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# A Theory of Ancillary Firm Development

by

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## Abstract

The recent decades have observed a new surge of interest in an important role for small- and medium-sized firms to play in economic development. They not only offer greater employment opportunities but can also be a potential source of indigenous industrialization. The present paper argues that machinery industry is an excellent basis for such development, because its engineering properties can lead to vertically disintegrated industrial organization, where a multitude of independent firms are specialized in the production of interchangeable parts and components. The paper attempts to assess major factors that may lead to the growth of such "ancillary firms", in particular the relative size of the product market as compared with the extent of scale economies. In the same vein, pertinent factors for determining the make-or-buy decisions by assembly firms are discussed and evaluated.

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## I

Characteristic to machinery production is that its industrial organization can be highly disintegrated. The whole process of machine building may be subdivided into multiple layers of independent firms which are engaged in the processing and the sub-assembly of materials and/or machine elements, which are eventually put together by final assemblers and transmitted to sales agents. For lack of better terms, the firms engaged in the production, and/or processing services, sub-assembly of machine components (original equipment) or replacement parts are referred to in this study as ancillary firms, whereas the companies that produce the final, complete products by assemblying original equipment are called primary firms. (It should be stressed here that the word "ancillary" is in no way meant to connote non-essentiality of the work that is being performed.)

Some authors have gone even further to suggest that the development of the network of ancillary firms is an essential ingredient of the successful growth of the machinery industry. The ultimate purpose

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of the present study is to identify, in the context of economic development, the factors which lead to the development of ancillary firms, and, by so doing, to examine whether or not the above assertion is correct. Provided that the premise is the right one, the study will help clarify the conditions which contribute to the successful development of the machinery industry in general.

In anticipation of the presentation of empirical findings from selected East and Southeast Asian countries, the present essay attempts at putting together some thoughts which seem relevant to the understanding of the problems at hand in the hope that it will help the readers place the factual information in perspective.

## II

The development of machinery industry (or, more broadly, of metal-working industry in general) is a necessary condition for industrialization. Although the industry has long ceased to be the front runner of technological progress, it is doubtful if a developing economy can achieve industrialization without ever acquiring the basic technology of metal working.[1] Especially when a country aims at import substitution and/or export promotion in manufacturing, some degree of maturity in machine production seems essential regardless of the specific pattern of industrial development that happens to be elected (see Pack and Todaro 1969 for a similar view). In order to carry out day-to-day manufacturing operations with no interruption, the economy must be capable of supplying basic tools and equipment, various

machine parts and components as well as maintenance and repairing services. Historically, many follower countries in industrialization have nurtured the industry by installing domestic content programs of one kind or another.

The economic significance of the growth of the machinery industry is not confined to the provision of producers' durables, general machine products and related services, as the development of metal-working activities will necessarily be accompanied by dynamic externalities such as the diffusion and the accumulation of engineering skills and mechanical knowledge, and the upgrading of engineering capabilities in the society. Moreover, the development of metal-working activities may further enrich the economy by not only creating new demand, but also stimulating inventions and prompting the cross-fertilization of new ideas. The machinery industry is abound with historical incidents where the development of one branch led to the growth of another. This dynamic linkage effect is attributable to the basic characteristic of machine building industry that it is made up of a relatively small number of basic processes whose engineering characteristics may be summed up by a few common properties such as power supply, friction reduction, heat treatment, machining, etc. As a result, the industry's technology has a relatively high chance of cross multiplication; a specific production technology developed for one commodity may either be adapted by or combined with others to create an entirely new output. In fact, Nathan Rosenberg argues that the machine tool industry of the nineteenth century United States performed the role of an intermediary

for the diffusion of engineering technology especially during the period of 1840 to 1880. For instance, the manufacturing technology of rifles was applied to the production of typewriters; the improvement in lathe operations eventually led to the appearance of bicycles and sewing machines, and so on (Rosenberg 1976, pp. 9-31).[2]

What the writer wishes to suggest here is simply that the development and diffusion of domestic capacity for machinery production is essential for successful industrialization. But the speed and the pattern of development will vary from one case to another depending upon environmental conditions, natural endowment, and the legacy of the past. Moreover, industrialization cannot always claim top priority in favor of all the other considerations. In many instances, agricultural development is equally (if not more) important. In addition, due care must be taken to foster and make best use of the technological potential of indigenous craftsmanship.[3]

The actual development of the machinery industry is conditioned by the principles of engineering economy and by the initial conditions of the modern economic growth. For this obvious reason, there is no guarantee that history will repeat itself or that the experience of a country is applicable to others.

