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## **Japan's Comparative Advantage in the Machinery Industry: Industrial Organization and Technological Progress**

RYUTARO KOMIYA



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The European Policy Unit at the  
European University Institute

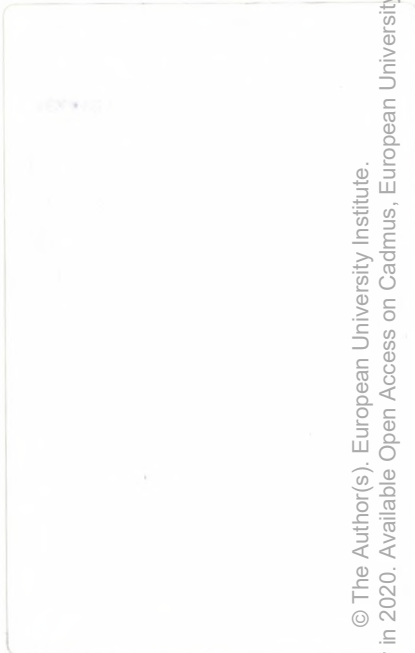
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**Komiya: *Japan's Comparative Advantage in the Machinery Industry:  
Industrial Organization and Technological Progress***

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## **Japan's Comparative Advantage in the Machinery Industry: Industrial Organization and Technological Progress**

**RYUTARO KOMIYA**

**1993**

**The European Policy Unit at the  
European University Institute**

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# Japan's Comparative Advantage in the Machinery Industry: Industrial Organization and Technological Progress\*

RYUTARO KOMIYA

## I. Introduction

Industrial fields where Japan now holds strong comparative advantage in international trade are limited to a rather narrow range, which may be characterized as mass-production type machinery industries. This paper asks why Japan has strong comparative advantage in such industries, and argues that the Japanese patterns of industrial and enterprise organization are conducive to rapid technological progress and realization of economies of scale in the machinery industry.

The paper first takes a look at the industries in which Japan holds strong comparative advantage in international trade. In short, Japan maintains strong comparative advantage in the mass-production type, fabricating and assembling manufacturing, especially in the broadly defined machinery or engineering industry. This includes electrical machinery, electronics, precision instruments and transport machinery (Section 2).

Compared with their foreign counterparts, Japan's mass-production-oriented machinery industries have certain distinct characteristics which seem to serve as the basis of its comparative advantage in these fields. One of the characteristics of Japan's industrial organization in these fields is that

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what I call 'tight vertical integration' is relatively unimportant. 'Tight vertical integration', or the 'organization (hierarchy) -type' relationship, is a form of industrial organization in which each manufacturer conducts product development and produces much of the required materials and parts within its own structure. Also, what I call 'arm's-length transactions', or the 'market-type' relationship, between enterprises with no special business relationships is less important than in other countries. What is more important in Japan's machinery industry is what I call 'loose vertical integration', which is an intermediate form of relationship between the organization-type and market-type ones. These are long-term, continuous transactions and joint projects for product development among cooperating enterprises. The intermediate type of relationships seem to work in favour of technological progress because competition and cooperation coexist under such organizational relationships (Section 3).

In general, basic technologies that have served as the basis for good performance of leading manufacturers in Japan's machinery industry are not those technologies which are highly original and patentable. Highly original technologies which cannot be easily reproduced by others play relatively minor roles in their success. What have been more important are technologies related to the manufacturing process, quality control and product planning, which result from step-by-step efforts to manufacture products more efficiently, to inspect them more accurately in large quantities, and to steadily increase productivity through rationalization, standardization and automation. Also important is the development of products which are well tailored to customers' needs and which meet those needs better than products provided by competitors (Section 4).

Under an industrial organization with a relatively high weight of 'loose vertical integration', these technologies can be easily mastered by other manufacturers in the industry. Hence new entry has been relatively easy in Japan's machinery industry. As a result, the number of major manufacturers in each product field in Japan is generally speaking far larger than in other countries, and this has served to promote competition and technological progress (Section 5).

There are various concepts and theories about economies of scale in economics and especially in the theory of industrial organization. In the case of the mass-production machinery industry in Japan, economies of scale in production on a plant basis or on a firm (enterprise) basis do not seem overly important: if they were really important there would be only one or a few manufacturers in each field. The high weight of 'loose vertical integration', one of the primary characteristics of the industrial organization of Japan's machinery industry, has helped create a combination of competition and cooperation among firms, accelerate 'learning effects'

among them, propagate these effects to adjacent industries and contribute to steady and rapid technological progress. These tendencies may be regarded as the most important kind of economies of scale in Japan's machinery industry (Section 6). Main conclusions of the paper will be summarized in Section 7.

## **II. Industries in which Japan has Strong Comparative Advantage**

Obviously Japan, or any country, does not – and cannot – have comparative advantage in international trade in every sector of the manufacturing industry.<sup>1</sup> In fact, industries in which Japan has strong comparative advantage are relatively limited in range. Generally speaking, Japan does not have comparative advantage in what is called the 'plant-based industry' in Japan, which requires large-scale, fixed plant and equipment, such as the chemical, petrochemical, oil refining, pharmaceutical, paper and pulp, glass and nonferrous metal industries, – perhaps with the exception of iron and steel. Japan has already lost, or is losing, comparative advantage in labour-intensive manufacturing industries dependent on cheap, unskilled labour, such as textiles, toys or sundry household merchandise, as well as in those machinery industries which depend on cheap, unskilled labour, such as sewing machines, bicycles (complete ones, but not parts), wrist watches, transistor radios and cameras in lower- to medium-priced categories.

Most of those industries in which Japan now has strong comparative advantage in international trade can be categorized as manufacturing industries involving product design, metalworking fabrication, assembling in a mass-production system; that is, the mass-production machinery industries in a broad sense. Japan has strong advantage especially in those types of general machinery, electrical and electronic products, precision instruments and transport machinery which require medium- to high-level, mass-production technologies and serve a large number of users.<sup>2</sup>

### **Characteristics of Japanese Industries with Strong Comparative Advantage: Mass-Production Machinery Industry**

General characteristics of the mass-production, fabricating and assembling type industries, the mass-production machinery industry for short, where Japan has strong comparative advantage, are as follows.

(1) Fabricating and assembling: In the process of production, first metal, plastics and other raw materials are processed into various parts, subassemblies and assemblies, and are then assembled into finished products.

(2) Product differentiation: Each manufacturer – or maker – produces and offers a variety of products slightly different from those of its competitors. Each maker relies on advertising and other sales promotion measures, after-sales service, and marketing and service networks to support its sales and service activities. Therefore it is important to lay out and implement ‘product planning’; that is to plan the kinds of new products that meet customers needs, set the timing of launches and model changeovers, and coordinate research and development, production and marketing.

(3) Mass-production type: The same product or nearly the same products are produced in large quantities, to be purchased by a large number of users. Therefore it is important to organize the manufacturing process to produce these products in volume at the lowest possible cost, and hence to increase productivity by controlling costs and reducing the ratio of defective products relative to the total output.

(4) Quality control: As a corollary from characteristics (2) and (3) above, the quality of mass-produced products must be kept highly homogeneous. Hence, quality control and product inspection is of critical importance.

(5) Technological progress: As a corollary from characteristics (2), (3) and (4), technological progress has been steadily made year by year, day by day, both in the products themselves and in the manufacturing process.

(6) Low importance of patents for firm’s performance: In areas where Japanese industries have a strong comparative advantage internationally, patented, patentable or licensable technologies and know-hows – patented technology for short – are, by and large, not of great importance. More specifically, there are few Japanese firms among the leaders in Japan’s mass-production machinery industries that enjoy competitive advantages due to highly original patented technologies to which others cannot gain easy access. Rather, the technological advantages enjoyed by leading Japanese firms in the machinery industry stem mainly from know-hows other than patented technologies. Japanese firms have had little comparative advantage in research and development of patented technologies, at least until quite recently, although the situation is likely to change substantially in the near future.

In addition to the characteristics stated above, the following one may also be pointed out as a characteristic of industries where Japan has strong comparative advantage.

(7) 'Compound' technology: The technological advantage Japanese machinery firms have is often based on a combination of several different kinds of technologies. In this context, different kinds of technologies mean mechanical, precision, electrical, electronic, optical and chemical technologies. In order to develop, design and produce products in large quantities which require such a 'compound' technology, close cooperation is necessary among researchers and engineers in different fields and among workers with different skills. Also firms with different specialities need to cooperate closely. It seems that Japanese engineers, workers and firms are better at such cross-field cooperation than their foreign counterparts.

### **Examples of Industries that Feature Characteristics Described Above**

The following are typical examples of Japanese industries with strong comparative advantage featuring most of the characteristics described in (1)-(7) above.

- (a) Automobiles: A typical case with characteristics (1)-(6). Recently in a development related to characteristic (7), electronic technologies (automatic control mechanisms) are becoming increasingly important for automobiles.
- (b) Machine tools, particularly numerically-controlled machine tools and machining centres: Japan is strong in mass-produced, standard, general purpose machines.
- (c) Consumer electronic products: The characteristics as described in (1)-(7) above are obvious. Televisions, cathode ray tubes, video cassette tape recorders (VCR or VTR), telephones, facsimile machines, video cameras and TV cameras all fall into this category.
- (d) Photocopiers: The characteristic described in (7) is observed here. Photocopiers incorporate such diverse technologies as mechanical engineering, optics, electronics, photoconductors and resins.
- (e) Audio equipment: In the area of amplifiers, tuners, speakers, compact disc players and tape recorders, Japanese audio equipment manufacturers have a dominant position in markets for relatively mass-produced, high-quality models, but not for very high-quality, luxury models.
- (f) Cameras: Japan stands without rival in the world market for mass-produced high performance cameras, which depend on a compound technology of optic (lens), precision-mechanical (shutters), electronic (automatic control mechanisms) and electric (mini-size motors) engineering.<sup>3</sup> But the camera market is now saturating, and becoming more oligopolistic than before. Major Japanese camera manufacturers are now diversifying into other fields such as photocopiers, semiconductor-manufacturing equipment,

semiconductors, and lens for video cameras, with the proportion of cameras in their total sales declining sharply.

(g) Semiconductors: Japan is particularly strong in mass-produced dynamic random access memory (DRAM) chips and other standardized chips. Products other than mass-produced ones are also generally marked by characteristics as described above in (1), (2), (4), (5) and (7). The characteristic (6) is not applicable for semiconductors and semiconductor-manufacturing equipment. With regard to characteristic (7), a powerful semiconductor industry will not develop in a country unless its technological levels are high in a number of closely related areas, such as electronics, materials (metallurgy, ceramics, chemicals), optics, and metal and plastic processing.

(h) Textile, construction and agricultural machinery: These sectors of machinery industry are not in the highly mass-production category, but are characterized by some of the features described above. The Japanese textile industry has generally lost comparative advantage except in high value-added apparel, with import exceeding export for many items, but the textile machinery industry is still quite strong. Japanese manufacturers of construction and agricultural machinery tend to have comparative advantage in smaller and mass-produced models.

### **Changing Pattern of Comparative Advantage**

Besides the industries cited above, there exist certain labour-intensive machinery industries, such as watches, sewing machines and bicycles, for which Japan had comparative advantage in the past, but has lost or is about to lose that advantage due to the rise of competitors in Asian NIEs (newly industrializing economies) and the sharp increase in domestic wage levels. Some Japanese manufacturers in these industries have moved their site of production to Asian NIEs and ASEAN (the Association of Southeast Asian Nations) countries or to importing countries (North America and Western Europe). As a result, products made in Asian NIEs and ASEAN countries, including those made by Japanese subsidiaries there, are driving out domestically-made products in the low- and middle-price ranges.<sup>4</sup>

### **Does Japan have Monopoly?**

Does Japan have strong comparative advantage in any sector of the machinery industry? The answer is obviously no. In such fields as aircraft, jet engines, mainframe computers, large machine tools, thermal power

plants, nuclear power plants and telephone exchange equipment, Japan either does not have comparative advantage, or has only limited advantage. It appears that Japan has not been strong in areas where large research and development outlays are needed, or those not involving mass production. Moreover, even in most of the industries cited above in which Japan holds strong comparative advantage, there exist leading foreign manufacturers with more or less the same (or even superior) levels of technology as their Japanese counterparts. Many of these foreign firms are quite successful over the long run (to cite a few, Robert Bosch, Daimler-Benz, General Electric., General Motors, International Business Machines, Phillips, Texas Instruments and Xerox). Hence it is a mistake in elementary economics to say that 'Japanese enterprises monopolize the world market'. Even in the case where only a few foreign manufacturers compete with Japanese ones in the world market, such as the case of VCR or facsimile machines, this has nothing to do with monopoly. Monopoly refers to a situation in which a market is dominated by only one firm. A situation in which more than 10 Japanese companies produce and sell VCRs, actively competing with each other, has nothing to do with monopoly. There are generally a number of Japanese firms competing with each other in industries where Japan has strong comparative advantage. Most of these industries are to be characterized as competitive oligopoly or 'polypoly', rather than monopoly, duopoly or oligopoly by few.

### **General Basis of Development of the Mass-Production Machinery Industry**

It should not be ignored that the following factors have served as basic general conditions fostering the comparative advantage Japan now has in the mass-production machinery industries; Japan's large population, the large size of the domestic market,<sup>5</sup> the relatively high level of education that provides workers capable of developing skills required by the machinery industry,<sup>6</sup> and the development of industries that support the machinery industry by supplying materials, castings (dies), machine tools, machines, electrical and electronic parts and semiconductors. Some of these are themselves mass-production type machinery industries.

### **III. Organizational Characteristics of Japan's Machinery Industry: Market versus Organization**

Let us consider what the organizational characteristics of Japan's mass-production machinery industries are compared with other Japanese industries or their counterpart industries in foreign countries.

