects of the Japanese wool spinning, weaving and apparel industry[1]. The paper will examine some of the current issues which have been created partly by the nature of today's wool product market and partly by the basic characteristics of manufacturing and product development in the industry. It will also discuss some cases of the manufacturers' responses to the problems at each stage of the supply chain.

In analyzing the Japanese wool industry, there are at least three important features that are worth pointing out.

First, the demands for wool products has generally changed and fluctuated widely, to which the manufacturers have to respond quickly and accurately. In this regard, the history of the Japanese wool production after the World War II can be divided into several stages (Figure 1-1). The first stage is between 1945 to 1960, when wool textile production in basic items expanded rapidly in volume to match the pent-up demand after the war. The second is between 1960 to 1965, when growth of wool production slowed down as synthetic fiber products became increasingly popular and rapidly substituted much of the wool products. The third was from 1965 to 1973, when wool production recovered from the slump and grew rapidly again, fueled by several years of high growth in Japan's macro economy (The peak year of Japan's wool production in volume was 1972). The fourth stage was between 1973 and 1981, during which production volume of wool again declined significantly due partly to the two oil crises and partly to the continued competition

[1] In the following discussions, the Japanese wool spinning, weaving and apparel industry, including other peripheral sectors such as dyeing and finishing, will be simply called "the Japanese wool industry".

with synthetic fibers. The fifth stage was after 1981, when the industry gradually recovered and showed modest but steady growth[2].

One of main causes of the fluctuation in wool production is the trend in macro economy. As growth of household income slows down in the period of recession, consumers tend to try to lower expenses for clothes before cutting other items. As figure 1-2 shows, the growth rate of expenses for clothes was higher than that of total household income up to 1973, but the former became lower than the latter when Japan's economic growth slowed down after the first oil crisis.

Competition against other textile materials also affects trends of wool production. Figure 1-3 summarizes shares of main textile materials in the selected final product categories.

In addition to competition between substituting materials, Japan's wool textile industry has confronted increasing competitive pressures from abroad in recent years. As the industry is generally labor intensive, it was inevitable that international competition against South East Asian countries, backed by low unit labor cost, has become intensified mainly in commodity markets. The industry has also been competing with such traditional centers of wool products as the United Kingdom and Italy mainly in high value added segments.

The second important feature of the Japanese wool industry is the complexity of the supply chain: starting from wool raw materials imported mainly from Australia, the production process goes through many steps and manufacturers before the products reach final customers. Therefore, in order to examine the entire production system of the wool textile/apparel industry, we have to first look at the patterns at each stage of the chain, and

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[2] For the classification of historical stages, see People's Finance Corporation Department of Research, Nihon no Chusho Sen-i Kogyo. (Japan's Small and Medium Size Textile Manufacturers), Chuusho Kigyo Research Center, 1990. pp. 253 - 255.

then analyze interactions and coordinations between the stages. A summary illustration of the production and distribution process is shown in Figure 1-4[3].

Thirdly, it is important to note that the Japanese wool industry has a relatively long history for a Japanese modern industry. The origin of the industry is said to be establishment of the National Wool Weaving Factory (Senju, Tokyo) in 1879. Two groups of manufacturers played a key role in subsequent evolution of the wool weaving industry: The first was spinning companies vertically integrated into the downstream by directly introducing technologies of the National Factory and specializing in high volume production of commodity type products such as uniforms and other monotone (piece dyeing, as opposed to yarn dyeing) items; The second group was an agglomeration of local companies mainly in Bisei (Ichinomiya) area near Nagoya city, which emerged as a result of transformation of the area from an old center of silk and cotton weaving to an intricate network of wool-related manufacturers and wholesalers in the early 20th century. The latter group specialized in relatively small volume items such as men's suits and female clothes with patterns. Both groups of the wool manufacturers grew rapidly during the era of shortage of clothes following the war, but the production peaked around 1972, after which the number of manufacturers started to decline steadily due to slow down in economy, competition against synthetic fibers, liberalization of wool textiles, regulations on exports to the U.S.A., and so on. Scrapping of old looms was accelerated during the same period[4].

To sum up, Japan's wool textile industry has faced tough competition internationally and against other materials in the domestic and international markets, whose

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[3] Annual production of the Japanese wool industry (in value) by production stages is as follows: Wool spinning manufacturers : 298 billion yens; wool weavers: 370 billion yens; Wool finishing companies: 112 billion yens; outer garment sewing companies: 2393 billion yens. As for value added, spinners: 81 billion yens, weavers: 104 yens; finishing companies: 65 billion yens; sewing companies: 1255 billion yens. (Ministry of International Trade and Industry, Census of Manufacturers, 1989. The statistics only include business establishments with more than 4 employees).

[4] People's Finance Corporation, Nihon no Chusho Sen-i Kogyo. (Japan's Small and Medium Size Textile Manufacturers), Chusho Kigyo Research Center, 1984, pp. 223-225; 1990, pp. 239 - 241.

volume growth have been relatively low in recent years. In addition, it is said that the market has become increasingly diversified, unpredictable, and rapidly changing. In order to compete effectively in today's volatile market, many companies in the industry have initiated some efforts to change their manufacturing facilities to a flexible and fast cycle production systems which can handle a wide variety of small lot items quickly, efficiently and effectively.

There are many potential obstacles to overcome, though. Inertia of the relatively old industry might be one of such problems. As is the case with other areas of the textile sector, the wool industry has a relatively long history and tradition, but this often means that obsolete structures, practices, rules and behavioral patterns of the industry, whose origins may be dated back to the 19th century, tend to persist and sometimes hamper effective responses by the manufacturers to the changes in the competitive environments. How can the manufacturers in Japan's wool textile industry respond to the new competitive reality, overcome weaknesses of the century-old industrial structures, and maintain or regain competitiveness in the international market? In addition to describing basic characteristics of the industry, the paper will explore production and development aspects of such efforts of the manufacturers.

The organization of the paper is as follows: Section 2 will illustrate the basic characteristics of competitive and market environments of today's Japanese wool industry, including a high uncertainty in demand as well as intense inter-material and international competition. Section 3 will describe production and product development systems of the manufacturers. Based on these analyses, Section 4 will identify some of the current issues to which the manufacturers have to respond, such as the lack of effective inter-stage coordination in product development and inventory accumulation in the wool supply chain. Some attempts by the companies to deal with the problem, such as vertical coordination and communication across the stages, as well as quick response production/delivery system, will be briefly discussed here. Finally, Section 5 will summarize the discussion and make tentative conclusions.

2 Basic Characteristics of the Competitive and Market Environment

2-1 Instability and Diversity of Demand

Let us first examine the demand side of the Japanese wool industry. At the fabric stage, about 90% of the the Japanese wool products are used for western style clothes(both men's and women's wears), whereas the rest are for Japanese Kimonos, overcoats, blankets and so on. There are two basic types of wool fabrics according to the types of yarns to be used: worsted and woolen[5]. According to the statistics of Japanese domestic production in the 1980s, over half of the worsted fabrics are used for men's clothes, while about three-fourths of woolen fabrics are applied to women's wears[6].

One of important characteristics of the wool textile and apparel industry is fluctuation of demand. First of all, the wool products are subject to uncertainty and instability of the demand. A significant fraction of wool products are fashion goods, whose modes in colors and styles tend to change unexpectedly every season or even within the season[7]. Although there are certain regular goods sold stably in the long run, many of the unsold products after the season are dumped on bargain or exported to other less fashion-conscious markets such as South East Asian countries[8]. In this sense, most of the wool products may be referred to as "perishable goods".

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[5] Most of the Japanese weaving companies are specialized in either worsted or woolen fabrics.

[6] Ministry of Industrial Trade and Industries, Sen-i Tokei Nenpo (Textile Annual Statistics) (1982), See People's Finance Corporation Department of Research, 1984, p. 221.

[7] Industry experts often classify the apparel products into three groups: basic (Teiban), seasonal, and fashion. The demand is most unpredictable in the third category, followed by the second. According to a large department store ("S") in Tokyo, at least one-third of retail sales of men's suits in the store are non-basic items.

[8] According to a study by Kurt Salmon Associates on the U.S. textile and apparel industry (including retailers), about 25% of the retail sales, or about 25 billion dollars annually is estimated to be lost by a combination of discount sales (15%), inventory carrying cost (6%), and lost sales opportunity (4%).

In addition to the annual changes, wool products are also subject to longer term fashion trends in terms of materials (e.g. natural materials versus synthetic materials). This is particularly true in women's clothes, whereas the trend in materials is more stable in men's clothes. It is said that domestic production share of women's clothes increased from about 40% in the 1960s to over 60%. Thus, the demand patterns of the wool products as a whole have become dependent heavily on the fashion trends of women's clothes. For example, the latter were the main engine of the boom of natural materials, as well as that of "new synthetic fibers" in the recent years.

Another source of instability for wool textile production is seasonal fluctuation: Wool products are traditionally consumed in winter seasons. Although new technologies for those products suitable for summer season have been developed in recent years, significant seasonal cycles still remain. The seasonal fluctuation in demand is amplified at the production level due to long production and development lead time. Typical order-production-shipment cycles are summarized in figure 2-1.

The fluctuations of demand explained above, together with the relatively long lead time, implies significant management risks on the suppliers' side. An additional factor that might further increase this risk is apparent fragmentation of market needs. As apparel companies perceive today's final markets as highly diversified in tastes, they try to match this perceived demands by offering many product variations. To the extent that accurate demand forecast for each variation is difficult in this volatile market, the result is inventories of final goods in some items, and lost sales opportunities due to supply shortage in other items.

It is important to note here that the increasing variety of the products mentioned above is likely to be a joint result of actual diversification of consumer tastes and suppliers' own activities of creating varieties in the market through product proliferation. On the one hand, there are various circumstantial evidences that varieties in consumers' tastes and life styles, as well as their desire to express themselves or differentiate themselves from others through clothes, are generally increasing in many markets worldwide. Thus, it is quite natural for the manufacturers to increase their product varieties to match the varieties on the market side, which also contributes to consumers' benefits. However, as is seen in Section 4, producers tend to create excessive product varieties through a process built into the industry.

2-2 The Inter-Material Competition

Let us now take a closer look at recent trends of intensifying inter-material competition in textile and apparel industries. Traditionally, it is said that wool products possess the following characteristics[9]:

Advantages: Low thermal conductivity by holding air in the cloth
Release humidity from inside
Easy to dye
Difficult to catch fire
Difficult to get stains
Difficult to get wrinkles

Disadvantages: Subject to fungus
Shrink when washed
Get heavy when absorbing humidity
Subject to yellowing

Table 2-1 illustrates quantified results of the above characteristics[10].

These advantages of wool products were highly appreciated by the Japanese consumers, which, together with relative shortage of the materials, contributed to creation of the high grade image of wool products. In fact, unit price of wool yarn is about 4 times as high as that of its acrylic counterparts[11].

The situation changed somewhat recently, though. On the one hand, innovations of a certain type of polyester filament, called "new synthetic fibers" (Shin Gosen) in Japan,

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9 People's Finance Corporation Department of Research, 1984, pp. 222-223.
10 Within the wool category, woolen yarns/fabrics (softer, more fluffy and more irregular) and worsted ones (harder, smoother and stronger) have quite different properties and applications.
11 Hirai, T., Sen-i Gyokai.(Textile Industry), Kyoiku-sha, 1991. p.38.

has effectively eliminated much of traditional weaknesses of synthetic fibers against wool products. These new synthetic fibers are generally very fine, have complicated surface structures, and are used by mixing various kinds of fibers in weaving. These new materials have demonstrated high performance in hygroscopic property, easiness to dry, and so on, as well as additional "intelligent" properties such as ability to absorb heat or to retain heat inside the fiber[12]. Thus, the new breed of synthetic fibers are becoming serious contender of wool. In fact, in the 1990 winter season, when women's overcoat demand was stagnant due to unusually warm weather in 1991, main apparel makers hastily increased its sale efforts for the overcoats by the new synthetic fibers because their sales was less subjective to climate changes than the wool [13]. There are also plans in the industry to introduce men's suits that use new synthetic fibers which are easy to dye and have sophisticated textures[14].

