The role and significance of mechanization in Japanese agriculture

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1. Introduction

The number of farms in Japan has shown little change for a long period of time. Table 1 shows the number of farms in 1874 as 5,517,000 units, compared with 5,465,794 in 1965 as shown in Table 2. During these 91 years, Japan has reduced the number of farms by only about 50,000 units.

There has also been little change in the size of farms. As indicated in Table 2, in 1908 37.3 % or 2,016,286 of a totalof 5,408, 363 units were less than 5 tan.[1] Today, almost 60 years later, this percentage has shown little change. There are now 2,096,340 units of less than 5 tan farms and 1, 762,235 units of 5-1 cho farms, 38.4 % and 32.2 %

Table 1. Number of farms, agricultural labor population, cultivated acreage and yield (7-year slide average, based on 1934-1936 value).

Year	Number of farms(1,000 units)	Agricultural labor population (1,000 persons)	Cultivated acreage (1,000 chō)	Yield (million yen)	Per capita Yield (yen)	Per capita Cultivated acreage (tan)
1874	5,517					
1880	5,500	14,660	4,777	1,462	100	3.26
1890	5,448	14,298	4,964	1,771	124	3.47
1900	5,502	14,191	5,228	2,005	141	3.68
1910	5,518	14,017	5,614	2,465	176	4.01
1920	5,564	13,939	6,016	2,893	208	4.32
1930	5,613	13,911	6,031	3,217	231	4.34
1940	5,484	13,504	6,155	3,322	246	4.56
1950	6,156	15,696	5,902	3,050	194	3.76
1953	6,062	15,420	5,972	3,535	229	3.87
1960	5,966	13,373	6,119	4,687	350	4.58

Source: *Nōringyō* (Agriculture and Forestry) by Matatsugu Umemura and others, 1966.

1) One tan is equal to 0.09917 hectare, or to 0.24507 acre. One chō consists of 10 tan.

Table 2. Number of farms by the size of farm land.

Size of farm land	1908		1965	
	Units	Percentage	Units	Percentage
Total	5,408,363	100.0	5,465,794	100.0
Less than 5 tan	2,016,286	37.3	2,096,340	38.4
5 tan–1 chō	1,763,890	32.7	1,762,235	32.2
1–2 chō	1,055,243	19.5	1,351,977	24.7
2–3 chō	348,153	6.4	214,391	3.9
More than 3 chō	224,791	4.1	40,851	0.8

Source: *Nōrinshō Ruinen Tōkeihyō* (Annual Statistics of the Ministry of Agriculture and Forestry), 1955, and *Nōka Chōsa Hōkoku* (Study Report on Farms) 1967, based on 1965 census, both edited by Ministry of Agriculture and Forestry.

of the total respectively. As Table 2 further illustrates, the number of larger scale farms of over 2 chō has decreased while the number of smaller scale farms of less than 20 tan has increased.

As shown above, small farming units have long been dominant in Japaese agriculture. For instance, the cultivated area per unit has averaged no more than 11.22 tan even in the highest period of 1940, and the cultivated area per capita of the agricultural labor population, which was 3.26 tan in 1880 and 4.32 tan in 1920, reached only 4.58 tan in 1960.

While, in the field of industry, in keepingup with the advance of capitalism, a good many small-scale manufacturers have been supplanted by large-scale enterprises, Japanese agriculture is still dominated by small-sized farms. Why is this? Various studies have been published on this theme, some typical examples of which are as follows.

Seiichi Tōbata (1947)[2] said: "In the management of agricultural enterprise as such, enlargement of the scale does not produce a resulting increase in efficiency. The enlargement of farms usually brings about the centralization of small-scale managements, paving the way for qualitative improvement in the future. However, as it has a stronger tendency merely to centralize small-scale managements, one can expect no immediate advances in agricultural productivity." And he concludes: "So far as the Japanese agriculture is concerned, little difference in productive efficiency is observed between large and small-scale enterprises. The Law of Constant Return to Scale is at work."

Kazushi Ohkawa (1945)[3] also used an explanation similar to Tōbata's,

2) *Nihon Nōgyō no Tenkai Katei* (Evolutional Processes of Japan's Agriculture) by Seiichi Tōbata, 1947, p. 19.

3) *Shokuryō Keizai no Riron to Keisoku* (Theory and Measurement of Food Economy) by Kazushi Ohkawa, 1945, pp. 145–163.

though somewhat different in its nuance. Ohkawa assumed the follow-
ing production function related to rice, which was the most important
Japanese crop, based upon research on production costs in the years
1937, 1938 and 1939.

$$P = bT^{\alpha}L^{\beta}C^{\gamma}$$
        P : Production quantity
        T : Land area
        L : Working hours
        C : Capital amount
   α, β, γ : Parameters to be estimated

According to his estimation of α, β and γ, as shown in Table 3, the
total sum of these parameters proved to be almost equal to 1-0.997 for
1937, 0.945 for 1938 and 0.998 for 1939.