#### **Manufacturing Process of Machinery Industry**

From the viewpoint of a 'parent' manufacturer – or a 'parent' maker – which produces and sells products under its own brands,<sup>7</sup> the process of 'production' in a broader sense may be considered as consisting of six stages, as described below.

- (1) Product planning and development, including basic research and development (including also obtaining licence of technologies from other firms);
- (2) Planning of the manufacturing process, including designing, production and installation of equipment, machinery and facilities;
- (3) Production of parts, and subassemblies;
- (4) Final assembly;
- (5) Inspection;
- (6) Marketing (including advertising) and after-sale service.<sup>8</sup>

When empirically analysing from an economic point of view the industrial organization of a sector of the machinery industry, one should consider the following organizational problems for each parent maker.

- (a) Which parts of each of the six stages above does the parent maker commit to undertake by itself, and how long will it continue to do so? Sometimes the parent makes a product itself on a trial basis or in the initial phase of commercial production, but lets other firms produce the item under subcontract later on.
- (b) In which parts does the parent use the market? That is, in which parts does it depend on 'arm's length' transactions?
- (c) Which parts does the parent maker decide to let other firms undertake, under long-term, continuous contract relationships? The parent may have a minority share in some of these other firms with which it establishes long-term relationships.



(d) Which parts are undertaken as a joint project between the parent and other firms? Such a project for R&D or development of a new model may or may not be based upon a formal contract.

## Markets and Organizations

By rough classification, (b) is the use of markets, while (a) is the use of organizations (or hierarchies); (c) and (d) are the use of some intermediate form between markets and organizations. The word 'organizations' here has the same meaning as in the economics of organization developed by Herbert A. Simon, Oliver Williamson and others.<sup>9</sup>

Herbert A. Simon, a Nobel-laureate economist, said in his recent paper "Organizations and Markets",<sup>10</sup> "No matter whether our visitor (from Mars) approached the United States, or the Soviet Union, urban China or the European Community the greater part of the space below it would be within the green areas" (organizations), rather than "red lines" (markets), and "organizations would be the dominant feature of the landscape". He also said "the economies of modern industrialized society can more appropriately be labelled organizational economies than market economies". But he seems to treat organizations and markets separately, in a black and white fashion, and does not touch on intermediate, grey forms; that is intercorporate relations based on 'loose' vertical integration, such as intercorporate shareholdings, long-term and continuous transactions, seconding and accepting of top executives, joint ventures for R&D, or sales and service networks in marketing.<sup>11</sup> These intermediate arrangements are very important forms of industrial organization, especially in Japan's machinery industry. A similar remark may be made regarding the discussion of the market and the firm by Ronald H. Coase, another Nobel laureate, in his book *The Firm, the Market and the Law*.<sup>12</sup>

In general, as forms of enterprise and industrial organization for each of stages 1-6 above, or for each subdivision of stages 1-6, (a) may be called 'tight' vertical integration; (b) may be called 'arm's length' market transactions; (c) and (d) may be called 'loose' vertical integration.

Generally, it is not possible to discuss *a priori* in a wholesale manner what organizational form and what kind of arrangements and relationships are best for each stage of manufacturing, because it depends on various factors and conditions. Since best forms and arrangements depend on the social and cultural environment, an organizational form that best suits a particular stage of manufacturing in one country may not necessarily be the best one in another country with different social and cultural traditions.

'Loose' vertical integration is a grey zone between 'tight' vertical integration (black?) and market transactions (white?), so that the exact

dividing line between 'tight' and 'loose' vertical integration is difficult to draw. But majority shareholding may be considered as a 'tight' integration relationship and minority shareholding as a 'loose' variety.<sup>13</sup>

## Organizations of Japan's Machinery Industry

Compared with the corresponding machinery industries in foreign countries, in Japan's mass-production machinery industry (c) and (d) are more prevalent among the four organizational problems listed above. In other words, the weight of 'loose vertical integration' is heavier, and especially (c); that is, long-term, continuous transactions based on mutual understanding and trust play an important role.

Typical organizational forms widely observed in the production process of Japan's mass-production machinery industry are as follows:

In *product planning and design* (1), of course, the parent maker plays a central role, which is case (a).<sup>14</sup> But in Japan, case (c) or (d) is often seen in the development and design of parts for a new product or a new model. The parent manufacturer and parts suppliers cooperate in developing and designing parts and subassemblies years before the parent puts a new product or a new model on the market.

In *planning of the manufacturing process and the designing and producing of manufacturing equipment, machinery and other facilities* (2), all cases of (a), (b), (c) and (d) are observed. But in Japan, the case in which the maker of a certain product produces plant and equipment by itself (facilities of production, equipment, machines, apparatus, dies, tools and jigs – equipment in short, in the following) needed in manufacturing that product is rare.<sup>15</sup> A Japanese characteristic here is that the maker of a certain product and the makers of equipment necessary in producing the product are separate but cooperate closely. They step extensively into each other's domain, with the former requesting many things from the latter and the latter seeking to understand the former's needs and giving advice on designing the manufacturing process.

For example, I was told at semiconductor manufacturing equipment maker in Japan that Japanese semiconductor makers tend to request various improvements in manufacturing equipment they wish to buy on the basis of their experience in using previously purchased equipment, and are willing to pay more for such improvements once they enter into steady, continuous business relationships. But it is said that US semiconductor manufacturers tend to buy standard models on the catalogues at as low a price as possible. Correspondingly, according to a Japanese semiconductor maker, whereas Japanese equipment makers listen to users' requests and try

to meet such requests as much as possible, US equipment manufacturers tend to give little attention to requests by the users.

It appears to me that such close relationships between manufacturers of finished products and the suppliers of manufacturing equipment in Japan tend to promote the spread of manufacturing know-how throughout the machinery industry.

In the *production of parts* (3), Japanese machinery makers are, by and large, characterized by the high ratio of purchases from outside subcontractors and suppliers – plus processing by outside processors –, and by a correspondingly low ratio of items produced within the firm. In other words, the proportion of parts, subassemblies and assemblies which the parent manufacturer procures from outside parts makers to the total value of final products is high in Japan.

These organizational characteristics would be borne out clearly if the proportion of the value of parts procurement to the total output by the parent maker, which is called the '*gaichu*' (external procurement) ratio in Japan, and that of value added within the parent, which is called the '*naisei*' (internal manufacturing) ratio, could be compared between machinery makers in Japan and in other countries. But such data are difficult to obtain on a comparable basis.<sup>16</sup> I compared the ratio of the number of employees (a proxy variable for the value added within the parent maker) of the major Japanese, US and European automobile parent makers to their sales (see Table 1). However, there are several conceptual difficulties in such an international comparison. Financial reports of US and European corporations are available only on a consolidated basis, while for many Japanese corporations detailed financial reports are available only on an unconsolidated basis. Also, there seem to be conceptual differences in preparing the consolidated accounts among countries and among corporations: for example, the number of employees of a partially-owned subsidiary seems to be included either wholly or not at all in the number of employees of the parent corporation on a consolidated basis. Moreover, parents' management policies and attitudes to minority-owned (and even majority-owned) subsidiaries may well differ among countries and among corporations.

Admittedly there are many difficulties and pitfalls in such an international comparison, yet it may be seen from Table 1, first, that some of the US and European automakers are huge, at least in terms of the number of employees; many of their Japanese counterparts are much smaller, especially on an unconsolidated basis.<sup>17</sup> Secondly, Japanese parent automakers employ far fewer employees relative to their sales than their US or European counterparts: the ratio of sales to the number of employees for Japanese automakers is generally higher, and often much higher than US or European automakers.<sup>18</sup> For example, when Mazda, which has so far been

engaged in few overseas operations and may be taken therefore as a more characteristically Japanese automaker in regard to procurement policy, and General Motors (GM) are compared, both on a consolidated basis, GM has sales about seven times higher than Mazda's but employs 20 times more employees than the latter. Fiat's sales are about 8 per cent less than Nissan's, but it employs more than twice as many employees as the latter, both on a consolidated basis. Renault and Honda are of equal size in terms of sales, but in terms of the number of employees Renault is about double the size of Honda.

There would be several factors behind such differences but the most important one, I believe, is that the US or European automakers tend to produce more parts and equipment by themselves, whereas Japanese parent makers depend more heavily on outside subcontractors and suppliers in procuring parts and equipment.<sup>19</sup>

For example, GM makes all batteries and a large proportion of electric and electronic parts at its own Delco Division, but Japanese automakers produce no batteries and few if any electric and electronic parts by themselves.

Among European automakers too, there seems to be a tendency to produce parts and equipment by themselves instead of procuring them from outside parts makers.<sup>20</sup> For example, when I visited Volkswagen's factory in Wolfsburg some time ago, it was proudly explained to me that the factory was a highly integrated one, that the only parts not made by the factory were electrical parts, windows, tyres and seats, and that those which could be produced by metalworking were all made by the factory. Also, I understand that a considerable proportion of machine tools used by French automakers such as Renault and Peugeot are produced by themselves, whereas almost all machine tools used by Japanese automakers are produced by other firms – which are often small in size and specialized in particular kinds of machine tools.

Table 1 is concerned with the automobile industry only, but a similar tendency seems to prevail in other mass-production machinery industries. For example, in the European consumer electronics industry, traditionally a much larger proportion of parts are produced by the parent makers and there exist fewer independent firms specialized in parts manufacturing and subcontracting than in Japan.<sup>21</sup>

In other words, the degree of 'tight vertical integration' of the parent maker in the mass-production machinery industry is much higher in the United States and Europe than in Japan, and the extent of 'loose vertical integration' is more extensive in Japan than in the United States and Europe.

I would like to cite four points regarding the production and processing of parts by suppliers in the automobile industry as exemplifying the organi-

zational characteristics of Japan's mass-production machinery industry in comparison with that of the US.

First, as stated above, the proportion of parts procured by a Japanese automaker from outside subcontractors and suppliers is generally high, and hence the ratio of value added by a parent maker to its total sales is low.

The second point is related to the design of parts produced by subcontractors. In the United States, a high proportion of automobile parts procured from subcontractors are produced according to a blueprint drafted by the parent manufacturer and 'lent' to the subcontractors, whereas in Japan almost all parts procured from subcontractors are produced according to a blueprint which is drafted by the subcontractors themselves and is based upon the specifications given by the parent maker and then 'approved' by the latter. This difference was first pointed out by Banri Asanuma in his pioneering study,<sup>22</sup> and since then many scholars have paid attention to it. This distinction reflects the high capability of Japanese parts makers in product development and their high degree of autonomy. In some cases, such 'approved' blueprints are the result of joint research and development projects by parts makers and their parent firms.<sup>23</sup>

Furthermore, in Japan's consumer electric appliances industry, according to a survey on the parts procurement practices for colour TV sets and washing machines, parts are produced in most cases by subcontractors and suppliers using blueprints drafted by them and then 'approved' by the parents rather than blueprints drafted and lent by the latter.<sup>24</sup>

Thirdly, Japan's machinery industry is characterized by deep involvement by the parent maker in the production process and the inspection method employed by their parts subcontractors and suppliers. The quality of finished products in terms of homogeneity and durability hinges crucially on the quality of the component parts purchased, and hence depends heavily on quality control in the production process of the parts makers. Thus the Japanese parent maker often sends its engineers to parts makers' plants. Before making a major contract, a number of engineers are often sent by the parent to the parts maker's plant for an extended period of time (sometimes lasting one month or more) to scrutinize the latter's manufacturing processes and inspection methods, and to propose improvements wherever necessary. The parent signs a formal contract only when assured that the parts maker can produce and supply high-quality parts with required homogeneity and durability. Such a practice appears to be an exception in the United States and Europe: in many cases, the machinery makers there decide whether the quality of parts is acceptable by inspecting the sample parts offered by parts makers.

Another aspect of the parent's deep involvement in the production process of the parts makers relates to information on the production cost of

the parts to be procured. In the European consumer electronics industry, the usual practice has been that the parts subcontractors and suppliers present to the parent maker only the prices at which they wish to supply the parts in question without disclosing any information about costs, and that the parent chooses the parts maker offering the lowest price. This is a typical 'arm's length' type of transaction. In contrast, in Japan the parent maker typically requests from the parts maker detailed information on cost components and discusses with the latter whether there is any room to reduce the total cost by improving production methods, the kinds of materials, procurement policies and so on. Such extensive involvement is possible because the parent maker and the parts maker work together in a long-term, cooperative relationship.<sup>25</sup>

In short, Japanese machinery makers depend more heavily on 'loose vertical integration' than on 'arm's length' transactions in procuring parts from parts makers, and the parent makers and parts makers cooperate and interact more closely and intensively in maintaining and raising the quality of products and productivity.

Fourthly, the number of parts makers each Japanese automaker deals with is quite small, even though the ratio of parts procured from outside is much higher in the Japanese auto industry than for their US and European counterparts. For example, GM is reported to purchase parts from some 6,000-8,000 parts makers (in earlier years it was said to be 20,000-30,000), but Japanese automakers, including Toyota and Nissan, directly deal primarily with only 200 to 400 parts makers. The difference is due to near absence of 'arm's length' transactions in automobile parts procurement in Japan.

On *marketing and after-sale service* (6), it is commonly the case in most countries including Japan that the parent makers of mass-produced machinery products establish domestic marketing and after-sale service networks of their own. Regarding exports, there are cases in which a Japanese parent maker sets up its own marketing and after-sale service network in a foreign country, other cases in which it depends on a Japanese general trading company or import agents abroad, and still other cases in which it exports products on an OEM basis. All of these arrangements, including marketing and after-sale service networks, represent 'loose vertical integration', but the degree of 'looseness' or 'tightness' varies. In the machinery industry, examples of 'tight vertical integration' in marketing, that is, of a manufacturer undertaking retail sales by itself, are rare: they are seen, whether in Japan, Europe or the United States, only in the case of industrial machinery or equipment sold in small quantities to a limited number of customers.