First, the process of industrialization evolves in accordance with the physical as well as economic laws that govern the engineering processes as well as the inter-industry relationships. The development of one kind of production technology may be preconditioned by that of

others. But the contemporary developing economies can shortcut the lengthy, round-about way by which the more advanced nations developed their machine industries. In theory at least, the follower countries can exploit the advantage of being late comers in development, for they have access to the wider variety of new materials, new equipments and new engineering knowhow. The learning process could also be several times more efficient than it was for the so-called advanced nations.

On the other hand, the choice of industry and of technology are affected by the initial conditions of the society at the beginning stage of industrialization, pertaining especially to the quality and quantity of economic resources, the mode and the proficiency of basic production activities, social institutions, and international economic environment. Involved here are such factors as population density, education level, the ability to mobilize national and foreign savings, the diffusion of modern science, agricultural productivity, the development of indigenous manufacturing industries, the economic efficiency of organizational decision making, the extent and coverage of market transactions, and, finally, the competitive pressure from abroad. Stronger are these forces excepting population density and foreign pressure, more favorable would it be for the growth of the domestic machine-building industry.[4]

## III

When a nation with relatively abundant labor but little accumulation of capital launches out into the process of industrialization with the help of borrowed technology from the highly industrialized, labor-scarce economy, the former is often placed in a predicament to adopt as capital-intensive technology as the latter despite the former's definitely low wage-rental ratio. The tendency is reinforced by the developing countries' inclination to choose the most advanced equipment currently available. Under the circumstance, part of the job-seeking mass might very well be termed not only as the involuntary but also as the technologically unemployed.[5]

Viewed in this setting, the machine-building industry merits special attention because of its relatively labor-using nature as well as its discrete production processes. There may be a good chance for small machine shops to participate in the industry's production activities. The growth of the industry may also present a favorable environment for manpower training, since it demands human resources with relatively rich skill contents.

According to an extensive research by Ozaki (1976), the contemporary machinery industry belongs to a group of industries which are relatively capital-intensive and approximated well by the fixed-coefficient, Leontief-type production functions with little scope for factor substitution. In this group, however, the machinery industry is relatively more labor-intensive than others which are delineated by

