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CHANGES IN OUTPUT AND IN CONVENTIONAL AND NONCONVENTIONAL INPUTS IN JAPANESE AGRICULTURE SINCE 1880†

Recently much attention has been given to the problem of devising efficient strategies of agricultural development as a crucial component of overall economic growth. The experience of Japan since the Meiji Restoration of 1868 has been singled out as a particularly significant case study. Impressive increases in agricultural output and productivity were clearly a necessary condition for the success of Japan's efforts to modernize her economy (*37*). It has also been emphasized that to a rather remarkable degree the increase in agricultural output in Japan in the decades following the Meiji Restoration is to be attributed to "technical progress" rather than an increase in physical inputs. The general argument has been advanced that this type of approach—emphasis on increasing the productivity of existing land and labor resources committed to the agricultural sector—is of general relevance to underdeveloped countries, in part because it permits the development of agriculture to contribute significantly to overall economic growth (*27*).

The purpose of the present paper is twofold. In the first part of the paper the long-term trends of output and in the use of conventional inputs in Japanese agriculture are examined for the period 1880–1959. It is found that the rate of increase in output was immensely greater than the increase in the use of conventional inputs of land, labor, and capital. There is increasing recognition that the "technical progress" implied by these disproportionate rates of increase in output and resource use is to be attributed in large measure to shifts in production functions associated with agricultural research and with increases in the

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† The first half of this paper is based upon studies under the research project of the long-term growth of national income in Japan, sponsored by the Rockefeller Foundation and the Asian Foundation and supervised by Kazushi Ohkawa. The remainder is drawn from my studies at the Food Research Institute from September 1963 to February 1965, under a Rockefeller Foundation Fellowship and a grant from the Stanford Committee on Asian Studies. I am indebted to Bruce F. Johnston for helpful suggestions and for editing the manuscript. Kenzo Hemmi, Toshio Kuroyanagi, Benton Massell, John Mellor, Kazushi Ohkawa, Harry Oshima, Anthony M. Tang, George Tolley, Luther Tweeten, and Clifton R. Wharton, Jr., made helpful criticisms and suggestions. I am, however, solely responsible for the opinions expressed in this paper and for any errors that remain.

level of technical knowledge, skill, and managerial competence of the farm population. In addition to the emphasis on this aspect of Japan's agricultural development in the work of Ohkawa and Rosovsky, Johnston, Tang, and Yamada, the importance of "nonconventional inputs" in relation to technical progress has been stressed by Schultz, Griliches, Heady, and others (*3, 5, 9, 25, 26, 37, 41, 42, 46,* and *55*).

The second part of the paper is devoted to an analysis of government expenditures for various nonconventional inputs such as agricultural research and education and extension-type activities. Studies of the Japanese experience have emphasized that government programs concerned with developing improved technology and with raising the level of technical knowledge and skills of Japan's farmers made a strategic contribution to the impressive increases in factor productivity evident in the large increases in farm output associated with only moderate increases in farm inputs.

Fundamental difficulties bedevil any attempt to identify the causal factors responsible for changes in agricultural productivity and output and to evaluate their importance. This is inevitable because of the way in which changes in output and productivity depend upon complex interactions between the management decisions and performance of individual farmers and the level, composition, and efficiency of government programs that condition the production possibilities available to farmers. Such interaction between factors at the farm level and government programs of research and other conditioning factors was clearly of great importance in Japan. Moreover, owing to the great importance of complementarities among many of the conventional and nonconventional inputs, it is not even possible conceptually to estimate the returns attributable to a particular nonconventional input. Observed changes in agricultural productivity may also be influenced strongly by more general economic forces, notably factors influencing the rate of increase in demand for farm products and the availability of nonfarm employment opportunities which is often the major determinant of changes in the size of the farm labor force (*25, 28*). Also important is technical progress in the manufacturing sector that leads to improvements in the quality and variety of nonfarm inputs available and to a relative decline in their supply price. Furthermore, technical advance in agriculture may be due to spontaneous innovation and diffusion of improved practices among farmers which is influenced little, if at all, by government programs. It will be argued below that this last factor was probably of great importance during the early years of Meiji whereas in later periods technical progress seems to have depended mainly on organized research, formal education, and extension activities.

Decisions with respect to the priority to be given to various measures to promote increased agricultural output and productivity are at the heart of the problem of designing rational agricultural development plans and programs. This historical analysis of the Japanese experience is presented in the belief that it throws considerable light on the difficult problems involved in determining the appropriate level and pattern of governmental expenditure to promote agricultural development. Examination of the magnitude of government expenditures for nonconventional inputs in relation to the value of the "unexplained output" gives some indication of the returns that can be expected from such outlays.[1] In

[1] See below for a definition of "unexplained output."

addition, the correlations between levels of expenditure for various types of non-conventional inputs and the magnitude of the unexplained output associated with such expenditures during different phases of Japan's agricultural development are scrutinized in considerable detail. Some of the correlations that emerge seem to be very suggestive and give at least a rough indication of the returns to various types of developmental expenditure.

I. LONG-TERM TRENDS OF OUTPUT AND USE OF CONVENTIONAL INPUTS IN JAPANESE AGRICULTURE

During the eight decades between 1880 and 1960 the output of Japanese agriculture increased tremendously. The value of farm output, which was 576 billion yen at 1955 prices in 1880–84, increased to 1,591 billion yen in 1955–59, a rise of 176 per cent. The net value of farm output also rose considerably, from 499 billion yen to 1,073 billion yen, an increase of 115 per cent. The changes in gross and net output by five-year averages are shown in Table 1 together with the associated changes in various categories of conventional inputs.[2]

The number of gainfully occupied persons in agriculture was relatively stable: 14.9 million in 1880–84 and 14.2 million in 1955–59. Except for the extraordinary increase immediately after World War II, the farm labor force showed a slight declining trend.

Land area expanded very moderately from 4.75 million hectares in 1880–84 to 6.01 million hectares in 1955–59, a rise of 27 per cent. The area classed as paddy fields increased from 2.75 to 3.20 million hectares, an increase of only 16 per cent whereas land in upland fields showed a rise of 41 per cent from 2.00 to 2.81 million hectares. Because of its small size and mountainous terrain Japan has found it difficult to expand the area of farmland. The increase that was achieved was mainly the result of agricultural settlement in Hokkaido, the northern island of Japan.

Fixed capital registered a moderate increase from 1,157 billion yen to 1,659 billion yen over the entire period. The major component of fixed capital is farm buildings and this item was relatively constant. Other components of fixed capital, such as trees and shrubs, livestock, and machinery and implements, increased considerably from 274 billion yen to 717 billion yen, a rise of 162 per cent. This percentage rise was close to that of gross output, but the increase in all types of fixed capital was only 43 per cent because of the dominant weight of investment in farm buildings in the total.

The most remarkable increase in physical inputs was in the category of working capital or variable inputs. The value of variable inputs was only 53 billion yen at 1955 prices in 1880–84 but rose to 353 billion yen in 1955–59. Thus the in-

[2] Since 1959 the writer has been engaged in a program of research aimed at obtaining the best possible historical estimates of changes in agricultural output and conventional inputs in Japan. This is, of course, a never-ending task as there is always scope for further refinement of such estimates. Subsequent to completing the analysis on which the present paper is based, the present author and co-workers at Tokyo Metropolitan University and the Hitotsubashi Institute of Economic Research undertook a further study that resulted in the "LTES estimates" that are presented in *52*. These new estimates are not quite 3 per cent higher than those presented here for the 1880–84 and 1890–94 quinquennia, and the five-year averages since the 1900–04 period are about 4 per cent higher (6.8 per cent higher as an average for 1930–34). A variety of tests that have been applied to the LTES estimates seem to confirm their reasonableness (*60*). And in view of the close similarity between the two series, they offer support to the reasonableness of the estimates used in the present monograph.

TABLE 1.—CHANGES IN OUTPUT AND CONVENTIONAL INPUTS IN JAPANESE AGRICULTURE, 1880–1959*

(Billion yen at 1955 prices, except as otherwise indicated)

Average	Output		Labor (*million persons*)	Fixed capital		Variable inputs	Land area (*million hectares*)		
	Gross	Net		Including building	Excluding building		Total	Paddy fields	Upland fields
1880–84	576	499	14.86	1,157	274	53	4.75	2.75	2.00
1885–89	669	574	14.62	1,155	280	64	4.82	2.78	2.04
1890–94	706	599	14.42	1,166	298	73	4.92	2.80	2.12
1895–99	742	629	14.33	1,190	328	78	5.05	2.82	2.23
1900–04	809	683	14.22	1,213	345	86	5.19	2.85	2.34
1905–09	872	723	14.04	1,236	377	102	5.36	2.90	2.46
1910–14	960	774	13.93	1,298	435	127	5.63	2.97	2.66
1915–19	1,079	844	13.80	1,331	469	160	5.83	3.03	2.80
1920–24	1,095	863	13.64	1,348	489	160	5.93	3.09	2.84
1925–29	1,160	891	13.66	1,383	521	183	5.88	3.16	2.72
1930–34	1,204	934	13.77	1,434	561	184	5.98	3.21	2.77
1935–39	1,244	996	13.57	1,458	591	196	6.07	3.21	2.86
1940–44	1,167	936	13.80	1,462	609	158	6.01	3.19	2.82
1945–49	1,020	854	16.19	1,402	514	114	5.81	3.10	2.71
1950–54	1,222	883	15.65	1,510	580	231	5.89	3.13	2.76
1955–59	1,591	1,073	14.17	1,659	717	353	6.01	3.20	2.81

* Gross output data from Saburo Yamada (*57*, p. 74). It was estimated using Laspeyres' formula, taking 1955 as the base. Price and quantity data from Japan, Department of Agriculture and Forestry, *16* and *14* respectively. The official estimates of crop yields for the earlier years of the Meiji period, which are generally considered to have been underestimated, have been revised to adjust for inconsistencies in the data. In the case of rice, the estimates of both yield and planted area were revised on the basis of prefectural data. Quantities not found in *14* were estimated using supplementary data mainly from *12*, *13*, *22*, and *31*.

Net output data, from Saburo Yamada (*55*, p. 50), were estimated by multiplying gross output by the ratio of value added to the gross value of farm products. The ratios were estimated on the basis of *16* and *36*. Since the net output series was obtained by this indirect method of estimation it is subject to a rather large margin of error.

Labor and fixed capital data are from Mataji Umemura and S. Yamada (*51*, pp. 133–36). The labor input should be based on the total working hours on farms, but the gainfully occupied population in agriculture has been used because of lack of data. For the prewar period, the gainfully occupied population in agriculture per farm household and the number of farm households (*56*) in each year during the period considered were estimated first as the basis for deriving the series for the total gainfully occupied population in agriculture. The estimates for the postwar period were made by the writer on the basis of census data.

Fixed capital is the real net capital stock employed on farms. It consists of machinery and implements, trees and shrubs, livestock, and farm buildings. Land improvement facilities are not included. Quantitative changes in component items of the respective categories were estimated first and were then aggregated with the components weighted by the same base-year (1955) net value (based on *16*). Thus changes in productive efficiency of new varieties or new models are not reflected in the real value of the item.

The value of variable inputs was estimated by subtracting the depreciation of fixed capital from the difference between gross and net outputs.

Land area data for 1883–1944 are from Yujiro Hayami and Saburo Yamada (*58*). Estimates for later years, also based on official statistics, include a few adjustments by the author. Only land classed as paddy field or upland field is included. The definitions used in the official statistics were not always the same; and the coverage was not complete in some years. An attempt has been made to correct for such deficiencies by using prefectural data.

crease was almost sevenfold in the course of eight decades. The absolute value of the outlays for variable inputs was small relative to the value of fixed capital inputs, but this rapid increase in use of variable inputs was a highly strategic factor in Japan's agricultural development. By far the most important item in the cate-

gory of variable inputs was fertilizer, but chemicals for insect and disease control have become a major item in the years since World War II (*8*).

Methodology for Analyzing the Relationships Between Output and Total Inputs

The method for analyzing the relationship between farm output and individual physical inputs is relatively simple. Complex methodological problems arise, however, when an attempt is made to analyze the relationship between output and the aggregate of conventional inputs in order, for example, to measure to what extent the increase in farm output is "explained" by the increase in inputs (*44* and *45*). Broadly speaking, there are two types of approach to this problem. One is based on comparing index numbers of farm output and of total inputs; the other is in terms of production functions. Both methods have their respective problems.

The major problem involved in the first method is that it cannot avoid the index number problems resulting from changes in relative prices within the components of the indexes. The principal problem with the production function approach is related to the instability of statistical estimates of the coefficients because of the problem of multicollinearity due to the high intercorrelation among time series for the different variables. This has been one of the reasons for the attention that has been given to production function analysis based on cross-section data as a check and a supplement to analyses utilizing time series data.

The writer finally adopted the index number approach to the problem after some tentative and unsuccessful attempts to compute Cobb-Douglas-type production functions.[3]

The aggregate indexes of farm output and of conventional inputs employed here were calculated by using the Laspeyres' formula, taking 1955 as the original base year. They are similar to those used in the works of T. W. Schultz (*40*), J. W. Kendrick (*29*), R. A. Loomis and G. T. Barton of the U. S. Department of Agriculture (*30*), and others. The conventional input index is composed of indexes of labor, fixed capital, land, and variable inputs, weighted by 1955 factor prices.[4] The last component, the cost of variable inputs, is also included in the U. S. Department of Agriculture index whereas Kendrick excludes them. Two kinds of output indexes were calculated: the index of gross output and that of net output, both weighted by 1955 farm product prices. These are in fact simply

[3] The results from the attempts to compute multiple-variable production functions gave results which were not significant statistically and were also meaningless in an economic sense. Another attempt was made to overcome the problem of multicollinearity by combining all variables into one composite variable. The results of this approach were of some interest and are discussed at the end of this section.