On the other hand, technological improvement on the side of wool product in response to the challenge of the new synthetic fibers has been also accelerated. An example of such efforts is so called "new generation wool", which combines CSIRO spun process and off scale treatment (scales removed from the surface of wool fibers), which enabled softer feeling, more shiny surface, and less shrinkage than conventional wool products. In fact, production of CSIRO spun wool, used mainly for soft suits for men, has recently been growing by about 10% annually[15].

To sum up, innovations in both synthetic fibers and wool tend to result in convergence in material properties between the two areas, rather than unilateral invasion of the one into the other field. For example, some synthetic fiber manufacturers are approaching to wool finishing subcontractors to have their cloth finished like wool in texture, whereas wool spinning companies are busy developing certain wool yarns with a

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12 Hirai, T., p.161., Nihon Keizai Shinbun (Japan Economic Journal) March 20, 1991.
13 Nihon Keizai Shinbun (Japan Economic Journal) October 15, 1990.
14 Nihon Keizai Shinbun (Japan Economic Journal) July 10, 1991.
15 Nikkei Sangyo Shinbun (Japan Industrial Economic Journal) July 10, 1991.

high anti-shrinkage performance, a traditional advantage of synthetic fibers. To the extent that the properties of the two materials tend to converge, though, competition between the two may intensify, as slight difference in customers' preference may now cause massive shifts in demand from one material to another.

2-3 International Competition

As mentioned earlier, international competition in the entire textile industry is increasingly intense, in addition to the inter-material competition. As a result, Japan's import of textile and apparel goods in the entire industry surpassed the imports in 1986[16]. What about, then, the current situation of competitiveness of wool sector of the industry ?

Table 2-2 shows the trend of imports and exports at different stages of the wool industry such as raw materials, yarns (spinning), fabrics (weaving), and garment (apparels)[17]. As the data show, except the raw materials, in which Japan is almost entirely dependent on imports, both import and export ratios are relatively small at each stage. However, it is true that the imports have surpassed exports. The growth in imports of apparel products is particularly remarkable.

What are the main causes of this erosion in competitiveness of the Japanese wool textile industry? As for the textile industry in general, it is often pointed out that the main determinant of competitiveness is unit labor cost. In this labor-intensive industry, unit labor cost of average Japanese manufacturers is lower than that of such industrialized countries as Germany and Italy, but is much higher than that of South East Asian countries[18]. However, as MIT's "Made in America" points out, the high unit labor cost does not necessarily mean low overall competitiveness: three countries with higher labor cost, Germany, Italy and Japan, are recognized as highly competitive in the report,

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16 Hirai, T. p.234.
17 Japanese Textile Industry Data Base, Australia-Japanese Research Centre.
18 Hirai, T. pp.94-95.

implying that factors other than labor cost are also important in determining competitiveness[19].

There are few data which systematically compared competitive strength of Japanese wool products with those of other countries. Table 2-3 shows cross-country evaluation of textile goods (not just wool) in the European market. As the table indicates, Japanese textile products are evaluated as weaker in price competitiveness compared with the South East Asian competitors, but its performance in such non-price factors as quality, after service and design, as well as overall competitiveness, is regarded as superior to these competitors. It is likely that the above evaluation basically applies to the Japanese domestic market, according to our interviews in Japan. The following comments are generally consistent with the above argument.

> The import ratio of wool yarns is on average 10%, although it differs depending upon exchange rates and wool prices. Most of the import yarns are for women's wear, whereas they are not used much for men's wear. Import yarns are usually thick (high denier) and does not fit well with the Japanese tendency to prefer fine yarns (low denier). Also the imports are not as good as domestic yarns in such aspects as texture, knots, evenness of spinning, due partly to insufficient skills and equipment. For example, there was a case in which the fabrics that we imported from China had many pills, which had to be removed manually. There are also cases where exporters send yarns of wrong denier, so we have to double-check the length of the yarn. (Company C, weaving, Ichinomiya).
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> It is difficult to weave and finish wool fabrics effectively in Asian countries, where it is hard to meet necessary such conditions as certain industrial agglomeration, quality of water, wether and so on. (Japan Wool Weaving Manufacturers Association)

However, this does not necessarily mean that the Japanese wool textile industry can sustain the current advantages in the qualitative factors in the long run. As the technological levels of manufacturers in South East Asian are increasing and labor shortage in Japanese makers is becoming a bottleneck, import ratio of wool yarns is gradually

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[19] Berger, et al., Made in America, Cambridge, Mass. MIT Press, 1989.

increasing[20]. Against this background, the Japanese spinning companies are increasing their efforts to transfer their know-how on shop floor operations to the factories exporting the yarns to Japan, rather than simply letting the Japanese trading companies buy the yarns from them.

Against the increase in the wool yarn imports, two types of competitive responses are observed on the side of the Japanese spinning makers. (1) Some companies invest massively on automated equipment, make commodity yarns in high volume by three shift operations, in order to be cost competitive against the imports. Companies adopting this strategy are minorities, though. (2) Most of the larger spinning companies are shifting their emphasis in operations to production of high-value-added, unique and differentiated yarns, while giving in to imports in the area of commodity yarns. This strategy may be effective for competition against South East Asian competitors, but this may also create more direct competition against Italy, United Kingdom,and so on.

> For us weaving companies, main rivals overseas are Italians. In a sense, Italian wool textile industry is somewhat similar to us in company sizes and in patterns of division of labor and networking. We tend to regard Asian counties as potential markets rather than rivals. (Japan Wool Weaving Manufacturers Association)
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> Italian fabrics are superior to the Japanese in color, design and texture. This is particularly the case with fabrics for men's soft suits, which requires certain types of appropriate yarns and raw materials. The Japanese fabrics are not using such materials, though. Also, Italians are more responsive to small lot delivery, partly because one lot of fabrics can be divided between Italian domestic market and export markets. The Japanese weaving companies tend to lack such flexibility, demanding a larger minimum lot sizes for delivery (M Trading Company).

In order to compete effectively with Italian and British products in high value added markets despite high brand images of the European apparels among the Japanese consumers, the Japanese makers have to make products that are at least as high in quality as

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20 At the fabric level, export ratio and import ratio of wool products were about 5% and 4% respectively in 1982. Both ratios are below 10% since the early 1970s. Over 80% of the fabric imports were from the U.K. and Italy. Ministry of Industrial Trade and Industries, Sen-i Tokei Nenpo (Textile Annual Statistics). See, also, People's Finance Corporation Department of Research, 1984, pp. 230 - 233.

the Europeans, and significantly lower in price. There are some obstacles to overcome, though. For example, the quality standards set by the Japanese government is very demanding in terms of physical performance (e.g. tensile strength, elongation, shrinkage, etc.) which contributes to higher costs. As a result, physical performance of Japanese yarns and fabrics are said to be generally higher than that of Italian counterparts. The problem is, however, that the Japanese spinning and weaving makers tend to focus too much on such physical measures while de-emphasizing more subtle "sensibility" factors such as feels and textures, and that what customers appreciate is not so much the physical factors as the sensibility factors. Thus, in order to compete effectively with the Italian makers, (1) the quality standard, which may excessively emphasize physical performance, may have to be relaxed, (2) and the companies at the upstream stages may have to develop higher sensitivities to non-physical aspects of the product quality mentioned above. The following comment by a Japanese wool finishing company is worth citing in this regard.

> The Japanese companies tend to kill the favorable properties of natural fibers by emphasizing too much on productivity. Their mind set is still driven by "good quality, but with low cost". In spinning, for example, the Japanese tend to pull too much, which might be good for strength, but not necessarily for feeling. In weaving,. also, the Japanese tend to overemphasize high speed looms, which bring about high productivity and yield, but they tend to overlook the fact that more conventional looms may be more appropriate for certain high value added products. Also, the Japanese companies tend to specialize too much by production stages, making coordination and integration between them difficult, and overemphasizing small-lot short-cycle production. The Italians and British, on the other hand, set a clear priority on high value added and emphasize high quality even when it sacrifices speed and productivity. (Company T, wool finishing)

3 Production and Development of the Japanese Wool Textile Industry

3-1 Basic Characteristics of Spinning, Weaving and Apparel Manufacturers

Let us now briefly discuss the structure of the Japanese wool textile/apparel manufacturer, with special emphasis on the weaving makers.

Geographical Agglomeration: Production bases of textile industry in general are geographically dispersed: Local areas with agglomeration of textile producers, each of which is specialized more or less in certain product categories, are found in virtually all prefectures Japan. As far as wool textile manufacturers are concerned, by far the largest agglomeration, occupying 36% of total wool textile production in Japan, is Bisei (Ichinomiya) area of Aichi prefecture near Nagoya city[21]. An intricate structure of division of labor has been developed over time in Bisei area with many local makers each specializing in a certain production process such as twisting, yarn dyeing, weaving, piece dyeing, finishing, and mending.

Size Distribution: Table 3-1 compares size distribution of the Japanese companies for the entire manufacturing sector, the weaving industry as a whole, and the wool weaving industry. On average, wool weaving companies are small in size, even compared with the Japanese weaving sector in general. In the textile industry in general, the sizes of manufacturing companies at downstream (sewing) and the midstream (weaving) tend to be smaller than those at the upstream (spinning)[22]. This is partly because product varieties increase and lot sizes decrease at the downstream, and partly because capital investment required in sewing and weaving is not as large as that at the upstream. An exception at the downstream area that is relatively capital intensive is finishing and piece dyeing.

Spinning Companies: Japan is one of the largest producers of wool yarn, and is the fourth largest consumer of wool raw materials only next to Soviet Union, China and Italy. Most of the wool raw materials are imported from Australia through the Japanese trading companies. Some of the Japanese spinning companies even own sheep ranches in Australia.

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21 Yoshioka, M., Sen-i.(Textile), Nihon Keizai Shinbun-sha, 1986., p.34.
22 Yoshioka, M., p.25.

There are five specific spinning companies whose products have won a high reputation for years. Even in the basic (Teiban) yarn market, yarns spun by these companies are recognized as high quality items (called Gomei-mono) and thus differentiated from products by other makers (Zappan-mono)[23]. Because of recent increase in imports of basic low-end yarns from Korea, China and others, larger spinning companies in Japan have been shifting their emphasis to product development and manufacturing of well differentiated high quality yarns. For example, these spinners concentrated on production of high grade CSIRO spun yarns all year round during the period of the soft suits boom.

The leading spinners are also showing their interest in such downstream businesses as weaving and apparel. These large spinning companies weave about 30% of yarns that they produce or import inhouse. Most of the fabrics that they weave are used for relatively high volume items such as uniforms, where they can enjoy economy of scale, while they subcontract small lot items to specialized finishing companies. Thus, the fraction of non-yarn businesses in the total revenue of the spinning companies is increasing in recent years.

Parent Weaving Companies: Parent weaving makers (Oyabata) are the core part of transactions in the local network of wool textile manufacturers. They buy yarns from wool yarn wholesalers, develop fabric designs and samples, subcontract out most of the operations in the process (twisting, dyeing, finishing, weaving, etc.), and sell the finished fabrics to wholesalers, apparel makers, retailers, etc. (see figure 1-4). Subcontractors of various specialties usually receive materials from the parent weavers, do their work on them, and return the products back to the weavers, with the exception of finishing and piece dyeing subcontractors, which deliver the finished fabrics directly to wholesalers or apparel makers. Although called "weaving maker", over 50% of them have no production function[24]. By contrast, the fraction of subcontracting in total wool fabric

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[23] These five companies of "Gomei-mono" tend to use more expensive raw materials than the others.
[24] People's Finance Corporation Department of Research, 1984, p. 246.

production increased steadily from about 50% in the mid 1960s to nearly 80% today. It is pointed out one of a main motivation of this increase in subcontracting was to absorb the cost increase at the parent weavers caused by the requirements of small lot high variety production[25].

Weaving Subcontractors: Many of the weaving subcontractors (Chinbata or Kobata) are small family businesses with a few workers (family members) and only 4 low speed looms on average. The subcontractors are generally characterized by low labor cost, old equipment, and long work hours per day (16 hours on average) by family members (typically fathers and mothers). It is estimated that about one-third of the weaving subcontractors are dedicated to one parent company as stable production sources, and the other two-third are independent or semi-independent subcontractors with temporary relations with the parent weavers, functioning as capacity cushions as they absorb fluctuations of parents' businesses. There are also brokers (Barashiya) between the parents and subcontractors, coordinating and allocating weaving jobs from the parents to subcontractors with idle capacity.

