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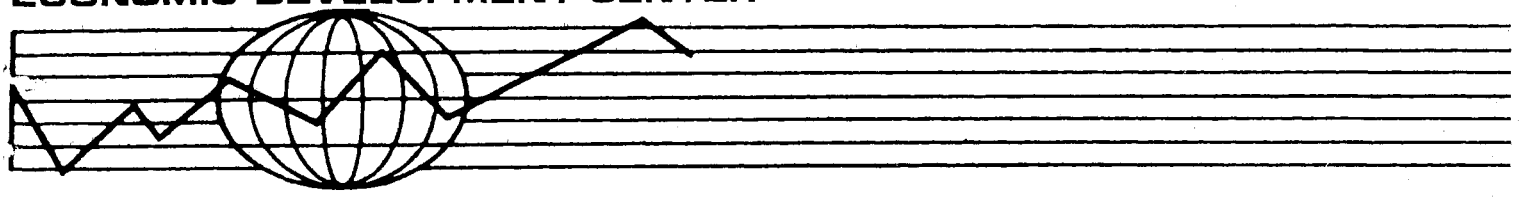

A COMPARATIVE ANALYSIS OF AGRICULTURAL PRODUCTIVITY TRENDS IN CENTRALLY PLANNED COUNTRIES

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A Comparative Analysis of Agricultural Productivity Trends in Centrally Planned Countries

Lung-Fai Wong and Vernon Ruttan*

I. Introduction

The objective of this study is to compare the differences in agricultural productivity changes between nine centrally planned countries - Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, Yugoslavia, the Soviet Union, and China for the period 1950-1980. Two kinds of productivity indices - the partial productivity and the total factor productivity - were constructed for this study. Although labor productivity and land productivity are expressions of output per unit of a single input, they are major components of total factor productivity which is commonly used as an indicator of technical change. The two partial productivity ratios also serve as indicators of the direction of technological change.

Although the nine countries included in this study are generally labelled as Centrally Planned Economies (CPE), which implies homogeneity, they are in fact different from each other in terms of the degree of centralization, agrarian policy, resource endowments, and growth pattern. As shown in Figures 1 and 2, the growth rate of agricultural output varies among the nine centrally planned countries, which also lead to the varies pattern of productivity changes.

The study, on which this paper draws, is a part of a larger on-going project on comparative productivity growth among countries. (Hayami and Ruttan 1981 & 1985, Binswanger and Ruttan 1978, Hayami, Ruttan and Southworth, 1979). This paper reports the results of an effort to measure and compare rate of change in partial and total

Figure 1
Countries Achieved High Growth Rate in Agricultural Production

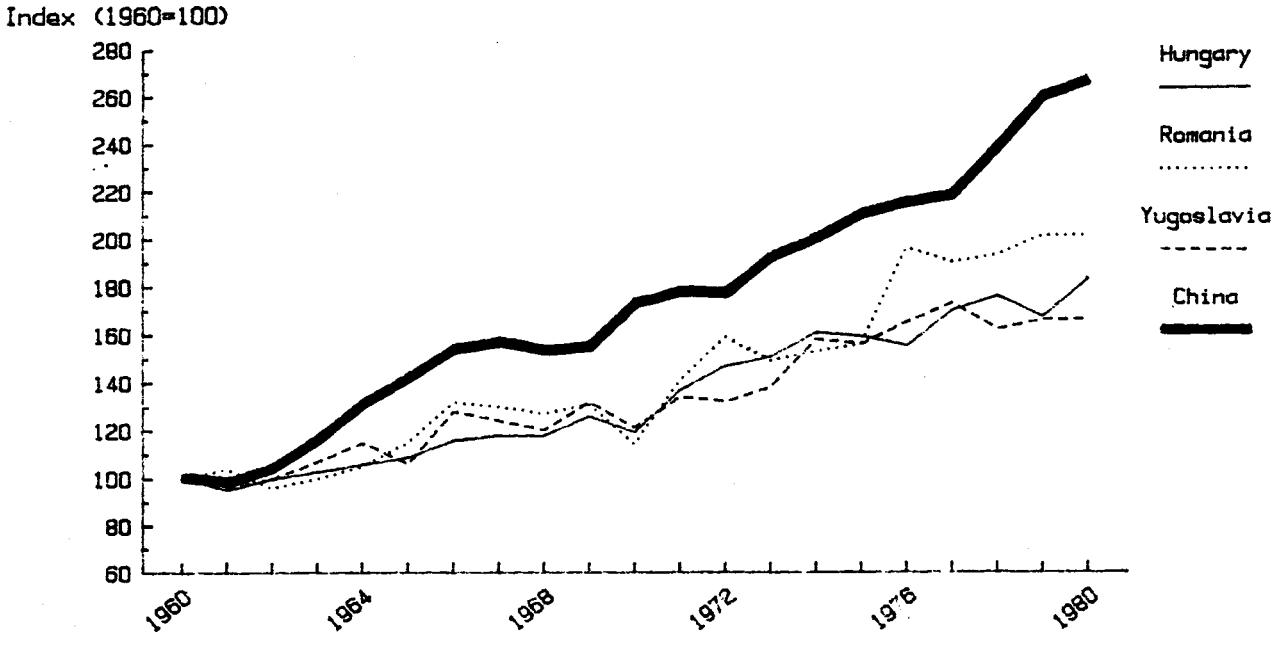
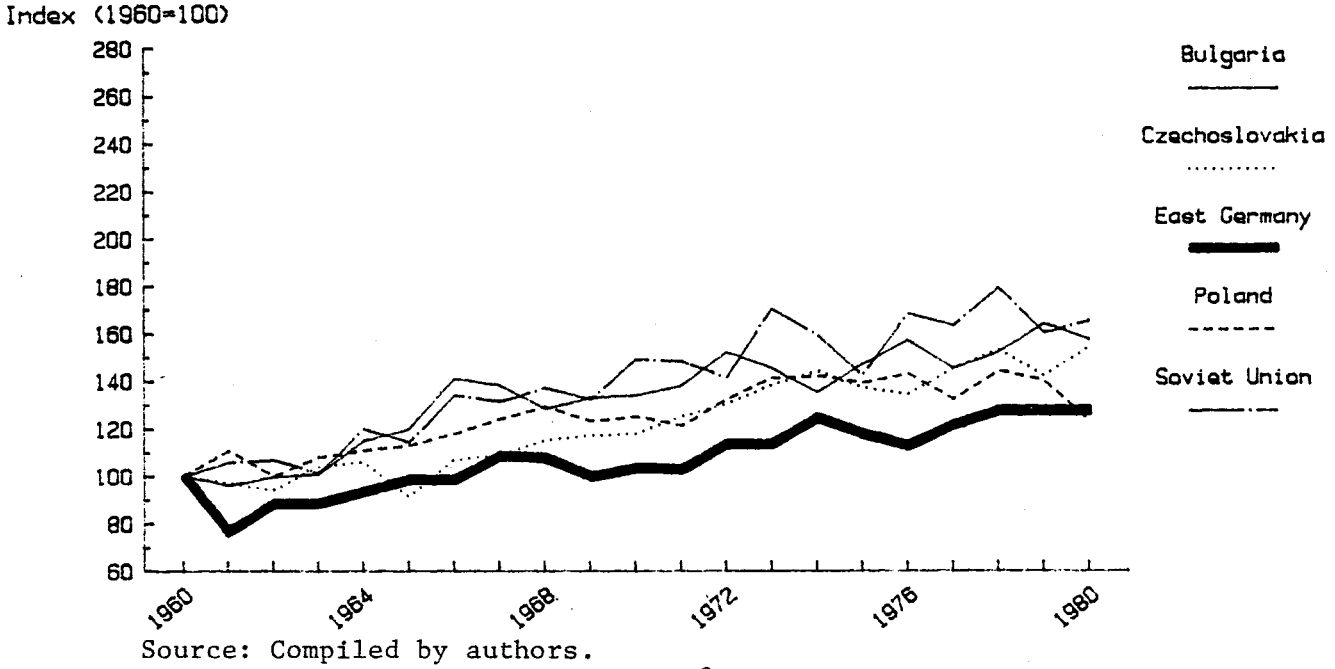


Figure 2
Countries Achieved Low Growth Rate in Agricultural Production



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productivity for the agricultural sector in nine centrally planned countries. Using a set of statistically estimated factor shares and the geometric index approach, a series of total factor productivity indices are constructed. Analysis of the trends of productivity changes and contribution of technical changes to agricultural growth are also presented here.[1]

II. Changes in Labor Productivity

Following the notation used in previous studies (Wong and Ruttan 1983), labor productivity is defined in terms of wheat units per agricultural labor, including male and female workers. This non-traditional definition has a special purpose for a cross-country comparison study. Not only does it allow comparison between countries that have different price structures, currencies, and output compositions, but the biases stemming from exchange rates can also be avoided.[2]

Labor productivity for the nine CPEs included in this study are computed and summarized in Table 1. During the last three decades, the ranking of labor productivity altered variously among these countries. Although the ranking for East Germany (highest), Yugoslavia, Romania, and China (lowest) remained the same, while there were shifts in rankings among other countries.

The most obvious is the ranking of Hungary. In 1950, Hungary was the fifth among the group; it climbed to second position in 1980. In contrast, during the same period, the ranking of Poland slipped from third to sixth. Bulgaria performed almost as well as Hungary - it gained two positions in the race. The other two countries, USSR and Czechoslovakia, each lost one position.