Marketing networks are sometimes called 'marketing *keiretsu*' in Japan, but it is misleading to describe them as '*keiretsu*', something peculiar to

Japan. They are called 'vertical restraints in distribution' in the United States. The Japanese 'marketing *keiretsu*' have recently been subject to criticism by the US government and others that they form a barrier against outsiders seeking access to the Japanese market, but there are few differences among Japan, the United States and Europe in the manufacturers' distribution strategies of mass-produced machinery, cosmetics and other differentiated products.<sup>26</sup>

### **Reasons behind Procurement of Parts from Outside**

There is thus a general tendency for Japanese machinery makers to procure a higher proportion of parts manufactured – and processed on commission – by outside subcontractors and suppliers than their counterparts in foreign countries. What are the reasons behind this?

#### **Wage differentials between large firms and small and medium firms**

In Japan, there are relatively small differences in wages among employees of one firm in relation to position, job classification, and skill. But the level of wages, or more precisely hourly labour costs, including wages, salaries, bonuses and fringe benefits vary widely according to the size of firm. Generally, the larger the firm the higher the wages paid; or conversely the smaller the firm the lower the wages.<sup>27</sup>

Under circumstances where wage differentials exist between large firms and small and medium firms as stated above, the parent maker would adopt a policy of procuring technically easy parts as much as possible from 'first-layer' subcontractors which are smaller in size and hence pay lower wages than the parent. This reduces labour costs compared to making such parts within the parent. These 'first-layer' subcontractors in turn farm out a portion of the work to 'second-layer' subcontractors with even lower wages. This creates a pyramid-shaped production system with the parent firm at the top, followed by its first-layer subcontractors, second-layer subcontractors, and so on. Procuring parts from outside parts makers appears to have been prompted by a strong incentive for parent firms to save labour costs in the 1960s and earlier. But the importance of wage differentials as a cause of subcontracting has declined substantially in recent years as wages have risen throughout the Japanese economy due to the nation-wide labour shortage.

Besides, procuring parts from outside parts makers is not a practice only seen between large and smaller firms in Japan. In the case of the automobile industry, major Japanese makers of electric auto parts and batteries, such as Nihon Denso, Hitachi, Mitsubishi Electric, Furukawa Battery, Japan

Storage Battery and Yuasa Battery, are all quite large firms, and their wage levels are more or less comparable with those at 'parent' automakers, although wage levels at automakers themselves vary to some extent from company to company. So reference to wage differentials cannot completely explain the large difference between Japanese and US automakers (or between Japanese and European automakers as well) in their parts procurement policies. The low ratio of parts produced in-house by mass-production Japanese machinery makers at present results, in my view, more from the following three factors than from wage differentials.

### **Benefits from division of labour**

Generally there are more independent parent makers in Japan's mass-production machinery industry than in other countries, and the benefits from division of labour appear larger in Japan. In the case of photocopiers, for example, there are more than ten parent makers in Japan, which have mostly diversified into the business from camera or consumer electric appliances. Since the lenses used in photocopiers are not easy to make, those which have diversified into the photocopier business from consumer electric appliances depend on a lens- or camera-maker for the designing and manufacturing of the lenses. For other parts and materials, such as photoconductors, power supply equipment, toners and rubbers, photocopier makers generally depend on specialized makers of such parts and materials. They cooperate closely with these parts (and materials) makers in R&D and product planning.

For example, most photocopier models usually undergo a major model changeover once every three years or so, and in developing a new type of toner for the new model each photocopier maker cooperates closely with a resin maker supplying toners on a long-term, continuous basis. By contrast, Xerox Corp. in the United States, which is about the only major non-Japanese photocopier maker at present, produces toners itself. According to Japanese photocopier makers, they would fail to keep step with new technology and would lag behind in introducing new models if they tried to make various parts and materials by themselves, because doing so delays development of new models. Incidentally, the number of makers specialized in particular kinds of parts and materials used in photocopiers are often fewer than the number of photocopier makers themselves, so that often one such supplier serves a number of photocopier makers.

In the automobile industry, electric machinery and electronics firms have a high level of electric and electronic expertise applicable to automotive parts which they have developed and accumulated through years of research and development. Each automaker can procure high-quality electric parts



and electronically controlled systems from these specialized suppliers on a long-term, continuous basis.<sup>28</sup>

I cited earlier the use of 'compound technology' as one of the characteristics of industries in which Japan has strong comparative advantage. In areas where compound technology is of great importance, it is particularly beneficial for firms having expertise in different special technologies to cooperate closely with each other while remaining independent. One of the benefits from the division of labour is that it enables firms to enjoy economies of scale in production or R&D in each kind of parts, materials, and manufacturing equipment. In the above example of the toner for photocopiers, if each of more than ten photocopier makers were to try developing its own toner technology the scale of production and R&D of each would be much smaller than the present arrangement in Japan under which one of seven or so resin manufacturers cooperates closely with each of more than ten photocopier makers.

### **Small organization and work incentives**

Generally speaking, salaries, bonuses and other benefits received by regular employees and the speed of their promotion in a Japanese company depend on the company's performance as measured by profits and growth rate, and vary greatly from company to company. On the other hand, compared with US and European companies, differences in wages and bonuses within a company between blue-collar and white-collar workers and between the highest paid (the president or chairman) and the lowest (newly hired young unexperienced employees) are far smaller in Japanese companies. Also, as is well known, Japanese labour unions are organized on a company-by-company basis. Therefore, keeping the size of the company as small as possible provides and enhances the incentive to work earnestly and cooperate closely among employees in a Japanese company. Japanese-style personnel management practices, such as job rotation and promotion at regular intervals, can be more easily carried out in a smaller organizational unit. Hence in Japan there is a tendency, especially in recent years, to keep the parent, 'core' company 'slim'; that is, to separate divisions and factories of the core as subsidiaries and affiliates, to keep each corporate unit as small as possible, and to procure parts, supplies and services as much as possible from the outside.<sup>29</sup>

### **Cooperation and competition**

In Japan's machinery industry, the relationship between the parent maker and its parts and manufacturing equipment subcontractors or suppliers is usually not an 'arm's length' one. It is not a relationship in which a parts maker supplies certain parts in a fixed volume only for a limited period, or

a maker of manufacturing equipment supplies a certain number of machines or manufacturing equipment only once when the parent maker expands its productive capacity. Rather it is a long-term, continuous relationship in which they deal with each other repeatedly over an extended period, and know each other's capability, needs, strengths and weaknesses. Such continuous transactions, or 'loose vertical integration' as described earlier, are dominant in transactions involving parts and manufacturing equipment in Japan's machinery industry.

There are cases in which such close inter-firm relationships are further strengthened by cross shareholdings, but such ownership relations between the parents on the one hand and subcontractors and suppliers on the other are exceptions. Even when they hold shares of each other's company, it is mostly a small minority holding, except shareholdings between companies which originally were one company or belonged to the same tightly organized business group.<sup>30</sup>

As stated above, arm's length transactions between parent firms and parts makers are more prevalent in the United States, and the number of parts subcontractors and suppliers for each parent firm is very large there. The reason why the number of such subcontractors and suppliers is far smaller in Japan is that there is a strong tendency for Japanese firms to make deals with mutual understanding and confidence on a long-term basis.

Although long-term, continuous transactions are dominant in parts procurement in Japan, the relationship between parent makers and parts makers is still a terminable one between independent firms, thereby leaving room for competition. This relationship is a 'loose vertical' integration, and contrasts sharply with the 'tight vertical integration' more prevalent in the United States or Europe. Vertical integration saves transaction costs, and facilitates easier transfer of information and better coordination of vertically-related productive activities. But in 'tight' vertical integration, the relationships between vertically related stages of production are rigid, and there is no element of competition. This contrasts with 'loose' vertical integration where the relationships are more flexible and there are always elements of competition, an advantage not available in the 'tight' type.

For instance, many Japanese parent automakers usually avoid dependence on a single parts maker for a category of parts or components, and instead purchase such parts from more than one parts maker and/or produce some portion themselves. They produce a portion by themselves in order to know better: (1) whether parts makers are making enough effort to improve the quality and design of their parts and reduce their costs; (2) whether prices are appropriately set on the basis of production costs; (3) what prospects there are for future technological development. It is also said that each automaker generally does not want its subcontractors and suppliers to deal

only with itself, but instead encourages each of them to deal with other parent automakers as well and to become a leading manufacturer in its respective field. From the automaker's perspective, the fact that a parts maker is capable of selling to several other automakers constitutes objective evidence that the parts it purchases are of top-level quality in the industry. Also, both from the parent maker's and the parts maker's points of view, it is thought desirable that a part maker should not depend too heavily on one particular parent maker.<sup>31</sup>

With regard to semiconductors, many people would consider that high technologies are involved and that the devices are difficult to manufacture. In Japan, however, many users of semiconductors in the machinery industry begin producing the devices themselves when the volume of their procurement reaches a certain level. Makers of consumer electric appliances, electric parts for autos, automobiles, cameras, and computer terminals now manufacture semiconductors themselves. Some of them began to sell semiconductors to other users, but most of them do not intend to become self-sufficient in semiconductors – which is 'tight' vertical integration. The purpose of their semiconductor manufacturing is – at least in the beginning – to be sure about (1), (2) and (3) in the above. Semiconductors are of strategic importance for the users in their product differentiation policy, so that many of them consider it advantageous or even necessary to be engaged in R&D in semiconductors and even in manufacturing thereof.

As stated above, relationships between parent firms and parts makers in Japan's machinery industry are developed through long-term and continuous transactions. Generally speaking, the relation is not an exclusive one in which a parts maker deals only with a single parent firm and the latter purchases a particular category of parts only from a single parts maker. The image of a pyramid-shaped system of hierarchy with a parent firm at the top of the pyramid followed by first-layer, second-layer and third-layer subcontractors, with each subcontractor belonging to the one pyramid, might have been applicable to Japan's machinery industry until the first half of the 1960s, but is not applicable today. Subcontracting relationships are now often multilateral ones.<sup>32</sup>

Even in cases where a parent maker has dealt continuously with a certain parts maker for years, if the parent maker were to become dissatisfied with the former's performance regarding quality, prices and development of new products, having found its parts inferior to and costlier than those made by other parts makers or the parent itself, the parent maker would reduce orders placed with it and scale down joint projects for new models or products as well. Even though close cooperative relations exist, each parts maker still has a strong incentive to compete with its rivals by increasing productivity, lowering costs, and investing in research and development.

## **IV. Technological Basis of Japan's Comparative Advantage**

It is widely believed both at home and overseas that Japan enjoys strong comparative advantage in industries oriented towards high and advanced technology, but such a perception is not quite correct. In the mass-production, machinery industry where Japan has strong comparative advantage, what most people conceive of as high and advanced technology would be 'patented (or patentable) technologies', that is, technologies subject to patent and know-how licensing. But Japan's performance in developing such technologies has played only a limited role in its industrial success, at least until recently.

### **Role of Patented Technologies in the Development of Japan's Machinery Industry**

Japan's mass-production machinery industry has depended heavily on patented technologies developed by foreign firms. The industry has paid, and is paying, a large amount of royalties to obtain licences for foreign-owned patents. This is seen in Table 2, although the balance of payments on technology in this table covers not only the machinery industry, but all industries. This state of affairs will continue for some time. Generally speaking, highly successful Japanese firms in this field have not necessarily been those which developed epoch-making, original, patented technologies. Successful management does not necessarily go parallel with epoch-making, original successes in engineering, and successful management is more important than highly original patents and know-how, both for firms and the national economy.

Nowadays there are many Japanese companies which actively engage in R&D and spend more on R&D than on investment in plant and equipment. Also it is often pointed out that Japanese firms account for an increasingly large share of patents granted in the United States.<sup>33</sup> Yet, it will take some more time before Japanese firms R&D investment will produce substantial returns.

### **Japan's Dependence on Foreign Technologies: Automobiles**

Japan is a latecomer in almost all sectors of the mass-production machinery industry (with a few exceptions such as VCRs, video cameras and facsimile machines) and has depended heavily on foreign technologies. This is particularly true of autos, transistor radios, television sets, semiconductors,

semiconductor manufacturing equipment and machine tools. This is true also of many industries outside the machinery sector, such as chemical, petrochemical, pharmaceutical, dyestuff, synthetic fibre, iron and steel, and shipbuilding. These industries have paid – and are paying – a large amount of royalties to obtain licences for foreign patented technologies and know-how, and have grown by steadily acquiring them.

Take, for example, the case of the auto industry:

(1) Toyota, Mazda and Nissan tried to develop their own technologies of automatic transmission respectively in 1959-61 and used them in their cars. But due to their inferior quality, the three companies gave up using their own technologies around 1970, and decided to acquire technologies from Borg-Warner, Ford and other foreign companies and set up joint ventures with them.

(2) Disc brakes were first developed in Europe, and Japanese automakers began to produce them around 1965 under licences from Girling and Bendix.

(3) Japanese automakers introduced electrodeposition painting technology in the latter half of the 1960s. But after Ford obtained a basic patent in this area in the early 1970s, the six Japanese paint manufacturers were involved in a patent dispute with Ford. A compromise was reached in 1974 and Japanese firms paid royalties to Ford until 1987.

(4) Technology of electronic fuel injection (EFI) was developed by Bosch of Germany, and since 1971 Japanese automakers have been using imported products or products produced domestically by four Japanese autoparts makers under licence from Bosch.