One of important trend in weaving is rapid decrease in the number of weaving subcontractors. In Bisei area, for example, there were 4022 weaving companies with 12661 looms (parents and subcontractors combined) in 1977, but the number of companies decreased to 2800 in 1991 (about 200 parents) with 12300 looms, 16% of which are high speed types (tables 2-4 and 2-5)[26]. A main reason for this decline is simply that the work force of the subcontractors are aged and that they do not have successors of the business. The heads of the subcontractors (also heads of the household in most cases) are now over 50 years old on average. Their sight is physically deteriorating, which makes operations with thin yarns difficult. Although new generations of high speed looms would fit such

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25 People's Finance Corporation Department of Research, 1984, p. 242.
26 Data are based on the autors' interviews in Bisei area.

jobs, a small family business cannot afford to purchasing the expensive equipment. In many cases, members of the subcontractors are also engaged in agriculture or working in other companies. It is difficult for them to persuade their children to succeed to this job which are often characterized as 3-D work (Dirty, Dangerous and Demanding). Thus, subcontractors, generally pessimistic about the future of the job, voluntarily quit the business one after another.

Wholesalers and Trading Companies: The fragmentation of the business into narrowly specialized companies, described above in the case of the weaving stage, is also observed in the entire value chain of the wool textile/apparel industries. Spinning, weaving, and apparel are all segmented by different group of specialist makers, with various types of wholesalers and trading companies between them. Although some makers at each stage are initiating moves toward vertical integration, the overall structure of the wool industry is characterized mostly by narrow vertical separation in transactions and communications. The wholesalers and trading companies bridging the separated manufacturing stages may be in a better position to organize information flows and facilitate communications and coordinations across the stages, but their actual functions tend to be limited to risk hedging in commercial transactions between the makers in most cases. The result may be lack of clear leaders integrating all the steps from the entire value chain's point of view, as well as lack of smooth information flows between the stages. (In extreme cases, the wholesalers of men's wear fabrics in Bisei areas disappeared, and the weaving companies started to deal directly with apparel makers.)

Apparel Makers: Although called "maker", apparel makers in Japan are in most cases wholesalers without manufacturing functions (with or without planning and design capabilities), which subcontract out sewing operations to outside factories. There are two basic types of apparel companies in Japan: comprehensive, and specialized. Each of the six largest companies in the former category sell over one hundred billion yen annually. There are very few apparel companies outside Japan that are as large as these comprehensive apparel makers. Despite the size of the leading apparel companies, it is also true that market share of the largest comprehensive apparel maker in the outer wear segment is less than 10%, which indicates that the apparel industry is fairly fragmented.

Since the 1980s, apparel makers of designer's character (DC) brands have grown remarkably. These DC apparel makers emphasized new product development and careful selection of sales places based on the fashion sense of the designers, whereas other apparel makers were still focusing sales volume[27].

One of recent trends in the apparel sector is that, as department stores and low cost retailer chains (called "road side shops") have increased their bargaining power against apparel makers, the latter have themselves become more like subcontractors of the retailers. In fact, only a few large comprehensive apparel makers today can supply men's suits of their own brands to department stores, partly because small apparel makers cannot respond effectively to a large variety of demands from them. As a result, the small apparel makers have to become suppliers of private brand suits of the department stores.

Vertical Division and Integration: As mentioned above, the Japanese wool textile and apparel industry is often characterized by separation and insufficient communication and coordination between narrowly fragmented stages of production. This fragmentation of makers and lack of smooth information flows across the production stages are said to have caused certain competitive disadvantages in developing and manufacturing sophisticated wool products that are increasingly popular among today's consumers.

In comparison with the Japanese case, another agglomeration of apparel companies in Prato (Italy) is worth studying. Without large companies as a core group, Prato area consists of intricate and flexible networks of many small shops, which are coordinated by "Impannatori" (offsprings of merchants in the Middle Ages) and "Verleger" (prototypes of modern retailers). These apparel coordinators buy materials at their risks, organize the

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27 Fukunaga, S. and Sakaino, M., Apparel Gyokai (Apparel Industry), Kyoiku-sha, Tokyo, 1991. pp. 59-71.

network of manufacturers, deliver the finished products to the market (merchants). In addition, Impannatori functions as designers, create or respond to fashions, and persuade the apparel manufacturers to make experiments on new processes and materials. In this way, the networks have flourished, while large integrated apparel companies disappeared from the area except one.

Prato was known as an early adopter of new weaving technologies: In the early 1970s, companies in Prato replaced as many as 13000 traditional looms with new automatic looms. They were also active in technological improvements of the machines. For example, the Prato apparel makers introduced NC (numerical control) looms in the late 1970s, which enabled them to respond to changes in the market environments flexibly. The linkage between the companies is reciprocal: a company which failed in forecasting the fashion trend this season, with idle capacity, can become a subcontractor of a successful company which needs additional capacity, but the latter may become a subcontractor of the former in the next season[28].

In the recent years, however, Japanese textile industry, spinning companies in particular, started to make some efforts toward vertical integration. Although downstream vertical integration by spinning makers tended to be limited to large lot production of piece-dyed products (e.g. uniforms) as a buffer against fluctuation of the spinning business in the past, they are now expanding their downstream operations to special grade items or technology-intensive products such as "new generation wools". The main motivation of such vertical integration by the spinning makers was to exploit their potential advantages in availability of popular yarns against the downstream players, and to narrow the gap in quality and design against the products made by the network of smaller companies in Bisei area[29].

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28 Piore and Sable, The Second Industrial Divide, Basic Books, 1984. PP. 213 - 216.
29 Nikkei Sangyo Shinbun (Japan Industrial Economic Journal) July 9, 1991.

3-2 Cases in Production Process

Main production process of the wool textile and apparel industry (woven products) can be generally described many as follows[30]:

Spinning: In the case of woosted spinning, the imported wool raw materials, in the form of fleece, are first classified into lots based on thinness. length, etc. (sorting). Each lot is then washed and converted to scoured wool (scouring)[31]. Wool fibers are then pulled and converted to slivers or tops through carding, gilling, combing and back washing[32]. The tops are then pulled further through a series of spinning processes. After spinning, the yarns are combined and twisted in most cases[33]. Dyeing may be carried out at the stage of tops or yarns (before twisting), or after weaving. Woolen spinning is simpler with material preparation, carding and spinning processes.

Weaving: Weaving process is basically combination of warps (4000 to 6000 yarns per standard 150 centimeter width) and weft (200 to 300 per 10 cm). Weaving itself is conducted by looms (traditional shuttle types or newer high speed shuttle-less machines such as Sulzer, Rapier, or Air Jet Looms), while set-ups of warps and wefts require separate processes. Warp drawing (changing patterns of warps between beams) is a particularly time consuming process.

Finishing: The crude (greige) fabrics have to go through a lengthy finishing process. A standard process for finishing a piece-died fabric at Company T (described later) is as follows: Checking the job card and the in-coming role to make sure that they

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30 Other than weaving, wool yarns may be knitted or tufted (for carpets), but this paper focuses mainly on weaving.

31 The Japanese spinning companies import either greasy wool or scoured wool.

32 These processes from raw materials to top are called "top making".

33 In the case of Australian wool, average yield is 63 to 65% from fleece to scoured wool; about 85% from scoured wool to top; 94 to 95% from top to yarn. Thus, the yield from fleece to yarn is 51 to 52%. See Akira Nakamura, Sen-i no Jissai Chishiki (Practical Knowledge on Textile), Toyo Keizai Shinpo-sha, Tokyo, 1980, p. 127.

match; Burning the surface when necessary; Scouring, either by traditional batch-type washing machines or continuous tandem type ones; Piece-dyeing when necessary (40% in Company T) by wince type, flow circulation type or high pressure type equipment ; Milling for making the fabrics fluffy, which applies subtly different pressures and operation patterns depending upon the orders; Washing again; Drying; Raising by using rollers with combs; Inspection and cleaning; Rolling; Shearing; Blowing (steaming); Final inspection.

Apparel: Manufacturing process at the apparel stage is basically a combination of cutting, sewing and pressing, which resembles ordinary assembly process in many senses. Cutting machines may be automated as apart of CAD-CAM (Computer-Aided Design and Manufacturing) system. The new generation of sewing machines today are either high-speed, automatic, special-purpose types, or low cost flexible types designed to match Just-in-Time sewing systems. Prior to cutting is a series of developmental activities from planning/designing, to pattern making, grading (making different sizes from the same pattern), and marking (laying out patterns on fabrics for better yield).

In the following part, some of the manufacturers that were studied in the present research are briefly described.

(1) *Company C (Weaving Parent Company):* Company C is a relatively entrepreneurial weaving company located in Bisei (Ichinomiya) area, which functions not only as weaving manufacturer but also as wholesaler. Under a strong leadership of the CEO Mr. I, Company C started to replace its traditional looms with high-speed automatic looms (Sulzer type) in 1975. By 1987, it had entirely converted its in-house commercial production to about 100 high-speed looms, while most of the old looms were transferred to subcontractors (about fifteen of them were kept for small volume sample production). Production rate per machine increased dramatically with the introduction of three shift operation by the Sulzer type machines, each of which was 4 times as fast as the traditional type. As the number of machines that one operator could handle also increased from 4 to 5

in the old looms to 10 to 20 in the new process thanks to the lower frequency of machine stops, labor productivity improved dramatically.

In addition, Company C is now testing feasibility of an air jet loom, which is potentially even faster than the Sulzer and has automatic recovery function when the weft is cut. In warping process, (i.e. setting up warps in a loom) , Company C invested on an expensive automatic drawing machine, which could dramatically shorten the set up time (from 8 - 10 hours in traditional type to about 1.5 hours) while reducing defects due to human errors. The shorter set up time, in turn, enables the company to operate economically with smaller lot sizes, other things being equal.

Introduction of the Sulzer machines also enabled Company C to operate for 24 hours in three shifts. Due to the labor shortage problem, though, the night shift is operated by only 70 to 80 looms.

(2) *Subcontractor of Company C:* One of Company C's subcontractor was a family business located one block from its main factory. With 6 old looms (about 30 years old), the husband and the wife regularly worked from early morning to late at night. As the machine run out of warps every 30 minutes, it is impossible to handle more machines and to operate the looms unattended. The subcontractor also lacked capability of warping without assistance from Company C.

(3) *Company T (Finishing and Piece Dyeing):* Company T, located in Bisei area, consists of 6 companies, each of which is operated semi-independently. As finishing is a relatively capital intensive process in the value chain of the wool industry, this stage is more oligopolistic than weaving: Company T itself has consolidated several finishing makers to become one of the largest and most sophisticated wool finishing makers in Japan.

The Wool fabrics right after the weaving process (greige) are very crude, and need to be finished (and sometimes dyed) through a long chain of production steps before becoming wool fabrics that we see in the final products. In high grade wool products, the finishing process is particularly critical for product differentiation. Thus, each role of the crude fabric coming in from various weavers to Company T is carefully controlled by job card which describes details of the finishing and dyeing methods specific to this particular role.

The operation is normally 2 shifts, with 3 shifts at peak times. As for throughput time, there is sometimes a conflict between quality and delivery: for better feel and texture, it is sometimes necessary to age the fabrics between the production stages, which means longer production throughput time and more work in process inventories.

The finishing process, although not as visible as spinning, weaving and sewing from the industry outsiders, is in fact a critical process for quality and distinctiveness of the final products, and is not only capital intensive but also relatively knowledge incentive. There are various know-hows accumulated in Company C, partly because it deals with both upstream (i.e. spinning and weaving makers emphasizing physical properties of fabrics) and downstream (i.e. apparel makers, wholesalers and retailers emphasizing sensibility or feeling) players, and partly because it take varieties of orders from many weaving companies. Thus, the finishing company is an obvious hub of product information flows, although it is merely a subcontractor of the weavers in terms of formal transactions. In fact, in order to prevent the weavers from stealing each others' designs, the clients are not allowed to enter certain critical parts of Company C's plants and sample making areas.

3-3 Product Development Process

Let us now turn to the product development process of a typical men's suits. One of the main characteristics of product development in the Japanese textile and apparel industry is fragmentation and lack of overt coordination: First, product planning and development is carried out by many players at different stages of the value chain including apparel, weaving and spinning; Second, these product development units at different stages tend to work semi-independently without close coordination and communication, playing guessing games each other.