[4] The weights of the index of total inputs are based on averages derived from the *Survey of Farm Household Economy* (*16*). The labor expenses were calculated on the basis of hourly farm wages multiplied by the total farm labor hours, including that of farm family members. Land cost is the sum of rental payments for rented land and the imputed rent for owned land. The latter is assumed to be 6 per cent of land value, evaluated by the prices of arable land prevailing in 1955. (These are estimates of the Japan Hypothec Bank in *11*; the land prices in *16* are not used in this study as they are underestimated.) The cost for fixed capital is the sum of interest estimated at 6 per cent and of depreciation of farm assets. The cost of working capital is obtained by subtracting wages for hired workers, depreciation, and rent from the total farm expenses.

The percentages of costs of each item defined above in total farm expenses in 1955 and which were used as weights in computing the index of total inputs are as follows: labor cost, 44.9 per cent; cost of fixed capital, 18.7 per cent; cost of working capital, 19.5 per cent; rent or imputed rents for paddy fields and upland fields, 11.4 per cent and 5.5 per cent respectively.

the index numbers that correspond to the gross and net output estimates valued at 1955 prices which were shown in Table 1.

The conventional input index calculated here presumably expresses the lower limit of the increase in the use of conventional inputs; labor which has become relatively dear has declined in importance, while use of other inputs which have become relatively cheap has expanded.[5] Owing to the absence of any major structural changes in Japanese agriculture during the period under consideration, there is reason to believe that index number problems do not seriously distort the analysis of the relative changes in output and inputs. The farm population and the average size of farms remained remarkably constant, except for the upsurge in farm population at the end of World War II that has already been mentioned. And throughout most of the period, the changes in the composition of agricultural output were very limited. It will be seen from Appendix Table I that rice, which accounted for 62 per cent of the gross value of agricultural output in 1880, still accounted for over 54 per cent of the total in 1955. The increase in relative importance of dairy and livestock products was very slow until the past 15 years. As of 1940 these items accounted for only 6.4 per cent of the gross value of output, but between 1955 and 1960 their share increased from 9 to 17 per cent. The only other conspicuous change in the composition of output was the fairly rapid increase in the absolute and relative importance of cocoon production until the 1930's and its subsequent decline during and since the war.

There are two different ways of comparing the indexes—the ratio of the output index to the input index and the difference between the two. To simplify the exposition, let us shift the base period to the starting year. The output and input indexes are then:

$$O_t = \frac{\Sigma P_o Q_t}{\Sigma P_o Q_o} \tag{1}$$

$$I_t = \frac{\Sigma R_o S_t}{\Sigma R_o S_o} \tag{2}$$

where O represents the output index, I the input index, P the prices of farm products, Q the volume of farm output, R represents input prices, S the volume of inputs used, and the suffixes o and t express the base year and the year of comparison respectively. Then, the former method is:

$$O_t/I_t = \frac{\Sigma P_o Q_t}{\Sigma R_o S_t} \Big/ \frac{\Sigma P_o Q_o}{\Sigma R_o S_o}. \tag{3}$$

This represents the ratio of the productivity in the period compared to that of the base year. The latter method—the difference between the two indexes—is:

$$O_t - I_t = \frac{\Sigma P_o Q_t}{\Sigma P_o Q_o} - \frac{\Sigma R_o S_t}{\Sigma R_o S_o}.$$

[5] T. W. Schultz (*40*), computed two kinds of input indexes weighted by 1910–14 and 1946–48 input prices respectively. The increase in the United States index from 1910 to 1950 was 33 per cent for the former, and 14 per cent for the latter index. The former was regarded as the upper limit of the increase in the index whereas the latter was considered the lower limit.

Multiplying this by $\Sigma P_o Q_o$, we get:

$$\Sigma P_o Q_o (O_t - I_t) = \Sigma P_o Q_t - \frac{\Sigma P_o Q_o}{\Sigma R_o S_o} \Sigma R_o S_t. \tag{4}$$

$\Sigma P_o Q_t$ is the gross output in period t and $\frac{\Sigma P_o Q_o}{\Sigma R_o S_o} \Sigma R_o S_t$ is the expected output with the given increases in inputs but with the overall productivity remaining the same as in the base year. So, $\Sigma P_o Q_o (O_t - I_t)$ represents the output which cannot be explained by the increase in conventional inputs. We call the former measure the "conventional input productivity index" and the latter is referred to as the "unexplained output" (see *46*). Both measures have their respective economic meaning, so we will refer to both in the first part of this paper; but in our examination of the relationship between nonconventional inputs and "technical progress" in the latter part of the paper we consider only the unexplained output.

Changes in Output and Total Inputs in Different Phases of Japan's Agricultural Development

The computed indexes of output, conventional inputs, and the input productivity index are shown in Table 2 and Chart 1. The indexes of input and output were shifted from the original base year, 1955, to 1880–84, the earliest period analyzed in the present paper. The unexplained output is also shown in Table 2. During the 80-year period from 1880 to 1960 the gross output index rose from

TABLE 2.—INDEXES OF OUTPUT, CONVENTIONAL INPUT, PRODUCTIVITY, AND UNEXPLAINED OUTPUT IN JAPANESE AGRICULTURE, 1880–1959*

Average	Output		Conventional input	Overall productivity[a]	Gross output index minus input index	Unexplained output (*billion yen*)[b]
	Gross	Net				
1880–84	100.0	100.0	100.0	100.0	.0	0
1885–89	116.3	115.0	100.3	115.9	16.0	92
1890–94	122.7	120.0	100.8	121.7	21.9	126
1895–99	129.1	126.1	101.7	126.9	27.4	157
1900–04	140.6	136.9	102.7	137.0	37.9	219
1905–09	151.5	144.9	104.0	145.6	47.5	274
1910–14	166.7	155.1	107.7	154.8	59.0	342
1915–19	187.4	169.1	111.2	168.5	76.2	439
1920–24	190.4	172.9	111.2	171.3	79.2	457
1925–29	201.7	178.6	113.6	177.6	88.1	508
1930–34	209.4	187.2	115.4	181.3	94.0	541
1935–39	222.9	199.6	116.2	191.8	106.7	615
1940–44	202.6	187.6	113.8	178.0	88.8	511
1945–49	177.1	171.1	118.0	150.1	59.1	340
1950–54	210.2	177.0	127.7	164.6	82.5	475
1955–59	276.2	215.0	134.8	204.9	141.4	814

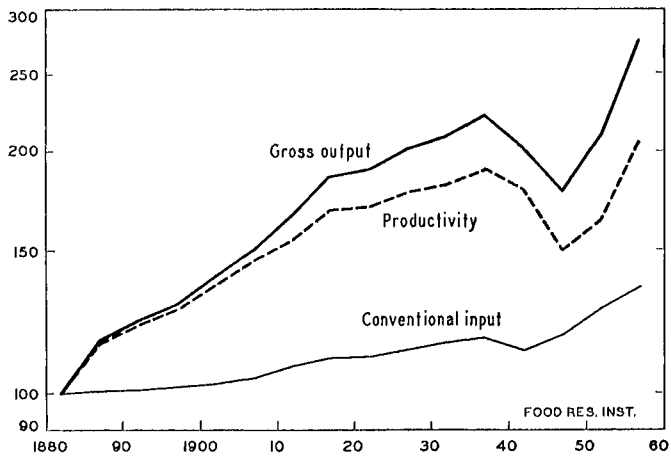
* Based on data from the sources cited for Table 1 which give indexes weighted by 1955 prices on 1953–57 base, here shifted to 1880–84 = 100.

[a] Gross output index divided by conventional input index.

[b] The unexplained output was obtained by multiplying 576 billion yen, value of gross output at 1955 prices in 1880–84, by the differences between the output and input indexes.

CHART 1.—CHANGES IN INDEXES OF FARM OUTPUT, CONVENTIONAL INPUT, AND PRODUCTIVITY*

(1880–84 = 100, 1955 prices)



* Data from Table 2.

100 to 276, the net output index increased more slowly from 100 to 215. The difference between them reflects the rather gradual decline in the ratio of net to gross output, from 87 per cent in 1880–84 to 67 per cent in 1955–59.

The conventional input index rose from 100 to 135, showing a very moderate increase relative to that of output. The difference in the rate of increase of output and input indicates a significant increase in the conventional input productivity index from 100 to 205. In 1880–84, the unexplained output was zero according to our definition. The unexplained output expressed in 1955 prices amounted to 615 billion yen in 1935–39; and by 1955–59 it amounted to 814 billion yen, a little more than half of the gross value of farm products in that period. As noted earlier, use of an input index weighted by input prices in an earlier period would have undoubtedly shown a more moderate increase in input productivity and in the unexplained output. But it seems certain that the "true" increase in these measures of "technical progress" was considerable.

The rates of increase in farm output, use of inputs, productivity, and in unexplained output showed considerable variation over the 80-year period under consideration. On the basis of the patterns of change summarized in Table 2 and Chart 1, we may identify four periods that were characterized by markedly different rates of increase in farm output: Phase I from 1880–84 to 1915–19; Phase II, from 1915–19 to 1935–39; Phase III, from 1935–39 to 1945–49; and Phase IV, from 1945–49 to 1955–59. These correspond approximately to the periods of agricultural development as defined by Johnston (*25*) and Ohkawa and Rosovsky (*35, 37,* and *38*). It must be emphasized that the four phases used in this paper simply refer to periods that were characterized by distinctly different rates of growth of farm output and productivity. They are not to be confused with the concept of phases as used by Ohkawa and Rosovsky to delineate time periods determined in accordance with a formal analytical framework. In a recent paper

Ohkawa (*35*) presents a highly interesting description and analysis of phases of agricultural development in terms of phases defined according to that type of analytical framework. The phases that he identifies are very similar to the time periods used here except that he treats the entire period 1919–53 as a single phase.

The *gross output index* rose from 100 to 187 in Phase I, from 187 to 223 in Phase II, declined from 223 to 177 in Phase III, and increased again from 177 to 276 in Phase IV. The average annual rates of growth were 1.78,[6] 0.80, −2.79, and 4.51 per cent respectively. Thus the gross output increased considerably, stagnated, decreased, and again increased dramatically in the four phases of Japan's agricultural development. These differences throw considerable light on the situation within agriculture itself and clarify the nature of its contribution to the rest of the economy in the respective phases.

The *net output index* increased from 100 to 169 in Phase I, from 169 to 200 in Phase II, declined from 200 to 171 in Phase III, and rose from 171 to 215 in Phase IV. The average annual rates of growth were 1.37, 0.69, −1.78, and 2.14 per cent respectively. The widening difference between the growth rates of gross and net output resulted from the decline in the net income ratio mentioned above.

The *conventional input index* increased from 100 to 111 in Phase I, from 111 to 116 in Phase II, from 116 to 118 in Phase III, and from 118 to 135 in Phase IV. The computed annual rates of growth were 0.28, 0.28, −0.03, and 1.41 per cent

[6] There is a considerable amount of uncertainty with respect to the annual rate of increase in output during the first period (1880–84 to 1915–19). The estimated annual growth rate as published by Ohkawa and others (*36*) is 2.7 per cent, an estimate which was based entirely on the official government statistics. There was, however, a certain amount of concealment and undermeasurement of arable land and underreporting of yield in the Meiji period. The government tried to check and correct such errors through cadastral surveys carried out in connection with the land tax revision. The inconsistencies in the official data seem to have been most significant for the periods just before and just after *Chio-chosa,* the survey of arable land carried out early in the Meiji period. Thus the figures Ohkawa used for the early years of Meiji were very probably underestimated as Ohkawa himself has pointed out. The estimates in the present paper are also based essentially on the official crop data, but prefectural data have been used in order to make adjustments for the inconsistencies mentioned above. James Nakamura has attempted to demonstrate that the increase in output in this period was between .8 and 1.2 per cent, but the basis for this low figure seems wholly inadequate (*32*). He has completely neglected the official data for the period before 1920 and has relied instead on some scattered data from the pre-Meiji period and on a few government statements, for instance, on a memorandum issued by the Meiji government in July 1873, "Instruction Notes for Local Government" (Dajōkan-fukoku 272 bessatsu: chihōkan-kokoroesho).

This memorandum contained an example of the computation of the value of a paddy field which assumed a paddy rice yield of 1.6 koku. It is this figure which Nakamura regards as an expected average yield. There is, however, an earlier statement in the instruction note to the effect that the "following procedures are merely instructions for computing the field value . . . and do not rest upon the real situation." Following intensive surveys under the supervision of the central government carried out during the period 1874–81, *The Summary Report of Prefectural Land Value Revision* (*21*) was issued in February 1882. The average rice yield shown in this publication was 1.3 koku per ton. This figure would seem to be considerably more reliable than the assumed figure of 1.6 koku used in the memorandum issued before the surveys. Even the 1.3 koku yield may have contained an upward bias because it was an average for *heinen,* i.e., years which exclude those with abnormal climatic conditions. Toshio Furushima has suggested that the average yield of *heinen* may well have been higher than the average of all years under consideration (*2*). Thus it seems difficult to justify attaching higher reliability to the fragments of information on which Nakamura bases his estimate than to the official data. Further investigations aimed at clarifying the level of agricultural productivity in the early Meiji period, based on evidence relating to the level of food consumption and the diffusion of improved rice varieties, was presented in a paper by the present author and Yujiro Hayami (*60*).