The shifts in relative ranking only reflect differences in relative growth rates. All nine countries achieved very substantial absolute increases in labor productivity during this period. Even China, which has the lowest labor productivity, increased 82 percent

Table 1: Labor Productivity, wheat units per labor

YEAR	BUL	CZE	GDR	HUN	POL	ROM	YUG	USSR	PRC
1950	2.43	7.16	11.36	5.27	6.08	1.67	1.71	5.51	1.31
1951	3.54	7.66	13.51	6.53	5.42	2.29	2.59	4.96	1.42
1952	2.76	7.87	14.02	4.61	5.42	2.04	1.54	5.68	1.63
1953	3.45	8.74	14.12	6.42	5.58	2.48	2.75	5.65	1.67
1954	2.90	7.76	14.43	5.96	6.12	2.29	2.29	5.85	1.71
1955	3.24	8.31	12.81	6.97	5.98	2.60	3.06	6.60	1.81
1956	2.95	9.11	13.71	6.16	6.83	2.11	2.48	7.44	1.87
1957	3.59	9.00	14.71	7.13	6.92	2.66	3.76	7.19	1.93
1958	3.46	8.98	15.21	6.78	7.09	2.19	3.14	8.29	1.97
1959	4.38	9.15	15.27	8.28	7.03	2.82	4.36	7.67	1.69
1960	4.69	10.69	19.86	7.99	7.65	2.64	3.96	8.00	1.46
1961	4.53	11.00	15.48	8.38	8.46	2.85	3.87	8.70	1.42
1962	5.06	10.96	17.93	8.89	7.61	2.64	4.10	8.93	1.49
1963	5.28	12.27	17.94	9.60	8.21	2.76	4.46	8.57	1.63
1964	6.19	12.78	18.85	10.26	8.39	2.91	4.88	10.10	1.81
1965	7.37	12.13	21.15	12.73	8.70	3.14	4.59	9.52	1.91
1966	8.95	14.32	21.72	13.70	9.11	3.69	5.64	11.28	2.02
1967	8.90	14.96	24.40	14.09	9.62	3.65	5.57	11.14	2.02
1968	8.67	16.03	25.47	14.21	10.04	3.58	5.49	11.74	1.93
1969	9.49	16.52	24.52	15.39	9.58	3.71	6.15	11.47	1.91
1970	9.97	16.81	26.32	14.91	9.76	3.21	5.75	13.06	2.07
1971	10.72	18.07	26.76	17.55	9.47	4.03	6.49	13.07	2.08
1972	12.07	20.04	30.91	19.30	10.42	4.56	6.53	12.48	2.02
1973	11.99	21.93	31.54	20.55	11.10	4.29	6.96	15.00	2.13
1974	11.56	23.06	35.22	22.65	11.12	4.42	8.13	14.02	2.17
1975	13.46	22.45	33.54	22.95	11.64	4.56	8.19	12.69	2.22
1976	15.12	22.42	32.72	22.96	12.21	5.79	8.84	15.05	2.22
1977	14.55	24.83	35.56	25.57	11.50	5.67	9.46	14.73	2.20
1978	15.65	26.69	37.19	26.60	12.81	5.84	9.04	16.18	2.37
1979	16.89	24.96	37.24	25.09	12.89	6.16	9.45	14.60	2.52
1980	16.46	27.12	37.19	27.44	11.61	6.28	9.65	15.14	2.39
GROWTH RATES:									
60-69	9.37	5.16	4.61	7.99	2.87	4.38	5.20	4.37	4.11
70-80	5.24	4.33	3.43	5.36	2.62	6.02	5.24	1.81	1.87
50-80	6.80	4.73	4.13	6.04	2.88	3.82	5.44	3.83	1.53
60-80	6.70	5.04	4.36	6.43	2.53	4.51	4.87	3.30	2.40

Source: Compiled by authors.

from 1950-1980. Among these countries, Bulgaria had the highest jump in 1960-1980, a 250 percent increase in labor productivity. Following Bulgaria was Hungary, Czechoslovakia, Yugoslavia, Romania, USSR, East Germany, China, and Poland, in that order.

The rate of growth for labor productivity was also computed for the periods 1960-1969, 1970-1980, 1950-1980, and 1960-1980.[3] As shown at the bottom of Table 1, most countries (except Romania and Yugoslavia) experienced a higher growth rate of labor productivity in the 1960s than in the 1970s. Overall, the average growth rate for these countries for the period of 1960-1980 was 4.46 percent, which is higher than most people would expect.

One of the explanations for the high growth in labor productivity is the high growth of aggregate agricultural production of 2.91 percent average of the nine CPEs for the period 1960-1980 (Wong 1986; 11). When the size of the labor force remained constant or decreased, the growth of production naturally translated to the growth of labor productivity.

Another important source of growth of labor productivity has been the shrinking size of labor forces in the agricultural sector in these countries. All East European countries experienced a large reduction in the agricultural labor force between 1950 and 1980. For example, the agricultural labor force in Bulgaria in 1980 was only 37 percent of the 1950 level - it was a 46 percent reduction for Czechoslovakia; 56 percent reduction for East Germany; 47 percent reduction for Hungary; 80 percent reduction for Poland; and 59 percent reduction for Yugoslavia.

The causes of the sharp decreases in agricultural labor in East European countries can be traced to both the agricultural and non-agricultural sectors. In the early 1960s, the process of collectivization in agriculture in most of these countries resulted in a massive movement of population to the urban areas (Vais 1981; 239). Simultaneously, many

East European countries suffered serve economic problems. To counteract the declining economy, policy makers sought to expand production capacity through construction of new factories and an increase in the demand for labor force. This resulted in a massive tapping of male and female labor from the agricultural sector. This situation continued through the 1970s when labor shortage was still a problem.[4] Thus, East European countries had been using agriculture as a reservoir of manpower for the non-agricultural sector.

The rate of reduction of the labor force in the USSR was not as large as in the East European countries. The size of the productive labor force declined by only 18 percent from 1950-1980, which is a smaller percentage than that of any East European countries. But having a sizeable agricultural labor force per se is not the major cause of low labor productivity. In fact, a large part of the country, especially the European part of the USSR, has been experiencing a shortage of agricultural labor. Also, it is increasingly common in Soviet agriculture to use temporary workers and factory workers during the peak seasons. But this does not stop the out-migration of agricultural labor. The inferior wage rate in the agricultural sector is the major cause of out-migration. According to Brooks' calculation, in nine of the fifteen Soviet republics, the ratios of average non-agricultural wages to agricultural wages in 1965 were close to 2.0 or above. In Georgia republic, the ratio was as high as 2.68 (Johnson and Brooks 1983; 182).

Theoretically, labor mobility is a mechanism for equalizing the differential wage rates that exist in the economy. But this has not happened in the Soviet economy. The educated, young and energetic farmers who were supposed to take responsibility for the process of "complex mechanization", as Soviets refer to it, have migrated out of the agricultural sector and left behind them the unskilled, untrained, aged population of agricultural laborers. This has generated additional problems as tractors and machinery are left idle because of a shortage of trained operators and experienced technicians.

Thus, the out-migration of young and trained people from the agricultural sector to the non-agricultural sector is an impediment to the growth of labor productivity and to narrowing the wage gap.

The causes of slow growth in China's agricultural labor productivity are completely different. Unlike the East European countries and the Soviet Union, China has faced a growing rural population which was sizeable to begin with. The rural population increased from approximately 500 million in 1952 to 780 million in 1977 (Tang 1980; 43). This added 127.8 million workers to China's agricultural labor force in the period of 1950-1980, which is a 77 percent jump. Despite the resulting decrease in land/man ratio, the labor productivity of wheat units per labor in Chinese agriculture increased 64 percent between 1960 and 1980.

China's labor productivity continued to grow through the 1970s, but the development and adoption of labor-intensive cultivation and the pressure to raise unit area output resulted in the slow growth of labor productivity. Furthermore, the commune establishment in China required members to contribute a significant amount of time to non-farming tasks such as building schools, roads, dams, etc. Consequently, labor productivity in China is the lowest among socialist countries, both in terms of productivity level and growth rate of productivity.

From the data in Tables 1, three general patterns can be observed. First, the three most industrialized countries (East Germany, Hungary, and Czechoslovakia) have the highest level of labor productivity. Second, the differences in labor productivity between these countries are large and are continuing to grow. In 1960, labor productivity in East Germany was 13.6 times that of China. This ratio grew to 15.56 times by 1980 - a 14.4 percent increase. Third, even though there has been much discussion about the favorable effects of decentralization, labor productivity data cannot be interpreted as supporting

the hypothesis that the less-centralized countries (Hungary, Poland, Yugoslavia, and Romania) have out-performed the centralized countries.

III. Changes in Land Productivity

Land productivity, measured in wheat units per hectare, is presented in Table 2. It represents only the physical relationships between production and land and should not be used as an indicator of performance. However, land productivity can be used as a useful indicator of agricultural productivity and agricultural development in areas where land is a constrained resource as in the Asian countries.

In contrast to the fluctuation of labor productivity, the overall picture of land productivity is fairly stable. The data in Table 2 show that from 1950-1980 only four of the nine countries had changes in their rankings of land productivity and they were small changes. Furthermore, ranking of the four highest countries in land productivity and labor productivity in 1980 are identical, which includes East Germany, Hungary, Czechoslovakia, and Bulgaria. Note that the low level of land productivity in the USSR is partly due to the fact that the USSR has a vast area of uncultivated agricultural land (so does China) which is also defined in this study as agricultural land.

During the past three decades, land productivity in all nine centrally planned countries has increased substantially in that period. A summary of the annual growth rate of land productivity for different periods of time are reported in Table 2.

The growth rates of land productivity were larger in 1960-1969 than in 1970-1980 for the majority of the nine countries. It also should be noted that in most countries the growth rate of land productivity was smaller than the growth rate of labor productivity. The reasons for slow growth of land productivity are not difficult to identify.

