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Agricultural Productivity in China and India: A Comparative Analysis

Lung-Fai Wong

I. Agricultural Development in China and India

China and India are the world's two most populous countries; together they comprise more than one-third of the total population. For a thousand years, most people in both countries lived in rural areas. Even today the rural population in each nation accounts for about 80 percent of its population.

Although China and India differ greatly in economic, social, and political circumstance, both emerged as net exporters of agricultural products after more than three decades of development.[1] Each country, however, employed different strategies and reforms and, therefore, they have been great interest to economists for many years.

As early as 1970, Bardhan (1970) made a comprehensive comparison of agricultural development in China and India. In their discussions of group farming, Dorner (1977) and J. Wong (1979) attempted to highlight key issues and to analyze the cooperative behavior of peasants in China and India as well as Israel, the Soviet Union, Yugoslavia, Peru, Tanzania, Sri Lanka, and Japan. The focus of Malenbaum's (1959, 1982) comparative studies was the economic performance of the agricultural and non-agricultural sectors in China and India. Concentrating on land reform and institutional changes, Bandyopadhyaya (1976) assessed the development of agriculture in China and India, especially the effectiveness of different land legislation enacted over the last three decades.

These economists explored some of the critical issues in the development of agriculture in the two nations. Yet, no comparative studies explicitly devoted to agricultural productivity are found in the literature. The objective of this study, therefore, is to examine the trends and differences in agricultural productivity growth in China and India. The investigation, on which this paper draws, is part of a larger on-going project on comparative productivity growth among countries (Hayami and Ruttan 1985, Binswanger and Ruttan 1978, Hayami, Ruttan, and Southworth 1979, Wong 1986, and Wong and Ruttan 1986). Reported here are the results of an effort to compare rate of change in productivities and to ascertain the contributions of land, labor, livestock, machinery, and fertilizer to production, and the productivity growth as well as the role of technology in agricultural development.

It may be helpful first to review the general context of agricultural development in China and India. Table 1 shows that, the two countries have somewhat similar economic profiles. In general, China has a richer resource endowment and lower population pressure. Also, the growth of aggregate agricultural output is faster in China than in India. However, there are as many differences between as similarities in the two nations. Although India and China each established a new form of government more than three decades ago, the political systems differ. Both countries initiated land reform legislation but with a distinction: India has private land ownership whereas China has communal land ownership. Both countries adopted a 5-year planning scheme, but each was constituted on different principles: market vs. centrally planned economy.

Table 1: Economic Profile for China and India (1983)

	China	India
Total Area (000 km^2)	9600	3287
Population (millions)	1025	685
Annual Rate of Population Growth (%)	1.2	2.5
Population Density (per km^2)	106.7	208.5
Percent of Rural Population (%)	81.5	76.7
Agricultural Land Area (mil hectare)	386.6	180.3
Population per Hectare of Agri. Land	2.65	3.80
Multiple Cropping Index	1.467	1.236
Agricultural Production Index (1964=100)	273.7	167.6

Land Reform in China and India

In their attempt to increase food production back in the early 1950s, the two nations laid out their own plans and time tables for land reform. The basic principle of China's land reform was "to confiscate the land of the landlord class and to redistribute it to peasants having insufficient or no land" (S. Liu 1953, 67). The first stage of the reform was carried out from 1949 to 1952, the years known as the period of rehabilitation. The basic features of this stage were to confiscate the land, machinery, livestock, and dwellings owned by large landlords and merchants and to redistribute them to landless peasants. By the end of 1952, more than 310 million peasants and 47 million hectares of land were affected. One unique feature of the reform was that properties (including land) of middle peasants were protected from infringement. The reform might have brought land ownership to additional millions of peasants but the individual holdings then would have been too small for efficient farming. The per capita share of distributed land varied from 0.05 hectare in the densely populated areas to 0.25 hectare in less populated areas (J. Liu 1952, 19). The reform led to little immediate improvement in China's agriculture because of the shortage of farm implements, loan credits, livestock, fertilizer, and seeds.

In India, land reform legislation was launched in 1951 with the objectives of increasing agricultural production and paving the way for industrialization. The reform had four major features: (a) elimination of land intermediaries, (b) tenancy reform, (c) limits on land holdings, and (d) consolidation of small holdings. In contrast to China's forceful policy, the Indian policy was carried out under the framework of parliamentary democracy. It led to large variations in the degree of practical implementation in different states; they tended to act slowly and reluctantly, especially when dealing with compensation matters. India's land reform, consequently, did not significantly affect the structure of land ownership in the country due to the fact that, on the whole, "the abolition of intermediaries removed only the upper layers of the feudal hierarchy in rural India" (Bandyopadhyaya 1976, 67).

In the following years, in addition to the attempt to reorganize the ownership of land, China launched more institutional reforms, such as collectivization, while India explored other development policies, such as initiating cooperatives and the Community Development Program.

Collectivization in China

When the Chinese launched their First Five Year Plan in 1953, they also adopted the Soviet style of collectivization. The initial target was to organize 20 percent of farm households into "Elementary Cooperatives" by 1957 with the objective of enlarging the scale of farms and better mobilizing the rural population. Within a year, 670,000 cooperatives were formed with 14.2 percent of the total peasant households enrolled.

By the middle of 1955, there appeared to be an urgent need to extract more agricultural surplus to finance industrialization and to halt the so called "re-emergence of capitalist elements." China's collectivization movement thus entered its second stage and the establishment of "Advanced Cooperatives" started. More than 100 million households (87.7%) became members of the 500,000 Advanced Cooperatives by the end of 1956. The momentum and speed of the movement to organize peasants may have looked very impressive, but it failed to improve the situation in rural China. Peasants' incomes derived from sideline production dropped, the percentage of marketed food grains declined, and many peasants were on the brink of starvation.

