Growth, Inequality, and Poverty in Rural China

The Role of Public Investments

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Foreword

Many developing countries increasingly face tighter budgets in the era of macroeconomic reforms. Therefore, it is hard for them to increase investments in rural areas. These investments have played critical roles in the past in meeting national food demand and reducing rural poverty. However, unstable food supply and the existence of large numbers of poor people remain thorny problems that require much government attention in many developing countries. As a result governments are asked to do more with the same or even fewer resources.

In this research report, Shenggen Fan, Linxiu Zhang, and Xiaobo Zhang show that the impact of government spending on agricultural growth, rural poverty, and regional inequality depends on the type of spending. Using provincial-level data for the past several decades, the authors construct an econometric model that tracks down the effects of government spending through different channels. The model has the ability to calculate the marginal returns to expenditures on agricultural research and development (R&D, irrigation, education, infrastructure, and anti-poverty programs, and to calculate trade offs between growth and reduction in poverty and regional inequality. Findings show that reprioritizing future spending can produce large gains for the poor.

The study found that agricultural research investment had the largest impact on agricultural production growth, which is much needed to meet the increasing food demands of a richer and larger population. Agricultural production growth also benefited the poor economically. To reduce rural poverty and promote rural economic growth, the government should not only increase agriculture-specific investment, such as agricultural R&D, but also gear broader investments, such as those on education and infrastructure, to rural areas. Government expenditure on education had the largest impact on reducing both rural poverty and regional inequality and a significant impact on boosting production. Increased rural nonfarm employment accounted for much of this poverty and inequality reduction. Like education, the large impact of rural infrastructure on agricultural growth and poverty comes mainly from improved nonfarm employment opportunities.

Government has played a prominent role in the past in using irrigation to promote agricultural growth. But today's marginal returns to irrigation investment have little effect on both agricultural growth and poverty reduction. However, making current irrigation investment more efficient by reforming institutions and policies should receive a higher priority. The low returns of anti-poverty loans imply that the government should better target this spending or improve the efficiency of its use. And in terms of regional priorities, if the government aims to maximize poverty and inequality reduction, then investment should be targeted to the western region (a less developed area).

This report on China is another major outcome of the International Food Policy Research Institute (IFPRI) research program on rural public investment. The first publication dealt with India. Similar work is under way in Viet Nam and Thailand, and is planned for Africa.

Per Pinstrup-Andersen
Director General

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Summary

China achieved world renown in reducing its rural poverty during the past two decades, despite the global slowdown in poverty reduction. Contributing to this success are a series of policy and institutional reforms, promotion of equal access to social services and production assets, and public investments in rural areas. Yet, as China's economy continues to grow, it is becoming harder to reduce poverty and inequality further. How the government can better design its policies, particularly public investment policy, to promote growth while, at the same time, reducing poverty and regional inequality, is hotly debated in both academic and policy circles. This report disentangles the roles of specific public investments in promoting growth and reducing poverty and regional inequality in rural China. It also provides insights on gainful future priorities for government investment.

Using provincial-level data for 1970–97, the report develops a simultaneous equations model to estimate the effects of different types of government expenditure. The model not only ranks the marginal effects of public investments on growth, inequality, and poverty, but it also tracks various channels of investment and their effectiveness. The latter is important because it enables policymakers to focus on strengthening the weak links in the poverty-reduction chain.

The results show that government's production-enhancing investments, such as agricultural research and development (R&D), irrigation, rural education, and infrastructure (including roads, electricity, and telecommunications) contributed not only to agricultural production growth, but also to reduction of rural poverty and regional inequality. But variations in the magnitude of the effects are large among different types of spending, as well as across regions.

Based on actual investments in 1997 and the parameters estimated from the model, we calculated the marginal returns of various investments in growth in agricultural and nonfarm production and reduction of rural poverty and regional inequality. These returns were calculated for the nation as a whole and for three different economic zones. Since the estimated returns are recent, they can serve as a direct input into the current policy debate.

Government expenditure on education had the largest impact in reducing rural poverty and regional inequality and significant impact on production growth. Increased rural nonfarm employment was accountable for much of this poverty- and inequality-reduction effect. Government spending on agricultural R&D substantially improved agricultural production. In fact, this type of expenditure had the largest impact on agricultural production growth, which is still much needed to meet the increasing food demands of a richer and larger population. Benefits of agricultural production growth also trickled down to the rural poor. The poverty-reduction effect per unit of additional agricultural R&D investment ranked second only to investment in rural education. Government spending on rural infrastructure (roads, electricity, and telecommunications) had substantial impact in reducing poverty and inequality as well,

owing mainly to improved opportunities for nonfarm employment and increased rural wages. Investments in irrigation had only modest impact on agricultural production growth and even less impact on rural poverty and inequality, even after trickle-down benefits were allowed for. A striking finding is the minimal impact of specifically targeted government anti-poverty loans. In fact, the poverty-reduction impact of these loans was the least of all the types of government spending considered in the study.

Disaggregating the analysis into different regions reveals that, for all types of government spending, returns to investments in poverty reduction were highest in the western region, while returns in agricultural production growth were the highest in the central region for most types of spending. Furthermore, for all types of government spending, investments in the western region led to the greatest reductions in regional inequality, while investments in either coastal or central regions worsened the existing large regional inequalities.

These findings hold important implications for future government investment priorities. In order to reduce rural poverty and promote rural economic growth, the government should not only increase agriculture-specific investment, such as agricultural R&D, but also gear broader investments, such as in education and infrastructure, to rural areas. In irrigation, government has played a prominent role in promoting agricultural growth in the past. But today marginal returns to investment in both agricultural growth and poverty reduction are small. No doubt investment in flood and lodging control is important and should remain a top priority in government investment portfolios. But making current irrigation investment more efficient by reforming institutions and policies should receive an even higher priority. The low returns of anti-poverty loans imply that the government should better target this spending or improve the efficiency of its use.

In terms of regional priorities, if the government aims to maximize poverty- and inequality-reduction effects, then investment should be targeted to the western region (a less developed area). However, to maximize returns to investment in agricultural production, investment should be targeted to the central region.

Suggested future research includes a general-equilibrium approach to analyze the overall impact of public investment on the whole economy, as well as on urban poverty and inequality. Further, China's entry into the World Trade Organization (WTO) calls for more research on how public investment can be used to alleviate possible adverse impacts. The political, economic, and institutional aspects of public investment in rural areas also need to be better understood to improve efficiency and effectiveness of use of public resources, an issue largely neglected in the past.

CHAPTER 1

Introduction

China is one of the few countries in the developing world that has made progress in reducing its total number of poor during the past two decades (World Bank 2000). Numbers of poor in China fell precipitously, from 260 million in 1978 to 50 million in 1997.[1] A reduction in poverty on this scale and within such a short time is unprecedented in history and is considered by many to be one of the greatest achievements in human development in the twentieth century.[2] Contributing to this success are policy and institutional reforms, promotion of equal access to social services and production assets, and public investments in rural areas.

The literature on Chinese agricultural growth, regional inequality, and rural poverty reduction is extensive. But few have attempted to link these topics to public investment.[3] We argue that even with the economic reforms that began in the late 1970s it would have been impossible to achieve rapid economic growth and poverty reduction without the past several decades of government investment. Prior to the reforms, the effects of government investment were inhibited by policy and institutional barriers. The reforms reduced these barriers, enabling investments to generate tremendous economic growth and poverty reduction. Similarly, public investment may have played a large role in reducing regional inequality, an issue of increasing concern to policymakers.

China's experience provides important lessons for other developing countries. In the general literature on public economics, the rationale behind government spending is to spur efficiency (or growth) by correcting market failures. Examples of such failures are externalities; scale economies; failures in related markets like credit, insurance, and labor; nonexcludability; and incomplete information about benefits and costs. Less attention is paid to the role of

[1] Unlike in many other developing countries, poverty in China has mainly been limited to rural areas. Urban poverty incidence is extremely low, although there has been a slight increase recently (Piazza and Liang 1998). The number of rural poor for each year is reported in the China Agricultural Development Report, a white paper of the Ministry of Agriculture. The poverty line is defined as the level below which income (and food production in rural areas) are below subsistence levels for food intake, shelter, and clothing.

[2] Even if the international standard of one dollar per day measured in purchasing power parity is used, China's poverty reduction is still remarkable when compared with other countries, having declined from 31.3 percent in 1990 to 11.5 percent in 1998. Using the same poverty line, the incidence of poverty in South Asia declined only from 45 percent in 1987 to 40 percent in 1998, while for Africa as a whole incidence changed very little, from 46.6 percent in 1987 to 46.3 percent in 1998 (World Bank 2000).

[3] Some studies link public investment to food security and agricultural growth (Fan and Pardey 1992; Huang, Rosegrant, and Rozelle 1997; Huang, Rozelle and Rosegrant 1999; Fan 2000). But very few link these investments to poverty reduction in a systematic way. Chapter 4 presents a more detailed literature review.

public investment in pursuing equity or poverty alleviation objectives. Many neoclassical economists favor solving poverty problems by using welfare redistribution means, for example, by taxing the rich and transferring income directly to the poor. But few countries, particularly developing countries, have succeeded in solving the poverty problem solely through direct income transfers. Therefore, more governments are now convinced that poverty and inequality may be more effectively reduced by promoting the income-generation capacity of the poor. Effective public spending policy is one of the instruments used to achieve this.

Because many developing countries are undergoing substantial macroeconomic adjustments and facing tight budgets, it is critical to analyze the relative contributions of various expenditures to growth and poverty reduction. Valuable insights can thus be gained to further improve the allocative efficiency of limited, even declining, public resources.

The primary purpose of this study is (1) to develop an analytical framework for examining the specific role of different types of government expenditure on growth, regional inequality, and poverty reduction by controlling for other factors such as institutional and policy changes and (2) to apply that framework to rural China.

Using provincial-level data for the past several decades, we construct an econometric model that permits calculation of economic returns, the number of poor people raised above the poverty line, and impact on regional inequality for additional units of expenditure on different items. The model enables us to identify the different channels through which government investments affect growth, inequality, and poverty. For instance, increased government investment in roads and education may reduce rural poverty not only by stimulating agricultural production, but also by creating improved employment opportunities in the nonfarm sector. Understanding these different effects provides useful policy insights to improve the effectiveness of government poverty alleviation strategies.

Moreover, the model enables us to calculate growth, inequality, and poverty-reduction effects from the regional dimension. Specific regional information helps government to better target its limited resources and achieve more equitable regional development, a key objective debated in both academic and policymaking venues in China.

The rest of the report is organized as follows. Chapter 2 details the evolution of growth, inequality, and poverty in rural China over the past several decades. Chapter 3 describes trends of public investment in technology, education, and infrastructure, as these have long-term effects on growth, poverty reduction, and income distribution. Chapter 4 develops the conceptual framework to track multiple poverty effects of public investment. Chapter 5 describes the data and estimation strategy and presents the estimation results. Chapter 6 concludes the report with policy implications and future suggested research directions.

CHAPTER 2

Growth, Inequality, and Poverty

This chapter examines trends in growth, inequality, and poverty, as well as associated changes in institutions and policies. It thus provides a background for analysis in later chapters of how various public investments affect growth, inequality, and poverty.

Macroeconomic Reforms

The dynamic growth of the Chinese economy over the past 50 years ranks among the most important developments of the twentieth century. China has experienced a number of policy and institutional reforms, some of which have involved abrupt dislocations of the country's economic, social, cultural, and political order. The official raison d'être for these reforms was to promote rapid economic development and a more equal distribution of wealth, to attain national self-sufficiency, and to further socialist or communist ideals. Two distinct stages are normally used in describing the development of the national economy: adoption and implementation of a Soviet-type economy from 1952 to 1977 and gradual economic reform toward a market-led economic system since 1978.

Prior to 1978, China faced a hostile international environment with political isolation and economic embargoes. Political leaders adopted a heavy industry-oriented development strategy to catch up with developed western countries. This approach is clearly stated in China's first five-year plan (1952–57) (Lin, Cai, and Li 1996).

To guarantee low production costs for the heavy industry sector, agricultural product prices were suppressed to subsidize the cost of living of urban workers. The government also established the hukou system of household registration in this period, confining people to the village or city of their birth in order to ensure enough agricultural laborers to produce grain for urban workers. This urban-biased policy created a large gap in income and standard of living between rural and urban residents 1982–2000 (SSB, various years).

The state or collectives owned production assets, and all firms produced products in accordance with government plans and quotas. Prices of both inputs and outputs were strictly controlled by government without regard for market demand and supply. Allocation of inputs among firms and products among consumers was also based on government plan rather than on market signals. Workers earned a fixed monthly salary or an amount based on their working hours, often without consideration of their work efforts. All these policies led to an egalitarianism within rural areas and within cities, despite the large gap between them.

In spite of the counterproductive economic policies, the Chinese economy did exhibit some important accomplishments during 1952–77. Foremost of these was a record of impressive economic growth. From 1952 to 1977, China's GDP grew at an average annual rate of 5.93 percent (Table 2.1). However, due to the obligatory savings inherent in the Soviet-type

Table 2.1 GDP and input growth by sector, 1952–97 (%)

Period	Total	Agriculture	Urban industry	Urban service	Rural enterprise
GDP					
1952–77	5.93	3.66	9.43	5.10	n.a.
1978–89	9.50	8.38	6.47	13.91	19.27
1990–97	11.18	5.27	10.27	7.04	27.86
1978–97	9.81	7.25	7.32	11.00	21.56
1952–97	7.68	5.32	8.66	7.06	n.a.
Labor					
1952–77	2.60	2.13	5.55	3.59	n.a.
1978–89	2.96	1.12	3.67	3.66	15.49
1990–97	1.23	–1.46	1.18	8.25	4.26
1978–97	2.94	0.90	2.86	6.65	11.01
1952–97	2.73	1.56	4.50	4.02	n.a.
Capital stock					
1978–89	8.54	2.28	9.97	8.90	11.75
1990–95	9.25	6.00	6.69	10.60	18.11
1978–95	8.70	3.40	8.92	9.38	13.20

Source: Fan, Zhang, and Robinson 2001. They constructed GDPs for the four economic sectors based on various China State Statistical Bureau (SSB) publications.

Note: N.a. means not available.

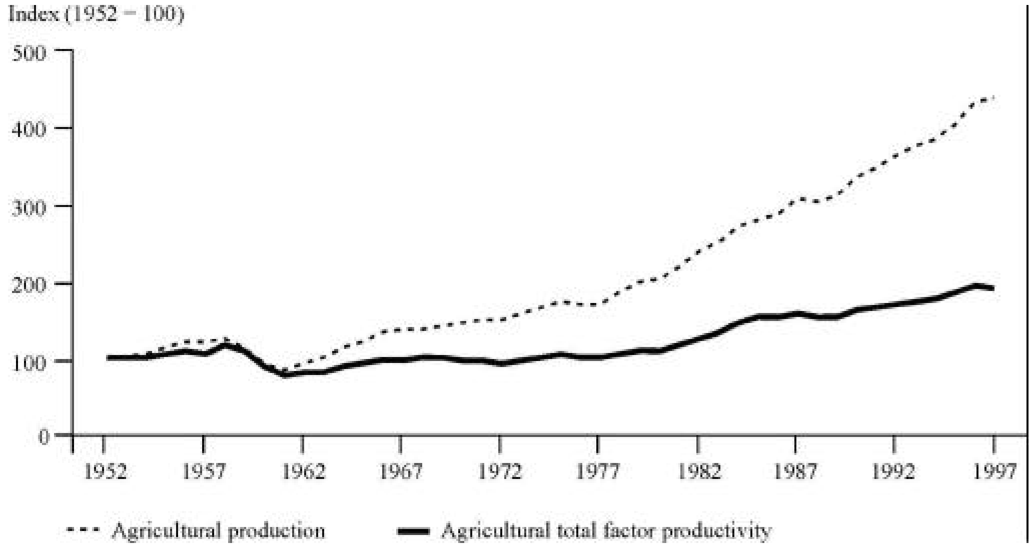
growth strategy, personal consumption grew at only 2.2 percent per annum during the same period. The result was extremely low living standards for the general population, rural residents in particular.

Chinese economic reforms began in the rural areas in 1978 (more details are included in the next section). Urban-sector reforms did not begin formally until 1984, before which some reforms were enacted piecemeal. But even after 1984, the reform package was far from the "big bang" programs then being advocated for Eastern Europe and the former Soviet Union. In particular, China's urban-sector reforms emphasized expansion of enterprise and local autonomy and incentives and the reduction—but not elimination—of within-plan allocations (Groves et al. 1994).

In addition, China gradually opened its economy to foreign trade and investment, which not only contributed directly to rapid economic growth but also helped to restructure the national economy. In the urban industrial sector, markets for most industrial products replaced the planned allocation of goods. In other words, state-owned enterprises were forced to operate according to market rules. Furthermore, non-state enterprises, both domestic and foreign, could be created and could compete with state-owned enterprises in these markets.

In terms of government fiscal and financial policies, which are directly relevant to our study, the government decentralized its management system by granting localities greater flexibility in collecting revenue and making expenditure decisions. This greatly increased incentives for local governments to develop their economies so as to retain more revenue for improving local infrastructure and human capital. Due to the regions' differing tax bases, the trend of decentralization might have affected the

Figure 2.1 Growth in agricultural production and productivity, 1952–97



Source: Fan and Zhang 2001.

level of public expenditures across regions, therefore perhaps leading to differential rates of growth and poverty reduction.[4]

As a result of the reform policies, national GDP grew at about 10 percent per annum from 1978 to 1997 (Table 2.1). Per capita income increased more than fourfold, or 7.8 percent per annum. The overall living standard of the Chinese population and national development indicators improved at an unprecedented rate, approaching those in many middle-income countries (World Bank, *World Development Report 2000*).

Policy Reforms and Agricultural Growth

This section reviews major institutional changes and policy reforms in rural areas and links these to production and productivity growth in the Chinese agricultural sector (Figure 2.1).[5] Rural policy and institutional changes were linked to the macroeconomic policies described in the previous section, but they exhibited different phases and they had much greater impact on growth and poverty reduction in rural areas.

Land Reform (Prior to 1953)

Large-scale land reform was one of the first priorities of the newly formed Communist government. Until the 1949 Revolution, land ownership was feudal, with approximately 70 to 80 percent of the agricultural land held by landlords who themselves constituted only 10 percent of the rural population. Most farmers were landless peasants who rented land, often at exorbitant rates,

[4] Lin and Liu (2000) analyzed the relationship between fiscal decentralization and economic growth in China. They concluded that fiscal decentralization contributed significantly to economic growth, in addition to other key factors such as rural reform, capital accumulation, and nonstate sector development.

[5] For milestones in reforming Chinese agriculture, see Appendix A.

from these landowners. Soon after 1949, land was confiscated by the government without compensation and redistributed to peasant farmers. By the end of 1952 the land reform was successfully accomplished (Ministry of Agriculture 1989).

Collectivization (1953–56)

Beginning in 1952, some small-scale peasant farmers voluntarily pooled their land and other resources into a cooperative mode of operation. At first, farmers were free to join or leave the cooperatives without penalty. Government efforts to develop large collective operations soon followed, and by 1956 most of China's agricultural production was done on a collective basis (Lin 1990; Putterman 1990). Under this system, land ownership was vested in a collective that usually consisted of some 200 families. Within the collective, an individual's income was tied to the number of work points accumulated throughout the year in relation to the time, effort, skill, and political attitude the laborer brought to the collective work. Households also farmed home gardens on "private plots," which then constituted about 5 percent of all arable land. Produce from these gardens could be sold on free markets (Ministry of Agriculture 1989). All these policies led to rapid growth in both production and productivity, with annual growth rates of 5.3 percent and 2.7 percent, respectively (Fan and Zhang 2001).[6]

Great Leap Forward and Communization (1957–60)

Beginning in 1958, the central government promoted an even larger scale of production in agriculture. Advanced cooperatives were merged into communes. The forced rapid collectivization gave farmers no incentives to increase production and productivity, since their income and well-being was no longer linked to their work efforts. At the height of the commune movement in 1958–59, the average communal unit had grown to 5,000 households covering 10,000 acres, and food was allocated as much on the basis of need as on accumulated work points. The communes owned virtually all production means except for agricultural labor. The government, through its administration and procurement systems, rigidly controlled both quantity and price of outputs and inputs. Commune leaders made production decisions, with the role of farmers limited to supply of labor for commune production. Work on private plots was also prohibited. As a result, both agricultural production and productivity declined sharply, by 6 percent and 5 percent per annum, respectively (Figure 2.1). The widespread drought and flood in most of China in 1959 worsened the devastating situation. An estimated 30 million people died of starvation, one of the largest human tragedies in history (Lin 1990; Lin and Yang 2000).

Economic Adjustments (1961–65)

The Great Famine (1959–61) led the government to implement an adjustment and consolidation policy after 1961. Production was decentralized into smaller units called "production teams," a sub-unit of the commune consisting of only 20 to 30 neighboring families. By 1962, production teams were the basic unit of operations and accounting in most rural areas. Decisions

[6] The growth rates of agricultural production and productivity used here are new measures constructed by Fan and Zhang (2001). They adjusted livestock and fishery output data to measure growth in output, input, and total factor productivity for Chinese agriculture based on detailed quantity and price information. Fan and Zhang found that official statistics overestimate both aggregate output and input, resulting in biased estimates of total factor productivity growth. Furthermore, the official data overstates the impact of the rural reforms on both production and productivity growth. Nevertheless, both production and productivity still grew at respectable rates during the reform period.

on farm operations, including the adoption of new technologies, were primarily made by team leaders (MOA 1989). Production and productivity recovered rapidly, growing at more than 9.0 percent and 4.7 percent per annum, respectively (Figure 2.1).

