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AGRICULTURAL DEVELOPMENT AND ECONOMIC TRANSFORMATION: A COMPARATIVE STUDY OF THE JAPANESE EXPERIENCE*

Development of agriculture in Japan and its contribution to general economic growth has rightly received much attention. The object of the present paper is to throw additional light on two aspects of the Japanese experience that are of particular interest in relation to the problems of other late-developing countries: first, the means by which substantial gains in agricultural productivity and output were achieved at very moderate cost, and secondly, the interrelationships between development of the agricultural sector and the expansion of manufacturing and other nonagricultural sectors leading to a transformation of the structure of the economy. The development of agriculture in Taiwan and Denmark is reviewed in more summary fashion, with emphasis on these same two aspects of their experience.

Principal attention is given to the period 1880–1940, a distinction being made between the decades prior to 1920, when rapid increase in agricultural productivity clearly played a "positive role" in the rapid transformation of the Japanese economy, and the interwar period, when there was marked retardation in the rate of agricultural progress and economic transformation. The resumption of rapid advance in the agricultural sector and in general economic growth during the 1950's is examined briefly.

In Taiwan, Japanese administrators, scientists, and technicians applied essentially the same type of approach that had been used in Japan. The specific measures differed somewhat, but there was the same reliance on inexpensive technological innovations, and the results obtained during the 1901–40 period that is examined were even more striking than in Japan. Agricultural development in Denmark, which reveals more contrasts than similarities, registered about the same rate of increase in agricultural output and labor productivity as Japan during the years 1880–1940.

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I. AGRICULTURAL DEVELOPMENT AND ECONOMIC TRANSFORMATION

In considering the experience of these three countries attention is given to the extent to which agricultural development was associated with structural transformation of their economies as reflected in changes in the occupational distribution of the labor force. It is generally recognized that the process of economic growth involves a secular decline of the agricultural sector and relative expansion of manufacturing and other components of the nonagricultural sector. A special case of this "general transformation model" has been examined by W. Arthur Lewis in his version of the classical growth model. In this two-sector model, Lewis assumes that the rural labor force is so large relative to the available supplies of land and capital that there is a surplus of labor in the "subsistence sector," which corresponds roughly to the traditional peasant agriculture of an underdeveloped country. The "capitalist sector" of the economy, which is characterized by the use of substantial amounts of capital equipment and the employment of wage labor for profit-making purposes, is viewed as the dynamic element of the economy which absorbs the surplus of manpower in the "subsistence sector."[1]

This view of the process of economic growth underscores the critical importance of capital accumulation which is the principal factor determining the rate of expansion of production and employment in the capitalist sector. It is, of course, the rate of expansion of the capitalist sector, relative to the total labor force, which determines how rapidly the surplus of labor in the subsistence sector will be reduced sufficiently so that wages are no longer depressed by the low level of earnings in the subsistence sector. Such a transformation of the economy is necessary to facilitate improvement of farm incomes by establishing a more favorable man/land ratio and by creating the conditions that make it economic to enhance the productivity of agricultural labor by capital-intensive, labor-saving methods. Other significant implications of the model concern (1) the importance of increasing productivity in the agricultural sector without making large demands on the resources that are indispensable for expansion of the capitalist sector, and (2) the strategic importance of agriculture's contribution to the capital requirements of the expanding sectors of the economy.

Dovring has called attention to a simple arithmetic relationship which clarifies the conditions under which the labor force of the agricultural (subsistence) sector will decline in relative or absolute terms (*9*). If employment in the nonagricultural (capitalist) sector is growing faster than the total labor force, its percentage share in the total labor force will increase at a rate which is the difference between these two growth rates. To this difference between the annual rates of increase of the labor force in the nonagricultural sector and of the total labor force Dovring has applied the term "coefficient of differential growth." Although the rate of change in sector proportions is determined by the "coefficient of differential growth," it is apparent that the reduction of the agricultural labor force in absolute numbers will also depend on the existing share of non-

[1] Lewis has elaborated his two-sector model in *24* and *25*. The present writer and John W. Mellor have examined the implications of the model with respect to agriculture's role in economic development in *19* and *20*. A valuable extension of Lewis's model has been presented by Gustav Ranis and J. C. H. Fei which analyzes the implications of increases in agricultural productivity and of the rates of growth of population and of the industrial labor force (*38a*).

agricultural employment in the total labor force—whether a coefficient of differential growth of one per cent means, for example, an increase in nonagricultural employment from 20 to 20.2 per cent or from 50 to 50.5 per cent. The time required to achieve a given change in occupational structure is, of course, very sensitive to the coefficient of differential growth. With a coefficient of differential growth of one per cent means 70 years would be required to alter a country's labor force from 70 per cent in agriculture and 30 per cent engaged in other industries to a 40:60 ratio; but with a differential growth rate of 2 per cent the same transformation of the country's occupational structure would be realized in 35 years. Decennial estimates of the "coefficient of differential growth" in Japan are examined in Section III, and these are compared in Section V with the differential growth rates experienced in Taiwan and Denmark.

It is argued here that conditions prevailing in Japan and Taiwan correspond rather well to the assumptions underlying the two-sector model, whereas the notion of a subsistence sector with a labor surplus has very little relevance to Denmark. The Danish example is of interest, however, as an example of the "general transformation model" in a country where agricultural exports are extraordinarily important. In spite of the fact that some 65 per cent of the country's farm output was destined for export at the end of the 1880–1940 period considered here, less than 30 per cent of the labor force was engaged in agriculture.

The impressive development of the agricultural sector in Taiwan was associated with only slight transformation of the country's economic structure, which is not surprising in view of its colonial status. Between 1905 and 1930, the agricultural labor force, as a share of the total labor force, declined only from 71 to 68 per cent. Taiwan was one of the first countries to experience a really rapid reduction in death rates, with the result that as early as the 1920's the annual rate of natural increase exceeded 2 per cent. Thus the magnitude of the task of structural transformation was much greater in Taiwan because the rate of growth of population and of the total labor force was nearly twice as high as in Japan and Denmark. This aspect of Taiwan's experience is extremely pertinent inasmuch as rates of natural increase of some 2.5 per cent are, in the 1960's, becoming increasingly common in underdeveloped countries.

Although the brief review of Danish and Taiwanese experience suggests interesting comparisons and contrasts, only the Japanese case is examined in detail. The development of Japanese agriculture during the period 1880–1940 is examined in the following section. Attention is then given in turn to agriculture's "positive role" in economic development prior to 1920, the reduced rate of agricultural progress and structural transformation during the 1921–40 period, and finally a very condensed account of the increase in agricultural output and economic growth during the 1950's.

II. AGRICULTURAL DEVELOPMENT IN JAPAN, 1881–1940

Increase in agricultural output and productivity.—The magnitude of the increase in agricultural output in Japan, and the major factors underlying the gains in productivity can be described with a fair degree of confidence. The physical output of Japan's six major crops nearly doubled between the 1880's and the decade 1931–40 (Table 1). Estimates of net real income produced in agriculture show a similar pattern of expansion, as would be expected considering the domi-

TABLE 1.—JAPAN: INDEX NUMBERS OF PRODUCTION OF SIX MAJOR CROPS, COCOONS, AND NET INCOME PRODUCED BY AGRICULTURE, TEN-YEAR AVERAGES, 1881–1940*

Period	Six major crops,[a] production in calorie equivalent	Cocoon production[b]	Net real income produced by agriculture[c]
1881–1890	100	100	100
1891–1900	127	172	133
1901–1910	146	263	163
1911–1920	177	470	200
1921–1930	179	714	206
1931–1940	195	754	239[d]

* Computed from data in sources listed below.

[a] SCAP, Natural Resources Section, *Crop Statistics for Japan, 1878–1946* (Rep. No. 108, 1948), pp. 16–28. The six crops are rice, wheat, naked barley, barley, sweet potatoes, and white potatoes, all expressed in brown rice (calorie) equivalent.

[b] Japan, Ministry of Agriculture and Forestry, *Statistical Tables of Agriculture and Forestry, 1868–1953* [translated title] (1955), p. 72.

[c] K. Ohkawa *et al.*, *The Growth Rate of the Japanese Economy Since 1878* (Tokyo, 1957), pp. 72–73.

[d] Average of eight years, 1931–1938.

nant position of the six staple crops—rice, wheat, barley, naked barley, and sweet and white potatoes.

Estimates of the value of output of most of the nonstaple crops during the early decades have a scant statistical basis, and Ohkawa and his colleagues were obliged to rely heavily on the proportion method (*32*, pp. 50–54). For the livestock industry, output of livestock and dairy products was assumed to equal 3 per cent of the total value produced in farming and sericulture for the years prior to 1900, this being the relationship suggested by data available for 1888. For later years the statistical basis for estimating the value produced in the livestock and dairy industry improves; during the 1920's these products accounted for 6 per cent of the gross value of all agricultural products and 8 per cent of the total during the 1930's (*32*, p. 57).

The increase in output of cocoons is shown separately in Table 1 because of the great importance of sericulture in Japan's economic development. In view of the tremendous expansion of physical output of cocoons, it is surprising to find that the increase in the share of cocoons in the gross value of agricultural production was rather modest. During the three decades prior to 1910, cocoons accounted for 9 or 10 per cent of the gross value of agricultural products. In the 1911–20 decade their share rose to 12 per cent of the total and reached a peak of 16 per cent during the 1920's before falling back to 12 per cent during the 1930's (*32*, pp. 55–57).

This surprisingly small increase in the value of cocoon production as a percentage of the value of all agricultural crops is to be explained by the marked difference in the course of price changes for cocoons and other agricultural products. Comparison of cocoon price relatives with the general agricultural price index used to obtain the real income series of Table 1 shows the long-term increase in cocoon prices to have been much less than the upward swing of agricultural prices in general. The decennial averages for these indices and a general

wholesale price index changed as follows (data from *32*, pp. 126–27 and 130 shifted to an 1881–90 base):

Period	Cocoon price index	Agricultural price index	Wholesale price index
1881–1890	100	100	100
1891–1900	110	133	117
1901–1910	137	182	164
1911–1920	190	302	275
1921–1930	237	401	347
1931–1938	136	300	274

The divergent price movement for cocoons was influenced heavily by world demand conditions for silk, and the evidence of deterioration in the terms of trade on which cocoons were exchanged for other products seems clear. The rapid expansion of silk exports was nevertheless of great importance. During the first quarter century of the Meiji period (1868–93), raw silk accounted for 40 per cent of the value of Japan's exports. As late as 1930, exports of raw silk still represented nearly 25 per cent of the total value of exports despite the expansion of exports of manufactures and the collapse of silk prices; the cocoon price index (1881–90 = 100) fell from a peak of 325 in 1925 to 99 in 1930 (*26*, pp. 336–42). Silk was Japan's only major export that did not depend heavily on imported raw materials; and the sevenfold increase in cocoon production and seventeenfold increase in output of raw silk resulted primarily from a series of striking technological advances leading to large increases in output per unit of input.

Throughout the 60-year period being considered here, the six major staple crops accounted for close to 80 per cent of the food calories produced in Japan and represented a little over 60 per cent of the gross value of all agricultural products as late as the 1930's. The doubling of production of the six major staples between 1881–90 and 1931–40 was mainly a consequence of the increased crop yields (Table 2). In the course of a half century, the area devoted to these crops increased by only 18 per cent whereas yields rose by 66 per cent. Moreover, the apparent early increase in planted area may be a statistical illusion resulting from more complete coverage as estimates of the cultivated area were improved. This

TABLE 2.—JAPAN: INDEX NUMBERS OF AREA, YIELD, AND PRODUCTION (IN CALORIE EQUIVALENT) OF SIX MAJOR CROPS, TEN-YEAR AVERAGES, 1881–1940*

	Index Numbers (1881–90 = 100)			Annual percentage rate of increase (compound) from preceding decade		
Period	Area	Yield	Production	Area	Yield	Production
1881–1890	100	100	100	...	...	...
1891–1900	113	113	127	1.19	1.23	2.43
1901–1910	116	125	146	.34	1.03	1.38
1911–1920	121	146	177	.41	1.52	1.94
1921–1930	117	153	179	−.41	.53	.12
1931–1940	118	166	195	.12	.77	.89

* Based on data in SCAP, Natural Resources Section, *Crop Statistics for Japan, 1878–1946* (No. 108, 1948), pp. 16–28.

would also mean some upward bias in the estimated increase of production, but the rate of increase in farm output during the period 1880–1920 was unquestionably impressive. The final two decades, and particularly the 1920's, were in contrast a period of relative stagnation.

Japan's farm labor force seems to have declined very gradually during the decades following 1880, making the increase in labor productivity in the agricultural sector a little larger than the increase in output. On the basis of estimates of the agricultural labor force summarized in Table 3, labor productivity

TABLE 3.—JAPAN: ESTIMATES OF AGRICULTURAL LABOR FORCE AND CHANGE IN LABOR PRODUCTIVITY, 1881–1940*

(Indexes 1881–90 = 100, except as otherwise indicated)

Period	Average farm labor force		Six main crops, physical output per worker	Net real income produced by agriculture, per worker
	Thousand workers	Index		
1881–1890[a]	15,511	100.0	100	100
1891–1900[a]	15,397	99.3	128	134
1901–1910[a]	15,184	97.9	149	166
1911–1920[a]	14,613	94.2	188	212
1921–1930	14,201	91.5	196	225
1931–1940	14,058	90.6	215	263[b]

* Farm labor force data are estimates of gainfully employed population in agriculture and forestry for 1921–40, from K. Ohkawa *et al., The Growth Rate of the Japanese Economy Since 1878* (Tokyo, 1957), p. 246; for earlier years comparable revised estimates from K. Ohkawa and H. Rosovsky, *The Role of Agriculture in Modern Japanese Economic Development* (Paper for Conference on Urban-Rural Relations in the Modernization of Japan, August 1959), p. 8, available only as five-year averages, see note *a*. The last two columns are the index numbers in Table I divided by the farm labor force index.

Estimates of Japan's agricultural labor force are subject to a considerable margin of uncertainty, especially for the years prior to 1920. But even for the 1930's there is considerable discrepancy in the figures available. Hemmi's estimates of the number of persons gainfully employed in agriculture, including forestry, show a gradual increase in the agricultural labor force during the 1930's and his figure for 1940 is some 500,000 larger than Ohkawa's estimate. Hemmi's estimates are presented in his article, "Estimates of Gainfully Employed Population in Agriculture," in Tōbata and Ohkawa, eds., *The Japanese Economy and Agriculture*, Vol. I [translated title] (Tokyo, 1956); they are based on the estimated number of farm households and an estimate of the average number of gainfully occupied per household.

[a] Farm labor force data are actually for the five-year periods 1883–87, 1893–97, 1903–07, and 1913–17 which are taken as representative of the decades shown.

[b] 1931–38 average (for which the labor force index is 90.9).

more than doubled between the mid-1880's and mid-1930's. In fact, the increase was some 160 per cent if the calculation is based on the estimated increase in net real income produced in agriculture. Here again we see the contrast between the impressive gains in productivity during the 1881–1920 period and the sluggish increase between 1921 and 1940. During the 30 years between the decade of the 1880's and 1911–20, the productivity of labor increased by nearly 90 per cent according to the index of output of the six major crops and by more than 100 per cent on the basis of estimates of the net real income produced in agriculture. But during the 20-year span between 1911–20 and 1931–40 the increase was only 15 per cent if based on the index of output of the six staple crops and 25 per cent according to the growth of net agricultural income.

The means by which agricultural productivity was increased.—Two factors of overwhelming importance in the expansion of farm output in Japan were the development and use of improved plant varieties and increased application of fertilizers. The two factors were, of course, highly complementary. Plant breeding in Japan was aimed primarily at raising crop yields by developing varieties that would give a strong response to increasingly heavy applications of fertilizers.[2]

Other major objectives seem to have been the creation of varieties resistant to troublesome diseases and the selection and breeding of early-maturing varieties for northern Honshu and Hokkaido. Rice-growing in Hokkaido was of negligible importance until early-maturing varieties became available. Considerable expansion followed the discovery and selection in 1895 of a variety known as *Bozu,* and another upsurge is apparent in the years following 1923 when an improved cross, *Hashiri-bozu,* became available (*30,* pp. 33 and 89).

Other factors also contributed significantly to the increase of crop yields. Various improvements in farm practices—seedbed preparation, transplanting techniques, weeding, the timing and density of planting, timing and placement of fertilizer applications—made their contribution. Without such improvements in farming techniques, the full potential of higher levels of soil fertility and superior varieties could not have been realized. There was also progress throughout the period in extending irrigation systems and improving water storage and drainage. Their contribution to raising yields during the period under review should not be exaggerated, however, since irrigation of paddy fields was already highly developed by 1880. In addition to the work of plant breeders in developing disease-resistant varieties, a variety of other measures to control disease, fungus, and pest damage also played their part. Among the important control measures were the use of disease-free seed, the soaking of seed before planting, the roguing of diseased plants, the rotation of crops, and spraying or dusting with pesticides and fungicides.

Examination of some of the specific factors that led to the spectacular increases in output and productivity in sericulture is also illuminating. Once again technological progress was the decisive factor. The seventeenfold increase in raw silk output was more than twice the increase registered in cocoon production, which in turn was almost twice as large as the expansion of mulberry area (Table 4). "Probably no Japanese industry is so dependent on research as is the silk industry," S. C. Salmon has remarked, "and certainly none has profited more from research" (*30,* p. 28).

Varietal improvement, better cultural practices, and higher rates of fertilization contributed to heavier production of mulberry leaves. In addition, the feeding value per unit area of mulberry was augmented by the introduction of better methods of gathering and feeding leaves. For example, methods were devised to reduce losses from excessive drying of the young mulberry leaves while also avoiding silkworm losses from diseases that thrive under high humidity.