The solution for these problems, the Chinese believed then, was to form people's communes that would transfer collective ownership to the ownership of all the people. In essence, the control of agricultural resources and surplus, as well as of sideline production and private activities, would be tightened even more. It was a new stage of socialist revolution advocating egalitarianism and "eating from one big pot." Under the commune system, peasants were paid according to when they reported to and left work instead of the contribution of their labor. Thus, incentive and productivity dropped to a low level because of the difficulties of supervision (Lin 1986). Nevertheless, the commune movement appeared to make at least one positive contribution: the massive mobilization of labor for infrastructure construction and the diversion of industrial materials to the agricultural sector. As it will become clear later, that the rapid growth of the application of fertilizer and machinery may have helped to increase partial productivities (labor and land productivity) in China but also caused a steady decline in total factor productivity. The commune movement, an extreme form of institutional reform, can be characterized as a campaign for mechanization with little technological innovation.

Not until 1978 did the situation in rural China change profoundly. The changes were due to the introduction of the Household Responsibility System, production autonomy, and several new policies on procurement price and sideline production. Since then agricultural production and productivity in China have increased steadily and significantly.[2]

Cooperatives and The Community Development Program in India

The idea of cooperative farming emerged in India as early as the year 1945 and carried a different meaning and orientation from that of China. It emphasized the development of cooperative credit, processing, marketing, small-scale industries, community projects, and consolidation of fragmented farm land. Although the Indians had watched Chinese collectivization closely, pilot cooperative farming societies were not launched in India until 1961.

Unlike the Chinese collectivization movement, cooperatives in India took a different approach to peasants in two ways: (a) the system was voluntary and (b) it gave full recognition to peasants' property rights. By 1965, 5,000 cooperative farming societies were active in India with an average of 20 members and 45 hectares per farm. Participating peasants managed and cultivated the land jointly; the profits after deducting wages and allotments to reserves, were divided in proportion to the wages earned by each peasant. The original purpose of the cooperatives was to achieve large-scale farming through mechanization. However, some large landowners formed cooperatives as a way to avoid tenancy and land-holding ceilings, and to obtain financial aid from the government. Furthermore, in some cases, only inferior land was pooled; the fertile land was retained by peasants for individual cultivation (Choudhary 1979, 224). Because of these shortcomings, the cooperatives did not yield the expected results and failed to draw support from the majority of Indian peasants. In fact, it was observed early in the program that "there is no advantage from cooperatives in terms of output per acre; only labor is saved" (Krishna 1961, 225). It is worth noting here that although production cooperatives were a failure from the program's point of view, service cooperatives, that is, purchasing, marketing, credit, and processing cooperatives, achieved moderate success (Bandyopadhyaya 1976, 98).

Another important event in the course of India's development was the launching of the Community Development Program in 1952. The primary objective of this ambitious program was to mobilize local population and resources, with government assistance for technical services and basic materials, to transform rural India. The program's strong emphasis on training, extension services, and research was intended to change the attitudes of rural people toward the use of new technology. By 1962, despite its huge requirement of management personnel, the program included more than 500,000 villages and 300 million rural residents. However, expectations were not met for two major reasons: (a) little new, profitable technology was available in the early stage and (b) the failure to eliminate the large propertied class and tenancy system caused a clash of interests in society. For these reasons the growth of Indian agriculture was less than anticipated. Not until the 1970s, when it was able to benefit from new technologies, did the basic agricultural production system expand and adjust its production structure to the changing demand associated with rising income (Mellor 1976, 30).

II. Land and Labor Productivity Growth

Despite the limited effects of institutional reform, agricultural production in China and India has kept pace with population growth. The increased productivity in both countries over the last three decades may be due to the amount of industrial inputs that were injected into agriculture; indeed, the rate at which the industrial inputs were added was considerably higher than the relatively slow growth of agricultural labor and far higher than the minuscule addition of lands (in fact, the area of land under cultivation was almost constant). It has been generally recognized that China's yield of grain production is higher than that of India's (Table 2).

In this section, there are compared, using aggregate output data, changes in partial productivities of the agricultural sector in China and India.

Table 2: Average Yield of Principal Crops (kg/ha)

	1970	1975	1980	1983	1970	1975	1980	1983
	China				India			
Rice	3398	3518	4133	5096	1120	1124	1330	1230
Wheat	1148	1635	1890	2802	1310	1410	1630	1840
Maize	2086	2539	3075	3623	1280	1200	1170	1100

Sources:
Ministry of Statistics, *Statistical Yearbook of China*, 1983, 84, Beijing: pp. 153-8.
Ministry of Planning, *Statistical Pocket Book of India*, 1983, Delhi: p. 32.

Following the usage in previous studies (Wong 1986; Wong and Ruttan 1983), labor productivity is defined in terms of wheat units[3] per agricultural laborer, including male and female workers; and land productivity is defined as wheat units per hectare, including arable land and pasture. This nontraditional definition has a special purpose in intercountry comparisons. Not only does it allow comparisons between countries that have different political systems, price structures, currencies, and output compositions, but the biases stemming from government controlled exchange rates also can be avoided.

Labor and land productivities, measured in wheat units, for China and India for the period of 1960-1983 are computed and summarized in Table 3. In the early 1960s, both agricultural labor productivity and land productivity were lower in China than in India, especially land productivity in China; in 1960 it was only 71 percent of that of India. This difference was mainly caused by the drastic setback in total agricultural production in China from 1958 to 1961. Specifically, the aggregate agricultural output in China dropped more than 26 percent during the period 1958-1961; in fact, the output level in 1961 was less than the level recorded in 1952.[4] The turmoil of the early 1960s was due in large part to the commune movement and to the Great Leap Forward campaign; together they destroyed peasants' incentive and squeezed large amounts of resources out of agriculture for the industrial sector.