This fact shows that if the input of each productive factor is
doubled, the production will also be double, and that if the input is
trebled, the production will be trebled. In other words, there is no
difference in productivity between large and small farm managements,
and it may be deduced that herein lies the basis for the possible
running of smallscale farms.

The existence of small farms in Japan before the Second World War
could be thus explained by the Law of Constant Return to Scale.

However, after the termination of the World War, from the end of
1947 to 1948, Japan underwent a land reform and great changes were
brought to her agricultural society. The gist of the Japanese agrarian
reform may be summarized in the following two points:

1) All the tenant farm-land owned by non-resident land-owners and
all the tenant farm-land remaining after deduction of a limited hold-
ing of 1 chō (approximately 1 hectare) for each resident owner were
taken by the Government for sale mainly to the traditional tenant farm-
ers.

As a result of the above-mentioned land reformation the tenant form
lond of 1,770,000 chō was distributed among tenant farmers, and 87 %
of the Japanese farmers became land-owners or quasi-land-owners.

2) On the remaining tenant farm-land, rent was regulated to a low
level cash rate. Tillage rights were also protected by law, and the
private confiscating of land was prohibited in principle.

After this land reform a majority of the traditional land-owners dis-
appeared and most tenant farmers became independent land-owning
farmers. As the feudalistic relations between land-owners and their
tenants ended, the improvements and stabilization of farm living con-
ditions contributed to the democratization of the agricultural society.

The above-mentioned land reform was certainly a big political up-

heaval, but it is open to question whether it has resulted in any change in the productive structure of Japanese agriculture. In order to further clarify this question, the author computed the coefficients of the production function by the same method used by Ohkawa, up to 1951, the year in which the land reform was completed, and tried to analyze its economic effects. The results are those figures shown in Table 3 (Tsuchiya, 1956).[4]

When Ohkawa calculated the producton elasticity of rice cultivation in the years 1937, 1938 and 1939 applying the Douglas type production function, such figures were obtained as 0.51-0.62 for land, 0.19-0.28 for labor and 0.16-0.21 for capital. As to the rice crop in 1951 after the agrarian reform, the author's estimation of production elasticity showed 0.56 for land, 0.19 for labor and 0.25 for capital. The difference in rice crop per tan (area unit) before and after the reform was negligible, both being around 315 kg. No noticeable gap was observed in the input of labor which has constantly remained a little more than 20 days per tan. Therefore, no technical advancement between the two stages was apparent. It is also interesting to note from Table 3 that the sum total of the three elasticities is just 100.

In effect, the Law of Constant Return to Scale continued in Japanese agriculture even after the land reform, and, as was pointed out by Tōbata and Ohkawa in the pre-war days, agricultural productivity is still independent of the size of farm. Herein again, it may be concluded, lie ample grounds for small-sized farms to be economically justified in Japan.

Table 3. Production elasticity.

Year	α	β	r	$\alpha+\beta+r$
1937	0.555	0.237	0.205	0.997
1938	0.510	0.280	0.155	0.945
1939	0.620	0.185	0.190	0.998
1951	0.56	0.19	0.25	1.00

Source: 1937-39 *Shokuryō Keizai no Riron to Keisoku* (Theory and Measurement of Food Economies) by Kazushi Ohkawa, 1945, pp. 145-163.

　　　　1951　*Nōgyō ni okeru Seisan Kansū no Kenkyū* (Studies on Production Function in Agriculture) by Keizo Tsuchiya, contained in *Nōgyō Sōgō Kenkyū* (Quarterly Journal of Agricultural Economy) Vol. 9, No. 1, 1956.

4) *Nōgyō ni okeru Seisan Kansū no Kenkyō* (Studies on Production Function in Agriculture), contained in *Nōgyō Sōgō Kenkyu* (Quarterly Journal of Agricultural Economy) Vol. 9, No. 1, by Keizō Tsuchiya, 1956.

On the other hand, however, the Japanese economy has undergone a phenomenal evolution through the post-war period and, as a matter of course, exerted far-reaching influences upon her agriculture. This aspect will be surveyed in the following chapter.

2. Changes in agriculture after the Second World War

Following the termination of the Second World War, the Japanese economy has grown at a very rapid pace, causing worldwide interest. The growth rate of her G. N. P. (Gross National Products) is 10.8%, as shown in Table 4, and ranks at the top of the developed countries. Her G. N. P. itself reached approximately 100 billion dollars (current prices) in the fiscal year 1966, following only the United States and the Soviet Union and being comparable to West Germany, Great Britain or France.

During the decade from 1954 to 1964 the Japanese agricultural labor population showed a great decrease of some 3,700,000 persons.

Table 4. G. N. P. growth rate and decrease in agricultural labor population (unit: % and 1,000).