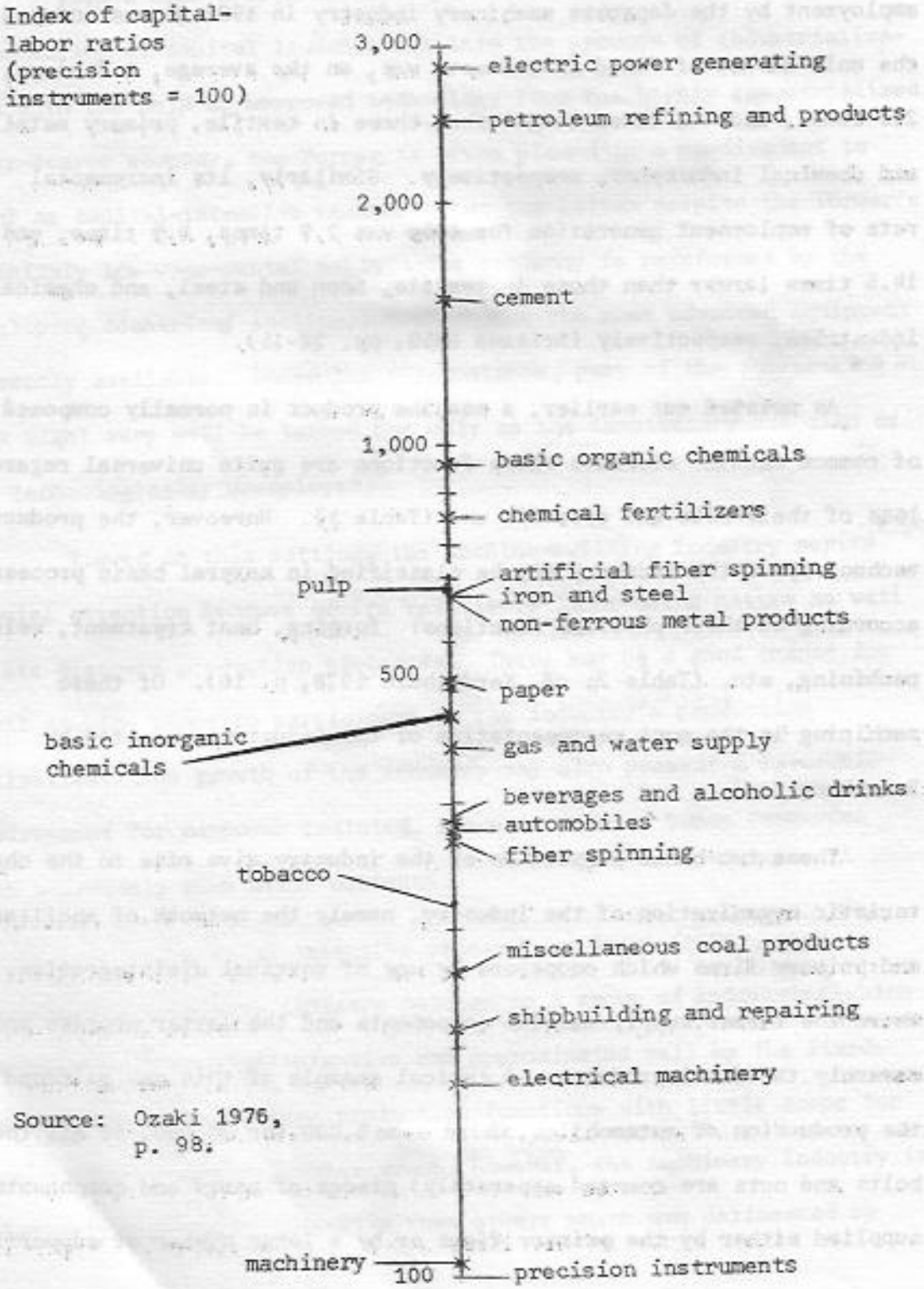
their massive, continuous-process operations such as chemical and primary metal industries (see Figure 1). In fact, the creation of employment by the Japanese machinery industry in 1922-36, as induced by the unit amount of fixed investment, was, on the average, 1.7 times, 2.1 times, and 3.2 times larger than those in textile, primary metal, and chemical industries, respectively. Similarly, its incremental rate of employment generation for 1956 was 2.9 times, 4.9 times, and 14.5 times larger than those in textile, iron and steel, and chemical industries, respectively (Arisawa 1959, pp. 12-15).[6]

As pointed out earlier, a machine product is normally composed of common machine elements whose functions are quite universal regardless of their size and specific use (Table 1). Moreover, the production technology of the industry may be classified in several basic processes according to their physical functions: forging, heat treatment, welding, machining, etc. (Table 2; cf. Kerdpibule 1978, p. 16). Of these machining is the most representative of the industry, as noted by Rosenberg.

These two basic properties of the industry give rise to the characteristic organization of the industry, namely the network of ancillary and primary firms which cooperate by way of vertical disintegration, where the former supply machine components and the latter process and assembly the final products. A typical example of this may be found in the production of automobiles, where some 6,000 (or 30,000, if all the bolts and nuts are counted separately) pieces of parts and components are supplied either by the primary firms or by a large number of supporting

Figure 1

Index of Capital-labor Ratios in the Relatively Capital-using Industries




Source: Ozaki 1976, p. 98.

Table 1

Major Machine Elements

| Major functions | | | |
|---|---|---|---|
| Connecting machine elements | Transmission of machine movement | | Fluid control |
| screw (bolt and nut) | axle and shaft | belt | pressure container |
| rivet | slide and roller bearing | pulley | pipe, tube, and joint |
| key | spline | chain | valve |
| cotter | spline fitting | sprocket | cock |
| wedge | screw and ball screw | clutch | vane and blade |
| pin | coupling | fly wheel | runner and impeller |
| spring | friction wheel | brake | nozzle |
| taper shank and tapered hole | gear and gearing | spring | sealing devices (packing, gasket, etc.) |
| bajonet | cam | damper | |

Source: Adopted from Kasuga (1979) and Tomizuka (1972).