(5) Bosch also owns a patent for antilock braking systems (ABS) to prevent skidding, which are now beginning to be used for luxury passenger cars.

These examples show that Japanese automakers, which are now considered as the global leaders of the auto industry, have depended heavily on advanced foreign technologies. Their royalty payments have been substantial, though many important patents have expired by now. The royalty payments, however, would look small in relation to the success of individual makers and the Japanese auto industry as a whole.

## **R&D and Managerial Success**

From a firm's management point of view, it is not necessarily advantageous to develop important patentable technologies, own them and receive royalties for them. It is profitable only when royalty incomes and profits – properly discounted – from the sales of the products using the patented technologies exceed the R&D costs involved. It would be a waste of money

for a company to engage in extensive research projects, unless it is capable of managing its R&D activities efficiently.

To be successful in medium- to high-technology industries, it is important for firms to make good use of other firms' technologies, particularly when the level of their research capability is limited. From the 1950s to the 1970s, many Japanese machinery makers, aware of the relatively low levels of their own technologies, wisely used available foreign technologies, and that is one of the reasons for their prosperity today.

It should be noted, however, that companies cannot evaluate, purchase and use profitably other firms' patented technologies unless they have achieved certain levels in R&D. When licensees' technological levels have risen high enough to improve the patent technologies acquired or develop related technologies, the royalties they have to pay are reduced, and eventually they become able to exchange their own technologies with the patent owners with little or no royalty payments. This is because when several companies in the same field actively spend on R&D and successfully develop new technologies, it is cheaper and less cumbersome for them to mutually provide their technologies for others' use than to contend at law over patent rights. Active investment in R&D serves as a sort of membership fee in this kind of 'patent club'.<sup>34</sup>

## **Patents and Barriers to New Entry**

In Japan's mass-production machinery industry, there have been few cases in which patent technologies constitute barriers to new entry. As far as technologies imported from abroad are concerned, it is generally beneficial for foreign patent owners to grant technologies to a number of licensees rather than just one. Most foreign patented technologies have been made available for a number of Japanese manufacturers, and patents have not formed high barriers to new entrants.

## **Important Technologies which Form the Basis of Comparative Advantage in Japan's Machinery Industry**

If patented technologies have carried a relatively low weight for Japan's mass-production machinery industry, then what type of technologies have been the most important there? Generally speaking, good performance of the leading firms in this field has been, and still is, based on technologies in the areas of product development, manufacturing management and quality control.

The following are kinds of technologies (in its wider sense) that have important effects on the performance of firms in the mass-production machinery industry. Few of them can be covered by patents and/or subject to licensing.

(1) Designing, producing, and marketing products matching users' needs with good timing. It is not easy to know exactly what functions, designs and prices are desired by various consumers.

(2) Choosing the best organizational form, from among markets, organizations and intermediate forms ('loose' vertical integration) for each production process, as discussed in Section 2.

(3) Efficiency of manufacturing in its narrow sense; that is, organizing manufacturing processes and the quality control scheme to enable mass-production of high-quality products at lowest possible costs. This includes efficient organization and coordination of steps in the manufacturing process and the use of manufacturing and inspection methods suitable for mass-production. The so-called 'QC (quality control) circles'<sup>35</sup> organized at many Japanese factories contributed much to improvement in productivity.

(4) Automation of manufacturing processes to save labour, including the use of industrial robots, especially after wages have begun to rise sharply in Japan.

(5) Inspection methods in each manufacturing process requiring as little labour as possible, but which can steadily lower the ratio of defective products at the final assembly stage.

### **Efficient Organization and Coordination of Steps in the Manufacturing Process**

The '*kamban*' system devised by Toyota, now well-known worldwide, is an example of an effective method of coordinating the work efficiently in different stages of the manufacturing process. Another example of an ingenious method of organizing manufacturing processes is an automated assembly and inspection system, introduced in the early 1970s in camera manufacturing in Japan which substantially reduced dependence on skilled workers. Through this innovation, Japan's camera industry overtook the German one which had been dependent on highly skilled male workers. Furthermore, in 1976, a new system called the 'unit system' was introduced to produce a model called the Canon AE-1. This involved assembling the camera by attaching, to the core, a die-cast body, five separate major units (or blocks) and 25 minor units. Until that time cameras had been manufac-

tured by attaching parts or small units one by one on conveyor belts. The new system is said to be one of the most epoch-making innovations in the mass-production of cameras, enabling greatly increased production of high-quality cameras. With defective units removed by inspection of each unit (block) before final assembly, it helped reduce almost to zero the ratio of defective products found after the final assembly.

The 'unit system' in Japan's camera industry reminds me of the 'block construction method' developed by the Japanese shipbuilders in the 1960s. With the block construction method, several blocks of a ship are first assembled separately, brought to the building slip, and then combined on the slip. When the size of a building slip was smaller than the size of the ship to be built, the fore and aft parts of a ship were built separately first, and later united at sea. Because of this block construction method, Japanese shipbuilders accounted for about half of the global shipbuilding tonnage in their golden years of the 1960s, while their share in the productive capacity was only about 25 per cent.<sup>36</sup> These were highly original, epoch-making innovations, but none of them could be patented or subject to licensing.<sup>37</sup>

## **Productivity and Labour-Management Relations**

The Japanese type of corporate organization and labour-management relationships have contributed much to a steady and fast rise in productivity and product quality in Japan's machinery industry. Japanese workers and labour unions have been cooperative with the management in saving labour and raising productivity in various ways, including extensive use of industrial robots and promotion of 'QC circle' activities. Their cooperation has been based on the understanding that labour-saving will be beneficial to themselves. In fact, Japan uses 70-80 per cent of all the industrial robots used in manufacturing plants worldwide.

Behind this is Japan's employment practice under which a worker is employed not as a worker specialized in a particular kind of job, but as an employee of the company. Labour unions are hence organized on a company-by-company basis. In contrast, in Europe and North America – and in some Asian and Pacific countries under the influence of European culture as well –, factory workers are employed as being specialized to perform a particular kind of job, and labour unions are organized either on a job-by-job basis or on an industry-by-industry one.

The most frequently-used industrial robots in Japan are welding and painting robots used in automobile factories. This is a result of ongoing efforts made by both the management and labour unions to have robots undertake those kinds of work which are most disliked by workers. Welding



and painting jobs involve danger, high temperature and/or bad odour. If welders were replaced by welding robots in Europe or North America, welders would lose their jobs and the membership of welders' unions would decline. If that is the case, it is quite natural that workers and their unions should resist such rationalization. In Japan, active use of robots means easier work for employees and a shift from jobs which require more physical labour and less brain work to ones requiring less physical labour and more brain work, possibly after some retraining. In addition, employees can enjoy higher wages and bonuses, faster promotion and greater employment opportunities if rationalization and labour-saving efforts lead to better performance of companies employing them.

There have been cases in Japan where workers and unions opposed the management's rationalization plan, especially when it involved dismissal of workers or undesirable transfers. But workers and unions have cooperated in most efforts for rationalization by the management because they have usually been advantageous for workers.<sup>38</sup>

## V. New Entries: A Few Examples

There have been quite a few new entries in many sectors of Japan's mass-production machinery industry. The following reasons may be cited:

- (1) Patent technologies have formed few barriers to newcomers because Japan has depended much on imported patented technologies, as already stated, and foreign patent owners have generally been willing to license their technologies to a number of licensees.
- (2) As stated earlier, the parent makers have tried to keep themselves as 'slim' as possible and have procured manufacturing parts, materials and equipment from outside producers. This creates the 'loose vertical integration' type industrial organization and a 'multilateral' pattern of transactions among parent makers and producers of parts, materials and manufacturing equipment. Thanks to such an environment, newcomers could procure parts, materials and equipment relatively easily from these producers when newly entering the business.
- (3) In the mass-production machinery industry, the most important technologies are of a general character, such as product planning, manufacturing management and quality control, which are not too difficult to acquire for new entrants into a sector coming from other sectors within the machinery industry, by adopting and modifying such technologies in other sectors.

(4) Because of the industrial organization characteristics given in (2), a new technology developed by a parent maker tends to propagate to others through parts makers and equipment producers, and one developed by a parts maker or an equipment producer tends to propagate to other parts maker or equipment producers through parent makers.

(5) The industry, or the size of the market, was growing rapidly when new entrants came in.

Though the mass-production machinery industry is generally oligopolistic, the market is more open to new entry, and generally the number of parent makers is larger in Japan than in other industrialized countries.<sup>39</sup> Many industries in Japan's mass-production machinery industry are 'polypolistic' industries – where a number of companies compete with each other – rather than monopoly, duopoly or oligopoly by few. Below are a few examples.

#### **Automobiles (passenger cars)**

Shortly after Japan resumed production of automobiles in 1947 after WWII, the industry became 'duopolistic', with Toyota and Nissan accounting for about 90 per cent of the market in the early 1950s. Except for those two makers, only Fuji Heavy Industries has continued operation since then up to the present. The late 1950s saw new entry by Mitsubishi Heavy Industries (currently Mitsubishi Motors), Toyo Industries (currently Mazda), and Isuzu, while Honda, Suzuki and Daihatsu followed them in the early 1960s. Hino and Prince entered the market in the 1950s, but the former withdrew shortly afterward from passenger car production, though it is still a major truck maker, and the latter merged with Nissan in 1966. Recently Isuzu also decided to withdraw, but remains as a major truck maker.

There have been no mergers among Japanese automakers since the Nissan-Prince merger, though there have been a few cases of minority share acquisition.<sup>40</sup> The newcomers had been engaged in truck or motorcycle production before launching passenger car production. Motorcycle makers first entered the market for light (mini) cars (with an engine size of 360-660cc) and then started producing larger cars.

At any rate, in Japan there are currently eight automakers mass-producing passenger cars with an engine size of 1,000cc or larger and marketing them under their own brand names. Toyota excels the others in technology and financial performance, followed by Nissan. But the other automakers are not far behind the top two in technology and new products. Luxury cars aside, there are only small technological gaps between the two and the other six. There is no country other than Japan in which as many as eight independent passenger car manufacturers coexist.<sup>41</sup>

One of the reasons, or perhaps the main reason, why the technological gap within the industry has remained relatively small is the rapid propagation of new technologies through the multilateral pattern of transactions under 'loose vertical integration', noted earlier. New technologies developed by one parent maker tend to spread to other parent makers via parts makers and manufacturers of equipment and machines, and those developed by one maker of parts or manufacturing equipment to others via parent makers. Also the lack of patented technologies controlled by the leading makers of the industry which exclude access to them by others, and industry-wide cooperation to produce low-pollution engines in the past may be noted. As a result, smaller automakers have been able to catch up with the industry leaders by acquiring new technological innovations without too much difficulty and time lag.<sup>42</sup>

In the early postwar period until about 1965, the Japanese government heavily protected the fledgling auto industry by import quotas, tariffs, low-interest loans and tax incentives. In the 1950s and 1960s MITI (the Ministry of International Trade and Industry, the Japanese Government) attempted to merge independent automakers into two or three makers, or to form two or three closely cooperating groups. But MITI's effort was not successful. At that time MITI thought it desirable that automakers become more specialized, with each specializing in one or two fields among passenger cars, mini-cars, buses, larger trucks, smaller trucks and commercial vans. In order to realize economies of scale and avoid 'excessive competition'.<sup>43</sup> But all the automakers except Prince chose to remain independent, resisting MITI's specialization idea. Truck and motorcycle makers wanted to enter the four-wheel passenger car business, while mini-car makers wanted to enter the regular-size car business. Most makers have more or less pursued a 'full-line' policy of producing and marketing a wide range of passenger cars and commercial vehicles.

## VCR

Manufacturing of VCRs as home appliances is one of the few sectors in the machinery industry where Japan was a forerunner and in which Japanese manufacturers hold important patents.<sup>44</sup> JVC (Japan Victor Corp.), Sony and Matsushita own one each of three basic patents essential for VCR manufacturing, and other companies cannot produce VCRs without using their patents (each of the three cannot do so without the licences from the other two). This has not impeded entry by latecomers, however, since the three makers have been quite willing to license their patented technologies. Many makers dependent on the three's basic technologies have achieved considerable success, and VCRs have long contributed substantially to the profits of the consumer electronic appliance manufacturers.

After commercial production of the VCR was launched by one maker in 1975 in Japan (and hence in the world), three entered in 1976, four in 1977, and more entered in the 1980s. Now 15 makers are manufacturing VCRs in Japan. Furthermore, there are now three makers in South Korea and two in Taiwan.

Of the 15 Japanese VCR makers, 10 produce cylinder heads, which are technologically the most sophisticated part of VCRs, subject to the COCOM regulations. The other five Japanese makers and the Korean and Taiwan makers buy cylinder heads either from the above 10 or from three electronic parts makers which do not produce VCRs themselves.

The United States has no VCR makers. Europe has a few, but they are not strong enough to compete effectively with Japanese and Korean makers. Japanese leaders in VCR manufacturing produce a wide range of models, from popular to luxury ones, while late-comers in Japan and makers in other countries produce lower- to middle-priced models without sophisticated functions. While Japanese consumers tend to prefer higher-priced, luxury models with many special functions, consumers in the United States – VCRs are more widely used among households in the United States than in Japan – and other countries favour simpler models.

It is not too difficult in Japan to become a 'set maker' (assembler) of VCRs by buying cylinder heads and other parts from the makers of electronics parts and assembling them. This has made it possible for latecomers in Japan, Korea and Taiwan to enter the VCR business successfully.

