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# The Determinants of Agriculture Growth in China, 1978-89

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*Eastern Illinois University*

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THE DETERMINANTS OF AGRICULTURE GROWTH

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IN CHINA , 1978-89

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(TITLE)

BY

JIEFEI QIU

1959 -

**THESIS**

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF

MASTER OF ARTS IN ECONOMICS

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IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY  
CHARLESTON, ILLINOIS

1997

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*Dec 18, 1997*  
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To my parents, Yangjun Qiu and Zongfu Yang,  
and my wife, Yeping Huang



**The Determinants of Agriculture Growth  
in China, 1978-89**

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Eastern Illinois University

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**The Thesis Committee:**

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### **Abstract**

Agriculture growth in China during the first dozen years of the economic reform could be attributed to an increase in inputs, technological progress, and institutional innovation. This paper introduces a couple of measurements for technological change and institutional reform, which include the imported capital for advanced technology, the number of high school graduates for improved human capital and the size of the free market for price reform. The study examines the effects of education, foreign capital, and price reform in rural China using data for both agriculture and farming over the period of 1978-89. Descriptions are made regarding the changes in those areas; regression is conducted for the econometric models generated from Cobb-Douglas production function. By providing an estimation of the function, the study identifies education, advanced technology and price liberalization as the major determinants of economic growth. As China is limited in terms of significant increases in the use of conventional inputs, in particular land, technological change is crucial to sustained production growth. To gain the maximum use from resources and technological progress, China also needs complete and continued institutional change.

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## **1. Introduction**

### **1.1 Theoretical Framework**

The sources of economic growth can be basically classified into three categories: the increase in inputs, technological progress, and institutional innovation which improves resource efficiency (Fan, 1991; Wen, 1993).

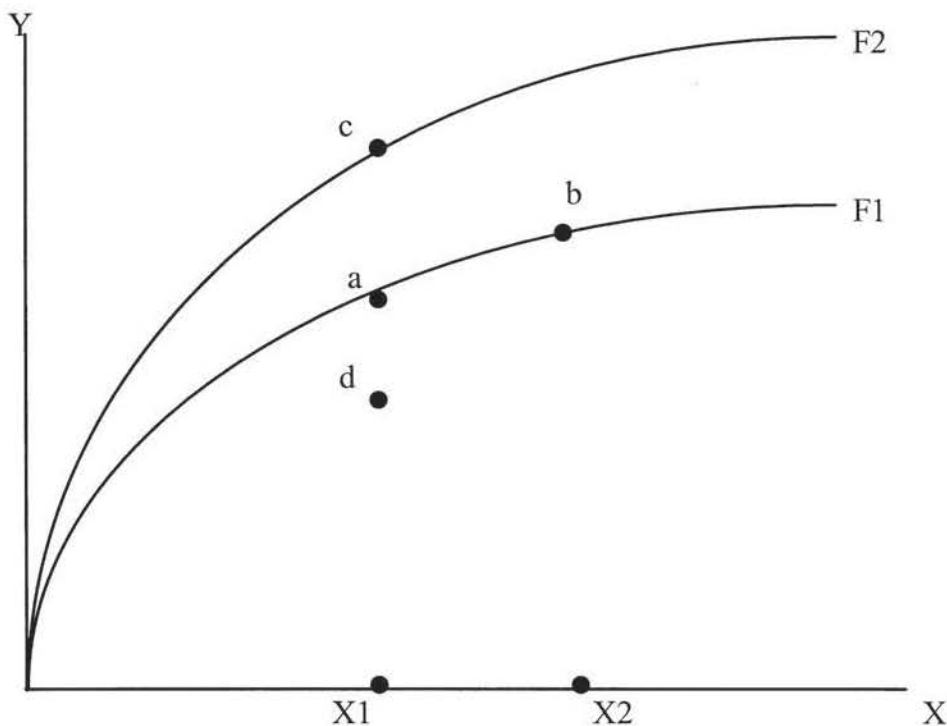
Output is a function of inputs. As we use more resources, we get more products. Technological progress does not act in the same way. Technological progress shifts the whole production function upward. Therefore, with the same amount of inputs, a society can produce more goods. Again, the improvement of resource allocation works differently. Resource allocation can be improved when an economy operates at an inferior position, i.e., a position which is below the production function frontier. As resource allocation is rearranged from one of inefficiency to efficiency, the economy moves close to or up to its production function frontier. This will result in more output without changing inputs.

Increased inputs is the most straightforward way to seek growth. However, due to the scarcity nature of resources, a society often encounters resource constraints when pursuing economic development through more inputs. By comparison, technological progress circumvents resource constraints; hence it may be a more constructive approach for development in the long run. Resource allocation is also important since a society should make the most of its limited resources. In a static situation, inefficiency means the underemployment of resources; in a dynamic state, technical inefficiency undermines a part of the

effects of technological progress. For developing and transitional economies in particular, one crucial problem is choosing institutions that promote efficient resource allocation and thus economic growth.

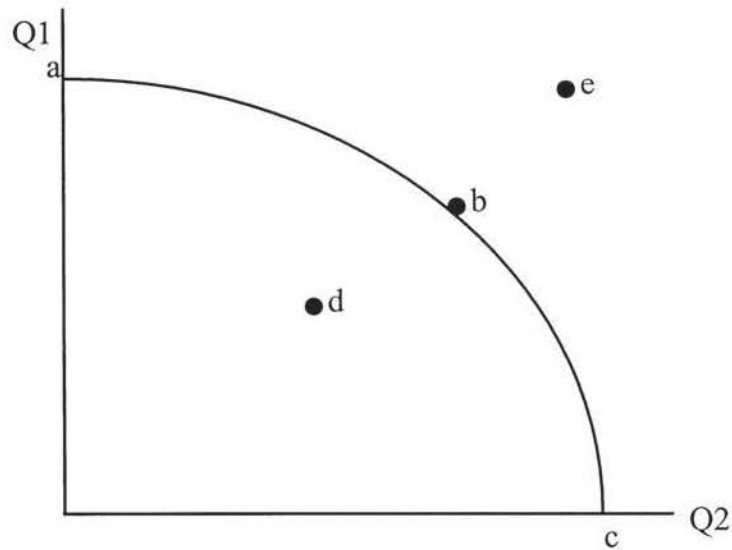
In view of the above statement, China's experience during the past two decades provides us with an interesting case. After the introduction of economic reform, the change in China's economy has been so vast that the country is widely recognized as one of the most dynamic economic developing regions in the world. Naturally, it is important to know what are the major factors that contributed to economic growth.

Figure 1. Three Sources of Growth



Note: In figure 1, if production was perfectly efficient, change from a to b is a result of an increase in input X, i.e., from X1 to X2; change from a to c is the effect of technological progress which shifts the whole production function upward, i.e., from F1 to F2; if production was one of inefficiency, e.g., at d, change from d to a represents the efficiency improvement.

Figure 2. Production Function Frontier



Note: The production function frontier,  $abc$ , shows the combinations of goods  $Q1$  and  $Q2$  that the economy is capable of producing with its present stock of economic resources and the existing technology. Any point below the curve, e.g., point  $d$ , is possible but inefficient; any point on the curve, e.g., point  $b$ , is possible and efficient; any point above the curve, e.g., point  $e$ , is impossible unless the society makes progress in technology and/or discovers new resources.

## 1.2 The Case of China since Economic Reform

Since the early 1980s, both Chinese and Western economists conducted empirical studies about China's post-reform economic performance. A large number of studies focused on reforms in economic institutions. Researchers affirmed the effects of institutional innovations in production. They found that output grew as some existing institutional restraints were eliminated.

Many studies concluded that Chinese agriculture greatly benefited from institutional innovations. For instance, Lin (1988), McMillan et al (1989), Johnson (1990), and Wen (1993) reported that the "Household Responsibility System" (HRS), which was introduced in the late 1970s, had a highly positive

impact on agricultural production. The HRS contracted land to each household, let farmers arrange production themselves, and linked their income directly to output. Very soon, the new system spelled an end to the commune system and brought about an agricultural production boom. It is believed that as much as 60% of agricultural production growth resulted from this institutional change during the early years of reform (Lin, 1987).

This is an example of growth led by the improvement of resource allocation. However, the effects of such changes should be short-term since they cannot break the bounds of the production function frontier. In a relatively longer period, technological progress may weigh more in determining growth.

McMillan et al (1989) used the accounting approach to capture the effects of reforms in prices and incentive systems on total productivity growth. Their results suggest that 22% of the increase in productivity in China's agriculture between 1978 and 1984 resulted from higher prices and 78% from change in the incentive system (mainly represented by the HRS system). They ignored the effects of technological progress.

Fan (1991) argued that rapid agricultural production growth in Chinese agriculture could be attributed to an increase in inputs, technological change, and institutional reform. He used an accounting approach to separate the relative contribution of these three factors to the growth of agricultural production. However, as the accounting approach treats technological change as a residual, his variables for technological change and institutional innovation are



theoretical, from which, we do not know what specific things can represent these two factors.

In a narrow sense, technological progress includes changes in technological knowledge (e.g., ways to use advanced machines), as well as new knowledge about how to organize businesses (Froyen, 1990). In a broad sense, it may be defined as the improvement of quality of inputs which leads to an outward shift of the frontier in the production function (Fan, 1991; Wen, 1993). More educated labor and advanced machines are two good examples. In his study of the sources of growth in U.S. output for 1929-82, Denison (1985) estimated that 14% of U.S. economic growth was due to increased education of the labor force and 28% of growth was accounted by technological change (in the narrow sense). For post-reform China, there is reason to believe that education and technological change (in the narrow sense) will have similar significance in determining economic growth. If an educated or skilled worker failed to bring his ability into full play before reform, he should be able to do so in a reformed (thus more efficient) system.

In terms of institutional innovation, there is reason to believe that price reform has a stronger influence on growth than many other reforms. The role of price is one of the fundamental differences between a centrally planned economy and a market economy. The former regards price as no more than a tool for the purpose of accounting and income distribution. But, in addition to these two functions, a market economy relies on price as the basic means of

resource allocation. The function of resource allocation through price is a major source from which a market economy draws its vitality. Therefore, the significance of price reform is very important as to its impact on economic growth.

The purpose of this study is to identify and estimate certain variables that represent technological progress and institutional innovation. It will be argued that input growth, improved human capital, advanced physical capital and price reform are among the major determinants of production growth in post-reform China. While it is believed this is true for many sectors, this study will focus on Chinese agricultural production. This study will try a measurement for price reform that is different from the one used by McMillan et al. Education will be used for the improvement of human capital, foreign technology for the improvement of physical capital, and price reform for the improvement of resource allocation. This paper will examine the effects of education, foreign capital, and price reform in rural China using data for both agriculture and farming over the period of 1978-89.