	G. N. P. growth rate* 1956-65	Agricultural labor population† 1954	1964	Decrease
Japan	10. 8	15,670	11,970	3,700
W. Germany	6.5	4,400	3,084	1,316
Italy	5.7	7,999	4,967	3,032
France	5.2	5,213	3,653	1,560
Belgium	4.1	322	216	106
Canada	4.0	870	630	248
U. S.	3.7	6,495	4,361	1,734
Gt. Britain	3.3	1,161	948	213

Source: *Keizai Hakusho (Economic White Paper), by Economic Planning Agency, 1967.
†Bōeki to Nihon Nōgyō (Foreign Trade and Agriculture of Japan), by Ministry of Agriculture and Forestry, 1967.

The aforementioned sharp decrease in the agricultural labor population of Japan, which is the most remarkable among the advanced countries, has taken place since approximately 1953. During those years that the Japanese economy started its high-rate expansion on a full scale, agricultural production again managed to reach the pre-war level, and some changes came into sight in the structure of agricultural production which had long been kept at a lower level.

The shortage of labor force for agriculture resulted in promotion of farm mechanization, which in turn resulted in the important increase in use of power cultivators.[5]

Table 5 shows the total production of major agricultural machinery and implements during the years from 1961 to 1965. So far as agricultural machines and implements are concerned, export is negligible compared with production, with the most part of their production destined for domestic use, of which about 56 % consists of power cultivators.

Table 5. Production of agricultural machines and implements (1961–65, million yen).

Power cultivators	208,745	(56.6 %)
Power threshers	45,099	(12.2 %)
Rice-hulling machines	14,664	(4.0 %)
Power sprayers	24,550	(6.7 %)
Others	75,669	(20.5 %)
Total	368,725	(100.0 %)

Source: *Nōgyō Kikaika Kankei Shiryō* (Collection of Data on Agricultural Mechanization), by Ministry of Agriculture and Forestry, 1966, p. 15.

Table 6 explains numerically how basic agricultural machines have come into wide use in the rural parts of Japan, with each kind of small machine increasing in number year by year. This spread of power cultivators is clearly pointed out as the most striking part of farm mechanization.

In 1931 no more than 100 power cultivators were in use. In 1939, just before the Second World War, however, they numbered 3,000. There was a rapid increase in use from 89,000 units in 1955 to 2,490,000 units in 1965. The ratio of their expansion, represented by the number of machines per 100 farms, grew from 8.6 units in 1960 to a nation-wide average of 38.2 units in 1965.

These Tables illustrate the fact that the mechanization of Japanese agriculture has been carried out mainly through the use of power cultivators. The mechanization of small-sized Japanese farms is, however, naturally different from that of large-scale Western farming enterprises in the form of its application. These different points will be studied in a little more detail as follows:

1) Mechanization in Western countries has been applied to unirrigated fields, while in Japan the work is mostly in watered paddy fields.

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5) The power cultivator is a small gasoline powered agricultural machine developed in Japan. Most cultivators have about 5 horse-power, and very rarely over 10.

Table 6. Numer of major agricultural machines in use, from 1927–1965 (1,000 units).

Year	Power threshers	Rice hulling machines	Power cultivators	Power sprayers	Tractors
1927	30	39	—	—	—
1931	56	77	0.1	—	—
1933	67	95	0.1	0.4	—
1935	92	105	0.2	1	—
1937	129	108	1	2	—
1939	211	133	3	5	—
1942	357	180	7	—	—
1945	352	177	—	—	—
1947	444	199	8	7	—
1949	764	348	10	11	—
1951	972	—	16	20	—
1953	1,269	540	35	44	—
1955	2,038	690	89	87	—
1957	2,283	—	227	155	—
1959	2,459	800	514	305	—
1961	2,703	—	1,020	361	7
1962	2,832	—	1,414	436	11
1963	2,982	—	1,812	565	—
1964	3,085	827	2,183	704	24.8
1965	3,048	—	2,490	851	36.0

Source: *Nōgyō Kikai Nenkan* (Year-book of Agricultural Machines), by Shin-nōrinsha Co., Ltd., 1967.

A study published in 1964 shows that the mechanization ratio in Japan was 78.6 % in paddy fields and 29.0 % in dry fields.[6]

2) Although mechanization was taken up evenly in all processes of cultivation in the Western countries, such a balanced advance was not observed in Japan. In the latter case, machines were not introduced in all the processes of paddy cultivation, but only replaced such human labors as plowing and harrowing, and levelling the ground. The toil of rice planting, reaping, etc. were not mechanized.

3) Mechanization increased yields through deep-tilling in the Western countries. In Japan, however, it is not clear what effect the use of cultivators exerted on the yield of aquatic rice per tan.[7]

6) *Chiiki Nōgyō no Bunseki* (Analysis of Regional Agriculture), by the Ministry of Agriculture and Forestry, 1965.
7) Yoshio Itoh points out that the deep tilling capacity of a power cultivator is no greater than that of work cattle. *Inasaku Chūgata Gijutsu no Keisei* (Formation of Medium-Sized Rice Production Technique), by Yoshio Itoh, 1966, p. 18.

Table 7. Change of aquatic rice yield by the use of power cultivators.