### **Photocopiers**

Until 1970 Xerox of the United States held a very important basic patent of dry copiers, and there was little room for other firms to enter the plain paper copier (PPC) business, although there were several wet copier makers. In a 1970 court ruling in an antitrust case, Xerox was ordered to open its patents with no charge. This prompted a number of Japanese makers to enter the industry and today there are more than ten Japanese parent makers in this field, whereas few firms in the United States and Europe took advantage of the opportunity. As a result, Japanese makers together with their overseas subsidiaries now account for a share of 80-85 per cent of the global photocopier output.<sup>45</sup>

Today there are many patents related to copier manufacturing, some of which are very important, but according to knowledgeable experts there are often ways to avoid infringing them. From the early 1980s on, Japan's eight major photocopier makers have been offering a free-charge cross-licensing to each other. These companies, in a sort of 'patent club', may be considered as having achieved more or less similar levels of the photocopier technology by spending comparable amounts of R&D expenditures.<sup>46</sup>

### **Semiconductors and semiconductor-manufacturing equipment**

Japan started late in these areas, too, but Japanese makers entered when the industry itself was still fledgling worldwide, and when only US makers were ahead. The semiconductor industry is somewhat different from other sectors of the mass-production machinery industry in which Japan has strong comparative advantage, in that it is an R&D-intensive, high-tech field, and patented technologies carry great significance. There have been frequent patent disputes in this industry.

In this sector Japan has strong comparative advantage in the manufacturing of 'memory-chips' (especially DRAMs), other mass-production type integrated circuits and some semiconductor-manufacturing equipment. In many other fields Japan cannot be said to have strong comparative advantage, nor the production technology of mass-production type.

In Japan, consumer electronics and telecommunications equipment manufacturers were the first to enter the semiconductor industry, but only five of them were members of the famous Super LSI (Large Scale Integration) Technology Research Association, a government-supported joint venture aimed at developing super LSI technologies. Since this Association laid emphasis on R&D of semiconductor-manufacturing equipment, however, its achievements were enjoyed not only by the five members but widely shared by the entire semiconductor industry, as time goes by.<sup>47</sup> In its initial stages, Japan's semiconductor makers depended heavily on US-made semiconductor-manufacturing equipment, but the rapid expansion of the industry thereafter prompted many firms in various industries in Japan to launch production of semiconductor-manufacturing equipment and machines, and now Japan exceeds the United States in value terms in the production of such equipment and machines. Most of the equipment and machines are not of mass-production type, and some of the manufacturers are small firms.

Japan's semiconductor makers and semiconductor-manufacturing equipment makers have maintained close cooperative relationships, especially in R&D. Japan's semiconductor industry would have never achieved remarkable successes without vigorous development of the semiconductor-manufacturing equipment industry. The two industries have prompted development of each other.

In turn, development of Japan's semiconductor industry was promoted greatly by rapid growth of non-military 'user' industries, such as consumers electronics, telecommunications equipment and computers. For example, 30 to 40 per cent of the production costs of a CD (compact disc) player is said to consist of the costs of semiconductors used in it.

Following manufacturers of consumer electronics and telecommunications equipment a number of other users of semiconductors have made entry into

the semiconductor industry. In recent years, moreover, firms in industries which are totally unrelated to semiconductors, such as steel, chemical, and several others, have entered the industry. As a result, there are now as many as 90 semiconductor manufacturers in Japan.

These cases show that in Japan's machinery industries, even in those which are considered high-tech oriented, there have been vigorous new entries, and as a result there are many firms in each industry, which has helped promote competition and technological innovation.

## VI. Economies of Scale

### Concepts of Economies of Scale in Economic Theory

What is meant by 'economies of scale' in economics? Below is a list of several answers to this question given by economic theory and especially the theory of industrial organization.

(1) Economies of scale based on the size of factories or firms: When the average cost curve is drawn for a certain product with the output of a factory along abscissa and costs along the ordinate, the long-run average cost reaches the lowest value for a certain range of its output. This range represents the 'optimum size' factory, which realizes economies of scale at the factory level. The left-hand end of this range is the 'minimum optimum size' factory of the industry producing this product. The average cost curve including the overhead costs of the firm's headquarters is lower for a firm with several factories than one with only one factory. Hence the firm with several factories enjoys economies of scale on a firm basis. But when the size of the firm is too large, it may suffer from 'diseconomies of scale', so that there is a certain range of 'optimum size' for a firm as well. The concept of economies of scale here is relative to the size of the market: economies of scale are said to be important or substantial when the 'minimum optimum size' factory or firm is large relative to the size of the market served by the industry.

(2) Economies of scope: When a firm engages in productive activities in several different fields, this is thought to help cut the costs involved in maintaining headquarter functions, enable more efficient utilization of in-house resources and productive capacity, create 'benefits from diversification', and lower the unit cost of products. Pursuit of 'economies of scope' tends to go counter to benefits from specialization, so that firms will choose

the right balance – which would change over time – between diversification and specialization.

(3) Economies resulting from expansion of the industry: This is also known as 'Marshallian external economies'. When a large number of firms produce the same kinds of products under perfect competition, the average cost curve of each firm shifts downwards because of greater specialization and division of labour, and because of the development of related firms supplying materials, equipment and services to the industry.

(4) Learning effect: This is an effect which shifts the average cost curve downward, as a result of the increase in cumulative output (the integral value of output), as firms or the industry accumulate experience and achieve technological progress.

### **Measurement of Scale in the Machinery Industry**

To what extent are these concepts of or approaches to economies of scale applicable to the machinery industry? First of all, it needs to be noted that in the machinery industry it is difficult to measure output, which is the crucial variable when considering economies of scale.

All the concepts stated above are generally based on assumptions that:

- (i) output is a single commodity which is homogeneous and of which the quantity is readily measurable;
- (ii) one kind of output is produced by a factory or firm;
- (iii) all factories and firms in a particular industry have the same or similar manufacturing processes with the same degree of vertical integration, that is, they procure raw materials and parts in the same way, and supply products manufactured to the same level of processing.

In the case of economies of scope (2), it is assumed that one firm supplies several kinds of outputs, but each output is considered as homogeneous. To measure the economies of scale in (3) and (4) resulting from the downward shift of the average cost curve in line with the industrial growth the following additional assumption is necessary:

- (iv) a firm's or an industry's output remains homogeneous and unchanged over the long run, or if it changes, the change can be measured somehow so that the output level can be given in terms of a single index.

The assumptions (i)-(iv) are more or less admissible for industries such as oil refining, chemicals, power generation, and cement, whose output is homogeneous. But in the case of the machinery industry, such assumptions are unrealistic, due to three problems: output mix, vertical integration, and product quality. Taking the automobile industry as an example:

(a) Output mix: Output mix differs from one factory to another, from one firm to another, and from time to time. The composition of output value, namely the proportions in output of passenger cars, trucks, commercial vehicles, and various parts, are different for different factories and firms, and at different times. Even within the category of the normal-size passenger cars the most expensive, luxury model would be priced 10 to 15 times higher than the cheapest one, and hence the counting of output by the number of cars produced is often meaningless.

(b) The degree of vertical integration: The proportion of parts produced within a factory or a firm, or the degree of vertical integration at each factory and firm, varies a great deal from one factory to another, from one firm to another, and from time to time. A part or a subassembly for a passenger car assembled in a factory may be made in-house, by another factory of the same firm, by a parts maker within the automobile industry, or by a firm belonging to some other industry, or it may be imported from a foreign country.

(c) Product quality: Steady improvement of the quality of products of the machinery industry makes it difficult to measure, over time, the output, or the size of a factory, firm and the industry, in value terms. When one measures the change in the output level or added value of a firm or an industry over time by using some price deflators for output, it would be bound to underestimate quality improvement, and hence the output growth and technological progress.

These three problems that complicate quantitative measurement of products are more or less common to the machinery industry, which always produces differentiated products through complex division of labour and is steadily improving the quality of products. Therefore, it is difficult just to measure the output, the size of factory or firm and the scale of industry, and it is even more difficult to measure economies of scale.<sup>48</sup>

### **Economies of Scale Based on the Size of Factory or Firm**

With these difficulties in measuring the economies of scale in the case of the machinery industry in mind, I will state my personal observations on



economies of scale in Japan's mass-production machinery industry.

It is obvious that the 'minimum optimum size' of a factory in the mass-production machinery industry is fairly large, since its technology is of mass-production type. But in the industries cited in Section 2 there are generally a number of firms in Japan, and many of them operate more than one factory. Moreover, several latecomers made successful entry as the industry developed. It is presumed, therefore, that the minimum optimum size of factory or firm relative to the size of market is not so large. If economies of scale based on the size of factory or firm were large in an industry relative to the size of market, the industry would have been dominated by one or only a few giant firms.<sup>49</sup>

The fact that there are few cases of monopoly, duopoly, or oligopoly by few in Japan's mass-producing machinery industry indicates that economies of scale at the factory or firm level are not overly important there.<sup>50</sup>

The automobile industry is often considered as one of the industries where economies of scale based on the size of factories and firms are substantial. For example, the minimum optimum scale of a passenger car factory today is said to be something like 200,000 cars in annual output. In fact, automakers whose sales come down below a certain level are often forced to go out of business or to merge with others in many countries. But in the automobile industry where a large proportion of parts and assemblies are procured from outside parts makers, as in Japan, smaller automakers can make up for the disadvantage by purchasing parts from parts makers and undertaking joint development projects with them.

A notable tendency in recent years is that automakers are producing an ever widening variety of models to satisfy preferences of diverse, sophisticated users. Japanese automakers appear to have developed technologies to produce at relatively low costs a wide variety of models, each in small quantities. An interesting trend is that one automaker is producing a number of models (brands) which are essentially the same and whose appearances are only slightly different from each other, and is selling them under different brand names through its different nationwide dealership networks.<sup>51</sup> Thus, dealers are competing keenly to sell similar cars made by the same automaker.<sup>52</sup>

This can happen, I suppose, because the demerits of diseconomies of scale due to the costs involved in producing different models and organizing not just one but several nationwide dealership channels are outweighed by the merits from dynamic competition among dealers and dealership channels and from the advantage of each dealer having a diversified range of models.

## Economies of Scope and Benefits from Specialization

In Japan's machinery industry, economies of scope are an important factor when firms come into a rapidly expanding industry, or when they diversify into other fields after the market for a product becomes saturated. In other situations most makers seem to lay emphasis on specialization and division of labour.

## Marshallian External Economies

The concept of Marshallian external economies is originally one applied to industries under perfect competition. Also it is perhaps not a concept applicable to situations where rapid technological progress is taking place. The concept applies better to what is called the 'producing region' (*sanchi*) type industry, which is composed of a large number of small- and medium-sized firms than to an oligopolistic or polypolistic industry, such as the mass-production machinery industry.<sup>53</sup>

But in Japan's mass-production machinery industry, parent makers are relatively small compared with their counterparts in other countries, and the producers of parts, materials, and manufacturing equipment have grown and played important roles in the process of development of the industry. Because of this organizational characteristic of the industry, technologies and management know-how acquired by a parent maker tend to propagate to others more readily through producers of parts and manufacturing equipment, and those acquired by a parts maker or an equipment maker do so through parent makers. Technological innovations by one firm and the growth of the entire industry have the effect of 'external economies' by lowering the average cost curve of each firm within the industry with a certain time lag. But this effect is not of static character, nor is it reversible as conceived of in the concept of 'Marshallian external economies': it is an irreversible effect resulting from technological progress and industrial development.

## Learning Effect

Obviously, the 'learning effect' has played a very important role in the development of Japan's mass-production machinery industry. But it would be simplistic to think that the average cost curve moves downward in proportion to the accumulated output of each firm or the entire industry. If the learning effect is like that, it would be very difficult, if not impossible,

for a latecomer country such as Japan to catch up with the forerunner countries, and latecomer firms to catch up with early-starter firms: latecomers would be hampered by the wide gap in accumulated output between them and the forerunners. Moreover, the latecomers often have to pay royalties on patented technologies to the forerunners. The latecomer country's only obvious advantage would be lower labour costs.<sup>54</sup>

With the exceptions of VCR manufacturing and a few other products, Japan started later (sometimes much later) than Europe and the United States in mass-production machinery industries. If the learning effect was simply in proportion to accumulated output, Japanese makers would never have been able to bridge the gap.

### **Industrial and Enterprise Organization and Technological Progress**

I hypothesize that one of the reasons why Japan's mass-production machinery industry could have caught up with and eventually outperformed their foreign counterparts is that Japan's industrial and enterprise organization promotes and accelerates learning effects and technological progress. The following reasons may be pointed to.

- (1) There are relatively more parent makers in Japan than in other major industrialized countries and they are always keenly competing.
- (2) Vertical integration (of the 'tight' variety) of parent makers is relatively limited in Japan, and both parent makers and parts makers are relatively small in size. This, together with Japanese employment, remuneration, and promotion practices, encourages both blue- and white-collar employees to work earnestly, leading to steady improvement in productivity and product quality.
- (3) In Japan, production of parts and manufacturing equipment are based more on 'loose' vertical integration than on 'arm's length' transactions. 'Loose' vertical integration depends on long-term, continuous business relations between the parent maker and producers of parts and manufacturing equipment. They are in close contact in that they exchange information and engage in joint R&D projects for parts and manufacturing equipment. Yet such a 'loose' vertical integration relationship always involves an element of competition, largely absent in vertical integration of the 'tight' variety. Parent makers and producers of parts and manufacturing equipment are cooperating partners, but they are competing with their respective rivals at the same time. Also, 'loose' vertical integration brings the benefits of specialization and division of labour, and sometimes also realizes economies of scale in each stage of production, more than 'tight' vertical integration.

(4) Under such industrial organization, 'innovators' in the sense of Joseph Schumpeter tend to be followed more quickly by others; and who is the 'innovator' and who are the 'followers' is always in flux.