Table 2: Land Productivity, wheat units per hectare

YEAR	BUL	CZE	GDR	HUN	POL	ROM	YUG	USSR	PRC
1950	1.18	1.97	2.58	1.50	1.61	0.73	0.69	0.27	0.66
1951	1.67	1.98	3.06	1.85	1.44	0.98	1.02	0.24	0.75
1952	1.27	1.96	3.22	1.29	1.44	0.88	0.59	0.28	0.89
1953	1.60	2.26	3.23	1.71	1.48	1.07	1.03	0.28	0.95
1954	1.33	2.02	3.38	1.56	1.62	1.00	0.83	0.27	1.02
1955	1.52	2.17	3.13	1.88	1.58	1.22	1.08	0.32	1.08
1956	1.40	2.34	3.21	1.70	1.80	0.95	0.85	0.36	1.13
1957	1.69	2.24	3.32	2.01	1.82	1.20	1.27	0.34	1.15
1958	1.68	2.16	3.45	1.89	1.86	0.99	1.04	0.40	1.19
1959	1.97	2.15	3.26	2.22	1.84	1.28	1.42	0.38	1.03
1960	1.92	2.35	3.79	2.07	1.99	1.23	1.27	0.38	0.88
1961	1.84	2.24	2.87	1.98	2.22	1.28	1.21	0.40	0.86
1962	1.91	2.18	3.33	2.11	2.01	1.17	1.27	0.41	0.91
1963	1.93	2.42	3.34	2.18	2.18	1.22	1.37	0.38	1.01
1964	2.17	2.61	3.51	2.25	2.24	1.28	1.47	0.46	1.12
1965	2.25	2.13	3.72	2.32	2.31	1.39	1.36	0.43	1.22
1966	2.64	2.51	3.72	2.48	2.41	1.59	1.64	0.51	1.32
1967	2.56	2.57	4.10	2.52	2.55	1.57	1.60	0.50	1.33
1968	2.37	2.71	4.14	2.53	2.65	1.52	1.55	0.52	1.25
1969	2.40	2.76	3.85	2.70	2.56	1.57	1.70	0.50	1.32
1970	2.42	2.79	4.00	2.56	2.60	1.37	1.56	0.57	1.47
1971	2.50	2.96	3.96	2.95	2.52	1.69	1.74	0.56	1.51
1972	2.74	3.09	4.39	3.17	2.77	1.91	1.72	0.54	1.51
1973	2.64	3.28	4.39	3.27	2.97	1.79	1.81	0.65	1.59
1974	2.45	3.43	4.82	3.51	3.00	1.84	2.07	0.61	1.69
1975	2.69	3.28	4.54	3.47	2.95	1.87	2.05	0.54	1.78
1976	2.75	3.22	4.35	3.39	3.04	2.35	2.18	0.64	1.78
1977	2.54	3.49	4.70	3.73	2.81	2.28	2.29	0.62	1.86
1978	2.66	3.69	4.94	3.88	3.07	2.31	2.14	0.68	1.97
1979	2.87	3.44	4.94	3.71	3.00	2.41	2.20	0.61	2.14
1980	2.76	3.77	4.94	4.08	2.64	2.41	2.20	0.63	2.20
GROWTH RATES:									
60-69	3.77	2.13	2.50	3.28	3.05	3.48	3.62	3.71	5.49
70-80	1.05	2.45	2.11	3.71	0.90	5.04	3.49	1.35	4.16
50-80	2.67	2.16	1.79	3.31	2.61	3.39	3.65	3.23	3.16
60-80	1.90	2.74	2.18	3.67	1.97	3.75	3.19	2.75	4.48

Source: Compiled by authors.

First, the growth of population in all East European countries and the Soviet Union was small, and in some cases the growth rate was negative (such as in East Germany). Thus, the pressure for raising per area production was not as acute as it was in countries in which there was increasing population pressure (such as China). Second, the land/labor ratio in these countries increased in 1950-1980 which implies that a unit of labor had more land to cultivate than before. This eventually led to the adoption of technology which was less labor intensive. Third, the mechanization program in East European countries and the Soviet Union opened some new agricultural land which further increase the land/labor ratio and at the same time more agricultural land was used for operation of machinery rather than for planting. And fourth, because land was owned by the state and rented to state and collective farms at a minimal charge, there was little incentive for farmers or managers of state farms to maximize either the utilization of land or the value of the marginal product of land. This was not the case when the land was designated to individual farmers as private garden plots.

The situation in China was the reverse. The increasing population in China, from 552 million in 1950 to 987 million in 1980, created enormous pressure on the agricultural sector to produce more food for the newly added population. The increase in total food consumption and the decrease in land/labor ratio led the Chinese to utilize their land with greater intensity. With experience that had accumulated over several centuries, Chinese peasants learned how to produce an increasing amount of food from a smaller amount of land per worker.

Rawski pointed out that two schemes were used in China in an effort to raise output per unit of land. The first scheme 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 increases the level of activity in land preparation,

planting, transplanting, and crop management, which absorbs a large number of the underemployed rural population.

The second scheme is the intensification of the cropping cycle. This refers to an increase in the number of crops harvested per unit of cultivated land. According to Rawski, the national index of multiple cropping in China (sown area divided by cultivated area) has risen from 1.31 in 1952 to 1.5 in 1977 or 1978 (Rawski 1982; 125).

There is no doubt that the intensive use of labor and other factor inputs such as fertilizer in Chinese agriculture has been the major cause of the relatively high growth rate of land productivity. In fact, the growth rate of land productivity in China is even larger than the growth rate of its labor productivity.

To summarize this section, several observations are worth mentioning. The three industrialized countries (East Germany, Hungary, and Czechoslovakia) have the highest level of land productivity. The differences in land productivity between countries are smaller than labor productivity and are shrinking over time. Apparently it has been easier to improve labor productivity than to improve land productivity. With the exception of China, none of the countries included in this study have been able to double their land productivity in the last 20 years.

In spite of the common perception that the growth of agricultural production in CPE has been rather slow, analysis presented in this study indicates that the labor productivity of the nine countries, including the highly populated China, has increased by at least 60 percent for the period of 1960-1980. Industrial inputs have played an increasingly important role in agricultural production. For example, from 1960 to 1980 the consumption of chemical fertilizer in Romania and China increased 16 and 19 times, respectively. The number of tractors in Yugoslavia and China increased 12 and 16 times, respectively.

Except for China, the rate of growth of labor productivity has been faster than the rate of growth of land productivity in these countries. Despite the fact that total agricultural area in the East European countries has decreased (or remained unchanged), the USSR and East European countries have emphasized mechanical technology in order to increase their labor productivity, while China has concentrated on labor-intensive biological technology to intensify land use.

IV. Cross-Country Comparison of Total Factor Productivity

The biased character of the partial productivity indices as indicators of technical progress motivated the employment of total factor productivity which is defined as the ratio of aggregate output to the aggregate of all inputs. Because the total factor productivity captures the effects of factor substitution, it represents a more adequate indicator of the effects of technical change.

It has been conventional since the mid-1950s, to follow Solow in using geometric index as to measure total factor productivity. 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

In the event that discrete annual data is used, the above equation can be approximated as:

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

where $\Delta y = (y_{t+1} - y_t)$ and etc.

t = 1950,...,1979

Thus, $(\Delta A(t)/A(t))$ can be obtained from the above equation which is the yearly shift factor of the production function.

The procedure for obtaining a series of annual geometric productivity indices is first to compute the term $(\Delta A/A)$ for each year. Then by arbitrary setting A(1950)=1, the time series of cumulated shift factor A(t) can be approximated by

$$A(t+1) = A(t)*[1+(\Delta A(t)/A(t))]$$

t = 1950,..., 1979

Complete price information was not available for all nine CPEs and if they were available they would be seriously distorted and would fail to reflect the actual resources scarcity. Thus, factor shares cannot be estimated directly. Instead, a set of statistically estimated production elasticities was used as a proxy for factor shares. The estimated production elasticities were from the estimated agricultural metaproduction function for socialist countries.[5] Compared with other studies summarized in Table 3, all of the

estimated production elasticities fall into a reasonable range. Thus, the factor shares used are the estimated production elasticities of socialist agricultural metaproduction function which 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). A summary of the computed indices are presented in Table 4 together with the annual growth rate of the indices for the period of 1950-1980, the sub-periods of 1960-1970, 1970-1980, and 1960-1980.

The geometric productivity indices A(t) which Solow called "a rough profile" of technical change, show some signs of decreasing trends of productivity in the 1950s and 1960s. The decreasing trend of total factor productivity is in sharp contrast to the increasing trends of labor productivity and land productivity. Except for Czechoslovakia and East Germany, all countries experienced negative growth rates in total factor productivity during all of the periods. The negative growth rate was particularly serious in Bulgaria, Romania, and the USSR. In the 1970s, after some major economic reform in agriculture, the negative growth rate started to slow down. In fact, during the early 1970s, Czechoslovakia and East Germany were able to regain some growth in total factor productivity and achieve positive growth in the sub-period of 1970-1980. A similar decreasing trend for the Soviet Union was reported by Douglas Diamond (Diamond 1983; 146). He reported that the total factor productivity index in Soviet agriculture declined from 2.1 in 1951-1960 to 1.0 in 1961-1970, and down to 0.2 in 1971-1979.

Beginning in the 1970s, four countries managed to pull out of the downward trend and achieve a modest positive growth rate in the sub-period 1970-1980. Overall, two of the nine countries had positive growth rates in the sub-period 1960-1980. Most noticeable was the 1.82 annual growth rate of East Germany in the sub-period 1970-1980. Perhaps a critical factor in the reversal of declining productivity in East European countries was a series of economic reforms that took place during the 1960s. The reforms were designed in an attempt to make the centralized planning system less rigid and the administration

Table 3: Comparisons of Previously Estimated Results

REGRESSION NO.	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
SOURCES	BHATTAC-HARJEE	HAYAMI-RUTTAN	YAMADA-RUTTAN	EVENSON-KISLEV	NGUYEN	MUNDLAK-HELLING-HAUSEN	WONG-RUTTAN	CLAYTON	BROOKS	WONG
	(1955)	(1971)	(1980)	(1975)	(1979)	(1982)	(1983)	(1980)	(1983)	(1986)
MODEL	OLS	OLS	OLS	OLS	OLS	RPC	RPC	OLS	RPC	MIX
NO. OF COUNTRIES	22	38	41	36	40	58	8	1	3	9
ESTIMATED PERIOD	49	55-65	1970	55-68	1970	60-63	59-79	60-75	60-79	50-80
DEPENDENT VARIABLE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
LABOR (N)	.301	.413	.325	.167	.351	.533	.225	.37	.12	.155
	(2.07)	(5.51)	(3.61)	(3.83)	(3.84)	(1.94)	(22.5)	(7.4)	(5.74)	(4.34)
LAND (L)	.364	.076	.019	.068	-.003	.190	.129	.20	.34	.042
	(1.94)	(1.21)	(.26)	(1.60)	(-.04)	(1.05)	(16.13)	(4.0)	(13.08)	(1.13)
FERTILIZER (F)	.270	.123	.243	.124	.178	.128	.208	.21	.30	.239
	(2.57)	(1.95)	(2.73)	(3.78)	(1.51)	(1.13)	(10.40)	(7.0)	(22.23)	(9.17)
MACHINERY (M)	.027	.116	.113	.049	.153	.082	.054	.14	-.04	.173
	(0.22)	(1.93)	(1.71)	(1.66)	(1.95)	(.60)	(2.84)	(2.33)	(-.98)	(5.32)
LIVESTOCK (S)	.037	.235	.234	.359	.323	.228	.200	.05	.30	.391
	(0.24)	(2.78)	(4.72)	(6.19)	(3.04)	(.54)	(1.55)	(0.56)	(13.56)	(5.29)
AG. RESEARCH (R)				.101			.097			
				(3.06)			(9.70)			
TECH. EDUCATION		.142	.135	.084	.169					
		(2.58)	(1.8)	(3.00)	(2.17)					
CLIMATE									.008	
									(5.68)	
SUM OF CONV. COEF.	.999	.963	.934	.767	1.002	1.161	.816	.97	1.02	1.00
R-SQ.	.95			.98	.94		.99	.99	.99	.96
R-SQ. ADJUSTED	.94	.95	.95				.99			.96

Note: Figures in parentheses are T-ratios for the coefficients

Source: Compiled by authors.