Development at Apparel Makers: New model development for men's autumn/winter suits starts in the summer one and a half years before the season. This means that the apparel makers have to predict fashion trends of the 1991 season without even knowing the actual trends of the 1990 season. The apparel makers decides designs of the new models in October, and finish grading (making paper patterns for production) in November.

In parallel with the above process, the apparel makers test new fabrics, which are either designed and proposed independently by the weaving companies or jointly developed by the apparel makers. In September, sample fabrics for sewing prototypes clothes are sent to the apparel makers and are inspected by development and manufacturing staff there. The fabrics are then converted to suits samples, inspected again, while the apparel makers start to place fabric orders to the weaving companies. In March, the fabrics are delivered to the apparel makers, which subcontract out sewing process. Final products starts to be sent back to the apparel companies at the end of April. In the case of basic regular products, the fabrics are ordered in October and are delivered to the apparel makers in February. In any case, men's suits for autumn/winter season complete sewing process in October and are supplied to retailers.

Development at Weaving Companies: The process at the weaving companies starts with product planning and sample making. In fabrics, parent weaving companies usually propose and release "checker pattern samples" (Masu-Mihon, or prototype fabrics that consist of many different patterns, each of which is 10 centimeters by 10 centimeters in size) to potential customers about 1.5 year prior to the season (i.e. apparel makers, wholesalers, etc.)[34]. During the 1960s, when the wholesalers of men's suits in

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[34] For example, product planning by a typical weaving company for men's wears of 1991 autumn/winter season (shipment: March to August of 1991) starts in June or July of 1990, and the sample fabrics are ready

the Bisei area still existed and possessed capabilities for collecting and analyzing final market information, these wholesalers told the weaving companies what to make. After the wholesalers virtually collapsed, however, the weaving companies had to develop their own capabilities to collect market information from apparel companies and department stores, as well as to propose product designs themselves.

Thus, today, there are many weavers that have a group of in-house designers. The designers of the weaving companies first do product planning by contacting designers of apparel makers and discussing design concepts. Next, the weavers develop drawings and specifications for the checker pattern samples, as well as actually weaving the samples by using warping and weaving machines that are often dedicated to sample making. Company C, for example, develop as many as 2000 samples per year. One sample costs about 30,000 yen, so the cost of developing samples alone (excluding cost for designers themselves) amount to 70 to 80 million yen (roughly 0.5 million U.S. dollars). The company possesses a few warping machines and about 15 traditional low speed looms both of which are dedicated to sample making. Besides, there are sample weaving specialists outside the company.

After the weaving, the sample fabrics, with two exactly the same pieces for each pattern, are sent to finishing companies. After the finishing process, one is sent back to the weaving company, while the other is kept by the finishing company.

After finishing, the samples are shown to the apparel companies, which pre-select the patterns that they may eventually order (Masu-nuki). On average only about 20% of the proposed patterns are chosen by the customers. The samples may be presented to only one customer (Tome-gara), or exactly the same pattern may be shown to more than one potential apparel companies which are assumed not to compete directly in final products, or they may be presented in exhibitions by local design centers and thus become open to

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in August of 1990. The weaving companies then take initial orders from September to March. The lead times for women's wear is normally shorter, reflecting more volatile nature of their demands. See, for example, People's Finance Corporation Department of Research, 1984, pp. 249 - 250.

public. However, the samples presented in public exhibition tend to be less important ones for the business of the weaving companies, as they are more subjective to being copied by rivals. In fact, there used to be many copycats called "camera-tex", which take pictures of designs of the competitors, quickly produce the fabrics (typically for 1 week) ahead of the original weavers (normally 2 to 3 months) and sell them in discount prices prior to the competitors. Thus, the samples which become open to public before the season tend to be second or third grade items.

The selected sample patterns are then woven in the form of enlarged samples (Kakudai-mihon), each of which is usually 5 to 10 meters with regular width. The selected patterns from the enlarged samples are then woven and sent to apparel makers as samples for sewing prototype clothes (Chaku-mihon).

In many cases, these samples are not exactly representative of the production version in subtle nuances, textures and colors, but a certain degree of the gaps are taken for granted. However, it is also true that the gap between the samples and the production fabrics is sometimes used by the apparel makers and retailers as an excuse for product returns.

Product Development at Spinning Companies: Spinning makers propose new designs of yarns about 3 months to half a year before the weaving makers start the checker samples. There are some cases in which new yarns are developed based on the requests or information from the weaving companies, but this still remains to be a minority of the yarn business (estimated roughly to be 20%). Overall, new products do not occupy a major fraction of the yarn business. In one Japanese spinning company emphasizing product differentiation, for example, as high as 60% of the yarns it sells are special (non-commodity) grades, but the new items are on average only about five per year.

Similar to the weaving companies, spinning makers develop their own sample yarns prior to sample fabrics when they propose new products. Although the spinning makers themselves make sample fabrics for promotion, each weaving company as a customer needs also to weave the samples using their own equipment, as the fabrics from the same yarn can be very different depending upon the weavers.

Overall, product development processes in the Japanese wool textile and apparel industry tend to be characterized by semi-independent market forecasting, product planning and product development at each stage of the supply chain, rather than well coordinated joint development efforts across the production steps. We will discuss this issue in the next section.

4 Current Problems and Responses

4-1 Problems Defined

So far we have described the basic characteristics of production and development in the Japanese wool textile and apparel industry. In the present section, two major issues that the industry today is facing in relation to its production and development system are analyzed in further detail. They are: 1) Insufficient coordination of product development activities across the production stages, and 2) Excessive proliferation of product variety and resulting accumulation of inventories at each stage. The two problems are interrelated with each other as they stem in part from the same basic issue of inter-stage communication or information processing.

Insufficient Coordination in Product Development: This is a typical problem observed in those industries with fragmented value chains. Information on final market needs does not flow effectively into the upstream areas supplying materials and semi-finished products, whereas the downstream information on technical feasibilities of material production and development does not reach the downstream timely[35].

[35] Ironically, tight coordination between the upstream and the down stream players is often referred to as one of the sources of international competitiveness in other Japanese industries such as the automobile (see, for example, Womack, Jones, and Roos, The Machine that Changed the World, New York, Rawson/MacMillan, 1990, and Clark and Fujimoto, Product Development Performance, Harvard Business

Companies at spinning, weaving and apparel stages tend to forecast each others' demands and offers for new product development, rather than explicitly coordinating each other. In other words, there tends to be a lack of clear development leadership that covers all the stages that affects design and quality of the final apparel products. As a result, market information on the final product markets does not flow smoothly to the upstream suppliers, which may lead to certain mismatches of product development between stages, wastes of R&D resources, and lack of total "product integrity" from consumers' point of view[36]. For example, the recent boom of "soft suits" in Japan's men's wear market was quickly recognized by the downstream merchants and apparel makers, but the information on the material requirements for such products was not transmitted to the upstream accurately and timely: the result was shortage of fine wool materials and yarns that would have been appropriate for the soft suits.

Another potential results of this fragmentation in product development activities is insufficient knowledge sharing between different stages, which, again, may deteriorate product competitiveness in the market that is sensitive to subtle nuances, sophistication and integrity of the products. For example, effective development of certain fashion-sensitive products requires not only technical knowledge on physical properties of materials, yarns and fabric, but also market knowledge on perceived quality in terms of designs, nuances, messages, sensibility and feeling of the products. The problem, however, is that the upstream players (spinning and weaving) know much about physical quality but not much about the sensibility quality, whereas the downstream apparel makers, being closer to the final consumers, tend to be capable of interpreting customer needs in terms of sensibility, but is lacking in knowledge on physical quality of fabrics and yarns. The players which

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School Press, Boston, 1991. The contrast between the textile industry and the automobile industry in Japan in terms of the inter-stage coordination seems to indicate that what is important in explaining industrial competitiveness is not so much something inherent and timeless about Japan, as patterns of evolution and timing in history in each individual industry.

[36] For the concept of product integrity, see Clark and Fujimoto, "The Power of Product Integrity", Harvard Business Review, November-December 1990.

could potentially bridge this gap of product knowledge, in our opinion, are finishing companies, which serve as the very linking pins or information hubs between the upstream and the downstream, but they are after all subcontractors and thus do not take business risks and responsibilities by selling and buying products.

In this way, there seems to be a fundamental mismatch between the structure of information processing in development and the structure of commercial transactions: those companies which might be best informed of both market and technical information are not in the position of taking responsibility and leadership in product development.

One of the source of the problem appears to be the historically rooted fragmentation of the Japanese wool textile and apparel industry mentioned earlier, and the resulting difficulty in inter-stage coordination. One classical solution to this problem is vertical integration. However, vertical integration may not be always efficient partly because optimal production scale may be very different by production stages particularly in low volume items. Neither is vertical integration a necessary condition for effective inter-stage coordination: as seen in the world automobile industry, for example, high vertical integration in terms of capital participation does not necessarily mean high level of coordination in production and development[37]. This indicates that certain looser vertical coalitions such as business tie-ups, agreements, or more informal networks may effectively improve cross-stage coordination and knowledge sharing without vertical integration in the traditional sense. After all, what is more important is to develop both formal and informal communication channels between the stages, to change attitudes and skills of the players at each stage toward cooperation and mutual trust, and to establish clear channel leadership that facilitates vertical collaboration.

Product Proliferation and Inventory: In the fashion-oriented wool apparel industry, where final demands by items are more or less diversified, unstable and

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[37]See, for example, Womack, Jones, and Roos, 1990 and Clark and Fujimoto, 1991.

unpredictable, it is necessary for each stage of the production chain to carry certain levels of inventories. On the one hand, fashions in color and design change season by season, consumer preferences on materials swing between synthetic and natural materials, and lifestyles and tastes of the customers become increasingly diversified, sophisticated and subtle, which makes accurate market forecasting beyond certain time horizon very difficult. On the other hand, the current planning-development-production lead time of the wool textile and apparel industry, with the long chains of production and many players and intermediaries, is long compared with the requirements for accurate forecasting. The result is an inevitable mismatch between demand and supply, creating either inventories or lost sales opportunities at each stage of the chain. Lost sales opportunity means constraints on consumer choices, and inventories often mean higher costs and lower prices at the end of the season, which tends to be passed on to higher initial retail prices at the beginning of the season. Thus, it is unrealistic to advocate zero (or near zero) inventory levels in this industry. After all, the question is how to find a good balance among accurate market forecasting, short lead time, low price, and wide product choices.

However, this does not mean that the present level of inventory is within a reasonable range. Although it is difficult to tell what is the socially optimal level of inventories and product varieties in a static sense, there seems to be a dynamic mechanism built into this industry, which tends to create excessive product variety and inventory level from the entire supply chain's point of view. This problem is related to incentives of the downstream players such as retailers, wholesalers and apparel makers to make more accurate market forecast.

To illustrate this problem more clearly, let us first assume that a retailer take full risks of both stock outs (i.e. lost sales opportunity) and inventory carrying costs (including dumping sales caused by excessive inventories). A hypothetical rational retailer would first make efforts to make the sales forecast more accurately by investing on collection and analysis of market information, as well as on shortening development-production-distribution lead times up to the point that incremental cost of the efforts exceeds incremental benefits from accurate forecasting. Second, the company will determine the production plan so that the incremental opportunity cost of lost sales and incremental cost of carrying and disposing inventories balance, and purchase materials according to the plan[38].

However, the actual situation of the Japanese wool industry is significantly different from the above model. That is, there are certain traditional mechanisms by which retailers and apparel companies at the downstream reduce the risk of excess supply by dispersing inventory risks backwards, including returns of already delivered goods (Henpin) and cancellation of previously ordered items (Mihikitori) without penalty[39]. These practices are based on tacit understanding rather than written contracts.

On the one hand, the practices of returns and cancellations function as shock absorbers by which the risks of demand-supply mismatch in the final market is dispersed and shared by many stages of the supply chain. This, in turn, enables the retailers to carry a wide variety of products (i.e. a wide consumer choices) despite highly unpredictable nature of the apparel demands. On the other hand, the practices of returns and cancellations lead to product proliferation and, as a result, accumulation of dead stocks. In this situation, regular retail prices tend to become relatively high so that they can absorb high inventory carrying (and disposing) costs.