[2] A wealth of detail concerning the techniques that were used to increase agricultural productivity in Japan is contained in *15a.* Long-term experiments have indicated that on plots receiving no fertilizer, rice yields averaged only about half the level obtained from plots receiving complete fertilization, and wheat yields were only a third the level obtained from fertilized plots (*29,* pp. 12–13). Such comparisons suggest the importance of fertilizers, although they exaggerate the gains as compared with the results obtainable with "good" farming but without commercial fertilizers.

TABLE 4.—INDEX NUMBERS OF MULBERRY AREA, COCOON PRODUCTION, AND OUTPUT OF RAW SILK, 1881–1940*

Period	Mulberry area	Cocoon production	Raw silk output
1881–1890	100	100	100
1891–1900	176	172	232
1901–1910	234	263	349
1911–1920	307	470	698
1921–1930	371	714	1,317
1931–1940	380	754	1,718

* Computed from Japan, Ministry of Agriculture and Forestry, *Statistical Tables of Agriculture and Forestry, 1868–1953* [translated title] (1955), pp. 68, 72, and 78.

Research leading to the selection and breeding of superior races or varieties of silkworms appears to have contributed greatly to the increase in output of raw silk. The yield of raw silk per metric ton of cocoons rose from an average of 76 kilograms during the years 1908–12 to 137 kilograms for the period 1938–42. It is believed that this rise was largely due to basic discoveries made in 1909 by K. Toyama of Tokyo Imperial University which led to the use of F_1 hybrids between certain Chinese and Japanese races of silkworms. These hybrids, which came to be used almost exclusively, are more vigorous, less susceptible to disease, and spin larger cocoons (*30*, pp. 28–29 and 89).

Other noteworthy achievements were made in the hatching of the silkworm eggs and in the rearing of the silkworms. Of great economic significance was the development of methods of hatching the eggs artificially. Prior to this innovation silkworms were raised only in the spring, but since 1920 the autumn crop of cocoons has been about as important as the spring crop (*1*, p. 512, and *37*, p. 219).

Efficiency in the silk industry was also enhanced by the introduction of more economical and better controlled methods of producing silkworm eggs. Although the raising of silkworms and production of cocoons was carried on by some two million small-scale producers, egg production came to be increasingly concentrated in a limited number of specialist firms—4,300 in 1934 compared with 8,500 in 1923. Because of considerations of quality and efficiency, egg production became increasingly dependent on technical skill and equipment that only the specialist firms could command; the tendency for this process to become separated from the main body of the sericulture industry was reinforced by legislation prohibiting individual farmers from producing their own eggs and requiring that egg producers be licensed (*1*, p. 512). Other organizational innovations also facilitated more efficient methods. One of these involved forward purchase contracts between large silk reelers and individual farmers or with associations of sericulturists whereby the producers were provided with eggs and instructions for rearing the silkworms and the reelers thus assured themselves of a supply of cocoons of standardized quality (*1*, pp. 513–14).

Certain general features of the Japanese pattern of agricultural development deserve special emphasis. Perhaps of greatest significance is the fact that the

increase in costs of production was moderate indeed in relation to the gains in output achieved. Investment in mechanical equipment was of slight importance, although improvements in a wide range of simple farm implements contributed to the growth of productivity. Horses and cattle remained the principal aids to manpower in performing field operations, but a notable increase took place in the use of inexpensive machines for performing auxiliary tasks. Kerosene and electric motors, used especially for pumping irrigation water, increased in number from 2,500 in 1920 to over 50,000 in 1927, and to nearly 300,000 in 1939; and a comparable increase took place in the number of hullers and threshers in use (*18,* pp. 10–11). Toshio Shishido has estimated that there was only a modest increase in the draft power used in Japanese agriculture in the decades prior to 1920, from a level of a million h.p. in 1878–82 to 1.2 million during the years 1913–17. (He arrived at these figures by evaluating horses at 0.6 or 0.8 h.p., depending on whether they were improved stock, and calculating cattle used for draft power at 0.5 h.p.) By the mid-1930's the stock of energy available to agriculture had increased to about 1.8 million h.p., an estimate which takes account of the capacity of electric motors, internal combustion engines, and steam engines used in agriculture as well as animal-draft power (*42,* p. 288). The outlays for implements and depreciation charges on machinery on the average farm were only a small fraction of the gross value of production—certainly less than 4 per cent even as late as 1940.

Commercial fertilizers stand out as the conventional input that increased most in importance throughout the 60-year period. A rough indication of the increase in fertilizer use is provided by the following provisional index numbers (computed by Hiromitsu Kaneda).[3]

Period	Index of consumption of commercial fertilizers	Index of total fertilizer consumption
1903–07	100	100
1908–12	220	125
1913–16	330	150
1917–21	465	180
1922–26	545	200
1927–31	665	230
1932–36	825	280
1937–41	1,060	335

The tremendously rapid increase in the consumption of commercial fertilizers is clear. Purchases of organic fertilizers were the first to increase in importance; imports of soybean cake, which bulked especially large in this category, rose sharply from just over 200,000 tons during the years 1903–07 to an average of close to 1.2 million tons during the 1917–21 period. An index for purchased fertilizers, prepared by Shishido on the basis of deflated values, shows a fifteenfold increase between 1878–82 and 1903–07 (*42,* p. 288). Since consumption of

[3] There is a very large element of approximation in the index of total fertilizer consumption. The earliest estimates pertaining to farm manures seem to relate to the years 1927–31, and it has been arbitrarily assumed that use of farm manures, which depends largely on the availability of labor and the number of farm animals, rose slowly from an index of 70 in 1903–07 to 100 in 1927–31. By 1937–41 this index number for consumption of farm manures had risen to 132. See *29,* p. 50, and *18,* p. 256, for the estimates of consumption (production plus imports prior to 1927–31) used in constructing this provisional index.

commercial fertilizers appears to have been only about a half million tons in 1903–07, this early increase was obviously from a very small base. Ammonium sulphate, superphosphate, and other inorganic fertilizers began to increase during the first World War, and by the late 1920's had surpassed the organic fertilizers in importance. Although estimates of consumption of farm manures for the early period are unavailable, it seems certain that they increased rather slowly. In the late 1920's, consumption of farm manures (including night soil, compost, and other organic products produced on the farm) were still as important as commercial fertilizers as a source of plant nutrients, and it is the slow increase in this component that accounts for the fact that total fertilizer use apparently increased only about threefold compared to the tenfold increase in commercial fertilizers. During the late 1930's, Japan ranked fifth in the world in per-acre consumption of plant food in fertilizers (*18*, pp. 12, 256–57).

Fertilizer expenditures were by far the most important item in farm production costs—defined to exclude land and labor charges but including seed costs, fertilizer, feed, sprays, fuel, nondurable agricultural implements and their repair, hiring charges for draft animals, and maintenance and depreciation costs of buildings for production use, machinery, and livestock. On the basis of the estimates published annually by the Ministry of Agriculture and Forestry in *Nōka Keizai Chōsa* (*The Economic Survey of Farm Households*), outlays for fertilizers increased from 36 per cent of the production costs of the average farm household during the years 1921–25 to 47 per cent for the period 1936–40 (*32*, pp. 68–69). Total production costs over this period were an almost constant share of the gross value of production, fluctuating between 20 and 25 per cent in most years. The rough estimates available for earlier decades suggest that production costs rose from about 15 to 20 per cent of the gross value of output between 1880 and 1920.

With respect to rice, data are available based on a broader definition of production costs. Estimates for 1937 published by the Imperial Agricultural Society indicate that labor and rent are by far the most important cost items, using the more inclusive definition; but even on this basis fertilizer expenditures are a conspicuously large fraction of the total (*18*, p. 14):

Item	Owner-Cultivators	Tenant Farmers
Rent (or imputed cost of land)	29	42
Labor	31	29
Fertilizer	17	15
Other	23	14
Total	100	100

The cost of labor is, of course, almost entirely an imputed cost since family members made up virtually all of Japan's farm labor force.

Agricultural research and education.—The foregoing account of the means by which the productivity of Japan's agriculture was increased has stressed the strategic importance of agricultural research and measures that led to widespread adoption of improved techniques. The significance of technological innovations is emphasized in a striking fashion by comparing the increase in agricultural

output with the increase in conventional inputs—cultivated land, labor, capital, and fertilizers and other current inputs.

Anthony Tang has calculated that between 1880 and 1938 net real output in agriculture increased by some 150 per cent, whereas measured inputs increased by roughly 30 per cent. (He uses Ohkawa's estimates of net real income produced in agriculture, and Toshio Shishido's estimates are the basis for his index of inputs.) Thus an increase in output of close to 2 per cent per year was associated with an increase in measured inputs of only 0.5 per cent annually. Tang follows the common practice of attributing this "unexplained output" to "technical progress" associated particularly with agricultural research, rural education, and extension activities. He identifies a number of factors that might be responsible for the discrepancy between the rate of increase in the index of real output and the index of conventional inputs. Apart from technical change in the strict sense and improvement in the quality of labor and farm management, these factors include (1) changes in scale of the firm (or of the industry if external economies are operative), (2) index number problems associated with construction of the indexes of outputs and inputs, (3) improvements in "general economic efficiency" resulting, for example, from better transportation and communications, and (4) increase in the intensity of use of resources, a change which is not adequately reflected in the index of inputs since several important components of that index are based on stock rather than flow statistics (*50,* pp. 3–5). Owing to the small importance of scale changes or other structural modifications of Japanese agriculture during the 1880–1940 period, Tang argues that it is reasonable to attribute most of the unexplained output to "investment in the human agent" defined broadly to include outlays for rural education, agricultural research, extension, and certain development activities. He has attempted to estimate returns to this composite "investment variable" by using a distributed lag scheme in which unexplained output is viewed as a function of past investment in the human agent. His computations suggest a long-run social return to the outlays for rural education, research, and extension equivalent to a marginal efficiency of about 35 per cent (*50,* pp. 17–19).[4]

Expenditures for "developmental services" other than rural education were remarkably small relative to their apparent contribution to the increase of agricultural output. During the 1880's the outlays for agricultural research, extension, and related development activities accounted for only 2–5 per cent of the total "investment variable," that is, total outlays for "nonconventional inputs" inclusive of educational expenditures in rural areas. Expenditures for agricultural research and extension increased at a faster rate than the much larger outlays for rural education, so that by the 1930's they accounted for nearly 10 per

[4] In addition to government outlays for rural education, the "investment variable" includes expenditures of agricultural experiment stations, subsidies to local farm associations, subsidies to prefectures for promotion of agricultural fairs, subsidies and awards to farmers to encourage improvements in sericulture and other farm enterprises, public outlays for control of plant and animal diseases, payments to encourage reforestation, expenditures related to training technical personnel, incentive payments to encourage village handicrafts and subsidiary enterprises, and public outlays for irrigation, flood control, and drainage. The sources used by Tang for the outlays for education and for research and development activities were, respectively, *An Eighty-Year History of Educational Statistics* [translated title] (Tokyo, Ministry of Education, 1957) and the detailed annual budget and expenditure accounts of the Ministry of Agriculture and Forestry (*50,* pp. 27–29).

cent of the "investment variable." But as late as 1936–40, agricultural research expenditures of the central and prefectural government averaged only about 13 million yen annually (*30,* p. 87). This represented a mere .05 per cent of the net national product and a little over 0.3 per cent of the net income produced in agriculture during those years. It also amounted to less than 0.4 per cent of the expenditures of the central government which were, of course, swollen by military outlays.

In an intangible but significant sense, the agricultural research effort in Japan was a good deal larger than is indicated by the annual budgets. A minimum level of budget support was a necessary but obviously not a sufficient condition for the impressive achievements of agricultural research. Of great importance was the fact that the experiment stations were staffed by competent research workers who devoted their efforts to problems that had great potential for increasing the output and productivity of the nation's agriculture. At the time Salmon carried out his study in 1946, the experiment stations included 42 scientists with the doctorate, 500 with other university degrees, and a thousand graduates of agricultural colleges.

There appears to have been effective division of labor between the Imperial (central) stations which emphasize basic research and work on problems of national significance and the prefectural stations which "center their attention on local problems with emphasis on results of immediate, practical importance" (*30,* p. 23). During the 1936–40 period 75 per cent of the total budget for agricultural experiment stations was allocated to prefectural stations and 25 per cent to stations and laboratories of the central government.

The work on varietal improvement in particular has emphasized the adaptation of varieties to particular localities. For wheat, for example, crosses are made at four central or primary breeding centers located in Kyushu, southern Honshu, northern Honshu, and Hokkaido. Emphasis at each center is on crossing varieties considered likely to contribute characteristics needed for the region served by the center. Third and fourth generation hybrids are distributed to designated prefectural stations that serve as secondary centers. These stations, chosen because of location, facilities, or personnel, make selections from the hybrids that are outstanding with respect to yield, disease-resistance, or other traits. Seed of the more promising selections is then distributed to tertiary breeding centers and finally to farmers. Because of the great range of climatic conditions and differences in the diseases prevalent in various localities, no single variety of wheat has been found that is well adapted to a large region. Of 19 hybrid varieties that are important in Japan, no single variety is grown on as much as 10 per cent of the total wheat area (*30,* pp. 25–26 and 35).

It is apparent from R. P. Dore's account that there was emphasis on agricultural improvement from the beginning of the Meiji period (*8*; see also *30,* pp. 12–14). Almost as soon as the Meiji government was established, an agricultural section was created in the Ministry of Home Affairs; and in 1881 this became the agricultural half of the Ministry of Agriculture and Commerce. The Shinjuku experiment station was established by the central government in 1872. By 1876 the station was growing 347 strains of foreign wheats and 247 Japanese

strains (*8*). Only Japanese strains of rice were being grown at that time, although introduction of foreign varieties contributed to the development early in the present century of varieties resistant to pericularis, the most important disease of rice in Japan. The early improvements in rice, however, were made by selection from native varieties. And it is noteworthy that important selections were made by individual farmers as well as by the experiment stations. As late as 1945 seventeen varieties selected by farmers were still being grown, and the most famous of these was being grown on about 10 per cent of the total rice area (*30*, p. 32).

Various techniques were utilized to promote the widespread use of improved agricultural methods. Japan did not create an agricultural extension organization *per se* until after World War II, but extension-type activities were important throughout the period under review. In 1880 the Department of Agriculture and Commerce sent a circular to prefectural governments urging the establishment of agricultural improvement societies; a number of these had already been created through the initiative of prefectural governments or private individuals. An Agricultural Associations Law enacted in 1899 gave legal backing to the societies; and in 1905 membership in the Agricultural Associations became compulsory (*8*). These associations were used by the government for a variety of purposes, including the dissemination of information and exhortations relating to technical improvements (*15a*, Chapter 9 and 15).

The prefectural agricultural experiment stations took an active part in promoting the adoption of better farming methods. Only 3 per cent of the total budget for experiment stations was allocated to "extension" in the restricted sense of the term. As much as 40 per cent of the budgets of these prefectural stations was, however, devoted to "service" activities which included the production and distribution of improved seed to farmers and other activities that contributed directly to increasing efficiency on individual farms (*30*, pp. 19 and 86).

A great many other factors influenced the gains in agricultural productivity. Political stability, the increasing commercialization of agriculture, economic incentives and pressures, and improved transportation were all part of an environment in which farmers were both able and willing to improve their efficiency. The Land Tax, to cite an important influence, seems to have exerted pressure on owner-cultivators and landlords to raise the production level of their holdings; since the valuations on which land taxes were assessed were revised infrequently, there was strong incentive for land improvement and maximum output.

Particularly significant among the changes that had taken place prior to 1880 was the transition from group farming to individual operation of farm units under well-defined conditions of ownership or tenancy that Thomas C. Smith has so ably described in his study of agrarian change in pre-Meiji Japan. Smith also makes it clear that significant technological progress occurred between 1600 and 1850, though at a very much slower rate than characterized the period considered here (*44*, pp. 87–107). Elsewhere, Smith has emphasized that the Meiji regime, which came to power in 1867, gave strong impetus to agricultural enterprise "by striking down monopolies, abolishing legal distinctions among classes, establishing universal education, withdrawing restrictions on the sale and cropping of land, and making possible the free choice of occupation" (*45*, p. 173).

Although all of these factors had an effect on "general economic efficiency" and contributed to the rise in agricultural productivity, the expansion of rural education stands out as the general influence that made the most decisive contribution. Schultz's work in recent years has been particularly important in calling attention to the importance of investment in the human agent.[5] Tang, who suggests that education should be regarded as a "technical complement" to the widespread adoption of new techniques of production, emphasizes that in addition to the specialized knowledge and skills that are imparted, education is likely to enhance labor's productive capacity by creating greater awareness of opportunities and greater receptivity to innovations, by changing values and aspirations so as to strengthen the will to economize, and by giving rise to inventive ideas that facilitate technical progress (*50*). It has been seen that innovations developed by individual farmers were an important component of Japan's agricultural progress. Development of the decision-making capacity of the rural population through general education and extension-type programs is especially important where, as in Japan, management of farm units is the responsibility of several million small-scale operators who must make production decisions in terms of their own capabilities and the specific soil and other characteristics of their holding. The high degree of variability in agriculture, the large number of "on-the-spot supervisory decisions" that must be made, and the importance of direct, individual interest in the outcome of the farm enterprise give an important economic advantage to decentralized management and decision-making.[6]

In addition to these general considerations, the salient facts concerning the rapid spread of rural education in Japan also suggest that this was a factor that contributed a great deal to the success of the measures that increase the productivity of Japan's agriculture. Exuberant expansion of public education took place in the decade of the 1870's. The educational system, initiated with the establishment of the Ministry of Education in 1871, marked an abrupt change with the past in placing major emphasis on the practical value of education and in regarding education as a universal privilege and obligation of all citizens. The Preamble to the Education Code of 1872 expresses this utilitarian viewpoint in language that harmonizes remarkably well with the current emphasis on investment in human resources: "Every man only after learning diligently according to his capacity will be able to increase his property and prosper in his business. Hence knowledge may be regarded as the capital for raising one's self; who then can do without learning?" (*21,* p. 68). Japan's first normal school was established in 1872; elementary school teaching methods were taught by an American instructor through an interpreter. Between 1873 and 1879 the number of elementary schools rose from 12,558 to 28,025, and the number of students increased from 1.1 to 2.3 million. In 1879 the attendance already amounted to 44 per cent of all children of elementary school age (58 per cent for boys). It was not until 1908,

[5] A good general summary of Schultz's viewpoint and references to more detailed analyses is given in his presidential address to the American Economic Association, "Investment in Human Capital" (*41*).