(5) Since makers of parts, materials and equipment usually deal with more than one parent maker,<sup>55</sup> innovative technologies developed by one parent maker are readily propagated to other parent makers through them, as can technologies developed by one of the producers of parts, materials and equipment be passed on to others through parent makers. Thus technological innovation tends to spread rapidly among firms in the industry.

(6) Under Japanese-type enterprise organizations, the corporate unit is kept as small and 'slim' as is compatible with economies of scale, and under Japanese employment practices, there are strong incentives for workers and labour unions to actively contribute to enhancing productivity (see Section 4).

## VII. Conclusions

The industries in which Japan has strong comparative advantage in international trade are mostly the mass-production type, fabricating and assembling manufacturing industries; that is, those producing machinery, electric machinery, electronics, automobiles and precision instruments for a large number of users. The characteristics common to these fields include product differentiation, mass-production, quality control, steady technological progress, and 'compound' technology – the combination of several different kinds of technologies. Patented technologies play a relatively minor role in these fields.

Among the typical industries where Japan enjoys strong comparative advantage are automobiles, machine tools – especially mass-produced numerically-controlled machine tools –, VCRs and other consumer electronics products, memory chips, photocopiers, audio equipment, cameras, textile machinery, construction machinery, and agricultural machinery. On the other hand, even within the broad machinery industry, Japan does not have comparative advantage, or has only limited advantage, in aircraft, jet engines, mainframe computers, large-sized machine tools, electric power generation equipment, and nuclear power generation equipment. Generally, Japanese makers have not, at least to date, been a strong competitor in those areas which require heavy R&D expenditure, and/or which do not use mass-production technologies. Japan does not have comparative advantage in so-called 'plant-based industries', such as

chemicals, petrochemicals, petroleum refining, pharmaceuticals, paper and pulp, glass, and nonferrous metal.

The factors that have helped develop the mass-production machinery industries in Japan include its relatively large population and large domestic markets, the high level of education among the populace that has contributed to bringing up workers who can readily master the complicated technologies required in the machinery industry, and the strength of those industries which support the machinery industry such as the ones producing iron and steel, other metals, plastics, dies, machine tools, electric and electronic parts, and semiconductors. Some of these are themselves mass-production machine industries (Section 2).

Compared with similar industries in other industrialized countries, a characteristic of Japan's mass-production machinery industries is that they depend relatively more on 'loose' vertical integration – such as long-term, continuous transactions and joint R&D projects – than on 'tight' vertical integration and 'arm's length' transactions in the production of – and R&D related to – parts, materials and manufacturing equipment.

The number of employees of 'parent makers' in Japan's machinery industry is generally much smaller than that of their US or European counterparts, in relation to their sales. Large US and European manufacturing firms employ far more employees than Japanese firms. The principal reason for the smaller number of employees at Japanese parent makers is that they procure a large proportion of parts and other inputs from outside subcontractors and suppliers. The three main factors in procuring the high proportion of parts and other inputs from outside are (1) the benefits of division of labour based on specialization, (2) the higher motivation among workers in smaller enterprise units, and (3) maintaining cooperative but at the same time competitive relations among organizational units.

It should be obvious that division of labour among specialized manufacturers contributes to productivity. With regard to the second point, the wages, salaries and other benefits Japanese workers receive generally differ from company to company, depending on the companies' performance in terms of profits and the rate of growth. Labour unions in Japan are also organized on a company by company basis. So the smaller the corporate unit is, the higher the motivation of the workers. On the third point, the relations between the parent maker and the producers of parts and manufacturing equipment are usually long-standing, continuous ones, based on mutual trust and understanding of the partners' capability, needs, strengths and weaknesses.

But even when parent makers and their part or equipment makers have long-term, continuous relationships, the two are still different firms and not the same company as in 'tight' vertical integration. The principles of the

market economy always work between parent makers and parts makers. If a parent maker is not fully satisfied with one of its parts suppliers concerning the quality of products, technology or services, the former will reduce the procurement from the latter and curtail the number of joint development projects for new products.

On the side of parts suppliers, in turn, most of them deal with several parent makers and will reduce the transactions with any of them over the long run if the transactions are not satisfactory to them. The parent maker usually procures the same kind of parts from several subcontractors and suppliers, and/or produces a certain amount of the parts by itself to avoid depending fully on only one parts maker for the supply of parts. The parent maker produces the parts by itself in order to know production costs precisely and to assess the potential for productivity improvement and future technological progress.

Thus the market principles and competitive factors work between the parent makers and parts makers, even though their relationships are long-term, continuous and cooperative ones. They create a strong incentive for both the parent makers and the parts makers to improve their productivity, reduce costs, and invest in research and development. Such multilateral competitive factors always exist among corporate organizations that are tied to each other in 'loose' vertical integration. The Japanese machinery industry today cannot be characterized, as has often been done, as a hierarchical, pyramid-shaped system with parent makers at the top and parts makers in several layers underneath.

In addition to the three factors (1), (2) and (3) above, a fourth factor that often used to be cited as a reason for the high proportion of outside procurement of parts among Japanese machinery makers is the so-called 'dual structure' in Japanese industry. In Japan, the difference in wages due to the difference in skills or jobs or between the white-collar and blue-collar workers is smaller, while the difference in wages between large and small firms is more pronounced, than in other industrialized countries. This is true even today. So, in order to reduce the production costs, the parent maker tends to procure components that do not require high-level technologies or skills from outside subcontractors and suppliers that employ workers at lower wages.

This tendency was clearly observed in earlier years, especially until the mid 1960s. But as the labour market has become tighter since the late 1960s this fourth factor has become less important, particularly under the recent severe labour shortage. Moreover, the difference in the wage levels between parent makers and parts makers has not always been large. For instance, in the automobile industry some of the parts makers are very large corporations such as Hitachi, Mitsubishi Electric, Nippon Denso, Furukawa

Battery, Japan Storage Battery, Yuasa Battery, and their employees have been as well-paid as their counterparts in Toyota, Nissan, or Honda. The remarkable difference in the proportion of outside procurements of parts, or, in other words, the difference in the degree of 'tight' vertical integration, between US and European automakers and Japanese ones cannot be explained primarily by this factor (Section 3).

As the basis for Japan's strong comparative advantage in the mass-production manufacturing industry, the importance of high technology, or more precisely the technologies that can be patented or licensed, has been relatively limited so far. The superior performance by Japanese leading firms in this area is supported more by technologies related to the manufacturing process, quality control, and product planning rather than by highly original patented technologies. Japanese leading makers in these fields excel in rationalization, automation and standardization of the manufacturing processes, in efficiently organizing and coordinating various steps of production, in raising the quality and functions of products through accumulation of small improvements, in establishing the inspection systems that guarantee homogeneity of products, and in developing and marketing the products that meet users' needs well.

Japanese employment practices have played an important role in making the bit-by-bit, but steady, improvements in productivity in Japan's machinery industry. The outstanding feature of the Japanese employment system is that workers are not employed to do a particular job, but are hired as 'general', regular employees of the company and are covered by a lifetime employment umbrella. Also constituting the Japanese corporate culture is the management-labour relations based on the labour unions organized on a company-by-company basis. Whereas in the United States and European countries – and also in the Asia-Pacific countries under strong European influences –, a worker is generally hired to do a specific job, and a labour union (or trade union) is organized for each type of job, or for each industry. The characteristics of Japanese employment practices and the labour-management relations have contributed to an improvement in productivity in the Japanese machinery industry.

For example, industrial robots are most widely used in Japanese factories: 70 to 80 per cent of all the industrial robots in the world are operated in Japan. The welding and painting robots at auto plants are the most numerous industrial robots in Japan. This is because workers in Japan's auto industry disliked these two jobs for the danger, heat and odour involved. Japanese automakers and labour unions cooperated eagerly to replace human work in these kinds of jobs by robots. In the United States or European industries, a massive instalment of robots to do welding or painting, for instance, would lead to loss of jobs for the welders and

painters, and therefore would meet strong oppositions from the labour union. At Japanese plants, workers who have been doing welding or painting jobs are relocated to less unpleasant jobs when robots are installed in welding and painting shops. The rationalization in Japan generally means the amount of tedious physical labour is curtailed and the workers are shifted – sometimes after retraining within the company – to jobs that require more intelligence and discretion (Section 4).

The characteristics of Japan's mass-production machinery industry described above have promoted the propagation of a new technology developed by one parent maker or one parts maker to others in the industry. They have also made it easier for latecomers to enter the industry. As a result, the number of parent makers in one field is generally larger in Japan than in other industrialized countries. There are, for instance, eight independent Japanese automakers that produce, market and export passenger cars with engine replacement of 1,000cc or larger. There were only a relatively small number of semiconductor manufacturers in Japan when integrated circuits were first manufactured and sold in Japan in the mid 1960s. Over three decades, there has been continuous entry of a large number of newcomers into the industry: first, makers of consumer electronics and telecommunications equipment entered the industry, followed by various users of semiconductors, that is, manufacturers of home electric appliances, electric and electronic automobile parts, automobiles, camera and computer terminals, and most recently firms in entirely unrelated fields such as steel makers and chemical companies. There are now some 90 companies manufacturing semiconductors in Japan. In VCRs, one company started production in 1975, three more in 1976, and four in 1977, and as a result of the active new entry into the market in the 1980s, there are now 15 'set makers' of VCRs in Japan. The PPC photocopier market was once monopolized by Xerox of the United States, which owned a basic patent for dry copying. But after an antitrust court ruling in 1970 which ordered Xerox to grant the patent licence free of charge, Japanese camera makers and consumer electronics makers entered the market in droves. And now 11 Japanese photocopier makers combined account for 80 to 85 per cent of the world market (Section 5).

The sectors of the machinery industry where Japan has strong comparative advantage are of the mass-production type so that 'economies of scale' are naturally a significant factor there. But economies of scale based upon the size of the plant or firm, relative to the size of the market, are apparently not so important in most sectors of the industry. It is demonstrated by the fact that quite a few parent makers coexist – and often co-prosper – in each sector.



The concept of 'Marshallian external economies', which presupposes perfect competition and a given level of 'technology', and where the production function and the cost function are assumed to shift in proportion to the level of the industry's total output, in a way reversible with respect to time, is not a concept that can describe well the conditions in the mass-production machinery industry in Japan. This industry is under competitive oligopoly – or polipoly –, and technological progress has been steady, with the production function and the cost function steadily shifting in an irreversible way. The situation in the industry can be better described by Joseph Schumpeter's theory of economic development, where new technologies invented by 'innovators' are the driving force of development and are propagated to 'followers', rather than by Marshallian external economies, although who are the 'innovators' and who are 'followers' are roles which change frequently.

The theory of the 'learning effect' which assumes that productivity rises in proportion to the accumulated output does not in its simple form seem to explain well the situation in the industry. If the learning effect was really important, Japan which started later than the United States or Europe in most of the mass-production machinery industry could not have caught up with the forerunner countries, nor could the latecomer firms in Japan have become able to compete with the forerunning firms (Section 6).

In my view, the 'economies of scale' in Japan's mass-producing machinery industry have much to do with the characteristics of its industry organizations. The industrial organization in this field in Japan is characterized by a relatively large weight of 'loose' vertical integration – long-term, continuous and cooperative relationships between parent makers and manufacturers of parts, materials and equipment –, and by low weights of both 'tight' vertical integration and 'arm's-length' transactions, concerning the production, processing, designing and R&D of parts and manufacturing equipment. These characteristics make possible the long-term, continuous and close cooperation among firms that could not develop through 'arm's-length' transactions, while creating competition through multilateral transactions that could not exist in 'tight' vertical integration.

Under such industrial organization, a new technology or a new product developed by one firm tends to spread to the other firms in the industry rapidly through the network of 'loose' vertical integration. Thus, the structure of Japan's mass-production type machinery industry is more conducive to the diffusion of new technologies among firms, and therefore to the overall technological progress of the industry, than that of its counterparts in other industrialized countries where a small number of highly and tightly integrated firms tend to dominate the industry.

Thus 'economies of scale' in Japan's mass-production machinery industry have worked through rapid and steady technological progress and the learning effect for the entire industry under the industrial organization characterized by 'loose' vertical integration.

Finally, the reason why Japan has strong comparative advantage in the mass-production type machinery industry is that Japan's industrial and enterprise organization characterized by a larger weight of 'loose vertical integration' and by smaller and 'slimmer' enterprise units than in other industrialized countries is conducive to steady and fast technological progress in this particular field.<sup>56</sup>

## Notes

1. Those who discuss international trade problems in terms of international 'competitiveness', rather than 'comparative advantage', of industries do not quite understand the basic factors underlying the pattern of international trade. If many industries of a particular country have strong international competitiveness, sooner or later that country's level of wages and rent on land will rise and the exchange rate will appreciate, resulting in a loss of 'competitiveness'. What determines a country's pattern of trade and the trade performance of its individual industries is *not* so much the productive efficiency of a domestic industry in relation to its counterpart industry in foreign countries, as the productive efficiency of an industry relative to other industries *within* the country. Hence, by definition only a limited range of industries within a country have strong comparative advantage.

2. In order to strictly identify a country's comparative advantage or strong comparative advantage, it is necessary to describe the pattern of trade and analyse the factors behind it. I have not gone into such an analysis, however, and have instead conjectured the pattern of Japan's comparative advantage on the basis of general observation. It should be mentioned that there are industries outside of the machinery industry where Japan seems to have strong comparative advantage rather unexpectedly, such as fishing nets, full-colour printing, musical instruments, 'new' (high-quality) synthetic fibre textiles and speciality fibres (carbon, photo, polyacetal, etc.). The reasons why a country has comparative advantage in a particular industry are apparently highly complex.