Table 2

Major Types of Machine-building Technology

1) product designing
2) materials engineering
3) primary forming
   (a) moulding
   (b) casting (including die-casting)
   (c) powder metallurgy
4) metal forming (hot and cold working and annealing)
   (a) primary working group
      (1) rolling
      (2) extrusion
      (3) drawing
   (b) secondary working group
      (1) forging
      (2) blanking
      (3) shearing
      (4) bending
      (5) drawing
      (6) coining
      (7) cold hobbing
      (8) impact extrusion
      (9) roll forming
      (10) components rolling
      (11) spin forming
5) machining (metal removal process)
   (a) boring
   (b) turning
   (c) shaping
   (d) planning
   (e) milling
   (f) grinding
   (g) drilling
6) joining
   (a) joining with fixed or removable joint
   (b) soldering
   (c) adhesive bonding
   (d) welding (fusion and pressure welding)
7) painting and plating
8) assembly
9) measuring and testing
10) plant layout, quality control and other production control measures

Source: Adopted from Kasuga (1979) and Tomizuka (1972).

industries and subcontractors. Parts and components may be subdivided according to the extent to which they form self-contained (autonomous) machine units, i.e., (a) general-purpose machine elements such as screws, gears, etc., and (b) special-purpose machine parts such as turbines, carburetors, etc. In the process of economic development, the manufacturers of parts and components are often identified as medium- and small-scale firms, whereas the primary firms as large firms, though there is no theoretical necessity for such correspondence.[7]

IV

In the past the discussion in Japan on medium- and small-scale firms has emphasized their negative aspects; their economic backwardness, their exploitation by, and subordination to, big businesses by way of subcontracting, and the like.[8] The common understanding has been that these problems constitute essential components of economic dualism in the Japanese economy.

It is difficult to deny the reality on which this argument stands. It cannot be taken for granted, however, smallness per se implies poor economic performance. In the Western countries, for example, small firms are by no means synonymous with economic weakness; they have played an essential role in the development of machine industries in these countries, and the term subcontracting does not carry the dark image that it conveys in Japan. The survival of small firms must be based on their comparative advantage, for they would otherwise fail to achieve the standard rate of return and thus drop

out of the market. By the same token, bigness by itself is no guarantee for high profitability. This question thus leads one to ask the basic rationale of the coexistence of big, medium and small firms in the same industry, as Steindl did many years ago (Steindl 1945).[9]

Important factors in determining the organizational structure of the machinery industry are the size of the output market (demand constraint) and the optimum scale of production (supply constraint).

Take the supply constraint first. Here one observes that the industry is made up roughly of two heterogeneous groups: one that is engaged in the mass production of highly standardized commodities (largely consumers' durables such as automobiles and electrical appliances), and the other that is represented by the small-lot production of made-to-order goods (largely producers' durables such as specific-purpose industrial machinery). Of these the second kind is relatively more labor intensive and calls for employment of a large number of skilled craftsmen.

The optimum size of production varies according also to the type of activities. A study made by a Japanese automobile assembler in the 1960's reported that the minimum monthly levels of output were as follows (in terms of 1,000 complete cars, assuming two shifts):

| | |
|---|---|
| assembly | 0.8 - 1.5 |
| machine shop | 1.0 - 2.0 |
| forging shop | 1.5 - 3.0 |

| | |
|---|---|
| casting shop | 3.0 - 4.0 |
| press shop | 4.0 - 5.0 |

Clearly the minimum efficient size of the firm is determined by the capacity of the press shop.[10] By contrast, it should be remembered that assembling is relatively labor-intensive and more monotonous than others. It is no accident that assembly operations are often involved in job enrichment movement. It also explains why foreign direct investment in machine building in the developing countries usually begins with the establishment of an assembly plant.

The optimum scale cannot be determined without reference to the type of equipment used. According to the same study as cited above, the optimum size of machining operations for internal combustion engine with the use of general-purpose lathes was (again assuming two shifts) about 2,000 units of complete cars per month, whereas the level was raised to 7,000 units/month with specific purpose lathes, and further up to 12,000-20,000 units/month with transfer machines. Correspondingly, the index of the minimum unit cost of production declined with the change of the machinery from 1.0 to 1/2 and 1/3, respectively.

The above considerations suggest the following two points. First, where production process enjoys little economies of scale, a relatively small machine shop can enter the market and compete with the bigger firms. The case is strengthened especially when the factor markets are characterized by economic dualism so that the smaller firms take advantage of the relatively cheap human and/or financial resources.