Cultural Revolution (1966–76)

During the Cultural Revolution of 1966–76, production and productivity growth were again depressed by policy failures. The government reinstated many controls that were loosened during the three-year adjustment period of 1962–65. Although production was still organized in the smaller unit production teams, it was nonetheless tightly controlled by government. Farmers' incomes were not closely related to their production efforts. The government controlled virtually all input and output markets. No market transactions of major agricultural products were allowed outside the procurement system. Market exchanges of land between different production units in the collective system were also outlawed. Because farmers had few incentives, inefficiency was rampant in agricultural production. Production during this period grew at 2.6 percent per annum, and there was virtually no gain in total factor productivity.

The First Phase of Reform (1979–84)

Due to the more than two decades of poor performance of the agricultural sector, central government decided to reform the rural areas in 1978. These reforms occurred in two reasonably distinct phases. The first phase focused on decentralizing the system of agricultural production, while the second phase emphasized liberalizing factor and output markets.[7]

During the initial phase of the reforms, the state raised its procurement prices for agricultural products and reopened rural markets for farmers to trade produce from their private plots. After two years of experiments, in 1981 the government began to decentralize agricultural production from the commune system to individual farm households. By 1984, more than 99 percent of production units had adopted the household production responsibility system. Under the system, farmers were free to make production decisions based on market prices as long as they fulfilled government procurement quotas for grains. Land was still owned by the collectives, but use rights could be transferred.

In addition to decentralization of the production system, government began to reform the agricultural procurement system. Prior to 1984, virtually all commodities were subject to various government procurement programs. In 1984, the number of commodities within the government procurement system was gradually reduced, from 113 to 38 (Ministry of Agriculture 1989).

Unsurprisingly, both technical efficiency (from the decentralization of the production system) and allocative efficiency (from price and marketing reforms) increased significantly during this first phase of reforms. Production increased by more than 6.6 percent and productivity by 6.1 percent per annum from 1979 to 1984 (Figure 2.1).

The Second Phase Reform (1985–89)

The second phase of reforms was designed to further liberalize the country's (agricultural) pricing and marketing systems. However, the government cut the marginal (above-quota) procurement price for grain in 1985. Meanwhile, input prices increased

[7] Various studies attempt to assess the impact of this reform on production growth (McMillan, Whalley, and Zhu 1989; Fan 1990, 1991; Lin 1992; Zhang and Carter 1997; Fan and Pardey 1997; Huang, Rosegrant, and Rozelle 1997). All found that during this initial stage of reform, institutional and market reform was the major source of productivity growth.

much faster than the government's output procurement prices, raising production costs.[8] The result was an end to the rapid output growth of the previous five years. Annual production grew at only 2.7 percent during this second phase of reforms, and there were no significant productivity gains (Figure 2.1).

New Developments in Agricultural Policy (1990–Present)

The 1990s marked a new development stage in Chinese agriculture.[9] The government continued to implement market and price reforms, and it further reduced the number of commodities under the government procurement system. The number of commodities subject to state procurement programs declined from 38 in 1985 to only 9 in 1991. In 1993, the grain market was further liberalized, and the grain rationing system that had been in existence for 40 years was abolished. In 1993, more than 90 percent of all agricultural produce was sold at market-determined prices, a clear indication of the degree to which China's agriculture had been transformed from a command-and-control system to a largely free-market one. To increase farmers' incomes, government increased its procurement prices for grains by 40 percent in 1994. In 1996, it increased procurement prices 42 percent further. As a result, agricultural production and productivity continued to rise rapidly with growth rates of 3.8 percent and 2.3 percent per annum, respectively, from 1990 to 1997 (although these were lower than during the first phase of the reforms).

Rural Nonfarm Sector

One of the most dramatic changes in rural China has been the rapid increase of rural enterprises during the past two decades.[10] Employment in the nonfarm sector as a percentage of total rural employment grew from 7 percent in 1978 to 29 percent in 1997 (Table 2.2). By 1997, rural enterprise accounted for more than a quarter of national GDP. Yet this sector was almost nonexistent even as late as 1978. In 1997, GDP produced by rural industry in China was larger than the GDP of the entire industrial sector of India.[11] Without development of the rural nonfarm sector, annual GDP growth in China from 1978 to 1995 would have been 2.4 percent lower per annum.

The rapid development of the rural nonfarm sector not only contributed to rapid national GDP growth, but also raised the average per capita income of rural residents. In 1997, more than 36 percent of rural income was from rural nonfarm activities (SSB 1998), while rural income in 1978 was predominantly from agricultural production.

The rural nonfarm sector developed in several stages. The first can be traced back as far as 1958, when communes set up many small-scale industrial enterprises (for example, steel mills), all of which failed immediately.[12] During the nationwide agricultural mechanization drive of the early 1970s, rural small-scale industrial enterprises reemerged. Most of these started as agricultural machine repair shops and food-processing mills. Many enterprises in the urban hinterlands soon became subcontractors of state-owned enterprises. These community enterprises were known as "com-

[8] The rising cost of production was reported by the Ministry of Agriculture in its Production Cost Survey (various years).

[9] Huang, Lin, and Rozelle (1999) provide a good summary of Chinese agricultural policies since the 1980s.

[10] Qian and Jin (1998), Chen and Rozelle (1999), Lin and Yao (1999), and Oi (1999) discuss the development of rural enterprise and its contribution to the Chinese economy from different angles.

[11] Calculated by the authors using data from the World Bank's *World Development Report 2000.*

[12] This is largely due to the national industrialization drive during the Great Leap Forward.

Table 2.2 Development of the rural nonfarm sector, 1978–97

Year	Employment (thousands)	Employment as a percentage of total rural employment	Rural nonfarm GDP (index)	Rural nonfarm GDP as a percentage of national GDP	Rural nonfarm annual wage (1990 yuan)
1978	2,243	7.00	100	4.00	640
1980	1,956	6.00	133	4.30	763
1985	6,715	18.00	370	6.70	1,141
1990	8,673	21.00	938	10.40	1,322
1995	12,708	28.00	4,662	25.50	2,001
1997	13,527	29.00	6,007	28.20	2,286
Annual growth rate (%)					
1978–85	16.96		20.56	7.56	8.61
1985–90	5.25		20.44	9.27	2.99
1990–97	6.56		30.38	15.30	8.14
1978–97	9.92		24.05	10.81	6.93

Sources: Calculated by authors from various issues of the *China Statistical Yearbook* (SSB) and the *China Rural Statistical Yearbook* (SSB).

mune and brigade enterprises." During most of the pre-reform period, the development of rural industry was embryonic and often restricted by the central and local governments, because it was in direct conflict with the government's top priority of producing the maximum amount of grain for both urban and rural needs.

After the 1979 rural reforms, the nonfarm sector became the most dynamic in the Chinese national economy. Rapid growth in agricultural labor productivity and rural income increased rural demand and generated tremendous labor surplus and initial investment, providing great opportunities for farmers to develop the nonagricultural sector. In addition, the local governments, particularly those in the relatively developed regions, shifted their focus to promote "township and village enterprises" (Rozelle and Boisvert 1994). In 1984, with the abolishment of the commune system, the central government renamed commune and brigade enterprises as township and village enterprises. Central government's attitude towards these enterprises also changed from tolerance to encouragement. Fearing that rural enterprises might become similar to the inefficient state-owned enterprises, since 1994 many local governments have tried to reform these rural enterprises by providing more autonomy to managers and modifying property rights.[13] For example, stock-sharing and privatization were introduced in recent years. These new reforms helped to maintain the rate of growth in the sector in the 1990s.

The success of the rural nonfarm economy had far-reaching impact on China's economy. In addition to providing employment and income for rural population (discussed earlier), the rapid development of rural industry and services not only demonstrated potential gains from reform, but it

[13] Many township and village enterprises, particularly large-scale industrial enterprises in coastal areas, had characteristics similar to state-owned enterprises (for example, heavy controls from township and village governments, unregulated taxes, subsidies, and donations for development of local roads, schools, and hospitals).

also created competitive pressure for urban sectors to reform as well. Without the successful reforms in agriculture, which increased agricultural productivity and released resources for work elsewhere, and rapid development of the rural nonfarm sector, the post-1984 urban reforms and rapid growth would have been impossible.

Structural Change and the Role of the Rural Sector

The Chinese economy experienced massive structural transformation over the past several decades as a result of differing sectoral growth rates (Figure 2.2).[14] In 1952, agriculture accounted for more than half of GDP, while urban industry and services accounted for 21 percent and 29 percent, respectively. The Chinese economy was largely agrarian. But by 1997 agriculture's share had declined to about 20 percent of GDP—about two-thirds of a percentage point per year, which is a rapid rate of structural change. At the same time, the share of rural enterprise increased from almost zero to 30 percent. Therefore the rural sector as a whole (agriculture and rural nonfarm) still accounts for more than half of total GDP in China today.

Labor shifts among sectors were also phenomenal. In 1952, more than 80 percent of the national labor force was in the agricultural sector, while only 6 percent worked in urban industry and 10 percent in the urban service sector. By 1997, less than half of the labor force was engaged in agricultural activities. More than 13 percent worked in the urban industrial sector and 10 percent in the urban service sector. Rural enterprises employed over one-fifth of the total labor in 1997 (Figure 2.2).

In 1978, agriculture accounted for 20 percent of the total capital stock, while urban industry and services accounted for 38 and 33 percent, respectively, and rural enterprises accounted for only 6 percent. By 1997, given slow growth in agricultural capital investment, the share of agriculture in the total capital stock declined dramatically to 8.8 percent. Both urban industry and services increased their shares to 44.5 and 38.7 percent, respectively. Although the total absolute amount of rural enterprise capital stock grew rapidly (13 percent per year), the growth was slower than the growth in the sector's GDP over 1978–95 (Figure 2.2).[15]

Rural Income, Inequality, and Poverty

Trends in Growth, Poverty, and Income Distribution

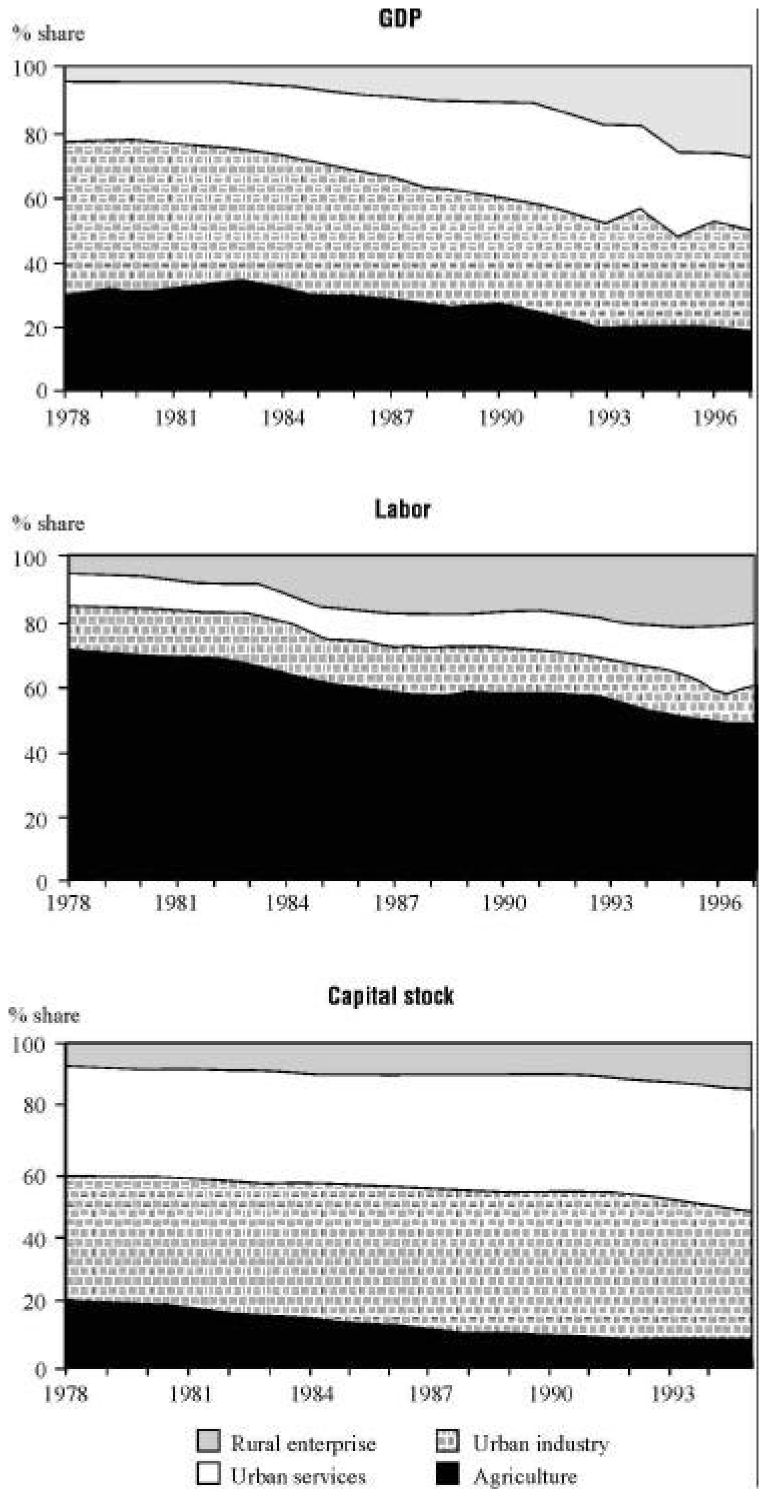
Per capita income in rural China was extremely low prior to the reforms. In 1978, average income per rural resident was only about 220 yuan per year, or about US$150 (Table 2.3).[16] During the 29 years from 1949

[14] For the effect of structural change on the Chinese economy, see Nyberg and Rozelle (1999) and Fan, Zhang, and Robinson (2001). Fan, Zhang, and Robinson found that more than 17 percent of economic growth during 1978–95 could be attributed to structural change among four economic sectors (agriculture, rural enterprise, urban industry, and urban service).

[15] Future structural change is needed since there still exist large differences in labor and capital productivities among sectors, according to Fan, Zhang, and Robinson (2001). Their findings indicate that the returns to capital investment in both agricultural production and rural enterprise are much higher than those in urban sectors, indicating underinvestment in rural areas. On the other hand, labor productivity in the agricultural sector remains low, a result of the still large surpluses of labor in the sector. Therefore, the further development of rural enterprise and increased labor flow among sectors and across regions are key to improving overall economic efficiency.

[16] Total and per capita incomes in this report are all measured in 1990 constant prices.

Figure 2.2 Structural shift of GDP, labor, and capital, 1978–97



Source: Fan, Zhang, and Robinson 2001.
Note: Total capital stock data only go up to 1995.

to 1978, per capita income increased by only 95 percent, or 2.3 percent per annum. China was one of the poorest countries in the world. Most rural people struggled to survive from day to day. In 1978, 260 million residents in rural China, or 33 percent of the total rural population, lived below the poverty line, without access to sufficient food or income to maintain a healthy and productive life.

This changed dramatically directly after the initiation of rural reforms in 1978. Per capita income increased to 522 yuan in 1984 from 220 yuan in 1978, a growth rate of 15 percent per annum (Table 2.3). The income gains were shared widely enough to cut the number of poor, hence the rate of poverty, by more than half By 1984, only 11 percent of the rural population was below the poverty line. Because of the equitable distribution of land to families, income inequality, measured as Gini coefficient, increased only slightly (Figure 2.3).

During the second stage of reforms (1985–89), rural income continued to increase, but at the much slower pace of 3 percent per annum (Table 2.3). This was due mainly to the stagnation of agricultural production after the reforms, as discussed in the previous section. The effects of fast agricultural growth on rural poverty were largely exhausted by the end of 1984. Over this same period, rural income distribution became less egalitarian, and the Gini index rose from 0.264 to 0.301 (SSB 1990). The ratio of per capita rural income in coastal regions to that in other areas also increased, from 1.21 to 1.51 (Zhang and Kanbur 2001). The changes in income distribution probably resulted from the changed nature of income gains and the growing differential in rural nonfarm opportunities among regions (Rozelle 1994).

With real crop prices stagnating and input prices rising, rural income gains had to come from increased efficiency in agricultural production and marketing or from

Table 2.3 Per capita income and incidence of poverty in rural China, 1978–97

Year	Per capita income: Yuan per person (1990 prices)	Per capita income: Percentage of urban residents	Incidence of poverty: Absolute number (millions)	Incidence of poverty: Percentage of population	Gini coefficient
1978	220	42	260	32.90	0.21
1979	263	43	239	30.00	0.22
1980	306	44	218	27.10	0.23
1981	349	49	194	24.30	0.24
1982	414	55	140	17.50	0.23
1983	467	59	123	15.20	0.25
1984	522	58	89	11.10	0.26
1985	593	58	96	11.90	0.26
1986	612	51	97	12.00	0.29
1987	644	51	91	11.10	0.29
1988	685	49	86	10.40	0.30
1989	674	44	103	12.40	0.30
1990	686	49	97	11.50	0.31
1991	700	42	95	11.10	0.31
1992	741	39	90	10.60	0.31
1993	765	39	80	9.40	0.32
1994	803	38	70	8.20	0.33
1995	846	41	65	7.60	0.34
1996	922	44	58	6.70	n.a.
1997	964	40	50	5.80	n.a.
Annual growth rate (%)					
1978–84	15.49	5.53	–16.36	–16.59	
1985–89	3.26	–6.67	1.78	1.03	
1990–97	4.98	–2.86	–9.03	–9.35	
1978–97	9.68	–0.30	–9.79	–10.28	

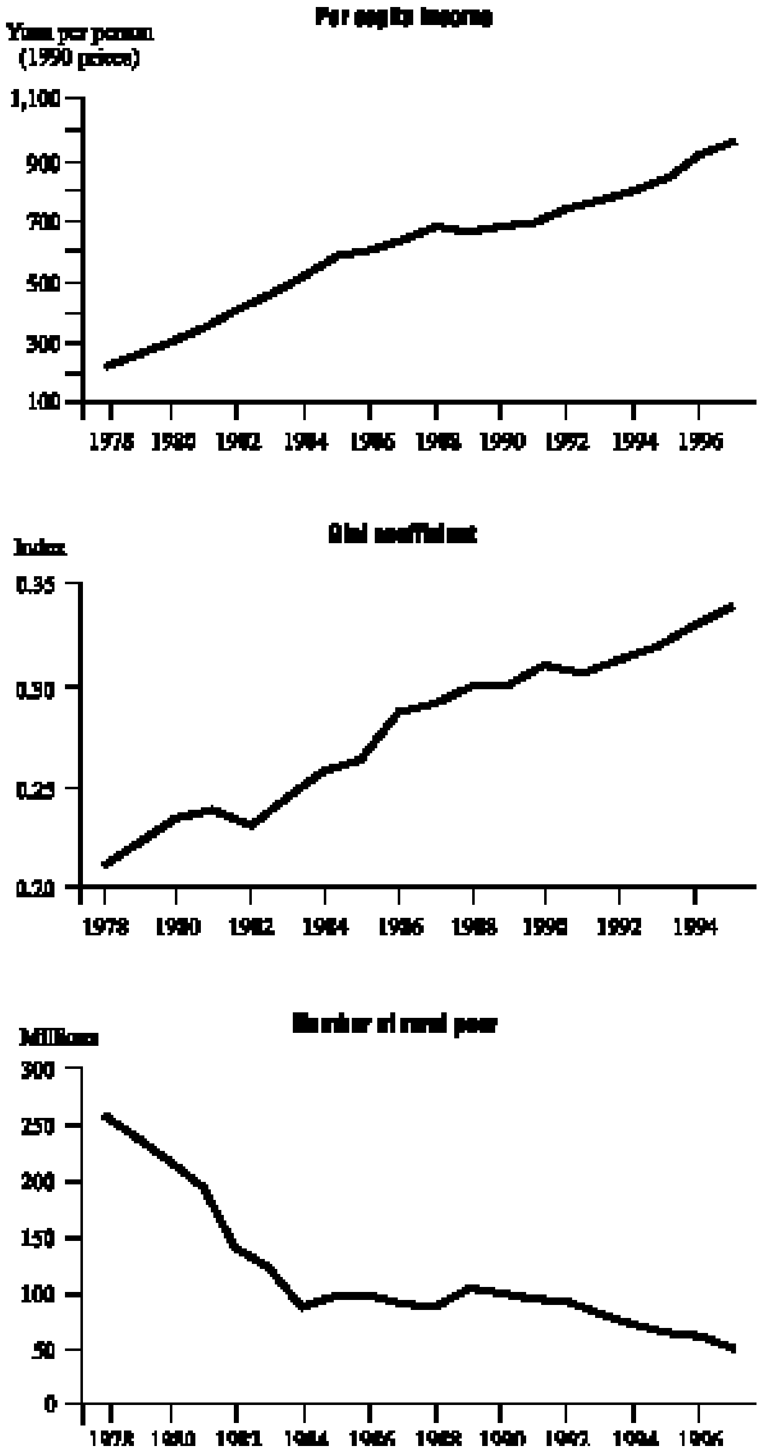
Source: The *China Statistical Yearbook* (SSB) and *China Agricultural Development Report* (MOA, various years).
Note: N.a. means not available.

employment outside of agriculture.[17] Although the poor had increased access to modern inputs, their generally adverse production conditions kept gains low. With nonfarm income an increasingly large proportion of rural income, regional variations in nonfarm income played a growing role in worsening income distributions, according to Rozelle. Development of the nonfarm sector was concentrated mostly in the coastal areas, where per capita income was already high and poverty incidence much lower than elsewhere. The large areas in the west and border provinces, home to most of the rural poor, lagged far behind. As a result, the number of poor increased from 89 million in 1984 to 103 million in 1989, a net gain of 14 million in five years (Table 2.3).