The rest of this article is organized as follows. Chapter 2 gives a description of technological progress in terms of improvement in human capital and physical capital. Chapter 3 reviews price reform and its impact on economic efficiency. Both chapters will discuss the relevant issues across the nation but pay special attention to agriculture and the years of reform. In addition to general descriptions, a specific case was made occasionally. These two chapters

will serve as background materials that will help readers achieve a better understanding of technological change and institutional innovation in China, particularly in the rural areas. Chapter 4 deals with the econometric model, specifications, conceptual variables and relations among variables. Chapter 5 explains data and sources. Chapter 6 presents the estimation results and analyzes them. Chapter 7 concludes with the findings and comments from this empirical study.

## **2. Technological Progress**

This study follows a broad definition of technological progress. Technological progress is embodied in the improved quality of human and physical capital.

This chapter approaches the issue from these two aspects.

### **2.1 Improvement of Human Capital**

Education may be the most important indicator for the quality of human capital.

The level of educational attainment is a measure of the workforce to process new information and to adapt to new technology. Generally speaking, the productivity of the labor force positively corresponds to its level of education.

The higher the level of education a worker has, the greater productivity he may exhibit. According to Meng Mingyi, a Chinese specialist on higher education research in Beijing, the main reason for underdevelopment in Chinese society and the economy is the poor quality of the workforce (Hayhoe, 1992). The first implication of the idea is that the overall level of educational achievement is low (in terms of graduation certificates).

Since 1949, the Chinese government put a great deal of effort into improving the educational level of the Chinese people. In spite of financial constraints, education became more universal in China after 1949 than before. Among other things, the following policy decisions contributed to the achievement: 1) incomes of teachers were kept at a low level; 2) primary schools in rural areas were subsidized by the government while mainly supported by the local people. In addition, government launched several campaigns to reduce the rate of

illiteracy and promote the study of science and technology. After 1976, education got more and more attention and was involved in reforms as well. The educational policy shifted from an emphasis on the ideological to intellectual pursuits. We can see progress and changes in education in several ways.

#### 2.1.1 Improvement of the Literacy Rate and Educational Attainment

As one of the developing countries, China used to have an extremely high rate of illiteracy. After efforts for dozens of years, the rate of illiteracy was continuously reduced. This change is more significant to agriculture than other sectors since the majority of illiterates are residents of rural areas. When the People's Republic of China was founded in 1949, about 80% of the Chinese adult population was illiterate, and enrollment figures at all levels of formal schooling were very low (Ruth Hayhoe, 1992). By 1957, China's illiteracy rate was still estimated at about 63% (John Cleverley, 1991). The 1964 census revealed this figure was reduced to 38.1%; again the rate of illiteracy continued to be lowered to 23.7% in the 1982 census (China Social Statistics, 1986). As a result, the proportion of illiterates was reduced to about 5% of workers employed in urban areas and about 25% among young and middle-aged farmers (Ruth Hayhoe, 1992).

#### 2.1.2 Employment Orientation

Due to the huge population and relatively small size of higher education, the majority of secondary school graduates had to enter into the job market. This reality required that China's education give more consideration to job training

and non-formal education. Professional education, technical education, adult education, and various part time education efforts were widely promoted. In addition to higher education, specialized secondary schools and vocational secondary schools saw great expansion while general secondary schools experienced a large reduction between 1977 and 1990. As a result, the specialized secondary schools rose from 2760 in 1978 to 3984 in 1989; agricultural middle schools and vocational schools increased from 3314 in 1980 to 9173 in 1989; schools for skilled workers advanced from 3367 in 1982 to 4102 in 1989 (China Statistical yearbook 1990). In rural areas, government programs promoted the integration of basic education, vocational-technical education, and adult education in order to raise the quality of the rural work force. For non-formal education, a major focus of reform in the 1980s was to extensively develop job-oriented training by focusing on the acquisition of job-specific skills and knowledge. From 1982 to 1989, the number of students enrolled in adult schools was maintained between 16 and 37 million for primary, secondary and tertiary schools (*ibid.*). Tables 1 and 2 show that the structural adjustment of education was clearly orientated towards employment.

Table 1. Average Expenditure (In Budget) Per Student (yuan), 1971-88

Year	Primary	Secondary	Higher	Ratios
1971	16.5	39.9	1844	1:2:112
1980	23.2	60.1	1752	1:3:76
1988	77.4	178.8	2610	1:2:34

Source: Adapted from Keith M. Lewin et al. (1994), Table 2.6

Table 2. Composition of Enrolment in Senior Secondary Schools, 1980-90

Year	Total	General senior secondary	Professional senior secondary	Specialized senior secondary	Skilled worker training school	Agricultural and vocational
	%	%	%	%	%	%
1980	100	81	19	10	6	3
1985	100	64	36	14	6	16
1986	100	61	39	14	7	18
1987	100	60	40	15	8	17
1988	100	57	43	16	9	18
1989	100	55	45	17	10	18
1990	100	54	46	17	10	19

Sources: Adapted from Keith M. Lewin et al. (1994), Table 2.5

### 2.1.3 Change in Educational Attainment of the Population

The absolute number of educated people in China kept increasing. There are several reasons that may have contributed to this increase. A few of the reasons include the promotion of universal education, an anti-illiteracy campaign, a change in population, etc. In general, the share of the educated in the population is also incremental. The enrollment rate of school-age children rose from 49.2% in 1952 to 94.0% in 1978, and 97.4% in 1989 (China Statistical Yearbook 1990). Tables 3 and 4 give a comprehensive picture of the educational attainment of the Chinese population as of mid-1982 and the changes in the ratio of technical personnel to workers in state-owned units. As evidenced by the progressive improvement in the education level of different age groups, the educational attainment of the workforce also improved markedly.

Table 3. Educational Attainment of the Population by Age Groups

Age group	Year of birth	Tertiary (%)	Senior sec. (%)	Junior sec. (%)	Primary (%)	Illiterates & semi-literate (%)
15-19	1967-63	n.a.	15.2	46.7	28.0	9.4
20-24	1962-58	0.2	28.3	33.4	23.1	14.3
25-29	1957-53	0.6	13.3	29.9	33.5	22.4
30-34	1952-48	0.7	5.4	23.2	44.3	26.2
35-39	1947-43	1.3	5.9	21.5	43.1	28.0
40-44	1942-38	2.0	6.1	14.5	38.4	38.7
45-49	1937-33	1.5	3.5	9.5	33.2	52.1
50-54	1932-28	0.9	2.4	7.8	27.3	61.7
55-59	1927-23	0.6	1.7	5.9	23.9	67.9
60 on	1922-	0.3	0.9	3.1	16.4	79.4

Source: Adapted from Ruth Hayhoe (Ed.) (1992), Table 6.1

Table 4. Scientific and Technical Personnel in State-owned Units

	1952	1978	1980	1985	1987	1988	1989
Total (1,000)	425	4345	5276	7817	8894	9661	10351
Tech personnel/1,000 workers	269	593	658	870	921	968	1024

Source: China Statistical Yearbook, 1990

#### 2.1.4 Change in Quality of Education

The change in the quality of China's education is also impressive. After the Cultural Revolution, educational policy shifted away from an ideological emphasis to an intellectual emphasis; academic excellence became more important than politics. Reforms led to changes in the curricula in primary, secondary and tertiary education, an extension for primary and secondary education from ten years to twelve years, and the re-emergence of the examination system characteristic of the pre-Cultural Revolution elite education in priority and experimental schools (Ruth Hayhoe, 1992). The student/teacher ratio was found to be decreasing for primary and secondary schools. For the former, the ratio changed from 28.0:1 in 1978 to 22.3:1 in 1989; for the latter, it



decreased from 20.2:1 to 14.8:1 during the same period (China Statistical Yearbook 1990). Curriculum reform resulted in an increase in academic study at the expense of non-academic subjects such as “Work” (which was designed to enhance students’ moral character through physical labor), a differentiation between humanities and science tracks, and a considerable increase in extracurricular activities. In addition, schools began to burden the students with tremendous amounts of homework, presuming that parents would assist their children or organize tutoring programs for them (Ruth Hayhoe, 1992). In fact, the population policy limiting the number of children per family made people more concerned about their child’s education and anticipated competition. It also enabled people to invest more money and time into their children’s education. Various efforts led to a continuous increase in the standard of entrance exams into colleges. This may represent precisely the improvement of the overall quality in education.

## 2.2 Improvement of Physical Capital

Science and technology are usually perceived as a vital component of the development process. But during the Cultural Revolution, as was the case in education, the promotion of science and technology was disturbed by ideological extremism. After the introduction of reform, China’s science and technology policy had greater effect on social and economic development.

### 2.2.1 Technological Change across the State

Technological progress implies changes in the quality of input rather than quantity. From this angle, we may want to examine technology generation measured by R& D expenditures, spending on technical upgrading and innovation, and new technology acquisitions measured by technology imports. While the absolute amount of spending in these areas increased a great deal, we can't see much change in the share of government spending on scientific research in total expenditure between the late 1970s and the late 1980s according to the China Statistical Yearbook. However, government official data exclude R&D expenditures of universities, colleges and enterprises, and research projects supported by funds collected from society. Therefore, the figures are underestimated in official statistics. Data for investment in state-owned units show that the share of spending on technical updating and transformation was incremental, from about 20% of total investment in 1978 to 31% in 1989 (CSY,1990). Again, this only includes efforts made by public finance. The fact is the source of finance changed a lot since the reform began. The share of state appropriations declined from 24% in 1983 to 8% in 1989 (ibid.). This means the increased spending on technical upgrading could have been much more by the year 1989.

Generally speaking, imported capital and technology are superior to the indigenous ones. Continued efforts by developing countries to acquire foreign technology are crucial in promoting their economic development. In the case of China, there has been a demand for foreign technology ever since the early

1950s. From 1952 to 1991 more than 5,000 technology import contracts were concluded between China and foreign countries, with a total contract value of more than US\$40 billion (Zhao, 1995). However, technology imports developed much faster after the reform than before. From 1979 to 1991, 4,423 technology import contracts were concluded with a total value of US\$26.75 billion (*ibid.*). That is to say, over half of the technology payments were made during the last 13 years out of the 40 years. This may indicate a significant change in Chinese technology.