Location of the National Agricultural Experimental Stations	Change of yield (kg per tan)
Akita	+ 2
Nara	+ 5
Hiroshima	− 8
Ehime	+11
Kōchi	+0.6
Yamaguchi	−37

Source: *Dōryoku Kōunki ni kansuru Shiken Kenkyū* (Studies on the Experimental Use of Power Cultivators), by Agricultural Improvement Bureau, Ministry of Agriculture and Forestry, 1960.

The results obtained by the National Agricultural Experimental Stations in various prefectures were divided, and some showed an increase in crop while others recorded a drop, as summarized in Table 7.

Table 8. Historical change of the power used in the Japanese agriculture.

Year	Plow cattle and horses		Machinery power
	(1,000 heads)	(1,000 H. P.)	(1,000 H. P.)
1907	2,163	1,277	1
1912	1,334	1,334	5
1920	2,266	1,320	3.7
1935	2,416	1,403	1,019
1947	2,503	1,400	1,129
1953	3,058	1,682	3,150
1955	3,575	1,880	4,606
1957	3,408	1,786	5,596
1959	3,093	1,624	6,341
1960	3,013	1,574	6,331
1961	2,931	1,527	6,491
1962	2,878	1,494	
1963	2,808	1,451	6,634
1964	2,603	1,341	7,485
1965	2,207	1,136	8,109
1966	1,815	949	

Source: As to the horse-power of plow cattle and horses, *Nihon Nōgyō no Kikaika* (Mechanization of the Japanese Agriculture), edited by the Planning Division, Minister's Secretariat and the Agricultural Policy Bureau, Ministry of Agriculture and Forestry, 1963.

As to the machinery power, the author computed the horse-power of the electric and petroleum motors. The computation method is the same as indicated in the above-mentioned book.

4) Machinery has substituted human for labor rather than work animal power in Japanese agriculture.

Cattle and horses are used for land cultivation in Japan, and if they are to be compared in the same terms of working power, one plow cattll is converted into 0.5 horse-power and a plow horse into 0.6 horse-power. Table 8 is made on this assumption, and it also contains the estimated figures for the aggregate horse-power of power machinery. Furthermore, these estimated horse-power figures as well as the agricultural labor population of Table 1 are graphically traced in Fig. 1.

According to Fig. 1, the total power of plow cattle and horses revealed no great changes for a long time but has decreased slightly since 1957. While the power of machinery has shown a sharp and sustained rise since 1947, the agricultural labor population has continued to show a downward tendency since 1950. In other words, Fig. 1 confirms the fact that the increase in agricultural machinery is in inverse proportion to the decrease of human labor in agriculture.
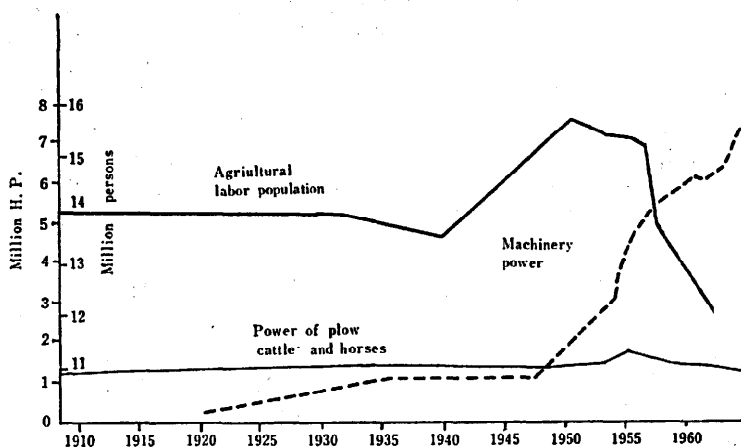

Fig. 1   Historical change of agricultural labor poulation and powers used in agriculture.

3.   Economic explanation of mechanization

As stated in the preceding chapters, the mechanization of Japanese agriculture, where the prevailing small-scale farming enterprises consist of a combination of household economy and business, is quite different from mechanization of the large-scale farms in the Western countries or of industry in general. Taking these points into account,

experts have often explained that some valuation other than the pure-
ly lucrative calculation incidental to the management of enterprises
should be included in the mechanization of Japanese agriculture. Vari-
ous studies have been made along these lines.

Nobufumi Kayo (1962)⁸ concisely classifies these studis into five
categories and adds his own critical opinions. The gist of each
category is as follows:

(1) "Income Effect Theory": The returns for the introduction of
cultivators fall short of their cost and, in fact, investment in cultiva-
tors results in over-investment. Nevertheless, cultivators are actually
brought into use, because farmers' income has increased. Furthermore,
the inducement for this investment is not the same as in cases of or-
dinary enterprises because household economy and business expenses
are not clearly classified in Japanese agriculture. In other words, this
theory regards the motive to purchase power cultivators as something
similar to the desire for durable consumer goods, such as washing
machines, rather than pure producer goods.