Moreover, such a low figure is difficult to reconcile with the fact that the Japanese agriculture was able to meet the increasing demand for food resulting from population growth and rising incomes with very little reliance on imports whereas the increase of output of .8 per cent in Phase II (1915–19 to 1935–39) was associated with substantial and increasing dependence on imported food supplies.

respectively. These growth rate figures are very moderate as compared with the rates of increase in farm output. It is to be noted that the rate of increase in use of conventional inputs was the same in Phases I and II in spite of the fact that the rate of increase in farm output was approximately twice as large during Phase I. This is an important point in clarifying the positive role that agriculture played in the economy during the decades between 1880 and 1920. During Phase III, the conventional input index declined until the end of the war, increased after that, and had a slight declining trend for the whole period which corresponded with a decline of farm output during the war and early postwar years. The rate of growth in the use of conventional inputs in Phase IV was more than five times as high as in Phase I or II. Thus the striking increase in gross output in Phase IV was, contrary to the case of Phase I, heavily dependent upon the increased use of conventional inputs. This is the reason, of course, why the growth rate of net output was only about half of that of gross output in Phase IV. The annual rates of change in gross output, net output, and in the use of conventional inputs are summarized in Table 3.

The changing relationship from period to period between the rates of growth of output and of conventional inputs are naturally reflected in different rates of change in productivity and unexplained output. Thus the index of conventional input productivity rose from 100 to 169 in Phase I, from 169 to 192 in Phase II, decreased from 192 to 150 in Phase III, and finally increased from 150 to 205 in Phase IV. The annual growth rates were 1.49, 0.49, −2.77, and 3.05 per cent respectively. (See Table 5 below.) The unexplained output measured in 1955 prices rose from zero to 439 billion yen in Phase I, from 439 to 615 billion yen in Phase II, fell from 615 to 340 billion yen in Phase III, and increased from 340 to 814 billion yen in Phase IV. The computed annual growth rates were 21.42 per cent from 1882 to 1897 and 5.12 per cent from 1897 to 1917 in Phase I, 1.38 per cent in Phase II, −6.50 per cent in Phase III, and 8.93 per cent in Phase IV. (See Table 9.)

The rapid rates of increase in productivity and in unexplained output in Phases I and IV indicate that the expansion of agricultural output in these periods was influenced strongly by technical progress. The much smaller rates of increase in Phase II suggest that technical progress was relatively stagnant during this period. It is of interest that the rate of increase in conventional in-

TABLE 3.—ANNUAL PERCENTAGE GROWTH RATES OF OUTPUT AND CONVENTIONAL INPUT IN DIFFERENT PHASES*

Index	Phase I 1882–1917	Phase II 1917–1937	Phase III 1937–1947	Phase IV 1947–1957
Gross output	1.78	.80	−2.79	4.51
Net output	1.37	.69	−1.78	2.14
Conventional input	.28	.28	− .03	1.41

* Computed from annual data for series shown in Tables 1 and 2. Computed by fitting $x = a(1 + r)^t$ to respective variable x, where a is a constant, r is annual rate of growth, and t is year. The estimated rates are statistically significant. Five-year moving averages of respective variables were used in fitting the data.

The indicated years for each phase are the midpoints of the first and last five-year periods included.

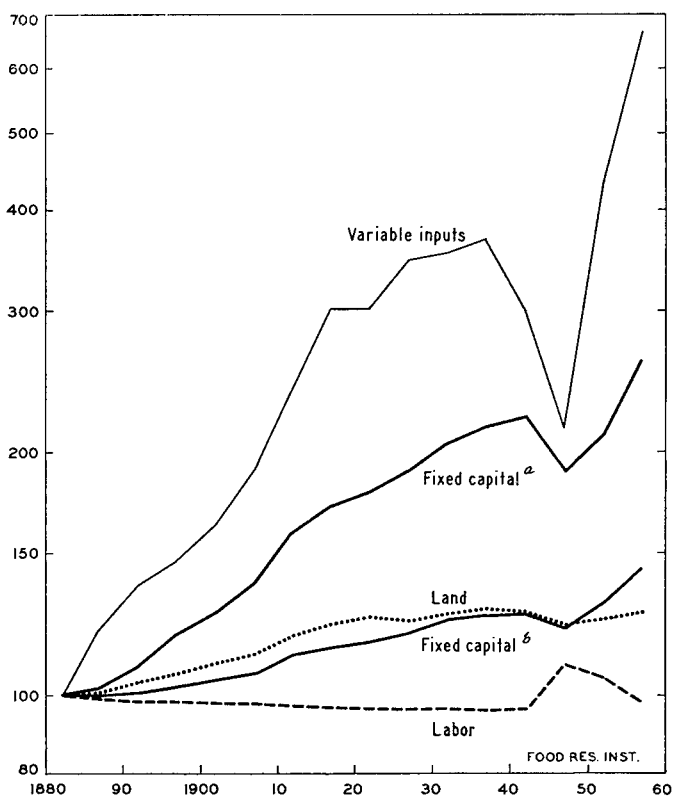
puts was the same in Phase I and Phase II, but as a result of the more pronounced increase in output per unit of input the rate of increase in agricultural production was twice as high in Phase I as in Phase II. During the war-dominated years of Phase III, there was virtually no change in the aggregate index of conventional inputs, but wartime shortages of fertilizers and other essential inputs disrupted agricultural efficiency and led to a considerable decrease in farm output. Finally, in Phase IV there was rapid increase both in conventional inputs and in productivity. Gross output increased at the remarkably rapid rate of 4.5 per cent annually; but owing to the substantial increase in the use of purchased inputs, the growth rate of net farm output was not quite half as rapid as the expansion of gross output.

Changes in the Use of Various Types of Inputs in Different Phases of Japan's Agricultural Development

The rates of change in utilization of the various categories of conventional inputs varied substantially from phase to phase as shown by Chart 2 and Table 4.

CHART 2.—CHANGES IN INDEXES OF RESPECTIVE INPUTS*

(1880–84 = 100, 1955 prices)



* Data from Appendix Table II.
[a] Excluding buildings.
[b] Including buildings.

TABLE 4.—ANNUAL PERCENTAGE GROWTH RATES OF CONVENTIONAL INPUTS IN DIFFERENT PHASES*

Input	Phase I 1882–1917	Phase II 1917–1937	Phase III 1937–1947	Phase IV 1947–1957
Labor	− .20	− .01	1.83	−1.36
Fixed capital				
Including building	.43	.52	− .46	1.70
Excluding building	1.66	1.24	−1.44	3.62
Variable inputs	2.93	1.15	−6.76	12.02
Land acreage total	.60	.15	− .54	.35
Paddy field	.27	.34	− .43	.31
Upland field	1.02	− .05	− .67	.39

* Computed from annual data for series shown in Table 1, according to the method described in Table 3. The indicated years for each phase are the midpoints of the first and last five-year periods included.

And the rates of change in productivity of individual factors, computed by dividing the index of gross farm output by the index numbers of the various factor inputs, also showed marked differences in the various phases as is shown in Table 5. As noted earlier, the labor input remained at approximately the same level throughout the entire period while gross farm output increased by three times so that labor productivity also registered a threefold increase. During the 40 years of Phase I there was a slow and steady decrease in the labor input at a rate of .20 per cent and its productivity doubled. Although this rate of decline was very small, agriculture played a significant role in supplying labor to other industries since virtually all of the natural increase in agriculture migrated to other sectors (*50*). In Phase II the labor force remained at about the same level but increased a little during the great Depression. During Phase III there was an increase in the farm labor force, especially immediately after the end of World War II as a result of the wartime bombing of cities, demobilization of military personnel, and other abnormal conditions. It was impossible for this sharply increased agricultural labor force to be employed very productively, given the inelastic supply of land and scarcity of fertilizers and other current inputs. Thus it is not surprising that the productivity of labor declined considerably. In Phase IV, the farm labor force diminished at an unprecedented rate of 1.3 per cent annually. This has been a result of the rural exodus associated with rapid development of the Japanese economy. Also significant, of course, is the fact that by this time the nonfarm sectors weighed more heavily in the total economy so that the rapid expansion of nonfarm output meant that the increase in the number of jobs available outside agriculture was large.

The scope for increasing the land input in Japan was strictly limited. The total area of arable land increased by only 27 per cent in 80 years, and it reached almost its present level by the end of Phase I. Thus, increase of land area contributed to a certain degree to the increase of farm output in Phase I, but it was of minor importance in the other phases. Expansion of upland fields accounted for a major part of the increase in land area during Phase I, but there was virtually no change in the area of upland fields between that time and the 1955–59 period. Paddy fields, however, showed a slight increase (Table 1).

TABLE 5.—ANNUAL PERCENTAGE GROWTH RATES OF PRODUCTIVITY IN DIFFERENT PHASES*

Input	Phase I 1882–1917	Phase II 1917–1937	Phase III 1937–1947	Phase IV 1947–1957
Conventional inputs	1.49	.49	−2.77	3.05
Labor	1.86	.81	−4.54	5.84
Fixed capital				
Including building	1.34	.27	−2.35	2.76
Excluding building	.11	−.44	−1.37	.85
Variable inputs	−1.12	−.45	4.25	−6.71
Land	1.17	.64	−2.27	4.14

* Computed by dividing the annual growth rate of gross output in Table 3 by those of conventional inputs in Tables 3 and 4. The indicated years for each phase are the midpoints of the first and last five-year periods included.

Technical progress in Japanese agriculture emphasized yield-increasing innovations, and land productivity increased 2.2 times over the 80-year period. The increase in crop yields was aided by an appreciable improvement in the quality of land as a result of land improvement measures. Those changes are examined later, but unfortunately it is not possible to express them quantitatively. The annual growth rates of land productivity were 1.17 and 0.64 per cent during Phases I and II and 4.14 per cent during Phase IV. Under the abnormal conditions of Phase III, land productivity declined at an average rate of a little over 2 per cent annually.

Fixed capital, including farm buildings, increased moderately during Phases I and II, declined in Phase III, and increased at an accelerated rate during Phase IV. The annual rates of change during the four phases were .43 per cent, .52 per cent, −.46 per cent, and 1.7 per cent. The increase in fixed capital exclusive of farm buildings increased at about the same rate as farm output, the rate of change in its productivity was fairly small. The rate of increase of farm output was considerably more rapid, however, than the increase in fixed capital including farm buildings in Phases I and IV so that there was an annual growth rate of 1.34 per cent and 2.76 per cent in those two phases respectively in the productivity of total fixed capital (Table 5).

Variable inputs showed a really striking increase. During the entire period the use of this category of inputs increased seven times. During Phase I variable inputs increased at an annual rate of nearly 3 per cent; the level of use during the years 1915–19 was three times as high as during the 1880–84 quinquennium. During Phase II the rate of growth was only 1.15 per cent. Under the conditions of Phase III the use of variable inputs declined at an annual rate of close to 7 per cent, certainly a major factor in the wartime decline in agricultural output. During Phase IV the use of variable inputs increased at the phenomenal rate of 12 per cent annually (Table 4). This was associated in part with the rapid return to prewar levels, but by 1955–59 the use of all variable inputs was nearly twice as high as during the prewar peak. Throughout the entire period fertilizers were the major item in the category of variable inputs, but in the years since World War II there has been extremely rapid increase in the use of chemical pesticides, vinyl sheeting for covered nursery beds, and other materials that had been of

little or no importance in prewar years. Since the rate of increase in variable inputs was much more rapid than the rate of growth of farm output, the computed productivity of this category of inputs naturally shows a decline, especially in Phase IV. This, together with the fairly rapid increase in inputs of fixed capital, accounts for the fact that the growth in net agricultural output in Phase IV was substantially less than the increase of gross output.

Changes in Production Patterns of Japanese Agriculture—Interrelationships Between Various Conventional Inputs

In the previous section changes in various categories of conventional inputs have been examined in relation to the concurrent changes in farm output. In order to clarify the factors responsible for the changes in output and productivity, it is also necessary to investigate the interrelationships among the various categories of conventional inputs. For this purpose, several types of analysis are undertaken.

The first approach is a correlation analysis. The correlation coefficients between various pairs of conventional inputs, which are shown in Table 6, give an indication of the direction (complementary or substitutional) and the degree of interrelationship between the various categories of conventional inputs. In general, the correlation coefficients between labor and the other inputs is negative and close to one, indicating a strong substitutional relationship. On the other hand, a high degree of complementarity among the other inputs is indicated by positive correlation coefficients which again are close to one for most periods. It is of some interest that the correlation coefficients were highest in Phase IV, next highest in Phase I, and lowest in Phase II. This order is exactly the same as that of the growth rate of output. It is also to be noted that the coefficients were high even in Phase III. During this abnormal period, however, all the inputs except labor were reduced and these negative changes in input levels were associated with a significant decline of output.

The second approach is the conventional one of measuring changes in the ratio of one factor input to another—capital per head, capital per unit of land area, and the man / land ratio. The indexes of these ratios are easily obtained by dividing one index by another. (The indexes for various inputs and of their

TABLE 6.—CORRELATION COEFFICIENTS BETWEEN SPECIFIED CONVENTIONAL INPUTS IN DIFFERENT PHASES*

Coefficient between	Phase I 1882–1917	Phase II 1917–1937	Phase III 1937–1947	Phase IV 1947–1957
Labor and fixed capital	−.922	−.020	−.981	−.984
Labor and variable inputs	−.931	−.118	−.844	−.965
Labor and land	−.963	−.161	−.927	−.982
Land and fixed capital	.992	.813	.946	.997
Land and variable inputs	.983	.561	.953	.995
Fixed capital and variable inputs	.981	.910	.853	.995

* Five-year moving average of the specified variables were used for the calculation of the correlation coefficients. For sources of basic data see preceding tables. The indicated years for each phase are the midpoints of the first and last five-year periods included.

productivity are given in Appendix Tables II and III.) The index representing the ratio of fixed capital per head rose from 100 to 124 in Phase I, from 124 to 138 in Phase II, declined from 138 to 111 in Phase III, and increased again from 111 to 150 in Phase IV. The annual growth rates were .63, .53, −2.29, and 3.06 per cent respectively. The rate of change in the indexes representing the ratio between variable inputs and labor and between land and labor were computed in similar fashion. The annual rates of change for variable inputs per head were 3.13, 1.16, −8.59, and 13.38 per cent for the four periods. The ratio of land to labor changed at annual percentage rates of .80, .16, −2.37, and 1.71 respectively. The change in the ratio of variable inputs to land area was 2.33, 1.00, −6.22, and 11.67 per cent. Thus, the increase in the ratio of capital to other inputs was an important factor in raising their productivity.