In forecasting future demand patterns in the highly unpredictable fashion markets, downstream players in the value chain such as retailers and apparel makers are normally in a better position in terms of efficiency and accuracy of the forecasts in that they can use their existing transaction networks for collecting information on the final markets. Although there are costs associated with information collection and market forecasts, the

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38 In managerial economics, this problem is often referred to as "critical fractile" problem, in which production volume is determined at the level at which subjective probability of stock out is equal to L/(G+L), where G is incremental gain from additional production, and L is incremental loss from unsold inventory.

39 This topic will be discussed by another member of the current study project.

downstream players will invest on them as long as the benefits from the resulting improvement in forecasting (e.g. reduction in inventories and in lost sales opportunities) outweigh the cost of forecasting. However, if the downstream players can return unsold items or cancel previously ordered items without penalty, their risk of holding dead inventory is transferred to upstream (e.g. weavers), and their incentives to invest on accurate demand forecasting decreases. Besides, the downstream players cannot easily transfer risks of lost sales opportunity to upstream. As a result, they tend to proliferate items to be ordered (i.e. the "shot gun" approach to the market), order more than they forecast "just in case" of demand underestimation, and then use the traditions of returns and cancellation to transfer cost of demand overestimation to upstream[40]. In this situation, "batting average" in this forecasting game (i.e. the degree of demand-supply matching by items) is not as important as "number of home runs" (i.e. hit items), so they tend to make many attempts regardless of the number of "struck outs" (i.e. failed items). .

The inventory risks usually come up to the stage of weaving, as the apparel makers tend also to cancel orders for slow items without penalty. The weavers, however, normally cannot transfer the risks further to the spinning makers, as the latter allow neither returns nor cancellation of the yarns in order to justify their relatively low margins. Thus, to the extent that orders exceed actual demands and subsequent cancellation increases, inventories of fabrics tend to be accumulated at the weaving stage. In fact, there are some internal data indicating growing number of fabric inventories in recent years. A further problem here is that the fabric inventories owned by the weavers are physically managed by finishing companies, and that weavers tend not to pay the warehouse fee, again in the traditional practices. Thus, the problem of piling inventories of the fabrics tend to be concealed due to the lack of signals about the inventory levels.

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[40] It is, however, both conceptually and practically difficult to separate the part of product varieties matching actual varieties of demand from the part of excessive varieties through empirical studies, as consumer's actual buying behaviors are an inseparable joint result of buyers' own independent needs and the needs derived by the very existence of the products.

To sum up, the problems of the current wool textile industry mentioned above are both related to mismatches between incentives and capabilities for inter-stage coordination and information processing in the wool supply chain. In development, for example, those players which might be in the best position to facilitate the communication of product quality information (i.e. finishing companies) are not motivated to take leadership in product designs. In production, those companies which are in the best position to make accurate demand forecasts (i.e. retailers and apparel makers) have little incentives to do so. Those companies which are subject to inventory accumulation (i.e. weavers) are not capable of closely controlling their inventory levels.

4-2 Inter-Stage Coordination and Knowledge Sharing

Let us now turn to some responses by the wool textile companies to the problems addressed above. The issue of inter-stage coordination in product development is discussed first.

Efforts by Individual Companies: Facing the challenge of inter-stage coordination for developing more competitive products, the upstream makers such as weavers have started to make significant efforts to develop capabilities of collecting and interpreting final market information. In the case of men's suits, the weaving companies in Bisei area did not have much opportunity to see how their fabrics are used and evaluated in the final market in the past, partly because the wholesalers handles such market information for the weavers, and partly because the majority of the fabrics for men's suits used to be sold eventually to numerous tailors through wholesalers in the cities (Kiriuri-ya).

Today, the majority of men's suits are ready made, and wholesalers in Bisei area almost disappeared from the supply chain. As a result, the weaving companies had to strengthen direct ties with apparel makers in the areas of product planning and development. As the tight linkages between the weavers and the apparel companies became important, though, the problem of communication gaps between the two players were revealed: the weaving companies did not have enough vocabulary and knowledge on subtle aspects of perceived product quality and design sense in the final market to communicate effectively with the apparel makers. To solve this problem, the weavers have made significant efforts to become more sensitive to the fashion trend and consumer tastes by hiring in-house designers, collecting information directly form the market, visiting fashion shows, and so on.

For example, Company C (weaving) have made significant attempts to be closer to the final markets in recent years by dealing directly with apparel makers of designer's character (DC) brands, selling a part of its fabrics to tailors while skipping wholesalers, and making men's suits in-house for the tailors with an assistance of computer aided marking/cutting system.

At the stage of finishing and piece-dyeing, which is a natural center of information flows for both physical quality on the technical side and sensibility quality on the market side, Company T is also moving towards more direct communication with apparel companies, although it does not have direct contractual relations with the downstream players. In other words, the finishing company is only indirectly connected to the downstream as a subcontractor of the weavers in the formal transactions, but it is in fact transmitting market information from the apparel makers to the weavers in the actual communications. The company has set up its own trading company, and is also continuing surveys on fashion trends for themselves.

Spinning makers are also getting closer to the final market through downstream vertical integration, as well as collaboration with weaving and apparel makers. With their existing strength of stable supply capacity and technological capability in fine yarns, combined with the improved market intelligence, some spinning makers are now recognized as strong competitors in sophisticated fabrics and other downstream products. The alliance with the downstream companies is also a source of the development of yarns.

Where individual companies are too small for such investments on better marketing and design capabilities, an alternative solution is certain collective efforts by an agglomeration of local companies. In the Bisei area, for example, Fashion Design Center was established by a trade association of local wool textile companies in 1984[41]. The center is now making promotion efforts for the products of the weavers by joint exhibitions and other events, serving as a center of information exchanges between weavers and apparel makers, making samples itself by using CAD (computer aided design) for simulation of patterns on papers, training and educating employees of the weavers, and so on.

Vertical Collaboration and Leadership: In addition to the efforts of individual companies at each stage to enhance capabilities of processing market information, collaboration among the different stages is also crucial. For example, development of men's soft suits was carried out jointly by spinning makers, weavers and apparel companies. As special types of fine yarns had to be developed specifically for such suits, the spinning companies had to share information on final customer tastes and translate them into specifications and requirements for their yarns. Joint efforts and knowledge sharing with the apparel and weaving companies is said to have been crucial for developing such capabilities of translating subtle nuances in consumer tastes into technical specifications of the yarns. However, it is still said that there is not enough inter-stage collaboration such as this in Japan, which causes mismatches between yarns, fabrics and apparel products.

Team work across the stages of the supply chain may not be a sufficient condition for developing highly integrated products in today's sophisticated market. Clear and powerful leadership in product development is another important factor for effective

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41 The Center has also been supported by the Japanese government, as well as Aichi prefecture and municipal offices in the area.

product development in many other industries such as the automobile[42]. It is often pointed out that project leadership of "Impannatori" cutting across different stages of production is a source of attractiveness and conceptual integrity of Italian wool products.

Such cases of inter-stage leadership are not observed as often in Japan, but there are some. For example, Company H, a popular apparel maker of designer's character (DC) brands, usually assigns a particular manager to a new product and let the person take full responsibility for total quality assurance in spinning, weaving, dyeing, finishing, sewing, and so on. Thus, when an inappropriate choice of certain imported yarns created quality problems at the dyeing stage, the product manager had to take full responsibility for solving the problem.

To sum up, the Japanese wool textile and apparel makers have started to move toward improved sensitivity to the final market at the individual company level, as well as better coordination and communication across the different stages and companies. They need to improve more on this front, though, in order to become internationally in the increasingly sophisticated market.

4-3 Inventory Problems and Quick Response Systems

Responsibility for Inventories: Let us now look at the second problem: accumulation of inventories. As we analyzed above, one of the reasons for this problem is lack of (or partial lack of) the inventory responsibility on the side of retailers and apparel makers, which tends to lead to excessive amount of orders by them for each item, as well as proliferation of product versions. In relation to this problem, an important development in recent years is the advent of so called "road side shop" chains (for further details of the road side shops, see another paper presented in the conference).

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[42]See, for example, Clark and Fujimoto, 1991, for the impact of project leadership on performance of product development.

Company A is a typical example of such "road side shop" chains. The company has many stores, mainly on the suburban areas of large cities, and is selling "volume zone" products (mainly men's wear) regularly at prices about 20% lower than those of other retailers and department stores. Note that what Company A is selling regularly are neither discount sale items nor low quality products.

In traditional transactions between weavers and apparel makers, the prices of fabrics tend to be set high in the first place, with the future returns and cancels taken into account. On the other hand, Company A limits product variety by focusing only on volume zone products, guarantees purchase of all of the ordered fabrics (i.e. no returns, no cancels), buy fabrics at significantly lower prices in exchange for the lower inventory risks on the weaving side, and let dedicated subcontractors sew the products. In this way, Company A enjoys strong price competitiveness while keeping reasonable levels of profits.

However, shifting the inventory risks from weavers to the apparel maker solves only a part of the problem. Indeed, with the inventory responsibility on the apparel side, Company A clearly has <u>incentives</u> to improve market forecast and to avoid excessive inventories. What about <u>capabilities</u> for better forecasting, though? Without significant improvement in accuracy of the demand forecasting in items, transferring the inventory risks from the upstream to the downstream may simply create piles of unsold stocks at the latter stage. In fact, some industry observers see that Company A now carries a significant level of in-store inventories. Limiting the product variety is one way to reduce the inventory risks, but this may limit consumer's choice and thus lead to lost sales opportunities for Company A.

Another potential problem of shifting inventories to the downstream is that the probability that the downstream inventories (e.g. in clothes) become dead stocks is usually higher than that at the upstream. When unsold after the season is over, upstream products such as yarns and fabrics (particularly before dyeing) have much better chances of being sold eventually than the clothes, which are naturally more fashion-specific. If, on the other hand, apparel makers and retailers carry a minimum level of inventories in clothes with a large amount of stocks in fabrics, the risk of stock out increases, to the extent that production of popular items lags behind the demand due to production and delivery lead time. Thus, the trade-off between stock out and inventory costs persists as to where to keep the inventories.

Quick Response System: An obvious solution to alleviate this trade-off problem is to shorten production lead time in the downstream areas. Many of today's apparel makers are moving toward this direction, which is often referred to as "quick response (QR) system"[43]. In some cases of Japanese apparel makers, quick response system means shorter lead time from fabrics to final delivery to the customers, so that risks of dead stocks are minimized without raising opportunity costs due to stock out.

While there is no clear consensus on the content of the QR system, a Japanese expert of the industry point out at least the following elements as essential[44]:

1. *Flexible Production System:* This includes not only advanced computer-aided technologies such as apparel CAD-CAM (Computer-Aided Design and Manufacturing) systems and robots, but also improvements in process flow design, layout, work design and so on.

2. *Improvement in Quality Assurance:* Total quality control involving all the employees, emphasis on defect prevention, eliminating the duplication of shipping inspection and receiving inspection in the supply chain, and so on.

3. *On-line Computer Network:* Development of the network within and across the companies in collecting the demand information real time, controlling and monitoring production systems, speeding up order entry process, reducing work load for inventory management, and so on.

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43 The origin of the term "quick response" is a study conducted in the United States by Kurt Salmon Associates and sponsored by the "Crafted with Pride in the U.S.A." Council in the mid 1980s. For further details, see, for example, Kurt Salmon Associates, "Progress Report on Quick Response", 1988, and Hammond, Janice H., and Maura G. Kelly, "Quick Response in the Apparel Industry", Harvard Business School Working Paper, 1991.

44 See, for example, Aichi-ken Shoko-bu (Aichi Prefecture Department of Commerce and Industry), <u>Aichi-ken Sen-i Sangyo Jitsuju Taio Sisutemu Chosa Hokoku-sho (Report on the Study of Real Demand Response System in the Textile Industry of Aichi Prefecture)</u>, March 1991, pp. 16 - 20.

4. *Quick and Flexible Delivery System:* For example, shifting such jobs as labeling and assortment from distribution centers of retailers to the sewing makers[45].

5. *Shortening Plan-to-Delivery Lead Time:* Planning and design of the apparel products have to be conducted later (i.e. closer to the sales period) for more accurate demand forecasts.

6. *Strengthening Product Planning and Market Research Functions:* Heavier use of real time market data (e.g. POS point of sales data), customer data base, closer communications with designers and creators, etc., for more accurate demand forecasting.

7. *Vertical Linkages of the Supply Chain:* Vertical collaboration is a key not only to the effective product development (discussed in the previous chapter) but also to successful implementation of the QR system. Again, mutual trust and information sharing in all players in the supply chain is important[46].