Second, production processes with large economies of scale cannot be easily duplicated so long as the market is small. In fact, vertical integration of several processes may be the best solution whereby the diseconomies arising from low production runs are compensated by gains from other operations. (The diseconomies could of course be diminished if the highly-priced capital equipments may be shared by several manufacturers and used for multiple purposes. However, this method will still entail high operation cost due to frequent interruptions of machine work and to long set-up time.)

As the market expands, however, specialization becomes not only feasible but leads to greater economic efficiency. One is reminded here of the famous proposition by Adam Smith that "the division of labor is limited by the extent of the market." According to a reiteration attempted by Stigler, the network of ancillary firms spreads only when the industry begins to expand. By contrast, he argues, that a firm in a declining industry will take back in as many functions as possible of the would-be ancillary firms so that it can maintain the standard rate of return by way of business diversification (Stigler 1951, pp. 189-190).

In any event, completely integrated operation is not necessarily the most efficient in the discrete process industry. One should be able to achieve equally (if not better) profitable performance by purchasing a maximum number of intermediate products, provided that the minimum optimum sizes of their manufacturing operations are guaranteed.[11] In an extreme case primary firms are entirely freed from physical production and specialized in product development and designing, and production

coordination: perhaps the most essential functions in view of the general scarcity of market and other information. It is likely that a subcontractor does not know enough about the final product of which his component forms a part; worse still, he may be ignorant about the precise functions that his component is expected to perform. One can hardly expect, therefore, that the ancillary firms are well informed about the mutual relationships (engineering as well as economic) of different parts and components.

The raison d'etre of the primary firm in vertically disintegrated industrial structure is to serve as the center for the assimilation, diffusion and exchange of information; its direct involvement in the physical execution of production activity is not essential. Thus the function of the primary firm may be likened to that of a general trading firm in international commercial transaction. Moreover, with the increase of the number of decision makers in the market, the economy may be equipped with the richer opportunities for innovative activities and dynamic externalities. According to Jacobs, this is precisely the social implication of the division of labor that escaped the attention of the original proponent of the concept (Jacobs 1969, ch. 2).[12]

V

It will be profitable here to review briefly the actual accounts of the history of the machine-building industry.

The origin of the production and repairing of machinery may be traced to a village blacksmith or a tinker; similar workshops of varying sizes can still be found among the contemporary developing nations. The ensuing development of metal working was stimulated in some cases by the demand for agricultural equipment, in others by the need for arms, especially swords and guns, which gave profound impact upon the improvement of forging technology. Some machine shops were initially organized as auxiliary sections attached to metal mines; still others originated as workshops in steel mills or a dockyards. In due course of time, these factories grew in size and finally acquired independence to form a separate branch of the manufacturing industry.

The growth of the industry was particularly noteworthy after the Industrial Revolution, in conformity with the growing need for various kinds of industrial machinery with increasingly stringent demand for precision, work performance, and durability. The standard of engineering requirements went up significantly for casted, forged and machined products especially after the renovation of the steam engine by James Watt (1765). The high demand for various types of industrial machinery stimulated the development of machine tool industry. Series of inventions and renovations were culminated finally in the appearance of internal combustion engine: a most sophisticated, and physically demanding kind of machinery. In developing industrial expertise and in meeting the demand for ever increasing degree of mechanical sophistication, England of course surpassed all the other nations. She was indeed the leading machine factory of the world.

Things developed differently in the nineteenth century, however, as the United States of America rapidly caught up with England in the process of industrialization. The United States, particularly after the Civil War, was overflowed with a flood of new inventions in machine tools, electrical machines, and others. Before long she probably surpassed England in terms of her improvement in productive efficiency (measured by the growth of average productivity of labor). According to an economic historian, the superior economic performance of the United States was basically due to the higher capital-labor ratio, being induced by the relative shortage of skilled labor which called for its substitution by capital goods (Habakkuk 1962). Irrespective of the validity of this hypothesis, the difference of the pattern of industrial growth between the two countries seems evident enough. According to an observation (in the early twentieth century) by an expert, even the types of American machine tools were distinct from the English: whereas single-purpose (specialized) machine dominated the former, all-purpose (general) machines were widely utilized in England with the help of highly skilled craftsmen (Hayasaka 1964, p. 185). Underlying the difference was also the rivalry of two engineering philosophies. For instance, the importation to England of the American system of machining was strongly resisted (Rosenberg 1976, pp. 151-72).