It is commonly assumed that the increase in labor productivity in the course of development will be associated with an increase in the value of capital per unit of labor. This tendency is clearly evident in the development of Japanese agriculture, although the predominant position of labor among the factor inputs in Japanese agriculture was modified only slowly. (See Table 7 below.) In an effort to further clarify these relationships between labor productivity and capital per head, estimates have been made of the relationship between labor productivity (p) and total farm capital per head (k) in each of the four phases, using the relation $p = ak^b$. For this purpose total capital is defined to include the value of fixed capital and variable inputs[7] and also the value of land which was estimated by multiplying the area in paddy fields and upland fields by their respective prices in 1955. The resulting estimates are as follows:

$$\text{Phase I (1882–1917):} \quad p = 0.0106 \cdot k^{(0.205)}_{2.682} \qquad R^2 = 0.834$$

$$\text{Phase II (1917–1937):} \quad p = 0.0127 \cdot k^{(0.211)}_{2.552} \qquad R^2 = 0.885$$

$$\text{Phase III (1937–1947):} \quad p = 0.0412 \cdot k^{(0.106)}_{1.792} \qquad R^2 = 0.970$$

$$\text{Phase IV (1947–1957):} \quad p = 0.0162 \cdot k^{(0.074)}_{2.532} \qquad R^2 = 0.992$$

The standard errors of the regression coefficients are shown in parentheses and the R^2's are the coefficients of determination. If we neglect Phase III because of the extraordinary wartime conditions, the estimates reveal some interesting characteristics throughout the entire period. It is to be noted first that the constant term increased during the period. This means that the efficiency level of k to p has increased in the course of agricultural development. The second interesting feature is that the regression coefficients were considerably larger than unity, indicating the existence of increasing returns to capital inputs.[8] The slight decline in the regression coefficients for the three phases suggests that the degree to which increasing returns to capital prevailed declined slightly from Phase I to Phase IV.

[7] It is assumed that the recovery period for variable inputs was one year so that the value of those inputs is simply added to the annual cost of fixed capital estimated by the procedure described in Footnote 4.

[8] The capital defined here includes land as well as reproducible capital. In this type of production function the capital input is a proxy variable and reflects the influence of technical progress. That is, the production elasticity for capital is almost certainly overstated because of specification bias that results from the intercorrelation between technical change and investment.

Finally it is to be noted that the R^2's were high and increased during the period. (In this case Phase III was not an exception.)

The above analysis suggests that in the course of time capital became a more important factor in explaining the changes in labor productivity. It was stated earlier that a production function analysis was not being used in this paper. These regression equations, however, are in a sense a kind of production function. And the increase in the constant term and the fact that the coefficient of regression was much larger than unity indicate that considerable technological progress must have been taking place.

The foregoing emphasis on the role of capital and increasing labor productivity in Japanese agriculture does not contradict the view put forward by Johnston and others that the most striking implication of Japan's experience is that it is both possible and desirable to emphasize a relatively labor-intensive, capital-saving approach to agriculture and to give a certain priority in the allocation of capital funds and foreign exchange to strategic investments to improve the economic infrastructure and to promote industrial expansion (*24, 25, 26,* and *27*). The reason is that, broadly speaking, the increase in fixed capital actually required relatively little in the way of scarce capital funds or foreign exchange, at least in the prewar period. The increase in capital items such as trees, tea bushes, and livestock was mainly achieved by an intensive input of labor which was relatively abundant in the agricultural sector. And the increase in small tools and implements was supplied mainly by small-scale enterprises in rural areas and by part-time work in subsidiary occupations by farmers themselves. Moreover, the weight of fixed capital to total inputs remained at very nearly the same level during the entire period so that the increase of capital intensity as represented by fixed capital was in fact very moderate (Table 7). There was a substantial increase in the relative importance of inputs of variable capital, especially fertilizers, and the supply of those items required considerable quantities

TABLE 7.—SPECIFIED INPUTS AS PERCENTAGES OF TOTAL CONVENTONAL INPUTS, AT 1955 PRICES, 1880–1959*

		Capital			Land			Total
Average	Labor	Total	Fixed capital	Variable inputs	Total	Paddy fields	Upland fields	conventional inputs
1880–84	59.1	22.5	18.1	4.4	18.4	13.2	5.2	100
1890–94	57.0	24.2	18.1	6.1	18.8	13.3	5.5	100
1900–04	55.2	25.5	18.5	7.0	19.3	13.3	6.0	100
1910–14	51.6	28.8	18.9	9.9	19.6	13.2	6.4	100
1915–19	49.5	30.8	18.8	12.0	19.6	13.0	6.6	100
1920–24	48.9	31.1	19.0	12.1	20.0	13.3	6.7	100
1930–34	47.6	32.8	19.5	13.4	19.6	13.4	6.2	100
1935–39	46.6	33.8	19.6	14.2	19.7	13.3	6.4	100
1940–44	48.4	31.8	20.1	11.7	19.8	13.4	6.4	100
1945–49	54.7	26.7	18.6	8.1	18.6	12.6	6.0	100
1950–54	48.9	33.7	18.5	15.2	17.4	11.8	5.6	100
1955–59	42.0	41.2	19.2	22.0	16.8	11.4	5.4	100

* Computed by dividing the weighted index of each of the specified inputs by the conventional input index.

of scarce resources; but the analysis in the following sections tends to confirm earlier conclusions that very high returns accrued to these increased inputs of variable capital. Thus, Japanese agriculture did not require large amounts of scarce capital funds or foreign exchange and was able to supply capital to the other sectors, in part through a heavy land tax (*48,* p. 375).

Finally, it is important to analyze the changes in the composition of factor inputs. In Table 7, we can see the relative weight of various conventional inputs and also observe the degree of factor substitution which took place in each phase. Broadly speaking, Japanese agriculture in the prewar days had a labor-using production pattern. In Phase I, however, the weight of labor in total conventional inputs decreased from 59 to 50 per cent, an increased input of capital, mainly variable inputs, being substituted for labor. There was a very slight increase in the relative weight of land inputs. In Phase II, the composition of farm inputs scarcely changed at all, although there was a little substitution of capital for labor. Phase III was characterized by a backward pattern of change in which the labor input increased from 47 to 55 per cent, being substituted for land and capital inputs, especially variable inputs. In Phase IV, the labor input decreased from 55 to 42 per cent and the land input decreased from 20 to 17 per cent whereas the capital input increased from 27 to 41 per cent. The increase in variable inputs was especially marked; between 1945–49 and 1955–59 they increased from 8 to 22 per cent of total conventional inputs.

The production patterns in Japanese agriculture can be characterized on the basis of the changes in the relative importance of the different conventional inputs and in the rate of technological progress in the four phases. Thus Phase I was a *phase of modernization.* A considerable increase in farm output resulted from significant technological progress with only a moderate increase in the use of conventional inputs. Capital was substituted for labor to some extent. Land area increased a little but much less than output so that land productivity rose by 50 per cent. The doubling of the productivity of labor between 1880–84 and 1915–19 reflected the fact that the farm labor force declined almost 10 per cent while gross farm output registered an increase of close to 90 per cent. Phase II was the *phase of relative stagnation.* The retardation of farm output occurred because of a slowing down of technological progress. Conventional inputs increased moderately at about the same rate as in Phase I, but the increase in capital and land inputs slowed down and the ratio of these inputs to labor scarcely changed.[9] As a result of the effects of wartime and postwar dislocations, Phase III was a *phase of backwardness.* Finally, Phase IV can be characterized as the *phase of increasing capital intensity.* Technological progress was rapid and conventional inputs increased considerably with the result that gross farm output expanded rapidly. The capital input increased sharply and was substituted for labor and even land inputs with the result that the productivity of labor and land rose sharply. Net output, however, did not increase nearly as rapidly as gross output, mainly because variable inputs increased at the extremely rapid rate of 12 per cent annually.

[9] The annual increase in variable inputs declined from nearly 3 per cent to just over 1 per cent, and the farm labor force showed virtually no change as compared to an average decline of .2 per cent per year during Phase I.

II. CHANGES IN NONCONVENTIONAL INPUTS AND THEIR INFLUENCE ON AGRICULTURAL OUTPUT AND PRODUCTIVITY

In the first half of this paper it was demonstrated that there was a significant increase in the productivity of conventional inputs, or in the magnitude of "unexplained output" in the course of Japan's agricultural development. Similar studies of American agriculture have also shown a significant rise in factor productivity (*4, 9, 29, 30,* and *40*).

It has also been emphasized that the increase in agricultural output and productivity is the result of complex interactions between the management decisions and performance of individual farmers and factors external to the farm that condition the production possibilities available to farmers, notably through determining the level of technical knowledge and the technologies and nonfarm inputs available to farmers. Descriptive studies of agricultural development in Japan indicate that government programs relating to agricultural research, extension activities, and education have been crucially important in making possible the gains in output per unit of input that have accounted for such a significant part of the increase in farm output in Japan (*24, 25, 26, 27, 34, 37, 46,* and *48*). It must be recognized that the interrelationships between the conventional and nonconventional inputs are of crucial importance (*28*). After examining the changes in the various nonconventional inputs and their relationship to changes in factor productivity, an attempt is made to evaluate the complementarities that exist between the conventional and nonconventional inputs.

Definition and Classification of Nonconventional Inputs

Study of the "nonconventional inputs" poses more difficult problems than the study of changes in the conventional inputs of land, labor, and capital. For present purposes the nonconventional inputs significant to agricultural development will be studied in terms of the following categories:

(1) agricultural research
(2) diffusion of knowledge relating to agricultural technologies
(3) public services for agriculture
(4) agricultural infrastructure
(5) general administration associated with the agricultural sector
(6) rural education

Any attempt to define and classify nonconventional inputs must be somewhat arbitrary and unsatisfactory because of certain conceptual problems as well as the difficulty of obtaining the desired statistical data. The results accruing from agricultural research by government and private industry are, of course, influenced significantly by the general level of knowledge of basic science and research techniques. Similarly, the "diffusion" activities that foster the adoption of new or improved techniques by farmers are not limited to agricultural extension activities and incentive payments by government. The efforts by individual farmers or farm organizations to obtain new technologies are also important. The rate and extent of diffusion will also be influenced by the quality of transport and communications facilities and other factors influencing the movement of people and information.

As a result of the conceptual difficulties and because of the problems related to the availability of data, the present study is limited to an analysis of expenditures by the central and local governments for the six categories of nonconventional inputs listed above. An attempt was made to estimate social overhead investment in transportation and communications, but the results were extremely questionable and the effort was abandoned. The failure is not too surprising considering the inherent difficulties involved in allocating this type of outlay for general infrastructure to a particular sector. It would have been desirable to include estimates of agricultural research expenditures by private industry, but adequate data for estimating private research activities are not available. Although the approach adopted can be criticized on the grounds that it is not sufficiently inclusive, it has an obvious advantage: the scope of the nonconventional inputs to be considered can be clearly defined. Moreover, there is good reason to believe that the nonconventional inputs analyzed here were of strategic importance in making possible the increases in factor productivity in Japanese agriculture. It will be noted shortly, however, that during the early years of the Meiji period informal diffusion activities were probably more important than government-supported research or diffusion programs (*59*).

Estimation of Government Outlays for Nonconventional Inputs

Among the basic data for the estimation of the nonconventional inputs, the most reliable and detailed data are those relating to expenditures for agriculture by the central government (*15*). Our estimation of the nonconventional inputs started with a breakdown of those expenditures into the six categories listed earlier and which are discussed in more detail in Appendix I. There are certain difficulties in arriving at satisfactory estimates. Expenditures were often overlapping so that it was necessary to decide, somewhat arbitrarily, into which category an item of expenditure should be classified. Another difficulty is that expenditures classified in the same budget category were actually intended for different purposes in different time periods, and there is always a possibility of missing such changes. The classification of expenditures was made as carefully as possible, but some errors have undoubtedly been made in consolidating the data for the present purpose.[10]

Changes in the Various Nonconventional Inputs

During the eight decades from 1880 to 1959, the nonconventional inputs in Japanese agriculture increased tremendously. Table 8 shows changes in the total government outlays for nonconventional inputs and for the various categories described in the preceding section. The total rose from an annual average of six billion yen at 1955 prices during the years 1880–84 to 219 billion or about 37 times the initial level by 1955–59. The nonconventional inputs classified as "agriculture proper" rose from .6 billion to 134 billion whereas expenditures for "rural education" increased from 5 to 85 billion yen. The most striking increase was in the outlays for agricultural infrastructure which were still negligible at the turn of the century but rose to 85 billion yen, or nearly 40 per cent of the total out-

[10] The major items included in each category of the nonconventional inputs are described in Appendix I.