(2) "Demonstration Effect Theory": This theory holds that farmers
buy a power cultivator to compete with next-door farmers who are
already using one. This would be called "Keeping up with the Jones's"
in the United States. Such a phenomenon is widely known as demon-
stration effect, a principle advocated by J. S. Duesenberry to explain
main motives for purchase of consumer goods. The application of
such a theory to the introduction of power cultivators is based on the
assumption that they are not producer but consumer goods.

(3) "Disintegration of Patriarchal Family Theory": As sons and
daughters of farmers have shown a strong tendency to abandon farms
in recent years, the heads of farm families buy cultivators to retain
their children in the traditional profession of agriculture. According
to this theory, this situation has occurred due to the weakening of the
patriarchal family system.⁹

(4) "Increased Leisure Valuation Theory": The mechanization is
not used to provide additional time for more intensive farm manage-
ment or for a side-business to incsease earnings, but is promoted only

8) *Nihon Nōgyō Kikaika no Kadai* (Problems in Mechanization of the Japanese
   Agriculture), edited by Nobufumi Kayō, 1962, pp. 20-28.
9) *Sngo Nōgyō ni okeru Shihon Keisei.* (Formation of Capital in the Post-War
   Agriculture), by Takeo Misawa and Yuzuru Katō, contained in *Nōgyō
   Keizai Kenkyū* (Journal of Rural Economics), Vol. 29, No. 4, 1959, pp. 29-
   40. *Iye no Kaitai to Nōgyō Keiei* (Disintegration of the Traditional Family
   System and Agricultural Management), by Takeo Wataya, contained in
   Nōgyō to Keizai (Agriculture and Economy), Aug. 1959.

to allow more spare time for leisure.[10]

(5) "Farmers' Physical Mutation Theory": In the days before the Second World War, real on-the-farm training was started at the age of about twelve years, when a young fellow was about to leave primary school. After the War, however, the previous severe traditional training was no longer enforced due to the collapse of the patriarchal family system, and the period of compulsory education was extended to the age of 15 years. Thus, more and more sons and daughters of farmers began to go on to high school, with the result of becoming less suitable for building a robust farmer-type body which could stand heavy labor. This theory holds that for those reasons cultivators have gradually been introduced.

All the above-mentioned theories try to explain the mechanization of small-scale farms from viewpoints other than economic rationality. However, the purchase price of a cultivator goes up to ¥190,000 (U. S. $528.00) without accessories. If accessories are included, the price may amount to ¥300,000 (U. S. $833.00).[11] It may be easily realized how expensive it is, if the fact that the annual average farm household income was ¥ 670,000 (U. S. $1,862.00) and the annual average farm income was ¥320,000 (U. S. $889.00) in 1964 is considered.

Such being the case, before a farmer decides to buy a power cultivator, he is naturally obliged to bear in mind foreseeable payments.

In fact, the result of an investigation as to 2,061 farms by the Association for Promotion of Machinery which is referred to in Table 9, shows that 84 % of all the investigated farms introduced power cultivators in order to alleviate human labor and very few did so for demonstration effect motive or for other non-economic reasons. It seems, therefore, necessary to review the motives for introduction of power cultivators by the Japanese farmers from the standpoint of economic reasons, as differing from the traditional opinions mentioned above. In doing so, further consideration would be required as to the conditions surrounding Japanese agriculture.

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10) *Kazoku Keiei to Nōgyō Kikai* (Family Enterprise and Agricultural Machines) by Morishige Matsuzawa, contained in *Nōgyō Keiei Keizai no Kenkyū* (Studies on Economics of Agricultural Management), 1958. According to his opinion, mechanization is caused by the decrease in the marginal valuation of money with relation to the increase in side business opportunities, which is after all the same thing as the increase in the valuation of leisure.

11) *Nōson Bukka Chingin Chōsa Hōkoku* (Study Report on Prices and Wages in Rural Areas), by Ministry of Agriculture and Forestry, 1964.

Table 9. Reasons for introduction of power cultivators (unit: %).

Scale of farms	To save labor	For side business	Other reasons
3-5 tan	53	10	37
5 tan-1 chō	73	11	16
1-1.5 chō	85	6	9
1.5-2 chō	92	2	6
2 chō-	90	2	8
Average	84	6	10

Source: *Dōryoku Kōunki Dōnyu Kōka ni Kansuru Kenkyū* (Studies on the Effects of the Introduction of Power Cultivators) edited by Kikai Shinkō Kyōkai (Association for Promotion of Machinery), 1963, 1964.

4. Causes for promotion of agricultural mechanization

First of all, let us take up the question of how power cultivators have spread throughout Japan. As shown in Table 10, there is a big difference among regions as to the number of power cultivators in use per 100 farms. For example, in the Tōhoku (North-eastern) and Hoku-riku (North-weatern) regions of Japan where rice-cultivating technique is most advanced, it is 44 units, while in remote areas like Kyūshū Island, it is only 17 units.

Such regional difference is attributable to various factors among which land improvement projects play the most important role.