[6] Brewster has stressed the difference between agriculture and industry in this respect that results from the biological character of the agricultural production process which means that the operations to be performed are separated in time and space (*6*).

however, that the period of compulsory education was raised from four to six years.

Of particular interest in relation to agricultural development is the emphasis which was placed on technical education. A Technical Education Bureau, one of three bureaus comprising the Ministry of Education, was responsible for administering government subsidies to technical schools and training teachers for such institutions. One of the first technical schools established was an agricultural college started in Hokkaido in 1872 under an American staff; and two years later a second agricultural college was founded in Tokyo. Technical schools were established at various levels, but most numerous were "technical supplementary schools" which were open to students of 12 or over who had completed the four-year course of elementary instruction. Schools of this type numbered only 221 at the turn of the century, but by 1906 there were 3,285. Most of them stressed topics useful in agriculture as well as supplementing the general instruction in reading, writing, and arithmetic received in the elementary school (*21,* pp. 346–51). Agricultural students were well represented among those sent abroad for training under government scholarships. The principal purpose of this program was to allow future teachers in the universities to complete their education abroad, and scholarship recipients were generally under an obligation to serve upon their return in positions designated by the Minister of Education for twice the number of years spent studying abroad.

The measures taken to launch a system of public education have further significance in illustrating the willingness of the Meiji leaders to make those changes in Japanese society which were necessary for the successful introduction of Western technology. They are also of interest in reflecting a very old tradition in Japan of importing ideas and techniques.

As in any historical analysis, the question arises whether the features unique to Japan were so important that her experience has little relevance to the possibilities of agricultural development in other countries. In the opinion of the present writer, the major lessons of Japan's experience are in fact widely applicable. It is perhaps necessary to stress, however, that it would be a misreading of Japan's agricultural history to conclude that there was anything automatic or even easy about the process. It is true and important that raising agricultural productivity in Japan made only very moderate claims on the country's material and financial resources; but it did depend on basic decisions that required impressive foresight, on intelligent and dedicated work by a substantial number of agricultural scientists and other key personnel, and on a certain degree of receptiveness on the part of the nation's farm population.

III. AGRICULTURE AND GENERAL ECONOMIC GROWTH IN JAPAN

Agriculture's positive role in economic development, 1880–1920.—During the four decades ending in 1920, gains in agricultural productivity made highly important contributions to Japan's overall economic development. Expanded domestic production satisfied virtually all of the increase in demand for food; imported supplies were of slight importance until the end of World War I. Per capita food supplies appear to have increased on the order of 20 per cent despite

a 40 per cent increase in population between 1885 and 1915. Large expansion of raw silk production and exports made a crucial contribution to Japan's foreign exchange earnings.

Rising productivity in agriculture also played a significant role in the structural transformation of Japan's economy which proceeded rapidly during the first four decades of the period under review. During the years 1883–87 something like 75 per cent of the total labor force was engaged in agriculture and forestry and the sector accounted for over 50 per cent of the net national product. Thirty years later—as an average for the years 1913–17—agriculture's share of the labor force and net national product had declined to about 56 per cent and 32 per cent respectively. For this initial 30-year period the total labor force increased at an annual (compound) rate of 0.8 per cent. But the nonagricultural labor force was increasing at the high rate of 2.9 per cent per annum, so the coefficient of differential growth averaged 2.1 per cent between 1883–87 and 1913–17 (Table 5). The growth of employment in manufacturing was especially rapid, averaging nearly 3.4 per cent annually between 1883–87 and 1913–17.

It is not necessary to dwell on the fact that nearly all of the workers for the rapidly expanding nonagricultural sectors were drawn from agriculture. Namiki has estimated that there was an outflow of approximately eight million migrants from agriculture between 1872 and 1920 which accounted for almost all the increase in working population in nonagricultural pursuits (cited in *34*, p. 28).

Agriculture's strategic contribution to the capital requirements for industrialization appears to have been extremely significant, especially during the early stages of Japan's economic growth (*35*, pp. 14–18). Inasmuch as consumption levels of the farm population increased much less than the rise in labor produc-

TABLE 5.—JAPAN: GROWTH OF TOTAL AND NONAGRICULTURAL LABOR FORCE AND COEFFICIENTS OF DIFFERENTIAL GROWTH, 1883–1940*

(1,000 persons except as indicated)

Period	Total labor force (1)	Nonagricultural labor force		Annual percentage rate of increase (compound) from preceding period			Coefficient of differential growth Col. (5)–(4)
		Total (2)	Manufacturing (3)	Total (4)	Total nonagriculture (5)	Manufacturing (6)	
1883–87	20,360	4,849	1,524	...	...	...	...
1893–97	22,258	6,861	2,393	.90	3.53	4.48	2.63
1903–07	24,252	9,068	3,263	.86	2.83	3.28	1.97
1913–17	25,967	11,354	4,131	.68	2.28	2.39	1.60
1920	27,263	12,976	4,357	...	...	...	...
1930	29,619	15,488	4,891	.83	1.78	1.16	.95
1940	32,478	18,636	7,160	.93	1.87	3.88	.94
Average for total period				.85	2.48	2.85	1.63

* Data from K. Ohkawa *et al.*, *The Growth Rate of the Japanese Economy Since 1878* (Tokyo, 1957), p. 245, except estimates of population engaged in agriculture and forestry included in total labor force are from Table 3. All figures refer to estimates of "gainfully employed," which was defined for census purposes in Japan as an individual's "usual status." Hence, persons employed part-time or temporarily unemployed are included. For the years prior to Japan's first census in 1920, the figures are only rough approximations.

tivity in agriculture, a substantial fraction of the increment of product in agriculture could be used to finance capital formation in the capitalist sector of the economy. The fact that the increase in farm output and productivity required only small capital outlays and but modest increases in other inputs naturally strengthens this presumption.

Since heavy taxes on agriculture were the principal device used to siphon off the increment in productivity in agriculture, it is possible to obtain some notion of the magnitude of this contribution in relation to total investment. Table 6 presents estimates of agriculture's relative contribution to total tax revenue, of governmental investment as a per cent of total investment, and gross investment as a share of net national product. The investment estimates are from Rosovsky (*39*), and he cautions that his data underestimate private investment for which coverage was less complete; private agricultural investment, including residences of farmers, is omitted completely because of lack of data. The division of the tax burden between agriculture and nonagriculture reproduces estimates of Seiji Tsunematsu (see *38*, p. 448). They represent an attempt to allocate all but 33–40 per cent of total government tax revenue between the two sectors. In the first decades of Meiji, the Land Tax was the dominant source, accounting for 73 per cent of the central government's tax revenue in 1880 and slightly over 50 per cent of the total a decade later. From 1900 excise taxes together with profits of the government's distribution monopolies were more important than the Land Tax (*38*, p. 446). The principal excises were on sake, soy products, sugar, and textiles; government monopolies handled distribution of tobacco, camphor, and salt.

The importance of agriculture's contribution to the financing of development is indicated very clearly by these estimates of agriculture's share of the tax burden

TABLE 6.—JAPAN: AGRICULTURE'S SHARE OF TAXES, AND GOVERNMENT AND TOTAL INVESTMENT, 1888–1922*

	Share of taxes[a]			Government investment as per cent of total investment[b]		Gross investment as per cent of net national product[b]	
Years	Agriculture	Non-agriculture	Year	(Including military investment)	(Excluding military investment)	(Including military investment)	(Excluding military investment)
1888–1892	85.7	14.3	1890	36.4	30.5	9.7	8.9
1893–1897	83.3	16.7	1895	63.5	50.5	8.9	6.5
1898–1902	73.9	26.3	1900	74.0	63.6	8.9	6.3
1903–1907	58.9	41.1	1905	63.5	51.2	9.8	7.3
1908–1912	53.7	46.3	1910	62.7	55.0	12.7	10.5
1913–1917	53.5	46.5	1915	46.1	36.8	14.1	12.0
1918–1922	40.7	59.3	1920	42.7	32.6	20.0	17.0

* Share of taxes are estimates of Seiji Tsunematsu, reproduced in *38*, p. 448; investment data are from Henry Rosovsky, "Japanese Capital Formation: The Role of the Public Sector," *Journal of Economic History*, September 1959, pp. 354–57.

[a] Revenue from the land tax, income tax, business revenue tax, and customs are included; "miscellaneous items" which amounted to 33–40 per cent of total tax revenue are not included because of the difficulty of allocation.

[b] Investment percentages are five-year moving totals centered on the years shown.

and of the position of government in total investment. It will be seen from Table 6 that during the years 1893–97 agriculture still accounted for more than 80 per cent of total taxes (apart from the miscellaneous taxes that Tsunematsu was unable to allocate). As late as 1918–22 agriculture's share of the total was slightly in excess of 40 per cent. I have not been able to analyze the uses of the government's tax receipts. But inasmuch as the public sector's share in total investment (excluding military investment) rarely fell below 30 per cent and frequently exceeded 50 per cent, it is apparent that the taxes levied on agriculture contributed directly and very substantially to Japan's requirements for investment. As stressed earlier, current expenditures of the government for education and for agricultural research and other "developmental services" also had an important impact on economic growth.

Expansion of the capitalist sector was, of course, facilitated by the light tax burden on industry made possible by the disproportionate tax load imposed on agriculture. During the period before 1920 the burden of direct taxes on agriculture ranged between 12 per cent of the net income of agriculture during the years 1913–17 to 22 per cent in the period 1884–87. By contrast, it is estimated that the burden of direct taxes on nonagriculture was only about 3 per cent of the net income of the secondary and tertiary sectors at the turn of the century (1898–1902) and reached a peak of 6 per cent in 1908–12 (*38*, p. 448). It was only after 1900 that the income tax and business taxes began to be important, and as late as 1910 these two categories still accounted for less than 15 per cent of the total tax revenue of the central government (*38*, p. 446).

Noteworthy among the governmental outlays to stimulate industrialization were the funds used to establish "model" factories, subsidies for the nation's fledgling merchant marine and shipbuilding industry, and investment in various types of social overhead capital. Government investments to extend and improve the country's rail network were especially significant, and during the first two decades of the present century accounted on the average for close to 50 per cent of the nonmilitary investment of the central government (*39*, pp. 368–69). The investment figures used in the foregoing calculations were exclusive of military outlays, but it should be noted that a considerable part of the expenditures in that category helped to develop domestic steel production and a machine tool industry that facilitated the subsequent diversification and technical maturity of Japanese industry.

Increased output and productivity in agriculture contributed to capital accumulation in other ways that were significant although they cannot be quantified. It is clear that a part of the increment in productivity in agriculture was siphoned off by an increase in the share of income in agriculture accruing to landlords. In part this was a direct result of the growth of tenancy from 31 per cent of the cultivated land in 1873 to 40 per cent in 1887. This increase resulted from growing indebtedness of farm operators who were obliged, following the Land Tax Revision of 1873, to make fixed tax payments regardless of variations in their crop or in the prices of their products. Owners of land, including an increased number of landlords, profited by the rising tendency of agricultural prices after 1873. At the price of rice prevailing in 1873, the land tax represented about 25

per cent of the value of production in a normal year, but in later years it seems to have amounted to perhaps 13 per cent of a normal crop (*17*, pp. 502, 504). Since population pressure on the land was severe, land rentals remained high—on the order of 50 per cent of the crop for paddy land. "The Japanese landlord of the Meiji era," Ranis observes, "presents a sharp contrast to Ricardo's wastrel type." And he further notes that "there is no evidence of any sizeable diversion of the landlord's respectable surpluses to high living or speculation" (*38*, p. 447). It is impossible to trace how these funds were used, but Thomas C. Smith has emphasized that investments by landlords in small local industries such as textile factories, rice mills, and factories for sake and soy sauce were of considerable importance.[7]

Growth of farm output and productivity also facilitated capital accumulation in the capitalist sector by minimizing the rise in food prices. Inflationary tendencies are inherent in a high rate of investment and rapid industrialization and urbanization, but the inflationary potential was reinforced by the fact that Japan's capitalists were able to finance part of their new investment by means of funds made available as a result of credit creation and expansion of the money supply. Japan's national debt expanded from 239 million yen in 1885 to 2.6 billion yen in 1914 (*17*, p. 504n; see also *38*, p. 454). Between 1902 and 1915, total bank deposits were expanded from 0.7 to 2.5 billion yen. Capital imports were a partial offset to the inflationary expansion of the money supply and credit in the decade preceding the first World War, but were unimportant earlier. The upward drift of the prices of wage goods would have been much sharper if it had not been for the expansion of agricultural output. This would have meant higher wages in the capitalist sector, to revert to Lewis's two-sector model, and would have thus reduced the profits available for reinvestment. But in fact the terms of trade between agriculture and nonagriculture did not change very much until World War I, when wartime conditions led to a sharp rise in food prices, provoking considerable urban unrest and the "rice riots" of 1918.[8] The index of agricultural prices averaged about three times as high in the decade 1911–20 as during the 1880's; but the index of nonagricultural prices increased nearly as much—185 per cent for nonagriculture against the 202 per cent increase in the index of agricultural prices (*32*, p. 130).

Retardation in the rate of agricultural progress and economic transformation, 1921–40.—The foregoing discussion was focused on the decades prior to 1920 for several reasons. This was the period in which agriculture most clearly played a "positive role," to borrow the term that Ohkawa has used to describe a situation in which there is a net flow of capital from agriculture to the rest of the economy (*34a*). By 1920 the modern or capitalist sector had become a major element in the economy—more important than agriculture in net income produced and not much smaller in terms of employment. Presumably reinvestment of profits had by this time outdistanced agriculture as a source of capital accumulation.

[7] Wealthy landlords were making significant investments in rural industries even in the late Tokugawa period (*45*, pp. 168–72).

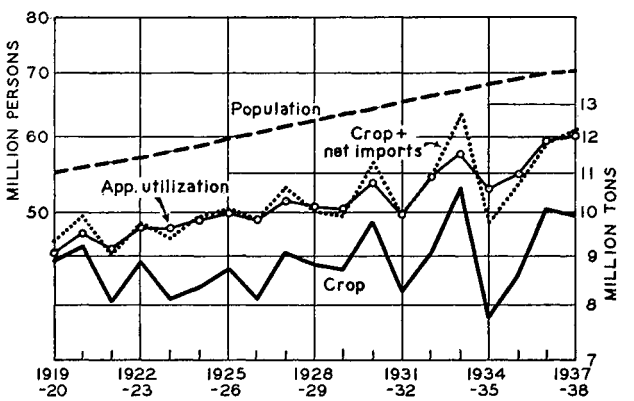
[8] The "rice riots" seem to have resulted chiefly from the fact that agricultural prices rose much more precipitately than wage rates. Between 1915 and 1918 the index of agricultural prices increased by 131 per cent compared to a rise of 61 per cent in the index of industrial wage rates and 96 per cent in the nonagricultural price index (*32*, pp. 130, 244).

It has also been seen that the period 1921–40 was characterized by relative stagnation in agriculture. Output of the six major crops increased at an annual (compound) rate that ranged from 1.4 to 2.4 per cent during the decades before 1920 (Table 2). During the 1920's, however, growth of output of these crops represented an increase of only 0.1 per cent per year over the preceding decade. The level of production for these crops during the 1930's represented a considerably higher rate of increase—about 0.9 per cent—but was still considerably below the lowest rate of growth in the pre-1920 decades. Since there was apparently little change in the slow rate of decline in the farm labor force throughout the 60-year period (Table 3), the same picture of relative stagnation applies to comparisons of the rate of change in labor productivity in agriculture.

What were the principal factors responsible for this marked retardation in the rate of increase in agricultural productivity during the 1921–40 period? Since an increase in labor productivity in agriculture presupposes an increase in output or contraction in the farm labor force, it is necessary to examine the factors that restricted the appropriate changes in those magnitudes.

The most obvious factor that limited the growth of domestic farm output was the expansion of food imports from Taiwan and Korea, which satisfied most of the increase in demand for agricultural products after 1920. Although imports were of slight importance until the first World War, it will be seen from Chart 1 that most of the expansion of rice supplies after 1920 resulted from the steady and substantial rise of imports.[9] The unfavorable impact on Japanese agriculture of expanding rice imports from Korea and Taiwan has been stressed by Ohkawa and Rosovsky, who emphasize that this was a matter of conscious policy, given

CHART 1.—JAPAN: POPULATION VS. TOTAL SUPPLIES, APPARENT UTILIZATION, AND DOMESTIC PRODUCTION OF RICE, 1920–38*
(*Logarithmic vertical scale*)



* Reproduced from B. F. Johnston, *Japanese Food Management in World War II* (Stanford, Calif., 1953), p. 77.

[9] The picture would be much the same in terms of imports and total supplies of all foodstuffs. During the 1930's, rice accounted for more than 60 per cent of domestic production and something like half of Japan's total food imports in terms of calories. Sugar and soybeans, the other major food imports, were of relatively small importance in Japanese agriculture.

impetus by the rice riots of 1918, but aimed more generally at holding down the cost of rice as the all-important wage good (*33*, pp. 27–28).