TABLE 8.—CHANGES IN THE NONCONVENTIONAL INPUTS IN JAPANESE AGRICULTURE, 1880–1959*

(Million yen at 1955 prices)

	Agriculture proper								
			Proximate support						
Average	Agricultural research	Diffusion	Public service	Infra-structure	Total	General	Total	"Rural education"	Total
1880–84	98	159	117	—	117	190	564	5,333	5,897
1885–89	27	289	204	—	204	118	638	5,361	5,999
1890–94	269	99	216	1	217	66	652	5,636	6,287
1895–99	455	144	367	1	368	35	1,002	7,454	8,456
1900–04	786	836	454	179	633	37	2,292	10,898	13,011
1905–09	918	1,396	543	1,126	1,669	37	4,020	13,219	17,239
1910–14	951	1,592	1,156	5,400	6,556	41	9,140	16,033	25,173
1915–19	1,283	1,241	758	8,052	8,810	71	11,405	16,650	27,950
1920–24	1,748	2,791	1,135	13,078	14,213	131	18,883	26,036	44,919
1925–29	1,414	3,035	2,486	18,591	21,077	258	25,784	44,897	70,681
1930–34	1,943	3,856	3,109	21,080	24,189	1,599	31,581	45,896	77,477
1935–39	2,350	7,179	2,418	17,215	19,633	4,823	33,985	34,897	68,882
1940–44	1,601	54,873	1,745	26,072	27,817	3,620	87,911	22,793	110,704
1945–49	2,176	21,059	1,390	29,090	30,480	8,655	62,370	35,683	98,053
1950–54	4,783	24,396	2,592	67,636	70,228	16,880	116,287	75,484	191,771
1955–59	7,469	20,666	3,168	84,892	88,060	18,065	134,260	85,050	219,310

* See text for definitions and description.

lays for nonconventional inputs by the end of the period. Agricultural research and especially diffusion also increased greatly.

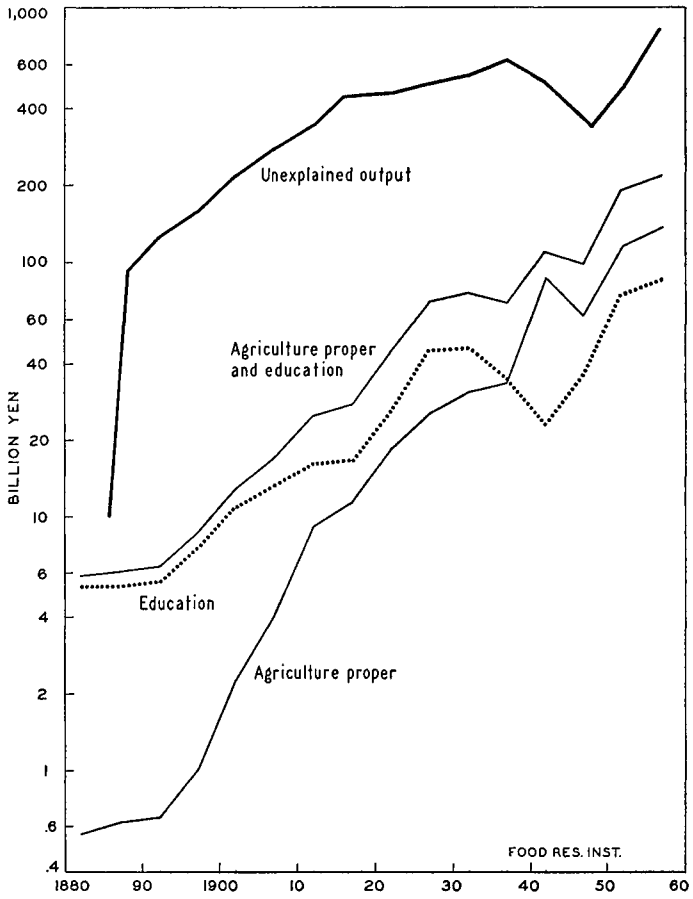
One approach to indicating the order of magnitude of these outlays for nonconventional inputs is to compare the level of government expenditure for these purposes with the net value of farm output in corresponding periods. Thus it may be noted that during Phase I the total outlays for nonconventional inputs rose from 1.2 per cent of net farm output in 1880–84 to 3.3 per cent of the total in 1915–19. The corresponding percentages for nonconventional inputs for agriculture proper, i.e., excluding outlays for rural education, were .1 per cent in the initial five-year period and 1.4 per cent at the end of Phase I. During the final five-year period of Phase IV, the total expenditures for nonconventional inputs amounted to 20 per cent of net farm output and the outlays for agriculture proper alone were equal to 12.5 per cent of net farm output.

Since it is being argued that the government outlays for nonconventional inputs were of strategic importance in making possible the increase in farm productivity and unexplained output that were explained in the first part of the paper, it is more meaningful to compare the outlays for nonconventional inputs with the estimated magnitude of unexplained output in various periods. During the years 1915–19 government expenditures for nonconventional inputs represented only 6 per cent of the estimated unexplained output. During the 1935–39 period, the end of Phase II, the outlays for nonconventional inputs were equal to 11 per cent of the unexplained output, and the 219 billion yen devoted to nonconventional inputs in 1955–59 amounted to 27 per cent of unexplained output for those years. Of greater interest than these comparisons of the magnitude of expenditures for nonconventional inputs and of unexplained output in selected periods is a comparison between the rates of change in the two variables in different phases of Japan's agricultural development as discussed in the following paragraphs.

The changes in unexplained output are shown in Chart 3 together with the changes in expenditures for the major categories of nonconventional inputs. A vertical logarithmic scale is used to facilitate comparison of the rates of change in these variables. The growth rates for expenditures for different types of nonconventional inputs within the "agriculture proper" category are shown in Chart 4. Outlays for public service and agricultural infrastructure are lumped together for this purpose, as throughout much of this section, as a combined category referred to as "proximate support."

The annual rates of change in unexplained output and in outlays for various categories of nonconventional inputs are shown in Table 9 for the four phases into which Japan's agricultural development has been divided. In this table, however, Phase I is divided into two subphases—1882–97 and 1897–1917. There were marked differences in the trends of unexplained output and in nonconventional inputs in those two subphases which are considered later. The striking feature of subphase 1882–97 is the remarkably rapid rate of increase in unexplained output—21 per cent per annum—associated with an annual growth rate of only 1.4 per cent in expenditures for nonconventional inputs for the same subperiod. Other factors, to be considered shortly, were almost certainly of primary

CHART 3.—CHANGES IN UNEXPLAINED OUTPUT AND NONCONVENTIONAL INPUTS*
(*5-year average, 1955 prices*)



* Data from Tables 2 and 8.

importance in accounting for the rapid rise in unexplained output in this initial period.

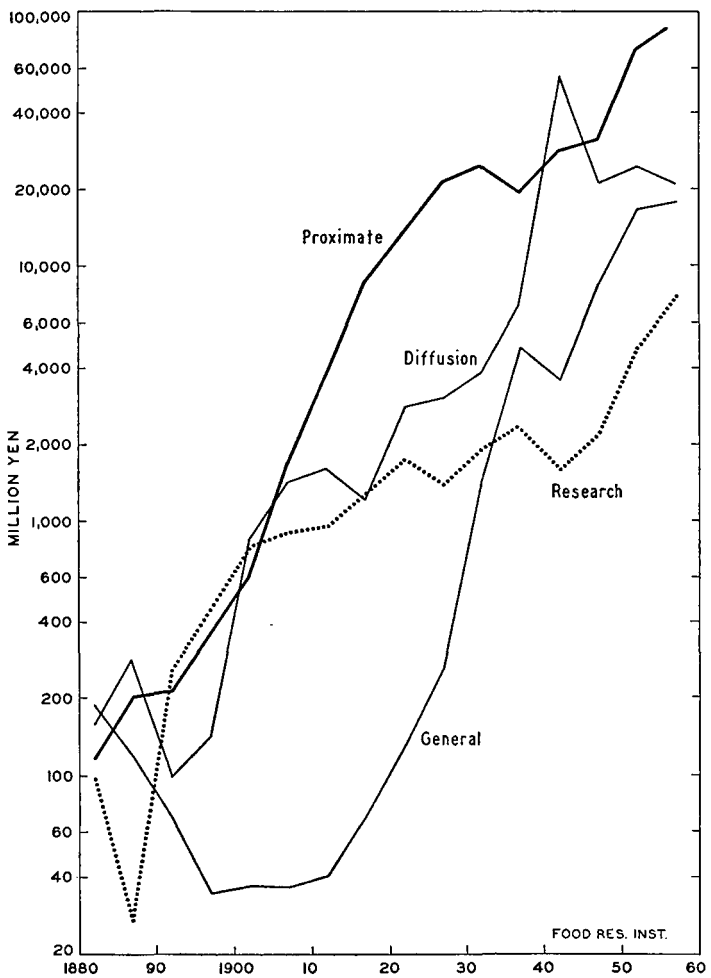
Except for this first subperiod of Phase I, the annual rate of growth in outlays for nonconventional inputs was larger than the rate of increase in unexplained output. This implies declining marginal productivity of the nonconventional inputs in aggregate. The rates of change for individual categories of nonconventional inputs are examined in more detail later. During the second subperiod of Phase I, 1897–1917, the rate of increase for the nonconventional inputs of 6.3 per cent annually was only a little larger than the 5.1 per cent rate of increase in unexplained output for the subperiod. During Phase II the annual growth rate of expenditure for nonconventional inputs declined a little to 5.1 per cent whereas the rate of increase in unexplained output fell abruptly to 1.4 per cent per year. During the war and early postwar years of Phase III the average annual rate of increase in nonconventional inputs was about the same

as during Phase II but, as noted earlier, output declined while total physical inputs were increased during this period so that the change in unexplained output was negative. Phase IV was characterized by a rapid increase of over 9 per cent per year in expenditures for nonconventional inputs while the rate of increase of unexplained output was nearly 9 per cent.

It is also apparent from Chart 3 and Table 9 that the rates of change in outlays for nonconventional inputs were quite different for the two major subcategories—the so-called "agriculture proper" inputs and expenditures for "rural education." In particular, it is to be noted that the outlays for agriculture proper increased at a rate of nearly 14 per cent during the last half of Phase I (1897–1917) and then declined abruptly to an average rate of 6 per cent for the two

CHART 4.—CHANGES IN RESPECTIVE NONCONVENTIONAL INPUTS FOR AGRICULTURE PROPER*

(5-year average, 1955 prices)



*Data from Table 8.

TABLE 9.—ANNUAL PERCENTAGE GROWTH RATES OF UNEXPLAINED OUTPUT AND NONCONVENTIONAL INPUTS IN DIFFERENT PHASES*

Output or input	Phase I 1882–1897	Phase I 1897–1917	Phase II 1917–1937	Phase III 1937–1947	Phase IV 1947–1957
Unexplained output	21.42	5.12	1.38	−6.50	8.93
Nonconventional inputs	1.37	6.26	5.06	5.09	9.24
Agriculture proper	2.33	13.98	6.04	8.18	9.79
Research	17.65	3.70	2.41	−4.23	13.71
Diffusion	− 5.80	8.87	6.87	12.68	3.62
Proximate	6.01	21.49	5.53	6.62	12.01
Public service	6.01	6.65	9.23	−8.48	7.22
Infrastructure	—	49.23	4.95	7.97	12.23
General	−12.14	2.41	23.46	5.23	9.23
Education	1.26	3.73	4.26	− .47	8.50

* Computed from annual data for series shown in Tables 2 and 8, according to the method described in Table 3. The indicated years for each phase are the midpoints of the first and last five-year periods included.

following decades. Conversely, expenditures for rural education increased more rapidly during Phase II than in Phase I. This suggests that the decline in expenditures for inputs in the agriculture proper category may have had a particularly significant bearing on the slow rate of increase in unexplained output in Phase II. Likewise there is a suggestion that the marginal returns to increased education expenditure as a factor influencing agricultural development were lower in Phase II than in Phase I. The major expenditures for education were for elementary schools until the post–World War II period. The percentage of children of school age receiving schooling increased sharply from 41 per cent in 1880 to 98 per cent in 1915. The rate of increase in coverage for children in rural areas was undoubtedly even more rapid than is suggested by these nationwide figures. There is a suggestion here that the rapid achievement of universal education leading to rapid increase in literacy and other basic skills may have been a rather strategic factor contributing to the increase of agricultural productivity in Phase I.

Within the category of "agriculture proper" inputs, the changes in outlays for agricultural research show a particularly close correlation with the changes in unexplained output. As shown in Table 9, the rate of change in government expenditure for research was remarkably similar to the rate of change in unexplained output in all four phases. Thus the annual rate of increase in outlays for research was very large in the first half of Phase I, moderate in the second half, decreased in Phase II, was negative in Phase III, and increased again at a rapid rate in Phase IV, corresponding closely to the increase in unexplained output. It is in fact rather surprising that the correlation between changes in outlays for agricultural research and in unexplained output was so very close, especially in view of the fact that there must be some lag between research inputs and their effect on factor productivity.

The close correlation between rates of change in outlays for agricultural research and the rate of increase in unexplained output certainly lends support to earlier qualitative studies of agricultural development in Japan that have empha-

sized the key importance of the breeding and selection of improved plant varieties and other types of research that contributed to significant increases in crop yields.

In the case of the sericulture industry, to cite one interesting example, research made major contributions at several levels to the phenomenal increase in factor productivity in that industry. Varietal improvement and better cultural practices, combined with higher rates of fertilization, raised the output of mulberry leaves, and the feeding value per acre of mulberry was further increased by better methods of gathering and feeding leaves. Even more important, research leading to the selection and breeding of superior races of silkworms made possible an increase in output of raw silk that was more than twice as large as the expansion in cocoon production. This last achievement was also associated with improvements in the hatching of silkworm eggs and the rearing of silkworms, notably the introduction of an autumn crop of cocoons made possible by the development of methods of hatching the eggs artificially. The net result was that the output of raw silk increased seventeenfold between the 1880's and the 1930's whereas there was less than a fourfold increase in the area planted to mulberry (*25,* pp. 229–30). With respect to varietal improvement for rice, the development of improved varieties by individual farmers during the Tokugawa and early part of the Meiji periods was of great importance, but from shortly after the turn of the century organized research was probably the major factor.