Only in 1990 did rural poverty begin to decline once again. The number of rural

[17] During this period, the real agricultural price increased by only 0.17 percent per annum, while the growth was 8.8 percent per annum during the first phase of the reform from 1978 to 1984 (SSB, 1984–95).

Figure 2.3 Income, inequality, and change in poverty in rural China, 1978–97



Source: Table 2.3.
Note: Gini coefficient estimates only go up to 1995.

poor dropped 9 percent per annum, from 103 million in 1989 to 50 million in 1997. Moreover, the rate of rural poverty reduction was faster than that of income growth (5 percent per annum) during the period, indicating that factors other than income growth were at play. In 1995, the government set itself a target of eliminating all rural poverty by 2000. To accomplish that goal, it introduced a series of policies and committed substantial financial resources.

Rural residents earned less than half their urban cohorts in 1978, with rural income 42 percent of that in urban areas (Table 2.3). Due to the success of rural reforms, that percentage increased to 59 percent in 1983. But it declined again to 40 percent in 1997, mainly owing to fast growth in urban areas and relatively sluggish increases in rural earnings.

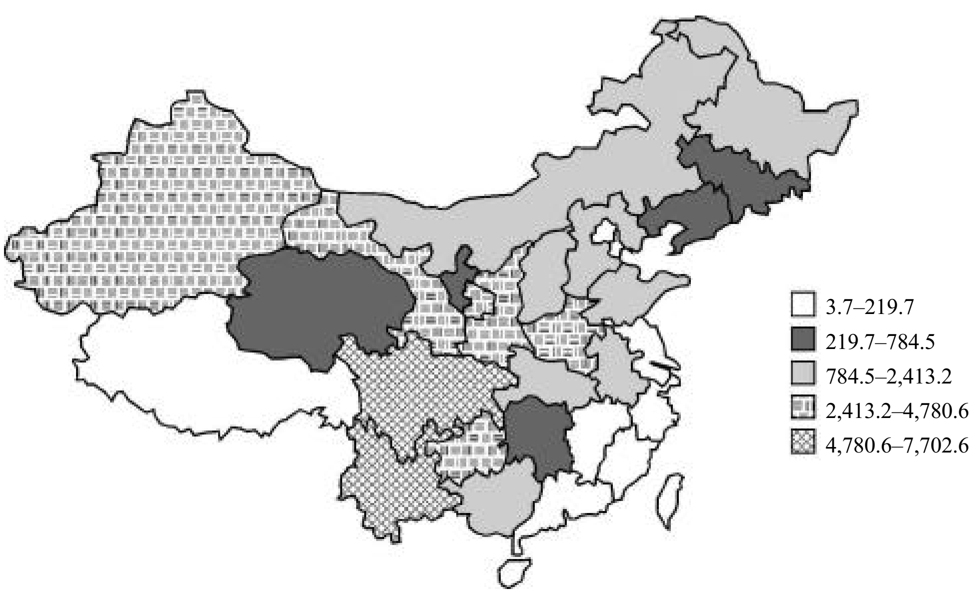
Poverty in China is therefore still mainly a rural phenomenon. Urban poor have been relatively few in number in China, although income distribution in the cities has deteriorated in recent years (Park, Wang, and Wu 2001; World Bank 1992). In 1990, average per capita income among the poorest 5 percent of urban residents was 689 yuan, more than double the urban absolute poverty line of 321 yuan and greater than the per capita income of 65 percent of rural residents. Less than 1 percent of the urban population—about one million people—had incomes below the estimated absolute poverty line each year from 1983 to 1990. Higher income levels, complemented by annual consumer food subsidies of at least 200 yuan per urban recipient, left the registered urban population much better nourished than their rural counterparts. In more recent years, however, many former state employees were laid off due to the reform of state-owned enterprises. Incidence of urban poverty may therefore have increased. Nevertheless, the size and severity of urban poverty remains of a much lesser scale than in the rural areas.

Geographic Distribution of Rural Poor

Rural poverty is concentrated in mountainous areas, primarily in the several ranges and high plateaus that define the western boundary of traditional Han agriculture and on the Northern China Plain (World Bank 2000a; Park, Wang, and Wu 2001). More than 60 percent of the rural poor in 1996 lived in border provinces such as Gansu, Yunan, Sichuan, Guizhou, Guangxi, Qinghai, Ningxia, Inner Mongolia, and Xinjiang (Figure 2.4). Given the low population density in these areas, the poverty incidence was much higher than the national average (Figure 2.5). For example, 23 percent of rural population in Gansu and 27 percent in Xinjiang lived under the poverty line in 1996. Another pocket of poverty is the Northern China Plain, where the poor account for 22 percent of the national total. This area includes Henan, Hebei, Shannxi, and Shaanxi, where meager natural resources, particularly poor soil and scarce water, are the major reasons for high concentration of rural poor.

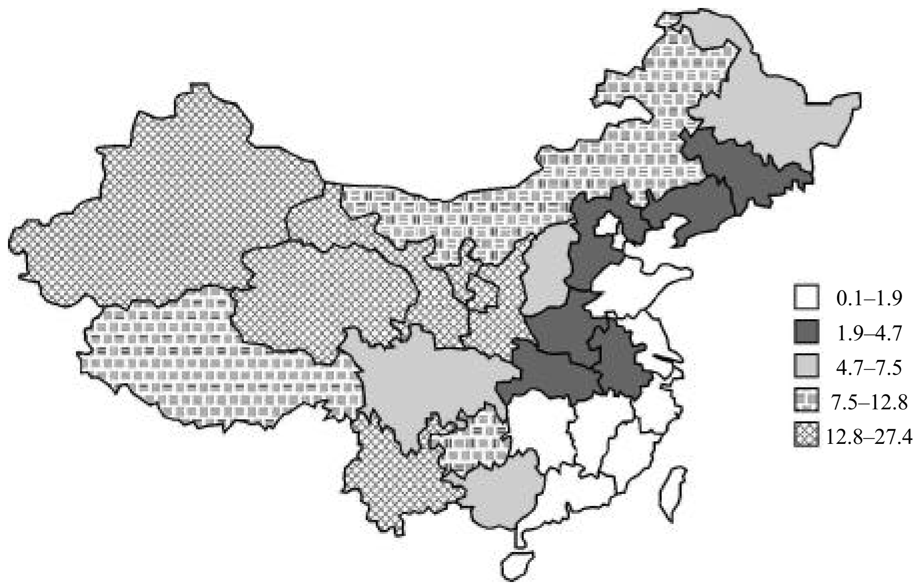
One salient feature of China's rural poverty is that individual and family characteristics appear to be less important than in other countries in explaining poverty. There are several reasons for this phenomenon. First, within villages, the egalitarian access to economic assets that began in the 1950s and continued through the distribution of collective means of production in the early 1980s limits the development of asset-based income inequality. In particular, land-use rights (not ownership) are equally distributed, and there are few if any landless laborers (Li 1998). This contrasts sharply with other developing countries such as India where a large percentage of the rural poor are landless laborers. Moreover, access to social services such as education and medical care in China tends to be village, not family, specific. Second, because of the compulsory system of primary and secondary education, most children receive basic education and become literate. Third, continued state control of major agricultural inputs, such as fertilizer, and of major outputs reduces opportunities to exploit different

Figure 2.4 Number of rural poor by province, 1996 (thousands)



Source: World Bank 2000a.

Figure 2.5 Percentage of rural poor in total rural population, 1996



Source: World Bank 2000a.

abilities in those markets. Finally, collectives directly control or strongly influence access to many forms of nonagricultural employment in an attempt to spread jobs among local families.

Government Anti-poverty Programs and Strategies

Prior to 1979, the major national objective of rural policy was to provide cheap food, capital, and labor for urban residents and industrial development. To achieve this, government tightly controlled rural production, marketing, and trade. Production targets and state mandatory procurement quotas were determined according to urban requirements. Procurement prices for agricultural products were normally set below international prices, transferring rents from farmers to the industrial sector. Urban- and industrial-biased development strategies were implemented at farmers' expense. Reducing rural poverty was therefore not formally part of the government's policy agenda during most of the pre-reform period.

A poverty alleviation program was not effectively formulated until 1986.[18] As the program's first step, central government designated 331 poor counties (roughly 16 percent of the total) based on per capita rural income. These counties received special funds from the central government for the explicit purpose of poverty alleviation. One billion yuan (in current prices) was allocated in 1986 alone. An additional 800 million yuan was added annually in subsequent years. These funds were supposed to be used as direct loans to poor farmers or to rural enterprises. In 1991, 36 more counties were designated as poor to receive 500 million yuan in loans for poverty reduction. In 1993, the designation

[18] For a chronology of major government events in poverty reduction, see Appendix B. Piazza and Liang (1998) and Park, Wang, and Wu (2001) also give excellent descriptions of China's anti-poverty programs and strategies.

of poor counties was adjusted based on changes in income and price indices. The number of poor counties was thereafter fixed at 592 (Table 2.4). Most of these counties are in the border and mountainous areas of Yunnan, Sichuan, Guizhou, Shaanxi, Shanxi, Hebei, Inner Mongolia, and Gansu.

With respect to government organizations, the State Council established the Leading Group for Economic Development in Poor Areas. This group brought together more than 20 ministries. In effect it encompassed all the government agencies whose work was relevant to poverty alleviation,

Table 2.4 Regional distribution of rural poor

	Official Chinese data				Khan (1997)		
Province	Share of households that are poor, 1989 (%)	Rural poor as share of total national poor, 1989 (%)	Number of poor counties, 1997	Poor counties as share of total provincial counties, 1997 (%)	Head count, 1988 (%)	Head count, 1995 (%)	Change (%)
Beijing	0.2	0	0	0.0	8.7	1.3	–7.4
Tianjin	0.4	0	0	0.0	n.a.	n.a.	n.a.
Hebei	13	7.1	39	28.3	29.9	22.7	–7.2
Shanxi	17.4	4.1	35	34.7	51.9	49.5	–2.4
Inner Mongolia	23.5	3.6	31	36.5	n.a.	n.a.	n.a.
Liaoning	8	1.9	9	20.5	27	21.9	–5.1
Jilin	12.2	1.9	5	12.2	41.5	18.3	–23.2
Heilongjian	18.3	3.6	11	16.4	n.a.	n.a.	n.a.
Shanghai	0	0	0	0.0	n.a.	n.a.	n.a.
Jiangsu	3.4	1.9	0	0.0	27.8	4.7	–23.1
Zhejiang	2	0.8	3	4.7	5.8	4	–1.8
Anhui	7.7	3.9	17	25.4	35.6	19.8	–15.8
Fujian	1.8	0.5	8	13.1	n.a.	n.a.	n.a.
Jiangxi	5	1.6	18	20.9	25.7	27	1.3
Shandong	6.8	5	10	10.6	28.3	19.3	–9
Henan	16.5	12.7	28	24.6	52.5	20.1	–32.4
Hubei	6	2.6	25	36.8	20.3	25	4.7
Hunan	6.2	3.5	10	11.2	13.1	37.5	24.4
Guangdong	0.9	0.5	8	8.3	4.8	5.2	0.4
Guangxi	15.4	6.1	28	34.6	n.a.	n.a.	n.a.
Sichuan	11.2	11.2	43	24.9	n.a.	n.a.	n.a.
Guizhou	17.8	5.4	48	60.8	32.5	43.1	10.6
Yunnan	19	6.5	73	59.8	58.3	61.8	3.5
Tibet			5	6.5	47.3	45.6	–1.7
Shaanxi	20.3	5.8	50	56.2	n.a.	n.a.	n.a.
Gansu	34.2	6.7	41	53.9	59.9	58	–1.9
Qinghai	23.7	0.8	14	35.9	69.7	69	–0.7
Ningxia	18.9	0.7	8	44.4	n.a.	n.a.	n.a.
Xinjiang	18.7	1.6	25	29.4	n.a.	n.a.	n.a.
China	11.1	100	592	27.8	35.1	28.6	–6.5

Sources: World Bank 2000a and Khan 1997.

Notes: N.a. means not available. The regional groupings are explained in footnote 33.

thus providing a mechanism both to influence the initiatives taken by the various ministries and to seek coordination in this area.

China's poverty alleviation strategy developed in three steps. Prior to 1984, social welfare and relief funds were mainly used to subsidize poor families. No formal strategy existed for reducing the number of poor in rural areas. From 1984 to 1995, government pursued a strategy of "regional targeting," that is, alleviating poverty by developing regional or local economies. This strategy effectively wiped out large-scale poverty by developing poor areas, although it brought little benefit to the extremely poor in the poorest areas. The poor were thus increasingly concentrated in remote locales with limited access to roads and other infrastructure, making it difficult for the development of the regional economy to trickle down to them. After 1996, the government altered its strategy to one of targeting poor households directly.

One program under this strategy is the food-for-work program, designed to build necessary infrastructure in poor rural areas. The scheme provides a fund through which roads, irrigation, and other construction projects are carried out by extremely poor farmers, most of whom are identified by village heads. Those employed on the projects sometimes receive food or, more frequently, vouchers that can be exchanged for food and other basic necessities.[19]

[19] Several studies assess the effects of these programs (Zhu and Jiang 1995; Park, Wang, and Wu 2001), concluding that most are modestly effective in rural poverty reduction.

CHAPTER 3

Public Capital and Investment

This chapter reviews the development of technology, education, and infrastructure and government spending on these types of capital. Such investments are a major source of long-term economic growth and poverty reduction. They have contributed not only to growth in agricultural production, providing an adequate food supply for the ever larger and richer population, but also to development of the rural nonfarm sector. The latter has become increasingly important for further poverty reduction in rural areas.

Research

China's agricultural research system expanded rapidly during the past four decades to become one of the largest public systems in the world. It employed more than 50,000 senior scientists and spent 4.1 billion current yuan (or 2.2 billion yuan in 1990 prices) on research conducted in national, provincial, and prefecture research institutes and agricultural universities in 1997.[20] By the early 1990s, the latest years for which comparative figures are available, the Chinese system accounted for over 18 percent of the less developed world's agricultural research expenditures (Pardey, Roseboom, and Fan 1998).

Nonetheless, the Chinese agricultural research system experienced many ups and downs over the last several decades. China's investment in agricultural research was minimal right after the founding of the People's Republic in 1949, but it grew rapidly thereafter until 1960. Growth in the 1960s was relatively slow due to the Great Famine (1959–61) and the Cultural Revolution (1966–76). Although investment increased steadily during the 1970s (Table 3.1), growth slowed in the 1980s to 23 percent during the entire 10 year period. In the 1990s, agricultural research expenditures again began to rise, largely due to government efforts to boost grain production through science and technology.

As a percentage of agricultural gross domestic product (AgGDP), agricultural research investment was relatively low during the first five-year plan period, at 0.12 percent, but it increased to 0.56 percent for the period 1958–76. The percentage then gradually declined to 0.3 percent in recent years. However, since AgGDP has grown rapidly, government investment in agricultural research has increased substantially in absolute terms over the last several decades, but it declined relative to the size of the agricultural sector (Fan 2000). In comparison with other low-income countries in Asia, China moved from investing relatively more

[20] In 1997, research expenditures in the Chinese agricultural research system (including research expenses by agricultural universities) were 4.1 billion in current Chinese yuan. This is equivalent to US$500 million measured by nominal exchange rate, and $2.03 billion measured by 1997 purchasing power parity.

Table 3.1 Public spending in rural China, 1953–97 (millions of 1990 yuan)

Year	R&D	Irrigation	Education	Roads	Power	Communi-cation
1953	17	177	2,584	194	3	18
1954	33	578	2,617	214	9	24
1955	55	530	2,490	224	13	26
1956	129	1,002	3,480	240	17	74
1957	128	970	3,583	359	18	50
1958	270	3,423	3,275	783	42	116
1959	452	3,139	4,815	522	58	172
1960	770	5,291	6,314	510	78	193
1961	386	1,879	3,876	432	31	34
1962	266	1,255	3,140	75	23	18
1963	379	2,147	3,551	224	39	22
1964	510	2,693	4,193	321	64	47
1965	584	2,520	4,405	424	136	110
1966	541	3,142	4,657	334	155	66
1967	337	2,899	4,114	382	191	75
1968	325	1,946	3,024	430	238	117
1969	530	2,905	3,038	488	290	138
1970	657	3,416	3,060	537	287	156
1971	613	4,002	3,917	488	345	171
1972	800	4,453	5,034	537	417	211
1973	763	5,691	5,590	585	419	251
1974	761	5,811	6,617	634	482	289
1975	883	5,859	6,944	572	623	278
1976	861	6,293	7,593	488	752	261
1977	897	6,089	7,882	525	734	249
1978	1,145	8,566	7,526	682	1,046	298
1979	1,319	9,856	9,198	733	1,044	260
1980	1,295	7,457	10,660	693	988	237
1981	1,212	5,188	11,289	381	1,073	240
1982	1,221	5,700	12,454	416	1,237	259
1983	1,516	6,160	13,815	449	1,551	303
1984	1,765	5,803	16,208	481	1,943	407
1985	1,764	5,183	19,025	1,253	2,565	457
1986	1,770	5,510	22,359	1,381	3,642	589
1987	1,644	6,154	26,432	1,626	4,522	847
1988	1,833	5,862	26,988	1,916	4,482	828
1989	1,754	5,744	22,917	2,082	4,151	900
1990	1,625	7,164	25,006	2,559	4,968	1,078
1991	1,790	9,820	28,530	2,973	5,607	1,414
1992	2,143	13,739	32,261	5,200	7,110	2,361
1993	2,230	14,344	38,059	3,795	8,633	5,003
1994	2,291	13,600	34,695	4,938	8,910	8,009
1995	2,267	15,417	34,139	5,673	9,597	7,795
1996	2,348	15,136	38,636	7,956	15,195	7,489
1997	2,170	23,415	41,024	10,700	14,147	9,350
Annual growth rate (%)						
1953–78	19.14	17.55	4.55	5.37	26.85	12.44
1979–89	2.89	–5.26	9.56	11.01	14.81	13.21
1990–96	4.21	18.43	7.33	22.68	16.13	36.15
1953–96	11.63	11.74	6.48	9.54	20.79	15.28

Sources: Fan and Pardey 1997, Fan 2000, and SSB various years.

Notes: For more details about the data sources refer to Chapter 5. R&D spending includes both national and sub-national government expenditures. Irrigation expenditures include government spending on reservoir construction, irrigation projects, and flood and lodging prevention. Expenditures on urban water supply, navigation, and hydropower generation are excluded. Spending on R&D, irrigation, and education include all expenditures (current and capitals), while spending on roads, power, and communication only include capital construction (usually 80–90 percent of total expenditure).

than average during the 1970s to below average at present (Pardey, Roseboom, and Fan 1998).

Agricultural research expenditure as a percentage of total government spending was comparatively low in the 1950s, averaging 0.10 percent during 1953–57 and 0.38 percent for 1958–60. Thereafter, the ratios of government spending remained relatively stable, hovering around 0.50 to 0.55 percent except during the Cultural Revolution when the share was substantially lower. Agricultural research spending as a share of total national research and development (R&D) expenditures was also quite stable. China earmarked some 10 to 13 percent of total R&D expenditures for agriculture during the past four decades. In contrast, agricultural research expenditures as a percentage of government spending on agriculture increased steadily, from just 1.5 percent during the first five-year plan period to surpass 6 percent in the last decade.

The development of China's research personnel has not matched the pattern of funds allocated to research. Specifically, three phases can be identified. During the 1950s and 1960s the number of researchers increased steadily. By 1973 about 10,000 scientists worked in the Chinese system.[21] From 1973 to 1990, numbers of research personnel increased rapidly, to almost 60,000 researchers, a rate of increase in excess of 10 percent per annum. During the third stage (after 1990), the number of researchers stabilized at around 60,000. After 1995, the number of researchers declined marginally, to about 53,000 in 1997.

Increased numbers of researchers from new graduates combined with a lack of growth in expenditures caused expenditure per scientist to drop sharply from 1979 to 1991. Although in more recent years expenditure per scientist has increased substantially in nominal terms, in real terms it has grown only marginally.

The regional pattern of R&D expenditures reveals that the Northwest region (Gansu, Shaanxi, Qinghai, Ningxia, and Xinjiang) spent much less than coastal areas, and expenditures of the latter were stagnant or even declining in the 1990s (Table C.2). It is not surprising that land productivity in the Northwest region was lowest among all regions. The coastal provinces (Guangdong, Zhejiang, Jiangsu, and Shangdong) experienced the most rapid growth in agriculture R&D spending.

Several studies have attempted to quantify the effects and returns of research investment on agricultural production. Fan and Pardey (1997) attributed about 20 percent of agricultural output growth from 1965 to 1993 to increased public investment in agricultural R&D. Rates of return to investment estimated using different lag structures range from 36 percent to 90 percent in 1997 (Fan 2000). Huang, Rozelle, and Rosegrant (1999) suggest that if China increased its investment in agricultural research and irrigation by 4.5 percent per year, it could become a net exporter of grains by 2020. With every 1 percent increase in agricultural research and irrigation investment, China could produce an additional 21 million metric tons of grain in 2010 and 36 million metric tons in 2020. Increased agricultural production from research investments has undoubtedly trickled down to the rural poor, although few studies have quantified their effect on poverty reduction.