China caught up with India in labor productivity by 1964 and has remained at a higher level since then. In 1983, labor productivity in China was an impressive 26 percent higher than in India. However, land productivity remained lower in China than in India until 1974. Note that the low level of land productivity in China was partly due to the fact that China has a vast area of uncultivated but arable agricultural land that is included in this study as agricultural land. It is also noteworthy that agricultural production and productivity increased substantially in China after the implementation of the new Household Responsibility System in 1978. Agricultural production during 1978-1983 grew at about 7% a year. Table 3 shows that the growth rates of land and labor productivity in China during the same period were 3.75% and 5.21%, respectively, compared to 2.44% and 2.96%, respectively, for the same period in India.[5]

Table 3: Production, Labor and Land Productivities in Wheat Units

	CHINA			INDIA		
	Agg	Productivity		Agg	Productivity	
Year	Output	Labor	Land	Output	Labor	Land
1960	264587	1.46	0.88	217809	1.60	1.24
1961	259295	1.42	0.86	223168	1.62	1.27
1962	275170	1.49	0.91	220843	1.59	1.25
1963	306921	1.63	1.01	234791	1.67	1.33
1964	346609	1.81	1.12	241766	1.70	1.37
1965	375714	1.91	1.22	225493	1.58	1.27
1966	407464	2.02	1.32	223116	1.53	1.26
1967	415402	2.02	1.33	244033	1.65	1.37
1968	404818	1.93	1.25	255653	1.71	1.43
1969	410110	1.91	1.32	267274	1.77	1.50
1970	457736	2.07	1.47	281219	1.83	1.58
1971	470965	2.08	1.51	285867	1.85	1.61
1972	468319	2.02	1.51	274246	1.76	1.54
1973	508007	2.13	1.59	297488	1.89	1.67
1974	529174	2.17	1.69	281219	1.77	1.56
1975	555633	2.22	1.78	316209	1.96	1.76
1976	568862	2.22	1.78	309926	1.92	1.70
1977	576800	2.20	1.86	339929	2.08	1.88
1978	629717	2.37	1.97	350752	2.12	1.94
1979	685280	2.52	2.14	329978	2.00	1.83
1980	703801	2.39	2.20	341523	2.05	1.89
1981	750369	2.45	1.94	367618	2.21	2.04
1982	833449	2.62	2.85	356043	2.13	1.97
1983	912296	3.00	2.45	405137	2.39	2.25
Growth Rate (%):						
1964-73	3.64	1.25	3.43	3.00	1.84	2.93
1974-83	5.94	2.95	4.66	2.98	2.35	2.96
1978-83	7.16	3.75	5.21	2.92	2.44	2.96
1964-83	4.57	1.96	4.08	2.77	1.84	2.63

Although the partial productivities seem slightly higher in India than those in China, their growth rate was slow in India in the early 1960s. It was during this period that India's land reform was put into practice but it did not generate much change in either land ownership or productivity, as noted earlier. It was also the period in which India experienced several years of bad weather and the new technology that accompanied the green revolution was not readily available. Together, these factors resulted in a particularly slow growth in both production and productivities.

Table 3 also reveals that the growth rates of labor and land productivity were larger in the period 1974-1983 than in the period 1964-1973 for both China and India. It also should be noted that in both nations the growth rate of land productivity was larger than the growth rate of labor productivity for the four periods. Conceivably, the intensive use of labor and other factor inputs, such as fertilizer, have been the major cause of the relatively high growth rate of land productivity. During the period 1960-83, the use of fertilizer increased 23 times in China and 16 times in India.

The causes of slow growth in China's and India's agricultural labor productivity are similar. Both had a growing rural population that was sizeable to begin with. For example, the rural population in China increased from approximately 500 million in 1952 to 780 million in 1977 (Tang and Stone 1980, 43) which added 150 million workers to China's agricultural labor force in the period of 1950-1983; a 60 percent jump. The resulting decrease in land/man ratio in China and India consequently, led to the development and adoption of labor-intensive cultivation. Despite the pressure to raise unit-area output, which resulted in the slow growth of labor productivity, the labor productivity of wheat units per labor increased 66 percent in China and 41 percent in India between 1964 and 1983.

The growth rate of labor productivity in China in 1964-1973 was particularly low: only 1.25% a year. It was during this period that the commune movement and Cultural Revolution reached their peaks. Commune members had to contribute a significant amount of their time to political activities and other non-farming tasks (e.g., building schools, roads, dams, etc). Consequently, the growth of labor productivity in China was lower than that in India from 1964 to 1973.

The comparison of land productivity shows a difference between China and India. The Chinese had a higher growth rate of land productivity from 1964 to 1983 and during three periods: 1964-1973, 1974-1983, 1978-1983. The increasing population in China, especially from 1965 to 1975, created enormous pressure on the agricultural sector to produce more food. The increase in total food consumption and the decrease in land/labor ratio led the Chinese to cultivate their land with greater intensity. With the experience accumulated over several centuries, Chinese peasants learned how to produce an increasing amount of food from a smaller amount of land per worker.

Rawski (1982) pointed out that two schemes were used in China to raise the output per unit of land. The first was the intensification of cropping practices. Over the past three decades, the application of resources to each unit of sown hectare, in the absence of changes in the type of crops grown or in the rotation cycle, has been increasing. This intensification increased the level of activity in land preparation, planting, transplanting, and crop management and resulted in the increase of land productivity. The second scheme was the intensification of the cropping cycle, that is, the increase in the number of crops harvested per unit of cultivated land. Rawski (1982, 127) found that the national index of multiple cropping in China (sown area divided by cultivated area) rose from 1.31 in 1952 to 1.5 in 1977 or 1978. In comparison, the index of multiple cropping in India rose only from 1.18 in 1970 to 1.24 in 1980.[6]

III. Total Factor Productivity Changes

The biased character of the partial productivity indexes as indicators of technical progress motivated the employment of a total factor productivity index (defined as the ratio of aggregate output to aggregate inputs). Total factor productivity (TFP) captures the effects of factor substitution and, hence, is a more adequate indicator of the effects of technical change.