The effect of improved technologies on total farm output obviously depends on the widespread diffusion of those technologies among individual farmers. Thus the nonconventional inputs that promote the diffusion of new knowledge and technologies are important complements to agricultural research.

In the early part of the Meiji period, diffusion activities appear to have played a strategic role largely through facilitating the wide use of better plant varieties and techniques that had been developed by progressive farmers, the so-called *rōno,* in various parts of the country. Thomas C. Smith has documented the fact that significant improvements in farm techniques had been evolved by progressive farmers during the Tokugawa era (*43*). It can be safely inferred, however, that these improved techniques had not been widely diffused, in part because of the severe restraints of the feudal system on travel and communication. Hence, "the actual shift in the production function was much slower than the potential shift" (*7,* p. 51). The feudal restrictions were abolished following the Meiji Restoration, and considerable emphasis was given to measures to spread the improved farming techniques being practiced by leading farmers in different parts of the country (*59*).

During the 1880's, diffusion activities were the most important of the "agriculture proper" inputs during the years 1880–84 and 1885–89 respectively. During the 1890's, however, outlays for diffusion declined not only in relative but also in absolute importance so that this category shows a decline during the first subperiod of Phase I. Throughout this period, however, the improvements in transportation and communication undoubtedly facilitated the spread of improved varieties and farm techniques, and their wide adoption was accelerated by the removal of feudal restraints which had restricted the freedom of farmers to choose what crops to grow and even the variety of seed to be planted. As

shown in Table 9, outlays for diffusion increased during the second subperiod of Phase I and also in Phases II, III, and IV.

The most rapid rate of increase in outlays for diffusion was, in fact, during Phase III when total farm output and unexplained output were decreasing. The explanation for this apparent anomaly lies in the fact that the diffusion category includes incentive payments and certain kinds of subsidies for agricultural development. Depending on the particular circumstances, incentive payments or subsidies to farmers can be effective or ineffective in fostering increased productivity. As previously noted, the subsidy payments to farmers during and shortly after World War II were associated with the government's agricultural price control program and represented an effort to maintain some sort of production incentive for farmers while at the same time holding down the increase in retail food prices. It is not possible to make a breakdown within the diffusion category between subsidies and other types of expenditure, but it is clear from the figures in Table 10, which show subsidies as a per cent of central government expenditures for agriculture, that subsidy payments dominated government outlays for agriculture during this period; the figure exceeded 75 per cent in 1940 and was close to 80 per cent in 1945. Furthermore, as the wartime food situation became critical, expenditures for agriculture were enlarged, rising from 4.2 per cent of the total budget in 1937 to 14.3 per cent in 1945 (*39*, p. 100). And the increase in expenditures for agriculture was mainly in the diffusion category. Between 1935–39 and 1940–44 the outlays for diffusion increased eightfold; expressed in 1955 prices the increase was from 7 billion to 55 billion yen (Table 8).

Even the seven billion yen outlay in the late 1930's was large in comparison with the expenditures for diffusion activities in earlier periods. During the 1880's and 1890's diffusion outlays averaged less than 200 million yen. The average level of expenditure did not reach three billion yen until the 1925–29 period (again in 1955 prices); and in that period the diffusion expenditures amounted to a mere .35 per cent of the net value of farm output and only .6 per cent of the unexplained output.

A key to the fact that an effective extension program was carried out with such a modest budgetary burden seems to have been the way in which efficient use was made of a network of farm organizations associated with the existing

TABLE 10.—SUBSIDIES AS PERCENTAGE OF TOTAL EXPENDITURES FOR AGRICULTURE BY THE CENTRAL GOVERNMENT, SELECTED YEARS, 1895–1955*

Year	Per cent	Year	Per cent
1895	.0	1930	37.5
1900	3.8	1935	58.5
1905	5.0	1940	75.6
1910	12.2	1945	77.7
1915	8.3	1950	49.2
1920	15.3	1955	26.6
1925	11.4		

* Data for 1895–1949 from Japan, the National Diet Library (*23*, pp. 34, 124); data for 1955 from Japan, Department of Agriculture and Forestry (*17*, p. 98).

framework of local government. The first step was to give encouragement to local groups such as agricultural discussion societies or seed exchange societies that emerged spontaneously during the early years of Meiji. These groups were then organized on a more systematic basis and the establishment of such groups was promoted in the districts where they had not yet developed. At the turn of the century (1899), "the agricultural association law was enacted with a view to introducing and disseminating advanced farming techniques" (*34*, p. 248). Under this legislation, agricultural associations were organized on three levels—village or town, county, and prefecture. A few years earlier, in 1893, a national agricultural experiment station was established and the Rules Governing Prefectural Agricultural Experiment Stations were enacted. The latter rules transferred the task of agricultural extension from the hands of progressive farmers, the *rōno*, to the national and local agricultural experiment stations (*33*, *34*). With the passage of the Law of State Subsidy for Prefectural Agricultural Experiment Stations and the agricultural association law, the system was completed whereby agricultural guidance was carried out through the agricultural associations under the direction of the experiment stations (*34*, p. 303). The agricultural association law stipulated that the governor of each prefecture was to be the president of the prefectural association and the heads of counties or villages were to be the presidents of their respective county or village associations; landowners held the position of vice president at all stages of the organization. Thus "the Association on one hand became an official organization to carry out the Government's agricultural extension program while on the other hand it became an organization through which landowners were able to voice their interests" (*34*, p. 304).

The next category of agriculture proper inputs to be considered relates to expenditures for proximate support—public services to agriculture and agricultural infrastructure. The rate of increase in this type of expenditure was very high during the last half of Phase I, declined to a little over 5 per cent in Phase II, rose somewhat in Phase III, and increased considerably in Phase IV. The rapid increase during the second half of Phase I reflected a remarkably rapid increase in outlays for farm infrastructure which increased at an average annual rate of almost 50 per cent between 1897 and 1917. The government started an active program to promote land improvements in 1900 and considerable government funds were devoted to that purpose. Outlays for this type of infrastructure project increased much more slowly during Phase II whereas outlays for both categories of proximate support increased considerably during Phase IV.

The "general" category of agriculture proper inputs includes both general administrative expenditures and outlays for items which cannot be classified into other categories. It is therefore understandable that this category is relatively large during the initial phase both because of the overhead expenditures that were required to launch the Department of Agriculture, Forestry, and Commerce following its creation in 1880 and the fact that, as administration became more orderly, expenditures could be more easily classified according to specific objectives. Thus the outlays for general administration and other items in this category show a declining rate during the first subperiod of Phase I and increased at only a very slow rate during the second subperiod. During Phase

II, however, expenditures under this rubric show a rapid increase of over 23 per cent annually. The principal explanation for this turn of events seems to be that there was a considerable expansion in farm relief payments during the late 1920's and the 1930's. Initially, these outlays were intended to alleviate to some extent the financial plight of Japanese farmers that were facing painful competition from rice imports from Korea and Taiwan. Later these programs were expanded to counter to some extent the adverse effects on farm incomes of the Depression of the 1930's. Outlays in the general category were also fairly high during Phase IV, but the objectives were quite different. Basically, these outlays during Phase IV were aimed at the reorganization of farm production. In some instances the emphasis was placed on encouraging a shift from overwhelming reliance on staple food production to more diversified farming; elsewhere the emphasis was on encouraging specialized farming enterprises, particularly for dairy, livestock, and fruit production.

Interrelationships Among the Nonconventional Inputs

The varying rates of increase in expenditures for different types of nonconventional inputs implies that the composition of the package of nonconventional inputs in Japan changed considerably during the considered period. As noted earlier, the agriculture proper inputs increased much more rapidly than the outlays for rural education. It will be seen in Table 11 that during the last two decades of the 19th century outlays for agriculture proper inputs accounted for only about 10 per cent of the total whereas expenditures for rural education represented approximately 90 per cent of the total nonconventional inputs. By the end of Phase I, however, the agriculture proper inputs had increased to 40 per cent of the total.

In view of the recent emphasis upon education in relation to economic development, it is of interest that resources were concentrated so heavily on achieving universal primary education during the first subperiod of Phase I. During the second subperiod of Phase I outlays for agriculture proper inputs rose rapidly and, as noted above, amounted to just over 40 per cent during the 1915–19 quinquennium. After a bulge during World War II, the share of agriculture proper outlays in total nonconventional inputs leveled off at a little over 60 per

TABLE 11.—AGRICULTURE PROPER AND EDUCATION AS PER CENT OF TOTAL NONCONVENTIONAL INPUTS, 1880–1959*

Average	Agriculture proper	Education	Average	Agriculture proper	Education
1880–84	9.6	90.4	1920–24	42.0	58.0
1885–89	10.6	89.4	1925–29	36.5	63.5
1890–94	10.4	89.6	1930–34	40.8	59.2
1895–99	11.8	88.2	1935–39	49.3	50.7
1900–04	17.6	82.4	1940–44	79.4	20.6
1905–09	23.3	76.7	1945–49	63.6	36.4
1910–14	36.3	63.7	1950–54	60.6	39.4
1915–19	40.8	59.2	1955–59	61.2	38.8

* Computed from Table 8.

cent with rural education outlays amounting to a little less than 40 per cent of the total.

The changing composition of outlays for various types of agriculture proper inputs are summarized in Table 12. The dominant position of diffusion outlays during the first decade of Phase I that has already been mentioned is a conspicuous feature. During the next two decades a marked increase in the relative importance of agricultural research expenditures is evident. During the last decade of Phase I outlays for agricultural infrastructure were dominant, and that situation continued through Phase II. The increased emphasis on outlays for agricultural infrastructure that is evident following the turn of the century may have been related to a slowing down in the expansion of agricultural output at about that time. Perhaps the most conspicuous change during Phase II was the decline in the relative importance of outlays for agricultural research and even an absolute decline in this category during the five-year period 1925–29. Outlays for diffusion and general inputs on the other hand increased in absolute and relative importance. As already noted, however, this was associated with a considerable increase in the percentage of subsidies in total government expenditure for agriculture, and Japan's experience during this period suggests that this represented an inefficient way to promote increases in agricultural productivity and output.

The inappropriateness of the package of nonconventional inputs which resulted from the abnormal circumstances of the war years needs no further comment. Expenditures for agricultural infrastructure have been the largest category during Phase IV. Diffusion outlays were also large during Phase IV, but their high level during the 1945–49 period was strongly influenced by subsidy payments to farmers associated with the government's program of staple food price

TABLE 12.—PERCENTAGE COMPOSITION OF THE AGRICULTURE PROPER COMPONENT OF NONCONVENTIONAL INPUTS, 1880–1959*

Average	Agricultural research	Diffusion	Proximate support			General	Total
			Public service	Infrastructure	Total		
1880–84	17.4	28.2	20.7	—	20.7	33.7	100
1885–89	4.2	45.3	32.0	—	32.0	18.5	100
1890–94	41.3	15.2	33.3	—	33.3	10.1	100
1895–99	45.4	14.3	36.7	—	36.7	3.5	100
1900–04	34.3	36.5	19.8	7.8	27.6	1.6	100
1905–09	22.8	34.7	13.5	28.0	41.5	.9	100
1910–14	10.4	17.4	12.6	59.1	71.7	.4	100
1915–19	11.2	10.9	6.6	70.6	77.2	.6	100
1920–24	9.3	14.8	6.0	69.3	75.3	.7	100
1925–29	5.5	11.7	9.6	72.1	81.7	1.0	100
1930–34	6.2	12.1	9.8	66.7	76.6	5.1	100
1935–39	6.9	21.1	7.1	50.7	57.8	14.2	100
1940–44	1.8	62.4	2.0	29.7	31.6	4.1	100
1945–49	3.4	33.8	2.2	46.6	48.8	13.9	100
1950–54	4.1	21.0	2.2	58.2	60.4	14.5	100
1955–59	5.6	15.4	2.4	63.2	65.6	13.4	100

* Computed from Table 8.

controls. Outlays for research were relatively small during Phase IV, although their share was increasing in the latter part of the period.

As in the case of the conventional inputs, it is of interest to consider the complementarity among the various nonconventional inputs as indicated by correlation coefficients. In Table 13 the correlation coefficients between various pairs of nonconventional inputs are shown for each phase. It seems especially interesting to note the combinations that were highly correlated during Phases I and IV, when impressive increases in farm output and productivity were achieved, and to identify the combinations for which the correlation coefficients were low or negative during Phases II and III.

During Phase I the highly correlated combinations were research and education, diffusion and education, and research and diffusion. In Phase II, the combinations with low correlation coefficients were research and education, diffusion and education, and research and proximate support activities. The abnormal conditions of Phase III were associated with high but negative correlations between a number of the inputs. The highest positive correlation in that period was between research and education, which reflected the fact that both were decreased so their significant influence as complementary inputs was working in the wrong direction. During Phase IV, proximate and education, research and proximate, and research and education all were highly correlated. Thus it appears that the key combinations among the nonconventional inputs changed in the different phases of agricultural development. Only one combination of nonconventional inputs appears to have been of key importance during the entire period considered, i.e., the combination of research and education. Thus we have still another suggestive indicator of the strategic importance of those two nonconventional inputs.