### 2.2.2 Technological Change in Agriculture

In agriculture, the promotion of technological change was one of the measures to increase production since the late 1970s. The State systematically expanded the production capacity of industry that serves agriculture and imported an appropriate amount of chemical fertilizers and other agricultural means of production (Hannan, 1995). In 1989 the total amount of chemical fertilizer applied reached 23.571 million metric tons (calculated in terms of effective components), the gross motive power of agricultural machinery reached 280.67 billion watts and the total amount of electricity consumed in the rural area reached 79.05 billion kilowatt-hours. This represented an increase over 1978 consumption of 166.6%, 138.9% and 212.3%, respectively (CSY, 1990). The State also exercised policy and programs that aimed at popularizing the adoption of improved crop varieties, dryland farming, water-saving irrigation, crop plant protection, epidemic prevention for poultry and livestock and other

advanced practical techniques. At the same time cooperation between scientific research, education and popularization was strengthened and grassroots service organizations were established forming a network of accessible technical services (Hannan, 1995).

Acquisition of foreign technology also increased substantially. The State promoted the exchange and training of personnel and cooperative research. Government and relevant scientific research and educational institutions have sent technical personnel abroad for research and advanced studies; foreign experts have been invited to come to China to teach and to conduct joint research. Policies accelerated importing technology, instruments, equipment and management expertise. These imports, together with popularization of attendant ideas, have included covering crops with plastic to provide large-scale hot-house cultivation of vegetables; the use of freeze-dried semen and artificial insemination for domestic animal breeding; embryonic implantation of cattle and sheep; remote sensing testing analysis in agriculture; spray irrigation of farmland; mechanized poultry and livestock raising; and processing of mixed feed (Hannan, 1990). China also actively sought foreign funds for the development of agriculture. Since 1978, the amount of foreign funds used by China has steadily increased. Some of these funds have been used for agricultural research, education, production and infrastructure construction (ibid.). Obviously, the effects of various efforts would bring about a considerable technological change in Chinese agriculture.

### **3. Price Reform**

#### **3.1 Pre-reform Price System**

The Chinese economic system in the pre-reform period was a mixed and duplicated consequence of the adaptation of the Soviet Union's socialist system and China's own development strategies during different development periods. Under this system, resource allocation by prices was replaced by the planning process. Prices were determined by the planners. The economy was not able to get to the simultaneous general equilibrium of exchange and production due to the distortion of prices. Two things happened at the same time: on the one hand the society suffered fundamental shortages in goods supplied; and on the other hand there existed underemployment of resources. The economy failed to achieve maximum output from its existing resources.

The problems of this pricing system can be seen in several forms. First, the state kept the prices of certain products low. Products affected are in two categories: those related to the basic needs of people's living, such as grain; those used as raw materials or important inputs, such as energy, mineral products, etc. In the first case, the system required heavy subsidies from the state for people's life. In the second case, part of the value created by one industrial department was transferred to another through unequal exchange (Hannan, 1995). Another shortcoming of the old price system was that products were not priced according to quality. Enterprises could neither expand the production of superior goods nor scale down the production of overstocked,

inferior goods (Guo, 1992). The last problem of this system was that industrial profit was computed in a cost basis; it underestimated the contribution of capital. Prices of relatively capital-intensive branches of industry tend to be low, and the incentive for an enterprise to use capital efficiently was quite weak (Hare, 1983). This pricing system led to inefficiencies in resource allocation since an enterprise's survival did not depend on profitability.

### 3.2 The Process and Trend of Price Reform

Since 1979, there were several measures used to promote growth in agricultural production: 1) price reform, which substantially raised the purchase price of agricultural products and gradually liberalized most prices; 2) enhancement farmers' work enthusiasm, achieved by measures like the household responsibility system; 3) readjustment of the rural production structure to promote efficiency in accordance with comparative advantage; 4) an increase in state input support for agriculture; 5) popularization and application of agricultural science and technology (Hannan, 1990).

As one of the major measures, price reform was first implemented in rural areas and gradually expanded to include industrial products. Price reforms were pragmatic. Started with a reliance on price adjustment, further reform employed both price adjustment and liberalization, and eventually moved in the direction of price liberalization.

From 1979 to 1984, major efforts were made to readjust prices in a planned manner. Price adjustments covered agricultural products, food, raw materials,

transportation, communication, textiles and other light industrial products.

Between 1979 and 1981 the purchase price for agricultural and sideline products rose by 38.5% (ibid.).

It was during the 1979-1984 period that different prices began to be introduced and tried. State price, floating price, negotiated price and market price existed in the Chinese economy simultaneously. By 1984 the proportion of State guided prices and market regulated prices for the purchase of farm and sideline products respectively rose from 1.8% and 5.6% in 1978 to 14.6% and 18.1% in 1984. Their proportion in terms of social retail sales of consumer goods rose from 0.5% and 2.5% in 1978 to 10.5% and 16% in 1984 (ibid.).

From 1985 to 1986 special attention was paid to decontrolling prices. In 1985 the State unified purchases of grain was changed to contract purchases. After they fulfilled their contracts, farmers could dispose of their surplus products at free markets. In 1986 the State quota for contract purchases of grain was cut by 22% and more grain was marketed at either negotiated prices or free prices (ibid.).

From 1987 to 1989 an effort was made to continue to readjust some prices and to ease the impact of free prices. In addition to agricultural products, the price of most consumer goods and small merchandise was released. Also the price for the bulk of services and repairs was freed (ibid.).

As pointed out above, one important outcome of the application of the different reform methods was that various forms of prices simultaneously



existed: state prices, floating prices, negotiated prices and free prices. Along with the development of reforms, the share of state-controlled prices continued to decrease while that part of prices regulated by market forces expanded. In 1983 free prices covered only approximately 4 percent of the items in domestic trade in cities (White, 1983). However, the situation rapidly changed and this percentage increase to 50-60 percent in the 1985-86 period. Correspondingly, state-controlled prices applied to only approximately 40-50 percent of the value of output in 1985-86 (Guo, 1992). By the early 1990s, raw material and output prices had been successively liberalized so that the great majority were sold at market prices (IMF, 1993). This dramatic change indicates that the trend of Chinese price reform was to move away from a system of price control in a centrally planned economy toward a system of little price control in a mixed economy.

### 3.3 Effects of Price Reform in Rural Economy

The reformed price system increased farmers' income. This stimulated their work enthusiasm, rationalized the structure of the rural economy and enhanced the efficient employment of economic resources. For example, in the early few years of reform alone, farmers received an additional income of 20.4 billion yuans through increased purchasing prices and the expansion in the scope of purchases at negotiated prices (Hannan, 1990). This was a definite incentive for farmers to increase production if we look at the fact that the average per capita



income of Chinese farmers was only 133 yuans in 1978 and only 191 yuans in 1980 (China Statistical Abstract, 1990).

Cotton production provides a good example of the incentive effect.

Shandong, one of major cotton producing provinces, became a net importer of cotton during the 1960s and 1970s due to state agricultural policy which emphasized self-sufficiency of grain production. After the price adjustments for cotton in the late 1970s, Shandong resumed its status as a cotton exporter. In 1984, after fulfillment of provincial demand, the state quota, the supply of 3.5 million tons to other regions, and the export of 0.45 million tons to the world market, Shandong still stocked 1 million tons of cotton (Guo, 1992).

At the national level, the average procurement price of cotton increased by 50 percent from 1978 to 1985. Farmers responded to the price increase not only by increasing cotton output but also by reducing input use. Production costs decreased from 103.95 yuan per 100 jin in 1977 to 92.5 yuan in 1980, and 75 yuan in 1983, a decrease of 38.6 percent from 1977 to 1983 (*ibid.*). The effects of price changes on cotton production included increases in total output, in output per capita and output per unit of land, and the expansion of sown acreage.

#### 4. Model

For this study, a general production function can be written as

$$(1) \quad Q = Af(X)$$

where  $Q$  is real gross output,  $X$  are the physical factor inputs such as labor and capital.  $A$  measures the total impact of other qualitative factors which represent technological progress and/or institutional innovation, in this study: education and foreign capital for the former and the size of the free market for the latter.

One way to specify  $A$  is to assume it is a product of the three qualitative factors

$$(2) \quad A = ED^{b_1} FK^{b_2} FRMK^{b_3}$$

where  $ED$  denotes education,  $FK$  denotes foreign capital,  $FRMK$  denotes the size of the free market, and  $[b_{sub.i}]$  denotes output elasticity of the qualitative factors.

Alternatively,  $A$  may be specified as an exponential function

$$(3) \quad A = e^{b_1(ED) + b_2(FK) + b_3(FRMK)}$$

where  $e$  is the base of the exponential function, all other notations stay the same as for equation (2). As a result, the sensitivity of both specifications will be examined in the empirical section.

Agriculture in China covers five branches: 1) farming (cultivation of crops), 2) forestry, 3) animal husbandry, 4) sideline production which includes the collection of wild plants, the hunting of wild animals and fowl, handicrafts and small scale industries concurrently run by farmers, and 5) fishery (CSY, 1990). Being limited by data sources, it was necessary to choose between using a proxy

or the interpolation of some data for certain variables. Of course there is a concern about the quality of any interpolations. For this reason, more tests were done by using data for farming and for agriculture.

For the agriculture study, labor and capital are used as inputs. As noted above, this study uses gross output as the dependent variable. At the aggregate level, a gross-output model may want to include labor, capital and raw materials as inputs (McGuckin et al, 1992). From China Statistical Yearbook, the information can be found for the production material consumption, which includes the capital investment as well as the raw materials used in production. This variable is defined as capital in the agriculture model. It is, however, a proxy variable since the data does not differentiate between the investment and the raw materials. The accumulation of this item over time may approximate capital stock. Therefore, with different specifications for A, the following are two models for the agriculture study

$$(4) \quad Q = cL^{a1}K^{a2}ED^{b1}FK^{b2}FRMK^{b3}$$

$$(5) \quad Q = cL^{a1}K^{a2}e^{b1ED + b2FK + b3FRMK}$$

where c is a constant, L denotes labor, K denotes capital, [a.sub.i] denotes output elasticity of inputs (i.e. labor and capital in this study), ED is high school graduates engaged in agriculture production, FK denotes foreign capital in agriculture, FRMK is the size of the free market for agricultural products, a.sub.i is output elasticity of inputs, b.sub.i is output elasticity of other qualitative factors.