Furthermore, the Americans developed a large number of independent metal-working factories. The growth of specialized producers and the concurrent spread of standardized machine components prepared

an extremely favorable environment for the process of the technological convergence; whenever one conceives of the development of a new machine, he could either procure its parts and components or subcontract their production.[13] The adoption and the popularity of standardized components expanded the size of their markets which in turn helped reduce their unit costs. The reliance on ancillary firms for the supply of necessary machine components helped the primary firms economize the initial investment cost and simultaneously keep their output prices low by virtue of scale economies. Precisely for this reason, the American automobile manufacturing achieved its rapid development and early shift into the system of mass production, despite the fact the original invention had been made in Germany. The secret of the success in the American automobile production thus lay in the full realization of the Smith's proposition, making a sharp contrast to the European automobile manufacturers who had to resort to the inhouse production of far more numerous number of parts and components (Maxcy and Silberston 1959, chs. 1 and 8).

This is not to say, however, that all the differences between the United States and Europe could be explained by the different characteristics of their machinery industries. For example, the English customers were more conservative, respectful of individuality, and thus little pleased with the standardized commodities (Rosenberg 1976, pp. 157-62).

In any event, the development of the network of ancillary firms preceded the growth (or the birth) of the mass production of automobiles in the United States. The trend was reversed by the 1920's, however, as market concentration proceeded rapidly, accompanied by the marked increase in the proportion of inhouse production of parts and components. In the case of General Motors, the company grew bigger by the amalgamation of parts and components producers. By contrast, Ford grew larger through the horizontal integration of medium-sized primary firms. As a result of the growth of the automobile market, the primary firms had reached the stage where sufficient scale economies could be realized by inhouse production ("making") alone. "Making" was considered to be superior to "buying" also from the inventory and production control points of view. Furthermore, the users showed strong inclination for the so-called genuine components.

Japanese economic history provides one with an example where the domestic production of general machinery and steel vessels preceded the development of machine tool industry and of fine instruments. Especially notable in this regard was the slow growth of the network of firms which were engaged in the production of machine parts and components. Furthermore, there is some reason to believe that the pace of the development of machine building was retarded after W.W.I due mainly to the recurrent economic recessions. Consequently, the majority of complete automobile component had to be manufactured internally which of course contributed to the high price of the final product (Hoshino 1966, pp. 45-47, 145-48). Toyota Motor Company, for instance, gave up

its original idea to subcontract as many auto parts as possible, because the procured parts and components were invariably the source of mechanical trouble for which the company was to be blamed.

The post-W.W.II decades of the Japanese machinery industry literally reversed this tendency. Thanks partly to the encouragement by the central government and partly to the strong support from the primary firms, the industry saw the mushrooming of the network of ancillary firms. As a result, the proportion of procured parts and components increased significantly in almost all the facets of the machine-producing industry after (say) around 1960. It seems that the growth of the ancillary firms contributed significantly to improving the international competitiveness of the Japanese machinery.

One can only speculate the possible reasons when and why the network of supporting industries develops. The relatively important considerations are:

(a) that it is better off for the primary firm to purchase such parts and components which cater to an extensive, outside market;

(b) that the primary firms have no choice but to subcontract the supply of a component whose production requires specific technology which is not available to the firms;

(c) that, in the period of rapid expansion, it is beneficial for the primary firm to economize investment both in fixed assets and in managerial resources by relying heavily on the network of ancillary firms.

(d) that the industry can exploit relatively cheap remuneration of labor by way of subcontracting;

(e) that there is an optimum size of the firm beyond which its organizational efficiency deteriorates markedly;

and so on. Table 3 summarizes the more important factors which seem relevant in determining the firms' choice in make-or-buy alternatives.