Irrigation

Because rainfall is concentrated during the monsoon, China's early civilizations developed an agricultural system that depended

[21] Research personnel here are defined as researchers who have at least a bachelor's degree and one to two years of research experience. They are commonly referred to as scientists and engineers in the Chinese system.

Table 3.2 Development of irrigation, education, and infrastructure in China, 1953–97

Year	Irrigated area (millions of hectares)	Irrigated area as percent of arable land	Primary school enrollment rate (%)	Illiteracy rate of agricultural laborers (%)	Road length (thousands of kilometers)	Rural electricity consumption (hundreds of millions of kilowatts)	Rural telephones (thousands of sets)
1953	22	23.25	43	n.a.	137	0.50	42
1957	27	26.17	61.7	n.a.	255	1.40	185
1962	31	32.94	56.1	n.a.	464	16.10	847
1965	33	34.67	84.7	n.a.	515	37.10	806
1970	38	38.80	84.7	n.a.	637	95.70	878
1975	43	47.60	96.8	n.a.	784	183.10	1,149
1980	45	46.12	93.9	n.a.	888	320.80	1,345
1985	44	45.87	96	27.9	942	509.20	1,498
1990	47	48.04	97.8	20.7	1028	844.50	2,474
1995	49	49.28	98.5	13.5	1157	1,655.70	8,070
1997	51	53.34	98.9	10.1	1226	1,980.10	17,866
Annual growth rate (%)							
1953–80	2.69	2.57	2.93	n.a.	7.17	27.05	13.70
1980–90	0.44	0.41	0.41	n.a.	1.47	10.16	6.28
1990–97	1.17	1.51	0.16	–9.76	2.55	12.95	32.64
1953–97	1.93	1.91	1.91	n.a.	5.11	20.72	14.75

Sources: *China Statistical Yearbook, China Fixed Asset Investment Yearbook, China Electronic Power Yearbook, China Water Conservancy Yearbook, China Transportation Yearbook, China Education Yearbook,* and *China Science and Technology Statistical Materials.*

Note: For more details about the data sources, refer to Chapter 5.

on water conservation and irrigation. The Dujiang Weir in Sichuan Province, dating from the third century B.C., still supplies water to 200, 000 hectares. During the Ming and Qing dynasties, extensive irrigation works were developed in the north and central China plains.[22] The greatest expansion of irrigation facilities took place from 1953 to 1980, when the irrigated area increased from 16 million to 45 million hectares (Table 3.2). About 70 percent of grains as well as most of the cotton and other cash crops are produced on irrigated land. Many Chinese rivers are tapped for irrigation, with the Yangtze and Yellow rivers supplying much of the country's irrigation water through a system of dams and reservoirs, which also function as flood-control units. Annual usable supplies in the two river basins doubled and in some cases tripled after 1949 as a result of an ambitious program of dam construction. The Northern and Northwestern provinces make extensive use of groundwater. By 1997, 84,937 reservoirs, with a storage capacity of over 458 billion cubic meters, had been constructed.[23]

In terms of public investment, the government assigned top priority to irrigation immediately after 1949. In 1953, government spent 177 million yuan in irrigation

[22] The Ming Dynasty lasted from 1368 to 1644; the Qing Dynasty lasted from 1644 to 1911.

[23] Information in this paragraph is summarized from the annual *Water and Power Yearbook* of the Ministry of Water and Power.

investment, 10 times more than investment in agricultural research.[24] The investment in irrigation continued to increase until 1966. Under the commune system, it was rather easy for government to mobilize large numbers of rural laborers to work on the projects. As a result of this increased investment, more than 10 million hectares of land were brought under irrigation (Table 3.2). However, the investment increased very little from 1976 to 1990. In fact, it declined over 1976–89 (Table 3.1). During this period, there was no increase in irrigated areas in Chinese agricultural production.

In response to the grain shortfall and large imports in 1994–95, the government increased its investment in irrigation markedly in 1996 and 1997. Among all regions, the Northwest accounted for the largest increase in the 1990s, followed by the Northern China Plain (Table C.2). Investments in the Northeast and Southwest remained flat during most of the 1990s. Despite the increased spending, irrigated areas as a percentage of total land area increased very little. The only exception was the Northern China Plain (Table C.6). Further expansion of irrigated areas has proved difficult because of competing industrial and residential uses of water resources. As a result, returns to irrigation investment may decline in the future.

Education

The root of formal education in China dates back to at least the Shang Dynasty of 1523–1027 B.C. Up until the end of the Qing Dynasty of 1644–1911, education was limited to a privileged few, mostly for producing government officials.

Shortly after the the Chinese Communists took power, a Soviet-type educational system was imported with little concern about the special features of the Chinese environment. At the time, the Soviet Union was regarded as the new prototype for success. But the Soviet model was largely driven by technological needs; it paid little attention to the problem of mass illiteracy that China faced. By 1956, less than half of primary- and secondary-aged children were in school. Most efforts during this period were devoted to developing and restructuring higher education. As a result of this restructuring, the number of comprehensive universities diminished while the number of specialized colleges increased significantly.

The periods of the Great Leap Forward (1958–60) and the subsequent Cultural Revolution (1966–76) were disruptive times for Chinese society in general and its education in particular. Educational infrastructure was decimated as a result of the revolutionary struggles, and students suffered vastly watered-down or nonexistent curricula. Perhaps the only gain (again at the expense of quality) was the delivery of elementary education to an unprecedented number of school-aged children, largely because agricultural collectivization enabled the creation of large numbers of "commune schools." These were overseen directly by the collectives rather than by higher-level agencies. The enrollment rate of school-aged children rose from 43 percent to 97 percent by 1976 (Table 3.2). In 1983 more than 90 percent of rural children were enrolled in school, only slightly less than the urban rate of 98 percent (SSB, 1980–2000).

After 1978, China adopted the "nine-year compulsory schooling" education policy. That meant all children were required to attend school for at least nine years to finish both primary and junior middle school.

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[24] Irrigation investments here include only those directly related to irrigation, such as reservoir construction, irrigation projects, and flood and lodging prevention. The investments in total water conservancy, which also includes urban water supply and hydropower generation, amounted to more than 1 billion yuan in 1953, 60 times higher than agricultural R&D investment.

As a result of these efforts, the illiteracy rate of the general population 15 years and older dropped from 48 percent in 1970 to less than 10 percent in 1997. In particular, illiteracy among agricultural laborers declined from 28 percent in 1985 to 10 percent in 1997 (Table 3.2). Consequently, labor quality improved substantially. This enhanced human capital in rural areas and provided great opportunities for farmers to use modern farming technology and to engage in nonfarm activities both in rural township and village enterprises and in urban industrial centers.

T. Paul Schultz (1987) has shown that increased government efforts in rural primary education not only have large economic returns, but also contribute to equity in rural areas. Although the high returns to education in rural China were not systematically documented, anecdotal evidence suggests that improved education (particularly of household heads) not only enhanced farm productivity (Nguyen and Cheng 1997; Li and Zhang 1998), but also improved farmers' off-farm opportunities and their ability to migrate to urban sectors (Zhao 1999; Yang 1997).

In terms of expenditure, China spent about 2 percent of national gross domestic product (GDP) on education, which is much lower than many developed countries but higher than most developing countries. However, total expenditure on education may in fact be much higher because rural education is also largely supported by rural communities, and their investment is not counted in the formal government budget.

Despite extraordinary success in basic education in China, many poor were not reached by the government efforts. Official provincial-level data presented in Table C.3 reveals astonishing differences among provinces in illiteracy rates of rural laborers. Not only was illiteracy higher in the western region, but its rate of decline there was the lowest of all provinces. The disparity can be even greater within a single province or county. According to official statistics, in the poorer half of the townships of 35 counties supported by a World Bank project in Yunnan, Guizhou, and Guangxi, average enrollment was at least 10 percentage points lower than the national average for the same age group (Piazza and Liang 1998). Special household surveys document even greater disparities at the village level. The State Statistical Bureau's (SSB) 1994 survey of 600 households in the poorest townships of these 35 counties showed that the average enrollment rate for children ages 6–12 was only 55 percent. It is therefore unsurprising that official statistics in these counties indicate an average literacy rate for the total population of only 35 percent according to Piazza and Liang.

Infrastructure

Development of rural infrastructure is key to rural social and economic life. But until recently, China's government gave relatively low priority to rural infrastructure in promoting agricultural production, rural nonfarm employment, and improved living standards for the rural population.

Among all transportation facilities, roads are the most crucial to rural development. However, the mountainous topography in many parts of China has hindered the development of roads. In 1953, total length of roads was only about 137,000 kilmeters (Table 3.2), and road density was about 14 kilometers per thousand square kilometers, much lower than that of India at the time.[25] Moreover, government investment in road construction increased very little from 1953 to 1976. Nevertheless, the length of roads has increased gradually. After 1985, the government geared up its

[25] India's road density was 129 kilometers per thousand square kilometers in 1950.

investment in roads, particularly high-quality roads such as highways connecting major industrial centers in coastal areas. Rural roads, usually of lower quality, accounted for about 70 percent of total road length.

In contrast to road development, one of the greatest achievements in rural China was the rapid electrification of rural areas during the past several decades. Introduction of electricity can profoundly affect village life. Electric lighting expands the productive and social hours in the day. Radios and television provide accessible, affordable entertainment and education. Power machinery can raise productivity and improve working conditions.

In the past several decades, China gave higher priority to electricity than to road development in its investment portfolio. Investment in power increased ninetyfold. Electricity consumption in rural areas increased from almost zero in 1950 to 198 billion kilowatts in 1997 (Table 3.2). The most rapid growth occurred in the 1970s and 1980s. The percentage of villages with access to electricity was 97 percent in 1996, and more than 95 percent of households had an electrical connection (Ministry of Electric Power 1997). This percentage was much higher than that of India in the same year.

Prior to 1980, growth in government investment in rural telecommunications was very slow. Investment increased from 3 million yuan in 1953 to 237 million yuan in 1980. However, large-scale development happened only in recent years, with the number of rural telephones increasing from 3.4 million in 1992 to 17.9 million in 1997 (Table 3.2). This was largely a result of both public and private investments in the sector. From 1989 to 1997, public investment alone increased more than tenfold.

But this trend at the national level disguises large regional differences in rural telecommunications development. As Table C.5 shows, the coastal provinces like Guangdong, Jiangsu, Zhejiang, and Fujinag experienced an exponential growth in the number of rural telephone sets, while western regions (Northwest and Southwest) showed relatively slow growth.

CHAPTER 4

Conceptual Framework and Model

This chapter reviews previous studies and develops a conceptual framework for the analysis. It then constructs and specifies the equations system based on previous studies, a theoretical economic framework, and reality in rural China.

Previous Studies

This section looks at the relevant studies on growth, regional inequality, and poverty reduction in rural China. In particular, it points out the knowledge gap in previous studies and develops the rationale for the current study.

Sources of Growth

The outstanding performance of Chinese agriculture after the reforms of the late 1970s triggered numerous studies to analyze the sources of the rapid growth. These include McMillan, Whalley, and Zhu (1989); Fan (1991); Lin (1992); Zhang and Carter (1997); Fan and Pardey (1997); and Huang, Rosegrant, and Rozelle (1997). Compared to the traditional accounting approach (Solow 1957; Denison 1962), most of these studies attempt to analyze the impact of institutional changes in addition to the increased use of inputs on production growth during the reform period up to the early 1990s. McMillan, Whalley, and Zhu claimed that 80 percent of the productivity growth over 1978–84 was due to institutional reforms, while 20 percent was due to output price changes. Fan found institutional reforms accounted for 27 percent of production growth or 63 percent of productivity growth, and technical change measured as the residual accounted for only 16 percent of the production growth or 37 percent of the productivity growth from 1965 to 1985. Using the percentage of households that adopted the production responsibility system as a proxy for institutional change in his production function, Lin attributed 94 percent of the productivity growth from 1978 to 1984 to institutional and policy reforms.

Fan and Pardey (1992) were the first to point out that omitted variables, such as research and development (R&D) investment, biased estimates of the sources of production growth. To address this concern, they included a research stock variable in the production function to account for the contribution of R&D investment to the rapid production growth in addition to the increased use of inputs and institutional changes. They found that ignoring the R&D variable in the production function estimation led to an overstatement of the effects of institutional change. Later, Huang, Rosegrant, and Rozelle (1997) used a supply function framework to comprehensively account for the sources of growth in grain production in Chinese agriculture. They concluded that public investment (mainly in R&D) accounted for 3 percent and 11 percent of rice production growth for the periods 1978–84 and 1984–92, respectively. For other grains, public investment accounted for only 6 percent of the total growth over 1978–92. For cash crops, the contribution of public investment was 18 percent and 111 percent for 1978–84 and 1984–92, respectively.

In addition to R&D investment, government spending on roads, electrification, education, and other public investment in rural areas contributed to rapid growth in agricultural production. Omitting these variables biases estimates of the production function for Chinese agriculture as well. To date, no studies have included a comprehensive set of public investment variables in the estimation of the Chinese agricultural production function.

Despite the phenomenal development of the rural nonfarm sector in China, few studies analyze the sources of growth of this increasingly important sector. The only exception is Fan, Zhang, and Robinson (2001), which decomposed the sources of growth into growth in capital and labor. But this study too failed to include public investment directly as a source of growth.

Factors Affecting Regional Inequality

A feature of the Chinese economy is the uneven distribution across regions of economic growth resulting from the reforms. The difference in growth rates between the coastal and inland regions was as high as 3 percent during the past two decades, and regional inequality for China as a whole increased significantly (Kanbur and Zhang 1999). China implemented a coast-biased development policy with a large portion of public investment concentrated in the coastal regions. It is legitimate to speculate that the skewed distribution of public investment might be an important factor behind the increased regional inequality.

Apart from their role in promoting growth, various types of public investment are also key instruments for governments to reduce inequality (*World Development Report 1994*). Despite the policy relevance on distributional grounds, few studies, except Martin (1999) and Jacoby (2000), attempt to investigate both the equity and growth impact of public capital. Jacoby found rural road development to have a positive effect on growth but an ambiguous effect on inequality in rural Nepal. Using a theoretical two-region endogenous growth model, Martin explored the link between infrastructure and regional inequality. Again, both studies consider only one specific type of public capital—roads, leaving out other types of investment and offering little guidance to policymakers. In the real world, policymakers are more concerned about the magnitude and directions of growth and distributional effects of various public investment instruments so as to target their investments more efficiently.

Many studies focus on rural inequality in China (Lyons 1991; Tsui 1991; Rozelle 1994; Yang 1999; and Kanbur and Zhang 1999). Rozelle decomposed inequality (Gini coefficient) into different sources of income. Using the county-level data from Jiangsu province, he revealed that the changing patterns of inequality were closely associated with the changes in the structure of the rural economy. In particular, policies that increased the importance of agriculture in the economy led to reduced inequality; those that simulated the expansion of rural industry gave rise to greater inequality.

From a different angle, Kanbur and Zhang decomposed overall regional inequality in China into inequality between rural and urban and between inland and coastal. Their study generated two important findings. On one hand, the contribution of rural-urban inequality to overall regional inequality was much higher than that of inland-coastal. On the other hand, inland-coastal inequality increased its contribution, while rural-urban inequality changed very little over time.

All these studies focus on measures of inequality decomposed by income sources (such as farm and nonfarm) or regions (such as developed versus less developed, rural versus urban). None try to link regional inequality to public investment. Since regional inequality has been driven mainly by natural resource endowments and government policies, information on the impact of government policies, particularly investment policies, could provide meaningful insights for policymakers in their attempts to achieve equity goals more efficiently.

Causes of Poverty Reduction

Approaches to reducing poverty evolved over the past 50 years in response to the deepening understanding of the complexity of development. In the 1950s and 1960s, many viewed large investments in physical capital and infrastructure as the primary means of development. In the 1970s, awareness grew that physical capital was not enough; at least as important were health and education. The World Bank articulated this understanding in its *World Development Report 1980,* arguing that improvements in health and education were important not only in their own right but also to promote growth in poor people's incomes.

The 1980s saw another shift of emphasis following the debt crisis and global recession and the contrasting experiences of East Asia and Latin America, South Asia, and Africa. Emphasis was placed on economic management rather than the play of market forces. The *World Development Report 1990* (World Bank) proposed a two-part strategy: promote labor-intensive growth through economic openness and investment in infrastructure and provide basic services to poor people in health and education. In the 1990s governance and institutions moved toward center stage—as did issues of vulnerability at the local and national levels.

The *World Development Report 2000* (World Bank) proposed a three-pronged strategy for attacking poverty: promote opportunity, facilitate empowerment, and enhance security. This meant more access for the poor to jobs, credit, roads, electricity, markets for produce, schools, water, sanitation, and health services. State and social institutions were to be responsive and accountable to poor people. Meanwhile, poor people's vulnerability to economic shocks, natural disasters, ill health, disability, and personal violence was to be reduced, as this was seen as intrinsic to enhancing well-being and encouraging investment in human capital and in higher-risk, higher-return activities. The key message of this strategy is that public investment, and its associated institutions and policies, in infrastructure, education, technology, health, and other social services is necessary in order to reduce poverty by enhancing opportunities for the poor to develop and to empower and protect themselves.

But governments in many developing countries face tight budgets. They desperately need information such as the number of poor that they can raise above the poverty line per unit of additional investment in specific areas. For example, should government spend more on infrastructure, education, or agricultural R&D, and in which region?

Few studies analyze the causes behind the rapid reduction of rural poverty in China. A 1992 World Bank country study was the first comprehensive analysis on the incidence and correlates of rural poverty in China. That study concluded that rural economic reforms contributed tremendously to the rapid reduction in rural poverty and that poverty is now almost entirely restricted to resource-constrained, remote uplands.

In more recent years, Ravallion at the World Bank used rural household survey data to lead a re-estimation of the incidence of poverty and changes over time in four provinces in Southwest China. Researchers devoted great effort to constructing a panel dataset at the household level from 1985 to 1990 (Chen and Ravallion 1996). Analyses from this panel dataset revealed that consumption variability accounts for a large share of observed poverty and is likely to severely constrain efforts to reach the long-term poor (Jalan and Ravallion 1997a, b, and c). They thus saw effective insurance and credit options for poor people as critical for alleviating the persistent problem of inequality. Jalan and Ravallion (2000) also found robust evidence of geographic poverty traps in their farm household data, illustrating the importance of public investment in lagging poor areas to improve efficiency and equity.

Gustafsson and Li (1998) analyzed the structure of Chinese poverty in 1988. One significant finding from this study was that the rural poor are not only in remote resource-poor areas, in contrast to the 1992 World Bank study. This implies that even resource-rich areas can have substantial numbers of poor if infrastructure and technologies do not reach them. Using a small sample of 500 rural households, Wu, Richardson, and Travers (1996) attributed rural poverty to low levels of factor endowment, immobility of labor, and demographic characteristics of households. They indicated that improved infrastructure and education might help the poor to participate in the labor market and to set up nonfarm businesses.

Khan (1997) updated data on the trend and pattern of Chinese poverty. One contribution of his study was to adjust the poverty measures at the provincial level—and his measures were vastly different from those of the Chinese government. But Khan's sample was small and may not be representative for all China.

Rozelle, Zhang, and Huang (2000) comprehensively reviewed government policies regarding poor-area development. They concluded that such policies generally failed to further reduce rural poverty in poor areas.[26] Moreover, they found high inefficiency and mistargeting of government poverty loans.

Most of these studies hint at the important role of public capital, particularly public infrastructure, in rural poverty reduction. But they fail to explicitly link public investment and poverty reduction. More importantly, most ignore the fact that different types of investments at different locations may have substantially different poverty-reduction outcomes. This study aims to fill the knowledge gap by empirically analyzing how government policies, particularly the allocation of public investment, contributed to poverty reduction in rural China.

Model

As reviewed in the previous section, numerous studies have examined the sources of growth and changes in income distribution in rural China. One significant feature of this previous work is the use of a single-equation approach. There are at least two disadvantages to this method. First, many poverty and inequality determinants, such as income, production or productivity growth, prices, wages, and nonfarm employment, are generated from the same economic process as inequality and poverty. In other words, these variables are also endogenous variables. Ignoring this characteristic leads to biased estimates of the poverty and inequality effects. Second, certain economic variables affect poverty and inequality through multiple channels. For example, improved rural infrastructure reduces rural poverty not only through improved growth in agricultural production but also through improved wages and opportunities for nonfarm employment. It is very difficult to capture these different effects using a single-equation approach.

Building on previous studies, this study develops a simultaneous equations model to estimate the various effects of government expenditure on production, inequality, and poverty through different channels.

[26] They use a data set from 43 poor counties in Shaanxi provinces over 1986–91 and an econometric model to assess how government investment in poverty alleviation affects growth in agriculture, township and village enterprise, and county-run enterprise. They found that poverty funds directly allocated to households for agricultural activity had a significant positive effect on growth, while investment in township and village enterprise or county state-owned enterprise did not have a discernible effect on growth.