The growth of demand for agricultural products was also restricted by the fact that Japanese diet patterns changed only slightly during this period. A change in the product mix in agriculture in the direction of a more expensive combination of commodities might have meant an increase in resource requirements analagous to a quantitative increase in demand. But this occurred to only a small extent, and the (real) value of farm output increased little more than output measured in physical (calorie) terms. The persistence of a diet pattern characterized by heavy dependence on the cheap starchy staples might be viewed as a sort of "scientific feeding" since it minimized the resource requirements to satisfy the growth in demand for food.[10] There was, therefore, a greater potential for rapid accumulation of capital and transformation of the structure of the economy than if there had been a marked increase in demand for meat, dairy products, and other items that are more expensive to produce.[11] But in fact the potential was not realized in the 1921–40 period, in the sense that capital accumulation could have been greater.

The major change in the combination of agricultural products resulted from the rapid growth of output of cocoons that had become a part of the productive activity of two out of five farm households. In contrast with the stagnant trend in output of the six major crops and of total agricultural income, output and productivity of the sericulture industry continued to increase rapidly until the 1930's. It is significant that most of the silk produced was exported, the bulk of it going to the United States, where demand was growing rapidly until the Depression. Cocoon prices rose sharply in 1922 and remained at unprecedentedly high levels through 1925. Raw silk exports reached a peak in 1929 that was 60 per cent above the average quantity shipped in the years 1923–25; but the value of exports rose by only 10 per cent owing to the decline of silk prices from the 1923–25 peak. A further and disastrous decline in silk prices occurred during the 1930's as a result of a drastic reduction in purchasing power in the United States and competition from rayon, but production of cocoons and silk remained at a high level until World War II (*12*, p. 894; *37*, pp. 219–20). Presumably, this reflected a certain inertia and above all a lack of alternative outlets for the labor and land committed to mulberry and the raising of silkworms.

Limited expansion of the demand for the products of Japanese agriculture clearly aggravated the farm adjustment problem. But the fundamental question

[10] A study by Chenery, Shishido and Watanabe notes that Japan's economy of 1954 was "a combination of an agricultural sector typical of a per capita income of about $150 with an industrial sector appropriate to an income level of about $275" (*7*, p. 37). This apparent anomaly is, of course, mainly a result of the relatively small decline in Japan's "starchy staple ratio." Although heavily dependent on cheap, starchy staples, the Japanese diet contained small but significant quantities of fish and soy products that provided high-quality protein which effectively supplemented the much larger quantities of cereal protein (*18*, pp. 83–88).

[11] Masao Ōtsuki's stimulating discussion of agricultural change in Japan since World War II and of "the conditions for future agricultural development" emphasizes the desirability of enlarging the domestic market for agricultural products through increased consumption of dairy products, meat and other high-value products. He argues that this is desirable for nutritional reasons, but he is particularly conscious of the fact that such a change in the combination of commodities produced will "increase the labour employment capacity" of the agricultural sector (*36a*, pp. 69–70).

remains: Why was the absorptive capacity of the nonagricultural sectors insufficient to reduce the surplus of labor in agriculture? Clearly, movement of excess rural population out of agriculture was the most basic requirement for raising the productivity of farm labor. In terms of Lewis's two-sector model, the imports of cheap rice from the colonies should have facilitated expansion of the capitalist sector unless the favorable effect on capitalist profits (assuming constant real wages as postulated in the model) was more than offset by a slowing down of capital formation in Japan as a result of capital export. Since investment in Korea and Taiwan was largely financed out of profits and taxes obtained locally, there is no indication that investible funds were reduced appreciably by colonial development expenditures; substantial export of capital did take place after 1932, especially to Manchuria, but this was a period of rapid industrial expansion in Japan proper as well as in the colonies (*26*, pp. 259–61).

By 1920 the industrial sector weighed more heavily in the economy so that a given percentage increase in nonagricultural employment represented a larger numerical increase in the demand for labor. Consequently, an accelerated transfer of population out of agriculture might have been expected.[12] In fact, this did not occur because of the marked retardation in the rate of increase in employment in the nonagricultural sectors from an annual rate of 2.9 per cent for the decades prior to 1920 to a rate of 1.8 per cent in the 1921–40 period. Consequently, the coefficient of differential growth averaged just under 1.0 per cent during the decade of the 1920's compared to 2.1 per cent during the earlier period. It will also be seen from Table 5 that the rate of increase in the manufacturing component of the labor force was only about 1.2 per cent in the 1920's compared with an average rate of 3.4 per cent during the decades before 1920 and 3.9 per cent during the 1930's. Most of the movement of population out of agriculture in the 1920's was absorbed in commerce and other services which "seem to provide the main outlet for surplus labor. The rapid rise in employment in the service sectors is therefore due less to increased demand than to ease of entry and lack of alternative employment" (*7*, p. 49; see also *26*, p. 210). Thus a considerable part of the movement out of agriculture in the 1920's is probably to be regarded as a transfer from one branch to another within the "subsistence sector" rather than as expansion of the "capitalist sector."

It is easy to point out that the proximate reason for the slight contraction of the farm labor force in the 1920's was the fact that investment in the nonagricultural sectors created a demand for additional labor that was only sufficient to absorb the growth of the labor force resulting from natural increase. Much more difficult is the task of identifying why investment and the rate of economic growth were, in this sense, "insufficient." Economic developments in Japan dur-

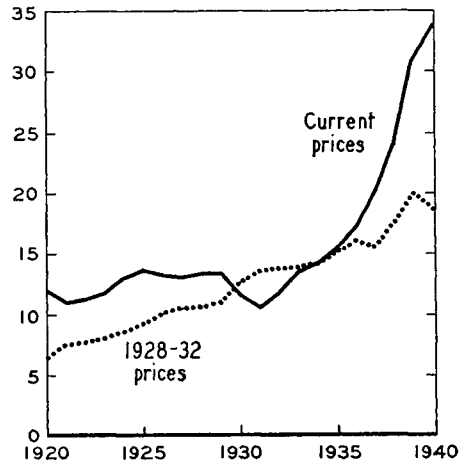
[12] Dovring has pointed out that for the agricultural labor force to remain stable (in absolute numbers) the rate of increase in nonagricultural employment must equal the rate of increase in total labor force multiplied by the denominator in the fraction formed by taking nonagricultural employment over the total labor force. Thus with nonagricultural employment accounting for as little as 20 per cent of the total and a rate of increase in the total labor force of 1.5 per cent per year, nonagricultural employment would have to increase by more than 7.5 per cent to effect a numerical reduction in the agricultural labor force. But if the nonagricultural sector accounts for 50 per cent of total employment, then any increase in nonagricultural employment greater than 3 per cent would suffice to reduce employment in agriculture, assuming the same 1.5 per cent rate of increase in the total labor force (*9*, p. 2).

ing the inter-war period were exceedingly complex.[13] World War I left a legacy of large foreign exchange balances and gold reserves, and an inflated price, cost, and debt structure. A major policy objective, finally realized in January 1930, was the return to the Gold Standard at prewar parity with the dollar and the pound. This dictated deflationary policies through most of the period, although credit restrictions were relaxed for a few years following the catastrophic Kwanto earthquake in 1923, which destroyed about three-fifths of Tokyo and all of Yokohama. The contrast with earlier periods was sharp. Lockwood has noted that the 1880's and the period 1920–32 were the only exceptions to the secular rise in Japan's price level, a tendency that was encouraged by chronic budget deficits and "a general predilection for easy money which seems to have been shared alike by the government and the business community, and which helped to maintain private investment at a high level through much of the period 1893–1913" (*26*, p. 518).

It also seems clear, on the basis of Miss Gordon's analysis, that the yen was consistently overvalued during the 1920–32 period. There were fairly brief periods when the value of the yen depreciated—and exports expanded in response. But for the most part the yen was pegged at a level that was high in relation to the Japanese price level, and the foreign exchange resources accumulated during World War I were drawn upon to support the yen and to finance a large import surplus.

It is not possible, however, simply to assert that expansion of employment in Japan's "capitalist sector" was retarded in this period because of depressed economic conditions. Estimates of net national product expressed in constant (1928–32) prices show a steady and substantial rise from 1920 to 1931; but in terms of current prices there was only slight increase until 1929 and then a sharp break (Chart 2).

CHART 2.—JAPAN: NATIONAL INCOME PRODUCED, 1920–40*



* Data from K. Ohkawa *et al.*, *The Growth Rate of the Japanese Economy Since 1878* (Tokyo, 1957), pp. 247–48.

[13] This section draws heavily on Miss Gordon's admirable account of the period 1920–31 (*12*, pp. 879–907) and the discussions of this period by Allen (*1* and *2*) and Lockwood (*26*).

There are indications that the creation of new employment opportunities in the nonagricultural sector was restricted to some extent by changes in both the volume and the character of investment. Rosovsky's estimates show gross investment declining from 20 per cent of NNP in 1920 to 14.5 per cent in 1930.[14] The decline in private investment was deeper since government's share in investment increased from 43 to 64 per cent. Earthquake reconstruction and other disaster expenditures accounted for a substantial part of the investment outlays during the 1920's, and such expenditures obviously did not create continuing job opportunities (*39*, pp. 354, 367).

Turning to a consideration of the character of investment during the 1920–32 period, the evidence seems to point to changes in the pattern of capital formation which reduced the amount of additional employment created by new investment. Japanese industry embraces a wide spectrum, ranging from large-scale, capital-intensive enterprises to family workshops that use little or no power machinery. Some of the latter rely so heavily on family labor and use so little capital that it is a moot question whether they should be included in the "capitalist" or "subsistence" sector of Lewis's two-sector model. Variation in capital-intensity is also evident in postwar estimates of capital stock per employee which show a range from $400 in trade and $420 in finished goods to $1230 in intermediate products, $2140 in services, and $3610 in transport (*7*, p. 49).

Allen's account of Japanese industry during the 1920's and 1930's suggests that expansion was probably concentrated in the more capital-intensive branches. Furthermore, much of the industrial investment seems to have been of the capital-deepening variety, particularly during the years 1927–31 when deflationary policies were most marked and both industry and government were stressing the need for "rationalization" of industry (*1*, pp. 493–624; 649–79). In commenting on this tendency, Ohkawa suggests that in spite of the abundance of cheap labor, the modern sector was forced to adopt relatively capital-intensive techniques because the technical coefficients for efficient operation were fairly rigidly fixed; and it was essential to increase efficiency "to cope with severe international competition" (*34*, p. 23).

It seems likely, however, that during the 1920's this tendency was exaggerated —carried beyond the point that would have been economically justified or desirable—because of the persistence of an over-valued exchange rate and deflationary policies which prevailed during most of the 1920–31 period. Lockwood has suggested that

> With the bank failures and mergers of the twenties small business became increasingly dependent on big financial institutions closely affiliated with the big industrial concerns. This gave the large firms a financial advantage which was often decisive, especially during periods of hard times. Centralized control over the supply of capital in the hands of big business and the State helped no doubt to perpetuate the dearth of credit for small business, keeping interest rates for them at high levels and exerting a corresponding pressure on wages and working conditions (*26*, p. 293).

[14] Rosovsky's estimates refer to the center years of 5-year moving totals. One of a number of contradictions in the data bearing on this period that I have not been able to resolve is that Shinohara's estimates of capital formation by the commodity flow method do not show a clear decline except in 1931 and 1932 (*32*, p. 195).

Since the banking system played such a dominant role as a source of finance for Japanese industry, there is indeed good reason to believe that the close links between the Zaibatsu-controlled banks and industrial firms meant that the impact of tight money policies was felt primarily by the smaller firms characterized by more labor-intensive methods. Thus the effect of the economic policies of the 1920's was not merely to slow down the over-all rate of investment and growth but to curb particularly the growth of those branches of industry which were labor-intensive and which might have offered a major outlet for surplus labor in the countryside.

There is another factor to be mentioned briefly. In examining agriculture's contributions to development during the 1881–1920 period, it was argued that the failure of farm levels of living to rise very much probably facilitated general economic growth because it maximized the surplus that could be siphoned off for nonagricultural investment. There seems to be some reason to suppose, however, that by the 1920's the economic base had expanded sufficiently so that the low level of consumer purchasing power was a more important factor in limiting investment than lack of investible funds. It is also pertinent, of course, that demand for exports tended to be weak because of an overvalued exchange rate.

From this admittedly incomplete and provisional examination of the evidence, it would appear that the chief factors accounting for a slowing down of the rate of expansion of industrial employment during the 1920–31 period were: (1) deflationary monetary policies; (2) an overvalued exchange rate; (3) concentration of investment in the large-scale, relatively capital-intensive segment of the capitalist sector, whereas investment of the capital-widening variety was restricted; and (4) a low level of consumer purchasing power that weakened the incentive to invest in creating or expanding productive capacity.

Despite the highly tentative character of these hypotheses, it has seemed worthwhile to advance them. Perhaps they will help to provoke a more authoritative treatment of a period of considerable historical importance as well as theoretical interest. Studies of the emergence of extremist groups in the 1920's and 1930's and of the seizure of power by the militarist clique that carried Japan into a disastrous military adventure make it clear that the damming up of population in the countryside and the associated economic and social tensions were important contributing factors. It was no mere coincidence that the murder of Premier Inukai and the attempted seizure of power in 1932—the so-called "May 15 Incident"—was carried out jointly by members of an extremist farm organization and young naval officers. Nor is there much room to doubt that such assassinations and other acts of violence weakened the more liberal groups in Japan's political arena and eventually eliminated determined opposition to the militarists (*40*, pp. 370, 389–92).

Agricultural progress and economic growth during the 1950's.—In the years since World War II, agricultural production in Japan has increased even more rapidly than in the decades prior to 1920.[15] Two factors in addition to those dis-

[15] This section leans heavily on Professor Ohkawa's brief but admirable analysis of "significant changes in Japanese agriculture since 1945" (*36*). I am also indebted to Professor Ohkawa for the opportunity to read several chapters of a study of agriculture and economic development prepared by a group of Japanese scholars that gives considerable attention to the postwar period. This study of "Agriculture and Economic Growth," which was sponsored by the Asia Foundation and supervised by Professor Ohkawa, is to be published in English in the near future.

cussed in the preceding section have been mentioned in connection with the reduced rate of agricultural progress during the 1921–40 period. It has been suggested that the potential for technological innovations had been substantially exhausted. Secondly, it has been argued by Ohkawa and others that Japanese landlords, who in the early period played a constructive role as rural entrepreneurs promoting agricultural improvement, were mainly absentee landlords during the 1920's and 1930's with the result that the land tenure system was entirely negative in its impact on farmer incentives and productivity (*36*, pp. 1103–04). The experience of the 1950's, although relating to a brief period, seems to refute the first of the propositions and to provide support for the second.

The average annual rate of increase in the value of agricultural output was 3.9 per cent during the 1951–60 decade. The average increase in net income produced in agriculture was appreciably less (2.7 per cent for the years 1952–59) owing to the substantial rise in expenditures for agricultural inputs. It will be recalled that the ratio of the cost of inputs to the gross value of output increased only very slowly during the 1880–1940 period. But between 1951 and 1958, the ratio rose sharply from 26.2 to 35.7 per cent. Inasmuch as there was a considerable reduction in the farm population, the rate of increase in income per capita—3.2 per cent during the 1952–59 period—was appreciably higher than the increase in net income produced in agriculture.

It is hazardous to make comparisons between farm labor force statistics for the 1930's and for the postwar period. During and immediately following World War II, the farm population and labor force was swollen as a result of the exodus of population from the cities because of food shortages, air raids, disruption of industrial production, and the return of several million Japanese repatriated to the mainland from overseas. As a consequence of these factors, the farm labor force increased from 13.9 million in 1940 to a postwar peak of 16.6 million. Approximately half of the total labor force was engaged in agriculture in 1947, compared with 43 per cent in 1940. But the proportion had declined to 38 per cent by 1955, and absorption of workers from agriculture has continued at a rapid pace owing to the remarkable expansion of industrial production during the past decade.[16] Japan's national income in constant prices increased at the rapid annual rate of 9 per cent between 1950 and 1960 (*3*, p. 4).

It would appear that Lewis's two-sector model now has only limited relevance to the Japanese economy, and analysis of statistics of the agricultural and nonagricultural labor force is inadequate for an understanding of the process of economic transformation during the recent period. Among the changes that are altering the structure of the Japanese economy is a sharp increase in the participation in industrial employment by members of farm households. In 1960, approximately two-thirds of all farm households had one or more members engaged in some sort of nonfarm employment compared to 45 per cent of the total in 1947. In 1950, nonfarm income of farm families was a little less than 30 per cent of the total income of farm households, but this proportion had risen to 45

[16] According to the ambitious targets fixed by the Japanese government's ten-year plan for economic growth (1961–70) the farm labor force is expected to decline by 2.9 per cent annually and the increase of per capita farm income of the agricultural population is set at 5.8 per cent, about the same rate as is envisaged for the nonagricultural sector.

per cent by 1959 (although Ohkawa cautions that some allowance should be made for an upward bias in this comparison due to a change in survey methods). In the vicinity of major industrial centers, many farms now represent something intermediate between a farm enterprise and a suburban home. As a result of the availability of small tractors and other mechanical equipment, it is possible for many farms to be operated by a farmer's wife and children assisted by week-end labor of the family head whose main occupation and source of income is a factory job.

The reasons for the remarkably rapid increase of agricultural output during the past decade are complex, and it is impossible to single out two or three factors as being of decisive importance. Ohkawa calls attention to the following as important factors that have contributed to the increase of farm output and productivity in the postwar period: (1) technical progress along the familiar lines of greater use of fertilizers and higher-yielding varieties, continuing advance in farm practices, and a notable increase in the use of chemicals for insect and disease control; (2) changes in the combination of farm enterprises, especially the rapid expansion of livestock enterprises; (3) the postwar land reform and an increase in the incentive, readiness, and ability of Japanese farmers to introduce improved farming methods; (4) further mechanization of auxiliary operations and, for the first time, a considerable mechanization of field operations; (5) government programs for land reclamation, irrigation, and drainage; (6) a government price support program; and (7) creation of an enlarged and more effective agricultural extension organization.