Once a land improvement project is carried out, water paddy is usually dried up and extended in area per unit parcel, and accordingly the introduction of machinery is made easier (Tsuchiya, 1964).[12]

In the pre-War Japan, land improvement projects were generally carried out by private land-owners, with very little investment by the Central Government or prefectures. As clearly shown in Table 11, however, the ratio of public investment to total investmenttwas gradually increased and after the Second World War the majority of the projects was carried out by public investment. This was because the land reform drastically reduced the margin of land-owners' capital. Thus, the portion of such governmental investments reached a total of 71.8 % in 1964.

On the other hand, the increase in pub lic investment also augment-

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12) The diffusion of mechanization is largely due to land improvement projects especially in the advanced rice producing areas. In this respect, refer to : "Land Improvement Schemes and Innovations in Agricultural Technology", by Keizo Tsuchiya contained in *Rural Economic Problems*, Vol. 1, May, 1964, pp. 45-60.

Table 10. Number of power cultivators in use per 100 farms and ratio of land acultivated by cultivators.

Kind of districts	Number of cultivators		Percentage	
	1960	1965	1960	1965
National Average	8.6	38.2	34.6	59.7
Industrial districts				
Districts surrounding big industries	9.6	38.0	25.5	59.5
Suburb districts of local industries	6.6	39.7	28.3	58.6
Agricultural districts				
Districts with high rice production	12.1	44.0	50.1	75.3
Districts producing commercial agricultural products	9.1	40.6	28.8	50.7
Districts producing rice crop in general level	7.5	36.7	31.7	62.2
Districts producing crops excluding rice	6.6	38.6	29.0	57.4
Remote districts	2.1	17.3	14.8	35.5

Source: *Chiiki Nōgyō no Bunseki* (Analysis of Regional Agriculture), by Ministry of Agriculture and Forestry, 1965.

Table 11. Investment in land improvement (1960 value, million yen).

Year	Total investment (A)	Public investment (B)	Ratio of public investment (B/A)
1910	11,979	999	8.3%
1920	15,982	1,267	7.9%
1930	23,849	6,534	27.4%
1940	19,438	7,185	37.0%
1950	33,626	22,550	67.1%
1960	76,407	52,901	69.2%
1964	98,262	70,518	71.8%

Source: *Nihon Nōgyō no Chōki Tōkeishū* (Long-Range Statistics for the Japanese Agriculture) Vol. 1, by Nōgyō Sōgō Kenkyūjo (The National Reseach Institute of Agriculture Ministry of Agriculture and Forestry), July 1967, pp. 2-5.

ed the total value of the investment in land improvement projects. For example, the investment in 1964 was about 8.2 times 8.2 times as muchas thatin 1910 in 1910. This increase in the total investment is one of the main factors in the extension of agricultural mechanization.

The land improvement investment (agricultural social investment), however, has not been made evenly all over the country; differences are found among regions. According to Table 12, which shows the estimates of the social capital stock of each agricultural region, other than the two newly developed industrial regions, Tōkai near Tokyo

Table 12. Amount of social capital stock per chō of cultivated land
(1963 value, ¥1,000).

Regions	1918–1952	1963
Tōhoku	128	225
Kantō	98	147
Tōkai	132	369
Hokuriku	200	334
Kinki	97	178
Chūgoku	97	225
Shikoku	95	197
Kyūshū	102	174

Source: Social capital stock for agriculture is calculated from the data in
Nōrin Gyogyō no Chiikibetsu Shihon Sutokku no Suikei Kekka (Estima-
tion of Regional Capital Stock for Agriculture and Forestry), by the
Ministry of Agriculture and Forestry, January, 1966; and cultivated land
area from those in *Nōrinshō Tōkeihyō* (Statistical Tables of the Ministry
of Agriculture and Forestry).

and Chūgoku near Osaka, the social capital stock is greater in such
advanced rice-producing regions as Tōhoku (North-eastern) and Hoku-
riku (North-We Stern) and less in remote regions like Kyūshū Island.
This fact seems to lead us to the conclusion that the increase of
social capital stock for land improvement accompanies the extended
use of power cultivators.

Next, let us consider the second factor for the extension of power
cultivators. As mentioned previously, the agricultural labor popula-
tion began to show a marked decrease since around 1954, reflecting the
high-pitched growth of the Japanese economy. At the same time, some
members of each farm family started to earn extra income by taking
up side jobs. There was in other words an increase in the number of
so-called part-time farmers.

The ratio of these part-time farmers has been calculated by Takeo
Misawa as shown in Table 13. If these estimaties are accurate, part-
time farmers remained close to 54.8 % of the total before 1950, but have
increased drastically since about 1955 and finally reached 78.5 % in 1965.
Furthermore, a detailed study of the income structure of these farmers
will reveal the fact that the income from side-business es surpasses
the regular income from agriculture, which accounts for the marked
increase in so-called second-class part-time farmers.[13]

13) "Part-time farmers" means those farmers whose family member or members
are earning extra income by taking up side jobs: the first-class part-time
farmers are those who are earning more income from farming than their
side jobs and the second-class are those who are doing the contrary.