Table 4: Geometric Indices for Total Factor Productivity (1960=100)

YEAR	BUL	CZE	GDR	HUN	POL	ROM	YUG	USSR	PRC
1950	185	226	94	264	132	578	192	99	1086
1951	241	230	103	336	108	890	269	86	1020
1952	168	218	105	221	101	731	152	95	732
1953	202	237	97	157	100	875	268	92	476
1954	147	197	101	140	103	518	135	87	407
1955	157	206	91	141	93	595	158	95	340
1956	120	123	89	126	101	260	93	105	265
1957	129	112	91	138	98	302	128	96	226
1958	123	101	93	118	101	100	88	111	167
1959	98	97	86	120	96	115	111	101	136
1960	100	100	100	100	100	100	100	100	100
1961	93	90	71	88	104	96	90	91	99
1962	94	83	80	83	90	82	88	85	92
1963	90	87	78	80	94	69	88	74	91
1964	89	84	77	78	91	71	93	83	95
1965	86	69	81	79	86	68	86	72	86
1966	95	77	80	83	83	72	100	81	82
1967	87	77	87	77	81	64	97	75	78
1968	75	78	84	72	80	60	93	77	79
1969	80	80	78	77	71	60	95	70	72
1970	83	79	80	67	69	50	87	76	76
1971	83	81	79	72	64	61	86	72	72
1972	89	84	87	78	65	67	81	66	66
1973	84	89	86	78	65	56	83	77	65
1974	79	90	92	81	62	56	88	69	66
1975	81	84	87	75	59	57	82	58	64
1976	85	82	84	78	61	69	86	68	62
1977	76	89	93	83	54	64	87	66	59
1978	80	91	96	86	60	64	78	71	57
1979	83	83	96	81	59	64	79	64	56
1980	79	91	95	90	50	64	79	64	53
GROWTH RATES:									
60-69	-2.29	-2.39	-0.31	-2.43	-3.56	-5.48	0.34	-2.96	-3.50
70-80	-0.63	0.87	1.82	2.11	-2.33	1.60	-0.79	-1.30	-3.19
50-80	-3.00	-3.18	-0.26	-3.48	-2.61	-8.83	-2.83	-1.61	-8.79
60-80	-0.90	0.17	0.83	-0.19	-3.35	-1.67	-0.86	-1.69	-3.14

Source: Compiled by authors.

more flexible. The reforms were also intended to change the terms of trade in favor of agriculture.

The declining total factor productivity index in China can be checked with the figures estimated by Anthony Tang (Tang 1980; 75). Using 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 estimated that the total factor productivity in China's agricultural sector declined 19 percent during the period of 1952-1977 (Tang 1980; 28). On the other hand, using the same weights as Tang's, Rawski also estimated that total factor productivity 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 negative growth after the 1960s was considerably smaller than in the 1950s. The fluctuation of trends and the inconsistency between partial and total factor productivity indices is intriguing. In the next section, an in-depth examination of the different trends of productivity indices is presented for the nine centrally planned countries.

One final note about the model of geometric index. When deriving the geometric index, Solow imposed a critical assumption of neutral technical change. His definition of neutrality means that the shifts in production function are pure scale changes, leaving marginal rates of substitution unchanged at given capital/labor ratios (Solow 1957; 316).

To ensure that data used in this study does not violate the neutrality assumption, scatterplots of the yearly shift factors against the land/labor ratio (L/N) were examined. From the scatterplots, no trace of relationship was detected between technical progress and input ratios. The statistical technique of Ordinary Least Squares was also used in an attempt to estimate this relationship. The statistics tests did not lead to a rejection of the assumption of neutral technical change.[6] Thus, it may be formally concluded that technical change in the nine centrally planned countries did not alter the marginal rates of substitution between inputs. Therefore, the use of Solow's model for this study does

not appear to grossly violate the assumption of neutral technical change. The question of neutrally will, however, be examined more vigorously in a test of the induced innovation hypothesis that is now being initiated.

V. Trends of Total Factor Productivity

The trends and fluctuations of total factor productivity in different countries can be easily observed in Figures 3 to 11 for individual countries. In most countries, the differences between partial productivity and total factor productivity index tend to diverge, though not necessarily, in the opposite direction. Furthermore, except for China, the divergence between labor productivity and total factor productivity is greater than the divergence between land productivity and total factor productivity. These divergences are in sharp contrast to the historical experience of other western countries where partial and total productivity moved in the same direction.

The figures presented highlighted the differences in agricultural productivity between CPEs. The differences in labor and land productivity among these countries are indeed great. Measured in wheat units, agricultural output per labor ranged from 1.46 (China) to 19.86 (E.Germany) in 1960 and from 2.39 (China) to 37.19 (E.Germany) in 1980. The agricultural output per hectare, measured in wheat units, ranged from 0.38 (USSR) to 3.79 (East Germany) in 1960 and 0.63 (USSR) to 4.94 (East Germany) in 1980.

The differences in agricultural productivity among non-centrally planned countries are even greater. In 1980, labor productivity ranged from 3.11 (India) to 285.06 (USA), and land productivity ranged from 0.15 (Australia) to 12.23 (Japan). The differences of such a comparison can be observed in Figure 12 and 13 where the agricultural labor and agricultural land productivity for the CPEs are plotted on Figure 12, and together with 24 non-centrally planned countries, plotted on Figure 13.[7]

Figure 3
Trends of Productivity for Bulgaria

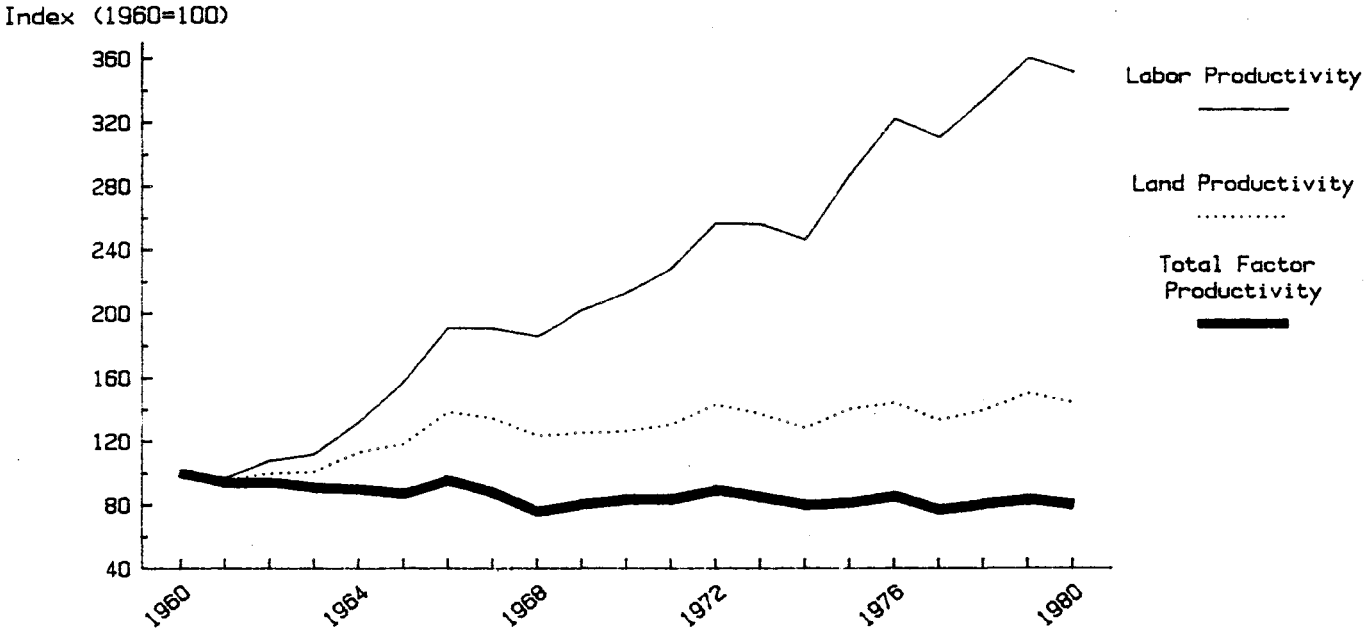
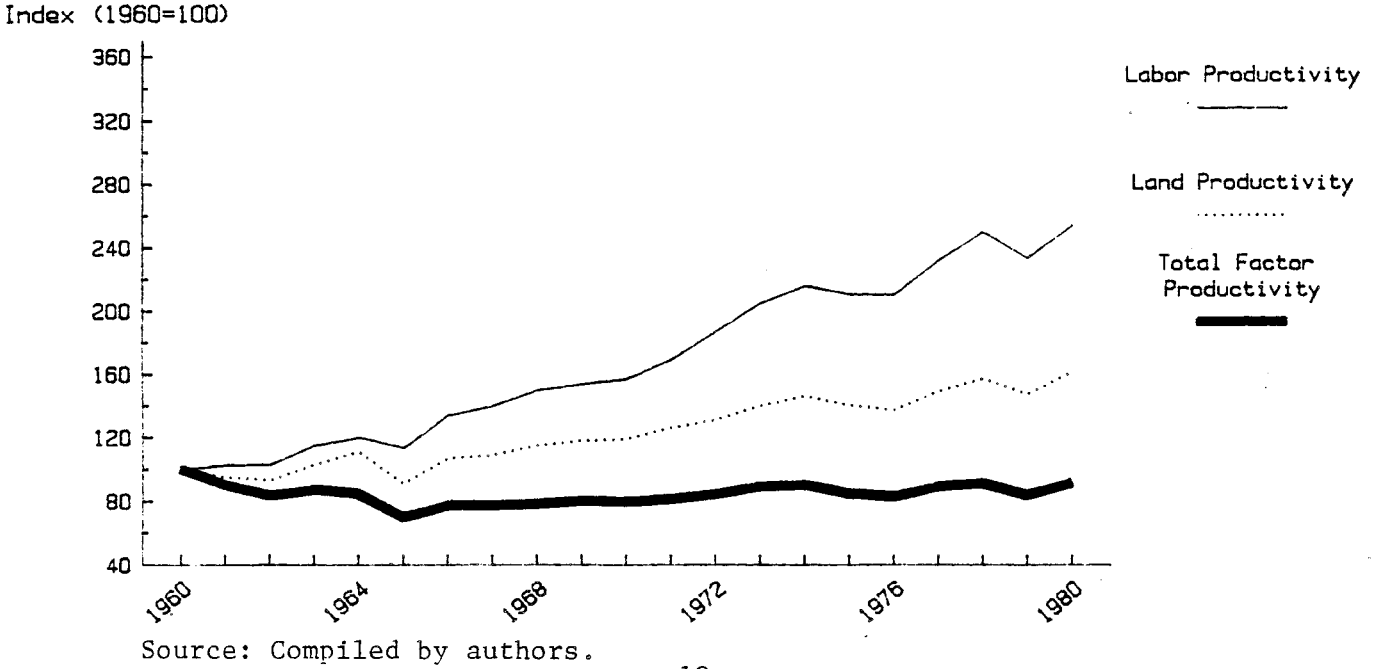