After taking the log, the functional forms for the two models are

$$(6) \quad \ln Q = \ln c + a_1(\ln L) + a_2(\ln K) + b_1(\ln ED) + b_2(\ln FK) + b_3(\ln FRMK) \\ + \text{error}$$

$$(7) \quad \ln Q = \ln c + a_2(\ln L) + a_2(\ln K) + b_1(ED) + b_2(FK) + b_3(FRMK) + \text{error}$$

For the farming study, the dependent variable is the gross output of farming. As in the agriculture model, the independent variables in the farming study also include inputs, technological change and institutional innovation. The inputs are labor, capital, fertilizer and land. The three qualitative factors are the same as for the agriculture study, but they are measured for the farming sector. With different specifications for education, foreign capital and market size, the following represents the two models for the farming study

$$(8) \quad FQ = cFL^{a1}FMK^{a2}FLZR^{a3}LND^{a4}FED^{b1}FFK^{b2}FFRMK^{b3}$$

$$(9) \quad FQ = cFL^{a1}FMK^{a2}FLZR^{a3}LND^{a4}e^{b1FED + b2FFK + b3FFRMK}$$

where FQ is the gross output of farming sector, c is a constant, FL is labor in farming, FMK is capital in farming, FLZR is fertilizer, LND is land, FED is high school graduates employed in farm production, which represents educational attainment, FFK denotes foreign capital in farming, FFRMK is the size of the free market for farming products, a.sub.i is output elasticity of inputs, b.sub.i is output elasticity of other qualitative factors.

After taking the log, we get the functional forms for the farming sector as follows

$$(10) \quad \ln FQ = \ln c + a_1(\ln FL) + a_2(\ln FMK) + a_3(\ln FLZR) + a_4(\ln LND) \\ + b_1(\ln FED) + b_2(\ln FFK) + b_3(\ln FFRMK) + \text{error}$$

$$(11) \quad \ln FQ = \ln c + a_1(\ln FL) + a_2(\ln FMK) + a_3(\ln FLZR) + a_4(\ln LND) \\ + b_1(FED) + b_2(FFK) + b_3(FFRMK) + \text{error}$$

To examine the factors that are linked to output growth, the focus was on three groups of variables. The first group includes all production inputs. They are labor, capital, fertilizer and land. It is common sense that an increase in inputs will lead to an increase in production. Thus, the coefficients of inputs should be positive. It should be noted, however, that the trend of certain inputs did not correspond to the trend in output. For example, as a result of rapid industrial development and the adjustment in economic structure, farm land and labor in agriculture as well as in farming fluctuated or even decreased during the 1980s, while output grew steadily. Perhaps the lack of correspondence between the dependent variable and the independent variables could lead to some unexpected results.

The second group of variables includes the education indicator and imported capital in real terms. According to the theoretical analysis at the beginning of this paper, these variables should have a positive effect on output growth assuming these resources are efficiently employed in the reformed economic system.

The third group of variables is the one associated with producers' work incentives. A proxy for changes in market prices is the size of the free market,.

Price reform may be measured by change in either the share of market prices or the share of state prices in the national economic transaction. In the first case, the coefficient of the independent variable should be positive; in the second case, it should be negative. As the size of the free market is a proxy for changes in market prices, it is expected that this variable will positively influence output.

As for the relationship between independent variables, it is necessary to point out that some of them may have strong interaction. The total labor force includes secondary school graduates who entered the labor market; the similar relation exists between the total capital stock and foreign capital. The regression proceeded with the above concerns.

## 5. Data and Sources

The data employed in this study is mainly taken from the China Statistical Yearbook (CSY), the China Statistical Abstract (CSA), and the China Trade and Price Statistics (CTPS). The data is compiled by the State Statistical Bureau of China, representing the most consistent and accessible data source about the Chinese economy.

### *Output Measures:*

Output is measured as gross output in money term. Data on gross output for both agriculture and farming are available in current value. The time series of annual gross output is adjusted for price changes with 1978 as the base year.

For agriculture output

$$(12) \quad Q_{(t)} = GQ_{(t)} / PQ_{(t)}$$

where  $Q$  and  $GQ$  are real output and nominal output of agriculture.  $PQ$  is the price index of the gross output value of agriculture for 1978 in constant yuan.

For the farming sector

$$(13) \quad FQ_{(t)} = GFQ_{(t)} / PQ_{(t)}$$

where  $FQ$  and  $GFQ$  are real output and nominal output of farming. The price index is the same as for the agriculture study.

### *Labor Input:*

Ideally, labor input should be defined as those engaged in production and measured as work hours. But data sources only provide for the total number of employees for each sector. An alternative approach is to assume that labor input

is proportional to the number of employees and uses this number as a proxy for labor input. While data on labor in agriculture is available, that in farming, is not. The number of farming labor is a product of the number of agriculture labor and the output share of farming in agriculture, assuming that the output share of farming is approximately equal to the labor share of farming.

$$(14) \quad \text{FMSHR}_{(t)} = \text{FQ}_{(t)} / \text{Q}_{(t)}$$

$$(15) \quad \text{FL}_{(t)} = \text{L}_{(t)} * \text{FMSHR}_{(t)}$$

where FL, L and FMSHR are the farming labor force, the agricultural labor force and the share of farming output in agriculture.

#### *Capital and Materials Inputs:*

The appropriate measurement of capital input might be the capital rent or capital services. Capital depreciation is an acceptable proxy for this (McGuckin et al, 1993). Since none of these statistics is available, the investment was used as a proxy capital variable for agriculture study.

Data on the investment in agriculture was calculated by finding the difference between gross output and net output. The accumulated sum of the investments made at different time period is a proxy for capital stock. Assuming that the investment in the first year of this item is used as a proxy for the capital stock as of that time, capital stock for subsequent time period is calculated by adding investment in those periods. This variable is measured in money terms deflated by the price index for secondary industry in 1978 constant yuan. This term is defined as capital in agriculture study.



$$(16) \quad NI_{(t)} = GQ_{(t)} - NQ_{(t)}$$

where NI, GQ and NQ are nominal investment, gross output and net output.

$$(17) \quad I_{(t)} = NI_{(t)} / 2NDINDEX_{(t)}$$

where I and 2NDINDEX are real capital and materials, and the index of the secondary industry.

$$(18) \quad K_{(t)} = I_{(t)} + I_{(t-1)}$$

where K is capital stock for agriculture production.

Capital inputs in farm production include machinery, land and fertilizer. Total power of agricultural machinery is used as part of capital inputs in farming, which is defined as capital in the model of the farming study. While this variable also includes the machinery used for production of other branches of agriculture (for instance, motorized fishing boats for fishery), farm machinery is by far the overwhelming majority in the total power of agricultural machinery. About 98% of machinery is farm machinery and the ratio was stable through the period under study (CSY, 1990). Therefore, it is acceptable to use this data as a proxy for farm capital.

As for the measure of farmland, total sown area of farm crops is used. Sown area is more relevant to output than other measurements of land, such as cultivated area.

Fertilizer is measured in metric tons. Data of fertilizer refer to the volume applied, all in terms of effective components. Data for both sown area and fertilizer are available from the data source.

*Measures for Education:*

Education improves the quality of human capital, thus enhancing productivity.

A good measurement for education may be the average years of education attained by the labor force, i.e., education years per labor. Unfortunately, such data are not available and there is not sufficient information which allows for the calculation of this data. Alternatively, the stock of high school graduates in the agricultural labor force is used as a proxy for education. This is the sum of current graduates and total graduates from the past.

$$(19) \quad ED_{(t)} = GR_{(t)} + ED_{(t-1)}$$

where ED and GR are education indicators and high school graduates who entered into the agriculture sector. College graduates are not considered since they do not engage in direct agriculture production. While data of high school graduates is available, there is no information on their employment. To estimate the number of graduates who joined in agriculture work, GR data was constructed by the following methods: first, the share of agriculture output in the national economy was recorded; second, assuming about a similar size of graduates entering the agriculture sector, their number was estimated to the agricultural share. This is the same approach used in constructing the farming labor force.

$$(20) \quad AGRSHR_{(t)} = NQ_{(t)} / GNP_{(t)}$$

$$(21) \quad GR_{(t)} = AGRSHR_{(t)} * TGR_{(t)}$$

where AGRSHR, and TGR are agriculture's share and total high school graduates at time  $t$ .

High school graduates engaged in farm production is found by multiplying the farm share by that engaged in agriculture

$$(22) \quad \text{FMSHR}_{(t)} = \text{FQ}_{(t)} / \text{Q}_{(t)}$$

$$(23) \quad \text{FED}_{(t)} = \text{FMSHR}_{(t)} * \text{ED}_{(t)}$$

where FED denotes high school graduates in farm production.

#### *Foreign Capital:*

While a country may import foreign goods for various purposes, such as making up the deficiency of domestic supply, import capital is considered superior to domestic capital in developing countries. As was the situation for education, the quantity of foreign capital in agriculture is unknown. To solve the problem, the same method employed above is used.

$$(24) \quad \text{GFK}_{(t)} = \text{AGRSR}_{(t)} * \text{IMP}_{(t)}$$

where GFK and IMP are the values of nominal foreign capital and total imports in nominal terms. Real foreign capital is found by dividing the index of the secondary industry into nominal foreign capital

$$(25) \quad \text{RFK}_{(t)} = \text{GFK}_{(t)} / \text{2NDINDX}_{(t)}$$

where RFK is real foreign capital.

Assuming foreign capital input is proportional to the foreign capital stock, the foreign capital stock is used as a proxy for the foreign capital input since the latter can't be found. The foreign capital stock at time  $t$  is calculated as follows,

$$(26) \quad FK_{(t)} = RFK_{(t)} + FK_{(t-1)}$$

where FK is the foreign capital stock at time t in agriculture.

Foreign capital for farming production is found by multiplying the farming share by that used in agriculture

$$(27) \quad FFK_{(t)} = FSHR_{(t)} * FK_{(t)}$$

where FFK is foreign capital used in farming production.

#### *Measures for Price Reform:*

It is very hard to design a comprehensive measurement for price reform since it is such a complicated project involved in the whole of economic reform.

Methods of price reform include price adjustment, price liberalization, and sometimes a combination of the both. It is particularly difficult to find a way which can simultaneously measure the effects of different methods and separate out inflation caused by reasons other than price reform.

Price adjustments refer to the government's action that manipulates the price ratio so as to correct the irrational price system. Due to the nature of price rigidity, price adjustments almost always resulted in the increase of lower prices, instead of decreasing higher prices. The measurement of price adjustments can be the change of the price ratio or the change of relative prices. Price adjustments were embodied in inflation and there is no data available to estimate its value. For this reason, this study does not consider price adjustment but only price liberalization for measurement of price reform.