Although the quick response concept, in a broad sense, prevailed both in the U.S. and Japan during the 1980s, industry observers suggest that there are subtle differences in nuances of the concept. First, the quick response concept advocated in the U.S. tend to emphasize vertical collaboration between the companies in the industry-wide supply chain, whereas the Japanese version tend to focus more on improvements in development-production-delivery systems within each individual companies, reflecting the fact that the vertical linkages of the Japanese apparel-textile supply chain has already been tighter than the U.S. counterparts[47]. This, however, does not mean that the Japanese level of vertical collaboration is high enough to compete effectively in today's market, as has been seen in the previous sections. It might be even misleading to concentrate efforts for quick response only on the individual company level, assuming that there is enough inter-company coordination at this point.

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45 An interesting counter-example is reported in a U.S. quick response program (Kokuryo, Jiro and Benn Konsynski, "Sara Lee Knit Products", Harvard Business School Case N9-191-021, 1991.

46 For the cases of vertical collaboration for the quick response system in Japan, see, for example, Chogin Sogo Kenkyu-sho (Long Term Credit Bank Research Institute), Johoka de Kawaru Apareru Sangyo (The Apparel Industry in Transition through Information Technology), March, 1991, Soken Chosa Number 5, pp. 13 - 17.

47 Aichi-ken Shoko-bu , pp. 9 - 10.

Second, the Japanese version of quick response system has been influenced more directly by the Just-in-Time concept which has been originated by the Japanese automobile industry compared with the U.S. counterpart, due in part to the physical and historical proximity between the two industry[48]. In fact, some of the Japanese apparel makers had already started attempts to introduce the JIT concept into their sewing process in the late 1970s, prior to the advent of the QR concept on the U.S. side. As a result, the Japanese version of the QR system at the apparel stage tend to include such JIT elements as emphasis on work-in-process inventory reduction, shorter set up change time, pull system of production control, piece-by-piece (unit) work flow system as opposed to traditional batch (or "bundle") production, vertical task assignment across the sewing line, continuous process improvement, and so on[49]. The U.S. version of the QR system is said to focus more on reduction of non-manufacturing lead time of the supply chain rather than small lot flexible manufacturing systems[50].

The patterns and levels of efforts for quick response system are also different depending upon the stages of the supply chain. As seen above, the apparel and sewing makers were the most active in moving toward the small lot quick response system, whereas textile companies tended to be oriented to large lot production, partly because of the nature of the production technology. Thus, to the latter, "quick response" tends to mean reduction of manufacturing throughput time rather than small lot flexible production. As a result, apparel and weaving companies have to accumulate significant amount of

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48 For example, Bisei-Ichinomiya wool textile center and Toyota Motor Company, the inventor of the JIT system, are both located in Aichi prefecture; Historically, the mother company of Toyota Motor Co. is Toyota Automatic Loom; One of Toyota's major parts suppliers, Aishin, is a producer of industrial sewing machines and is an advocate of Toyota Sewing System (TSS) an application of the JIT system to the apparel industry.

49 For the application of the JIT concept to the Japanese apparel industry, see, for example, Chogin Sogo Kenkyu-sho 1991, pp. 17 - 18.

50 One of background data that might explain why quick response program the U.S. emphasize quickness in non-manufacturing activities is provided by an estimate by Kurt Salmon Associates: of the 66 weeks lead time from fiber to customer, only 11 weeks was spent on manufacturing, while 55 weeks was for non-manufacturing activities such as inter-company delivery, material inventory and finished goods inventory. See Chogin Sogo Kenkyu-sho 1991, p. 10.

material inventories (fabrics and yarns) before the season starts even under the quick response system that is currently envisioned[51]. Let us now take a brief look at some cases of the QR efforts by manufacturers at each stage from the downstream.

Apparel and Sewing: As mentioned above, the center of the quick response activities so far has been apparel and sewing. Company M (men's wear apparel), for example, departed from its traditional practices of piling up inventories at the beginning of the season in the fear of stock out by introducing its version of quick response program in 1978. The program aimed at reducing inventory costs and increasing product variety at the same time by a combination of zero inventory in finished products and shorter production lead time for ready-made suits. By 1988, lead time from order to delivery of ready-made suits had been reduced from 20 to 25 days to about 2 weeks.

The fast cycle principle has been applied not only to production system but to order processing at Company M, with the assistance of EDS (Electronic Data Interchange). As customers choose fabrics and have their sizes measured in the store, the information is immediately input into the system through personal computer terminals. The information is transmitted on-line to the factory computer for production control, which prints out production orders real time, as well as sending data on customers and sizes to CAD-CAM (Computer-Aided Design and Manufacturing) system. As exactly the same fabrics as the samples are stored at the factory, production preparation can be started immediately after the order entry.

In production process, a computerized production control system keeps track of the status of each garment from station to station. CAD-CAM serves as a powerful tools in design, marking, grading and cutting. Improvement of production methods and work designs, such as multi-task work assignment (i.e. one worker in charge of more than one

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51 According to the U.S. version of the quick response program, the present practice of buying 80% of total fabrics for the season by initial orders and re-ordering 1 - 2 times during the season is expected to change to a system with about 50% initial orders and 6 re-orders for the season. However, the 50% level of the initial orders prior to the season may be still relatively high from the point of view of many other industries.

machines across the production line), modification in material handling equipment, and mixed model line, and the unit production system (piece-by-piece process) as opposed to traditional "bundle" system, also contributed to the faster production cycle[52].

Company M still has to order a large lot of fabrics at the beginning of the season to avoid stock out, as it is difficult to purchase additional fabrics in the middle of the season. However, the risk of dead stock is much lower than the case of final product, as the fabrics (particularly for the men's wear) can be used elsewhere after the season is over.

Company S, an apparel maker of women's bottom wears with its own in-house cutting-sewing operations, also introduced a small lot quick response system by receiving a technical assistance on Just-in-Time methods from a Toyota group parts supplier in the early 1980s. In the sewing process, the company developed a flexible production process with piece-by-piece work flows and smaller lot sizes. In the new system, sewing and press machines were organized by products; Line workers stood up to handle more than one machines along the line (the workers sat down and worked on one machine in the traditional system); The machines got wheels, their height was standardized, and the floor was made flat, so that the entire layout of production lines could be changed quickly from one lot to another; Low cost material handling devices were developed by using bicycle wheels, ropes, etc. The cumulative effect of such minor modifications on reduction of lot sizes, throughput times, inventories, stockouts, and forced markdowns was more than enough to compensate for the investments.

Finishing and Dyeing: Reducing capacity of the equipment is one of major ways of reducing lot sizes in finishing and dyeing, which are relatively capital-intensive with many batch operations. For example, Company T (finishing and piece-dyeing) recently

52 In the case of Company R, unit production system in women's bottom wears reduced average lot size by 42% (from 195 to 113), shortened production lead time by 78% (from 8.25 days to 1.85 days), while increasing productivity by 21%. See Chogin Sogo Kenkyu-sho 1991, pp. 17 - 18.

added capacity of traditional small batch bleaching machines, as opposed to the latest high-speed tandem machines, in order to become more flexible to small lot orders.

The problem in finishing and dyeing, however, is that average cost per batch does not decrease in proportion with the capacity in the current system. In dyeing, for example, going from 100 kilogram batch machine to 10 kilogram machine reduce the equipment cost only by 50%, and both machines need one operator[53]. There is also limits to faster operations, as it tends to damage the fabrics. Thus, the present production technologies and equipment make it difficult to move to small lot and short throughput time.

This implies that a major prescription for quick response at this production stage is improvement in equipment and its system toward flexible automation[54]. Some of larger dyeing and finishing companies have actually started to invest on flexible-continuous dyeing system with automatic color changes, group-controlled dyeing machines for small lot operations, flexible finishing system, and so on. However, the efforts are relatively limited so far, partly because most of the smaller companies cannot afford to introduce expensive flexible automation, and partly because there are not enough production engineers to deal with advanced manufacturing technologies in most of the companies at this stage.

Weaving: At the weaving stage, also, small lot fast cycle production has been rather difficult partly because time and cost for set up change (mostly for warp drawing process) was high, and partly because excessive speed of the looms tended to deteriorate quality of the fabrics and increase machine down time. Thus, historically, the Japanese weaving companies tended to rely more on low cost subcontractors in order to absorb the increasing set-up cost due to small lot production.

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53 Aichi-ken Shoko-bu 1991, p. 28.

54 For quick response attempts in finishing and dyeing, see Aichi-ken Shoko-bu 1991, pp. 61-80.

The main bottleneck against small lot weaving is time and cost for warp drawing[55]. When the pattern of warps (typically 5000 yarns for the standard width of wool fabrics) is unchanged between two beams, automatic tieing machines, widely used in the industry, can change beams for 20 to 40 minutes. When the patterns change between the beams, warp drawing operations are needed, but this process is hardly automated. Traditional drawing process takes 8 to 10 hours, which create a significant burden on frequent set up changes. While the latest automatic drawing machines can reduce the set up time to 1 - 1.5 hour, high equipment price (about 120 million yen, or nearly one million U.S. dollars per set) and high speed of the machines make it difficult for most of smaller weavers to operate them economically. In fact, there are very small number of companies that have introduced automatic drawing machines[56]. Thus, with or without automation, it is rather difficult to justify small lot production at the weaving stage.

In the weaving process, introduction of high speed looms, such as Sulzer machines and air jet looms, tend to result in larger lot sizes because of its high speed. According to a survey on the wool weavers of Bisei Area (conducted by Aichi Prefecture in 1986), average lot size of traditional looms was about 10 tan (about 600 meters), while that of high speed machines was roughly 30 tan. According to another survey conducted by Ministry of International Trade and Industry in 1988, the average lot size of wool fabrics was about 10 tan and did not change between 1981 and 1986, although this was smaller than the lot sizes of other fabrics such as cotton, silk and synthetic. In the same survey, average delivery time decreased from 92 days to 83 days, but the latter is still the longest among all of the Japanese weaving and knitting sectors[57]. Thus, dramatic reduction of both lot size and throughput time of weaving process has been so far difficult.

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55 The following data on the drawing process is based on the authors' interviews with Company C in Bisei, as well as Aichi-ken Shoko-bu, 1991, pp. 36 - 44.

56 About ten companies in the entire Aichi prefecture.

57 Aichi-ken Shoko-bu, 1991, pp. 29 - 33.

Spinning: In spinning, quick response was achieved mostly through automation of equipment, reflecting relatively capital intensive nature of the process. In a wool spinning factory (top making, top dyeing and spinning) of Company K , for example, production throughput time was reduces by 10 to 15 % by improving and automating combers, top dyeing equipment, spinning machines and winders[58]. The system does not aim at flexible small lot production, though.

Computerized production control system is another tool for shortening delivery time. At company U, for example, improvement in vertical production control of spinning, weaving and dyeing lead to reduction of lead time from 7 weeks to 1 to 2 weeks[59]. Company U is also increasingly emphasizing development and production of differentiated yarns, as opposed to high volume commodity yarns. However, the efforts for quick production system at the spinning stage is mostly those for shorter delivery time, rather than smaller lot flexible production.

Overall, there are a growing number of companies which have started their transformation process toward quick response and small lot production systems, which would help the companies alleviate the problem of growing inventories, but the degree of their introduction differs widely across the production stages. As a result, there is still a large gap between lot sizes of the downstream (apparel) and those of the upstream (textile). While the fragmented nature of the industry and difficulty of inter-stage coordination still persist in many areas, the entire supply channel of the Japanese wool industry would need far more efforts to improve coordination in production control across the stages.

5 Conclusion

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58 Aichi-ken Shoko-bu, (Aichi Prefecture Department of Commerce and Industry), Aichi-ken Sen-i Sangyo Jitsuju Taio Sisutemu Chosa Hokoku-sho (Report on the Study of Real Demand Response System in the Textile Industry of Aichi Prefecture): Case Studies. March 1991, pp. 10 - 14.

59 Chogin Sogo Kenkyu-sho, 1991, p. 20.

In this paper, we focused on the basic characteristics of production and development systems in the Japanese wool textile and apparel industry. The Japanese wool industry is facing an intensifying competition both against foreign companies and against other materials.