Especially noteworthy among the postwar technological innovations are developments which greatly extend the range of planting dates for the all-important rice crop (*36a,* pp. 22–25, 40–44). This increased flexibility has resulted first of all from recent progress in plant breeding that has led to the introduction of early-, medium-, and late-maturing varieties suitable for various planting dates. The second line of development has been in the use of rice nurseries covered with oil paper or vinyl sheeting, sometimes even electrically heated, which permit the increasingly important "early seasonal rice cultivation"—transplanting in May and harvesting in August instead of the traditional practice of planting at the end of June or early July and harvesting in October. Moreover, the discovery of more effective pest and disease controls allows a spreading of the seasonal work load by permitting a farmer to cultivate early-, medium-, and late-maturing varieties of rice in the same area without undue concern about the outbreak and spread of rice stem borer or other pests. It has long been stressed in Japan that one advantage of the practice of transplanting rice seedlings is that it economizes on the amount of land required in the period before seedlings are transplanted—about a quarter of the total growing period. With the typical lowland paddy nursery about 1/25 as large an area was required for the seedbed as would be required later for the main field, but with one of the new upland nurseries protected by vinyl sheeting an area equal to only 1/60 of the main field is required for the seedbed. Moreover, the "early seasonal cultivation" made possible by these developments gives substantially higher yields than the usual method of cultivation.

The net result of these innovations, as Ōtsuki has stressed, is to "alleviate the limiting factors of season and space" (*36a,* p. 25). Double-cropping becomes feasible farther north than in the past, and in southwestern Japan three or four crops a year can be harvested. These techniques, combined with heavy use of chemical fertilizers together with animal manure to offset a deficiency of organic matter, make further intensification of Japan's already intensive agriculture an economic proposition. Diminishing returns do not come into play until an even higher level of inputs and output has been reached.

Another noteworthy line of technological development relates to livestock production based on intensively cultivated and high-yielding fodder crops such as sweet potatoes (tubers and leaves) and ladino clover, the latter being a postwar introduction that does well in Japan's hot and humid climate. In former years, when a livestock industry was conceived of as relying chiefly on grass and red and white clovers that do not thrive with high temperatures and strong sunlight, Japan appeared to be poorly endowed for livestock production because of her physical environment as well as a high density of population which made extensive farm enterprises inappropriate. It is now considered, however, that through intensive year-around production of fodder crops Japan can become an efficient producer of livestock products. Ladino clover and sweet potatoes grown with heavy applications of manure, and chemical fertilizers yield on the order of 250 tons of green matter per hectare; and the planting of such crops for feeding animals appears to offer one of the most promising possibilities for utilizing agricultural land made available as a result of the more intensive multiple-cropping permitted by the recent advances in rice cultivation mentioned above (*36a,* pp. 32–37, 50–57). The potential for increased farm output opened up by these postwar technological innovations is only beginning to be tapped, but the marked increases in crop yields and production already achieved would seem to refute the notion that the potential for technological innovations had been exhausted prior to World War II.

Expansion of livestock production has been impressive although it must be emphasized that it started from an extremely low base. The number of milch cows has increased approximately eightfold, from a prewar level of less than 100,000 to 750,000 in 1960 (*36,* p. 1105). There is clear evidence that Japanese diet patterns are, for the first time, undergoing substantial modification. Average annual consumption of rice among urban families has declined from an estimated 150 kilograms prewar to a level of about 110 kilograms. This has been most directly associated with a marked increase in wheat consumption—up 2.5 times over prewar—but it has also been accompanied by noteworthy increases in some of the high-value nonstaple foods. Consumption of milk and dairy products by urban consumers has increased fivefold and meat intake has doubled (*36a,* pp. 17–18). The expansion of Japan's livestock enterprises started from such a low level, however, that even in 1960 they accounted for only 14 per cent of total farm income. But this trend is expected to continue at a rapid pace, and the current plan for economic growth anticipates that livestock products will account for some 30 per cent of the value of agricultural output in 1970 (*36,* p. 1107).

Ohkawa seems to attach particular importance to the land reform program

and the accompanying democratization of village life and social emancipation of Japanese farmers as a factor contributing to the postwar expansion of agricultural output. Prior to the land reform, high rents levied as a proportion of crop output reduced the incentive to increase production and left the farmer with meager financial resources for carrying out agricultural improvements. As a consequence of the land reform, rented land declined from about 50 per cent to less than 10 per cent of the total cultivated area. The hyper-inflation of the immediate postwar period drastically reduced the real burden of the payments farmers were obliged to make for the newly acquired land, so Japan's agriculture has been characterized in recent years by a new owner-cultivator system with a very light debt burden. Ohkawa believes that these changes have not only strengthened the incentive to increase output, but in addition have created a mentality more receptive to innovations and have left farmers with sufficient cash income to substantially increase their use of purchased inputs. Moreover, during the postwar period of food shortage and inflation the terms of trade turned in favor of agricultural producers with the result that many farmers had the financial resources and added incentive for investment in new plantings of fruit trees and in acquiring livestock.

Another factor representing a new departure in Japanese agriculture has also been of considerable importance. It was noted above that there was considerable increase in the use of electric motors and internal combustion engines for auxiliary operations in Japanese agriculture in the decades prior to 1940, but that field operations continued to depend almost exclusively on animal draft power and human labor. In the postwar period there has been further expansion of the use of mechanical power for auxiliary operations, the percentage of farm households using electric motors or internal combustion engines increasing from 58 per cent in 1950 to 88 per cent in 1960. Much more striking, however, has been the increased use of mechanical equipment for field operations. By 1960, just over a third of all farms were using mechanical draft power, their own or hired, and there were half a million small tractors or cultivators in use. This represented an eightfold increase between 1950 and 1960, and over the same period there was a sixfold increase in the use of motor-sprayers, which numbered 400,000 in 1960 (*36*, p. 1105). It is of interest that one of the considerations that seems to influence decisions to purchase the garden-type tractors that have spread so rapidly is a desire to lessen the drudgery of farm work in order to retain young people in farming. (The reduction of the farm labor force in recent years has been concentrated in the younger age brackets.) Ōtsuki stresses particularly "the emancipation of female labour from hard field work," in part because it is difficult for farmers today "to find suitable girls to marry to their sons who will inherit their farms" (*36a*, p. 63).

The unprecedented expansion in farm output during the past decade was associated with a rapid growth of demand for agricultural products which was sufficient to absorb the additional production. The shift away from overwhelming dependence on starchy staple foods in the direction of increasing reliance on livestock products and other more expensive foods was, of course, one factor contributing to enlarged demand for the output of Japanese agriculture. The

growth of population from 69 million in 1935 to the current level of 94 million would have accounted for a 36 per cent increase in demand even without the rise in per capita food expenditures that has occurred. The enlarged demand of the postwar period has been satisfied mainly by the expansion of domestic production. Wheat imports exceeded 2.6 million tons in 1960 and 1961, a great increase compared to the 1930's, when a policy of self-sufficiency in wheat held imports to a very low level (*18*, p. 61). But the sharp rise in wheat imports is nearly offset by the reduction in rice imports from a level of about two million tons annually in the mid-1930's to less than 200,000 tons in 1960 and only 126,000 in 1961. It is in imports of feed grains that Japan has shown a major increase; maize imports have risen from less than 100,000 tons annually during the years 1948–52 to 1.4 and 1.8 million tons in 1960 and 1961 respectively.

IV. AGRICULTURAL DEVELOPMENT IN TAIWAN (1901–40) AND IN DENMARK (1880–1940)

A rapid increase in farm output and productivity was a common characteristic of the agricultural sectors in Taiwan and Denmark during the decades under review. In both countries a large part of the increased output was destined for export so that the rate of expansion of production was not limited by the growth of domestic demand. The Taiwanese experience is interesting as an example of the Japanese approach to agricultural development applied in a different setting, whereas the Danish example was chosen because of the important contrasts it offers.

Taiwan, the Japanese pattern repeated.—Between 1895 and the turn of the century, Japan's control of Taiwan was consolidated to a point that made it feasible to launch a program to develop the agricultural potential of the island and to maintain tolerable statistical records for the major crops.[17] A comprehensive Land Survey was carried out between 1898 and 1905; and the census enumerations of Taiwan in 1905 and 1915, which were completed before Japan's first enumerative census in 1920, maintained high standards (*4*, p. 10).

Three crops—rice, sweet potatoes, and sugar—are of overwhelming importance in Taiwan. Sugar production was unimportant during the initial decade, accounting for only about 90,000 tons of the output of the three crops which totaled over 800,000 tons. In the final decade, sugar production exceeded a million tons, the rice crop averaged 1.3 million tons, and production of sweet potatoes was a little above 400,000 tons, all figures in brown rice (calorie) equivalent. As of 1939, rice claimed 57 per cent and the other crops 10 and 12 per cent of the total planted area. Rice and sugar accounted for 50 and 22 per cent respectively of the total value of agricultural output; livestock products represented only 11 per cent of the total (*46*, p. 16; *15*, p. 34; *4*, p. 34). It is, therefore, possible to obtain a fairly satisfactory picture of the changes in agricultural output and productivity by focusing on these three crops. A summary picture of the increase in area, yield, and production of these crops is presented in Table 7. The crop

[17] I have used primarily the compilation published in *46* prepared under the direction of Clark C. Milligan who also supervised a valuable compilation of Japanese agricultural statistics for the period 1878–1946 (*31*).

TABLE 7.—TAIWAN: INDEX NUMBERS OF TOTAL AREA, YIELD, AND PRODUCTION (IN CALORIE EQUIVALENT) OF THREE MAJOR CROPS, TEN-YEAR AVERAGES, 1901–40*

Period	Index Numbers (1901–10 = 100)			Annual percentage rate of increase (compound) from preceding period		
	Area	Yield	Production	Area	Yield	Production
1901–10	100	100	100	...	...	...
1911–20	126	111	140	2.36	1.02	3.40
1921–30	143	146	209	1.25	2.81	4.09
1931–40	166	197	327	1.52	3.02	4.60

* Based on data in Chinese-American Joint Commission on Rural Reconstruction, *Taiwan Agricultural Statistics 1901–1955*, pp. 6, 20, 32, 44.

estimates indicate that during the span of 30 years (comparing the midpoints of the first and final decades) output increased more than threefold, a rate of growth considerably more impressive than Japan achieved between the 1880's and the decade 1911–20.

More rapid increase of farm output in Taiwan was mainly due to the much larger expansion of crop area. The true increase in Taiwan's crop area (and output), however, was considerably less than is shown by the statistical record, since it seems certain that for the years prior to 1905 the area planted to rice and sweet potatoes was under-reported by a substantial margin. It is, therefore, advisable to examine the changes in total "arable" or "cultivated" area, and in the fraction thereof classed as paddy land, using 1906–10 as a base. Comparable figures for Japan show changes between 1881–90 and 1911–20 (*46*, p. 11; *31*, p. 95):

Taiwan			Japan		
Period	Total cultivated area	Paddy area	Period	Total cultivated area	Paddy area
1906–10.....	100	100	1881–90.....	100	100
1931–40.....	128	150	1911–20.....	126	111

This comparison suggests that the changes in total cultivated area were modest and of about the same magnitude in the two countries but that the area of paddy land increased much more in Taiwan. This seems reasonable.

Compared with Japan of the 1880's, Taiwan's agriculture was relatively undeveloped at the turn of the century, allowing more scope for land improvement. Moreover, the incentive to enlarge the paddy area was strong because climatic conditions in Taiwan permit the growing of two rice crops in a season if water control is adequate. Both Taiwan and Japan are characterized by highly intensive utilization of available arable land. As a result of widespread multiple-cropping, the area planted in a year averages about 30 per cent larger than the total "arable" or "cultivated" area in both countries. In Japan, multiple-cropping is nearly as important on upland as on paddy fields. Prior to the revolutionary developments since World War II, it was only in limited areas of the southern islands that a second crop of rice figured in the succession of crops grown. But in Taiwan most of the multiple-cropping is on paddy land and double-cropping of rice is common.

In 1926, for example, the area *planted* to rice was 40 per cent larger than the cultivated area classed as paddy and, counting all crops grown on paddy land, the "annual frequency of utilization" was 184 per cent (*28,* p. 236).

In Japan, the fraction of the total cultivated area classed as paddy appears to have declined from not quite 60 per cent of the cultivated area in the 1880's to about 50 per cent in the decade 1911–20. An exactly opposite change took place in Taiwan, the paddy area rising from 50 per cent of the total in the initial decade to close to 60 per cent during the 1930's. There, the expansion of the paddy area was accompanied by a still more rapid extension of irrigation and drainage facilities. In earlier years a considerable part of the paddy area represented level land provided with dikes but with no source of water other than direct rainfall. It would appear that by 1940 virtually all of the paddy area was provided with water storage and irrigation ditches, so that there was a measure of control over the water supply for growing crops (*4,* pp. 40–41).

The extension of irrigation facilities was a major objective of Japan's development policy. Large-scale irrigation projects were undertaken directly by the Government-General, the largest being the Chianan Irrigation Area in Tainan which served 150,000 hectares—more than a quarter of the total paddy area. Still more impressive was the construction of numerous small-scale irrigation works maintained by local water utilization associations. These were fostered and controlled by the government and generally received public funds to cover more than half of the costs of construction (*11,* pp. 6, 30).

Expansion of irrigation in Taiwan was important for sugar cane as well as for rice; and throughout the period under review there was considerable competition between the two crops for land and water. Taiwan's tropical climate made it the one region of the Japanese Empire suited for cane production, and it became the principal source of sugar for Japan proper. Official Japanese policy favored sugar until incipient rice shortages on the eve of World War II prompted a reversal. In the competition between these two major crops, the scales were weighted in favor of sugar by various devices. In the Chianan area irrigation water was rationed in such manner as to oblige farmers to include sugar cane in their rotation, and more generally sugar was favored by a tax policy which assessed cane fields at the lower rate applicable to upland whether they were irrigated or not (*11,* p. 34; *4,* p. 30).

There was tremendous expansion in the area devoted to sugar cane—nearly a fourfold increase according to the ten-year averages for 1901–10 and 1931–40 shown in Table 8 and better than a threefold increase if 1906–10 is taken as a basis for comparison. The yield of sugar per hectare of cane tripled between 1901–10 and 1931–40, and there was close to a twelvefold expansion of output. By 1929 Taiwan's sugar exports reached 750,000 tons and provided nearly all of Japan's sugar supplies.

Taiwan's production of sugar in 1905, which amounted to less than 50 thousand tons, was produced almost entirely in small, primitive mills. Investment in sugar processing facilities was stimulated by subsidies and the attraction of a large, protected market in Japan. By 1915 sugar production exceeded 200 thousand tons, and by far the greater part of it was produced in modern mills. It is

TABLE 8.—TAIWAN: INDEX NUMBERS OF AREA, YIELD, AND PRODUCTION (IN CALORIE EQUIVALENT) OF RICE, SWEET POTATOES, AND SUGAR, 1901–1940*
(1901–10 = 100)

	Rice			Sweet Potatoes			Sugar		
Period	Area	Yield	Production	Area	Yield	Production	Area	Yield	Production
1901–10	100[a]	100	100	100[a]	100	100	100	100	100
1911–20	112	104	117	124	103	128	323	95	306
1921–30	128	120	154	137	134	183	371	164	608
1931–40	152[a]	145	220	149[a]	168	251	387	298	1155

* Based on data in Chinese-American Joint Commission on Rural Reconstruction, *Taiwan Agricultural Statistics 1901–1955*, pp. 6, 20, 32, 44.

[a] There is reason to suspect substantial under-reporting of the rice and sweet potato area prior to 1905. If the years 1906–10 are used as a base, the 1931–40 index number for planted area is 140 for rice and 128 for sweet potatoes.

reported that in 1937 six large Japanese corporations accounted for 95 per cent of the million tons of sugar produced in that year (*13*, p. 98). Although the processing of sugar thus became a large-scale industry, the production of cane was predominantly in the hands of small-scale farmers.

For rice and sweet potatoes the expansion of crop area, yield, and output was much less than for sugar. The area planted to rice in Taiwan increased considerably more between 1901–10 and 1931–40 than the rise in Japan's rice area increased between the 1880's and 1911–20, even allowing for the upward bias in the area comparisons in Table 8. The 45 per cent increase of yield of rice in Taiwan over the 30-year period was slightly larger than the increase in rice yield in Japan between 1881–90 and 1911–20. For sweet potatoes, the percentage increase in area, yield, and output was much the same in the two countries; it is probable that the available statistics exaggerate the increase in area in both countries.

In Taiwan, as in Japan, the increase of crop yields was mainly the result of varietal improvement and increased use of fertilizers. The exceptionally large increases in sugar yields resulted from the fact that Taiwan was able to take advantage of the spectacular achievements in cane breeding which took place in the decades following 1887–88 when it was discovered almost simultaneously in Java and Barbados that sugar cane yields viable seeds. Particularly notable were the POJ varieties developed in Java after 1910 on the heels of the highly successful crossing of "noble" cultivated canes with a semi-wild cane. It is reported that 99 per cent of the cane acreage in Taiwan was being planted to POJ varieties as early as 1930 (*51*, pp. 127–29).

Varietal improvement of rice in Taiwan faced special problems. Native varieties in the island were of the long-grained *indica* type of rice, whereas Japanese consumers have a marked preference for the shorter and rounder *japonica* varieties that are softer and moister after cooking. There are significant differences between these two types of rice with respect to their yield and climatic requirements. The higher-yielding *japonica* varieties are normally grown in warm temperate regions characterized by lower temperatures, longer summer days, and

more sunlight than the tropical and subtropical regions where the *indica* varieties are grown.