Price liberalization is the reform policy designed to let market forces correct the distorted price system. This means less government intervention and more market influence in setting prices. Therefore, liberalization can be measured as changes in share of transaction value conducted by either market prices, or state prices. Both measurements reflect the change of liberalization. The difference is that they move in the opposite direction. A greater degree of liberalization can be represented by the decrease in the share of state prices or is measured by the increase in the share of market prices.

However, the increase in the share of market prices may result in a biased measurement if we do not consider the influence of the third type of prices in China. There were so called negotiated prices under the dual-track price system and other prices for a while. Negotiated prices arose from the policy that allows the state-owned enterprises to sell their above quota products at a price floating within a range set by the government. This price normally lies somewhere between market prices and state prices. For agriculture, government exercised above quota prices during the early years of reform; they were higher than state procurement prices but lower than market prices. As negotiated prices and above quota prices tended to move toward market prices (i.e. a higher price), they bore a clear influence of market forces. One has reason to add the weight of negotiated prices to that of market prices for the measurement of price liberalization. Obviously, the weight of state prices is more convenient, since the sum of the weight of the three prices equals to one.

However, there is not sufficient information to prepare a complete set of data which can cover the whole period under study. Therefore, the ratio of free market transaction value to total value of retail sales is chosen as a proxy of price liberalization. This is the size of the free market. The shortcomings of this proxy are obvious. First of all, it is a proxy of market prices only, which, as previously discussed, excludes the influence of above quota prices and/or negotiated prices. Secondly, it is a poor proxy since information shows that this ratio moves slower than the actual share of market prices. For instance, free prices reached about 60 percent of the items in domestic trade at the national level as early as 1986 while the free market size was only 24.4% for agriculture and 13.7% for farm products by 1989 (CSY, 1990; Guo, 1992).

The strength of this measurement is that free market transactions include basically agricultural products. To this extent, this variable seems more relevant to this study than a measurement based on the whole economy. Besides, it is the only complete data set which can be found. The following is the way to find the size of the free market

$$(28) \quad FRMK_{(t)} = FMV_{(t)} / TRV_{(t)}$$

where FRMK, FMV and TRV denote the size of the free market, the value of the free market transaction and the total value of retail sales. As FRMK is a ratio of different transaction values, data are not subject to inflation.

The size of the free market for farming products is found by multiplying the farming share by the size of the free market.

$$(29) \text{FFRMK}_{(t)} = \text{FMSHR}_{(t)} * \text{FRMK}_{(t)}$$

where FFRMK is the size of the free market for farm products.

## **6. Estimation Results and Analysis**

### **6.1 Results and Analysis**

The discussion in Chapter 4 leads to the development of four models that will be econometrically tested; they are equations (6), (7), (10) and (11). The results of the production function estimation for the different specifications and data sets are shown in tables 5 to 8. The ordinary least squares technique is used for each estimation.

The initial run of the regression shows that few variables of agricultural data and none of farming data are significant for the original model. Continuous tests were made by following the principle of dropping out the least significant variable in each consecutive run. The tests stopped at where all or most of the remaining variables became significant and Adjusted R Square increased at the same time. This procedure brought about the optimum models for this study when both independent variables and Adjusted R Square improved. The exception is equations (6) and (11), in which Adjusted R Square was lowered slightly (both decreased about 0.001) in its last run and only one variable was significant for the former, while all independent variables became significant for the latter.



Table 5: Estimated Production Function for Agriculture (Equation 6)

Equation (6)	1st run	2nd run	3rd run
Intercept	-5.658 (-0.615)	-3.560 (-0.495)	0.791 (0.129)
lnL	1.909 (1.051)	1.392 (1.130)	0.866 (0.750)
lnK	-0.593 (-0.822)	-0.322 (-1.166)	-0.020 (-0.357)
lnED	0.375 (1.111)	0.346 (1.116)	
lnFK	0.226 (0.695)		
lnFRMK	0.684 (1.699)	0.837*** (5.746)	0.778*** (5.643)
R Square	0.983		
Adj.R Square	0.969	0.973	0.972
D.W. statistic	2.125		1.791
the White statistic	2.314		
the VIF test	1.017		

Note:

- 1) Numbers in parentheses are t-test values.
- 2) Single asterisk indicates significant at the 10% level, double asterisk indicates significant at the 5% level, and triple asterisk indicates significant at the 1% level.
- 3) L = labor; K = capital; ED = education indicator; FK = foreign capital; FRMK = the size of the free market.
- 4) There are 12 observations.

Table 6: Estimated Production Function for Agriculture (Equation 7)

Equation (7)	1st run	2nd run
Intercept	-5.665 (-0.810)	-6.231 (-1.174)
lnL	1.690 (1.505)	1.772* (1.995)
lnK	0.609** (2.352)	0.633*** (3.514)
ED	-5.89E-05* (-2.105)	-6.16E-05*** (-3.309)
FK	0.0012 (2.048)	0.0013*** (4.693)
FRMK	0.0034 (0.141)	
<hr/>		
R Square	0.991	
Adj.R Square	0.984	0.986
D.W. statistic	2.252	2.255
the White statistic	2.913	
the VIF test	1.008	

Note:

- 1) Numbers in parentheses are t-test values.
- 2) Single asterisk indicates significant at the 10% level, double asterisk indicates significant at the 5% level, and triple asterisk indicates significant at the 1% level.
- 3) L = labor; K = capital; ED = education indicator; FK = foreign capital; FRMK = the size of the free market.
- 4) There are 12 observations.

Table 7: Estimated Production Function for Farming (Equation 10)

Equation (10)	1st run	2nd run	3rd run
Intercept	-6.677 (-0.214)	-3.422 (-0.139)	0.654 (0.220)
lnFL	-0.877 (-1.359)	-0.789 (-1.752)	-0.829** (-2.381)
lnFMK	-0.281 (-0.217)		
lnFLZR	0.986 (1.560)	0.900* (2.024)	0.932** (2.533)
lnLND	1.142 (0.252)	0.538 (0.167)	
lnFED	0.262 (0.558)	0.352 (1.760)	0.356* (1.965)
lnFFK	-0.339 (-0.605)	-0.444 (-1.742)	-0.472** (-2.675)
lnFFRMK	0.488 (1.382)	0.482 (1.522)	0.519** (2.526)
R Square	0.982		
Adj.R Square	0.951	0.960	0.967
DW statistic	2.159		2.150
the White statistic	0.159		
the VIF test	1.072		

Note:

- 1) Numbers in parentheses are t-test values.
- 2) Single asterisk indicates significant at the 10% level, double asterisk indicates significant at the 5% level, and triple asterisk indicates significant at the 1% level.
- 3) FL = labor in farming; FMK = capital in farming; FLZR = chemical fertilizer; LND = farm land; FED = education indicator for farming sector; FFK = foreign capital in farming; FFRMK = the free market for farm products.
- 4) There are 12 observations.

Table 8: Estimated Production Function for Farming (Equation 11)

Equation (11)	1st run	2nd run	3rd run	4th run
Intercept	-13.027 (-0.368)	-13.236 (-0.434)	-11.566 (-0.616)	9.340* (3.891)
lnFL	-0.898 (-0.560)	-0.929 (-1.379)	-0.957* (-1.884)	-1.050* (-2.058)
lnFMK	-0.815 (-0.384)	-0.848 (-0.848)	-0.941* (-1.900)	-0.967* (-1.920)
lnFLZR	1.021 (1.729)	1.020 (1.937)	1.044** (2.755)	0.817** (2.503)
lnLND	2.480 (0.517)	2.549 (0.786)	2.381 (1.122)	
FED	-9.3E-07 (-0.022)			
FFK	-6.1E-05 (-0.066)	-6.2E-05 (-0.074)		
FFRMK	0.045 (1.251)	0.045 (1.458)	0.045 (1.597)	0.069*** (3.539)
R Square	0.981			
Adj.R Square	0.948	0.958	0.965	0.964
DW statistic	2.075			1.774
the White statistic	0.587			
the VIF test	1.012			

Note:

- 1) Numbers in parentheses are t-test values.
- 2) Single asterisk indicates significant at the 10% level, double asterisk indicates significant at the 5% level, and triple asterisk indicates significant at the 1% level.
- 3) FL = labor in farming; FMK = capital in farming; FLZR = chemical fertilizer; LND = farm land; FED = education indicator for farming sector; FFK = foreign capital in farming; FFRMK = the free market for farm products.
- 4) There are 12 observations.

The final results show the best fit line for the agricultural data is equation (7) and that for farming, it is equation (10). Since the former is a semi-log model while the latter is a log linear model, the analysis here has limitations on the sensitivity of the results to two different specifications. As this study has special

concerns about the effects of technological progress and institutional innovation, the significance of these two group variables in Equation (10) inspires further study. In contrast, estimation of Equation (7) without the free market variable in the last regression produced extremely small coefficient estimates for education and foreign capital variables. On the whole, log linear specifications seem superior to semi-log specifications in this study.

The significant variables in equation (7) include labor, capital, education, foreign capital while those in equation (10) are labor, fertilizer, education, foreign capital and free market. Given the data, regression results suggest that agricultural production growth in China does result from technological progress, and it appears that farm production is more responsive to price reform than the other sectors.

In the log linear model for agriculture (i.e., equation 6), however, the free market was significant. The last run of equation (6) resulted in a P-value [1] equal to 0.00048 for this variable. This may indicate that price reform did make an effective impact on the improvement of resource allocation in the rural economy.

Results differ for the production inputs variables. Evidence suggests that machinery and modern inputs (such as chemical fertilizer) are important factors that contribute to production growth. However, land is statistically insignificant and the total power of machinery does not seem to affect prediction or it may be a poor measurement for the capital stock of farming sector. Labor is a

significant variable but its coefficient estimate has a negative sign in the farming study. To a certain extent, this might reflect the restructuring in rural area, in which, labor moved from farm production to other branches of the economy. The fact is that both land and labor fluctuated and even decreased during the period under study. Land and labor might have contributed to growth only through improved efficiency, i.e., changes in quality rather than quantity.

To find the best linear unbiased estimators, the standard assumptions must be held for regressions, otherwise the statistical inference will not be reliable. The initial regression for all four models was unsatisfactory and seemed to indicate serious interaction between variables. The data source, sample size and the nature of the time series study enhanced the suspicion that the models might have some problems. The Durbin-Watson statistic <sup>[2]</sup>, the White test <sup>[3]</sup> and the VIF test (Variance Inflationary Factor) <sup>[4]</sup> were used to detect whether there was autocorrelation, heteroscedasticity and multicollinearity in the models.