Figure 4
Trends of Productivity for Czechoslovakia



Source: Compiled by authors.

Figure 5
Trends of Productivity for East Germany

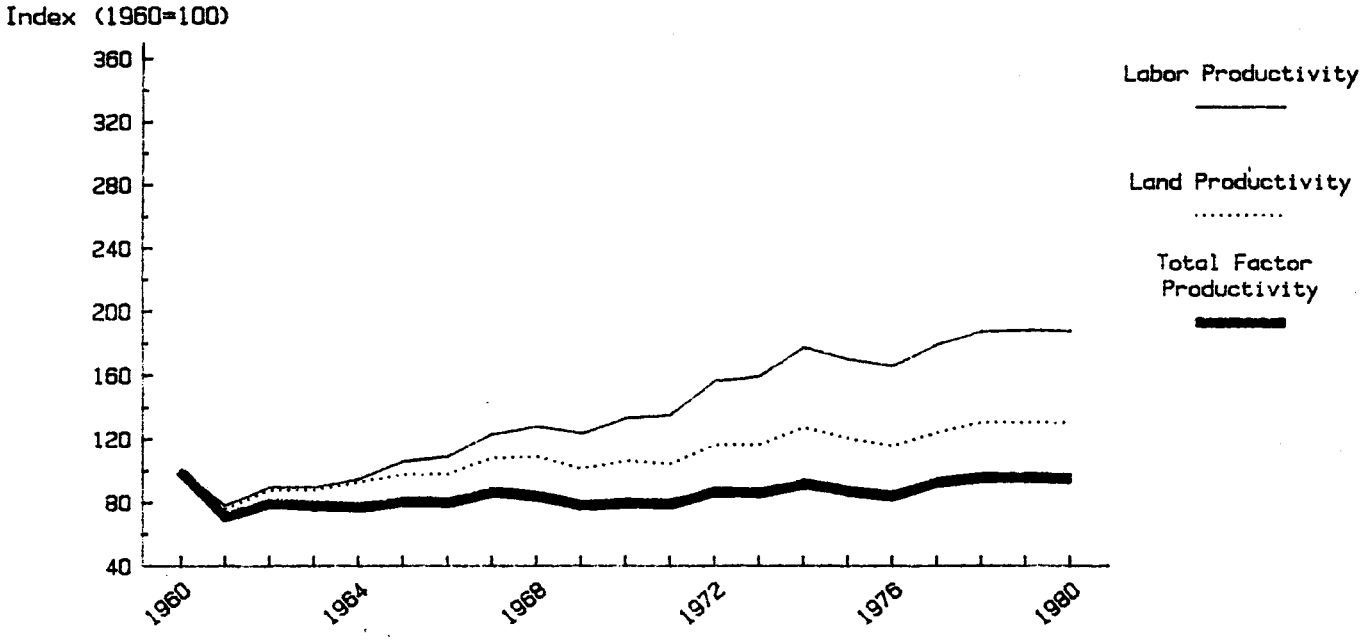
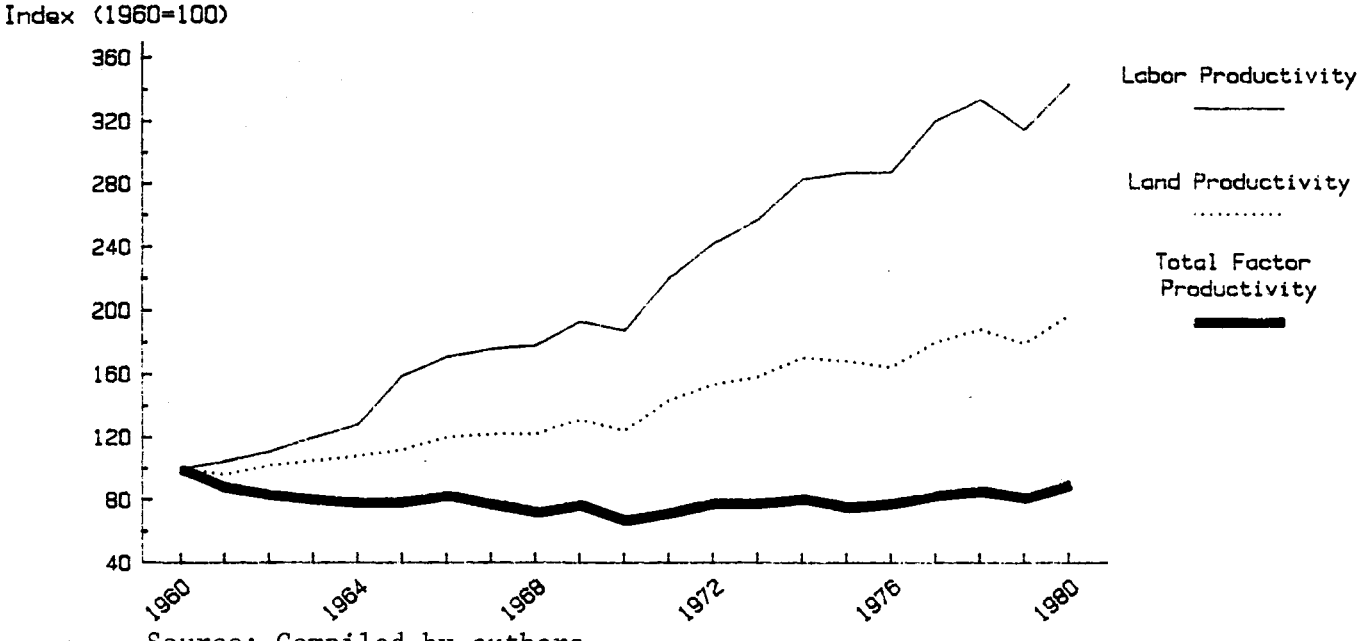