The early efforts at varietal improvement in Taiwan emphasized pure line selection of native varieties characterized by high yields. Prior to 1906 more than a thousand varieties were being grown, but at that time the government restricted the number permitted to be grown to 375; moreover, no more than three varieties could be grown in any one locality. It is reported that this substitution of inferior native with superior native varieties raised yields by 10 to 30 per cent, although the increase of yield indicated by the over-all crop statistics was small until 1920 (*27,* p. 76).

Prior to 1912 the efforts to introduce Japanese varieties were a failure. In that year, Dr. Iso, Director of the Government-General's Agricultural Research Institute, began his notable work on this problem. He found that by reducing the sojourn of rice seedlings in the seedbeds from 40–60 days to only 20–30 days the Japanese varieties could be grown successfully; with the previous methods they matured too early with very poor yield. Subsequent efforts were directed at producing superior hybrids, incorporating characteristics of the native varieties to eliminate defects of Japanese varieties grown under Taiwan conditions (*27,* pp. 78–80). These improved varieties (referred to as *Horai* in Japanese or *Ponlai* in Chinese) have a high yielding capacity but are very sensitive to soil fertility and moisture conditions; "good farming techniques are required," Kung observes, "to grow the Ponlai variety" (*23,* p. 9). The *Ponlai* varieties were grown only on an experimental basis prior to 1922 when 400 hectares were planted. A decade later close to 200,000 hectares were planted to *Ponlai* varieties, about a third of the total rice area. In 1940 some 325,000 hectares—half of the total rice area—were planted to *Ponlai* (*46,* p. 22).

Introduction of the *Ponlai* varieties was a key factor in facilitating rice exports to Japan. Prior to 1923 exports to Japan were fairly small; they reached a level of close to 150,000 tons in 1908 and continued to fluctuate about that level until the period of rapid expansion. Between 1923 and 1938 Taiwan's rice shipments to Japan rose steadily from 170,000 to almost 750,000 tons (*18,* pp. 56 and 264). Even with the introduction of the *Ponlai* varieties, however, Taiwanese rice sold at a considerable discount on the Japanese market (*28,* pp. 251–52).

Increased use of fertilizers made a crucial contribution to raising crop yields in Taiwan. Considerable attention was given to promoting the increased use of composts and other farm-supplied manures, but no data are at hand concerning their quantitative importance. Imports of commercial fertilizer rose rapidly from negligible levels during the first decade of the century. The value exceeded 3 million Taiwan dollars for the first time in 1915, and then fluctuated between 3 and 8 million Taiwan dollars until the early 1930's and then rose abruptly (*48,* p. 957). Taiwan's capacity for producing chemical fertilizers amounted to less than 30,000 tons in 1938, so imports were nearly equal to consumption.

I am unable to say whether the expansion of fertilizer use in Taiwan—in total or of commercial fertilizers only—was more or less rapid than in Japan. Taiwan's estimated consumption in 1935 and 1938 was equivalent to 0.5 and 0.6 of a metric ton per hectare (*15,* p. 38). These are presumably product weight figures so they can be compared only roughly with the estimated consumption

of chemical fertilizers in Japan, expressed in fertilizer equivalents, which rose from 0.4 ton per hectare in 1926, to 0.6 ton in 1935 and 0.7 ton in 1938 (*29*, p. 50). It would appear that by the 1930's Taiwan's use of commercial fertilizers was not much below the Japanese level, but that the expansion in Taiwan was heavily concentrated in the last decade of the 1901–40 period.

Various improvements in farming techniques also contributed to higher yields in Taiwan; and it is quite possible that the changes were more marked than during the 1881–1920 period in Japan. For example, it is reported that before the Japanese occupation rice was planted by broadcasting, whereas under Japanese influence it came to be almost entirely transplanted (*27*, p. 54).

Various changes in the general economic and social environment contributed to the success of the measures pursued to enlarge agricultural output in Taiwan. Especially noteworthy was the establishment of domestic peace and effective political administration in a region which had been marked by turbulence and an unstable if not incompetent government. The substitution of a well-defined land tenure system for the complex and uncertain regime which had prevailed was also significant. Overhead investment in transportation and port facilities was a necessary condition for the expansion of production and exports of rice and sugar.

The spread of rural education in Taiwan was rapid but started from a very small base and was largely confined to primary schooling. In 1901 there were only 18,000 students in primary schools and another 28,000 in private tutorial schools devoted mainly to Chinese studies. By 1920 enrollment in primary schools had reached 175,000, and the number in the tutorial schools had fallen to 10,000. As of 1940 there were close to 700,000 students in primary schools and 20,000 in high schools, this latter figure representing a tenfold increase over 1920. Thus by the end of the period being reviewed, a large percentage of the population of school age was receiving a few years of schooling; but even in 1940 only a tiny fraction was in high schools or vocational schools (*48*, pp. 1212–13 and *4*, pp. 50 and 68n).

It is therefore not surprising that virtually all of the agricultural scientists and administrators in the island were Japanese. This was a "technical assistance" program on a large scale. Taiwan was Japan's first colonial enterprise, and the specialists sent there appear to have been of high calibre and many of them accepted their work in Taiwan as a challenging lifetime career. A crucial component of Taiwan's agricultural development during these decades was the vigorous and competent activity by Japanese scientists and administrators engaged in agricultural research, in promoting the development of irrigation facilities, and in encouraging the adoption of improved farm practices. Barclay remarks that in the field of public health the Japanese program "relied on administrative efficiency and energy in execution to make up for what it lacked in elegance and equipment," which is also an excellent characterization of their agricultural program. With respect to the latter, he emphasizes that the achievement by the Japanese of their economic goals in Taiwan depended heavily on "their ingenuity in finding cheap ways to aid its agriculture" (*4*, pp. 171 and 256).

It is a debatable question whether a colonial authority faces a more or less difficult problem than a national regime in securing widespread adoption of

improved agricultural techniques. Japanese rule in Taiwan was certainly not notably solicitous of the rights and interests of the local population, and antagonism toward an alien authority might have been expected to impair the effectiveness of measures adopted to develop Taiwan's agricultural economy. The particular technique of "indirect rule" known as *pao-chia* (or hō-kō in Japanese) that was applied in Taiwan appears to have contributed a good deal to the success of efforts to develop agriculture. After the failure of early efforts to rule the countryside directly, the Japanese issued the so-called *pao-chia* regulations in 1898 which were

> rules of conduct imposed on inhabitants of villages and smaller towns, under the threat of punitive action against the whole community. Virtually all Taiwanese outside the Aborigine Territory (with special provisions applying to certain cities) were assigned to household groups (*chia*), which were in turn grouped into village units (*pao*) for supervision. Responsibility for law observance and public order was allotted jointly among the households of each village. Positions of authority, carrying explicitly defined duties, were conferred on heads of prominent (i.e., wealthy and influential) families (*4*, p. 50).

A wide range of specific responsibilities was imposed on each *chia*. Most pertinent to Taiwan's agricultural development were the obligations to mobilize labor for road-building and irrigation projects and to disseminate information concerning improved farming methods and instructions for maintenance of land improvements. The head of each *chia* was responsible for the fulfillment of these obligations. This use of the structure of *pao* and *chia* enabled the Japanese "to apply sanctions against wrongdoing more selectively and less frequently. Penalties fell on those persons in positions to exercise a deterrent influence on others" (*4*, p. 51). So effective was this device that the *chia* regulations were maintained in force throughout the period of Japan's rule. It must have been particularly useful in fostering the labor-intensive construction of irrigation facilities, a conspicuous feature of Taiwan's agricultural development. Moreover, it would appear to have been well adapted to the task of securing the adoption of new agricultural practices among a rural population that was predominantly illiterate.

It remains to take note of the changes in the farm labor force. Unlike Japan, Taiwan witnessed considerable growth in its agricultural labor force. The estimates of the population gainfully employed in agriculture are somewhat puzzling because of the abrupt changes in the rate of participation of women in the farm labor force as indicated by successive census returns. This accounts for the divergence in the increase of total agricultural labor force and the male labor force as shown by the index numbers below (*48*, pp. 130-31 and *47*, p. 60):

Year	Total agricultural labor force	Male workers in agriculture
1905	100	100
1915	117	106
1920	115	104
1930	122	120
1940	141	126

Clearly, the increase in labor productivity in Taiwan was considerably less than the expansion of total output. Using the crop estimates considered above and the same type of rough measure of labor productivity as was used for Japan, it would appear that farm labor productivity in Taiwan increased by something like 2.3 to 2.6 times depending upon whether one adjusts according to the indicated increase in total or male labor force in agriculture.

Denmark, development of an agricultural exporting economy.—The development of Danish agriculture during the period 1880–1940 took place under circumstances that differed greatly from those that prevailed in Japan and Taiwan. Unlike the situation in the latter countries, the rural labor force was not excessively large relative to available supplies of capital and resources; the representative farm had something like 25 hectares of arable land compared with a mere 1.1 hectares in Japan and about 1.8 hectares in Taiwan. The hiring of labor and investment of capital in agriculture were of considerable importance throughout this period. Nor was the farm labor force large relative to the "required" increase in farm output since the market for agricultural output was not restricted to the growth of domestic demand. Denmark enjoyed easy access to the large and expanding markets for livestock and dairy products in Germany and, more so, in the United Kingdom; during the 1930's the value of agricultural exports ranged between 55 and 68 per cent of the Gross Domestic Product in Agriculture (*7a,* p. 73). In short, the agricultural sector in 1880 was already an integral part of the "capitalist sector," and Lewis's two-sector model is not applicable in the case of Denmark.

Although the commercial orientation of Danish agriculture was well established by 1880, the following decades constituted a period of rapid change—most notably in the shift to a more intensive agriculture producing a new and more valuable combination of products. Likewise, there were major changes in the nature and quantities of inputs used, and many activities were transferred from the farm household to specialized processing units.

A simple index of physical output such as was used for Japan and Taiwan is not applicable to Denmark. The changes in total agricultural output are summarized in Table 9 (Col. 3) on the basis of estimates of net domestic product originating in agriculture. It appears that over the half century between 1885 and 1935, net agricultural output increased approximately threefold. Comparison of annual rates of growth in various decades is complicated by the sharp curtailment in agricultural output during the first World War, but with that exception it appears that the rate of increase was at a high level throughout the period, reaching a peak of 3 per cent per annum in the rise from the level of the 1920's to that of the 1930's.

It is possible to indicate in a very general way some of the changes in output and inputs that generated the changes in aggregate farm income. One of the most illuminating chapters of Einar Jensen's valuable study of Danish agriculture analyzes the changes in farm enterprises and inputs on a hypothetical "representative farm." In constructing the accounts for this representative farm he was guided by aggregate data on farm output, inputs, and prices supplemented by farm records, intimate knowledge of the development of Danish agriculture, and

TABLE 9.—DENMARK: INDEX NUMBERS OF CEREAL AND ROOT CROP PRODUCTION AND NET INCOME PRODUCED BY AGRICULTURE, TEN-YEAR AVERAGES, 1881–1940*

Period	Production of cereals[a] (1)	Production of root crops[a] (2)	Net domestic (real) product agriculture[b] (3)	Annual (compound) rate of increase net product from preceding decade (per cent) (4)
1881–1890	100	100	100	—
1891–1900	109	217	116	1.5
1901–1910	118	517	148	2.5
1911–1914	120	713	176	1.8[c]
1911–1920	116	729	157	—
1921–1930	162	1,038	217	2.1[c]
1931–1940	190	1,321	295	3.1[c]

* Data for cols. (1) and (2): 1881–1927 from Einar Jensen, *Danish Agriculture, Its Economic Development* (Copenhagen, 1937), p. 392a; data 1928–36 from issues of Denmark, Statistiske Department, *Statistiske Meddelelser,* and data for 1937–40 from *Statistisk Aarbog*; for col. (3) from Kjeld Bjerke, "The National Product of Denmark 1870–1952," *Income and Wealth Series V* (International Association for Research in Income and Wealth, London, 1955), p. 147.

[a] Based on production estimates expressed in crop units of equivalent feed value.

[b] Based on estimates expressed in 1929 kroner.

[c] Using 1911–14 as if it were 1911–20 average for calculating per cent increase.

production statistics for the island of Sjaelland where he places his hypothetical middle-sized farm of 28 hectares. He believes that the changes traced on this farm are "representative of what is found in the whole east-Danish loam section, and in principle, but not in degree, of what has taken place in the rest of the country" (*16,* p. 256). His results are reproduced in abbreviated form for three years only in Table 10.

In 1881, receipts from the sale of cereals were still about as important as proceeds from livestock products, but 20 years later the sale of cereals provided less than 15 per cent of the total, whereas butter and pork accounted for 65 per cent of the farm receipts compared with just over 30 per cent two decades earlier. This trend continued, and in 1929 these two products provided about 70 per cent of the receipts of the representative farm. Butter and pork production were highly complementary enterprises for Danish farmers because skim milk finds a profitable use as the main protein feed for raising hogs.

A tendency for livestock prices to rise relative to cereal prices appears to have provided the initial impulse to the increasing emphasis on livestock. This shift also offered the advantage of making it possible to intensify farming and increase incomes on the middle-sized farms of 15 to 60 hectares that occupied well over half of the country's agricultural land. Increasing awareness of the declining trend of soil fertility also contributed to the readiness to emphasize livestock production (*16,* pp. 133, 263). Expansion of butter and pork production was also aided by certain technological and organizational innovations to be mentioned shortly.

It will be seen from Column 1 of Table 9 that the production of grain crops nearly doubled between the 1880's and the 1930's, but with the expansion of the

TABLE 10.—DENMARK: APPROXIMATE CHANGES IN STRUCTURE OF FARM RECEIPTS AND CASH OUTLAYS OF A REPRESENTATIVE FARM, 1881, 1901, AND 1929*

	1881		1901		1929	
	Kroner	Per cent	Kroner	Per cent	Kroner	Per cent
Receipts						
Cereals	1,509	39	645	13	2,206	13
Butter	761	20	2,101	41	6,161	35
Beef	383	10	551	11	1,372	8
Pork	448	12	1,199	23	5,852	34
Eggs	...	...	115	2	945	5
Sub-total: butter, beef, pork, eggs	(1,592)	(42)	(3,966)	(78)	(14,330)	(82)
Total (including items not listed)	3,781	100	5,112	100	17,400	100
Cash Outlays						
Hired labor	615	27	836	23	3,425	28
Concentrates	108	5	335	9	2,365	20
Grain	120	5	176	5	1,712	14
Fertilizer	12	0.5	38	1	700	6
Machinery repairs	100	4	200	6	500	4
Land taxes	270	12	320	9	700	6
Mortgage interest	950	41	1,250	35	1,250	10
Total (including items not listed)	2,310	100	3,620	100	12,042	100

* Data from Einar Jensen, *Danish Agriculture: Its Economic Development* (Copenhagen, 1937), p. 262.

livestock enterprises their role shifted from providing the major source of cash income to that of raw material. By far the greatest part of the grain produced on the representative farm was fed to livestock. The fairly small quantities sold were more than counter-balanced by purchases of cheaper feedgrains and oilcake that were being imported in increasing quantity. A major change in the farming system is evident in the huge expansion of root crops. As a result of a thirteen-fold expansion, the production of root crops during the final decade was equal in feed value to the output of cereals.

This rapid increase in fodder roots—chiefly mangels and swedes—was another aspect of the intensification of Danish agriculture. By 1928 the area devoted to root crops exceeded half a million hectares compared with only about 65,000 hectares in 1881. To a large extent the expansion was superimposed on the antecedent farming system by suppression of the fallow which claimed some 260,000 hectares in 1881 and less than 75,000 in 1928. A decline also occurred in the rotation area occupied by pasture and hay so that the total area of arable land increased only from about 2.4 to 2.8 million hectares between 1881 and 1928

despite the huge expansion of root crops and a small rise in the cereal area (*16*, pp. 236–38, 389).

Technological advance on many fronts was a highly significant factor in the gains in agricultural productivity in Denmark. The great expansion of fodder roots was feasible only because better cultivation practices made it possible to eradicate weeds while the land was occupied by root crops and thus eliminate the fallow which had been the weapon of last resort in controlling troublesome weeds (*16*, p. 236). More generally, plant breeding, increased use of commercial fertilizers and animal manure, and improved cultural practices led to substantial increases in crop yields. Higher levels of soil fertility were needed not only to raise crop yields but to counter a tendency of yields to decline as a result of the heavier demands on soil reserves which accompanied expanded grain production and exports beginning in about 1750. Particularly in the decades after 1850, the extension of clay pipe drainage and widespread liming led to heavier cereal crops since these practices made the nutrients present in the soil more readily available. Drawing on the soil's reserves of plant nutrients in this way gave rise to serious concern for future yields, but by and large that consequence was forestalled by heavier application of commercial fertilizers and manures. The increased application of manure as a result of growth in the livestock population and better feeding was even more important than enlarged use of commercial fertilizers. It has been estimated that nearly four times as much nitrogen, twice as much phosphoric acid, and three times as much potassium was applied to the land in the form of manure in 1924 as in 1871 (*16*, pp. 160–64). The representative farm analyzed by Jensen used only 200 kilograms of commercial fertilizer in 1881 and was still using only 400 kilograms in 1901, but by 1929 the figure had risen to 6,000 kilograms.

Technological advance also contributed a great deal to the growth of output and productivity in the livestock enterprises. Scientific breeding and heavier and more scientific feeding of livestock led to large increases in the efficiency of converting feed into livestock products. Between 1881 and 1920 butter production increased nearly five times, whereas the number of cows did not quite double. Thus the rise in milk yield per cow, together with an increase in butterfat content, was a more important factor than the expansion of dairy herds.

To a much greater extent than in Japan and Taiwan, agricultural progress in Denmark was tied to developments off the farm. One technological innovation in particular was of decisive importance. The development of an improved cream separator in 1878 greatly facilitated the expansion of the dairy enterprise on Denmark's medium and small farms. Prior to the introduction of these new separators, the production of quality butter was restricted to large farms or manors with the substantial investment in elaborate facilities needed to turn out a quality product by the old methods.