3. Patented technologies cannot be said to be unimportant in camera manufacturing, and there have been patent disputes between foreign patent owners and Japanese camera makers. But Japanese camera makers have long cooperated in R&D through a research association for optical industry technologies (established in 1956 with assistance from MITI and dissolved in 1981), and they have mutually licensed out patents they owned. Therefore as far as patented technologies are concerned, the technological levels of Japan's leading camera makers have been more or less comparable: when one of them produces and puts on the market a ground-breaking new model, it has been soon followed by other makers.

4. Industries in which Japan had strong comparative advantage in the past, or still has such advantage now to some extent, are characterized by some of the features (1)-(7) and/or the following ones:

(8) Programming of the successive stages of the production process and coordination of the work thereof are of great importance.

(9) Short delivery time and/or accuracy in the time of delivery is important. Examples may be textiles, iron and steel, and shipbuilding.

5. Among Japan's mass-production machinery industries, only a few had a high ratio of exports to sales in their early stages of development. Examples are sewing machines, cameras, transistor radios and audio equipment. In the early post-World War II period, many Japanese machinery industries developed by producing for domestic markets under various forms of government protection (tax incentives, low-interest financing, import quotas, tariffs and preferential government procurement) against imports and direct

foreign investment. But such protective measures for the machinery industry were gradually abolished under the Japanese government's trade (import) and foreign exchange liberalization programmes (mainly from 1963 to around 1972) and the 'capital liberalization' (liberalization of inward direct investment) programmes (mainly from 1967 to around 1976), as Japan became a party to the General Agreement on Tariffs and Trade in 1955, and its Article 11 member, an Article 8 member of the International Monetary Fund, and a member of the Organization for Economic Cooperation and Development in 1964.

6. Also, when Japan's manufacturing industry grew rapidly in the 1960s and 1970s the government actively supported the education of engineers and scientists by setting up schools of engineering and science in universities and elsewhere, and by expanding the capacity of existing ones.

7. 'Parent' manufacturers or makers, as defined rather loosely in the text, are the central agents in the machinery industry and are distinguished from 'cooperating firms' or 'parts subcontractors' (or suppliers), which produce and/or process parts and assemblies on the formers' behalf. The parent manufacturer is occasionally called 'set-maker' (that is, assembler) in some Japanese industries. Its definition given in the text is not quite satisfactory. For instance, a somewhat strange business practice known as 'original equipment manufacturing' (OEM) is now seen in the production of a wide range of products including automobiles, tractors (combines), construction machinery, machine tools, radios, television, watches, VCRs, computer terminals, personal computers and many other products. In the case of automobiles, finished cars such as passenger cars, vans and pickup trucks are or were supplied by Suzuki, Isuzu, and Korea's Daewoo to General Motors, by Mazda to Ford, and by Mitsubishi to Chrysler. These cars are sold under the brand names of the companies supplied with them. In the case of NUMMI, a Toyota-GM joint venture in the United States, the output is shared by Toyota and GM for sale. In Japan, Suzuki's Celvo is almost the same as Mazda's Carol, and in fact the two models are produced at the same Suzuki plant. In the case of VCRs, a leading Japanese manufacturer which exports some 50 per cent of its total production, manufactures a substantial part (10-20 per cent of total production) on an OEM basis for several foreign companies with their brands. Some of the world's major retail companies, such as Sears-Roebuck of the United States, purchase good-quality, low-priced goods around the world on an OEM basis and sell them under their own brands. Even leading firms in an industry supply a variety of products to other firms in the industry on an OEM basis. Recently IBM was reported to have decided to supply a certain type of personal computer to Hitachi on an OEM basis. Conversely, Hitachi was reported to be negotiating to supply other types of personal computers to IBM, also on an OEM basis.

8. Besides these six stages, there is a stage prior to (3), that is the production of materials for the machinery industry, such as steel, special steel, nonferrous metals, plastics and chemicals. But it is an exceptional case where an automaker is engaged in extensive 'backward integration', and owns iron and steel plants and iron ore mines as Ford Motors did in the past.

9. See H. A. Simon, *Administrative Behavior*, New York: Macmillan, 1947, 3rd ed., 1976; O. Williamson, *Markets and Hierarchies*, New York: Free Press, 1975; Kenichi Imai, Hiroyuki Itami, and Kazuo Koike, *Economics of Internal Organizations* (in Japanese), Toyo Keizai Shimpo-sha, 1982.

10. H. A. Simon, *Jour. of Econ. Perspectives*, Vol. 5, No. 2 (Spring 1991).

11. For a discussion of the importance of such intercorporate relations, see K. Imai, H. Itami, and K. Koike, *The Economics of Internal Organizations*, *op. cit.*, chapters 7 and 8; K. Imai, *The Society with Information Network* (in Japanese), Tokyo, 1984; K. Imai and I. Kaneko, *On Network Organizations* (in Japanese), Tokyo, 1988.

12. The University of Chicago Press, 1988. See especially ch. 2.

13. Masahiko Aoki characterizes the relationships between the Japanese parent manufacturer and its subcontractor as "quasi integration". See M. Aoki, *Information, Incentives, and Bargaining in the Japanese Economy*, Cambridge University Press, 1988, p. 214.

14. Exceptions are production under licence and certain cases of OEM production, where manufacturers depend on licensors or OEM buyers for the design of the products. In the early post-WWII period, passenger cars such as Austin, Hillman or Renault were produced in Japan under a licence provided by British and French automakers. There are cases where the modelling of cars and consumer electric appliances, or the design of semiconductor circuits, are undertaken by outside designers and software engineers.

15. Exceptions are some of the Japanese firms which enjoy a dominant position close to monopoly in their respective fields. YKK, a zipper maker, and Shimano, a maker of bicycle parts, make by themselves most of manufacturing equipment they use, or design such equipment by themselves and have other specialized firms manufacture it for them. The exclusive access to such manufacturing equipment seems to be the basis of their dominance.

16. Various sources cite the external procurement ratio of Japanese automakers in the range of 65 to 75 per cent, that of US automakers from 30 to 50 per cent, and that of European automakers in between. See for example B. Asanuma and T. Kikutani, "Risk absorption in Japanese Subcontracting: A Microeconomic Study of the Automobile Industries", *Jour. of the Japanese and International Economies*, Vol. 6, No. 1, 1992, footnote 2, p. 2, and R. E. Cole and T. Yakushiji (eds.), *The American and Japanese Auto Industries in Transition*, Center for Japanese Studies, Univ. of Michigan: Ann Arbor, 1984, p. 30.

17. This is true also of large manufacturing corporations in other fields such as electric machinery and chemicals. The number of employees (in 1990-91) of some of the giant US and European corporations are: IBM (383.2 thousand employees), General Electric (298.0), Siemens (287.6), Bayer (168.0), BASF (137.0), Imperial Chemical Industries (ICI, 134.0). The only comparable giant manufacturing corporations in Japan are Hitachi (309.8 thousand employees on a consolidated basis and 81.8 on an unconsolidated basis),

Toshiba (162.0 and 72.0) and a few others. For large corporations in the retail trade, see note 18 below.

18. The same tendency is observed also in a comparison between large Japanese and US retail companies as the table below shows. The reasons for this are: (1) in Japan, a larger part of retail-related operations, such as purchasing, transportation, packaging, delivery and consumer credit services are undertaken by outside companies or subsidiaries, that is, the degree of 'tight vertical integration' in Japan's retail trade is lower; and (2) part-timers and sales clerks seconded from wholesalers or manufacturers account for a large part of sales clerks at Japan's large retailers and are not counted as 'regular employees' of the 'core' retailing firms.

A Comparison of Sales and the Number of Employees between  
Japanese and US Large Retailers Corporations

Retailers	Sales (US\$bn)	Number of Employees (Thousands)	Sales per Employee (US\$m)	Labour Costs per Employee (Thousand US\$)
[JAPAN]				
Daiei (c)	18.6	30.8	0.60	n.a.
(uc)	15.0	18.7	0.80	56
Marui (c)	4.5	12.6	0.36	n.a.
(uc)	4.2	8.7	0.48	41
[US]				
Sears-Rueback (c)	57.2	450.0	0.13	n.a.
K-Mart (c)	34.6	349.0	0.10	n.a.

Sources: Same as for Table 1. For the accounting year ending December 1991, January or February 1992. (c) and (uc) mean data on consolidated and unconsolidated bases respectively.

19. If wages, salaries and other labour costs were lower, and other components of value added higher in Japan than in other industrialized countries, the ratio of sales to the number of employees could be higher in Japan without a higher ratio of procurement of parts and other supplies from outside. This is not the case, however. It is seen from the last column of Table 1 that labour costs per employee paid by Japanese automakers seem higher than, or more or less comparable to, those paid by their counterparts in other countries, although here again conceptual differences may not be easy to reconcile.

A second reason for the differences between Japanese automakers and US and European automakers in the ratio of sales to employees may be that annual working hours of Japanese workers (some 2,050 hours) are longer than those of the United States and European workers (some 1,800 hours in the United States, 1,600 hours in West Germany, and 1,400 hours in Sweden). Also usually only regular employees are counted as employees in financial reports of Japanese corporations, leaving temporary workers,

seasonal workers, part-timers and workers sent to the factory from outside firms uncounted (I wonder how part-timers and temporary workers are counted in financial reports of US and European corporations). But taking into account these factors would not alter the main conclusion in the text.

By the way, it is sometimes argued in Western Europe that Japan's much longer annual working hours than those of West European countries poses a threat to West European industry. This is something like 'the yellow peril' argument in the past, and is absurdly ridiculous as well. The labour factor that affects international comparative advantage or 'competitiveness' of an industry is the labour costs per hour as measured by wages, bonuses, employee benefits and social welfare costs, and how intelligently and efficiently employees work each hour. Whether annual working hours in a country are longer or shorter than those of its trading partners has nothing to do with an advantage or disadvantage for industries in international trade.

20. In Western Europe, the sales tax in the past might have promoted vertical integration and its effects and resulting practices might still persist today.

21. See Masataka Ikeda, "An International Comparison of the Production System in the TV Set Industry" (in Japanese), in *Papers Commemorating the 100th Anniversary of Chuo University, Faculty of Economics, Chuo University, 1985*; "Parts Procurement Policy of Japanese-Owned Manufacturing Firms in Britain" (in Japanese), *Shoko Kinyu* (Commercial and Industrial Finance), Vol. 42, No. 12 (December 1992), pp. 3-20, and his other works quoted therein.

22. See B. Asanuma, "The Structure of Parts Transactions in Japan", *Keizai Ronso* (Collection of Articles on Economics, Kyoto University), March 1984, and "The Structure of Parts Transactions in the Auto Industry", *Kikan Gendai Keizai* (the Contemporary Economy Quarterly) No. 58, 1984 (both in Japanese).

23. In Japan, parts makers in the automobile or other machinery industries are sometimes called *shitauke* firms, which may be translated as 'subcontractors'. This word may not be inappropriate for parts makers using the 'lent' plan, or metalworking firms undertaking processing of parts for the parent maker under piecework payment contracts. But it would not be too fitting to parts makers using the 'approved' plan. The latter type parts maker include giant firms such as Hitachi, Mitsubishi Electric, and Nihon Denso, and often have high technological capability and strong bargaining power vis-à-vis the parent automakers.

24. See the Office of the Fair Trade Commission, *A Survey of Interfirm Transaction Practices* (in Japanese), June 1991, p. 33.

25. M. Ikeda, "Parts Procurement Policy of Japanese-Owned Manufacturing Firms in Britain", *op. cit.*, pp. 15-16.

26. See K. Shibayama, K. Kiyono and M. Kiji, "Competition and Organization in the Distribution Sector: An International Comparison of Systematization of Distribution", *Studies in International Trade and Industry*, No. 2, Tokyo: MITI/RI, 1990.

27. The wage differentials are now not as large as in the 1950s and 1960s, but still exist. There are several views on how to explain the wage differentials. For my own view, see Ryutaro Komiya, *The Japanese Economy: Trade, Industry, and Government*, The University of Tokyo Press, 1990, chs. 4-6.

The wage differentials between large and small firms had been described previously as reflecting 'the dual structure' of the Japanese economy, which means an economic system consisting of two different sectors – the modern sector (large firms) and the pre-modern or semi-feudal sector (small firms and agriculture). Marxist economists, as well as those economic historians and economists specialized in small business problems who were strongly influenced by Marxist economics, argued that under the dual structure large firms (monopoly capital) exploited workers by keeping wages low from the Meiji era until the 1960s (or even afterward). The traditional theory of the dual structure, therefore, is that parent manufacturers exploit subcontractors supplying parts and survive recession mainly at the expense of subcontractors by transferring the burden of recession on to them, thus exploiting the working class, small businesses and farmers.

It appears to me impossible, however, that parent firms exploit subcontractors constantly and always pass the burden of recession on to them. The exploitation and burden-transfer argument, which was once dominant in Japan, is contradictory to the basic principle of economics that accumulation of profits (owned capital) is necessary for the development of industries and enterprises. If parent firms do always 'exploit' subcontractors or transfer the burden of recession on to subcontractors, the latter would turn away from the parent firms or have to quit the business. The growth of parent firms requires that their subcontractors grow too. To that end, the subcontractors themselves must increase their owned capital and borrowings, which requires sufficiently high profits – there would be no financial institutions which lend money to firms that do not earn adequate profits. During a period of high growth when the sales of a parent firm doubled or tripled over three or five years, the sales of its first-layer and second-layer parts suppliers also doubled or tripled or even more. During that period, natural selection or survival of the fittest prevailed as some firms failed while new ones entered and prospered.

28. See F. Ohta, H. Nakanishi, K. Kida and T. Ohtani, "Application of Electronic Technology and a Changing Pattern of Division of Labour in the Automobile Industry", MITI/RI Discussion Paper, June 1991.