Figure 4.1 Effects of government expenditures on rural poverty

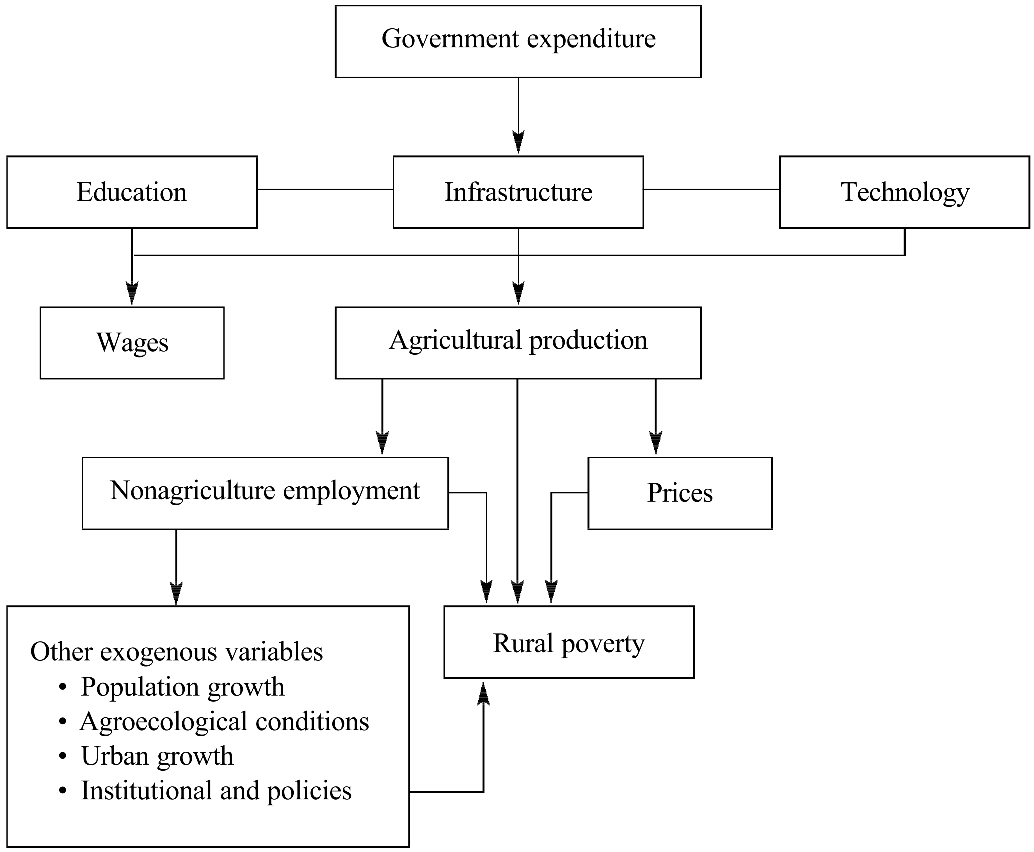

Figure 4.1 portrays the conceptual framework for the model, and equations (1) to (11) give the formal structure of the system. Table 4.1 pre-sents the definition of variables. The equations can be grouped into three blocks. The first block is a poverty equation (equation 1); the second block is productivity, wages, and employment equations (equations 2 to 5); and the third block models the relationship between government spending and public capitals and presents a terms-of-trade equation.

Equation (1) models the determinants of rural poverty (P).[27] Determinants include agricultural GDP per agricultural laborer (*AGDPPC*), the rural nonfarm daily wage (*WAGE*), nonagricultural employment (*NAGEMPLY*), the domestic terms of trade for agriculture (*TT*), growth in rural population (*APOP*), and a three-year lagged moving average of per capita government spending on poverty alleviation loans (*PLOAN*). Agricultural GDP per worker is included as a variable in the poverty equation because agricultural income still accounts for a substantial share of total income among rural households. Even in 1997, the percentage was as high as 64 percent. In less developed areas, this percentage is even higher (often over 90 percent).

[27] All variables without subscripts indicate observations in year t at the provincial level. For presentation purposes, the authors omit the subscript. The variables with subscript " –1, . . . –j" indicate observations in year t–1, t–j.

Table 4.1 Definitions of exogenous and endogenous variables

Variable	Definition
Exogenous variable	
LANDPC	Land area per worker
AKPC	Agricultural capital per worker
NAKPC	Capital per worker in rural nonagricultural sector
APOP	Rural population growth
UGDP	GDP produced by the urban sector
IRE	Government expenditure on irrigation, both from revenue and capital accounts
RDE	Government spending (both revenue and capital) on agricultural R&D
ROADE	Government investment and spending on rural roads
EDE	Government spending on rural education
RTRE	Government spending on rural telecommunications
PWRE	Government spending on rural power
PLOAN	Government expenditures for poverty alleviation per capita, measured as last three years moving average
RAIN	Annual rainfall
Endogenous variable	
P	Percentage of rural population below poverty line
SCHY	Average years of schooling of rural population 15 years and older
ROADS	Road density in rural areas
IR	Percentage of total cropped area that is irrigated
ELECT	Electricity consumption
RTR	Rural telephone
WAGE	Wage rate of nonagricultural labor in rural areas
NAGEMPLY	Percentage of nonagricultural employment in total rural employment
AGDPPC	Agricultural GDP per laborer
AGDPPCn	Agricultural productivity growth at the national level
NAGDPPC	Nonagricultural GDP per worker in rural areas
TT	Terms of trade, measured as agricultural prices divided by a relevant nonagricultural GNP deflator

Block 1: Poverty Equation

$$P = f(AGDPPC, WAGE, NAGEMPLY, TT, APOP_{-1}, PLOAN) \quad (1)$$

Block 2: Productivity, Wages, and Employment Equations

$$AGDPPC = f(LANDPC, AKPC, RDE, RDE_{-1}, \ldots IR, SCHY, ROADS, ELECT, RTR) \quad (2)$$

$$NAGDPPC = f(NAKPC, SCHY\ ROADS, ELECT, RTR) \quad (3)$$

$$WAGE = f(ROADS, SCHY, RTR, ELECT, APOP_{-1}, AGDPPC_{-1}, UGDP_{-1}) \quad (4)$$

$$NAGEMPLY = f(ROADS, SCHY, ELECT, RTR, AGDPPC_{-1}, UGDP_{-1}) \quad (5)$$

Block 3: Investment and Price Equations

$$IR = f(IRE, IRE_{-1}, \ldots, IRE_{-j}) \quad (6)$$

$$ROADS = f(ROADE, ROADE_{-1}, \ldots, ROADE_{-k}) \quad (7)$$

$$SCHY = f(EDE, EDE_{-1}, \ldots, EDE_{-m}) \quad (8)$$

$$RTR = f(RTRE, RTRE_{-1}, \ldots, RTRE_{-1}) \quad (9)$$

$$ELECT = f(PWRE, PWRE_{-1}, \ldots, PWRE_{-n}) \quad (10)$$

$$TT = f(AGDPPC, AGDPPCn) \quad (11)$$

Nonfarm employment income is the second most important source of income after agricultural production for rural residents in China. The wage and number of nonfarm laborers are good proxies for nonfarm income. Moreover, we can distinguish the differential impacts of changes in wages and number of workers in the nonfarm sector on rural poverty reduction. These differential impacts may have important policy implications for further poverty reduction. If improvement in rural wages reduces rural poverty more than increased rural nonfarm employment does, then government resources should be targeted to improve rural wages, or vice versa.

The terms-of-trade variable measures the impact on rural poverty of changes in agricultural prices relative to nonagricultural prices. Price policy can have a large effect on the rural poor. We hypothesize that in the short run the poor may suffer from higher agricultural prices if they are usually net buyers of food grains. But they may gain from higher prices if they are net sellers of agricultural products. In the long run, however, increased agricultural prices may induce government and farmers to invest more in agricultural production, shifting the supply curve outward.[28] Population growth also affects rural poverty since fast growth

[28] This is a traditional induced innovation theory proposed by Hayami and Ruttan (1985).

in population may increase rural poverty if there is insufficient growth in rural employment. This is particularly important for a country like China in which resources are limited and the population base is large.

Public spending on rural poverty loans has been a major policy instrument for the government to reduce poverty. For example, in 1996 such loans accounted for 82 percent of total government spending on poverty alleviation.[29] Since these funds often take time to affect rural poverty, we use a moving average of the past three years' spending in our regression.

Block 2 equations consist of two neoclassical productivity functions for agricultural and nonagricultural activities in rural China and wage and employment equations derived from labor demand and wage determination in a competitive labor market. For the agricultural productivity function (equation [2]), labor productivity is the dependent variable, while independent variables include land and capital per worker (*LANDPC* and *AKPC*) as conventional inputs. The following supply shifter variables capture the direct impact of technology, infrastructure, and education on agricultural labor productivity growth: current and lagged government spending on agricultural research and extension ($RDE, RDE_{-1}, \ldots, RD_{-i}$), percentage of irrigated cropped area in total cropped area (*IR*), average years of schooling of rural population (*SCHY*), road density (*ROADS*), per capita agricultural electricity consumption (*ELECT*), and number of rural telephone sets per thousand rural residents (*RTR*).

For the nonagricultural productivity function (equation [3]), the dependent variable is nonagricultural (township and village enterprise) GDP labor productivity (*NAGDPPC*). Independent variables are capital per worker (NAKPC), workers' years of schooling, and infrastructure. Equations (2) and (3) are also used to analyze the sources of changes in regional inequality.

Equations 4 and 5 are wages and employment determination functions in the rural nonfarm sector. These equations are reduced forms of labor supply and demand, where equilibrium wages clear the labor market. The derived labor and wages are a function of labor productivity. Labor productivity in turn is a function of capital/labor ratio and production shifters such as infrastructure and improvements in education. Therefore, final labor and wage equations are functions of capital/labor ratios and production shifters. However, when we include capital/labor ratio in our model, the coefficients are not statistically significant. We therefore drop them from the equations. This may be because in the long run, capital/labor ratio does not significantly impact either wages or nonfarm employment. Growth in the urban sector ($UGDP_{-1}$) is included to control for the effects of urban growth on rural wages and nonfarm employment.

The rest of the equations are grouped in Block 3, which models the relationships between physical infrastructure levels and past government expenditures for different items and presents a terms-of-trade determination equation. Equation 6 defines the relationship between the share of cropped

[29] The central funds for poverty alleviation come from three different government sources. The largest portion is from the poverty loans managed by the Agricultural Development Bank, which usually have zero or very low interest rates. The second largest portion comes from the State Development and Planning Commission, called employment scheme funds. Repayment of these funds is not required and they are usually used to hire rural poor for public work. The third portion comes from the Ministry of Finance and is called development funds. Repayment of these funds is also not required and they are usually used for poor-region development. According to the *Statistical Yearbook of the China Agricultural Development Bank* (SSB 1997), in 1996 government spending on poverty loans amounted to19.9 billion yuan, on the employment scheme 3.12 billion yuan, and on development funds 1.3 billion yuan.

areas irrigated and current and past government spending on irrigation (IRE, $IRE_{-1}, \ldots IRE_{-j}$); equation 7 defines the relationship between road density and current and past government spending on rural roads ($ROADE$, $ROADE_{-1}, \ldots ROADE_{-k}$); equation 8 defines the relationship between average years of schooling of rural population and current and past government expenditures on education (EDU, $EDU_{-1}, \ldots EDU_{-m}$); equation 9 models the relationship between the number of rural telephones and government expenditures on telecommunications ($RTRE$, $RTRE_{-1}, \ldots$ RTRE–l); and equation 10 models the relationship between the consumption of electricity (*ELECT*) and government spending on power ($PWRE$, $PWRE_{-1}, \ldots PWRE_{-n}$).

Equation 11 determines the agricultural terms of trade. Growth in agricultural productivity at the province and national level (*AGDPPCn*) increases the supply of agricultural products and thus reduces agricultural prices. The inclusion of national productivity growth reduces any upward bias in the estimation of the poverty alleviation effects of government spending within each province, since production growth in other provinces will also contribute to lower food prices through the national market. Initially, we also included some demand-side variables in the equation such as population and income growth. But they were not significant and so were dropped.

As Chapter 3 discussed, institutional changes and policy reforms made large contributions to the rapid growth in agricultural and nonagricultural production and to poverty reduction in China's rural areas. This study does not aim to quantify these effects, as previous studies have already done so (Fan 1991; Lin 1992; Fan and Pardey 1997). However, in order to reduce or eliminate the estimation bias from omitting these effects in our model estimation, we add year dummies in all equations to capture the year-specific institutional and policy changes on growth in agricultural and nonagricultural production and on poverty reduction. This specification is more flexible than in Fan and in Fan and Pardey, which use time-period dummies to capture the effects of institutional change on production growth. Regional dummies are also included to control for region-specific fixed effects.

Marginal Impact on Growth, Poverty Reduction, and Regional Inequality

By totally differentiating equations 1 to 11, we can derive the marginal impact and elasticities of different types of government expenditures on growth in agricultural and nonfarm productivity and on reductions in regional inequality and rural poverty.

Growth Effects

As an example, the marginal impact of R&D investments in year *t–i* on agricultural labor productivity in year t can be derived as

$$\partial AGDPPC/\partial RDE_{-i} = \partial AGDPPC/\partial RDE_{-i}. \quad (12)$$

Equation (12) measures the direct impact of investment in research on agricultural productivity growth. By aggregating the total effects of all past government expenditures over the lag period, the sum of marginal effects is obtained for any particular year. Returns to investment in irrigation can be derived similarly.

As another example, the returns to expenditures on roads in nonfarm labor productivity growth is derived as

$$\partial NAGDPPC/\partial ROADE_{-i} = \partial NAGDPPC/\partial ROADE_{-i}. \quad (13)$$

Poverty Effects

The impact of government investment in agricultural R&D in year *t–i* on poverty at year *t* can be derived as

$$
\begin{aligned}
\partial P/\partial RDE_{-i} = {} & (\partial P/\partial AGDPPC)\,(\partial AGDPPC/\partial RDE_{-i}) \\
& + (\partial P/\partial WAGE)\,(\partial WAGE/\partial AGDPPC)\,(\partial AGDPPC/\partial RDE_{-i}) \\
& + (\partial P/\partial NAGEMPLY)\,(\partial NAGEMPLY/\partial AGDPPC)\,(\partial AGDPPC/\partial RDE_{-i}) \\
& + (\partial P/\partial TT)\,(\partial TT/\partial AGDPPC)\,(\partial AGDPPC/\partial RDE_{-i}). \qquad (14)
\end{aligned}
$$

The first term on the right-hand side of equation 14 captures the impact on poverty of government investments in R&D through yield-enhancing technologies such as improved varieties, and therefore agricultural labor productivity. Increased agricultural labor productivity also affects poverty through changes in rural nonfarm wages and employment and relative prices, which are captured in the remaining terms on the right of the equation.

As with government investments in agricultural R&D, the impact of government investments in irrigation is captured through improved productivity, rural wages and nonfarm employment, and relative prices.

The impact of government investments in rural roads in year $t–k$ on poverty in year t is derived as

$$
\begin{aligned}
\partial P/\partial ROADE_{-k} = {} & (\partial P/\partial AGDPPC)(\partial AGGDPC/\partial ROADS)(\partial ROADS/\partial ROADE_{-k}) \\
& + (\partial P/\partial WAGE)(\partial WAGE/\partial AGDPPC)(\partial AGDPPC/\partial ROADS) \\
& \quad (\partial ROADS/\partial ROADE_{-\mathrm{k}}) \\
& + (\partial P/\partial NAGEMPLY)(\partial NAGEMPLY/\partial AGDPPC)(\partial AGDPPC/\partial ROADS) \\
& \quad (\partial ROADS/\partial ROADE_{-k}) \\
& + (\partial P/\partial TT)(\partial \mathrm{TT}/\partial AGDPPC)(\partial AGDPPC/\partial ROADE_{-i}) \\
& + (\partial P/\partial WAGE)(\partial WAGE/\partial ROADS)(\partial ROADS/\partial ROADE_{-k}) \\
& + (\partial P/\partial NAGEMPLY)(\partial NAGEMPLY/\partial ROADS)(\partial ROADS/\partial ROADE_{-k}). \qquad (15)
\end{aligned}
$$

The first term on the right side of equation 15 measures the direct effects on poverty of improved productivity attributable to greater road density. Terms 2, 3, and 4 are the indirect effects of improved productivity through changes in rural nonfarm wages, employment, and prices. Terms 5 and 6 capture the direct effects on poverty of higher nonfarm wages and greater nonagricultural employment opportunities arising from government investment in roads. We can similarly derive the impact on rural poverty of increased investment in telecommunications, electricity, and education.

Impact on Regional Inequality

To decompose the sources of changes in regional inequality of labor productivity, we consider equations (2) and (3) in the following double-log form:

$$y = a + \sum_i \beta_i x_i + \varepsilon, \qquad (16)$$

where all the variables are in logarithms, y is the dependent variable and x_i represents a set of independent variables. An error term ε is added to represent stochastic shocks to output and is assumed to be unrelated to the other variables. Following Shorrocks (1982), the variance of y in equation 16 can be decomposed as

$$\begin{aligned}\sigma^2(y) &= \sum_i \operatorname{cov}(y, \beta_i x_i) + \operatorname{cov}(y,\varepsilon) \\ &= \sum_k \beta_i \operatorname{cov}(y,x_i) + \operatorname{cov}(y,\varepsilon) \\ &= \sum_k \beta_i \operatorname{cov}(y,x_i) + \sigma^2(\varepsilon), \qquad (17)\end{aligned}$$

where $\sigma^2(y)$ is the variance of y and cov(y,•) represents the covariance of y with other variables. Since none of the variables on the right side of equation 16 is correlated with the error term, the covariance of y and ε is equal to the variance of ε. Considering that y is already in logarithmic form, is a standard inequality measure known as the logarithmic variance (Cowell 1995), having the property of invariance to scale. According to Shorrocks, the covariance terms on the right side of 17 can be regarded as the contributions of the factor components to total inequality.

Using estimates from equations 2 and 3 and applying the above decomposition method, we can quantify the contributions of various public investments on regional inequality in both agricultural and nonagricultural labor productivities. Moreover, we can calculate the impact of public investments on regional inequality in total labor productivity. For this purpose, we further write total rural labor productivity as

$$Y = a_1 Y_1 + a_2 Y_2, \qquad (18)$$

where Y, Y_1, and Y_2 are total, agricultural, and nonagricultural productivities, respectively; a_1 and a_2 are, respectively, the shares of agricultural and nonagricultural laborers in total labor. Under six axioms proposed by Shorrocks, a broad class of inequality measures such as Gini coefficient, the Atkinson index, and the logarithmic variance index can be written as

$$I(Y) = s_1 I(a_1 Y_1) + s_2 I(a_2 Y_2), \qquad (19)$$

where

$$s_1 = \frac{\operatorname{cov}(Y, a_1 Y_1)}{\sigma^2(Y)}, \quad s_2 = \frac{\operatorname{cov}(Y, a_2 Y_2)}{\sigma^2(Y)}.$$

If we still use the logarithmic variance as an inequality measure, then we can substitute the estimated variance for Y_1 and Y_2 from 17 into 19 to obtain the contributions of public inputs to total inequality.

CHAPTER 5

Data, Estimation, and Results

This chapter describes the data and discusses the estimation technique and estimation results. It further details the calculation and analysis of the marginal returns derived from additional units of expenditure on various types of public capitals and in different regions.

Data

Poverty

There are several estimates of rural poverty in China. Official statistics indicate that the number of poor declined to about 50 million by 1997 (MOA, *China Agricultural Development Report 1998*). World Bank estimates (Piazza and Liang 1998) are similar to Chinese official statistics. A third set of estimates, based on a much higher poverty line (Ravallion and Chen 1997), shows a far greater proportion of the total population subject to poverty, with a poverty incidence of 60 percent in 1978 and 22 percent in 1995. However, the declining trend of rural poverty in this last set of estimates is steeper than that in the official Chinese statistics. Khan, using samples of the household survey, obtained 35.1 percent for 1988 and 28.6 percent for 1995.[30] Although these poverty rates are higher than the official rates, the change over time differs little from the official statistics.

The present study uses provincial-level poverty data from official sources. Few scholars have reported their estimates by province. Khan estimated provincial poverty indicators (both head count ratio and poverty gap index) for 1988 and 1995 using the household survey data. To test the sensitivity of our estimated results, we first used both official statistics and Khan's estimates, obtaining similar results, largely because the two sets of poverty figures share similar trends. Our final results are based on the official data simply because poverty data are available by province for more years.

Agricultural and Nonagricultural GDP

Both nominal gross domestic product (GDP) and real GDP growth indices for various sectors are available from the *The Gross Domestic Product of China* (SSB 1997a). Data sources and construction of national GDP estimates were also published by the State Statistical Bureau (SSB) in *Calculation Methods of China's Annual GDP* (SSB 1997b). According to this publication, the SSB used the U.N. standard SNA (system of national accounts) definitions to estimate GDP for 29 provinces by three economic sectors (primary, secondary, and tertiary) in

[30] The dataset included 10,258 rural households in 1998 and 7,998 in 1995.

mainland China for the period 1952–95. Since 1995, the *China Statistical Yearbook* has published GDP data every year for each province by the same three sectors. Both nominal and real growth rates are available from SSB publications.

The agricultural sector is equivalent to the primary sector used by the SSB. We use the following procedures to construct GDP for the nonagricultural sector in rural areas: Until 1996, China published the value of annual gross production for rural industry and services. In 1996, it began to publish value-added figures. The definition of value added is equivalent to the GDP data. The Ministry of Agriculture published data on both gross production value and value added for rural industry (including construction) and services in the *China Agricultural Yearbook 1996.* The data on nominal value added for rural industry and services prior to 1995 were estimated using the growth rate of gross production value and 1995 value-added figures, assuming no change in the ratio of value added to gross production value.