A major institutional innovation—the establishment of co-operative creameries—was also of crucial importance since it enabled thousands of medium- and small-sized farmers to profit from the economies of scale that characterize buttermaking. The first co-operative creamery was started in 1882, and by 1890 approximately 600 were in operation. An immediate consequence was a shift from

the sale of low-grade farm butter to high-quality creamery butter, which meant a considerable improvement in the prices that farmers received. Production efficiency in the co-operative creameries was steadily increased as various types of auxiliary machinery were introduced — mechanical churners, pasteurizers, heaters, coolers, and automatic scales being especially important additions (*16,* pp. 174–78, 264).

In similar fashion, co-operative packing plants facilitated the expansion of pork production. The first of these was launched in 1887, but their number increased more slowly than the co-operative creameries. The co-operative packing plants had difficulty in raising capital for the large fixed plant required for efficient operation, and they also encountered opposition and competition from existing packing plants. Nevertheless, by 1928 there were 48 of them processing about 85 per cent of the pack of "bacon"—i.e., pork that is lightly cured and exported as whole carcass sides (*16,* pp. 332–37).

A number of the major changes in Danish agriculture, notably the enlarged production of livestock products and the expansion of root crops, substantially increased farm labor requirements. But the increased use of horses and more efficient farm machinery, the transfer of on-farm activities to specialized economic units, and a more even seasonal distribution of the work load made possible a threefold expansion of net farm output with only a slight increase in the labor force. Estimates of changes in the farm labor force point to a slow rise to a peak in 1925 followed by gradual decline:

Year	Farm labor force (1,000 persons)	Index numbers
1880	510	100
1925	630	124
1940	584	114

Using the crude measure that was used for Japan and Taiwan, it appears that labor productivity in Danish agriculture in the 1930's was a little over 2½ times its level in the 1880's. In view of the importance of labor-saving devices and the availability of capital with which to purchase them, it seems somewhat surprising that the increase in farm labor productivity in Denmark was apparently no larger than in Japan. Among the various types of labor-saving machinery introduced, the binder seems to have been especially important; one man with three horses and a binder could accomplish the work of 10 to 14 men harvesting by hand methods (*16,* p. 170). Mowers, reapers, and threshing machines also significantly reduced farm labor requirements, and toward the end of the period under discussion tractors began to assume some importance. The incentive to introduce labor-saving equipment was strong since agricultural wages rose substantially; Jensen's estimates indicate a cash wage of 170 kroner for a farm worker in 1881 compared with 650 kroner in 1929. Moreover, capital was readily available and interest rates in rural areas were remarkably low. Co-operative credit societies, which began as early as 1851, were able to obtain funds at between 4 and 4½ per cent during most of the 1881–1940 period (*16,* pp. 138, 406, 408). Most of the labor-saving innovations at the farm level seem to have related to crop production. Production of root crops, however, did not afford as much

scope for labor-saving equipment as the cereal crops and remained a rather labor-intensive enterprise. There is also reason to believe that the possibilities for economizing on labor were more limited in the increasingly important livestock enterprises—except for those processes that became a part of the manufacturing sector.

What were the principal factors that contributed to the successful introduction of this wide range of technological and organizational innovations in Denmark? Many of the agricultural changes and reforms that created an environment conducive to agricultural progress occurred long before 1880. For example, Jensen describes the abolition of peasant bondage in 1788 as "the turning point in the agricultural economy of Denmark" (*16,* p. 92). Universal public education became the law of the land in 1814, although many years elapsed before elementary education attained a satisfactory standard. The initiation of the Folk High School movement in 1844 and its rapid extension during the 1860's and 1870's appear to have been particularly influential in creating the social and intellectual climate that facilitated agricultural progress.[18] In particular, it seems evident that the co-operative movement could not have achieved its great success without widespread literacy and the leadership provided by graduates of the Folk High Schools. An ability to co-operate and relatively easy relations and good communication between large landowners, farmers, smallholders and urban interests were obviously crucial to the success of the co-operatives. Kindleberger has stressed the importance of the social mobility and cohesion that existed (*22,* p. 45). He also concurs in the common view that the prevalence of freehold was favorable to the co-operative movement, quoting with approval Haggard's dictum: "Tenant farmers will not co-operate because, co-operative accounts being open to inspection, they fear their landlords might raise the rents if it were found that they are prospering" (*22,* p. 45). The stable and predominantly freehold tenure that prevailed also maximized the incentive to invest and to improve holdings.

The quality of the "human factor" and the existence of a literate, reasonably homogeneous rural population with the ability and willingness to co-operate loom particularly large because the government's role in promoting agricultural improvement in Denmark was much more passive than in Japan or Taiwan. Jensen may go too far in asserting that "the state has not done much for the technical and economic development of agriculture" (*16,* p. 178). But the contrast with the active role of government in inducing agricultural development in Japan and Taiwan stands out clearly. The most important work on plant breeding in Denmark has been carried out by private firms and the Farmers' Co-operative Seed Supply. Even the government laboratory for seed testing was started privately and later taken over and expanded by the state.

Since early in the nineteenth century, the Royal Agricultural Society had sought to promote agricultural progress (*43,* p. 87). It encouraged the planting of hedges and extension of drainage, awarded prizes to pioneering clergymen

[18] Skrubbeltrang (*43,* pp. 84–87, 126–36, 174–81, 242–57) gives a detailed and interesting account of these educational developments. Jensen (*16,* pp. 100–104, *passim*) also emphasizes this factor.

who distributed improved seed, and as early as the 1820's prepared plans for feeding tests. Being directed by high government officials and scientists with no contact with the farmers, the Society worked primarily through large landowners and agricultural clergymen.

During the period considered here, agricultural associations seem to have been the principal agency for carrying out extension-type activities. Initially, these consisted primarily of sponsoring agricultural shows, exhibitions of implements and machines, and prizes to farmers. Later it became increasingly common for local associations to employ agricultural advisers, many of whom were graduates of the Royal Veterinary and Technical College established in 1858. State support for the work of the agricultural associations in promoting technical progress was largely indirect. Government grants to the associations covered something like 40 per cent of the cost of the animal breeding and other experimental work carried out and 50 per cent of the salaries of the local farm advisers.

V. ECONOMIC TRANSFORMATION IN TAIWAN AND DENMARK

Taiwan.—It has already been noted that there was very little structural transformation of Taiwan's economy during the 1901–40 period. The farm labor force, which represented 71 per cent of the total labor force in 1905, still accounted for 68 per cent of the total in 1930. During the 1930's, especially after 1936, belated efforts were made to develop mining and manufacturing in Taiwan to bolster Japan's military potential. It will be seen from Table 11 that the nonagricultural labor force increased sharply between 1930 and 1940; and by the latter year the share of agriculture had declined to 62 per cent of the total.

The transformation of Taiwan's economy prior to 1930 was even more limited than is suggested by Table 11. Workers in sugar mills accounted for some 55 per cent of total employment in factories; and this was an export processing industry that had relatively little impact on the domestic economy (*4*, pp. 63–64). An indication of the absence of any significant social transformation is the limited urbanization that occurred. As late as 1940 there were only three cities in Taiwan with over 100,000 population, and their growth was not substantially more rapid than the rate of increase of total population (*4*, p. 106).

The lack of structural transformation of Taiwan's economy can be explained very largely by the nature and objectives of Japan's colonization policy. Indeed, it is questionable to what extent Taiwan can or should be regarded as a separate economy during this period. In line with the prevailing colonial policy of that epoch, Taiwan was viewed essentially as a source of raw materials and as a market for Japanese manufactured products. It would seem that very little of the economic surplus resulting from agricultural development was available for financing investment in manufacturing and other nonagricultural enterprises in Taiwan (*4*, pp. 19–21, *passim*; *13*, pp. 154–59). In 1896 subsidies from Japan amounted to about seven million yen and provided most of the administrative budget for Taiwan in that year. But beginning in 1905 local taxation—principally the land tax, excises, and profits of government distribution monopolies for salt, camphor, opium, tobacco, and alcoholic beverages—fully covered the expanding budgets of the Government-General (*49*, p. 134; *11*, pp. 26–27). Part

TABLE 11.—TAIWAN: GROWTH OF TOTAL AND NONAGRICULTURAL LABOR FORCE AND COEFFICIENT OF DIFFERENTIAL GROWTH, 1905–1940*

(1,000 persons except as indicated)

Year	Total labor force (1)	Nonagricultural labor force		Annual percentage rate of increase (compound) from preceding period			Coefficient of differential growth Col. (5)–(4)
		Total (2)	Manufacturing (3)	Total (4)	Total nonagriculture (5)	Manufacturing (6)	
A. Total Labor Force:							
1905	1,404	411	80				
1915	1,643	478	132	1.82	1.52	5.13	−.30
1920	1,637	500	146	−.075	.90	2.03	.97
1930	1,790	578	152	.90	1.46	.40	.56
1940	2,244	844	221	2.29	3.87	.37	1.58
1905–40				1.35	2.08	2.95	.73
B. Male Workers Only:							
1905	1,089	358	62				
1915	1,165	389	86				
1920	1,181	420	109				
1930	1,475	597	122				
1940	1,608	687	175				

* Data for 1905 through 1930 from Taiwan, Govt. Stat. Bureau, *Statistical Summary of Taiwan in Past 51 Years* [translated title] (Taiwan, 1946), Table 59, pp. 130–31; for 1940 from Taiwan, Bureau of Accounting and Statistics, *Results of the Seventh Population Census of Taiwan, 1940* (Taiwan, 1953), Table 15, p. 60.

Estimates refer to population "gainfully employed" defined as in the source note to Table 5.

of the increment in output in agriculture was also drawn off in the form of rental payments to landlords, many of whom were Japanese. Furthermore, the magnitude of Taiwan's export surpluses in commodity trade provides another indication that a major part of the economic surplus resulting from the increase in agricultural productivity accrued to Japan so that only limited funds were available to finance expansion of the capitalist sector in Taiwan.

Expansion of economic activities outside of agriculture was also restricted by the virtual isolation of the Taiwanese population from the Japanese elite, which monopolized the key positions in government, industry, and commerce. The limited educational opportunities for Taiwanese at the high school and university level had a similar effect.

Taiwan under Japanese rule appears to have been a classic example of the "dangers of partial modernization," i.e., the introduction of changes that lead to rapid growth of population but without the concomitant changes in economic and social structure, income levels, education, and attitudes which seem to be necessary conditions for a reduction in birth rates to a level consistent with a drastically reduced death rate. The period 1901–1940 was one of rapid growth of population which foreshadowed the high rates which have occurred in a number of countries since World War II (*4*, p. 13):

Year	Total population (1,000 persons)	Taiwanese population (1,000 persons)	Annual (compound) rate of growth Taiwanese population (Per cent)
1905	3,040	2,973	
			1.1
1915	3,480	3,326	
			0.8
1920	3,655	3,467	
			1.7
1925	3,883	3,775	
			2.2
1930	4,593	4,219	
			2.5
1935	5,212	4,883	
			2.4
1940	5,872	5,510	

Except for a reduction between 1915 and 1920, when mortality was increased by three outbreaks of disease that approached epidemic proportions, the *rate* of growth increased steadily. Over the 30-year span 1905–1935, the Taiwanese population increased by 64 per cent, a much larger increase than the 39 per cent rise in Japan's population between 1885 and 1915. Even more striking, however, is the contrast between the limited transformation of the structure of Taiwan's economy between 1905 and 1935 and the great strides made in Japan between 1885 and 1915 in developing a modern economy with a substantial industrial sector. In important respects the problem Taiwan faced in transforming its economy and eliminating surplus labor in the agricultural sector was more difficult in 1935 than at the turn of the century. The capitalist sector was still a very small part of the economy and possessed only a limited capacity for cumulative growth; and the population dependent on agriculture may well have increased by close to 60 per cent, that is, by nearly as much as the rate of increase in total population.

Denmark.—It was emphasized in section IV that even at the outset of the period 1880–1940 the Danish economy could not be aptly described as comprising a "subsistence" sector distinct from a "capitalist" sector. Thus the change in the occupational composition of the Danish labor force has a different meaning than the occupational shifts in Japan and Taiwan where the two-sector model was relevant. A related contrast is the fact that as early as 1880 the farm labor force accounted for only about one-half of the total labor force in Denmark compared with perhaps 75 per cent in Japan.

During the periods 1880–1920 and 1920–40 the annual growth of the nonagricultural labor force in Denmark was less than 2 per cent compared with an increase of just over 1 per cent in the total labor force (Table 12). The coefficient of differential growth averaged only about 0.6 per cent during the first four decades and 0.7 per cent during the last two decades. Thus Denmark's differential growth rate was no higher than that registered in Taiwan and was only about a third as high as the differential growth rate in Japan during the 1880–1920 period. But owing to the fact that the nonagricultural labor force already weighed so heavily in the total in 1880, the agricultural labor force increased

TABLE 12.—DENMARK: GROWTH OF TOTAL AND NONAGRICULTURAL LABOR FORCE AND COEFFICIENT OF DIFFERENTIAL GROWTH, 1880–1940*

(1,000 persons except as indicated)

Year	Total labor force (1)	Non-agricultural labor force (2)	Annual percentage rate of increase (compound)		Coefficient of differential growth (4)–(3)
			Total (3)	Nonagri-cultural (4)	
1880	1,013	503			
1885	1,043	533	.58	1.17	.59
1890	1,074	570	.59	1.35	.76
1895	1,132	618	1.06	1.63	.57
1900	1,205	685	1.26	2.08	.82
1905	1,276	750	1.15	1.83	.68
1910	1,351	811	1.15	1.58	.43
1915	1,439	879	1.27	1.62	.35
1920[a]	1,540	965	1.37	1.89	.52
1920[b]	1,636	1,019	...	...	...
1925	1,788	1,158	1.79	2.59	.80
1930	1,880	1,258	1.01	1.67	.61
1935	1,999	1,404	1.24	2.22	.98
1940	2,084	1,500	.84	1.33	.49
1880 to 1920[a]			1.05	1.64	.59
1920[b]–1940			1.22	1.95	.73

* The labor force estimates were kindly made available by Dr. Holger Gad, Department of Economics, University of Aarhus; a virtually identical series is presented by Bjerke (*5*, p. 151), but he gives the 1920 figure only inclusive of North Schleswig.

[a] Estimates excluding North Schleswig.

[b] Estimates including North Schleswig which was incorporated in Denmark in 1920.

much less than in Taiwan and began to decline in absolute terms from 1925. As of 1940 the agricultural sector accounted for only 28 per cent of the total labor force.

Denmark is characterized by such a conspicuous lack of natural resources—other than its excellent agricultural potential—that it may seem surprising that the agricultural sector accounted for as little as 28 per cent of the labor force and 22 per cent of the net domestic product in 1940 (*5*, p. 147). Demand was certainly not restricted to the size of the home market; shipments abroad absorbed some 65 per cent of total farm output. In view of this orientation of Danish agriculture to foreign markets, it might have been supposed that the structural transformation of the Danish economy would have been much more limited. And in a sense the statistical distinction between the agricultural and nonagricultural sectors does exaggerate the secular decline of agriculture. The food industries, which accounted for 20 per cent of employment in industry in 1940, were performing many activities that had formerly been carried out on the farm.

To a major extent, however, the pervasive growth of nonagricultural output simply reflected the diverse demands for goods and services of a population that

had attained fairly high levels of income—a per capita product of $750 according to the UN estimates for 1952–54 compared with a Japanese level of $190 per capita for those years. Scrutiny of the occupational distribution of the labor force as shown in Table 13 certainly seems to suggest such a pattern of diversification. Employment in the various branches of the tertiary sector was in aggregate twice as large as in manufacturing, and there is no indication that this reflected a reservoir of underemployed labor as was true of many service trades in Japan. It is pertinent to note, however, that a large segment of Danish industry was organized on a rather small scale, and some trades seem to have been distinguished more for the skill of their craftsmen than the amount of mechanical equipment employed.

It seems likely that higher labor earnings in Denmark compared with Japan are to be explained in part by the fact that they were not depressed by low levels of farm productivity and income. One significant contrast lends support to the view that there was a persistent surplus of labor in Japanese agriculture but not in Denmark. Agriculture's share of the national product in Japan fell much more sharply than its share of the labor force, whereas in Denmark the farm labor force as a percentage of the total declined almost as rapidly as farm income.

TABLE 13.—DENMARK: ECONOMICALLY ACTIVE POPULATION BY INDUSTRY, 1940*

Item	Number employed *(thousand persons)*	Per cent of total
A. Major classifications		
Agriculture	562.3	28.5
Industry	485.9	24.7
Building & construction	120.5	6.1
Transportation & communication	114.2	5.8
Commerce	245.0	12.4
Hotels, domestic service, etc.	291.0	14.8
Public services, professions	138.8	7.0
Not specified	13.6	0.7
Total	1,971.3	100.0
B. Industry: by branches:		
Food, beverages, and tobacco	95.4	19.6
Textiles and clothing	80.0	16.5
Wood and wood products	38.1	7.9
Leather and leather products	20.9	4.3
Stone, clay, and glass	19.4	4.0
Metal and machinery	126.9	26.1
Chemicals[a]	16.6	3.4
Paper and printing	28.7	5.9
Water, gas, and electricity	9.3	1.9
Not specified	50.6	10.4
Total	485.9	100.0

* Data from Denmark, Dept. Stat., *Statistisk Arbog, 1951*, pp. 14–25.
[a] Including oilseed crushing.

The percentage shares of agriculture in national product and labor force, and the ratio of the two percentages were as follows:[19]

Period	Denmark Agriculture's share of (A) National product	(B) Labor force	Ratio (A)/(B)	Japan Agriculture's share of (A) National product	(B) Labor force	Ratio (A)/(B)
1881–90	36	49	.73	53	73	.73
1931–40	18	30	.60	17	46	.37

The overwhelmingly important contribution of Danish agriculture to general economic growth was, of course, in providing the bulk of the nation's foreign exchange earnings, nearly 90 per cent of the total at the turn of the century and in excess of 70 per cent in 1938. This made it possible to import a wide and important array of commodities ranging from pig iron and steel to oilseeds and automobile parts and thereby overcome the limitations imposed by lack of natural resources and the small size of the home market.