Figure 6
Trends of Productivity for Hungary



Source: Compiled by authors

Figure 7
Trends of Productivity for Poland

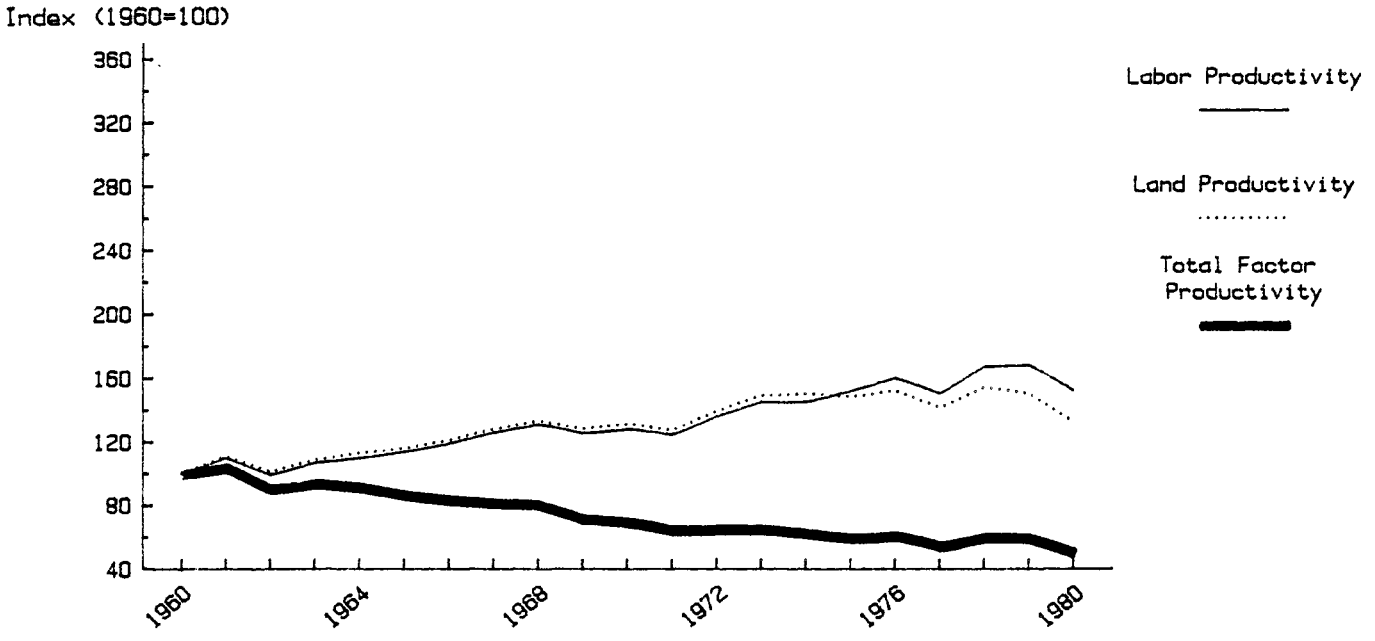
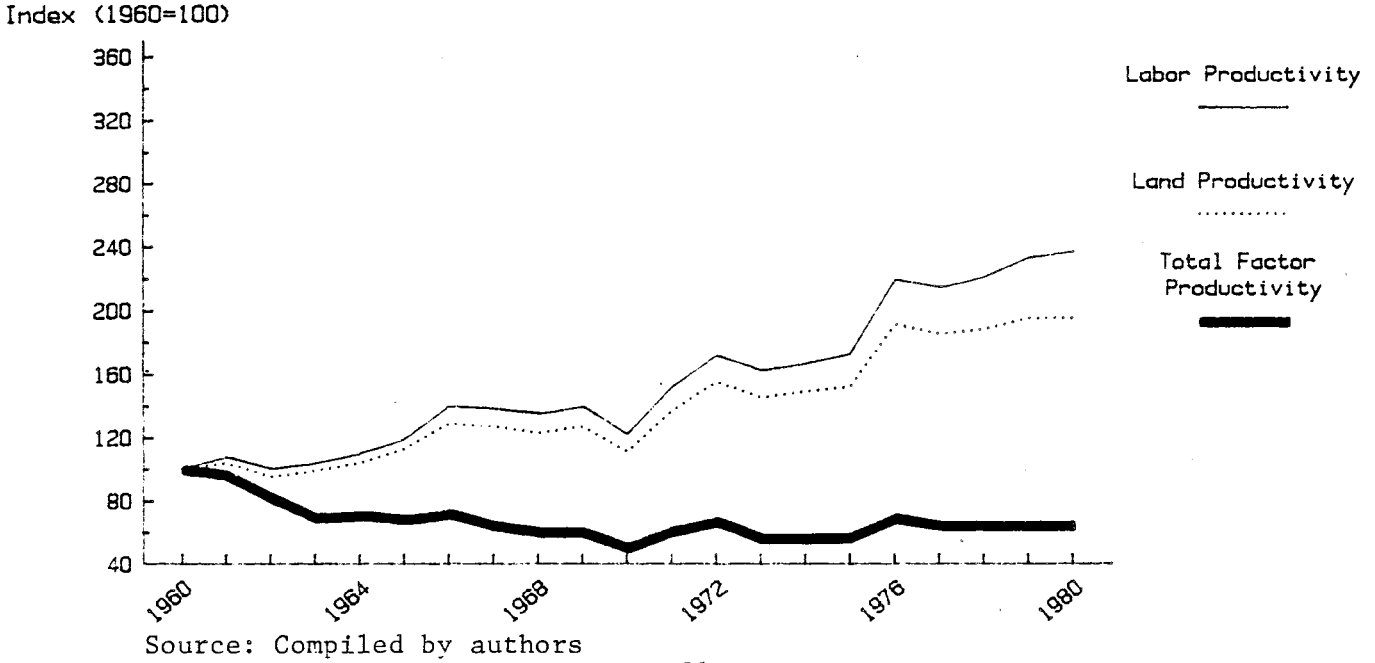


Figure 8
Trends of Productivity for Romania



Source: Compiled by authors

Figure 9
Trends of Productivity for Yugoslavia

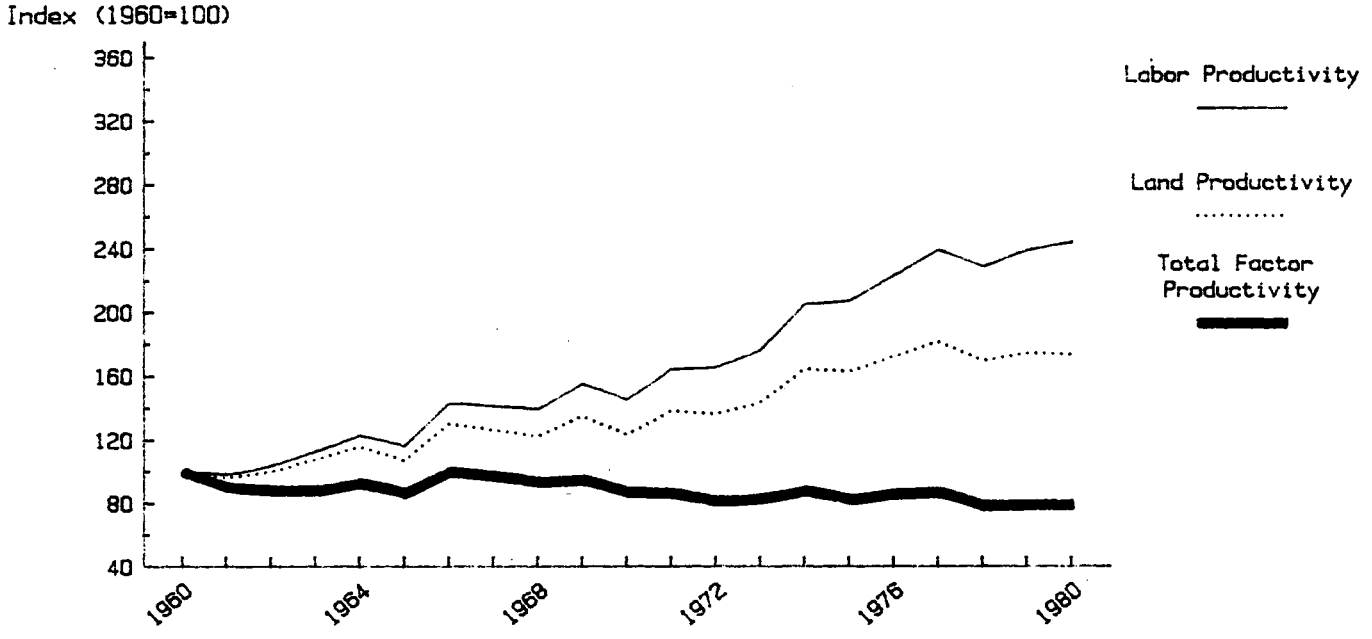
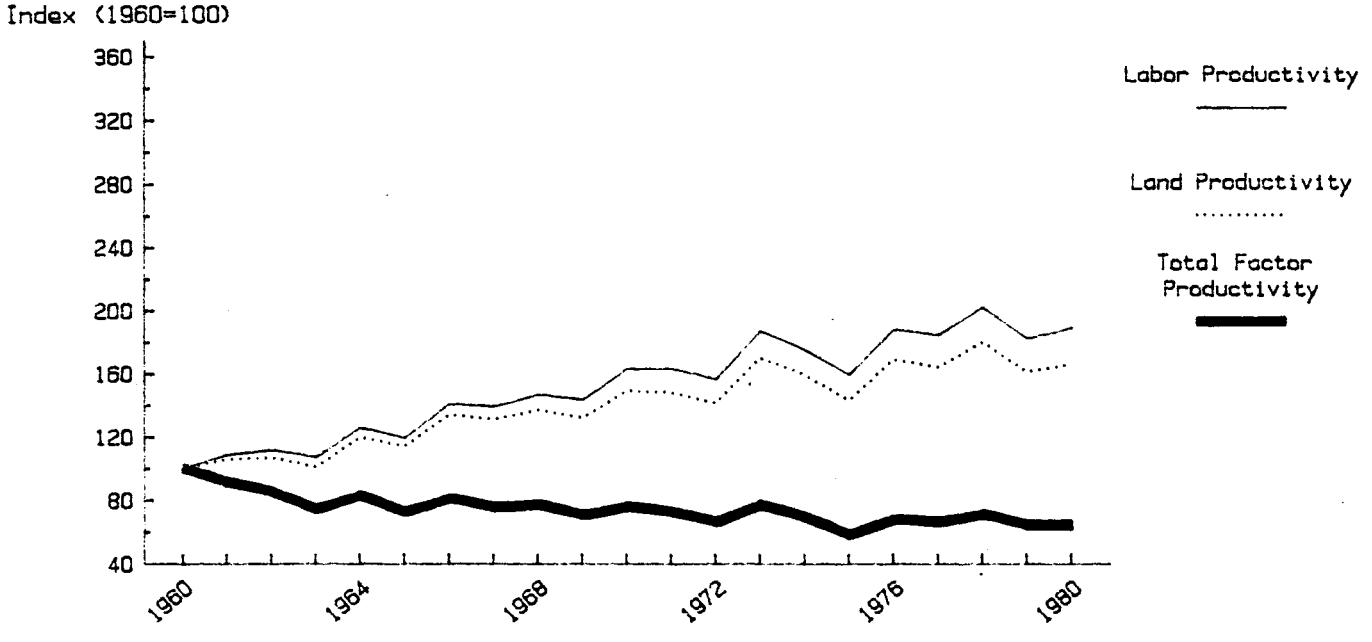
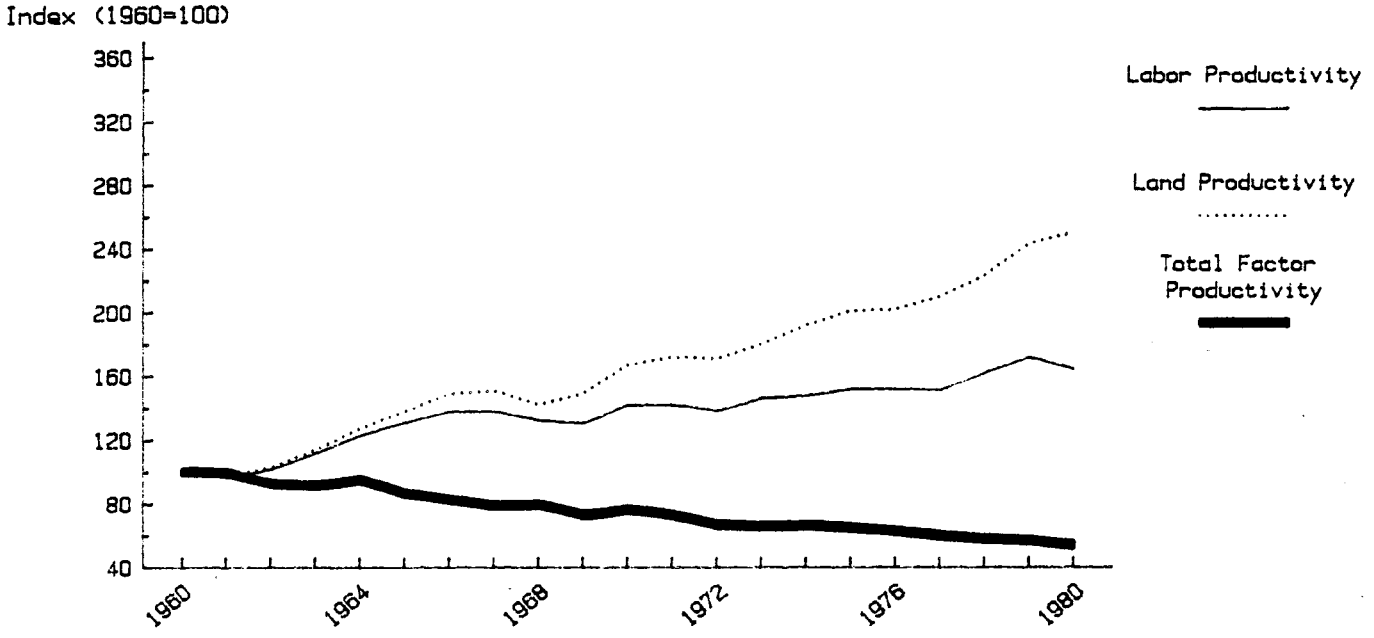