III. INTERRELATIONSHIPS BETWEEN THE CONVENTIONAL AND NONCONVENTIONAL INPUTS

The procedure followed in the present paper has been to first analyze relationships between farm output and the conventional inputs, and then to examine the relationships between the "unexplained output" and the nonconventional inputs. Attention has also been given to the interrelationships among the conventional inputs and also among the nonconventional inputs.

TABLE 13.—CORRELATION COEFFICIENTS BETWEEN SPECIFIED NONCONVENTIONAL INPUTS, IN DIFFERENT PHASES*

Coeffcient between	Phase I 1882–1917	Phase II 1917–1937	Phase III 1937–1947	Phase IV 1947–1957
Research and diffusion	.857	.883	−.898	.532
Research and proximate	.757	.606	−.820	.975
Research and education	.951	.299	.665	.936
Diffusion and proximate	.707	.680	.648	.657
Diffusion and education	.938	.419	−.843	.641
Proximate and education	.825	.885	−.207	.980

* Five-year moving averages of the specified variables were used for the calculation of the correlation coefficients. The indicated years for each phase are the midpoints of the first and last five-year periods included.

In reality the increase in farm output has clearly been affected simultaneously by changes in conventional and nonconventional inputs and by interactions between the two types of inputs. It would thus be desirable to analyze relationships between changes in conventional and nonconventional inputs and in farm output simultaneously. Some models that included both kinds of inputs simultaneously were constructed and various computations made on that basis. Unfortunately, the results obtained do not appear to be meaningful, and an approach along that line has been deferred to another occasion.

That important complementarities exist between the conventional and nonconventional inputs is, however, beyond doubt. Consequently, an alternative approach has been adopted to throw some light on the nature of these complementarities. I have estimated correlation coefficients between the various components of the conventional and nonconventional inputs as an indication of the degree of the complementarity; it seems reasonable to infer that the higher the correlation coefficient the greater the degree of complementarity. The correlation coefficients (r's) for various combinations of conventional and nonconventional inputs are presented in Table 14.

An interesting finding is that, generally speaking, the degree of correlation corresponds fairly well to the pace of agricultural development. As we have seen

TABLE 14.—CORRELATION COEFFICIENTS BETWEEN CONVENTIONAL AND NONCONVENTIONAL INPUTS, IN DIFFERENT PHASES*

Coefficient between		Phase I	Phase II	Phase III	Phase IV
Nonconventional	Conventional	1882–1947	1917–1937	1937–1947	1947–1957
Research	Labor	−.954	−.147	−.339	−.963
	Land	.959	.950	.621	.995
	Fixed capital	.933	.884	.374	.993
	Variable inputs	.916	.684	.729	.998
	Average[a] : $\bar{r}$	.941	.666	.513	.987
Diffusion	Labor	−.838	−.421	.078	−.393
	Land	.872	.870	−.359	.492
	Fixed capital	.869	.865	−.056	.490
	Variable inputs	.807	.750	−.516	.528
	Average[a] : $\bar{r}$	.847	.727	−.252	.476
Proximate support	Labor	−.911	−.081	.779	−.889
	Land	.893	.487	−.903	.955
	Fixed capital	.931	.858	−.769	.951
	Variable inputs	.938	.891	−.903	.975
	Average[a] : $\bar{r}$	.918	.579	−.839	.942
Education	Labor	−.911	−.142	.343	−.829
	Land	.963	.130	−.027	.913
	Fixed capital	.963	.611	−.332	.912
	Variable inputs	.913	.771	.157	.940
	Average[a] : $\bar{r}$	.938	.414	−.136	.900

* Five-year moving averages of the specified variables were used for the calculation of the correlation coefficients.

[a] Simple average of individual coefficients with the sign for labor changed to the opposite sign.

already, there is relatively rapid progress in agricultural development in Phase I and Phase IV, and the absolute values of the r's for those two phases are very close to unity. On the other hand, Phase II was a period of stagnation, and the r's turn out to be considerably lower. In Phase III the farm output declined, and the r's either declined or became negative. A simple average of the r's in each phase, $\bar{r}$, indicates the average level of r for each nonconventional input with respect to the various conventional inputs. Except for the $\bar{r}$ with respect to the diffusion inputs in Phase IV, the differences in the $\bar{r}$'s for each phase correspond exactly to the pace of development.

So far as the various nonconventional inputs are concerned, research has the highest correlations with the conventional inputs, proximate the second, education the third, and diffusion the lowest. All r's of the first three nonconventional inputs for Phase I and Phase IV are very large—more than .9—whereas the r's of the diffusion category are relatively small. These results are consistent with the earlier conclusions with regard to the particularly significant roles of the first three in agricultural progress whereas the diffusion input appeared to be relatively inefficient. It is remarkable that the r's of research with respect to land, fixed capital, and variable inputs for Phase IV are more than .99, and those for proximate support are more than .95. Although causation cannot be established by correlation analysis, it is nevertheless tempting to infer from these highly complementary relationships that the interacting changes in these inputs made a very significant contribution to the remarkable increase in output in Phase IV.

With respect to the conventional inputs, the r's of labor were always negative except in Phase III, implying of course that labor's relationship to the nonconventional inputs was one of substitution rather than complementarity. The r's of the other conventional inputs were positive and very high in Phase I and Phase IV. It is noteworthy that the correlation between variable inputs and the various nonconventional inputs for Phase IV was the highest of all r's during that period, which points once again to the particularly important role of variable inputs in that period.

IV. ESTIMATES OF THE RATES OF RETURN TO NONCONVENTIONAL INPUTS

It has already been pointed out that the outlays for nonconventional inputs were small relative to the magnitude of the "unexplained output" with which they were associated. It is tempting to estimate the rate of return to these nonconventional inputs even though this is a hazardous operation because of the serious difficulties that bedevil any such attempt. Nevertheless, a number of attempts have been made to estimate the rate of return to nonconventional inputs, including Tang's estimates for Japan based on a distributed lag model (*46*).[11]

Rough estimates are presented here that are based on a different approach which yields separate estimates of the rates of return to the nonconventional inputs for the different phases of agricultural development in Japan. The approach adopted is to assume that the effect of nonconventional inputs in a period

[11] In addition to Tang's estimate for Japan, see C. R. Wharton (*53*) for the Brazilian case; T. W. Schultz (*40, 41*), Zvi Griliches (*3, 5*), E. O. Heady (*9*), and L. G. Tweeten and F. H. Tyner (*49*) for the American case.

is expected to continue into subsequent periods and the amount of the "unexplained output"—the output which cannot be explained by the increase in conventional inputs—at time T is attributed to the total value of nonconventional inputs which have been invested from time 0 to time T. In other words, the nonconventional inputs are treated as a stock.

Like all attempts of this nature, the estimates must be treated with great caution. Nevertheless the results appear to be of some interest as rough indications of the rate of return to the nonconventional inputs. The following assumptions underlie the present estimates of the rate of return.

(1) The scope of nonconventional inputs is restricted to the government expenditures for nonconventional inputs as defined above. The influence of possible changes in nonconventional inputs other than these government services is disregarded and the influence of general economic and institutional conditions is also disregarded.

(2) It must be admitted that the effect of some nonconventional inputs in a period cannot be expected to continue into subsequent periods, and to this extent the inputs have a flow aspect. To simplify the calculation of the rate of return, however, this flow aspect is neglected.

(3) The rate of return to nonconventional inputs is measured in terms of the ratio of the amount of the "unexplained output" at time T to the total value of outlays for nonconventional inputs from time 0 to time T. That is, the rate of return to nonconventional inputs at time T, R_T, is the ratio

$$y_T \Big/ \sum_{t=0}^{T} x_t$$

where y_T is "unexplained output" at time T and x_t denotes the outlays for nonconventional inputs at time t.

In fact, there will be a lag between outlays for nonconventional inputs and their effect on output or "unexplained output." It proved impossible to determine an appropriate lag period, and in the present approach this lag problem and also the "obsolescence" of nonconventional inputs has been ignored.[12]

(4) The rate of return to nonconventional inputs as defined in paragraph (3) represents only a direct return in terms of farm output. L. G. Tweeten and F. H. Tyner have argued that allowance should also be made for the social return which results from the transfer of labor from the agricultural sector where labor productivity is relatively low to the nonagricultural sector where it is relatively high (*49*). No attempt is made to consider this type of indirect return in the present estimates.

(5) The government outlays that are taken as a measure of the nonconventional inputs consist of various categories such as expenditure for research, diffusion activities, rural education, and so forth. In a strict sense, these are heterogeneous and cannot be aggregated (*6*). They each contribute to technical progress in different ways. Owing to the great importance of complementarities

[12] One would expect, of course, that the lag between outlays for various types of nonconventional inputs and the effect on productivity would vary considerably. An attempt to identify these lags by comparing cycles in the increments of unexplained output and nonconventional inputs did indicate that the lags for the various types of nonconventional inputs were different and that the lag patterns varied in the course of time.

among them, however, it is very difficult to estimate the returns attributable to a particular nonconventional input. The rate of return has, therefore, been estimated only in relation to the total of these expenditures, thus assuming that they are homogeneous and only their aggregate effect on technical progress is considered. It would be of considerable interest to estimate the rate of return to individual categories of nonconventional inputs, but such an attempt would encounter the extremely difficult problem of allocating the increase in "unexplained output" to particular categories of nonconventional inputs. It would also give a somewhat misleading picture because of the importance of complementarities among the nonconventional inputs, but nonetheless could be of considerable interest as a rough indication of the relative efficiency of different types of nonconventional inputs.

(6) Changes in conventional inputs were measured without regard to possible changes in their quality which might occur as a result of technological progress in factor-supplying industries. This would cause an overestimation of the rate of return to nonconventional inputs as defined here.

R_t, the rate of return estimated on the basis mentioned above, decreased from 153.3 per cent in 1885–89 to 11.7 per cent in 1940–44, then increased to 16.4 per cent in 1955–59. The average rate of return for each phase was 111.2 for Phase I, 43.2 for Phase II, 16.5 for Phase III, and 14.4 for Phase IV. (See Table 15.)

These estimates of the rates of return to the nonconventional inputs are, of course, subject to the important qualifications mentioned earlier. The extremely high rates of returns shown for the early periods are undoubtedly overestimated to some extent, mainly because of the oversimplifications involved in assumptions (1) and (6). In particular, the output increases during Phase I were influenced considerably by the spontaneous diffusion of a backlog of improved technology in the favorable environment provided by the institutional reforms of the Meiji period and by investments in irrigation and land improvement that are not fully reflected either in the estimates of conventional inputs or the estimated outlays for nonconventional inputs that are used in the present study. The government outlays for infrastructure, treated here as nonconventional inputs, include only central government expenditures for irrigation works or subsidies for such work paid to farmers or local government units. Of equal or greater importance, however, were the investments by farmers and landowners for irrigation facilities and land improvements that could not be included in the capital category of conventional inputs because the data are not available. Nonetheless, it is clear that such investment was of considerable importance (see *34*, Chap. 12). In spite of the fact that these estimates must be treated with considerable reserve, they would seem to be of interest as a rough indication of the order of magnitude of the returns accruing to the nonconventional inputs. Thus they seem to offer considerable support for the view that a suitable combination of nonconventional inputs can yield exceedingly high returns through raising the productivity of the conventional inputs.

V. CONCLUDING REMARKS

In this paper we have examined changes in output and in the use of conventional and nonconventional inputs in the course of Japan's agricultural develop-

TABLE 15.—THE "RATE OF RETURN"

Period	Unexplained output (*billion yen*)[a]	Nonconventional inputs cumulated from 1880 to date (*billion yen*)[b]	Rate of return (*per cent*)[c]	Rate of return by phase: Phase number	Rate of return by phase: Per cent[d]
1885–89	92	60	153.3		
1890–94	126	91	138.5		
1895–99	157	134	117.2		
1900–04	219	199	110.1	I	111.2
1905–09	274	285	96.1		
1910–14	342	411	83.2		
1915–19	441	551	80.0		
1920–24	457	776	58.9		
1925–29	508	1129	45.0	II	43.2
1930–34	541	1516	35.7		
1935–39	615	1860	33.1		
1940–44	511	2414	21.2	III	16.5
1945–49	340	2904	11.7		
1950–54	475	3863	12.3	IV	14.4
1955–59	814	4960	16.4		

[a] From Table 2 (y_T).

[b] Computed from Table 8; average values of total nonconventional inputs times 5, cumulated from 1880 $\left(\sum_{t=0}^{T} x_t\right)$.

[c] Column 1 as per cent of Column 2 $\left(R_T = y_T \div \sum_{t=0}^{T} x_t\right)$.

[d] Arithmetic mean rates in Column 3.

ment. The analysis supports the view that "technical progress" which resulted in an increase in output considerably greater than the associated increase in conventional inputs has been a highly important feature of agricultural development in Japan. The pace of "technical progress" has, however, showed considerable variation during the 80-year period studied. It has been suggested that agricultural development in Japan can be demarcated into four phases: Phase I, a phase of *modernization* from 1880–85 to 1915–19; Phase II, a period of *relative stagnation* from 1915–19 to 1935–39; Phase III, a period of *backwardness* from 1935–39 to 1945–49; and Phase IV, the phase of *increasing capital intensity* from 1945–49 to 1955–59.

The principal features that characterized those four phases are summarized in the following paragraphs.