It is difficult to say whether agriculture made a net contribution to financing the expansion of the nonagricultural sectors. Youngson quotes a statement made in 1854 by the founder of a provincial bank referring to the need "to establish connections with the peasants and small farmers, the richest class, the class with the most and the largest accumulations of money lying unused and unprofitable" (*52*, p. 198). This was at a time when many provincial banks, credit associations, and savings banks were being organized to mobilize rural savings to meet the capital requirements of commerce and industry. But in the 1880's, according to Youngson, the modification of the Danish farming system gave rise to substantial requirements for capital so that "agriculture required all its surplus funds for its own use, and industry and commerce became dependent on overseas capital" (*52*, p. 223). Borrowing abroad was encouraged by the low interest rates prevailing in the London and Paris money markets, and there seems to have been a large net import of capital during the three decades following 1880. Here again, however, it should be noted that the question does not have the same significance as in the Japanese and Taiwan cases. There seems good reason to believe that funds were being invested, in agriculture and elsewhere, according to the prospective returns to investment. Inasmuch as there was no significant surplus of labor in agriculture, the considerations that made it advantageous to develop Japanese agriculture by relying almost entirely on introducing technological innovations within the framework of a labor-intensive agriculture were simply not applicable to Denmark.

CONCLUSIONS

Of the many conclusions suggested by the experience of these countries, two stand out as being of paramount importance. The first relates to an element common to the experience of all three countries—the large potential that exists for raising agricultural productivity by technological innovations that make only limited demands on the capital and other critically scarce resources of an under-

[19] Based on data from *5*, pp. 147, 151; *32*, pp. 72–73, 246–47; data for Japan refer to agriculture and forestry, and the farm labor force figure used for 1881–90 is Ohkawa's estimate for 1883–87 given in Table 4.

developed country. The second conclusion, which has been illuminated by certain contrasts in the relationship between agricultural development and economic transformation in these countries, is that late developing economies are likely to face a formidable task in achieving a "satisfactory" rate of structural transformation. And as a corollary, initiation of a cumulative process of growth is likely to depend on the agricultural sector's making a net contribution to the capital required for development.

All of the countries witnessed substantial rates of increase in agricultural output and productivity. The most rapid rate of increase seems to have been attained in Taiwan where labor productivity in agriculture increased by something like 130 to 160 per cent over the 30-year span between the decade 1901–10 and the 1930's. It was noted, however, that overstatement of the increase in area may have given a small upward bias to these figures. In Japan and Denmark an increase in farm labor productivity of perhaps a little over 160 per cent appears to have been attained during the half century that elapsed between the 1880's and 1930's, although in Japan a large part of the increase was concentrated in the decades prior to 1920. Expressed as average annual (compound) rates, the increase in farm labor productivity in Japan and Denmark over the period considered was about 2 per cent; the increase over the 30-year span considered for Taiwan was between 2.9 and 3.2 per cent, subject to the qualifications mentioned above.

Particularly impressive is the extent to which the gains in output and productivity resulted from technological advance. In examining the strategic role of agriculture in Japan's early economic development, Ranis suggests that agriculture was able to make a highly significant contribution because of the potential that existed for "taking up the slack" in the economy. "In the case of Japan," Ranis argues, " 'slack' was in evidence mainly in the form of excess labour on the land and reserves of productivity in the land" (*38,* p. 440). The concept is a useful one in focusing attention on the possibilities that exist for increasing agricultural productivity with "a minimum need for additional investment." The term "slack" is unfortunate and misleading, however, in suggesting that the process is easy and almost automatic, although there is a kernel of truth even in that notion.

The advances in scientific understanding, particularly during the past century, represent a possible windfall gain for a country launching a program of agricultural development today. As a result of accumulating knowledge and understanding in such fields as soil science, plant nutrition, and genetics, there are important "potential increments of productivity" that can be realized.

It has been seen that agricultural advance in Denmark was to a considerable extent an evolutionary process that depended on technical and institutional inventions that could not simply be borrowed from abroad. Particularly noteworthy was the invention of the cream separator in 1878 and, subsequently, the institutional invention represented by the development of co-operative creameries.

The contrast with late-developing countries like Japan and Taiwan is illustrated even more clearly by the history of agricultural change in Great Britain, which the writer has reviewed in an earlier paper (*17,* pp. 505–8). The develop-

ment of British agriculture was a slow, evolutionary process which depended upon the emergence of improved techniques through a process of trial and error and in the absence of scientific understanding of the underlying principles. Lord Ernle, in his well-known history of English farming, singles out the period 1780 to 1813 as one of exceptional progress in agriculture (*10,* p. 210). Inclosures were being effected rapidly and new crops, better rotations, and improved livestock were being introduced. During the nineteenth century, increase of agricultural output was facilitated by laying of pipe for drainage, by the adoption of all-iron plows and harrows which came into manufacture in 1830, by a considerable increase in the use of fertilizers after about 1840, and by the use of stationary steam engines for threshing grain, pumping, and other operations from about 1850. It was in the 1840's that Lawes and Gilbert inaugurated the experimental work at Rothamsted which represented the first program of systematic agricultural experiments—not merely in Great Britain but in the world. Despite notable advances in agricultural practice initiated by a small number of enlightened farmers, on the basis of their experience and intuitive judgment, the general level of farming in the mid-nineteenth century was still extremely low. Wide differences of opinion prevailed concerning the best crop rotations, fertilizer use, and other aspects of farm practice because the scientific basis for these practices was weak and experimental methods for testing conflicting viewpoints had not been developed. Progress in spreading the application of improved methods was accelerated greatly when, in Ernle's phrase, practice had been "reduced to principles and rules which make the best methods more nearly common property" (*10,* p. 354). Thus Sir A. D. Hall dates modern agricultural science from the publication in 1840 of a report by Liebig which first set forth the basic principles of plant nutrition; and it was not until 1886 that the "fixing" of nitrogen in the soil by legumes was understood (*14,* pp. 2–3).

Late-developing countries are able to draw upon the experience of many countries that have faced similar problems and which have contributed to the cumulative growth of scientific knowledge. The pattern of agricultural development in Japan and Taiwan emphasizes, however, that intelligent and vigorous efforts on the part of research workers, agricultural administrators, and individual farmers were required to reap that harvest. Although an underdeveloped country can draw on the fundamental research and understanding that have been accumulated, the identification of promising avenues of progress and the testing and adaptation of improved seed and cultural practices to local conditions are indispensable for realizing the gains that are attainable. This might appear to be laboring the obvious were it not for the many indications that agricultural research is being neglected both in the technical assistance activities of economically advanced nations, especially of the United States, and in the agricultural development programs of many underdeveloped countries.

A closely related point emphasized by agricultural development in these countries is the importance of the complementarities that exist among various agricultural inputs. It was noted particularly in the case of Japan that it was the combined effect of heavier application of fertilizers and plant breeding aimed at developing varieties that respond well to high levels of soil fertility that were the

key factors in raising crop yields and productivity. It was also seen that the success of varietal improvement of rice in Taiwan was dependent upon concurrent increases in fertilizer use and other improvements in cultural practices. With respect to Denmark, Jensen has observed: "The combined effect of a higher level of soil fertility and improved cultural practices is of vital importance. To separate the effects of the different factors seems well nigh impossible because the varieties grown today are superior only under present-day conditions of 'high farming' . . ." (*16,* p. 240). The possibility of obtaining very high returns relative to the expenditures for agricultural development, requires the introduction or expanded use of an appropriate combination of conventional inputs, such as fertilizer, and unconventional inputs or "developmental services" such as agricultural research, extension, and rural education.

Marked contrasts have been observed in the relationship between agricultural development and general economic growth in the countries considered here. In Denmark the pace of industrial development was fairly leisurely; but thanks to the substantial transformation of the economy that had already occurred by 1880 and a favorable initial land/labor ratio, Denmark has not faced problems of rural congestion and associated economic and social pressures.

Japan of 1880 and Taiwan at the turn of the century were characterized by rural populations that were large relative to the agricultural land available and as a fraction of the total population. They faced a formidable task in securing sufficient expansion of their "capitalist" sector to absorb the surplus of labor in the "subsistence" sector. In Taiwan, relatively little was accomplished in transforming the structure of the economy, and there is every indication that the surplus of labor in agriculture increased. This was largely a result of Japan's colonial policies which, until the 1930's, were based on the view that the island should be developed merely as a source of raw materials and a market for manufactured products. It is also to be stressed, however, that Taiwan faced a particularly difficult problem because of the extremely rapid rate of population growth. The Taiwanese population increased by nearly 65 per cent between 1905 and 1935 compared with the increases of just under 40 per cent that Japan and Denmark experienced during the three decades between 1885 and 1915. With the rate of increase in population and total labor force that occurred in the 1930's—approximately 2.5 per cent per annum—a fairly rapid rate of expansion of nonagricultural employment was required simply to prevent further increase of the excess labor force in agriculture.

The historical experience of Japan and Taiwan underscores the strategic role of agriculture as a potential source of capital for over-all development. The nature of the relationship between capital accumulation and expansion of the capitalist sector suggested by Lewis's two-sector model, together with the pattern of development in Japan, suggests that the need for a net flow of capital out of agriculture is of special significance during the early stages of growth. When the capitalist sector is only a small segment of the economy, the potential for accumulating capital through re-investment of profits is severely limited. Under those conditions the capital funds and recurrent expenditures needed for a "sufficient" expansion of the manufacturing sector, for overhead investment, and for

the expansion of education and other essential governmental services loom very large relative to the savings potential of a low-income nation.

Attention is directed to agriculture as a source of capital first of all simply because it is, with few exceptions, the only major industry in an underdeveloped economy. The significance of its role is enhanced, however, by the substantial potential that exists for increasing agricultural output and productivity by rather moderate outlays of capital. Both Japan and Taiwan are noteworthy in demonstrating that sizeable increases in farm output and productivity can be achieved by methods that emphasize the use of resources that are already abundant within agriculture and are difficult to transfer—notably labor and land—and which minimize requirements for the critically scarce resources that are indispensable for industrial expansion.

CITATIONS

1 G. C. Allen, "Japanese Industry: Its Organization and Development to 1937," in Elizabeth B. Schumpeter, ed., *The Industrialization of Japan and Manchukuo 1930–1940* (New York, 1940).

2 ———, *A Short Economic History of Japan* (London, 1946).

3 Bank of Japan, Stat. Dept., *Economic Statistics Monthly,* February 1962.

4 G. W. Barclay, *Colonial Development and Population in Taiwan* (Princeton, 1954).

5 Kjeld Bjerke, "The National Product of Denmark, 1870–1952," *Income and Wealth Series V* (International Association for Research in Income and Wealth, London, 1955).

6 J. M. Brewster, "The Machine Process in Agriculture and Industry," *Journal of Farm Economics,* February 1950.

7 H. B. Chenery, S. Shishido, and T. Watanabe, *The Pattern of Japanese Growth 1914–1954* (processed).

7a Denmark, Stat. Dept., *Nationalproduktet og Nationalindkomsten 1930–46* (Statistiske Meddelelser, Ser. 4, Vol. 129, No. 5, 1948).

8 R. P. Dore, "Agricultural Improvement in Japan, 1870–1900," *Economic Development and Cultural Change,* October 1960, Part II.

9 F. Dovring, "The Share of Agriculture in a Growing Population," FAO *Monthly Bulletin of Agricultural Economics and Statistics,* August/September 1959.

10 Lord Rowland E. P. Ernle, *English Farming Past and Present* (London, 1922).

11 N. S. Ginsburg, *Economic Resources and Development of Formosa* (New York, 1953).

12 Margaret S. Gordon, "Japan's Balance of International Payments, 1904–1931," in Elizabeth B. Schumpeter, ed., *The Industrialization of Japan and Manchukuo 1930–1940* (New York, 1940).

13 A. J. Grajdanzev, *Formosa Today* (New York, 1942).

14 Sir A. D. Hall, *The Book of Rothamsted Experiments* (London, 1919).

15 S. C. Hsieh and T. H. Lee, *An Analytical Review of Agricultural Development in Taiwan—An Input-Output and Productivity Approach* (Chinese-American Joint Commission on Rural Reconstruction, Economic Digest Series, No. 12, 1958.

15a Japan, Agricultural Policy Research Committee, *Agricultural Development in Modern Japan* (project undertaken in contribution to the FAO Freedom From Hunger Campaign and translated by the Japan FAO Association, processed, September 1962).

16 Einar Jensen, *Danish Agriculture: Its Economic Development* (Copenhagen, 1937).

17 B. F. Johnston, "Agricultural Productivity and Economic Development in Japan," *Journal of Political Economy,* December 1951.

18 ———, *Japanese Food Management in World War II* (Stanford, Calif., 1953).

19 B. F. Johnston and J. W. Mellor, "The Nature of Agriculture's Contributions to Economic Development," *Food Research Institute Studies,* November 1961.

20 ———, "The Role of Agriculture in Economic Development," *American Economic Review,* September 1961.

21 Baron Kikuchi, *Japanese Education* (London, 1909).

22 C. P. Kindleberger, "Group Behavior and International Trade," *Journal of Political Economy,* February 1951.

23 Peter Kung, *The Distribution of Rice Varieties and Their Trend of Changes in the Recent Three Decades in Taiwan* (Chinese-American Joint Commission on Rural Reconstruction, Plant Industry Series No. 10, 1956).

24 W. Arthur Lewis, "Economic Development with Unlimited Supplies of Labour," *The Manchester School,* May 1954.

25 ———, "Unlimited Labour: Further Notes," *The Manchester School,* January 1958.

26 W. W. Lockwood, *The Economic Development of Japan* (Princeton, New Jersey, 1954).

27 N. B. Mendiola, "Rice Culture in Taiwan," *Philippine Journal of Agriculture,* First Quarter 1949.

28 S. Nasu, *Land Utilization in Japan* (Tokyo, 1929).

29 Natural Resources Section, GHQ, SCAP, *Fertilizers in Japan* (NRS Rep. No. 55, Tokyo, 1946).

30 ———, *The Agricultural Experiment Stations of Japan* (NRS Rep. No. 59, Tokyo, 1946).

31 ———, *Crop Statistics for Japan 1878–1946* (NRS Rep. No. 108, Tokyo, 1946).

32 K. Ohkawa et al., *The Growth Rate of the Japanese Economy Since 1878* (Tokyo, 1957).

33 K. Ohkawa and Henry Rosovsky, "The Role of Agriculture in Modern Japanese Economic Development." Paper prepared for the Carmel Conference on Urban-Rural Relations in the Modernization of Japan, August, 1959; published in a shorter version in *Economic Development and Cultural Change,* October 1961, Part II.

34 Kazushi Ohkawa, *The Pattern of Japanese Long-Term Economic Growth* (processed, 1960).

34a ———, "Economic Growth and Agriculture," *Annals of the Hitotsubashi Academy,* October 1956.

35 ———, "The Role of Agriculture in Early Economic Development." Paper presented to the Conference of the International Economic Association, Gamagori, Japan, May, 1960.

36 ———, "Significant Changes in Japanese Agriculture Since 1945," *Journal of Farm Economics,* December 1961 (Proc. issue).

36a Masao Ōtsuki, *Japanese Agriculture and the Direction of Its Development* (Bull. No. 3, National Research Institute of Agriculture, Tokyo, 1961).

37 E. F. Penrose, "Japan, 1920–1936," in Elizabeth B. Schumpeter, ed., *The Industrialization of Japan and Manchukuo 1930–1940* (New York, 1940).

38 Gustav Ranis, "The Financing of Japanese Economic Development," *Economic History Review,* April 1959.

38a Gustav Ranis and J. C. H. Fei, "A Theory of Economic Development," *American Economic Review,* September 1961.

39 Henry Rosovsky, "Japanese Capital Formation: The Role of the Public Sector," *Journal of Economic History,* September 1959.

40 R. A. Scalapino, *Democracy and the Party Movement in Prewar Japan: The Failure of the First Attempt* (Berkeley, 1953).

41 T. W. Schultz, "Investment in Human Capital," *American Economic Review,* March 1961.

42 Toshio Shishido, "Japanese Agriculture: Productivity Trend and Development of Technique," *Journal of Farm Economics,* May 1961.

43 F. Skrubbeltrang, *Agricultural Development and Rural Reform in Denmark* (FAO Agricultural Studies No. 22, 1953).

44 T. C. Smith, *The Agrarian Origins of Modern Japan* (Stanford, Calif., 1959).

45 ———, "Landlords and Rural Capitalists in the Modernization of Japan," *Journal of Economic History,* June 1956.

46 ———, Taiwan Agricultural Statistics *1901–1955* (Economic Digest Series No. 8, December 1956).

47 Taiwan, Department of Statistics, *Results of the Seventh Population Census of Taiwan, 1940* (Taiwan, 1953).

48 ———, *Statistical Summary of Taiwan in Past 51 Years* [translated title] (Taiwan, 1946).

49 Yosaburo Takekoshi, *Japanese Rule in Formosa* (Tokyo, 1907).

50 Anthony Tang, "Research and Education in Japanese Agricultural Development." Paper presented at the annual meeting of the Econometric Society, Stillwater, Oklahoma, Aug. 30–Sept. 1, 1961, to appear in English and Japanese in a forthcoming issue of *Economic Studies Quarterly* (Riron Keizai-Gaku), Vol. 13, No. 2.

51 V. P. Timoshenko and B. C. Swerling, *The World's Sugar: Progress and Policy* (Stanford, Calif., 1957).

52 A. J. Youngson, *Possibilities of Economic Progress* (Cambridge, England, 1959).