GDP for rural industry was subtracted from GDP for industry as a whole (or the secondary sector as classified by the SSB) to obtain GDP for urban industry. Similarly, GDP for rural services was subtracted from the aggregate service sector GDP (or the tertiary sector as classified by the SSB) to obtain GDP for the urban service sector. GDP for rural enterprise is the sum of GDP for rural industry and rural services.

The implicit GDP deflators by province for the three sectors are estimated by dividing nominal GDP by real GDP. These deflators are then used to deflate nominal GDP for rural industry and services to obtain their GDP in real terms.

Labor

Agricultural labor is measured in stock terms as the number of persons engaged in agricultural production at the end of each year. The data prior to 1978 were available in the SSB's *Historical Statistical Materials for Provinces, Autonomous Regions and Municipalities (1949–1990).* The data after 1977 were taken from various issues of the *China Agricultural Yearbook* (MOA), the *China Statistical Yearbook* (SSB), and the *China Rural Statistical Yearbook* (SSB).

The labor input for the nonfarm sector is calculated simply by subtracting agricultural labor from total rural labor.

Capital Stock

Capital stocks for the agricultural and nonagricultural sectors in rural areas are calculated from data on gross capital formation and annual fixed asset investment. For the three sectors classified, the SSB (1997) published data on gross capital formation by province after 1978. Gross capital formation is defined as the value of fixed assets and inventory acquired minus the value of fixed assets and inventory disposed. To construct a capital stock series from data on capital formation, we use the following procedure: define the capital stock in time t as the stock in time t–1 plus investment minus depreciation,

$$K_t = I_t + (1-\delta)\, K_{t-1}, \qquad (20)$$

where K_t is the capital stock in year t, I_t is gross capital formation in year t, and δ is the depreciation rate. *China Statistical Yearbook* (SSB 1995) reports the depreciation rate of fixed assets of state-owned enterprises for industry, railways, communications, commerce, and grain for the period 1952–92. We use the rates for grain and commerce for agriculture and services, respectively. After 1992, the SSB ceased to report official depreciation rates. For the years after 1992 we used the 1992 depreciation rates.

To obtain initial values for the capital stock, we used a procedure similar to Kohli (1982). That is, we assume that prior to 1978 real investment grew at a steady rate (r), which is assumed to be the same as the rate of growth of real GDP from 1952 to 1977. Thus,

$$K_{1978} = \frac{I_{1978}}{(ä + r)}. \quad (21)$$

This approach ensures that the 1978 value of the capital stock is independent of the 1978–95 data used in our analysis. Moreover, given the relatively small capital stock in 1978 and the high levels of investment, the estimates for later years are not sensitive to the 1978 benchmark value of the capital stock.

Estimates of capital stocks for rural industry and services are constructed using the annual fixed asset investment by province from 1978 to 1995. These are from the China Statistical Yearbook (SSB, various years) and the *China Fixed Asset Investment Statistical Materials, 1950–95* (SSB, 1996). Initial values are calculated using equation 21, but the growth rate of real investment prior to 1978 is assumed to be 4 percent. Again, the initial capital stock is low so the estimated series is not sensitive to the benchmark starting value.

Capital stock for rural industry is subtracted from that of total industry (or secondary industry as classified by the SSB) to obtain capital stock for the urban industrial sector. Similarly, capital stock for rural services is subtracted from the aggregate service sector (or tertiary sector as classified by the SSB) to obtain the capital stock for the urban service sector. Finally, capital stock for rural enterprise is the sum of capital stocks for rural industry and services.

Prior to constructing capital stocks for each sector, annual data on capital formation and fixed asset investment was deflated by a capital investment deflator. The SSB began to publish provincial price indices for fixed asset investment in 1987. Prior to 1987, we use the national price index of construction materials to proxy the capital investment deflator.

Research and Development (R&D) Expenditures

Public investment in agricultural R&D is accounted for in the total national science and technology budget. The sources of agricultural R&D investment are different government agencies. Science and technology commissions at different levels of government allocate funds to national, provincial, and prefectural institutes, primarily as core support. These funds are mainly used by institutes to cover researchers' salaries, benefits, and administrative expenses. Project funds come primarily from other sources, including departments of agriculture, research foundations, and international donors. Recently, revenues generated from commercial activities (development income) became an important source of revenue for the research institutes. The research expenditures reported in this study include only those expenses used to directly support agricultural research. The data reported here are from Fan and Pardey (1992) and various publications from the Government Science and Technology Commission and the State Statistical Bureau. Research expenditures and personnel numbers include those from research institutions at national, provincial, and prefectural levels, as well as agricultural universities (only the research part).

When calculating returns to R&D investment, expenditures on agricultural research as well as extension at the national and sub-national levels are used as total R&D spending. This implicitly assumes that research conducted at the national level affects each province's production in proportion to the province's research expenditures, and the impact of extension conducted in each province is proportional to research impact.

Irrigation Expenditures

Provincial irrigation expenditures refer to total government fiscal expenditures in construction of reservoirs, irrigation and drainage systems, and flood and lodging prevention, as well as maintenance of these systems. However, government reports of such data are available only after 1980 in the *China Water Conservancy Yearbook* (various years). Prior to 1979, the Ministry of Water Conservancy reported total expenditure (not by item) on reservoirs, irrigation and drainage systems, flood and lodging prevention, water supply, and hydropower (Ministry of Water Conservancy 1980). This spending item is much broader than irrigation, as it also includes urban water supply, flood control, and hydropower generation. To calculate the cost solely of irrigation prior to 1979, we use the percentage of irrigation spending in total expenditures on water conservancy in 1980.

Education Expenditures

Provincial expenditures for primary- and middle-school education in rural areas after 1990 are reported in the *China Education Yearbook* (Ministry of Education, various years) and the *China Education Expenditure Yearbook* (SSB). Expenditures prior to 1990 are extrapolated using the percentage of rural students in total students. Since education expenditure per student in urban areas is higher than that in rural areas, we use the cost difference in 1990 to adjust down the total education expenditures in rural areas.

Road Expenditures

Road expenditures are reported in *China Fixed Asset Investment Statistical Materials, 1950–95* (SSB 1996) and the *China Transportation Yearbook* (Ministry of Transportation, various years). However, there is no breakdown between rural and urban road expenditures. We use the percentage of the length of rural roads in total length of roads to extrapolate the cost of rural roads by assuming the unit cost of rural road construction is one third that of urban roads (Ministry of Transportation 1995).

Power Expenditures

Provincial power expenditures are available in *China Fixed Asset Investment Statistical Materials, 1950–95* (SSB 1996) and the *China Power Yearbook* (Ministry of Electric Power, various years). We use the unit cost of electricity per kilowatt to calculate power expenditures for rural areas.

Telecommunications Expenditures

Telecommunications expenditures by province are available in *China Fixed Asset Investment Statistical Materials, 1950–95* (SSB 1996) and of the *China Transportation Yearbook* (Ministry of Transportation, various years). However, similar to expenditures on roads and power, there is no breakdown between rural and urban expenditures. We use the number of telephones in rural and urban areas to extrapolate the cost of rural telecommunications.

Rural Education

We use the percentage of population with different education levels to calculate the average years of schooling as our education variable, assuming 0 years for a person who is illiterate or semi-illiterate, 5 years for primary-school education, 8 years for a junior high-school education, 12 years for a high-school education, 13 years for a professional-school education, and 16 years for college and above education. The population census and the Ministry of Education report education levels for population above age 7.

Roads

The road variable is measured as road density, road length in kilometers per thousand square kilometers of geographic area. The length of total roads by province is reported in the *China Statistical Yearbook* (SSB, various years) and the *China Transportation Yearbook* (Ministry of Transportation), while the length of rural roads in the 1980s is reported in of the *China Rural Statistical Yearbook* (SSB, various years). In more recent years, the *China Rural Statistical Yearbook* stopped reporting rural roads. We therefore use the trend of total length of roads (except highways) to extrapolate the length of rural roads for the years in which data are not available.

Electricity

Total rural electricity consumption for both production and residential uses by province are available in of the *China Rural Statisti-*

cal Yearbook and the *China Agricultural Yearbook* (MOA). In more recent years, the China Rural Energy Yearbook (SSB, various years) (MOA 1995–2000) began publishing the use of electricity separately for residential and production purposes by province. We use this newly available information to backcast the different use by province for earlier years.

Rural Telephony

Number of rural telephones is used as a proxy for the development of rural telecommunications. The number of rural telephones by province is published in of the *China Rural Statistical Yearbook* (SSB, various years), the *China Statistical Yearbook* (SSB, various years), and the *China Transportation Yearbook* (Ministry of Transportation, various years).

Model Estimation

Functional Form and Estimation Procedure

We use double-log functional forms for all equations in the system. More flexible functional forms such as translog or quadratic impose fewer restrictions on estimated parameters, but many coefficients are not statistically significant due to multicollinearity problems among various interaction variables. For the system equations, we use the full information maximum-likelihood estimation technique.

Since our provincial poverty data are available only for seven years (1985–89, 1991, and 1996) a two-step procedure is used in estimating the full equations system. The first step involves estimating all the equations except for the poverty equation using the provincial-level data from 1970 to 1997. Then the values of *AGDPPC, WAGE,* and *NAGEMPLY* and *TT* at the pro-vincial level are predicted using the estimated parameters. The second step estimates the poverty equation using the predicted values of the independent variables at the provincial level based on the available poverty data for 1985–89, 1991, and 1996. The advantage of this procedure is to fully use the information available for all non-poverty equations, thereby increasing the reliability of estimates and avoiding the endogeneity problem of the poverty equation.

Lags and Distribution of Public Investments

Government investments in R&D, roads, education, power, telecommunications, and irrigation can have long lead times in affecting agricultural production, and their effects can be long term once they kick in. Thus, one of the thornier problems to resolve when including government investment variables in a production or productivity function concerns the choice of appropriate lag structure. Most past studies use stock variables, which are usually weighted averages of current and past government expenditures on certain investments such as R&D. But what weights and how many years' lag should be used in the aggregation are under debate.[31] Since the shape and length of these investments are largely unknown, we use a free-form lag structure in our analysis; that is, we include current and past government expenditures on certain investment items such as R&D, irrigation, roads, power, and education in the respective productivity, technology, infrastructure, and education equations. Then we use statistical tools to test and determine the appropriate length of lag for each investment expenditure.

[31] Alston, Craig, and Pardey (1998) argue that the research lag may be much longer than previously thought or even infinite. But in many developing countries the national agricultural research systems are much younger than those in developed countries (often 30 to 50 years old) and their research is of more the applied type. Therefore, it is certain that research lags in developing countries are much shorter than those in developed countries.

Various procedures have been suggested for determining the appropriate lag length. The adjusted R^2 and Akaike's Information Criteria (AIC) are often used by economists (Greene 1993). This report simply uses the adjusted R^2. Since R^2 estimated from the simultaneous system does not provide the correct information on the fitness of the estimation, we use the adjusted R^2 stimated from the single equation. The optimal length is determined when adjusted R^2 reaches a maximum. The AIC is similar in spirit to the adjusted R^2 in that it rewards good fit but penalizes the loss of degrees of freedom. The lags determined by the adjusted R^2 approach are 17, 14, 16, 12, and 17 years for R&D, irrigation, education, power, and roads. These are generally very short in comparison to those in the United States (Alston, Craig, and Pardey 1998).

Another problem related to the estimation of lag distribution is that independent variables (for example, RDE, RDE_{-1}, RDE_{-2}, . . . and RDE_{-i} in the productivity function) are often highly correlated, making the estimated coefficients statistically insignificant. A number of ways to tackle this problem have been proposed. The most popular is to use what are called polynomial distributed lags, or PDLs. In a polynomial distributed lag, the coefficients are all required to lie on a polynomial of some degree *d.* This analysis uses PDLs with degree 2. In this case, we only need to estimate three instead of $i+1$ parameters for the lag distribution. For more detailed information on this subject, refer to Davidson and MacKinnon (1993). Once the lengths of lags are determined, we estimate the simultaneous equation system with the PDLs and appropriate lag length for each investment.

Estimation Results

Table 5.1 presents the results of the systems equation estimation. Most of the coefficients in the estimated system are statistically significant at the 10 percent confidence level (one-tail test). Since we use the double-log functional form, the estimated coefficients are elasticities in their respective equations.

The estimated poverty equation (equation 1) supports the findings of many previous studies. Improvements in agricultural productivity, higher agricultural wages, and increased nonagricultural employment opportunities have all contributed significantly to reducing poverty. The coefficient of the terms-of-trade variable is negative and statistically significant, meaning that higher agricultural prices are good for the poor. This is explained by the fact that most poor farmers in China are net sellers of agricultural products. When agricultural prices rise, their incomes rise. This is in sharp contrast to India where the poor generally suffer from higher agricultural prices because they tend to be landless laborers and net buyers of food grains (Fan, Hazell, and Thorat 1999). In China, equal distribution of land-use rights among households guarantees equal access to land, the result being virtually no landless laborers in rural areas.

Although the population growth variable is positively related to poverty, the coefficient is not statistically significant. Government spending on poverty alleviation loans helps to reduce rural poverty, but the coefficient of the variable is not statistically significant.[32]

The estimated agricultural labor productivity function (equation 2) shows that agricultural research and extension, roads,

[32] The authors also tried other specifications of the poverty equation. For example, instead of rural nonfarm wages and employment, they included labor productivity of the nonfarm sector. The results were similar, however. They prefer the current specification because it permits modeling the separate effects of wages and employment on rural poverty reduction.

Table 5.1 Estimates of the simultaneous equation system

(1)	*P*	=	–1.13 *AGDPPC*	– 0.560 *WAGE*	– 0.863 *NAGEMPLY*	– 0.064 *TT*		
			(–2.76)*	(–2.27)*	(–3.48)*	(–1.82)*		
		–	0.071 *PLOAN*	+ 0.102 $APOP_{-1}$				$R^2 = 0.652$
			(–0.71)	(0.88)				
(2)	*AGDPPC*	=	0.516 *LANDPC*	+ 0.104 *AKPC*	+ 0.085 *RDE*	+ 0.079 *ROAD*	+ 0.412 *IR*	
			(16.25)*	(7.06)*	(3.97)*	(3.53)*	(16.39)*	
		+	0.458 *SCHY*	+ 0.071 *RTR*	+ 0.038 *ELECT*	+ 0.123 *RAIN*		$R^2 = 0.903$
			(3.58)**	(5.26)*	(0.79)	(4.92)*		
(3)	*NAGDPPC*	=	0.289 *NAKPC*	+ 0.229 *ROADS*	+ 0.581 *SCHY*	+ 0.011 *ELECT*	+ 0.179 *RTR*	$R^2 = 0.812$
			(6.54)*	(4.74)*	(3.71)*	(0.21)	(4.78)*	
(4)	*WAGE*	=	0.152 *ROADS*	– 0.029 *ELECT*	+ 0.107 *RTR*	+ 0.667 *SCHY*		
			(3.47)*	(–0.55)	(3.46)*	(3.49)*		
		+	0.870 $AGDPPC_{-1}$	– 0.258 *APOP*	+ 0.120 $UGDP_{-1}$			$R^2 = 0.542$
			(11.36)*	(–1.36)	(0.89)			
(5)	*NAGEMPLY*	=	0.103 *ROADS*	+ 0.032 *RTR*	+ 1.97 *SCHY*	+ 0.420 *ELECT*		
			(6.60)*	(2.90)*	(12.57)*	(5.20)*		
		+	0.370 $AGDPPC_{-1}$	+ 0.583 $UGDP_{-1}$				$R^2 = 0.990$
			(3.23)*	(7.62)*				
(6)	*IR*	=	0.246 *IRE*					$R^2 = 0.975$
			(3.371)*					
(7)	*ROADS*	=	0.469 *ROADE*					$R^2 = 0.999$
			(1.743)*					
(8)	*SCHY*	=	0.339 *EDE*					$R^2 = 0.978$
			(1.755)*					
(9)	*RTR*	=	0.295 *RTRE*					$R^2 = 0.982$
			(2.14)*					
(10)	*ELECT*	=	0.251 *PWRE*					$R^2 = 0.988$
			(5.93)*					
(11)	*TT*	=	–0.192 *AGDPPC*	– 0.043 *AGDPPCn*				$R^2 = 0.939$
			(–2.85)*	(–1.88)*				

Notes: Region and year dummies are not reported. Asterisk indicates that coefficients are statistically significant at the 10 percent level. The coefficients for the technology, education, and infrastructure variables are the sum of those for past government expenditures.

irrigation, and education have contributed significantly to growth in agriculture. But the coefficient for the electricity variable is not statistically significant. The coefficient reported here for agricultural research and extension is the sum of the past 17 years' coefficients from the PDLs distribution. The significance test is the joint t test of the three parameters of the PDLs.

The estimates for equation 3 shows that improved roads, education, and rural telecommunications have all contributed to the development of the rural nonfarm sector. Similar to the equation (2) estimation, in the agricultural productivity function the access to electricity variable is not statistically significant, although the sign of its coefficient is positive.

The estimates for equation 4 show that rural nonfarm wages are determined mainly by government investments in roads, education, and telecommunications. An important finding in this equation is that agricultural labor productivity affects rural nonfarm wages significantly. But urban growth has no statistically significant impact on rural wages.

The estimates for equation 5 show that improved rural roads, telecommunications, electrification, and education have contributed to growth in nonfarm employment. Growth in agricultural productivity has contributed significantly to the development of rural nonfarm employment. In contrast to the wage equation, development in the urban sector had significant impact on rural nonfarm employment.

The estimated results for equations 6 to 10 show that government investments in irrigation, roads, education, rural telecommunications, and power have contributed to the improvement of irrigation, to the development of roads, to rural education, to rural communication, and to the increased use of electricity. All the coefficients are statistically significant.

Finally, the estimated terms-of-trade equation equation 11 confirms that increases in agricultural productivity at the local and national levels exerted a downward pressure on agricultural prices, worsening the terms of trade for agriculture.

The Effects of Public Investment

Marginal Effects on Growth and Poverty Reduction

Using equations 1 to 11 and the estimates in Table 5.1, we can derive the marginal returns to different types of government expenditures in growth and reduction of rural poverty as shown in equations 12 to 15. We calculate marginal returns by different types of investments in three regions.

Table 5.2 presents major development indicators of these three regions. The coastal region is the most developed with the best infrastructure and human capital as well as superior agroclimatic conditions.[33] The western region is the least developed and has poor natural resources and social infrastructure. The central region falls in between the other two.

Table 5.3 shows the marginal effects of government spending on agricultural and nonagricultural production and rural poverty for the three regions and for China as a whole. Effects are measured as the returns in yuan or the number of poor brought out of poverty per unit of spending in 1997. For example, the returns to investments in irrigation are measured as yuan of additional production or number of persons brought out of poverty per one additional unit spent on irrigation. These measures provide useful information for comparing the relative benefits of additional units of expenditure on different items in different regions, particularly for setting future priorities for government expenditure to further increase production and reduce rural poverty.

An important feature of the results in Table 5.3 is that all production-enhancing investments reduce poverty while at the same time increasing agricultural and nonagricultural GDP. However, there are sizable differences in production gains and poverty reductions among the various expenditure items and across regions.

For the country as a whole, government expenditure on education had by far the

[33] The coastal region includes the following provinces: Hebei, Liaoning, Shandong, Jiangsu, Zhejiang, Fujian, Guangdong, and Guangxi. The central region contains Shanxi, Inner Mongolia, Anhui, Jiangxi, Henan, Hubei, and Hunan. The remaining provinces are classified as the western region. Tibet is excluded due to the lack of data. Hainan is included in Guangdong Province. Beijing, Shanghai, and Tianjin are excluded because of their small share of rural areas and population.

Table 5.2 Social development, productivity, and poverty in rural China among regions, 1985 and 1996

Indicator	Coastal region	Central region	Western region	National
1985				
Illiteracy rate (%)	22.5	28.0	35.8	28.0
Years of schooling	4.8	5.1	4.5	5.1
Road density (km/1,000 km^2)	221.9	122.9	69.1	111.1
Irrigation (%)	58	36	40	44
Labor productivity (yuan/person)	707.3	718.8	465.3	645.6
Annual rainfall (millimeters)	1,097.6	716.7	506.9	n.a
Number of poor (millions)	10.8	30.4	59.5	100.8
Incidence of poverty (%)	4.5	12.5	35.8	15.5
1996				
Illiteracy rate (%)	8.6	11.4	19.8	12.1
Years of schooling	6.9	6.6	6.1	7.0
Road density (km/1,000 km^2)	306.2	136.6	81.5	138.3
Irrigation (%)	62	45	46	51
Labor productivity (yuan/person)	1,116.0	990.7	611.9	928.2
Annual rainfall (millimeters)	1,127.3	686.6	506.9	n.a
Number of poor (millions)	5.9	12.7	31.6	50.2
Incidence of poverty (%)	1.9	3.5	14.3	5.6

Sources: SSB various years.
Note: N.a. means not available.

largest impact in reducing poverty. In addition, it had the second largest return to agricultural gross domestic product (AgGDP) and the third largest return to nonfarm *GDP* and overall rural GDP. Therefore, investing more in education is the dominant "win-win" strategy. For every 10,000 yuan investment, some nine people are brought out of poverty, 30 percent more than comparable R&D investments, which had the second largest poverty-reduction effect.