Figure 10
Trends of Productivity for USSR



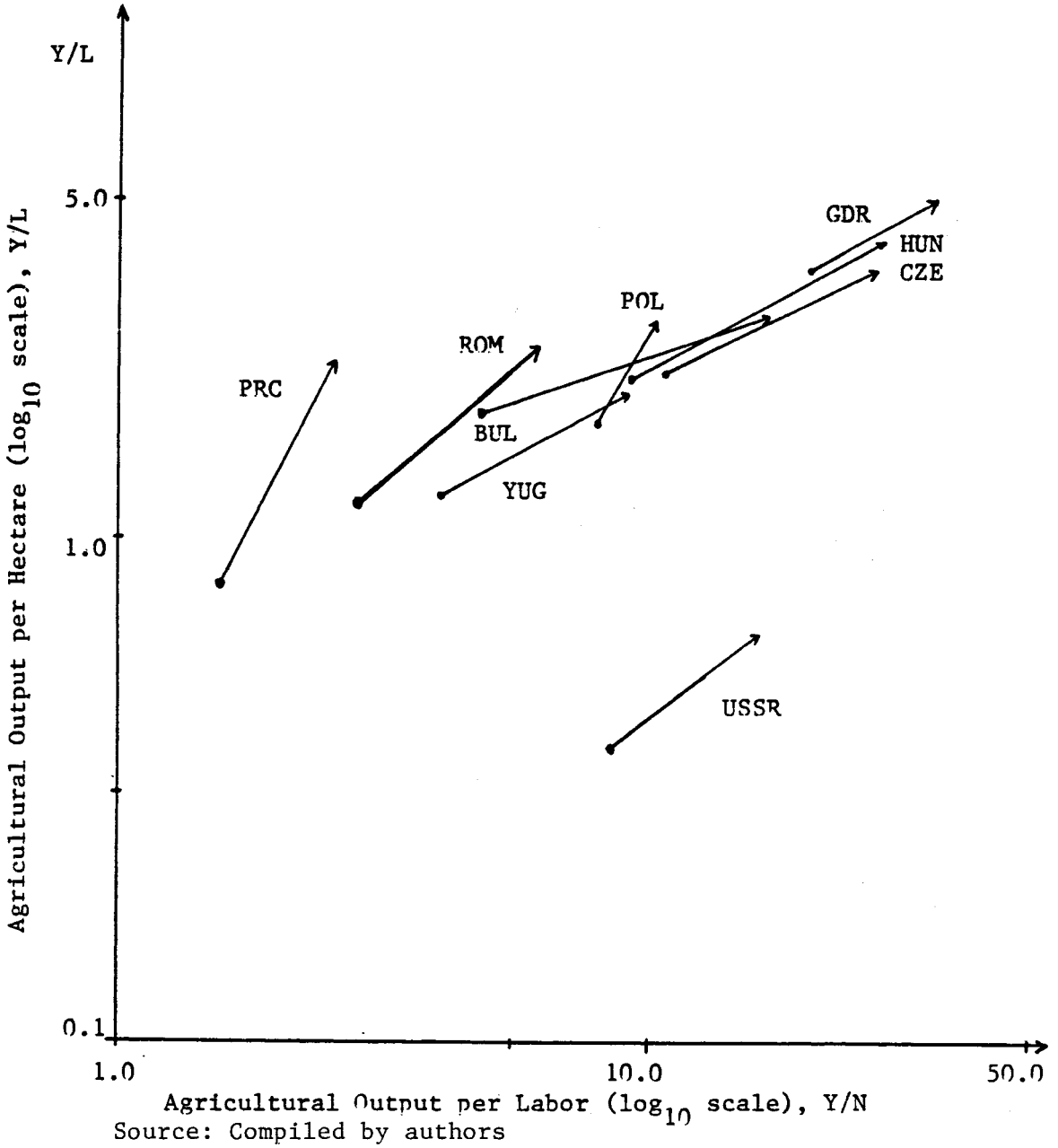
Source: Compiled by authors

Figrue 11
Trends of Productivity for China



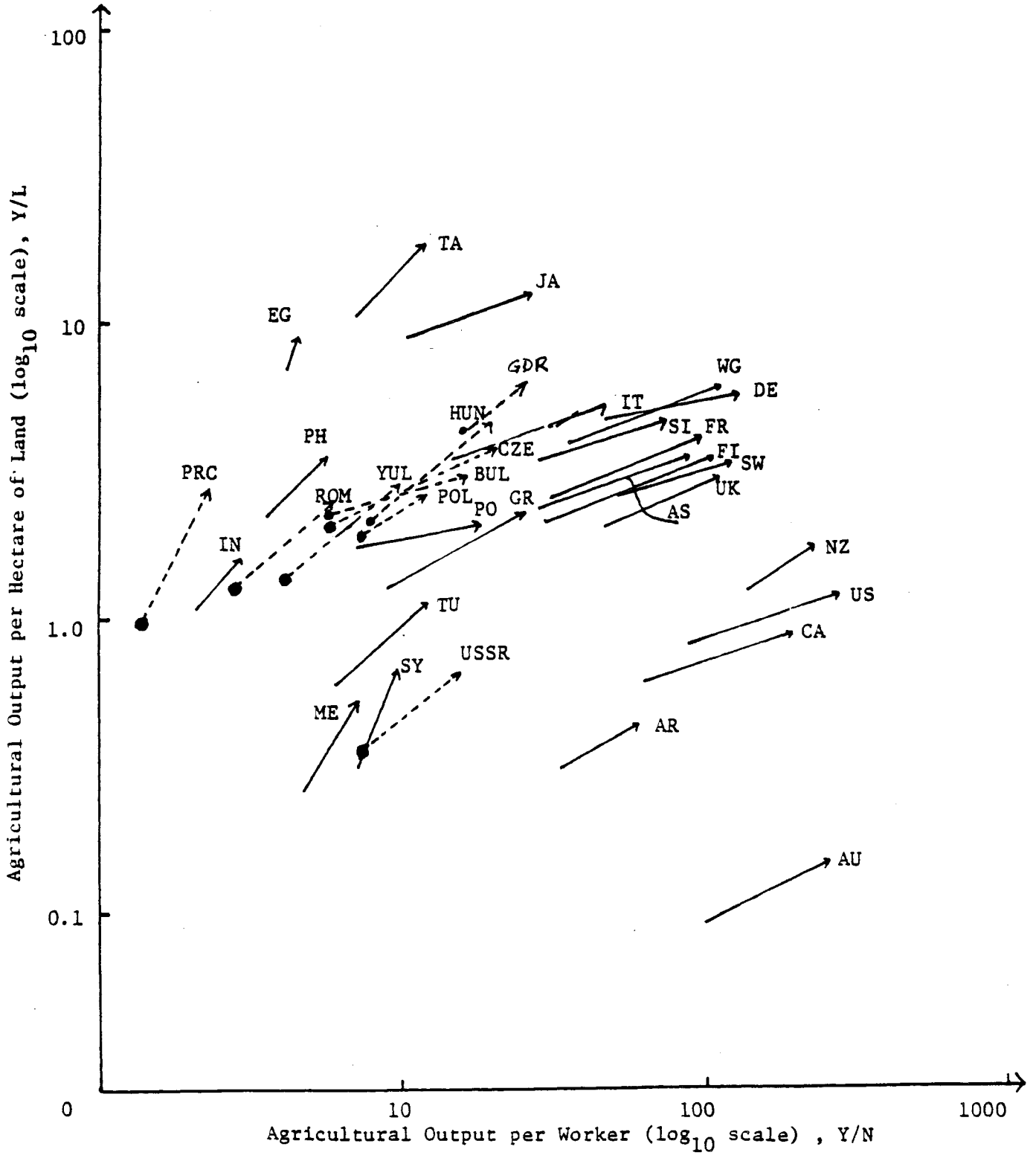
Source: Compiled by authors

Figure 12 : Comparison of Productivity Trends Among Centrally Planned Countries, 1960-80.



Source: Compiled by authors

Figure 13 : Intercountry Comparison of Productivity Trends



Source: see note 7.