The test results were summarized in tables 5 to 8. The value of Durbin-Watson statistic shows the error terms in equation (7) are not autocorrelated. The test for equation (10) is inconclusive for  $\alpha = 0.05$  but shows no autocorrelation for  $\alpha = 0.01$ . The D-W tests for equations (6) and (11) are inconclusive. According to the results of the White test, heteroscedasticity was not present in any of the four models. The VIF scores also suggest that none of the models suffers from multicollinearity.

## 6.2 Objectivity of the Study

The test results seem to favor this study on the whole. However, the possible biases must not be ignored since the study involves several unfavorable factors. The following is an analysis on these issues.

### 6.2.1 About Constructed Data

The study employed constructed data for several variables. The method used to construct data is less likely to produce high quality data for a rapidly and comprehensively changing economy. For example, data of labor in the farming sector is estimated by multiplying agricultural labor by the share of farming in agriculture. Through the years under study, the farming share decreased a great deal while agricultural labor had a moderate increase with fluctuations in certain years. The share was 77% in 1978 but only 56% in 1989. Therefore, the data was decreasing in general, from 217.65 million in 1978 to 187.15 million in 1989. One has reason to suspect the quality of this constructed data considering the change in real output in farming, which reached 1,951.39 million yuan in 1989, which represented an increase over the 1978 output level by 82.1% (CSY, 1990). Variables which were obtained by a similar method included Education and Foreign Capital for both agriculture and farming and Free Market data for farming.

### 6.2.2 About the Price Index

The price index may also impair the data quality. There is a divergence of views on what is the appropriate price index for studies on the Chinese economy. A

few researchers used the state price index, while others tried a market price index for their studies. But many researchers believed that both are biased prices and need to be corrected. In addition, deflation of capital stock and raw material requires a specially designed weighted price index (Perkins, 1996). Perkins (1996) adopted such a price index designed by Zheng Yuxin, a Professor from Beijing, while McGuckin et al (1993) prepared one for themselves. This paper used the official price index. To be exact, the index of gross output value of agriculture as the deflator for output and the index of secondary industry as the deflator for capital stock were used. Although the latter is likely to create biased data, it was adopted as a capital deflator because it covers all machinery and manufactured products. Moreover, there is no other proper price index available for a capital deflator.

### 6.2.3 Proxy Variables

In addition to potential errors in data, the study involved a number of proxy variables. For example, the average education in years of the labor force is a far better measurement for educational attainment than the number of secondary school graduates in labor; again, changes in the share of state prices in the economy will capture the trend of price liberalization more accurately than changes in the size of the free market. In the model, proxy variables include the number of workers for labor input, the investment in capital inputs and raw materials used in agriculture, the number of secondary school graduates for



educational attainment of the labor force, foreign capital for advanced technology, and the size of the free market for price reform.

#### 6.2.4 Other Potential Problems

For a time series study, the sample size may conceal some problems. For example, the Durbin-Watson statistic may be inaccurate with only twelve observations; heteroscedasticity may not be exhibited when the sample size is small; an incorrect diagnosis is likely to occur for the detection of multicollinearity when the sample size is small and coefficients have the correct sign and a good t-ratio. In fact, the correlation matrix does show there is a very strong correlation between most independent variables. Due to the strong correlation between the dependent variable and independent variables, the problem of multicollinearity may not be obvious.

The best fit line for agriculture is the log linear model, while that for farming, it is the semi-log model. This inconsistency puts model specifications into question. Besides, negative signs of the coefficients on certain variables seem to suggest some important significant variables are omitted in the model.

## **7. Summary**

### **7.1 Findings of This Study**

The major findings of this study are summarized as follows: Given the data, the estimates of the production functions indicates that we have reasonable confidence to claim a combination of production inputs, technological progress and institutional innovation determined the agricultural growth in China during the first dozen years of the reform.

For production inputs, the importance of the factors varied. Physical capital and modern inputs (e.g., chemical fertilizer, machinery, etc.) have certainly contributed a great deal to output. Land was not among the major determinants of growth. While the change in labor inputs appears to have a certain impact on production, the evidence should be interpreted with caution since the coefficients of labor had negative signs in the farming study.

Both education and foreign capital are acceptable indicators for technological progress. Advanced capital appears more important than education. We may conclude that changes in physical capital will contribute to production more quickly and directly than changes in human capital.

Although the free market is not a perfect proxy for price reform, the evidence is good enough to support the argument that price reform was one of the most important determinants in advanced agricultural production.

### **7.2 Policy Implication**

Chinese agriculture may gain in growth from all three sources. The government should not ignore any of the three. However, to each category of growth sources, policy may emphasize one area over the others according to time and conditions.

The huge population and rapid industrialization in China require a fast, large and continuous increase in agricultural production. The government has set goals of producing 500 million metric tons of grain, 48 million tons of meat and 28.5 million tons of aquatic products by the year 2000. Those figures represent increases of, respectively, 50 million tons, 9.6 million tons and 10.27 million tons from 1993 to 2000 (Bangsberg, 1994). However, the total land input is likely to decline in the future as arable land is being swallowed up by rapid industrialization and the need for housing. Also in remote regions, deserts are growing as trees are cut for commercial and energy use (*ibid.*). Since there already exists a labor surplus in rural China, there is no reason to advocate increasing the amount of labor used in agriculture. Instead, multi-economy and industrialization should be developed in order to reduce resource waste and ease the pressure from the labor market.

In spite of the limit of land and labor inputs, the experience from the first dozen years of economic reform shows that increased use of modern inputs has great potential for increasing total production. For example, chemical fertilizer input per unit of land in China is lower than in developed countries. The output increase from greater fertilizer use may be potentially large in China. The

government should pursue efforts to ensure the sufficient supplies of modern inputs.

The mode of Chinese agricultural production is small scale based on household production. The rural infrastructure is poor and technology is backward in general. For such an economy, mechanization is not a top priority at present. However, China is far behind the industrialized countries in agricultural mechanization and it is important for the country to pursue this goal. If the resources are efficiently allocated, production may be increased greatly through greater machinery input. Major efforts should be devoted to promoting agricultural mechanization in the near future when the situation is improved. The current policy should encourage the things such as specialized production and development of rural production bases so as to increase agriculture's ability to use more machinery.

It is not advisable to seek growth by increasing the quantity of labor inputs in agriculture, but it is critical to improve the quality of the labor force. Continuous efforts should be made to lower the rate of illiteracy and to increase educational attainment. While education is a long term investment and less likely to show an immediate effect, this is one of the major conditions that will enable China to modernize the economy and accomplish the task of sustained agricultural growth. Education should be relevant to the social and economic needs of the system. The government should give more aid to rural education so as to advance the long run interest of the country.

Promoting technological change is certainly one of the most urgent tasks facing the system. Unlike education, investment in new technology is likely to have both immediate and long term impacts. For many years, China underinvested in agriculture. In 1985, the agricultural sector produced 28.1% of total national output and 41.1% of national income, although agricultural investment was only 3.4% of total investment (CSY, 1986). An increase in agricultural investment is needed to stimulate technological change. A combined effort from both the public and private sectors is essential. The effective import of foreign capital and advanced technology is a short cut to achieving the growth targets set by the government. Investment should aim at research and development, improving rural infrastructure, and popularization of new technology.

The old economic system needs a complete reform and change. There is no single solution for the transition of an economic system. Any partial institutional innovation is far from enough. Price reform is just one part of economic reform, without which, other reform measures would not get a satisfactory result; similarly, price reform works better when more parts of the system get reformed. The household responsibility system definitely had a positive impact on production. However, past innovations may be insufficient to the continued development and will pose new issues as time goes on. The pattern of land holdings, land tenure and other contractual arrangements in agriculture should be adjusted appropriately to gain more efficiency.

### 7.3 Future Research

The limitations of this study suggest several areas for further research. First of all, the same or similar studies can be conducted when accurate data becomes available. As analyzed previously, the current data set may contain a lot of errors, which would lead to biased estimates of variables that have poor data. Any conclusions based on these data must, of course, be considered tentative, pending analysis of more accurate data and more proper measures. To get accurate data means that we need proper price indexes and actual data for farm labor, education, foreign capital, etc. Another thing that depends on data availability is that we want to use true variables instead of proxy variables. It is likely that too many proxies would fail to accomplish the designated task of this paper.

It has policy implication to find those factors that make significant contributions to production. More independent variables can be tried in future studies to identify other important factors that represent technological progress and institutional innovations, and inputs as well.

Sensitivity study on variable specifications is needed. Further research with data from different industries should help in this regard. The sample size should be expanded. It is advisable to conduct a study that uses data from all the years of economic reform, including newest data of the most recent years; it is also advisable to include years before economic reform for comparison purposes. Some variables representing economic reform can only be estimated with a

sample that covers the years before and after economic reform. For example, the Household Responsibility System was established in the first few years of reform. The HRS may be better estimated with a dummy variable in a data set covering both the pre- and post-reform period.

## **Appendixes**

[1] P-value

[2] The Durban-Watson Statistic

[3] The White Test

[4] The VIF Test

Table A-1 Correlation Matrix of Model 1 (Equation 6)

Table A-2 Correlation Matrix of Model 2 (Equation 7)

Table A-3 Correlation Matrix of Model 3 (Equation 10)

Table A-4 Correlation Matrix of Model 4 (Equation 11)

Table A-5 Price Index and Shares of Agriculture and Farming (1978-89)

Table A-6 Annual Data for Agriculture Study, Log Linear Model (Equation 6)

Table A-7 Annual Data for Agriculture Study, Semi-log Model (Equation 7)

Table A-8 Annual Data for Farming Study, Log Linear Model (Equation 10)

Table A- 9 Annual Data for Farming Study, Semi-log Model (Equation 11)

Figure A-1 Trend of Variables in Equation (6)

Figure A-2 Trend of Variables in Equation (7)

Figure A-3 Trend of Variables in Equation (10)

Figure A-4 Trend of Variables in Equation (11)



## [1] P-value:

In a right-tailed test, the P-value is the area to the right of the test statistic. In a left-tailed test, the P-value is the area to the left of the test statistic. In a two-tailed test, the P-value is twice the area of the extreme region bounded by the test statistic. P-value gives us the probability of getting a sample result that is at least as extreme as the sample result actually obtained. A small P-value indicates that such sample results are less likely to occur by chance, assuming that the null hypothesis is true (Picconi, et al, 1993).