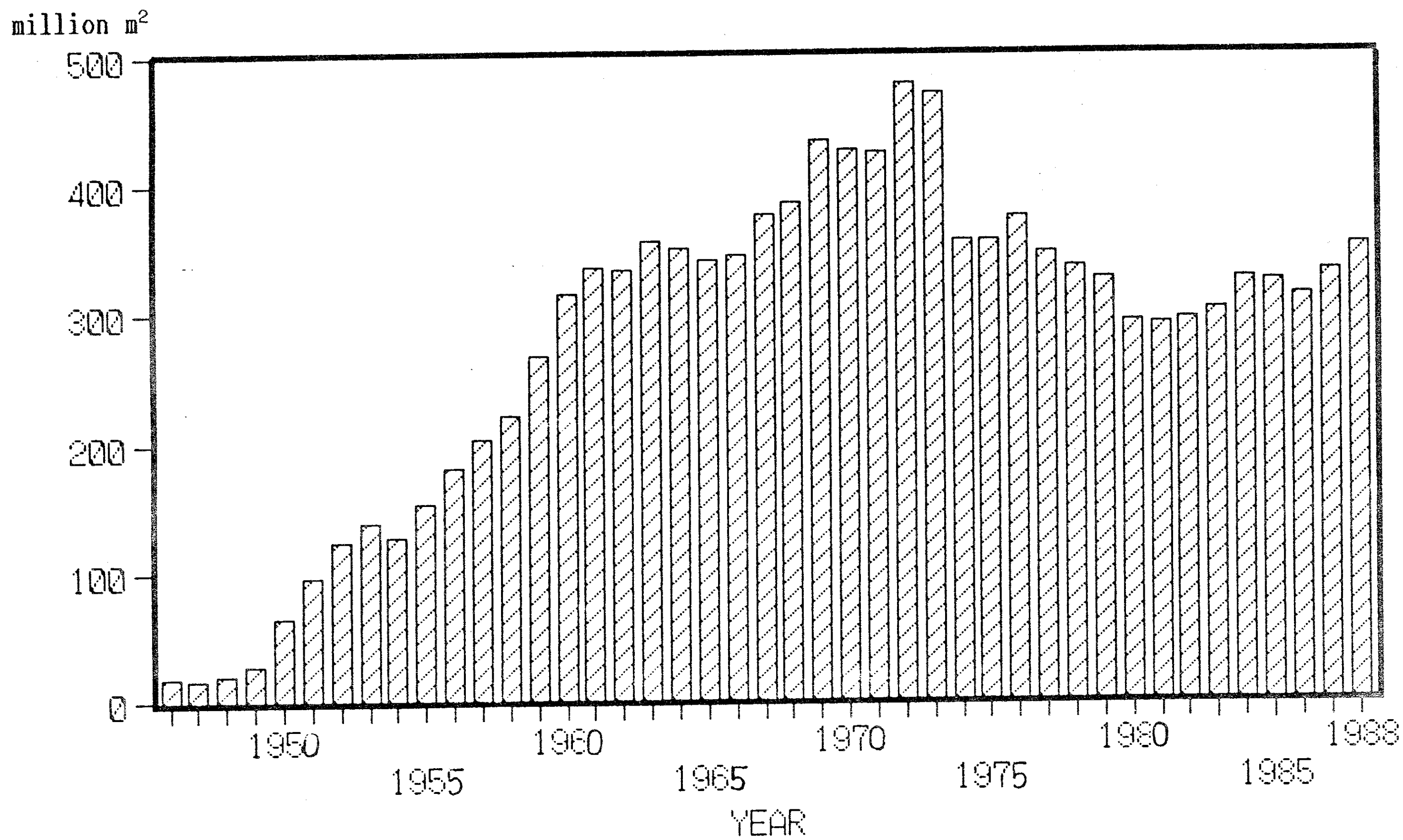
Indeed, the industry has been relatively successful (compared in particular with some other sectors of the Japanese textile industry) in maintaining its competitive strength. The flexible network and geographical agglomeration of many local companies, with intricate systems of specialization and coordination, certainly contributed to this modest success of the industry so far in responding to increasingly diversified and sophisticated needs of today's consumers.

However, a closer look at the current system revealed some significant problems that the industry would have to deal with, including insufficient inter-stage coordination in product development, and accumulation of inventories. These problems stemmed in part from essentially the same basic problems: fragmentation of producers in the supply chain, as well as mismatches between structures of incentives, responsibilities and capability among the fragmented players in terms of the inter-stage communication, coordination and leadership.

We also looked briefly at some examples of responses of the companies to the above challenge: For the inter-stage coordination in development, we presented some cases of knowledge sharing between upstream and downstream, improved capabilities in interpreting and forecasting consumer tastes, cross-stage joint development, and clear leadership for product development covering the entire supply chain; For the problem of the inventory, we examined efforts for shifting inventory risks to the downstream, as well as introduction of quick response and small lot production systems.

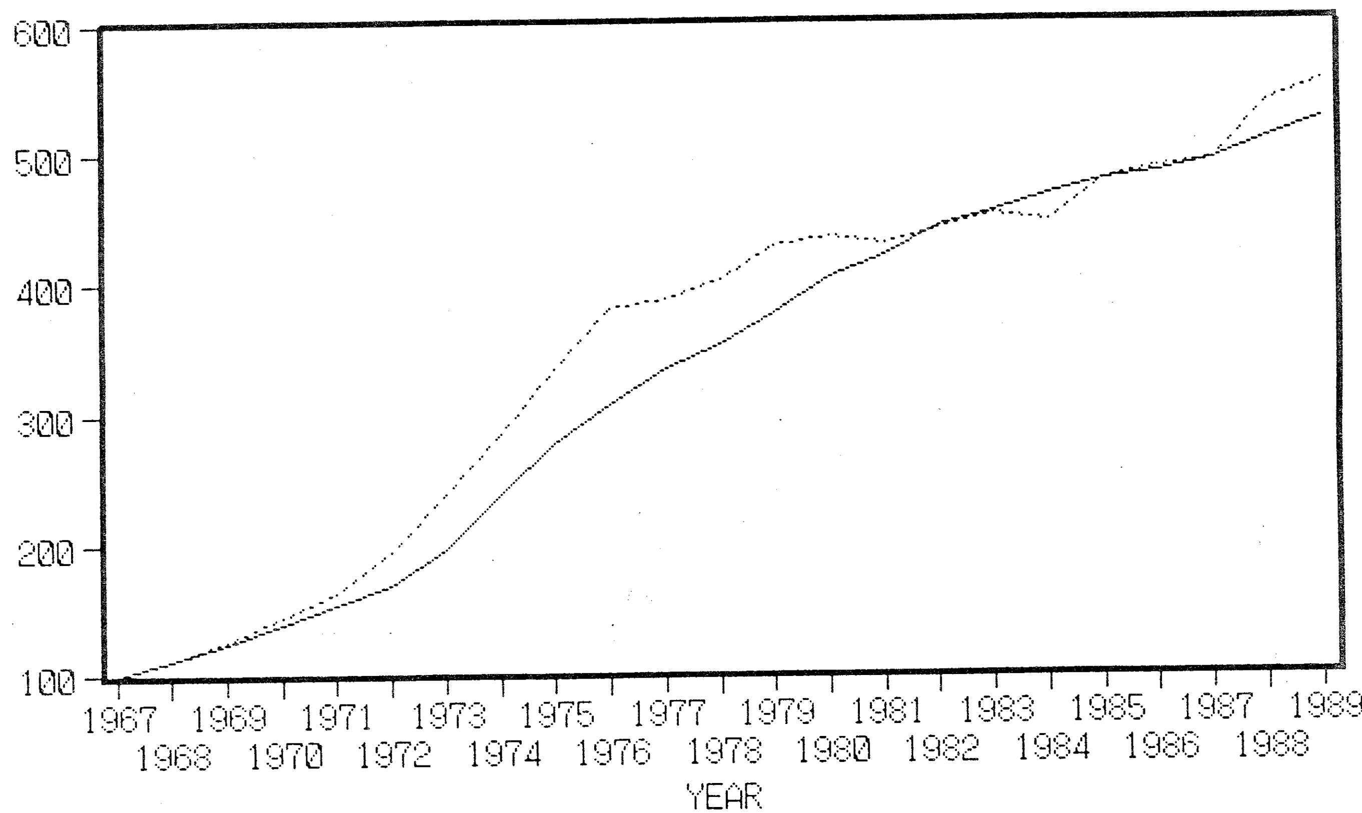
There are, of course, no perfect set of solutions to the present problems. Trade offs and dilemmas persists in many aspects of the industry. However, the entire industry is making slow but steady steps in response to intensifying competition and sophistication of consumer tastes. Whether this process of adaptation can successfully lead to self-renewal of this relatively old industry in Japan is not yet known. One thing we can say for sure at this point, though, is that it is too early to label this industry as "matured".

Figure 1-1 Production of Fabrics

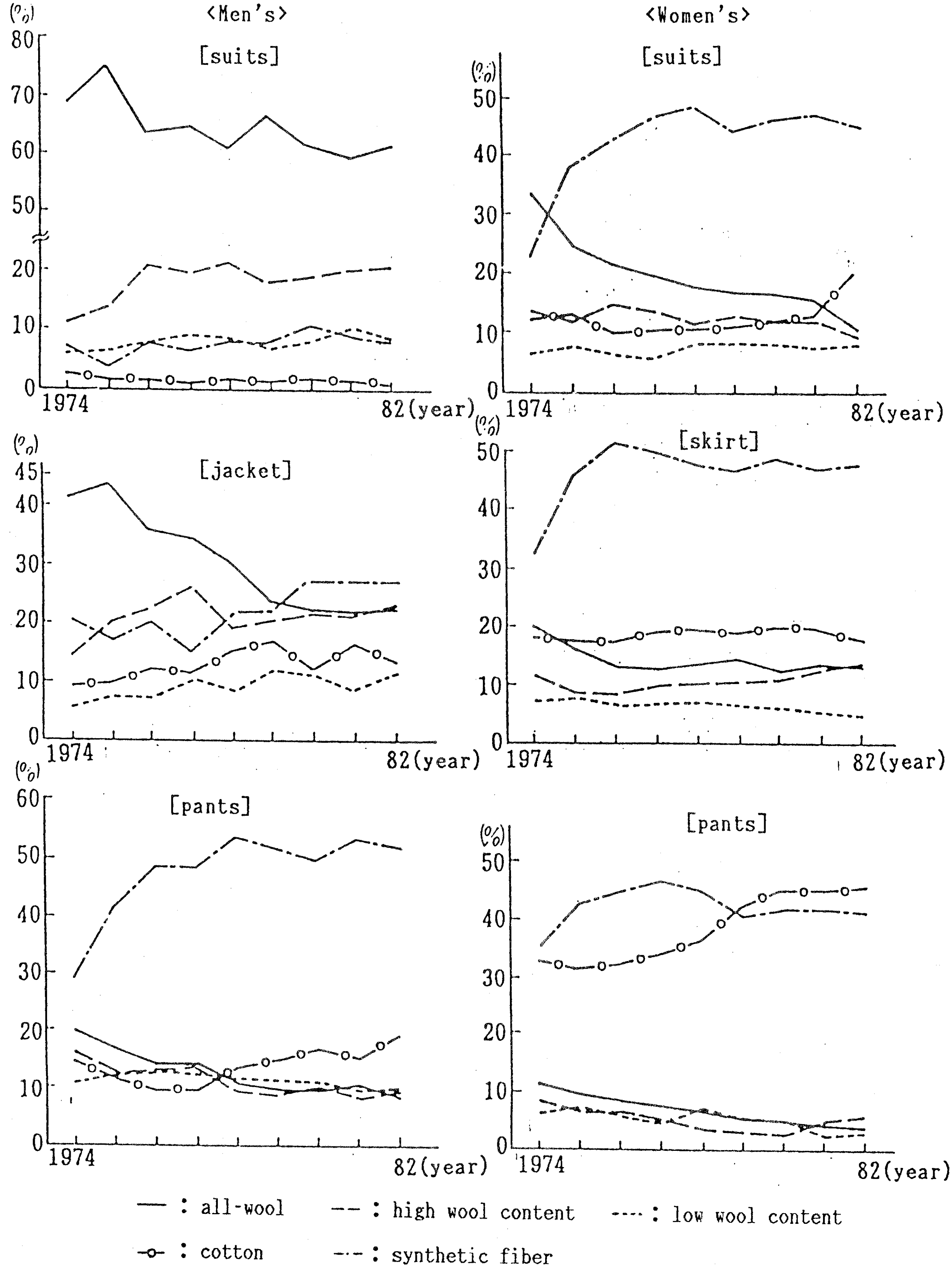


Source: Ministry of International Trade and Industry,
Yearbook of Textile Statistics