## VI

The discussion so far has implicitly assumed that the machine-building industry faces no deficiency in factor inputs, that market underdevelopment has been eliminated, and that relevant social overhead capital has been sufficiently accumulated. However, these things cannot be simply assumed away. Take, for instance, the shortage of skilled manpower. Of this one may further distinguish (a) manual dexterity as well as the ability to make judgment on production execution, and (b) the capacity to develop, design, and redesign machine products in conformity to the socio-economic conditions of the economy. In addition, the upgrading of managerial capacity will prove to be essential in shaping up and running economic organizations efficiently. By the same token, the existence of the network of market transactions of goods and services (inclusive of technology transfer) may not be applicable in certain cases, since the market may be segmented either by sector or by region. The sub-standard provision of social overhead may be a reason for such underdevelopment.[14]

Table 3

Factors Pertaining to the Choice of Make-or-Buy Policies by a Primary Firm

| Conditions | Decisions: Make | Decisions: Buy |
|---|---|---|
| A. Production Technology | | |
| (1) If it is characterized by scale economies, | | x |
| (2) If it requires firm-specific technology available only to ancillary firms, | | x |
| (3) If it demands large amount of factor inputs (capital and labor), | | x |
| (4) If it is of high engineering standard, | x | |
| (5) If it makes use of industrial secrets that need to be protected, | x | |
| B. Market Conditions | | |
| (1) If the firm's outputs must grow rapidly, | | x |
| (2) If low wage labor is available under subcontracting, | | x |
| (3) If the firm's capital equipments are underutilized, | x | |
| (4) If the firm desires to achieve a higher value-added/sales ratio, | x | |
| C. Management Policy | | |
| (1) If it stipulates the minimization of economic risk due to business cycles, | | x |
| (2) If the firm plans diversification by accumulating production know-how, | x | |
| (3) If the firm asks for a high standard of quality control, | x | |
| (4) If the firm demands the assurance of prompt delivery and the minimization of transportation cost, | x | |

Sources: Adopted from Hayashi 1961, pp. 230-33, 249-63 and Kikai Shinkō Kyōkai 1975, pp. 10-11.

Whatever the reason, these are precisely the problems which are at the core of the developmental issues, which, furthermore, are closely related to the initial conditions of the modern economic growth. In this sense, the present discourse on the development of ancillary firms has finally reached the gateway to its introductory step.

## Notes

1. In the present essay the term technology refers to the combination of product designing, production technology, and production management.

2. Rosenberg termed this phenomenon technological convergence, which was obviously an outcome of the interplay between the engineering properties which had universal application, and the historical factors which were unique to the United States. Inasmuch as the technological convergence took place in the specific historical context, one must be careful in assessing the general applicability of the hypothesis.

3. In the experience of Japan, for instance, the indigenous components have played profoundly significant roles in (1) restraining the demonstration effect in personal consumption, (2) supplying hand-made commodities (furniture, simple metal products, processed food, etc.) and (3) providing off-farm employment opportunities.

4. Think, for instance, of the Bangkok area which has utilized long-tail boats for internal transportation. The popularity of this ingenious device must have helped cultivate engineering expertise among the common people. One might also surmise that the country began industrialization under relatively favorable political conditions because she experienced no colonialism in contrast to other Southeast Asian countries.

5. Shiba reports from his field surveys of thermal electric power generating stations in eight countries (conducted between 1965 and 1970) that the variations in labor productivity were largely due to differences in the physical performance of capital equipments, and that job assignment and work contents were regulated largely by technological factors. The number of operators per equipment, for instance, does not seem to vary much among the countries especially after adjustments have been made for technology requirements and the existence of temporary laborers (helping hands, messengers, servants, etc.) who perform auxiliary jobs (Shiba 1973, chs. 2-3).

6. Direct employment effects only; ideally, indirect effects should also be taken into account.

7. A characteristic of the machinery industry arising from this organizational setting is that the smaller firms in general are engaged in the production of intermediary goods whereas large firms perform the work which is directly in touch with consumers. This makes a sharp contrast to other industries such as textiles where the medium-and small-scale firms are closer to the final demand (see Sakura and Nakamura 1960).

8. The definition of medium- and small-scale firms is largely technical. In the mid-1970 Japan, for instance, it referred to firms with 300 or less employees and equity capital of ¥1,000 million or less.

9. In Japan and Korea, small firms are characterized by low productivity of labor (in value-added terms) relative to big corporations. However, the former are compensated for by the higher capital turnover ratio. As a result, one would expect that small and big firms are on a par in terms of total factor productivity. (And in fact they are!)

10. Similar figures are given in Jidōsha Gijutsu Kai (1970, p. 13-2/3). However, opinions do not necessarily agree as to what is the optimum size of automobile production.

11. According to Culliton (1942, p. 98), a firm should choose "buying" in favor of "making" whenever such a choice is feasible.