As shown in Figure 13, the pattern of agricultural productivity growth in the nine centrally planned countries also diverges to three different paths that are similar to those observed by Hayami and Ruttan (1971; 69). Extended outward from the origin, the three paths can be classified as: (a) the path characterized by the group of countries with the new continents including New Zealand, Australia, Canada, and the U.S.A., where favorable man/land ratios prevail; (b) the path characterized by Asian countries where unfavorable man/land ratios prevail, including such countries as Japan and China; and (c) the path characterized by European countries, both in the East and the West, where relative factor endowments are between the (a) and (b) groups.

These growth patterns indicate the different processes of agricultural growth under alternative man/land ratios common in both centrally planned and non-centrally planned countries. The relative availability of resources in the agricultural sector not only determines the growth pattern, it is also the source of differences in land and labor productivity between centrally planned and non-centrally planned countries.

VI. Contribution of Technical Change in Agricultural Growth

Decreasing total factor productivity and increasing labor and land partial productivity characterize the performance of agriculture in the CPEs. Moreover, despite the fact that the average annual growth rate of aggregate agricultural production in these countries is not low, several countries have difficulty maintaining growth at a level consistent with the rate of growth in demand. Although growth in agricultural production can 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 this does not come easily.

Over the last three decades, there have been several factors identified as sources of agricultural growth in the nine centrally planned countries. First, the Soviet Union

expanded their sown acreage. Second, East European countries and the USSR invested heavily in fertilizer and irrigation systems in an effort to raise yield per hectare. Third, the Chinese intensified their use of land by multiple cropping and labor-intensive farming. Also in the Soviet Union, change in the efficiency of converting feed into livestock products as well as the increase in feed available for output of livestock products due to reduction in use of draft animals were both sources of total agricultural output growth as cited in the literature (Diamond, Bettis, Ramsson 1983; 146).

The sources of growth in agricultural production from conventional inputs is not too difficult to identify. It has, however, been more difficult to adequately characterize the rate of technical change. The generation of technological change is a costly, resource using activity. The evidence of declining total factor productivity suggests that the increases of agricultural output have been achieved by increasing use of conventional inputs more rapidly than growth in output.

The divergence between total factor productivity and partial productivity suggests that there has been a slow or even negative shift in the production function. In order to examine the different degrees of contribution by technical change, Table 5 was tabulated for the nine centrally planned countries.

The first two rows of Table 5 are labor productivity in 1960 and 1980, respectively. The difference between row 1 and row 2 is the gross growth caused by increases in inputs and/or technological advances during 1960-1980, as shown in row 3. Row 4 is the total factor productivity in 1980 (from Table 4) which is a indicator of technical change during the period 1960-1980. Hence, the "constant technology" labor productivity in 1980 can be obtained by dividing row 2 with row 4, as shown in Row 5. It can be interpreted as the productivity, net of technical change, that would have occurred in 1980 should technology remained constant. In other words, it is the increase in productivity that caused solely by the increase of inputs. For example, the 1980 labor productivity for

Table 5: Contribution of Technical Change in Agricultural Labor Productivity Growth

	BUL	CZE	GDR	HUN	POL	ROM	YUG	USSR	PRC
Labor productivity:									
(1)=Y/N, 1960	4.69	10.69	19.86	7.99	7.65	2.64	3.96	8.00	1.46
(2)=Y/N, 1980	16.46	27.12	37.19	27.44	11.61	6.28	9.65	15.14	2.39
Gross growth:									
(3)=(2)-(1)	11.77	16.43	17.33	19.45	3.96	3.64	5.69	7.14	0.93
Technology index:									
(4)=A(1980)/A(1960)	0.79	0.91	0.95	0.90	0.50	0.64	0.79	0.64	0.53
"Constant Technology" productivity in 1980:									
(5)=(2)/(4)	20.84	29.80	39.15	30.49	23.22	9.81	12.22	23.66	4.51
Growth of productivity, net of technical change:									
(6)=(5)-(1)	16.15	19.11	19.29	22.50	15.57	7.17	8.26	15.66	3.05
Productivity growth explained:									
by increased input (%)									
(7)=(6)/(3)*100	137.17	116.33	111.29	115.68	393.18	197.05	145.08	219.28	327.90
by technical Change (%)									
(8)=100.00-(7)	-37.17	-16.33	-11.29	-15.68	-293.18	-97.05	-45.08	-119.28	-227.90

Bulgaria would have been 20.84 should they have used the 1980 input level but the 1960 technology. Thus the 1980 "constant technology" productivity in row 5 minus the 1960 productivity in row 1 is the net growth of productivity in 1960-1980 which is solely due to the alteration of input level, as shown in row 6. When the figure in row 6 is larger than the figure in row 3, it indicates that technical change had not brought 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, as shown in row 7. And the unexplained proportion of growth of productivity is attributable to technical change, as shown in row 8.

The figures in the last row of Table 5 suggest that all countries exhibited no net gain from technical change. This implies that agricultural growth have come 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 and consequently misallocated resources. Figures in Table 5 also shown that Czechoslovakia, East Germany, and Hungary have smaller negative values which indicates that misallocation of resources was less serious in these countries.[8]

VII. Conclusion

Several productivity indices - labor, land, and total factor productivity measures- are computed and presented here. The results indicate strong upward trends of labor productivity and land productivity but strong downward trends of total factor productivity indices in the 1950s and some upward and downward trends in the 1970s. Despite the fact that several countries appeared to be able to regain positive growth of

total factor productivity in the 1970s, the divergence between partial and total factor productivity continued.

The results of the preceding analysis suggest that higher labor productivity has been achieved at a relatively high cost. On the other hand, the increase in land productivity indicates that even though these countries experienced food problems and had large scale economic reforms in the last three decades, they managed to increase food production out of an almost constant area. Although increased land productivity released some of the pressure on food supply, this was also achieved at a relatively high cost.

The discouraging aspect is that there are sharp decreases in total factor productivity in the 1950s, continuing through the 1970s. The divergence between partial and total factor productivity indicates that the gain in labor and land productivity may come from the loss of total factor productivity. Worse than that, it also implies that inefficiency and unbalanced cost structure are embodied in the centrally planned agricultural system. The divergence also indicates that the value of marginal products of fertilizer and machinery is less than their costs, which reduces economic growth of the country as a whole. If this is true, then these countries have paid a high cost for the increases in labor and land productivity that they have achieved.

The analyses also suggest that technical change has made little net contribution to the process of agricultural growth. This does not necessarily imply that there has been no technological change in the agricultural sector. It is possible that the potential gains from technical change were wiped out by the losses from the misallocation of resources. It is also possible that what has been interpreted as technical change has largely been the effect of factor substitution along a production function that has been shifting at a relatively slow rate.

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Notes

* Dr. Lung-Fai Wong is legislative analyst and research specialist in the Research Department of the Minnesota House of Representatives and Dr. Vernon Ruttan is Regent Professor in the Department of Agricultural and Applied Economics at the University of Minnesota. The authors wish to thank Karen Brooks, Anna Burger (Hungary), Elizabeth Clayton, Anton Malish, John Mellor, Todor Popov (Bulgaria), Philip Raup, Anthony Tang, Karl-Eugen Wadekin, Augustyn Wos (Poland), and Michael Wyzan for their comments on methodology and accuracy of data.

1. Data used in this study is collected from a large pool of sources which include books, reports, statistical yearbooks published by individuals and countries as well as international organizations. The collected data then sent to scholars in East European countries for review. For the details of these sources, readers are referred to, Lung-Fai Wong, Agricultural Productivity in the Socialist Countries, (Boulder, Westview, 1986) Appendixes A and B. Even with multiple levels of caution, it is realized that data from these countries may has larger inaccuracy than one would normally expect.

2. 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 gross agricultural outputs are constructed from the growth index of individual countries estimated by USDA and the annual production figures from FAO Food Balance Sheets. For the details of the construction procedure and sources of data, readers are referred to Lung-Fai Wong, Agricultural Productivity in the Socialist Countries (Boulder, Westview, 1986), pp 125-127.

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

4. According to Vais (1981; 239) there are quite a few explanations for the existence of labor shortages in the East European countries. Deficiency in national planning is one of the reasons why labor plans call for greater increase in employment than is possible. The second reason is planners' unfounded optimism with regard to the growth of labor productivity. Thus, when the level of labor productivity is lower than planned, an increase in labor force to above plan level is necessary in order to fulfill output targets. The third reason is that enterprises intentionally underestimate the actual labor demand in order to get an easy approval of their new investment project. Therefore, labor shortage in East European countries is the result of creating more job opportunities than available labor supply.

5. Agricultural metaproduction function was estimated using time series cross-country data. The Cobb-Douglas production function was selected as the functional form for the socialist agricultural metaprodcution function. Other forms of production function were considered and tried but not satisfactory. Because of the presence of multicollinearity, special statistical procedures were employed. Other than using ordinarily least squares, two alternatives were considered - principal components regression and mixed estimation model. Statistically, principal components regression is a restricted regression which provides biased estimators. On the other hand, the mixed estimation model combines results from earlier studies as prior information and the information provided by the data

used in this study. The prior information used in the mixed estimation model is the coefficients (Table 3, R2) of the agricultural metaproduction function estimated for 38 market economies (Hayami and Ruttan 1971; 93). Because of its unbiased characteristics, results of the mixed estimation (Table 3, R10) are used in the construction of total factor productivity.

6. For detailed testing procedures, readers are referred to Lung-Fai Wong, A Comparative Analysis of Agricultural Productivity Growth Among Socialist Countries, Ph.D. dissertation, University of Minnesota, Minneapolis: March 1985.

7. Data of agricultural productivity for the non-centrally planned countries was estimated by Hayami and Ruttan (Hayami and Ruttan, 1985; 457-465). They used only male labor in the calculation of labor productivity. Hence, the absolute values of labor productivity may vary between the two studies, but the directions and trends of changes should be essentially the same.

8. Since 1978, China has been restructuring the commune establishment and moving to less-centralized agriculture. The adoption of Agricultural Production Responsibility System might have brought about more efficient in resource allocation and higher productivity in Chinese agriculture.

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