Table 13. Ratio of the part-time farmers. (unit: %).

	1938	1950	1955	1960	1965
Total	100	100	100	100	100
part-time farmers	54.8	54.8	65.1	65.7	78.5
1st-class //	30.6	31.8	37.6	33.6	36.8
2nd-class //	24.2	23.0	27.5	32.1	41.7

Source: "Farm Economy and Part-Time Farming in the Post-War Period",
    unpublished paper presented by Takeo Misawa to the Conference of
    Agriculture and Economic Development: A Symposium on Japan's Ex-
    perience, July, 1967.

This fact signifies the decrease in the agricultural labor population
or the decrease in the agricultural labor force, which is accordingly
reflected in the sharp rise of agricultural labor costs, as shown in Table
14.

Table 14. Agricultural part-time wages (male) and price index of agricul-
    tural machines and implements (100: Average during the period 1934-
    1936).

Year	Agricultural part-time wage index (A)	Price index of agricultural machines and implements (B)	(A/B)
1887	17	60	28.3
1900	43	78	55.1
1910	49	77	63.6
1920	191	160	119.4
1930	131	93	140.9
1940	222	146	152.1
1950	28,949	18,831	153.7
1955	41,673	34,283	121.6
1960	51,362	34,200	150.2
1963	88,249	34,439	256.2

Source: Calculated from the data in Nōringyō (Agriculture and Forestry)
    Vol. 9, by Matatsugu Umemura, and others, 1966.

In addition, the relatively lower down payments and the improved
performance of agricultural machines and implements may be counted
as the third factor for the extension of the agricultural mechaniza-
tion. Before the Second World War, agricultural machines were manu-
factured mostly in middle or small-sized factory enterprise on the basis
of past experience as to needs. After the War, however, production
techniques made progress by leaps and bounds. This was, in a sense,

one of the results of the switch-over from munitions plants to facto-
ries for the production of agricultural machines and implements. Me-
chanical engineering is now scientifically applied to production plan-
ning and materials are also inspected by experts. Thus, improvement
in quality and stabilization of prices of machinerus have been
attained (Uno, 1958).[14]

Now, let us take up the comparative price ratio between the average
male part-time wage in agriculture and the prices of agricultural
machines and implements. The annual part-time wage, which was
equivalent to 28.3 % of the prices of agricultural machines and imple-
ments in 1887, gradually rose to 153.7 % in 1950 and reached 256.2 % in
1963 (Refer to Table 14). The prices of agricultural machines and im-
plements have grown relatively less expensive compared with labor cost.

Fourthly, the rise of the farmers' income level could be pointed out.
This is mainly due to two causes; the popularization of side-business
among farmers and the inflated price of rice. Table 15 shows the
result of the investigation conducted by the Committee on Agricultural
Machines and Implements as to 2,061 farmers in 1964. According to
this Table, 77 % of the funds for the purchase of power cultivators
were from individual resources. Very little capital is secured from
the "Modernization Fund" (a governmental low-interest fund), or other
sources.

Table 15. Ratio of farmers and resources in the purchase of power cul-
tivators (%).

Farmers owning land	Own fund	Moderniza-tion fund	Farming fund	Fund of cooperatives	Others
Less than 5 tan	73	—	12	6	21
5 tan–1 chō	78	16	6	6	7
1–1.5 chō	76	16	7	8	3
1.5–2 chō	79	15	5	6	6
More than 2 chō	79	17	5	7	5
Average	77	16	6	7	5

Source: *Nōgyōyō Torakutā no Keizaiteki Kōka ni kansuru Chōsa* (Studies on
the Economic Effects of the Use of Agricultural Tractors) edited by
Nōkigu Iinkai (Commitee on Agricultural Machines and Implements),
Sept., 1965, p. 23.

(Note) "Less than 3 tan" and "3–5 tan" are totalled as "less than 5 tan".
In the case where a farmer utilizes several resources, he is included in
the figure in each corresponding column, in calculating the ratio of such
farmers to the total number. Therefore, the total in each line makes
more than 100 %.

14) *Nihon Nōgyō Nenpō* (Annual Report on the Japanese Agriculture), Vol. 8,
edited by Kōzō Uno, and others, 1958, pp. 70–82.

Such a high ratio of personal financing indicates a levelling-off of farmers' income and also reflects the limitations of financial organizations with regard to agricultural mechanization.

In this situation with the financial organizations not yet developed, farmers are obliged to raise the necessary funds and to arrange repayment themselves; this forces them to take economic or practical type of actions.[15]

In the last place, as the fifth and most important factor, the change in the farmers' entrepreneurship should be explained.

Prior to the Second World War, Japanese farmers possessed very little personal initiative. Seiichi Tōbata regarded them as "mere managers" in 1936.[16] This points to the fact that in Japanese agriculture the role of entrepreneurs was long played by such bodies as the Central Government, local public entities or agricultural cooperatives, and the farmers themselves did not display sufficient initiative. In the words of J. A. Schumpeter, who defined entrepreneurs as those who furthered the economy, the Japanese farmers in the pre-War period were not actively developing Japanese agriculture.