## [2] The Durbin-Watson test:

The Durbin-Watson (DW) statistic, named after the two statisticians who devised it, can indicate, in most cases, the extent of the autocorrelation problem.

The d calculated is defined as:

$$d\text{-cal} = [\Sigma(e_t - e_{t-1})^2] / \Sigma e_t^2 = 2(1-\rho)$$

The hypothesis and decision rule are as follows,

Ho: error terms are not autocorrelated

Ha: positive autocorrelation among error terms

D.R.: reject Ho if  $d\text{-cal} < d_{\text{lower}}$ ;

accept Ho if  $d_{\text{upper}} < d\text{-cal}$ ;

inconclusive if  $d_{\text{lower}} < d\text{-cal} < d_{\text{upper}}$ . (Dao, Stat-II, 1995)

## [3] The White test:

Regression assumes constant variance: residuals are distributed normally around the regression line throughout its length. The White test of Heteroschedasticity

was suggested by Halbert White in 1980 *Econometrica*, Vol.48, 817-38. It is applicable only to the residuals from a LS regression. If the LS regression is, say

$$Y = C + X + Z$$

and the residuals from this regression are denoted by  $e$  and the predicted  $Y$  are denoted by  $\text{Pred}Y$ , the auxiliary regression is

$$e^2 = C + \text{Pred}Y$$

The result from the second regression is a value  $nR^2$  ( $R^2$  from the auxiliary regression), which will have an asymptotic chi-square distribution with degrees of freedom equal to one. The test determines whether homoschedasticity exists or not (Bates, Research Method, 1996).

[4] The VIF test:

The VIF test (the variance inflationary factor) measures the extent of multicollinearity problem. The VIF is defined as:

$$\text{VIF}_j = 1/(1-R^2_j)$$

where  $R^2_j$ =coefficient of multiple determination explanatory variable  $X_j$  with all other  $X$  variables.

If there are only two explanatory variables,  $R^2_j$  is just the coefficient of determination between  $X_1$  and  $X_2$ . If, for example, there were three explanatory variables, then  $R^2_j$  would be the coefficient of multiple determination of  $X_1$  with  $X_2$  and  $X_3$ .

If a set of explanatory variables is uncorrelated, then  $VIF_j$  will be equal to 1. If the set is highly correlated, then  $VIF_j$  might even exceed 10. If this is the case, there is too much correlation between variables  $X_j$  and the other explanatory variables. However, a conservative criterion would be if the maximum  $VIF_j$  exceeds 5. The  $H_0$  that says no correlation among explanatory variables will be rejected if the maximum  $VIF_j$  exceeds 5 (Dao, letter, 1997).

Table A-1, Correlation Matrix of Model 1 (Equation 6)

	lnQ	lnL	lnK	lnED	lnFK	lnFRMK
lnQ	1					
lnL	0.946	1				
lnK	0.967	0.977	1			
lnED	0.899	0.936	0.917	1		
lnFK	0.939	0.957	0.936	0.990	1	
lnFRMK	0.989	0.945	0.948	0.902	0.947	1

Note: L = labor; K = capital; ED = education indicator; FK = foreign capital; FRMK = the size of the free market.

Table A-2, Correlation Matrix of Model 2 (Equation 7)

	lnQ	lnL	lnK	ED	FK	FRMK
lnQ	1					
lnL	0.946	1				
lnK	0.967	0.977	1			
ED	0.973	0.972	0.953	1		
FK	0.982	0.923	0.921	0.966	1	
FRMK	0.984	0.917	0.931	0.952	0.992	1

Note: see Table A-1 for notations.

Table A-3: Correlation Matrix of Model 3 (Equation 10)

	lnFM Q	lnFML	lnFMK R	lnFLZ	lnLND	lnFMED	lnFMF K	lnFMFRM K
lnFMQ	1							
lnFML	-0.830	1						
lnFMK	0.966	-0.855	1					
lnFLZR	0.952	-0.756	0.981	1				
lnLND	-0.505	0.272	-0.600	-0.711	1			
lnFMED	0.869	-0.627	0.908	0.965	-0.843	1		
lnFMFK	0.926	-0.742	0.970	0.993	-0.765	0.982	1	
lnFMFRM	0.975	-0.820	0.978	0.955	-0.516	0.870	0.936	1

Note: FL = labor in farming; FMK = capital in farming; FLZR = chemical fertilizer; LND = farm land; FED = education indicator for farming sector; FFK = foreign capital in farming; FFRMK = the free market for farm products.

Table A-4: Correlation Matrix of Model 4 (Equation 11)

	lnFMQ	lnFML	lnFMK	lnFLZR	lnLND	FMED	FMFK	FMFRM K
lnFMQ	1							
lnFML	-0.830	1						
lnFMK	0.963	-0.855	1					
lnFLZR	0.966	-0.756	0.981	1				
lnLND	-0.505	0.272	-0.600	-0.711	1			
FMED	0.869	-0.732	0.975	0.995	-0.737	1		
FMFK	0.926	-0.882	0.988	0.946	-0.481	0.939	1	
FMFRMK	0.930	-0.836	0.964	0.928	-0.432	0.916	0.980	1

Note: see Table A-3 for notations.

Table A-5: Price Index and Shares of Agriculture and Farming (1978-89)

YEAR	GRSINDEX	2NDINDEX	AGRSHR	FMSHR
1978	100.0	100.0	0.275	0.767
1979	107.5	108.2	0.307	0.746
1980	109.1	122.9	0.297	0.717
1981	115.4	125.2	0.316	0.705
1982	128.4	132.1	0.332	0.705
1983	138.4	145.8	0.331	0.706
1984	155.4	166.9	0.323	0.683
1985	160.7	197.9	0.291	0.630
1986	166.1	218.2	0.281	0.623
1987	175.7	248.1	0.279	0.607
1988	182.6	284.1	0.273	0.559
1989	188.3	297.2	0.267	0.562

Sources: China Statistical Yearbook (1990), China Statistical Abstract (1990)  
& China Trade and Prices Statistics (1989)

Table A-6: Annual Data for Agriculture Study, Log Linear Model (Equation 6)

YEAR	lnQ	lnL	lnK	lnED	lnFK	lnFRMK
1978	7.2421	5.6480	6.0186	8.7935	3.9318	2.1972
1979	7.3649	5.6592	6.7417	9.5438	4.7875	2.3026
1980	7.4745	5.6761	7.1952	9.8412	5.2575	2.3979
1981	7.5443	5.6983	7.5337	10.0941	5.6525	2.5025
1982	7.5672	5.7339	7.8018	10.2697	5.9269	2.5465
1983	7.5944	5.7433	8.0110	10.4041	6.1549	2.5878
1984	7.6344	5.7342	8.1862	10.5158	6.3818	2.6387
1985	7.7196	5.7426	8.3333	10.6120	6.6542	2.6870
1986	7.7899	5.7466	8.4665	10.7035	6.8763	2.9076
1987	7.8866	5.7595	8.5878	10.7932	7.0484	2.9897
1988	8.0746	5.7779	8.7139	10.8765	7.2071	3.0815
1989	8.1521	5.8077	8.8361	10.9504	7.3441	3.1930

Sources: China Statistical Yearbook (1990), China Statistical Abstract (1990)  
& China Trade and Prices Statistics (1989)

Table A-7: Annual Data for Agriculture Study, Semi-log Model (Equation 7)

YEAR	lnQ	lnL	lnK	ED	FK	FRMK
1978	7.2421	5.6480	6.0186	6591	51	9.0000
1979	7.3649	5.6592	6.7417	13958	120	10.0000
1980	7.4745	5.6761	7.1952	18793	192	11.0000
1981	7.5443	5.6983	7.5337	24200	285	12.2128
1982	7.5672	5.7339	7.8018	28846	375	12.7626
1983	7.5944	5.7433	8.0110	32995	471	13.3010
1984	7.6344	5.7342	8.1862	36893	591	13.9950
1985	7.7196	5.7426	8.3333	40618	776	14.6876
1986	7.7899	5.7466	8.4665	44513	969	18.3131
1987	7.8866	5.7595	8.5878	48691	1151	19.8797
1988	8.0746	5.7779	8.7139	52918	1349	21.7917
1989	8.1521	5.8077	8.8361	56977	1547	24.3612

Sources: China Statistical Yearbook (1990), China Statistical Abstract (1990)  
& China Trade and Prices Statistics (1989)

Table A-8: Annual Data for Farming Study, Log Linear Model (Equation 10)

Year	lnFQ	lnFL	lnFMK	lnFLZR	lnLND	lnFED	lnFFK	lnFFRM K
1978	6.9769	5.3829	4.7664	9.0870	7.7194	8.5283	3.6667	1.9321
1979	7.0723	5.3668	4.8963	9.2931	7.7085	9.2514	4.4951	2.0102
1980	7.1414	5.3432	4.9936	9.4489	7.6943	9.5083	4.9246	2.0650
1981	7.1946	5.3488	5.0550	9.4992	7.6859	9.7446	5.3029	2.1529
1982	7.2175	5.3841	5.1128	9.6247	7.6831	9.9199	5.5771	2.1967
1983	7.2462	5.3951	5.1942	9.7170	7.6778	10.0559	5.8067	2.2397
1984	7.2532	5.3529	5.2728	9.7641	7.6794	10.1345	6.0005	2.2574
1985	7.2575	5.2803	5.3430	9.7846	7.6753	10.1497	6.1919	2.2248
1986	7.3159	5.2726	5.4359	9.8682	7.6793	10.2296	6.4023	2.4337
1987	7.3872	5.2602	5.5149	9.9033	7.6845	10.2939	6.5491	2.4904
1988	7.4925	5.1957	5.5826	9.9718	7.6839	10.2943	6.6250	2.4994
1989	7.5763	5.2319	5.6372	10.0678	7.6954	10.3747	6.7683	2.6173

Sources: China Statistical Yearbook (1990), China Statistical Abstract (1990)  
& China Trade and Prices Statistics (1989)

Table A-9: Annual Data for Farming Study, Semi-log Model (Equation 11)