Investment in agricultural R&D had the second largest impact on poverty, and its impact on AgGDP and overall rural GDP ranks first. Agricultural R&D is thus another very favorable investment.

Government expenditure on rural infrastructure also made large contributions to poverty reduction. These impacts were realized through growth in both agricultural and nonagricultural production. Among the three infrastructure variables considered, the impact of roads is particularly large. For every 10,000 yuan invested, 3.2 poor are lifted above the poverty line. Roads, thus, rank third in poverty-reduction impact, after education and R&D. In terms of impact on growth, for every yuan invested in roads, 8.83 yuan in rural GDP is produced, only slightly less than the return to R&D investments. This stems from high returns to both agricultural and nonagricultural GDP. Roads yielded the largest return to rural nonfarm GDP, at 6.71 yuan for every yuan invested, 35 percent higher than the return to education investment. With respect to agricultural GDP, the return to road investment ranked third, after R&D and education investments.

Although electricity investment showed low returns to both agricultural and nonagricultural GDP, it ranked fourth in poverty impact. For every 10,000 yuan investment, 2.3 people were brought out of poverty. This is because access to electricity is essential to the expansion of nonfarm employment (Table 5.3). For rural telephony, investments had favorable returns to both

Table 5.3 Returns of public investments to production and poverty reduction, 1997

Public investment	Coastal region	Central region	Western region	Average
Returns to total rural GDP from investments in (yuan per yuan expenditure):				
R&D	8.60	10.02	12.69	9.59
Irrigation	2.39	1.75	1.56	1.88
Roads	8.38	13.73	4.29	8.83
Education	9.75	7.78	5.06	8.68
Electricity	1.52	1.35	0.61	1.26
Telephone	7.12	8.54	4.13	6.98
Returns to agricultural GDP from investments in (yuan per yuan expenditure):				
R&D	8.60	10.02	12.69	9.59
Irrigation	2.39	1.75	1.56	1.88
Roads	1.67	3.84	1.92	2.12
Education	3.53	3.66	3.28	3.71
Electricity	0.55	0.63	0.40	0.54
Telephone	1.58	2.64	1.99	1.91
Returns to nonfarm GDP from investments in (yuan per yuan expenditure):				
Roads	6.71	9.89	2.37	6.71
Education	6.22	4.13	1.78	4.97
Electricity	0.97	0.71	0.21	0.72
Telephone	5.54	5.91	2.14	5.07
Returns to poverty reduction from investments in (number of poor reduced per 10,000 yuan expenditure):				
R&D	1.99	4.40	33.12	6.79
Irrigation	0.55	0.77	4.06	1.33
Roads	0.83	3.61	10.73	3.22
Education	2.73	5.38	28.66	8.80
Electricity	0.76	1.65	6.17	2.27
Telephone	0.60	1.90	8.51	2.21
Poverty loan	0.88	0.75	1.49	1.13

Notes: The parameters from the productivity functions were used to calculate the returns to GDP (Table 5.1). Under the assumption of constant return to scale, coefficients for nonlabor parameters in the production function should be the same as those in the labor productivity function. The marginal returns can be easily derived and calculated by multiplying production elasticities by partial productivity of each spending item. Since only two coefficients (on electricity) are not statistically significant, the results are little different when one uses the only statistically significant coefficients in the calculation.

agricultural and nonagricultural GDP, and the impact on rural poverty was similar to that of electricity investments.

For the nation as a whole, irrigation investment had relatively little impact on rural poverty reduction, although its economic returns were still positive and higher than electricity. This is because irrigation affects poverty reduction solely through improved agricultural productivity.

One striking result from our study is the very small and statistically insignificant impact of government poverty alleviation loans. In fact, their impact was the smallest of all the expenditures considered. For every 10,000 yuan invested, only slightly more than one person is brought out of poverty. The effect is only 13 percent of that for education, 15 percent of that for agricultural R&D, 50 percent of that for rural infrastructure, and is even smaller than that for irrigation.

Regional variation is large in the marginal returns to government spending in both GDP growth and poverty reduction. In terms of poverty-reduction effects, all kinds of investments had high returns in the western region. For example, for every 10,000 yuan invested in agricultural R&D, education, roads, telecommunications, and electricity, the respective number of poor reduced were 33, 29, 11, 9, and 6. These effects are 4.8, 3.3, 3.2, 3.9, and 2.8 times higher than the national average. Even for irrigation, every 10,000 yuan additional investment was sufficient to bring four people out of poverty, three times higher than the national average.

With respect to returns to growth in agriculture, R&D investment had the highest return in the western region, while irrigation investment had the highest return in the coastal region. For education and rural infrastructure (roads, electricity, and telecommunications), the central region had the highest returns. In the coastal region, a large amount of land has been converted for nonagricultural use due to rapid industrialization and urbanization. Moreover, incentives to intensify farming are lower there because of more nonfarm employment opportunities. In contrast, land in the western region is more marginal with limited water and soil of low quality. Therefore, major growth potential for agricultural production lies in the central region, where land is relatively less scarce and agricultural production is still the main source of farmers' income.

Not surprisingly, most government expenditures had their largest impact on rural nonfarm GDP in the coastal and central areas.

Contributions to Regional Inequality

Given the estimated coefficients for equations (2) and (3), we are in position to apply the inequality decomposition method outlined in equations (17) and (18). Table 5.4 reports the contributions of each factor to agricultural, nonagricultural, and total labor productivities, respectively, for selected years.

It is clear from Table 5.4 that regional inequality in agricultural labor productivity has not changed much. But the contributions of various inputs to the inequality have changed dramatically. The contributions of three conventional inputs (capital, labor, and land) declined, while the contributions of most public investments, especially R&D, electrification, and telephones, increased. Public investment's total contribution increased from 0.110 to 0.221 in the study period.

In contrast to agricultural productivity, regional inequality in nonagricultural labor productivity almost doubled. Capital and labor contributed little to worsening inequality, with public investment in electricity, telephones, and in total the dominant factor. Public investment's contribution to regional inequality in nonagricultural labor productivity increased by 118 percent from 0.144 to 0.305 during the period.

In order to evaluate the effects of these input factors on overall inequality, we substitute the log variance of agricultural labor productivity and nonagricultural labor productivity into equation (18). Using the estimated parameters and the decomposition method, we obtain the contributions of various input factors to overall inequality. Capital's contribution to worsening regional inequality increased from 0.085 to 0.220, although its shares in the inequality of agricultural and nonagricultural labor productivity changed little. This is probably due to a structural shift in capital from agricultural to nonagricultural production in the economy because rural industry is more capital intensive than agriculture. For the same reason, land and land-enhancing technologies, especially irrigation, which are mainly used in agricultural production, accounted for a decreasing share of overall inequality. The contributions of roads, agricultural R&D, electricity, and telecommunications in-

Table 5.4 Contributions of input factors to regional inequality, 1978–95

Year	Inequality	Capital	Labor	Land	Education	Irrigation	Roads	R&D	Electricity	Tele-phones	Public investment
Agricultural labor productivity											
1978	0.681	0.053	0.370	0.371	0.049	0.069	0.008	–0.012	0.002	–0.007	0.110
1985	0.661	0.052	0.364	0.344	0.028	0.097	0.008	–0.012	0.001	0.004	0.127
1990	0.666	0.045	0.358	0.348	0.043	0.091	0.007	–0.004	0.006	0.003	0.147
1995	0.727	0.049	0.322	0.319	0.038	0.087	0.008	0.012	0.064	0.013	0.221
Nonagricultural labor productivity											
1978	1.320	0.358	0.600		0.063	0.054		0.006		0.020	0.144
1980	1.480	0.353	0.605		0.045	0.044		0.018		0.032	0.140
1985	1.556	0.381	0.563		0.033	0.048		0.039		0.038	0.158
1990	1.786	0.389	0.517		0.041	0.047		0.036		0.076	0.200
1995	2.639	0.365	0.427		0.030	0.044		0.052		0.178	0.305
Total labor productivity											
1978	0.751	0.085	0.389	0.276	0.042	0.082	0.013	–0.010	–0.010	0.004	0.121
1980	0.791	0.090	0.390	0.262	0.026	0.085	0.013	–0.007	–0.007	0.006	0.116
1985	0.779	0.131	0.403	0.248	0.029	0.076	0.017	–0.008	0.010	0.006	0.131
1990	0.873	0.163	0.405	0.211	0.045	0.057	0.021	–0.002	0.013	0.024	0.158
1995	1.510	0.221	0.380	0.105	0.036	0.032	0.028	0.004	0.027	0.116	0.243

Note: The last column is the summation of columns for education, irrigation, roads, R&D, electricity, and telephones.

creased significantly. All these results suggest a regionally biased public investment strategy over the past two decades. As discussed earlier, the coastal region enjoyed the most favorable investment from the government.

Using the estimated coefficients in Table 5.1 and 1995 values for all relevant variables, we are able to calculate the marginal effects of different types of public investments on regional inequality. Table 5.5 reports the percentage change in regional inequality in agricultural, nonagricultural, and total rural labor productivity, as a result of an additional 100 yuan (about $12) public investment per rural resident in each of the three regions. A positive number in Table 5.5 implies that increasing public investment in that region will widen regional inequality. If the figure is negative, then public investment in that region will lead to reduced regional inequality.

The results show large regional variations in the impact of different public investments on regional inequality. Additional investments of all types in the western region reduce regional inequality, whereas additional investments of all types in the coastal and central regions worsen regional inequality. In particular, more investments in the coastal region lead to a much greater regional inequality among the three regions.

Education has the largest impact, and again additional investment in the western region reduces regional inequality the most, whereas additional investment in education in the central and coastal regions worsens regional inequality. These results are true for agricultural, nonagricultural, and total GDP. Additional investments in agricultural R&D and rural telephones also have large impacts on regional inequality, following much the same pattern as investments in education.

Table 5.5 Marginal impact of public investments on regional inequality, 1997

Public investment	% change in regional inequality resulting from additional 100-yuan investment per capita: Coastal region	Central region	Western region
Agricultural labor productivity			
Roads	0.04	0.05	–0.06
Education	2.15	2.97	–9.15
Phone	2.16	0.86	–0.86
Electricity	0.27	0.35	–0.70
Irrigation	0.73	0.66	–1.29
Agricultural R&D	11.00	9.35	–4.94
Nonagricultural labor productivity			
Roads	1.29	0.17	–1.75
Education	13.96	2.20	–39.46
Electricity	2.78	0.40	–5.06
Telephones	23.01	1.04	–6.19
Total rural labor productivity			
Roads	0.43	0.41	–0.82
Education	6.23	6.90	–24.72
Telephones	9.03	2.88	–3.41
Electricity	1.09	1.13	–2.79
Irrigation	0.64	0.46	–1.06
Agricultural R&D	6.25	3.72	–7.40

Note: One hundred yuan equals about US$12. Calculations are based on the most recent year for which data are available, except for telephones, which are based from 1988 to 1993.

CHAPTER 6

Conclusions

This chapter concludes our study by reporting major findings. It then highlights implications for future government investment priorities, points out future research directions, and draws lessons for other developing countries.

Major Findings

Using provincial-level data for 1970–97, this study developed a simultaneous equations model to estimate the effects of different types of government expenditure on growth, regional inequality, and rural poverty in China. The results show that government spending on production-enhancing investments, such as agricultural research and development (R&D) and irrigation, rural education, and infrastructure (including roads, electricity, and telecommunications) all contributed to agricultural productivity growth and reduced regional inequality and rural poverty. But variations in their marginal effects on productivity were large, among the different types of spending as well as across regions.

Government expenditure on education had the largest impact on poverty reduction and very high returns to growth in agriculture and the nonfarm sector, as well as to the rural economy as a whole. Among all types of investments, additional spending on education in the less-developed areas (the western region) also had the largest role in reducing regional inequality.

Government spending on agricultural research and extension improved agricultural production substantially. In fact, this type of expenditure had the largest returns to growth in agricultural production and overall in the rural economy. Since China is a large country, growth in agriculture is still much needed to meet the increasing food needs of its richer and larger population. Agricultural growth also trickled down in large benefits for the rural poor. The impact of R&D on poverty ranked second only to education investments.

Government spending on rural telecommunications, electricity, and roads also had substantial marginal impact on rural poverty reduction. These poverty-reduction effects came mainly from improved nonfarm employment and increased rural wages. Specifically, road investment had the largest return to gross domestic product (GDP) growth in the nonfarm economy and the second largest return to the overall rural economy, only slightly lower than R&D investment.

Irrigation investment had only modest impact on growth in agricultural production and even less impact on rural poverty reduction, even after trickle-down benefits were allowed for. This is consistent with the results of Fan, Hazell, and Thorat (1999) for India. Another striking result is that government spending on loans specifically targeted for poverty alleviation had the least impact on rural poverty reduction. Neither did this type of spending have any obvious productivity effect. Again this is consistent with the Indian findings of Fan, Hazell, and Thorat.

Additional investments in the western region contribute most to reducing poverty and regional inequality, because this is where most of the poor are now concentrated. The poverty-reduction effect of spending in education, agricultural R&D, and roads is especially high in the region. However, economic returns to most investments are larger in the central region. Fortunately the trade-off between poverty reduction in the western region and production increases in the central region is rather small.

Priorities of Future Government Investment

The results of this study have important policy implications for future priorities in government expenditure. As Table 3.1 showed, rural education spending accounted for 41 percent of total expenditures in rural areas in 1997. Irrigation is next, accounting for 23 percent. The irrigation spending considered in this study was only that directly related to irrigation, not including urban water supply, navigation, and hydropower generation. If the latter is included, the spending easily doubles. Investment in rural infrastructure took about 33 percent of total government spending in rural areas, with 14 percent for rural power, 10 percent for rural roads, and 9 percent for rural telecommunications. Agricultural research accounted for only a small fraction of total government investment in rural areas, at 2.2 percent.

Are these allocations optimal for maximized growth and poverty reduction and balanced regional development? This study reveals large differential impacts of various types of government spending on growth, poverty reduction, and regional inequality. Potential gains from reallocating government resources are enormous. Based on the results of our study, we offer the following policy suggestions:

1. The government should continue efforts to increase its overall investment in rural areas. Rural investment accounted for only 19 percent of total government expenditures in 1997, but rural residents account for 69 percent of China's total population. Moreover, almost 50 percent of national GDP was produced by the rural sector (agriculture and rural township and village enterprises) in 1997. Government's rural spending as a percentage of rural GDP is only about 5 percent compared with 11.6 percent for the whole economy. China has implemented an urban- and industry-biased investment policy for the past several decades. As a result, the rural-urban income gap is gigantic and has increased over time. Any policies against the rural sector will aggravate the existing disparity and should be discontinued.

2. There is an urgent need to increase investment in agricultural R&D. Agricultural research expenditure as percentage of agricultural gross domestic product AgGDP is only 0.3 percent. This is extremely low in comparison to the 2 percent spent in many developed countries; it is even lower than in most developing countries (0.5 percent). Various evidence, including this study, shows that agricultural research investment not only has high economic returns (Fan 2000), but it also has a large impact in reducing rural poverty and regional inequality. Moreover, new evidence has revealed that agricultural research contributes to a large drop in urban poverty through lowered food prices (Fan, Fang, and Zhang 2001). Without agricultural research, China would have many more urban poor today. Finally, increased agricultural research investment is one of the most efficient ways to solve China's long-term food-security problem (Huang, Rosegrant, and Rozelle 1999). All this suggests that increased investment in agricultural research is a "win-win-win" (growth, poverty and equity, food security) national development strategy.

3. The government should gear up its investment in rural education, even though its current rural education spending is already the largest of all rural expenditures. Improved education helps farmers gain access to and use new technologies generated

by the research system, thereby promoting agricultural growth. But more importantly, education helps farmers to gain and improve the skills they need for nonfarm jobs in rural enterprises and for migration to the urban sector. Our results show that rural education investment has the largest poverty-reduction effect per unit of spending. Therefore, continued increases in rural education investment, particularly in the less-developed western region, are a very effective means of promoting growth in agriculture and rural nonfarm employment and reducing rural poverty and regional inequality.

4. Rural infrastructure should receive high priority in government's investment portfolio. Like rural education, investments in infrastructure contribute to reduce rural poverty and regional inequality mainly by spurring nonfarm employment and growth in agricultural production. Among all rural infrastructures, roads should receive special attention, as they have the largest poverty-reduction and growth impact (compared with telecommunications and electricity).

5. China invested heavily in irrigation in the past. Large-scale irrigation facilities were built, and a high percentage of the country's arable land is now under irrigation. The marginal returns from further investment may therefore be small and declining, and future investments should be geared to improving the efficiency of existing public irrigation systems.

6. The low returns of rural poverty alleviation loans to poverty reduction indicate that these loans should be better targeted. Studies show that a large part of the funds have gone to the nonpoor regions and to nonpoor households, and many rural poor do not benefit from them at all. The funds are also often used for purposes such as covering administrative costs of local governments instead of for poverty alleviation. Although government has realized the seriousness of the problem, more efforts are needed to better target the funds to the poor, or otherwise use the moneys to improve rural education and infrastructure, which promote long-term growth and thereby offer a long-term solution to poverty reduction.

7. The highest returns in the western region to all kinds of investment in reducing both rural poverty and regional inequality, as evidenced in this study, are consistent with the national strategy to develop the western region. In particular, investment in agricultural research, education, and rural infrastructure there should be the government's top priority. Considering China's decentralized fiscal system and the western region's small tax base, fiscal transfers from the richer coastal region are called for to develop the vast west.

Future Research Directions

A number of issues deserve more attention in future research. First, China is on the brink of joining the World Trade Organization (WTO). It is unclear how the government can use public investment as an instrument to alleviate any negative effects of WTO membership on national food security and the welfare of the rural population. In particular, the poor in less-developed areas such as the Northwest and Southwest will suffer disproportionately, because they are most sensitive to changes in agricultural prices.

Second, a general-equilibrium analysis is needed to analyze how government investment in rural areas affects not only the agricultural sector and rural areas, but also other sectors and cities. Studies that ignore these impacts severely underestimate the overall impact of public investment on poverty.

Finally, an analysis of the political and institutional context of public investments and conditions for efficient provision of public goods and services is also much needed to improve the efficiency of public investments. In particular, how the government can design a mechanism (policies, regulations, fiscal systems) to mobilize public resources to invest in rural areas deserves more research attention in the future.

How to reform public institutions by improving the incentive system, accountability, human capital, and management is also an important research issue.

Implications for Other Developing Countries

The results of this study provide important insights for other developing countries that are redesigning their spending policy to achieve development goals. Many developing countries are undergoing substantial macroeconomic adjustments. It is unclear whether such programs will affect government expenditures, and therefore growth in agricultural production and reductions in poverty.

Various empirical studies confirm the important role of government spending in spurring long-term growth in the national economy (Tanzi and Zee 1997; Barro 1990) and in agriculture (Elias 1985; Fan, Hazell, and Thorat 1999; Fan and Pardey 1997). But equally important to discern is that different types of spending (for example, by sector and by region) may have different impacts on growth, as shown in this report. Moreover, different types of spending may have different implications for the distribution of economic gains. Most importantly, differing types of government spending may result in different consequences for the poor. Ways to alleviate poverty are being increasingly debated among academicians and policymakers. Less known is how recent changes in the level and composition of government expenditures have affected growth and poverty reduction in developing countries.

Since significant increases in public rural investment seem unlikely, countries will have to give greater emphasis to using their public investment resources more efficiently. This requires better targeting of investment to achieve growth and poverty alleviation goals and improved efficiency within the agencies that provide public goods and services. Reliable information on the marginal effects of various types of government spending is crucial for government to make sound investment decisions. Without such information, it is difficult for governments to hone future investment priorities to achieve national development goals. There is therefore an urgent need to conduct studies similar to this one in other developing countries.

APPENDIX A

Major Milestones in Reforming Chinese Agriculture

1950–52	*Land reform:* Land owned by landlords was confiscated and redistributed to landless or small-scale farmers. By 1952, the land reform was complete.
1953–57	*Cooperatization:* After 1952, mutual aid farming groups were formed on a voluntary basis. Land was still owned by individual households. From 1955 on, more advanced cooperatives were formed at the strong suggestion of the government. Land and other production inputs were owned by cooperatives. By 1957, 90 percent of households participated in these cooperatives.
1958–60	*Great Leap Forward and communization:* Communes were formed based on advanced cooperatives. The size of communes was large and the distribution of food was based on need rather than any economic mechanism.
1961–65	*Economic adjustments:* Adjustments and consolidation policy were implemented in 1962 after the failure of the commune system. Agricultural production was decentralized into small units (the production teams).
1966–76	*Cultural Revolution:* Three levels of ownership—commune, brigade, and production team—were implemented with the production team as their basis. Private ownership of land and marketing of agricultural products were severely restricted outside the government procurement system.
1979–84	*First phase reforms:* In 1979, procurement prices for 18 commodities were raised (50 percent increase for above-quota sales). The household production responsibility system was introduced and by 1984 more than 96 percent of households operated under the system. The number of commodities under state monopoly procurement control was reduced from 100 to 51 in 1993, and to 38 by the end of 1984.
1985–89	*Second phase reforms:* The monopoly procurement system was changed from mandatory to a voluntary contract system. Above-quota prices were reduced.
1990s	*New stage:* The urban grain rationing system was abolished in 1993. Land contract between farmers and collectives was extended for another 30 years. Procurement prices for grains were increased by 40 percent in 1994 and again by 42 percent in 1996. In 1997, the government regained a certain amount of control over the grain marketing system.