It has been conventional since the mid-1950s to follow Solow (1957) in using the geometric index to measure total factor productivity.[7] Assuming a linearly homogeneous production function, competitive equilibrium, and neutral technical change, the residual or unexplained growth can be treated as an index of technical change and can be measured econometrically. The mathematical expression for the geometric productivity index with five conventional factor inputs is as follows:

$$\frac{\dot{A}}{A} = \frac{\dot{y}}{y} - W_l \frac{\dot{l}}{l} - W_f \frac{\dot{f}}{f} - W_m \frac{\dot{m}}{m} - W_s \frac{\dot{s}}{s}$$

where
A = shift factor,
y = output per labor (Y/N)
l = land per labor (L/N)
f = fertilizer per labor (F/N)
m = machinery per labor (M/N)
s = livestock per labor (S/N)
W_i = factor share of corresponding factor

Because complete price information for the two nations for the period 1960-1983 was not available, factor shares could not be obtained directly. Instead, statistically estimated production elasticities were used as proxies for factor shares for the two nations. The estimated production elasticities for China were taken from the estimated agricultural metaproduction function for centrally planned countries. The elasticities are: 0.155 for labor, 0.042 for land, 0.239 for fertilizer, 0.173 for machinery, and 0.391 for livestock (Wong 1986, 37). For India, the estimated factor shares were taken from the estimated metaproduction function of 22 developing countries that included India, adjusted for constant return to scale; they are 0.45 for labor, 0.10 for land, 0.15 for fertilizer, 0.10 for machinery, and 0.20 for livestock.[8] A summary of the computed indexes are presented in Table 4 with the annual growth rate of the indexes for 1964 to 1983, and for the periods 1964-1973, 1974-1983, and 1978-1983.

Table 4: Indexes of Production and Productivities (1964=100)

	CHINA				INDIA			
	Agg	Productivity			Agg	Productivity		
Year	Output	Labor	Land	TFP	Output	Labor	Land	TFP
1960	76.34	81.01	78.66	100.04	90.09	94.22	90.56	110.82
1961	74.81	78.69	76.95	103.35	92.31	95.66	92.67	108.70
1962	79.39	82.39	81.22	98.71	91.35	93.53	91.53	103.43
1963	88.55	90.38	89.60	95.83	97.12	98.26	97.16	103.61
1964	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1965	108.40	105.93	108.47	89.40	93.27	92.97	92.99	84.80
1966	117.56	112.15	117.33	84.70	92.29	90.18	91.81	75.53
1967	119.85	111.99	118.55	78.75	100.94	97.52	100.31	87.88
1968	116.79	106.75	111.66	79.37	105.74	101.02	104.77	84.34
1969	118.32	105.69	117.30	69.86	110.55	104.44	109.87	84.80
1970	132.06	114.89	131.31	75.62	116.32	107.99	115.45	87.70
1971	135.88	115.14	134.91	70.16	118.24	109.29	117.59	71.84
1972	135.11	111.64	134.24	60.58	113.43	103.73	112.48	64.70
1973	146.56	118.10	141.20	58.63	123.05	111.33	122.08	72.73
1974	152.67	120.08	150.85	60.12	116.32	104.14	114.19	64.09
1975	160.31	123.11	158.13	58.63	130.79	115.47	128.59	76.63
1976	164.12	123.12	158.57	56.02	128.19	112.95	124.59	67.23
1977	166.41	121.93	165.46	51.60	140.60	122.57	137.44	72.94
1978	181.68	131.31	175.55	46.70	145.08	125.17	141.65	71.53
1979	197.71	139.70	190.96	46.06	136.49	117.69	133.59	61.64
1980	203.05	132.61	196.38	40.53	141.26	120.60	137.82	62.94
1981	216.49	135.50	172.88	44.46	152.06	130.06	148.90	69.98
1982	240.46	145.24	253.85	50.22	147.27	125.40	143.67	64.44
1983	263.21	166.09	218.60	59.99	167.57	140.76	164.25	75.81
Growth Rates (%):								
1964-73	3.64	1.25	3.43	-5.28	3.00	1.84	2.93	-3.04
1974-83	5.94	2.95	4.66	-1.82	2.98	2.35	2.96	-0.06
1978-83	7.16	3.75	5.21	4.59	2.92	2.44	2.96	1.51
1964-83	4.57	1.96	4.08	-3.86	2.77	1.84	2.63	-1.63

The geometric productivity indexes - what Solow called "a rough profile" of technical change - show some signs of decreasing productivity in the 1960s and 1970s in both China and India. The trend of decreasing TFP is in sharp contrast to the trends of increasing labor productivity and land productivity. The figures estimated by Anthony Tang (Tang and Stone 1980, 75) can be used to check the declining TFP index in China. By employing a different aggregate procedure and a different set of factor shares (0.54 for labor, 0.27 for land, 0.11 for capital inputs, and 0.08 for current inputs), Tang was able to estimate that the TFP in China's agricultural sector declined 19 percent during the period 1952-1977. On the other hand, using the same weights as Tang's, Rawski also estimated that the TFP in Chinese agriculture declined 26 to 36 percent between 1957 and 1975 (Rawski 1983, 132). Although the declining trend was not reversed, the rate of the TFP's negative growth in 1974-1983 was considerably smaller than it was in 1964-1973. Paralleling the case of the partial productivities, the TFP in China has reversed from a decrease to an increase since the implementation of the Household Responsibility System in 1978; it achieved an impressive annual growth rate of 4.59 percent for the period 1978-1983.

Total factor productivity in India is slightly better than that in China. Although the agricultural sector in India also experienced some declining trends, its rate of decrease is lower than that in China. In particular, India experienced a significant gain in TFP in 1967 and 1970, which reduced the decrease in the rate of the TFP to only about 3 percent in the period 1964-1973. Furthermore, like China, India also reversed its decreasing trend in the period 1978-1983 to a healthy growth rate of 1.51 percent, thus making the trend of TFP in India in the period 1974-83 a mere 0.06 percent decrease a year, a rate that is not significant at all.

Figures in Table 4 show that the TFP in India was higher in 1983 than in 1971 and about the same as it was in 1966. Indian agricultural development in the 1960s was a period of policy adjustments focusing on price incentives and new technologies. The country made substantial social and political transformations and paved the way for accelerated growth in the following decade. The 1970s was a period of refining, adjusting, and expanding the food production economy; it was reaping the benefit of development efforts in the preceding decade. This sequence of events may have caused the reversal in the declining trend of the TFP. The TFP in India has increased slightly since 1971. Overall, the rate of change of the TFP from 1964 to 1983 was a 1.63 percent decrease a year. Although the choice of factor shares may affect the computed TFP indexes, the trends of TFP remained fairly stable under different sets of factor shares.[9]

When comparing productivities in China and India, an intriguing fluctuation of trends and inconsistency between partial and total factor productivity indexes can be discerned. The trends and fluctuations of partial and total factor productivity in the two countries are show in Figures 1 and 2. In both, the differences between partial productivity and total factor productivity indexes tend to diverge, though not necessarily, in the opposite direction (see Figures 1 and 2). Furthermore, the divergence between land productivity and total factor productivity is greater than the divergence between labor productivity and total factor productivity. These divergences are in sharp contrast to the historical experience of western countries where partial and total factor productivity seem to move in the same direction.