12. The industrial organization envisioned here is somewhat similar to that of Professor Imai (1976, ch. 10).

13. The use of interchangeable, standardized components is reported to have started in arms making in the nineteenth century United States. See Deyrup (1970).

14. These issues are elaborated in Ishikawa-Odaka (1979).

## References


Arisawa, Hiromi, ed. Kikai kōgyō no kindaika to kōyō kōzō [The Modernization of the Machinery Industry and Employment Structure], Tokyo: Japan Productivity Organization, 1959.

Culliton, James W. Make or Buy, Cambridge, Mass.: Harvard University Graduate School of Business Administration, 1942.

Deyrup, Felicia J. Arms Making in the Connecticut Valley, A Regional Study of the Economic Development of the Small Arms Industry, 1798-1870, York, Pa.: George Shumway, 1970.

Habakkuk, H.J. American and British Technology in the Nineteenth Century: The Search for Labour-Saving Inventions, Cambridge: Cambridge University Press, 1962.

Hayasaka, Tsutomu, Kōsaku kikai to bummei [Machine Tools and Culture], Tokyo: Komine Kōgyō Gijutsu, 1964.

Hayashi, Shintarō. Nihon kikai yushutsu ron [On the Export of Japanese Machine Products], Tokyo: Tōyō Keizai Shimpōsha, 1961.

Hoshino, Yoshirō. Nihon no gijutsu kakushin [Technological Innovations in Japan], Tokyo: Keisō Shobō, 1966.

Imai Ken'ichi. Gendai sangyō soshiki [Contemporary Industrial Organization], Tokyo: Iwanami Shoten, 1976.

Ishikawa, Shigeru and Konosuke Odaka. "Technology, Management and Market Factors in the Development of Machinery Industry in Asia: Selected Issues for Further Research on Ancillary Firm Development," Tokyo: Institute of Economic Research, Hitotsubashi University, Discussion Paper Series No. 14, March 1979.

Jacobs, Jane. The Economy of Cities, Penguin Books, 1969.

Jidōsho Gijutsu Kai (Society of Automotive Engineers of Japan). Shimpen jidōsha handbook (Automobile Engineers' Handbook), revised edition, Tokyo: Tosho Shuppan Kai, 1970.

Kasuga, Yasuo. Kikai yōso to seisan kakō [Machine Elements and Production Technology], Tokyo: Kyōritsu Shuppan, 1979.

Kerdpibule, Udom. Planning Development of the Light Engineering Industries, Honolulu: Technology and Development Institute, East-West Center, September 1976.

Kikai Shinkō Kyōkai, Keizai Kenkyūjo (The Institute of Economic Research, The Society for the Promotion of Machinery Industry). Nichibei kikai kōgyō ni okeru nai-gaisei mondai ni kansuru chōsa kenkyū — nichibei jidōsha ni okeru nai-gaisei mondai [A Report on Research Findings on the "Make-or-Buy" Issues in the Automobile Industry, A Comparison of Japan and the United States], Tokyo, 1975.

Maxcy, George and Aubrey Silberston. The Motor Industry, London: George Allen and Unwin, 1959.

Ozaki, Iwao. "The Effects of Technological Changes on the Economic Growth of Japan, 1955-1970," in Karen R. Polenske and Jiri V. Sholka, eds., Advances in Input-Output Analysis (Cambridge, Mass.: Ballinger, 1976), pp. 93-111.

Pack, Howard and Michael Todaro. "Technological Transfer, Labour Absorption, and Economic Development," Oxford Economic Papers, n.s., Vol. 21, No. 3 (Nov. 1969), pp. 395-403.

Rosenberg, Nathan. Perspectives on Technology, Cambridge: Cambridge University Press, 1976.

Sakura, Itasu and Takafusa Nakamura. "Sangyō renkan no kigyō kibo betsu bunseki (Size of Business in Interindustry Relations)," Keizai kenkyu (The Economic Review), XI, No. 4 (October 1960), pp. 369-78.

Shiba, Shōji. A Cross-national Comparison of Labor Management, with Reference to Technology Transfer, Tokyo: Institute of Developing Economies, 1973.

Steindl, Joseph. Small and Big Business, Economic Problems of the Size of Firms, Oxford: Basil Blackwell, 1945.

Stigler, George. "The Division of Labor is Limited by the Extent of the Market," Journal of Political Economy, LIX, No. 3 (June 1951), pp. 185-93.