29. See Ryutaro Komiya, *The Japanese Economy: Trade, Industry and Government*, *op. cit.*; Kenichi Imai and Ryutaro Komiya (eds.), *Japanese Firms* (in Japanese), The University of Tokyo Press, 1989 (an English version translated under the supervision of – and edited by – Ronald P. Dore to be published shortly by MIT Press).

Japanese executives and employees dislike seeing their companies absorbed or taken over by and merged with other companies. Japanese companies seriously endeavour to maintain their corporate independence unless they face severe financial difficulties and find it hard to remain independent. This is because in many cases, mergers and acquisitions will go not only against executives but also against middle-management employees in absorbed or acquired firms in terms of promotion and career. This tendency to remain independent can be observed, for instance, even among the top companies in the Mitsubishi group, whose presidents meet regularly: there are a number of chemical companies among them such as Mitsubishi Chemical (Kasei), Mitsubishi



Petrochemical, Mitsubishi Gas Chemical, Mitsubishi Resin., Mitsubishi Monsanto Chemicals, and Mitsubishi Rayon. In US or European environments, these companies would be organized as just one company. The presidents meeting of the Mitsubishi group once requested Mitsubishi Chemical and Mitsubishi Petrochemical to merge, but such a merger did not materialize because Mitsubishi Petrochemical resisted strongly.

30. According to a survey conducted by the Fair Trade Commission, the parent makers of consumer electric appliances (colour TV sets and washing machines) generally do not hold shares of their parts subcontractors and suppliers. Moreover, when they hold shares of subcontractors and suppliers, generally the proportion of shares held amounts to less than 10 per cent. In the case of colour TV sets, the parent makers are the shareholders of only 5.5 per cent of their subcontractors and suppliers, and in the case of washing machines of 8.9 per cent. See *A Survey of Interfirm Transaction Practices*, *op. cit.*, pp. 45-46.

31. For details, see F. Ohta *et al.*, "Application of Electronic Technology and a Changing Pattern of Division of Labour in the Automobile Industry", *op. cit.*

32. For the situation in the automobile industry, see the article cited in the preceding note. Nissan and Toyota each has a sort of 'league' of 'cooperating' companies, of which 'first-layer' subcontractors are members. The number of such companies for Nissan or Toyota is 190-230, with some 50 firms overlapping. In the consumer electric appliances industry also, the parent makers and parts makers deal with each other on a long-term, continuous basis, but the pattern of relationship is multilateral rather than pyramidal, perhaps more so than in the automobile industry. See *A Survey of Interfirm Transaction Practices*, *op. cit.*, pp. 29-43.

33. The number of patents a company has obtained is not always a good measure of the extent of its success in R&D. Commercial value of patents varies widely and most patents bear no or little value.

34. See below for the case of Japan's photocopier makers.

35. 'QC' here originally meant quality control, but 'QC circles' activities have evolved to cover not only quality control but all sorts of efforts for improving productivity, product quality and working conditions.

36. However, fierce competition among Japanese shipbuilders meant that their profit rates were generally low. Their success benefited shipping business worldwide, consumers in general, and workers in Japan's shipbuilding industry, but did not benefit the shareholders of Japanese shipbuilding companies a great deal.

37. There are arguments that consider patent and other intellectual property rights as sacred and inviolable, but it should be remembered that certain types of new ideas and excellent inventions, however beneficial they are to mankind, bring little economic remuneration to the conceivers.

38. See R. Komiya and K. Yasui, "Japan's Macroeconomic Policies during the Two Oil

Crises'', *Carnegie-Rochester Conference Series on Public Policy*, Vol. 20 (1984); reprinted in: R. Komiya, *The Japanese Economy*, *op. cit.*, esp. pp. 340-44.

39. There are more machine tool makers and semiconductor makers in the US than in Japan, but most of them are not categorized as the 'mass-production' type.

40. The fact that the merger between Nissan and Prince (it may be more appropriately called Nissan's absorption of Prince) was not too successful has perhaps discouraged similar deals. The market share of the merged company dropped below the aggregated share of the two partners and the merger improved financial conditions little.

41. Some of the eight automakers are in shareholding relations. As of March 1991, Toyota holds 14.5 per cent of Daihatsu's shares, while Nissan owns 4.23 per cent of Fuji's. But the former shareholding is smaller than Ford's 24 per cent share in Mazda, and the latter is smaller than Chrysler's 11 per cent share in Mitsubishi Motors. Toyota and Daihatsu cooperate in technological development and production, but compete in sales both at home and overseas, as is the case with Nissan and Fuji.

42. Beginning from the assertion by Karl Marx in *Das Kapital*, there is a widespread belief that capitalistic development necessarily results in concentration and accumulation of capital leading to 'monopoly capitalism'. It can be seen from the following table that the fact of the matter is not so simple, even in the case of the automobile industry where many people believe economies of scale are most important.

Shares of Japanese Automobile Manufacturers in  
Domestic Production of Passenger Cars  
(Unit: %)

	1977	1991
Toyota	34.7	32.6
Nissan	29.8	20.0
Honda	10.6	12.5
Mazda	9.2	11.1
Mitsubishi	8.9	9.4
Suzuki	1.0	5.4
Daihatsu	1.5	4.3
Fuji	2.9	3.4
Isuzu	1.4	1.3

Source: *Handbook of the Automobile Industry* (in Japanese).

It is difficult to foresee, however, whether the trend stated here will continue in the future when electronic control technology is more widely applied to automobiles and auto manufacturing, and when the auto market becomes saturated. More mergers, acquisitions and tie-ups might take place, and it is not altogether unlikely that a trend toward oligopoly by few will emerge in the more and more integrated global auto market.

43. This idea is close to the philosophy of the former COMECON (or CEMA). Under COMECON, each member country was planned – or ordered – to specialize in one, two or three subsectors of the auto industry – such as passenger cars, trucks, buses and forklifts – to realize economies of scale.

44. Ampex (US) and Philips (Netherlands) held the basic patents of VCR – which have now expired – and began producing VCR for broadcasting and industrial use much earlier than Japanese makers. Later the Japanese makers became pioneers in manufacturing much cheaper VCRs for household use.

45. It is interesting to ask why no (or few) European makers successfully entered the market of photocopier machines and VCRs, which are among the contemporary growth industries, while many Japanese (and some Korean and Taiwanese firms) succeeded to establish footholds in these markets.

46. Yet there are three makers (Matsushita, Sanyo, and Brother) which produce photocopiers without belonging to this 'patent club'. Since the court ruling on Xerox' patent right in 1970, patent technologies have been little barrier to latecomers in photocopier manufacturing. Since the Xerox patent in question was to expire in 1974, Japanese makers would have entered this field sooner or later. There is a view, however, that a technological gap might develop among photocopier makers in the future when electronic technologies are applied more extensively to photocopiers.

47. See Y. Tarui and Japan Association of Semiconductor Manufacturing Equipment (eds.), *Handouti Rikkoku Nipon* (Development of Japan as a Leading Semiconductor Producing Country), Nikkan Kogyo Shimbun-sha, 1991, esp. pp. 100ff.

48. For these reasons, I doubt the validity of the econometric studies attempting to measure the extent of 'economies of scale' in the machinery industry. In such studies, the results of *Census of Manufacturers* or their returns are used as a starting point for the quantitative analysis of plant-based economies of scale, but the three problems stated in the text already exist there. Studies on firm-based economies of scale need to be based upon corporate financial reports, where the three obstacles are much more serious.

49. Some of the manufacturers of parts and manufacturing equipment serving Japan's mass-production machinery industries are enjoying large – nearly monopolistic or duopolistic – market shares and are reaping high profits. Examples are: Kyocera (semiconductor ceramics packages), Fanuc (CNC for NC machine tools), Shimano (bicycle parts), and some of the makers of semiconductor-manufacturing equipment.

50. As a result of the formation of a 'Single European Market' in 1992 many European experts say that some benefits of economies of scale will be realized soon. But what kind of benefits exactly are they? As far as the machinery industry in a wider sense is concerned, can one expect the Single Market to increase the sizes of plants and firms in Europe through mergers and acquisitions, thereby creating the benefits of 'economies of scale'? Even now, however, major European firms and their factories seem larger than their Japanese counterparts. European automakers generally employ many more workers than Japanese automakers (see Table 1). Yet some of them cannot compete effectively with Japanese automakers, even in their own home markets. It seems to me

that an attempt by the Europeans to seek economies of scale by simply enlarging the size of firms, for example, by encouraging mergers, is unlikely to succeed.

51. In Japan, a dealership network or channel, sometimes called 'distribution *keiretsu*', in automobile marketing means a nationwide sales network of dealers under the same channel name. Major automakers have three to five such dealership networks. Each dealer in a network deals with the same 5-10 brands of passenger cars and commercial vehicles channelled through the network.

52. For instance, Toyota's Mark II, Chaser, and Cresta are only slightly different to each other but are sold through different networks, as are Honda's Accord and Ascot.

53. In a survey conducted by MITI, a 'producing region' is defined as an area in which a large number of small- and medium-sized manufacturing firms – sometimes more than 50, or even more than 100 firms – produce the same kind of products amounting to more than 500 million yen in value, and where the products are marketed nationwide or exported. Well-known examples of such products are ceramics of Arita (Saga Pref.), Seto (Aichi), and Mino (Gifu); cutlery of Seki (Gifu); spectacles of Sabae (Fukui); and student uniforms of Kojima (Okayama). There are no less than 500 (!) such 'producing regions' in Japan. I suppose there are far fewer such regions in other industrialized countries.

54. It was often said in the past that Europe lost its competitive edge in such fields as shipbuilding, cameras, watches and motorcycles to Japan because of lower wages in the latter. But was this really the case? The low wage level in one country is undoubtedly an important factor that determines the competitiveness of its industries in international markets. But do the European countries whose wage levels are now lower than that of Japan, such as Britain, Italy, Portugal and Spain, have competitive edge over Japan in labour-intensive machinery industries? It appears to me that certain factors other than the wage level, such as industrial and enterprise organization, were more important in the relative decline of Europe and the rise of Japan in certain fields of the machinery industry.

55. As noted earlier, even when a parent maker holds shares of a parts maker such shareholding is usually a very small minority holding in most cases, except where the latter was first established as a subsidiary of the former. The parts maker is little restrained in dealing with parent makers other than the particular one, unless the latter holds a large amount of shares of the former.

56. Recently I have come to realize that the same reason applies regarding the basis of Japan's strong comparative advantage in 'new' (high-quality) synthetic fibre textiles. In this field, synthetic fibre makers, spinners, weavers, dyers and apparel makers cooperate closely on a long-term basis under 'loose' vertical integration in Japan.

## Tables

Table 1 A Comparison of Sales and the Number of Employees between Japanese, American and European Automakers

(Unit: as given in each column)

Automakers		Sales (US\$bn)	Number of Employees (Thousands)	Sales per Employee (US\$m)	Labour Costs per Employee <sup>1</sup> (Thousand US\$)
<b>[JAPAN]</b>					
Toyota	(uc) <sup>2</sup>	66.4	75.3	0.88	46
Nissan	(c)	47.6	143.9	0.33	n.a.
	(uc)	31.7	55.6	0.57	44
Mazda	(c)	20.2	36.6	0.55	n.a.
	(uc)	17.1	29.8	0.57	41
Honda	(c)	32.6	90.5	0.36	n.a.
	(uc)	21.6	31.5	0.69	42
Mitsubishi	(uc)	19.0	26.5	0.72	47
Suzuki	(c)	9.3	24.4	0.38	n.a.
	(uc)	7.8	12.8	0.61	36
Daihatsu	(c)	6.5	19.7	0.33	n.a.
	(uc)	5.8	11.8	0.49	45
Fuji Heavy Industries	(c)	7.7	18.8	0.41	n.a.
	(uc)	6.1	14.8	0.41	41
<b>[US]</b>					
General Motors	(c)	123.1	756.3	0.16	39
Ford	(c)	88.3	332.7	0.27	38
Chrysler	(c)	29.4	124.0	0.24	n.a.
<b>[EUROPE]</b>					
Daimler-Benz	(c)	57.3	376.4	0.15	47
Volkswagen	(c)	46.0	260.1	0.18	n.a.
Fiat	(c)	45.5	288.0	0.16	38
Renault	(c)	29.4	147.2	0.20	36
Volvo	(c)	12.8	63.6	0.20	46

Sources: Financial reports of each corporation for 12 month period ending March 1992 (Japan) or December 1991 (others). Sales and labour costs are converted to US dollar values by the annual average exchange rates published in International Monetary Fund, *International Financial Statistics*.

1. For Japanese corporations total labour costs, for others 'pay-roll', 'employee compensation', 'staff costs' or 'wages and salaries', divided by the number of employees.

2. (uc) and (c) indicate data in the unconsolidated and consolidated financial reports.

Table 2 Japan's Balance of Payments on Technologies Vis-à-vis Europe and the United States

(Unit: billions of yen)

	Fiscal year	Exports	Imports	Balance
[EUROPE]	1975	14.0	59.9	-45.9
	1980	29.0	82.1	-53.1
	1985	45.4	81.6	-36.1
	1989	65.0	118.2	-53.1
	1990	61.5	112.8	-51.3
[US]	1975	14.2	107.5	-93.3
	1980	29.5	156.8	-127.4
	1985	58.7	210.3	-151.5
	1989	115.1	210.7	-121.1
	1990	108.1	257.9	-149.8

Source: The Bureau of Statistics, the Prime Minister's Office, *Report on the Survey of Scientific Research and Development* (in Japanese), 1991. Exports here mean the receipts of technology royalties and other payments related to technology transfer, while imports mean the payments for them.

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