Figure 1: Trends of Productivity in China

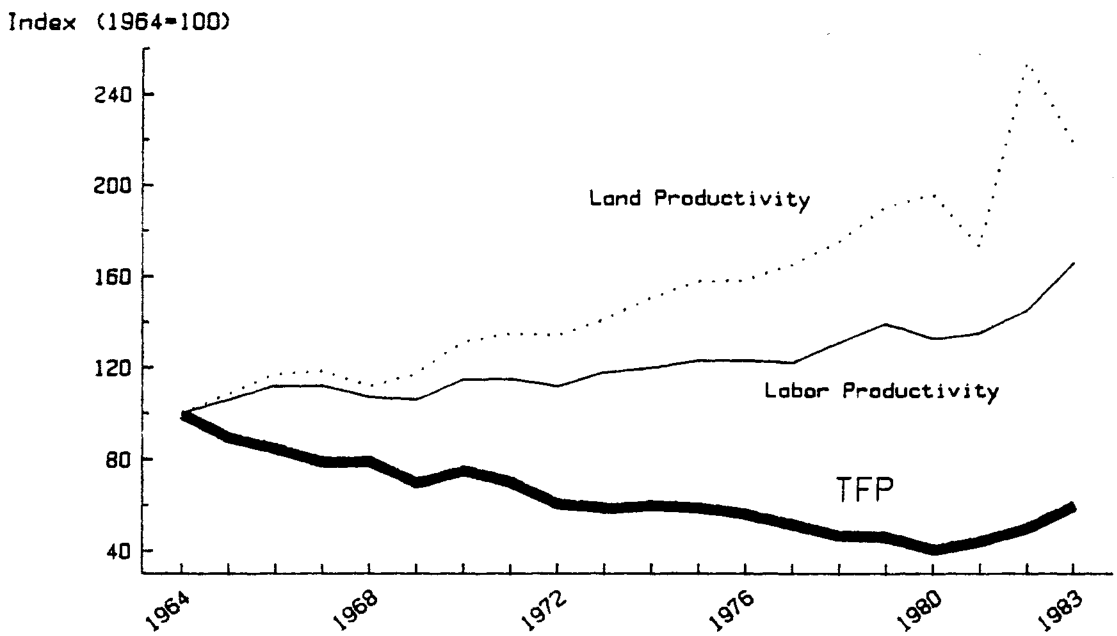


Figure 2: Trends of Productivity in India

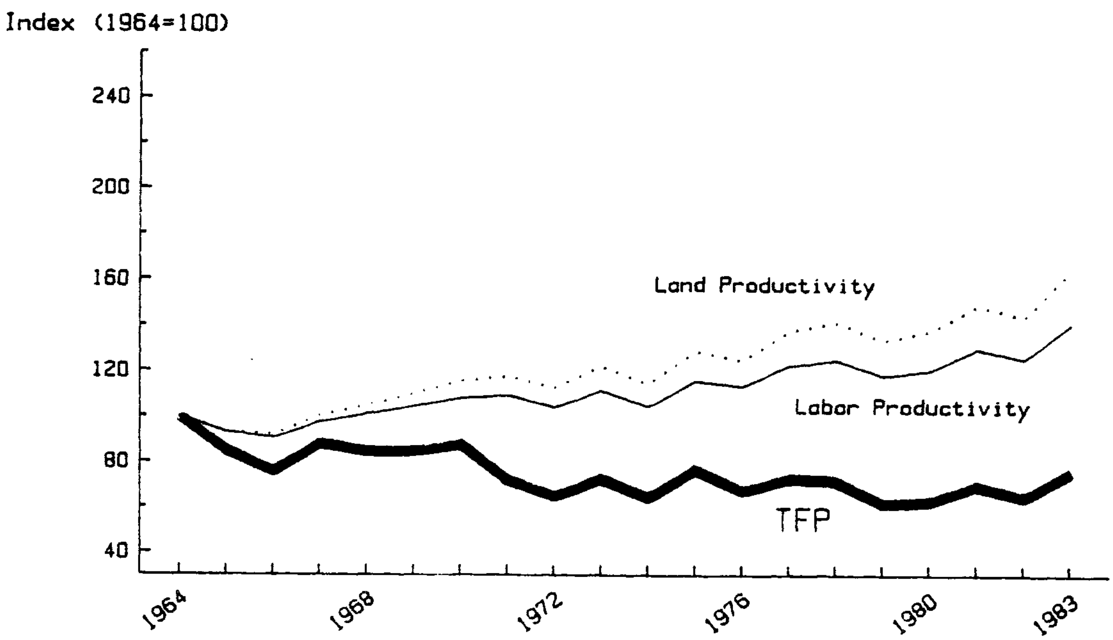
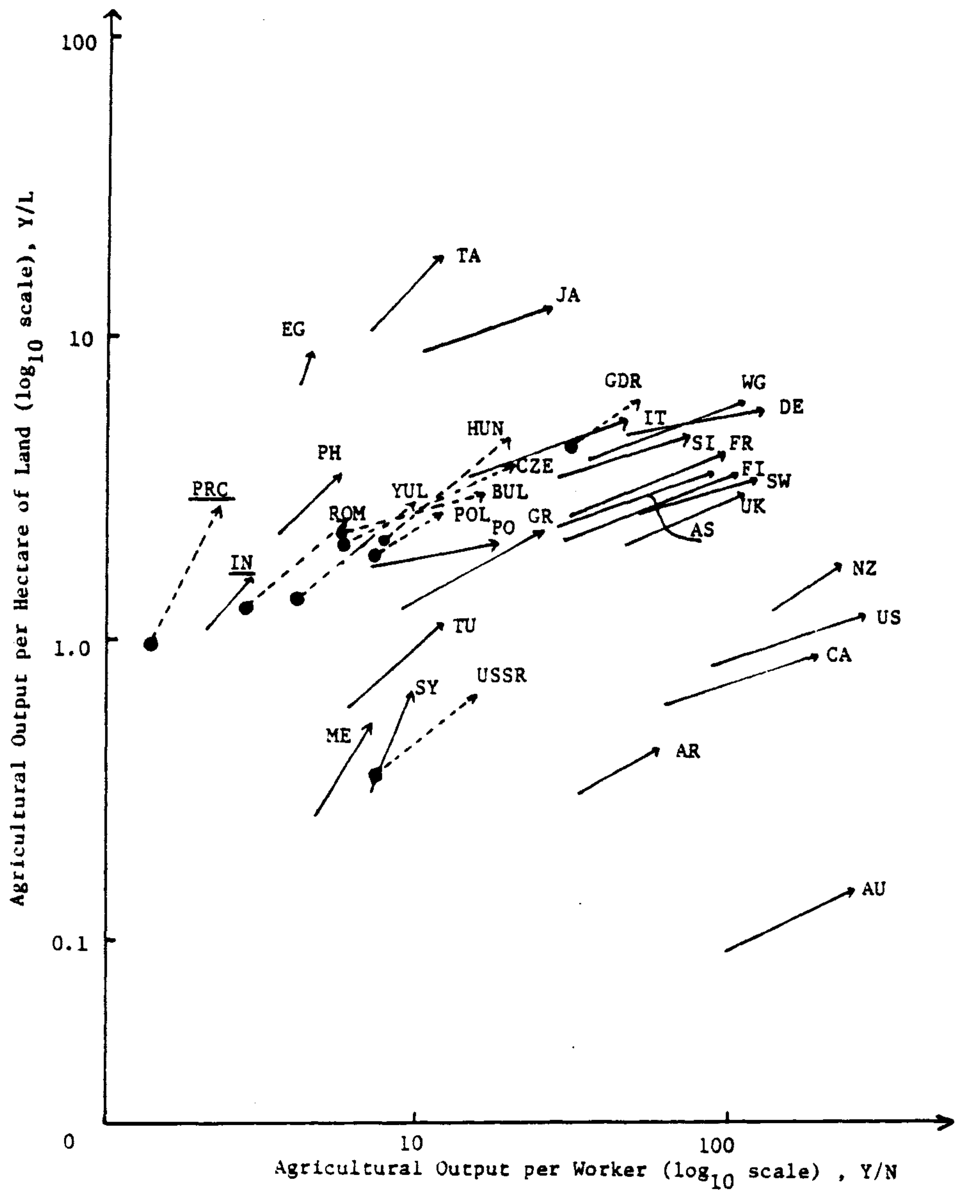