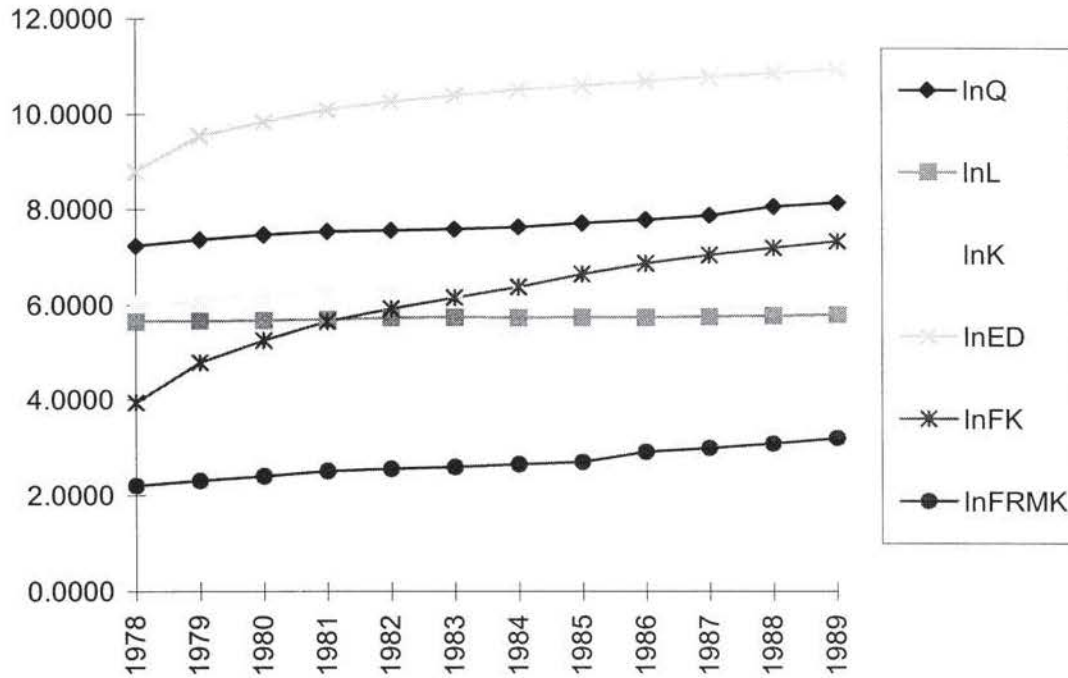
Year	lnFQ	lnFL	lnFMK	lnFLZR	lnLND	FED	FFK	FFRM K
1978	6.9769	5.3829	4.7664	9.0870	7.7194	5055.97	39.12	6.90
1979	7.0723	5.3668	4.8963	9.2931	7.7085	10419.56	89.58	7.46
1980	7.1414	5.3432	4.9936	9.4489	7.6943	13471.25	137.63	7.88
1981	7.1946	5.3488	5.0550	9.4992	7.6859	17061.16	200.93	8.61
1982	7.2175	5.3841	5.1128	9.6247	7.6831	20331.78	264.31	9.00
1983	7.2462	5.3951	5.1942	9.7170	7.6778	23293.28	332.51	9.39
1984	7.2532	5.3529	5.2728	9.7641	7.6794	25196.45	403.63	9.56
1985	7.2575	5.2803	5.3430	9.7846	7.6753	25583.85	488.78	9.25
1986	7.3159	5.2726	5.4359	9.8682	7.6793	27711.47	603.25	11.40
1987	7.3872	5.2602	5.5149	9.9033	7.6845	29552.86	698.60	12.07
1988	7.4925	5.1957	5.5826	9.9718	7.6839	29564.87	753.68	12.17
1989	7.5763	5.2319	5.6372	10.067	7.6954	32038.07	869.87	13.70

8

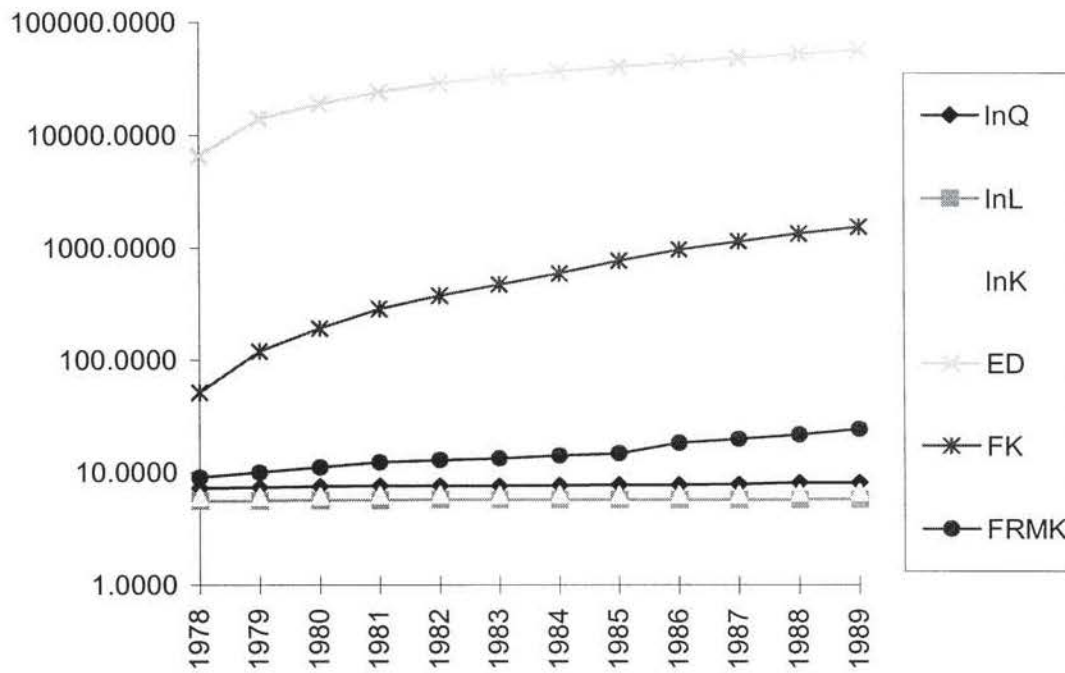
Sources: China Statistical Yearbook (1990), China Statistical Abstract (1990)  
& China Trade and Prices Statistics (1989)



**Trendlines of Variables in Equation (6)**

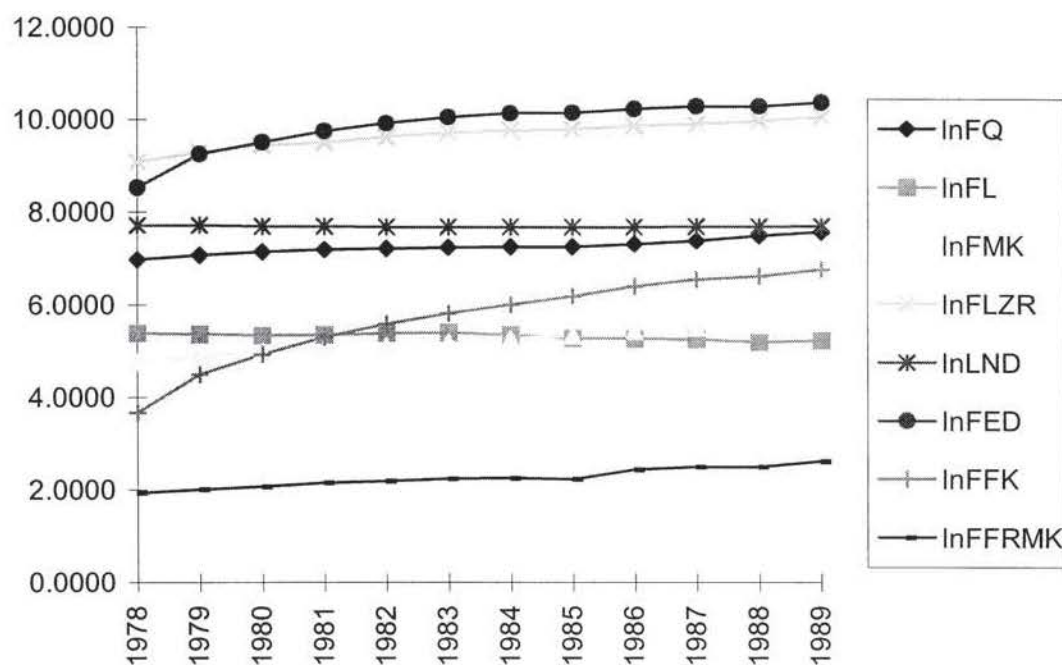


**Trendlines of Variables in Equation (7)**

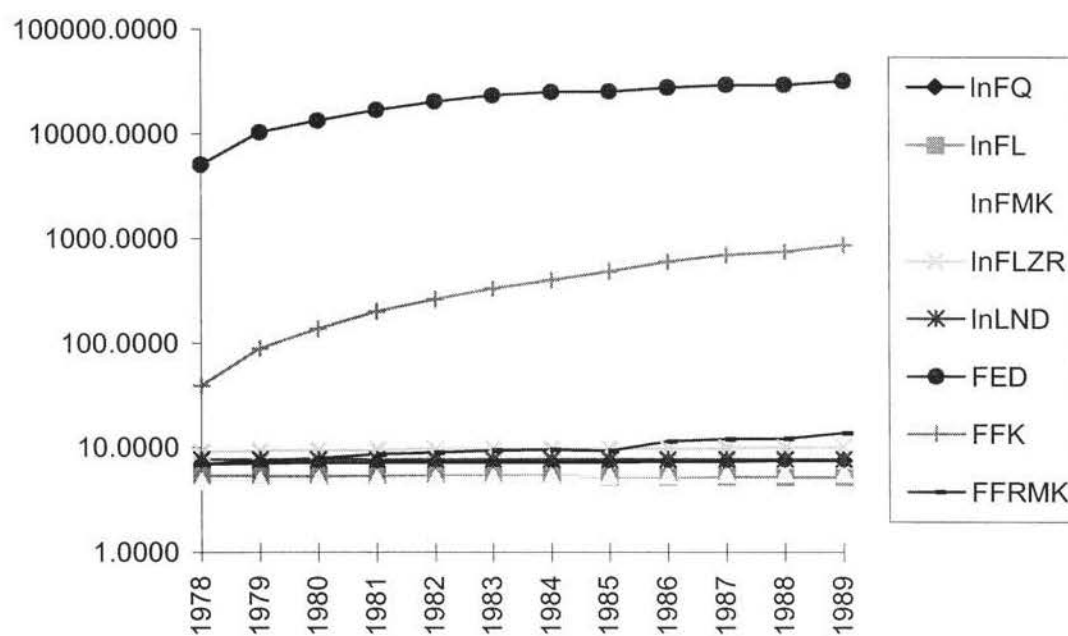




**Trendlines of Variables in Equation (10)**



**Trendlines of Variables in Equation (11)**



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