To sum up, the promotion of agricultural mechanization centering around the distribution of power cultivators has made the Japanese farmers familiar with practical econom (economy). It has also forced them to cease being "mere managers". Thus, it may be concluded that the recent extension of power cultivators is only the practical substitution of machinery for human labor···for maximum efficiency to the Japanese farmers (Tsuchiya, 1967).[17]

5. Conclusion

The mechanization of Japanese agriculture as of 1960 was carried out on very small-sized farm lands with only 4.58 tan per person of the agricultural labor population. This placed a major stress on the use of the power cultivators of approximately 5 horse-power.

Table 16 shows the annual yield of rice per tan in the Tōhoku region where mechanization is most advanced. The yield of rice, however,

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15) "An Economic Study of Farm Machinery of Japanese Family Farm", by Kudo coutained in *Tōhoku Nōgyō Shikenjo Hōkoku* (Bulletin of the Tōhoku National Agricultural Experimental Station), Oct., 1962, No. 25, pp. 119-144.

16) Ibid. by Seiichi Tōbata.

17) "Economics of Mechniazation in Small-Scale Agriculture", unpublished paper presented by Keizo Tsuchiya to the Conference of Agriculture and Economic Development : A Symposium on Japan's Experience, July, 1967.

Table 16. Yield of rice per tan in the North-eastern Region.

(unit: kg)

Year	Average	3-5 tan	5 tan-1 chō	1-1.5 chō	1.5-2 chō	More than 2 chō
1957	451	471	433	450	439	473
1958	442	431	431	431	434	471
1959	464	451	450	458	456	487
1960	488	486	473	486	491	499
1961	482	462	474	489	482	492
1962	486	481	484	488	482	489
1963	475	480	472	469	484	482
1964	475	468	461	467	481	485

Source: *Kome Seisanhi* (Rice Production Cost), by Ministry of Agriculture and Forestry, 1957-1964.

is scarcely increasing in spite of this promotion of mechanization. In recent years mechanization has been advanced in order to secure a certain amount of rice at the lowest possible cost, rather than to increase the yield. In other words, this is the practical substitution machinery for human labor. In this sense of the term, by the mechanization of Japanese agriculture is really logical. However, such mechanization does not contribute very much to increasing agricultural labor productivity.

Table 17 compares agricultural productivity with that of the manufacturing industry on the basis of per capita of labor population. Even in 1965 the comparative productivity of agriculture was only 31 %

Table 17. Comparative productivity of agriculture (1960 value)

Year	Net national income per captia at work.		Comparative productivity of agriculture (A/B) (%)
	Agriculture (A) (1,000 yen)	Manufacturing industry (B) (1,000 yen)	
1957-1959	87.6	304.8	28.7
1960	96.5	388.5	24.9
1961	101.2	420.8	24.0
1962	111.0	421.7	26.3
1963	117.8	448.1	26.3
1964	128.8	473.3	27.2
1965	144.1	465.5	31.0

Source: *1966 Nendo Zusetsu Nōgyō Nenji Hōkoku* (Graphical Annual Report on Agriculture, Fiscal Year 1966), by Nōrin Tōkei Kyōkai (Agricultural Statistics Association), 1967, p. 28.

of that of the manufacturing industry, and the increase of productivity still remains a big problem in Japanese agriculture. The solution will require an increase of scale of cultivated areas as well as the utilization of bigger machines adapted to large-scale farming.

The increased use of larger farm machinery, however, is considered quite difficult in Japan. As indicated in Table 6, only 36,000 tractors were in use by 1965. Most of these tractors are of less than 10 horse-power; with very few tractors of more than 20 or 30 horse-power. There is little prospect for more extensive use in the future.

Farmers leaving the farm-lands will continue to increase in number in the years to come, but the desire to retain their traditional farm-lands is strongly felt by the Japanese farmers and land is seldom disposed of. The same picture could be seen in the results of the farmers' census carried out in 1965 by the Ministry of Agriculture and Forestry. Of the total 6,000,000 farm owners in the country, about 10 % are supposed not to hesitate to abandon agriculture. However, those willing to give up their farmland represented only 1.6 % of the total or only 1.1 %, if the ratio is converted into cultivated area (Hatanaka, 1967).[18]

Such being the case, it is also very difficult to establish Japanese agriculture on a large-scale management basis. It will be many years before agriculture reaches full mechanization with the use of major agricultural eguipments such as combines and tractors. With such changed technology in the future, greater progress in increasing productivity in Japanese agriculture can be projected.

18) Nōgyōkan no Chigai ni yoru Nōmin no Shōrai Dōkō (Farmers' Prospective Attitudes by the Difference in their Views of Agriculture) by Koichi Hatanaka, contained in Nōgyō to Keizai (Agriculture and Economy), January. 1967, pp. 17-25.