Figure 3: International Comparison of Productivity Trends (1960-80)



Centrally Planned Countries: Bulgaria(BUL), China(PRC), Czechoslovakia(CZE), East Germany(GDR), Hungary(HUN), Poland(POL), Romania(ROM), Yugoslavia(YUG), Soviet Union(USSR).

Noncentrally Planned Countries: Argentina(AR), Australia(AU), Austria(AS), Canada(CA), Denmark(DE), Egypt(EG), Finland(FI), France(FR), West Germany(WG), Greece(GR), India(IN), Italy(IT), Japan(JA), Mexico(ME), New Zealand(NZ), Philippines(PH), Portugal(PO), Sweden(SW), Switzerland(SI), Syria(SY), Taiwan,China(TA), Turkey(TU), United Kingdom(UK), United States(US).

The similar trends of productivities and the divergences between productivities in China and India indicate that both nations were moving toward a similar pattern of agricultural development, even though their differences in development policies and political system were significant. The similarity was even more obvious when the two nations were compared to the general pattern of development in other countries. Such a comparison is shown in Figure 3; the agricultural labor and agricultural land productivities for China and India are plotted along with those of eight centrally planned and 23 noncentrally planned countries. The development pattern for China and India can be seen to fall along the path characteristic of Asian countries, such as Japan and the Philippines, in which favorable man/land ratios prevail.

IV. The Role of Technology in Productivity Changes

Decreasing total factor productivity and increasing labor and land partial productivities characterized the performance of agriculture in China and India. Although growth in agricultural production could be achieved by replicating the existing level of factor inputs, this growth would be very costly to the economy. Another source of growth would be to increase productivity, but it does not come easily. Over the last three decades, several factors have been identified as sources of agricultural growth in the two nations. Both China and India invested heavily in fertilizer and irrigation systems in an effort to raise yield per hectare. The Chinese put more emphasis on fertilizer while the Indians put more emphasis on machinery. The use of fertilizer and machinery in China jumped 23 times and 17 times, respectively, between 1960 and 1983; the comparable figures for India were 16 and 22. Both countries intensified their use of land by multiple cropping and labor-intensive farming. The Chinese, however, appear to have had more success in multiple cropping than did the Indians (Table 1).

The sources of growth in agricultural production from conventional inputs are not too difficult to identify. Adequately characterizing the rate of technical change, however, has been more difficult. The generation of technological advancement is a costly, resource-using activity. The evidence of the declining TFP suggests that increased agricultural output has been achieved by increasing the use of conventional inputs to exceed the growth in output. The divergence between the TFP and partial productivities suggests the occurrence of a slow shift in the production function. In order to examine the contribution of technical change, Table 5 was tabulated.

The first two rows of Table 5 show the partial productivities of labor and land in 1964 and 1983, respectively. The difference between row 1 and row 2 is the gross growth caused by increases in inputs and/or technological advances during 1964-1983 (see row 3). Row 4 is the TFP in 1983 (from Table 4), an indicator of technical change during the period 1964-1983. Hence, the "constant technology" labor productivity in 1983 can be obtained by dividing row 2 by row 4 (see Row 5). It can be interpreted as the productivity, excluding technical change, that would have occurred in 1983 had technology remained constant. In other words, it is the increase in productivity that was caused solely by the increase of inputs. For example, the 1983 labor productivity for China would have been 5 instead of 3 wheat units per labor had the 1983 input level and the 1964 technology been used. Thus the 1983 "constant technology" productivity in row 5 minus the 1964 productivity in row 1 is the net growth of productivity in 1964-1983 which is solely due to the alteration of input level (see row 6). If the figure in row 6 is larger than the figure in row 3, it indicates that technical change did not bring about higher productivity, and vice versa. Therefore, the portion of productivity growth that can be explained solely by increased input is the ratio of row 6 to the gross growth in row 3 (see row 7).