Figure 1-2 Transition of Clothing Consumption
(1967=100)



Source: Burea of Statistics Office of the Prime Minister,
<u>Annual Report on the Family Income and Expenditure Survey</u>



source: People's Finance Corporation,

Department of Research (1984), P.237

Figure 1-4 Production and Distribution process of Wool products

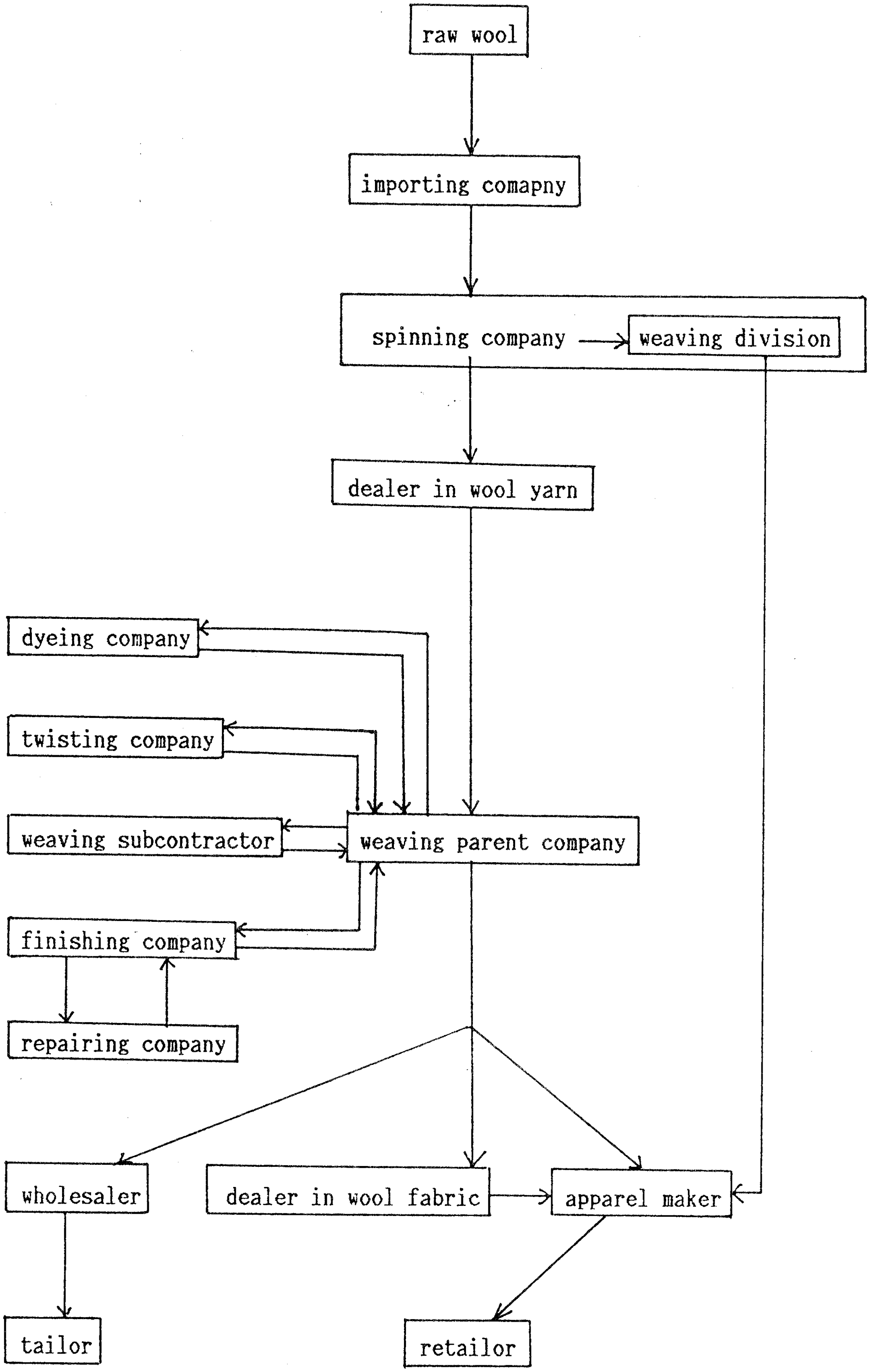
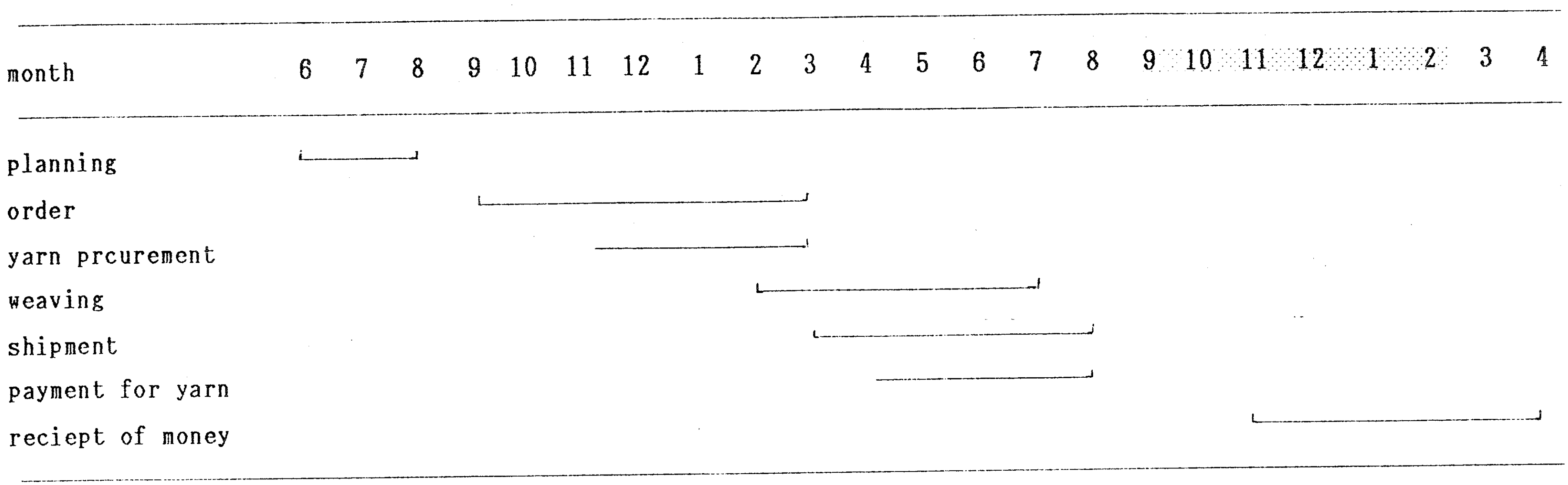


Figure 2-1 Order-Production-Shipment Cycle of Weavers(Men's for winter season)



Source: People's Finance Corporation
Department of research, 1984, P. 250

Note: sales season = shaded area

Table 2-1 Comparison of Characteristics among Materials

	wool	silk	cotton	nylon	polyester	acrylonitrile
specific gravity	1.32	1.33-1.45	1.54	1.14	1.38	1.14-1.17
hygroscopic property(%)	16	9	7	3.5-5.0	0.4-0.5	1.2-2.0
Young's modulus(g/D)	11-25	50-100	68-93	10-25	25-45	25-62
elongation(%)	25-35	15-25	3-7	38-50	40-50	27-48
elongation recovery(%)	99	54-55	74	95-100	85-95	90-95
tensile strength(g/D)						
(dry)	1.0-1.7	3.0-4.0	3.0-4.0	4.7-6.7	4.4-5.5	2.5-4.6
(wet)	0.76-1.63	2.1-2.8	3.3-6.4	3.9-5.7	4.4-5.5	2.0-4.5
resistance to rubbing	weak	slightly strong	slightly strong	weak	strong	strong
resistance to heat	scorches at 205℃	burns at275-455℃	resolves at 150℃	softens at 180℃	softens at 238-240℃	softens at 190-240℃
resistance to sunlight	strength lowers	strength lowers remarkably	strength lowers yellows	strength lowers slightly	strength lowers slightly	no chang
resistance to acid	strong	strong	weak	slightly strong	strong	stron
resistance to alkali	weak	weak	strong	strong	strong	stron
electrification	weak	weak	weak	strong	very strong	stron

Source: IWS, Wool no Chisiki (Knowledge on Wool), P.14

Table 2-2 Import and Export of the Japanese Wool Industry

(unit: M Kg, clean)	1981	1982	1983	1984	1985	1986	1987	1988	1989
RAW MATERIAL									
Import	138.5	156.2	139.4	162.9	169.3	154.2	189.8	166	167.8
Export	0.6	0.3	1.0	0.8	0.7	0.4	0.6	0.2	1.3
MillConsumption	137.9	155.9	138.4	162.1	168.6	153.8	189.2	165.8	166.5
TOTAL IMPORT QUANTITY OF WHICH:	12.4	19.4	17	25.2	26.6	26.3	37.1	41.9	50.2
Yarn	0.9	4.1	3.2	6.8	6.8	3.0	5.5	9.4	6.8
Fabric	2.4	2.7	2.5	3.1	4.0	3.7	4.8	6.5	7.3
Garment	9.1	12.6	11.3	15.3	15.8	19.6	26.8	26	36.1
TOTAL EXPORT QUANTITY OF WHICH:	21.6	16.9	19.4	18.6	15.4	16.9	15.8	13.1	16.9
Yarn	13.4	8.2	10.7	10.3	7.7	9.9	9.3	8	10.7
Fabric	3.7	3.9	3.6	3.8	4.7	4.0	4.0	3.8	4.7
Garment	4.5	4.7	5.2	4.5	4.0	3.0	2.5	1.3	1.5
WOOL AVAILABILITY	128.7	158.5	136	168.7	179.8	163.2	210.5	194.6	199.8
NDS	138.4	137.9	143.5	151.2	151.7	153.9	160.6	170.4	169.5

Source: IWS (Japan Branch).

Table 2-3 Cross-Country Evaluation of Textile Goods in the European Market

factors	1	2	3	4	5	6
price	China	Taiwan	Korea	Hong Kong	Singapore	Japan
quality	Japan	Korea	Hong Kong	Singapore	Taiwan	China
after sales service	Japan	Taiwan	Hong Kong	Singapore	Korea	China
design, packing	Japan	Hong Kong	Singapore	Korea	Taiwan	China
credibility	Japan	Taiwan	Hong Kong	Singapore	Korea	China
new product development	Japan	Hong Kong	Singapore	Taiwan	Korea	China
settlement condition	Japan	Hong Kong	Singapore	Taiwan	Korea	China
exception to import regulation	China	Hong Kong	Korea	Singapore	Japan	Taiwan
small lot	Hong Kong	Taiwan	Singapore	Japan	China	Korea
rapid sampling	Japan	Hong Kong	Taiwan	Singapore	Korea	China
marketing	Japan	Hong Kong	Taiwan	Singapore	Korea	China
punctuality	Japan	Hong Kong	Taiwan	Singapore	Korea	China
quick response to claims	Japan	Taiwan	Hong Kong	Singapore	Korea	China
overall competitiveness	Japan	Hong Kong	Taiwan	Singapore	Korea	China

Source: Korean Department of Commerce and Industry, 1982
in Yoshikawa, M., 1986, P.46.

Table 3-1 Size Distribution for Business Establishments

number of employees	entire manufacturing sector	weaving industry	wool weaving industry
1 - 3	295,469(41.2%)	24,796(75.5%)	4,189(79.1%)
4 - 9	231,364(32.3%)	6,077(18.5%)	895(16.9%)
10 - 19	86,109(12.0%)	1,024(3.1%)	104(2.0%)
20 - 49	67,687(9.4%)	676(2.1%)	73(1.4%)
50 - 99	20,664(2.9%)	158(0.5%)	19(0.4%)
100 -	15,933(0.2%)	105(0.3%)	13(0.2%)
total	717,226	32,836	5,293

Source: Ministry of international Trade and Industry, Census of Manufacturers, 1989.