Phase I (1880–85 to 1915–19).—A considerable increase in farm output in Phase I resulted from significant technical progress and was associated with only a moderate increase in the conventional inputs. There appears to have been considerable difference in the factors mainly responsible for the technical progress in the early period (1882–97) and the later period of Phase I (1897–1917). The major factor in the later period was the highly appropriate combination of nonconventional inputs; research and education, which dominated the

nonconventional inputs at that time, appear to have been especially significant. For the earlier period, however, the major factor seems to have been a country-wide process of diffusion of locally developed improvements in traditional farm techniques which was facilitated by the abolition of feudal restraints following the Meiji Restoration, by the improvement of transportation and communications, and by activities of *rōno* (progressive farmers) or landowners. Government action, for example in employing some of the *rōno* as itinerant instructors, undoubtedly helped accelerate the diffusion of the backlog of improved techniques that has been developed during the Tokugawa period.

With respect to the conventional inputs, there was a very moderate increase in the cultivated area, a moderate increase in fixed capital inputs, and a fairly rapid rate of increase in variable inputs. The available evidence suggests that there was a slight decline in the farm labor force. Thus the increase in labor productivity was considerable and justifies the characterization of the period as the phase of modernization.

Phase II (1915–19 to 1935–39).—The rate of increase in conventional inputs in Phase II was about the same as in Phase I, although the rate of expansion of the variable input component was considerably slower. The much slower rate of increase in farm output therefore implies a situation of relatively stagnant technical progress. The rate of increase in outlays for nonconventional inputs was about the same as in the second subperiod of Phase I, but it appears that the "package" of nonconventional inputs provided was much less appropriate. Statistical evidence which suggests a decline in the degree of complementarity among the conventional and nonconventional inputs supports that interpretation. There was virtually no change in the farm labor force during Phase II, and the rate of increase in labor productivity was slow.

Phase III (1935–39 to 1945–49).—The wartime conditions that dominated this period resulted in a considerable decline of agricultural output and a general condition of backwardness. The increase in the farm labor force over the period was the result of the exodus of population from the major cities as a result of bombing and the economic disorganization at the end of World War II and the repatriation of Japanese nationals from overseas. All other conventional inputs registered a decline, most striking in the case of variable inputs that declined at a rate of nearly 7 per cent annually. The rate of increase in government outlays for nonconventional inputs was considerable, but they were mainly devoted to programs to lessen the adverse effects of wartime conditions on agricultural output. Factor productivity declined sharply because of the unfavorable conditions, including the sharply reduced availability of fertilizer and other variable inputs.

Phase IV (1945–49 to 1955–59).—The final phase examined in the present paper was characterized by an unprecedented rate of increase in gross farm output; but unlike Phase I and Phase II the rate of increase in net output was much less rapid—2.1 per cent annually compared to the 4.5 per cent rate of increase in gross farm output. Conventional inputs rose much more rapidly than in those earlier periods in spite of the fact that for the first time the farm labor force registered a significant decline in absolute size. The increase in fixed capital was considerably higher than in previous periods, but the rate of increase of

variable inputs was a good deal more striking. The marked increase in variable inputs and in fixed capital is, of course, the reason that the rate of increase in net farm output was so much slower than the increase in gross farm output and accounts for the characterization of Phase IV as the phase of increasing capital intensity. The rate of increase in total factor productivity during this period is impressive. As would be expected, the increase in labor productivity was very much greater than during earlier periods because of the substantial substitution of capital for labor as well as rapid technical progress.

For the entire period considered certain generalizations are suggested. During the periods of rapid expansion of farm output—Phase I and Phase IV—there appears to have been a high degree of complementarity between the conventional and nonconventional inputs. Among the conventional inputs the increased use of fertilizer and other variable inputs was clearly of strategic importance. Agricultural research, rural education, extension and other diffusion activities, and outlays to strengthen the agricultural infrastructure were all important nonconventional inputs. Research seems to have been a crucial factor in both Phase I and Phase IV. There is an indication that the rate of return to education was particularly high during the early decades of Japan's modern economic growth whereas the investments in the agricultural infrastructure were especially significant during Phase IV. Diffusion activities, many of them essentially spontaneous in character, were of great importance in Phase I, but the government outlays in that category during Phases II and III seem to have been inefficient means of fostering technical progress.

There is an interesting contrast between the patterns of agricultural development in Japan and in the United States. In the United States expansion of land area and investments in farm machinery seem to have accounted for a major part of the increase in agricultural output until the 1930's. During the late 19th and early 20th centuries the increase in output was only a little more rapid than the increase in farm inputs. (Until about 1915 there was a considerable increase in the farm labor force along with the increase in other inputs.) Since the mid-1930's, however, the growth of output has been much more rapid than the increase in farm inputs (*30*). It is interesting to note that it is during this period of marked increase in factor productivity that the use of fertilizers, insecticides, and other biological-chemical forms of capital have greatly increased their importance in American agriculture.

In Japan, on the other hand, there was a notable increase in factor productivity in the decades prior to 1920; and in contrast to the United States expanded use of fertilizer and other variable inputs accounted for a major part of the increase in conventional inputs. Presumably the small size of the farm units in Japan, the result of a large farm labor force, and the very limited scope for expanding the cultivated area, explain the fact that the "Meiji technology," which was influenced more by German than American experts, placed much greater emphasis on yield-increasing innovations than on the introduction of farm machinery. Commercial fertilizers were highly important in Japanese agriculture well before the discovery of a process for fixing atmospheric nitrogen and the long series of developments in fertilizer technology that followed had wrought their miracle in increasing the elasticity of supply and reducing the real cost of

fertilizers. In fact, it was not until the mid-1930's that ammonium sulfate became a more important source of nitrogen than soybean cake, and both soybean cake and fish meal continued to be highly important in Japanese agriculture until World War II (*34*, pp. 371–74). Thus Japan had a "fertilizer-consuming agriculture" long before the fertilizer explosion began in the United States following World War II, touched off in no small measure by substantial reductions in the real cost of producing and applying fertilizers. This revolution in fertilizer technology stands out as one highly important change that would seem to increase the relevance for contemporary developing nations of the Japanese pattern of agricultural development with its heavy reliance on increased use of fertilizers and other variable inputs—and the associated nonconventional inputs that enhanced and sustained the profitability of the variable inputs.

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APPENDIX I

NOTES ON ESTIMATION OF GOVERNMENT OUTLAYS FOR NONCONVENTIONAL INPUTS

The major items included in each of the categories are summarized in the following paragraphs.

Research.—This included expenditures for all types of experiment stations and research institutes for agriculture. It includes outlays for research, for improvement of plant varieties, control of livestock disease, improvement of fertilizers, and so on.

Diffusion.—Outlays for training of extension workers and farmers and the financing of extension activities for agricultural improvement are the obvious items in this category. In addition, subsidies to farm cooperative associations and for prefectural activities such as agricultural fairs and prizes to promote improved farming are also included as are incentive payments to encourage the adoption of improved practices.

Public service.—This category includes expenditures for the support of services responsible for plant inspection and inspection of livestock, silk, fertilizers, and agricultural chemicals; outlays for controlling insect damage and animal disease; and the cost of introducing foreign breeding stock and maintaining government stud farms.

Infrastructure.—Outlays and subsidies for land improvement and reclamation, land reform, flood control, reconstruction following natural disasters, and subsidies for construction of cooperative warehouses for agricultural products and other public farm facilities are included.

General.—Expenditures for administrative offices, agricultural statistical services, and farm relief payments.

Separate sources were used for the period 1880–1945 (*15*), for 1946–52 (*10*), for 1953–56 (*18*), and for 1957–59 (*20*). In instances in which detailed data were not available for individual years, estimates were made by interpolation or similar procedures. To get real value of nonconventional inputs, the cost of living index (*57*) was used as deflator.

The data available concerning agricultural expenditures by local governments are rather unsatisfactory. In fact, it is necessary to make a fairly arbitrary breakdown of total yearly expenditures by prefectural and local governments for promotion of all types of economic activity. Total expenditures for agriculture were estimated by multiplying this total by the ratio of net farm income to total net income, using five-year moving averages, on the assumption that local government allocations for agriculture were roughly related to the share of farm income in total income. As a second step, the various categories of expenditure by local government were estimated on the assumption that the breakdown is the same as for central government expenses except that the "general" category was omitted. The basic statistical source for the whole period was *10*. These expedients are clearly unsatisfactory, but data were not available for more accurate estimates concerning agricultural expenditures by local governments. The assumption does not seem unreasonable in view of the central government's strong control over the policy of local government, but it would clearly be desirable to revise these estimates when more appropriate data become available.

Rural education.—Total expenditures for education by the central government and also by the local governments are readily available. A compilation published by the Ministry of Education (*19*) provided data for the 80-year period 1873–1952 and the *Japan Statistical Yearbook* (*10*) provides data for the subsequent years. There is, however, no really satisfactory way to estimate the "rural education" component of the total outlay for education. The approach adopted was to multiply the national total for educational expenditure by a ratio of annual increments to the farm labor force to total increments to the labor force, using five-year moving averages.*

Tang's study of research and education in Japanese agricultural development used a somewhat different approach, making the allocation of education expen-

* The ratio was computed as follows: the replacement requirement by the agricultural sector was estimated on the basis of the national mortality rate and the share of the population in the farm and nonfarm labor forces. This figure was then adjusted for the net change in the farm and total labor forces and the ratio computed accordingly. Data for these calculations are from *1*, *19*, and *51*.

ditures to the agricultural sector on the basis of agriculture's share in the total labor force (*46*). Although any estimation procedure is somewhat arbitrary, the present writer considers it preferable to base the allocation of educational expenditures on the ratio of new entrants to the farm labor force compared to the annual increment of the total labor force rather than on the total size of the two components.

APPENDIX TABLE I.—CHANGES IN PERCENTAGE COMPOSITION OF OUTPUT, 1880–1960*

	Crops									
Year	Rice	Other cereals	Potatoes	Beans	Vegetables	Industrial crops	Fruits	Total	Cocoons	Dairy and livestock
1880	62.2	14.6	2.4	4.8	4.0	7.4	.9	96.2	3.1	.7
1890	62.4	13.7	2.5	4.7	4.6	7.2	1.2	96.4	2.5	1.1
1900	55.5	14.7	3.2	5.3	4.9	7.1	1.8	92.4	5.4	2.2
1910	55.0	13.1	3.4	4.7	5.8	6.1	2.5	90.5	6.8	2.7
1920	56.9	10.9	3.7	4.6	5.3	5.2	2.4	88.8	8.4	2.8
1930	54.8	8.3	2.7	3.5	5.3	4.8	3.1	82.7	12.8	4.5
1940	49.8	10.7	3.1	2.7	6.0	6.6	4.2	83.1	10.5	6.4
1945	63.8	9.9	4.5	2.8	5.5	4.5	3.3	94.2	3.6	2.2
1950	57.0	11.3	5.8	3.6	6.1	4.6	4.0	92.3	2.8	4.9
1955	54.4	9.7	5.0	3.7	5.5	5.9	3.7	87.8	3.0	9.2
1960	48.3	8.1	4.2	3.3	5.8	4.9	5.9	80.5	2.5	17.0

* Computed from data in Saburo Yamada (*55*, pp. 8–10).

APPENDIX TABLE II.—INDEXES AT 1955 PRICES OF SPECIFIED CONVENTIONAL INPUTS, 1880–1959*

		Fixed capital			Land area		
Average	Labor	Including buildings	Excluding buildings	Variable inputs	Total	Paddy field	Upland field
1880–84	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1885–89	98.4	99.8	102.2	120.8	101.5	101.1	102.1
1890–94	97.0	100.8	108.8	137.7	103.7	101.8	106.0
1895–99	96.4	102.9	117.9	147.2	106.5	102.5	111.7
1900–04	95.7	104.8	125.9	162.3	109.5	103.6	117.3
1905–09	94.5	106.8	137.6	192.5	112.9	105.5	123.1
1910–14	93.7	112.2	158.8	239.6	118.5	108.0	133.0
1915–19	92.9	115.0	171.2	301.9	123.0	110.2	140.5
1920–24	91.8	116.5	178.5	301.9	125.1	112.4	142.4
1925–29	91.9	119.5	190.1	345.3	123.9	114.9	136.2
1930–34	92.7	123.9	204.7	347.2	126.1	116.7	138.6
1935–39	91.3	126.0	215.7	369.8	128.1	116.7	143.4
1940–44	92.9	126.4	222.3	298.1	126.7	116.0	141.3
1945–49	109.0	121.2	187.6	215.1	122.5	112.7	135.8
1950–54	105.3	130.5	211.7	435.8	124.2	113.8	138.3
1955–59	95.4	143.4	261.7	666.0	126.7	116.4	140.8

* Computed from Table 1.

APPENDIX TABLE III.—INDEXES OF PRODUCTIVITY OF SPECIFIED INPUTS, 1880–1959*

Average	Labor	Fixed capital		Variable inputs	Land
		Including buildings	Excluding buildings		
1880–84	100.0	100.0	100.0	100.0	100.0
1885–89	118.2	116.5	113.8	96.2	114.6
1890–94	126.4	121.7	112.8	89.1	118.3
1895–99	133.9	125.5	109.5	87.7	121.2
1900–04	146.9	134.1	111.7	86.6	128.4
1905–09	160.3	141.8	110.1	78.7	134.2
1910–14	177.9	148.5	104.9	69.6	140.6
1915–19	201.7	162.9	109.5	62.1	152.4
1920–24	207.4	163.4	106.7	63.1	152.2
1925–29	219.5	168.8	106.1	58.4	162.8
1930–34	225.9	169.0	102.3	60.3	166.0
1935–39	244.1	176.9	103.3	60.3	174.0
1940–44	218.0	160.2	91.1	68.0	159.9
1945–49	162.4	146.1	94.4	82.3	144.5
1950–54	199.6	161.1	99.3	48.2	169.2
1955–59	289.5	192.6	105.5	41.5	218.0

* Computed by dividing the gross output index in Table 2 by the specified conventional input index in Appendix Table II.