The figures in the last row of Table 5 suggest that both nations exhibited no net gain from technical change, which implies that agricultural growth came from increased use of factor inputs and not from technical change. This means that despite the fact that the production function in these countries may have shifted upward over the past 20 years, the production point moved away from the expansion path in a way that may have counteracted the benefit of technical change; thus resources were misallocated. Figures in Table 5 also show that in the attempt to increase partial productivities, the misallocation of resources was less serious in India. On the other hand, it is believed that the adoption of the Household Responsibility System in China since 1978 may have brought about more efficient resource allocation and higher productivity in Chinese agriculture.

Table 5: Contribution of Technology to Agricultural Productivity

	Labor Productivity		Land Productivity	
	China	India	China	India
(1) = Productivity,1964	1.81	1.70	1.12	1.37
(2) = Productivity,1983	3.00	2.39	2.45	2.25
Gross Growth: (3)=(2)-(1)	1.19	0.69	1.33	0.88
Technology Index: (4)=TFP(1983)/TFP(1964)	0.60	0.76	0.60	0.76
"Constant Technology" Productivity in 1983: (5)=(2)/(4)	5.00	3.14	4.08	2.96
Growth of productivity, excluding Technological Change: (6)=(5)-(1)	3.19	1.44	2.96	1.59
Productivity growth explained by increased input :(7)=(6)/(3)x100%	268.07	209.38	222.81	180.74

All the evidence presented so far points to the fact that the achievement of agricultural growth in the two nations came with a cost. Labor and land productivity have substantially increased but technological advancement played only a minor role in this increase. Much growth resulted from moving along the production function rather than from an upward shift of the production function. Using Euler's theorem and the principle of growth accounting, the percentage differences in output per labor and output per land over time can be expressed as the sum of percentage differences in conventional inputs per labor (or land), weighted by their respective production elasticities, as shown in the following equation:

$$\frac{\Delta(Y/N)}{(Y/N)} = W_l \frac{\Delta(L/N)}{(L/N)} + W_f \frac{\Delta(F/N)}{(F/N)} + W_m \frac{\Delta(M/N)}{(M/N)} + W_s \frac{\Delta(S/N)}{(S/N)} + \text{Unexplained}$$

Table 6: Accounting for Changes in Productivity (1964 vs 1983)

	Labor Productivity Changes				Land Productivity Changes			
	China		India		China		India	
	percent	index	percent	index	percent	index	percent	index
Changes in productivity (%)	39.79	100.00	36.89	100.00	54.25	100.00	45.92	100.00
Resource endowment	-7.39	-18.56	-4.82	-13.07	8.51	15.69	6.59	14.35
Land (or Labor)	-1.33	-3.34	-1.67	-4.52	3.72	6.86	6.43	14.01
Livestock	-6.06	-15.23	-3.15	-8.55	4.79	8.83	0.16	0.34
Technical inputs	38.27	96.17	22.13	59.99	38.97	71.83	22.54	49.09
Fertilizer	21.17	53.20	13.05	35.39	21.83	40.23	13.33	29.04
Machinery	17.10	42.97	9.08	24.60	17.15	31.60	9.21	20.06
Explained	30.88	77.61	17.31	46.92	47.48	87.52	29.13	63.45
Unexplained	8.91	22.39	19.59	53.08	6.77	12.48	16.78	36.55

In Table 6, the figures in the "percent" columns represent the percentage change in agricultural labor productivity from 1964 to 1983. Other entries in the "percent" columns are the percentage change of factor/labor ratios during the same period. The "index" columns account for the percentage of change in productivity that can be explained by the respective factor inputs; the first row is set at 100 for comparison purposes.

From the "index" column it can be seen that the changes in fertilizer/labor and machinery/labor ratios explained 96 percent and 60 percent of the changes in labor productivity in China and India, respectively. In addition, these columns reveal that about 22 percent of labor productivity growth in China and 53 percent in India were not accounted for by the four conventional inputs. The unexplained factors may include investment in research and infrastructure, climate, and shift in policy and political system. Thus, a larger portion of productivity gain in India may have come from these sources. It was estimated in another study (Wong 1986, 90-98) that agricultural research accounted for 16 percent of labor productivity growth and 11 percent of land productivity growth in China in 1960-1980.

The growth accounting approach also can be applied to the growth of land productivity. In Table 6 the right hand side shows the analysis of land productivity in China and India to which labor and livestock contributed some portion of land productivity changes, although not to a very large degree. It also reveals that technical inputs are the major factor affecting land productivity growth in these two nations; in particular, fertilizer accounted for 40 percent and 29 percent of the growth in China and India, respectively. Compared to growth in labor productivity, a smaller portion of land productivity is explained by the two technical inputs.

It should be noted that the computations in this and the previous section are somewhat dependent on the choice of base year and factor shares. Because the growth rates were computed using linear log trends, they are independent of the choice of base year. The results of growth accounting, however, depend on which base year is used. On the other hand, the choice of factor shares for the fast-growing factors -- fertilizer and machinery -- may have a significant effect on the results. But again, the trends of TFP would not change significantly even if different factor shares were used.

VI. Conclusion

Several agricultural productivity indexes -- labor, land, and total factor productivity measures -- were computed for China and India. The results indicate strong upward trends of labor productivity and land productivity in 1960-1983 but a strong downward trend of total factor productivity in the 1960s. The results also show slow downward trend or no growth of total productivity in the 1970s. Despite the fact that the two countries appeared to be able to achieve positive growth of total factor productivity in the late 1970s, the divergence between partial and total factor productivity continued. This divergence suggests that inefficiency and an unbalanced cost structure are embodied in both agricultural systems.

Over the last three decades, China and India made several attempts to reorganize agriculture. In the pre-green revolution period, large-scale land reforms were carried out in the two countries. In the 1950's decade, China attempted to install a land reform program and several stages of collectivization: from Elementary Cooperatives and Advanced Cooperatives to communes. Each attempt increased the degree of collectivization in Chinese agriculture but had only a modest impact on growth of production. During the same period, land reform was also initiated in India; the effect was both more controversial and less drastic than in China. The objective of land reform in India was to free the peasants from the control of landlords. In China and India alike, land reform and institutional reform were viewed as important means to achieve production growth. Yet, in retrospect, increased production and productivity were due primarily to the introduction of new technology and/or inputs. In their attempts at institutional reform, China lacked the administrative personnel needed for the success of its collectivization movement, and India lacked the technology needed for the success of its cooperatives and Community Development Program. Although the two countries were able to increase agricultural output in the 1960s by adding more inputs, partial productivities may have been increased at the cost of efficiency.

The 1960s is the period in which new technologies and new varieties were discovered by the international research community. Many developing countries benefited from the new technology and the green revolution. During that time, however, China was at the peak of the Cultural Revolution and Communal movement. Commune officials and state farm managers in China were more interested in fulfilling their production quotas than in efficient production. Thus, the green revolution had almost no effect on Chinese agriculture, and total productivity in China continued to decline during the 1960s and early 1970s. Although the green revolution was more visible in India in the 1960s, agricultural resources were arrogated to finance the rapid growth of India's industrial sector. The prices set during that period favored urban workers over peasants. The result was that the resources and new technologies available in India were not used to their full potential. Nevertheless, in the early 1970s, the green revolution started to have some effects on Indian agriculture and stopped the downward trend of India's total factor productivity.

In both countries technical changes have been directed primarily to achieving increases in land productivity. Because labor inputs continued to increase, the growth of labor productivity had to be achieved by even more rapid growth of land productivity. The adoption of High Yield Varieties since the mid-1960s clearly contributed to the substantial increase in output/hectare. The high yield potential of the new varieties could be achieved only when their adoption was accompanied by higher levels of fertilizer and other industrial inputs. When the market in India and commune officials in China failed to respond effectively to the new technology, a larger increase of input use than output gain may have resulted. Thus total factor productivity in China and India declined. This does not necessarily imply that no technological change has occurred in the agricultural sector. The potential gains from technical change may have been wiped out by losses from the misallocation of resources. It may be true, particularly in India, that the technical change occurring in the late 1960s was barely able to cover the loss of efficiency in the earlier years. It is also possible that what has been interpreted as technical change in the 1960s was largely the effect of factor substitution along a production function that had been shifting at a relatively slow rate. Overall, technical change made little net contribution to the process of agricultural productivity growth during the period 1964-1983.

The results of the preceding analysis suggest that increased land and labor productivity in China and India has been achieved at a relatively high cost. In the early 1970s, India began to adjust its policy to discriminate less against the agricultural sector, and Indian peasants effectively responded to the changes of market condition and agricultural prices. Total factor productivity in India started to increase at a very low growth rate. In China, the agricultural reform in 1978 provided more incentive for Chinese peasants to produce and to allocate resources rationally. Since then, both production and productivity in China have been increasing.

The remarkable achievements in agriculture by China and India are largely attributable to the increase of inputs used, technological advancement, expansion of cultivated areas, and institutional changes. The combination of these factors not only altered these countries' partial and total factor productivities but, also turned the two nations into net exporters of agricultural products.

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Notes

1. Trade volumes of agricultural, fishery, and forestry products in 1984: China imported $6.04 billion and exported $6.15 billion; India imported $2.16 billion and exported $2.74 billion. FAO, Agricultural Trade Yearbook, 1984, Rome: FAO, pp 40.

2. It is estimated that since its emergence in 1978, the Household Responsibility System has brought, on the average, a 14% increase in farm productivity in China (Justin Lin 1986).

3. Wheat units are constructed by taking the geometrical mean of 53 gross agricultural outputs net of intermediate products weighted by the relative price (to wheat) in the U.S., Japan, and India. The time series of gross agricultural output is constructed from the growth indexes of China and India. The growth indexes were derived from various volumes of Statistical Yearbook of China and FAO Production Yearbook. Data on the 53 agricultural outputs were derived from the FAO Food Balance Sheets. Data on production factors were derived from each nations' official data and FAO estimates.

4. It is for this reason that 1964 was chosen as the base year for this study instead of 1960 (in order to avoid the biases caused by the abnormally low level of production in China during 1958-1961).

5. All of the growth rates reported in this study are computed by estimating linear regressions of natural exponential function, i.e., $\ln Y = a + bT$, where Y is the variable to be measured, T is the time variable, and b is the estimated growth rate.

6. Central Statistical Organization, Department of Statistics, Statistical Pocket Book of India, 1983, Ministry of Planning, Government of India, New Delhi: 1984, pp 26.

7. Several other productivity measures were considered but rejected due to the larger volume of data they require. For instance, the Divisia index approach satisfies the invariance indexing property but is path dependent and requires changing the weights for every period. On the other hand, although the production function approach allows the use of a more generalized functional forms, it is readily useful only for a production function that involves not more than two inputs.

8. The agricultural metaproduction function for the socialist countries was estimated using time series cross-country data. The Cobb-Douglas production function was selected as the functional form for the estimation. Because of the presence of multicollinearity, the procedures of principal components regression and mixed estimation were employed in the model. The prior information used in the mixed estimation model is the coefficients of the agricultural metaproduction function estimated for 38 market economies (Hayami and Ruttan 1971; 93). The agricultural metaproduction function for 22 developing countries was estimated by Hayami and Ruttan using principal component regression (Hayami and Ruttan 1985; 145, Q19).

9. To test the effect of different factor shares on the computation of the TFP, three different sets of factor shares were tested. The first test was to switch the factor shares between China and India; the second test was to apply the Chinese factor shares to both countries; and the third test was to apply the Indian factor shares to both countries. The computed indexes of TFP were different for the three tests but the trends of TFP for the two countries were essentially unaffected.