Sources: Compiled by the authors from various government documents.

APPENDIX B

Chronology of Poverty Alleviation Policies

September 29, 1984	The Communist Party of China (CPC) Central Committee and State Council jointly issued a circular calling on party committees and governments at all levels to adopt practical measures to help people in impoverished areas eliminate poverty at the earliest possible date.
April 1986	Poverty relief work was included in the Seventh Five-Year Plan for National Economic and Social Development. The State Council established a Leading Group for Economic Development of Impoverished Areas. The State Science and Technology Commission, State Nationalities Affairs Commission, and the Ministry of Agriculture launched their respective poverty-relief programs geared to selected areas.
October 30, 1987	The State Council announced the Circular on Promoting Economic Development in Poor Areas. It demanded the efficiency of funds for development be raised to realize the Seventh Five-Year Plan objectives for solving problems of food and clothing among the majority of population in poor areas.
May 1991	The State Council approved the Report on the Work of Poverty Alleviation and Development in the Eighth Five-Year Plan by the Leading Group for Economic Development of Impoverished Areas. It stipulated that efforts should focus on promoting farmland capital construction and raising grain output so as to enable rural households to have a stable source of income for adequate food and clothing.
September 1993	The State Council approves the National Poverty-Relief Program, which aims to ensure adequate food and clothing for the existing 80 million poor within seven years (from 1994 to 2000). At the same time, the Leading Group for Economic Development of Impoverished Areas is renamed the State Council Leading Group Office of Poverty Alleviation and Development.
March 6, 1995	At the UN World Summit on Social Development held in Denmark, Premier Li Peng announces that China will eliminate abject poverty in rural areas by the end of this century.
September 23, 1996	General Secretary Jiang Zemin delivers an important speech at the CPC Central Committee's meeting on poverty-relief work. He urges no effort be spared to realize the goals of the National Poverty-Relief Program as planned.
May 6, 1997	At the 25th meeting of the National People's Congress (NPC) Standing Committee, State Councilor Chen Junsheng suggests that poverty-relief work be listed on the agenda of legislation to guarantee the continuity and stability of the work and that a national law on poverty relief be formulated.

Sources: Compiled from official Chinese documents.

APPENDIX C

Provincial Data on Rural Public Spending

Sub-national-level data on public spending by various investment items are not easily available for most developing countries. China is no exception in this, although these data have become more accessible. Most such data are published in Chinese and must be compiled from different sources. Moreover, the definitions, scope, and coverage of the variables may vary over time and across regions (explained in detail in Chapter 5). For these reasons, this appendix includes some of the recently released provincial data used in the authors' analysis, which might be of more general interest.

All spending data were deflated into 1990 prices using the GDP deflator unless specified otherwise. Income data was deflated into 1990 prices using the consumer price index, while agricultural output values and agricultural and nonagricultural GDP were measured in 1990 constant prices.

China has also experienced boundary changes over the last two decades. Hainan province was created in 1987, having been part of Guangdong province prior to that. This analysis still includes Hainan as part of Guangdong. Chongqing was created in 1997 out of Sichuan province. For the 1997 data, Chongqing was thus aggregated into Sichuan province.

Table C.1 Annual growth of production, inputs, and productivity, 1979–97 (%)

Province	Production	Inputs	Total factor Productivity
Anhui	5.00	1.67	3.34
Fujian	5.60	0.83	4.59
Gansu	4.77	2.09	2.79
Guangdong	5.95	–0.07	5.68
Guangxi	7.87	1.65	6.02
Guizhou	4.12	2.49	1.88
Hebei	5.23	1.42	3.76
Heilongjiang	4.60	1.24	3.33
Henan	4.88	1.90	3.05
Hubei	4.33	0.78	3.45
Hunan	3.49	0.70	2.72
Inner Mongolia	7.27	2.18	5.03
Jiangsu	4.41	0.28	3.94
Jiangxi	4.79	1.19	3.54
Jilin	3.54	1.82	1.87
Liaoning	4.49	0.33	3.97
Ningxia	6.84	2.46	4.40
Qinghai	2.61	0.99	1.67
Shaanxi	3.94	1.67	2.36
Shandong	4.75	0.78	3.84
Shanxi	3.32	0.87	2.43
Sichuan	3.44	0.82	2.57
Xinjiang	6.66	1.60	4.94
Yunan	5.59	2.16	3.49
Zhejiang	3.18	–0.46	3.37
National	4.57	1.25	3.28

Source: Fan and Zhang 2001.

Table C.2 Agricultural research expenditures, 1990–97 (millions of 1990 yuan)

Province	1990	1991	1992	1993	1994	1995	1996	1997	Annual growth rate (%)
Beijing	71.02	28.87	28.88	48.11	41.82	44.12	42.16	47.05	–5.71
Tianjin	12.51	12.45	15.89	15.61	15.30	20.61	22.10	23.16	9.19
Hebei	29.78	28.25	33.70	34.66	38.37	45.61	42.63	42.23	5.11
Shanxi	26.93	33.15	38.19	38.64	38.41	39.79	43.21	46.99	8.28
Inner Mongolia	18.81	19.21	21.91	20.80	19.52	17.78	17.96	22.91	2.86
Liaoning	72.00	82.45	95.99	87.66	89.24	86.09	84.30	87.55	2.83
Jilin	63.71	62.27	78.43	69.08	48.03	65.92	126.82	123.13	9.87
Helongjian	48.11	55.32	70.80	72.58	59.23	59.42	52.21	48.21	0.03
Shanghai	19.75	26.36	26.23	35.99	34.79	38.35	37.44	33.38	7.79
Jiangsu	53.19	78.72	74.28	73.87	98.14	84.17	107.36	115.62	11.73
Zhejiang	33.18	37.46	48.10	50.55	46.32	53.90	45.27	57.40	8.14
Anhui	12.90	13.18	14.55	17.82	22.35	23.74	34.52	28.78	12.15
Fujian	30.75	27.88	29.71	24.40	29.40	34.15	33.08	42.86	4.86
Jiangxi	51.64	64.41	92.11	102.09	119.35	118.01	86.59	74.42	5.36
Shandong	46.29	53.98	66.52	71.09	58.10	53.87	70.36	83.93	8.87
Henan	27.50	30.88	29.35	34.09	43.65	43.30	69.96	61.53	12.19
Hubei	46.69	46.22	51.75	53.91	58.36	54.95	60.98	61.07	3.91
Hunan	49.70	54.38	67.91	77.04	63.11	57.76	55.71	60.18	2.77
Guangdong	105.84	199.62	230.64	248.22	307.94	258.25	274.79	278.32	14.81
Guangxi	35.68	40.34	44.16	52.25	57.12	52.50	53.59	50.62	5.13
Sichuan	56.82	69.86	121.62	126.96	157.17	122.58	109.43	117.52	10.94
Guizhou	17.69	17.96	20.77	21.92	22.86	22.36	24.67	56.36	18.00
Yunnan	39.60	46.50	63.88	74.88	66.19	61.94	65.78	56.36	5.17
Tibet	5.20	7.67	6.43	5.82	5.85	6.94	8.39	7.54	5.45
Shaanxi	26.55	17.99	23.39	55.17	20.05	26.76	19.00	20.93	–3.34
Gansu	22.76	23.91	23.28	21.32	18.93	17.79	21.95	20.53	–1.46
Qinghai	8.71	8.47	9.07	7.54	6.86	6.36	7.84	8.27	–0.74
Ningxia	12.27	20.07	16.36	18.07	17.49	18.00	15.72	16.99	4.75
Xinjiang	33.74	37.72	46.81	37.64	38.25	40.10	47.61	110.01	18.39

Source: Ministry of Agriculture 1990–97.

Table C.3 Rural education expenditures, 1990–97 (millions of 1990 yuan)

Province	1990	1991	1992	1993	1994	1995	1996	1997	Annual growth rate (%)
Beijing	96	99	98	89	73	66	64	64	–5.61
Tianjin	189	198	210	252	219	208	222	236	3.23
Hebei	1,339	1,343	1,522	2,038	1,909	1,919	2,227	2,458	9.06
Shanxi	804	828	928	1,144	1,039	1,019	1,341	1,318	7.32
Inner Mongolia	529	487	538	574	526	520	654	662	3.25
Liaoning	961	1,016	1,093	1,190	1,052	1,010	1,012	1,084	1.74
Jilin	592	619	671	866	769	742	732	758	3.59
Helongjian	588	608	657	861	768	743	845	959	7.23
Shanghai	340	368	414	522	488	490	564	630	9.22
Jiangsu	1,791	1,843	2,081	2,395	2,032	1,883	2,066	2,289	3.57
Zhejiang	1,448	1,522	1,681	908	795	757	874	1,012	–4.98
Anhui	750	791	898	1,355	1,428	1,553	1,773	1,923	14.40
Fujian	1,193	1,265	1,404	1,314	1,241	1,254	1,326	1,490	3.22
Jiangxi	693	704	849	979	862	825	982	1,055	6.18
Shandong	2,245	2,405	2,744	3,318	3,119	3,142	3,459	3,429	6.23
Henan	1,767	1,845	2,173	2,386	2,241	2,256	3,124	3,060	8.16
Hubei	1,212	1,265	1,441	1,743	1,626	1,630	1,756	1,950	7.03
Hunan	1,763	1,840	2,020	2,186	2,098	2,146	2,358	2,438	4.74
Guangdong	3,305	3,555	4,193	4,572	4,339	4,402	5,481	4,233	3.60
Guangxi	1,294	1,361	1,506	1,811	1,637	1,600	1,764	1,779	4.66
Sichuan	1,689	1,680	1,876	2,649	2,337	2,238	2,459	2,641	6.59
Guizhou	455	457	533	661	587	566	588	664	5.55
Yunnan	1,060	1,122	1,284	1,572	1,360	1,282	1,629	1,851	8.28
Tibet	82	82	82	74	67	66	61	158	9.82
Shaanxi	689	733	788	903	823	810	990	930	4.37
Gansu	453	447	502	620	544	519	591	676	5.90
Qinghai	89	90	99	126	105	96	122	132	5.81
Ningxia	120	117	126	148	127	118	139	161	4.26
Xinjiang	383	397	436	620	574	572	630	663	8.14

Sources: Constructed from the *China Education Expenditures Yearbook* (SSB, various years).

Table C.4 Irrigation and water conservancy investments, 1990–97 (millions of 1990 yuan)

Province	1990	1991	1992	1993	1994	1995	1996	1997	Annual growth rate (%)
Beijing	189	91	139	356	260	230	102	271	5.28
Tianjin	44	75	64	108	82	110	136	119	15.23
Hebei	110	102	162	204	228	297	1,204	473	23.15
Shanxi	108	136	223	297	413	396	128	699	30.57
Inner Mongolia	111	132	154	154	110	86	50	473	22.99
Liaoning	270	286	444	555	407	503	141	285	0.78
Jilin	105	119	153	168	165	186	34	223	11.38
Helongjian	157	188	269	269	373	303	106	277	8.43
Shanghai	136	207	293	359	383	204	174	151	1.50
Jiangsu	161	254	345	371	469	583	372	890	27.67
Zhejiang	101	168	265	265	359	412	695	976	38.28
Anhui	214	284	431	321	204	268	365	314	5.61
Fujian	113	153	263	402	441	471	208	573	26.10
Jiangxi	143	185	235	233	275	234	104	227	6.84
Shandong	214	258	525	489	564	504	731	726	19.06
Henan	498	569	868	1,146	1,325	2,120	2,684	2,764	27.74
Hubei	344	366	657	374	539	507	365	530	6.38
Hunan	156	197	385	552	551	690	439	801	26.32
Guangdong	438	824	995	960	1,147	716	1,207	1,770	22.08
Guangxi	72	152	220	245	310	320	98	399	27.71
Sichuan	264	523	655	865	894	1,004	296	968	20.39
Guizhou	127	128	139	152	155	163	60	198	6.54
Yunnan	149	159	198	268	293	382	296	500	18.88
Tibet	4	0	0	12	19	88	25	155	68.57
Shaanxi	94	109	144	155	150	187	127	554	28.83
Gansu	56	297	330	352	303	296	238	423	33.48
Qinghai	72	45	75	52	59	69	72	146	10.63
Ningxia	56	55	62	40	37	36	71	23	–11.70
Xinjiang	65	179	189	191	229	181	462	602	37.45

Source: Ministry of Water Conservancy 1980.

Table C.5 Illiteracy rates of rural laborers, 1988, 1990, and 1997 (%)

Province	1988	1990	1997	Annual growth rate (%)
Beijing	8.63	5.10	1.81	–15.93
Tianjin	8.81	6.80	2.85	–11.79
Hebei	15.49	12.18	4.59	–12.64
Shanxi	11.59	8.97	5.71	–7.56
Inner Mongolia	20.03	16.93	9.68	–7.76
Liaoning	7.66	5.68	1.86	–14.55
Jilin	11.63	9.24	3.66	–12.05
Helongjian	16.54	12.44	3.89	–14.86
Shanghai	12.58	9.94	5.79	–8.26
Jiangsu	26.79	22.36	7.93	–12.65
Zhejiang	19.57	16.39	9.02	–8.25
Anhui	34.36	28.91	10.47	–12.37
Fujian	29.78	23.42	8.79	–12.68
Jiangxi	24.69	20.11	7.75	–12.08
Shandong	22.61	17.43	6.54	–12.87
Henan	25.48	19.82	8.85	–11.09
Hubei	19.72	16.53	6.65	–11.38
Hunan	14.47	10.82	4.62	–11.91
Guangdong	15.52	12.84	5.94	–10.12
Guangxi	15.79	13.40	7.36	–8.13
Sichuan	26.66	21.12	10.76	–9.59
Guizhou	39.04	34.77	24.47	–5.06
Yunnan	39.95	33.62	21.83	–6.49
Tibet	75.43	73.30	63.86	–1.83
Shaanxi	25.85	21.98	12.48	–7.77
Gansu	42.71	37.89	25.89	–5.41
Qinghai	52.42	47.57	33.76	–4.77
Ningxia	38.19	36.76	25.28	–4.48
Xinjiang	28.87	22.05	12.43	–8.94

Sources: *China Rural Statistical Yearbook* (SSB, various years).

Table C.6 Length of roads, 1990–97 (kilometers)

Province	1990	1991	1992	1993	1994	1995	1996	1997	Annual growth rate (%)
Beijing	9,648	10,259	10,827	11,260	11,532	11,811	12,084	12,306	3.54
Tianjin	4,007	4,068	4,088	4,117	4,156	4,243	4,264	4,287	0.97
Hebei	43,640	45,464	47,034	49,195	50,496	51,630	54,146	56,009	3.63
Shanxi	30,784	31,040	31,554	32,210	32,693	33,644	35,911	44,043	5.25
Inner Mongolia	43,274	43,396	43,704	43,789	44,202	44,753	45,744	49,992	2.08
Liaoning	40,109	40,195	41,548	41,638	42,763	43,434	43,753	44,041	1.34
Jilin	26,468	27,110	27,193	28,374	29,581	31,321	32,098	33,075	3.23
Helongjian	47,169	47,188	47,882	48,023	48,356	48,819	48,987	49,631	0.73
Shanghai	3,050	3,165	3,625	3,677	3,721	3,787	3,881	3,961	3.80
Jiangsu	24,772	24,929	25,325	25,505	25,891	25,970	26,659	27,102	1.29
Zhejiang	30,195	30,700	31,924	32,838	33,170	34,121	34,924	36,127	2.60
Anhui	30,126	30,448	30,571	30,723	30,876	35,178	36,182	37,481	3.17
Fujian	41,011	41,745	41,882	43,558	44,608	46,574	47,196	47,680	2.18
Jiangxi	33,203	33,222	33,986	34,207	34,556	34,915	34,963	35,234	0.85
Shandong	40,772	4,1937	43,134	46,033	50,225	54,243	57,271	59,260	5.49
Henan	43,150	44,199	45,049	46,487	47,704	49,707	50,907	55,015	3.53
Hubei	47,511	47,661	47,892	48,008	48,349	48,728	49,757	50,779	0.95
Hunan	57,460	57,693	58,110	58,110	58,803	59,125	59,554	59,761	0.56
Guangdong	67,564	68,229	68,820	80,491	88,731	99,375	104,528	107,108	6.80
Guangxi	36,214	36,660	37,291	38,495	39,550	40,904	42,696	45,378	3.28
Sichuan	97,234	98,122	98,920	99,342	100,002	100,724	101,646	103,111	0.84
Guizhou	31,157	31,588	31,889	32,092	32,398	32,487	32,700	33,211	0.92
Yunnan	56,536	58,123	60,045	63,086	65,578	68,236	70,279	73,821	3.88
Tibet	21,842	21,944	21,944	21,944	21,842	22,391	22,391	22,455	0.40
Shaanxi	37,986	38,193	38,318	38,536	39,058	39,620	40,200	41,202	1.17
Gansu	34,708	34,776	34,822	34,875	34,984	35,194	35,338	35,594	0.36
Qinghai	16,732	16,769	16,854	16,963	17,061	17,223	17,383	17,640	0.76
Ningxia	8,200	8,200	8,200	8,301	8,324	8,554	8,738	9,048	1.42
Xinjiang	25,425	25,697	26,024	27,961	28,611	30,298	31,609	32,053	3.36

Sources: *China Statistical Yearbook* (SSB, various years).

Notes: Length of roads here refers to the total length of roads. The length of rural roads for the selected years is available in the *China Rural Statistical Yearbook* (SSB, various years).

Table C.7 Rural telephones, 1990–97 (thousands of sets)

Province	1990	1991	1992	1993	1994	1995	Annual growth rate (%)
Beijing	18.50	19.10	19.10	20.60	n.a.	n.a.	n.a.
Tianjin	1.54	1.47	3.90	5.36	23.00	108.70	189.71
Hebei	37.69	43.60	53.25	79.91	191.00	459.00	86.81
Shanxi	16.00	16.00	17.00	20.00	33.30	76.00	47.63
Inner Mongolia	19.00	20.00	21.00	30.00	25.10	30.00	12.10
Liaoning	111.00	122.00	135.50	168.90	190.00	375.00	35.57
Jilin	50.00	56.30	67.80	84.50	116.00	222.00	45.16
Helongjian	35.70	41.30	50.20	67.10	94.00	180.00	49.85
Shanghai	64.30	79.60	103.90	147.10	76.17	145.95	22.74
Jiangsu	266.39	306.75	394.16	569.00	826.00	1,580.00	56.06
Zhejiang	125.80	156.50	222.10	346.90	785.00	1,440.00	83.94
Anhui	50.30	57.20	46.90	64.20	116.00	229.00	46.07
Fujian	41.40	51.10	71.90	131.40	295.00	548.00	90.74
Jiangxi	24.94	27.13	31.35	39.11	57.00	139.00	53.65
Shandong	73.00	81.00	95.00	128.00	363.00	755.00	79.33
Henan	52.40	56.00	63.20	78.10	114.00	209.00	41.32
Hubei	70.70	75.05	81.77	97.74	180.00	396.00	53.84
Hunan	42.00	52.00	72.90	98.10	166.00	321.00	66.27
Guangdong	410.80	544.10	748.50	129.40	2,019.00	2,810.00	61.72
Guangxi	34.98	37.78	42.97	50.41	71.30	121.00	36.38
Sichuan	58.81	65.79	75.35	87.46	118.00	229.00	40.47
Guizhou	16.31	16.66	16.94	17.18	18.90	31.00	17.42
Yunnan	36.83	38.39	41.45	47.34	62.10	112.00	32.05
Tibet	0.31	0.31	0.30	0.30	0.30	0.28	-2.19
Shaanxi	21.18	23.38	27.61	31.67	44.30	100.80	47.69
Gansu	11.47	12.76	14.46	17.73	23.50	36.00	33.11
Qinghai	12.50	11.70	11.60	11.80	2.14	4.60	-22.11
Ningxia	1.83	2.02	2.37	3.05	5.50	14.90	69.01
Xinjiang	10.52	11.12	12.96	17.54	23.20	15.20	9.64

Sources: *China Statistical Yearbook* (SSB, various years).

Table C.8 Share of irrigated areas in total arable land, 1990–97 (%)

Province	1990	1991	1992	1993	1994	1995	1996	1997	Annual growth rate (%)
Beijing	80.93	78.86	75.20	77.62	76.85	80.85	80.91	80.12	–0.14
Tianjin	80.06	80.43	80.66	79.19	81.42	83.24	82.52	82.61	0.45
Hebei	57.29	58.62	59.38	60.14	60.73	61.99	65.18	65.26	1.88
Shanxi	30.64	31.16	31.56	32.03	32.46	32.98	33.07	32.83	0.99
Inner Mongolia	25.48	26.43	33.37	33.86	33.03	32.35	33.71	33.75	4.10
Liaoning	30.53	31.48	33.03	34.10	34.71	35.51	36.23	36.39	2.54
Jilin	22.41	23.45	23.27	23.08	23.01	22.88	23.68	24.45	1.26
Helongjian	12.22	12.63	12.99	13.05	11.39	12.17	14.82	18.23	5.88
Shanghai	98.66	99.27	98.93	99.07	99.05	99.21	98.28	98.16	–0.07
Jiangsu	87.04	84.62	85.28	85.07	85.10	86.16	86.28	86.27	–0.13
Zhejiang	85.33	86.08	86.55	87.21	87.31	87.71	87.32	87.28	0.32
Anhui	60.22	62.46	63.88	65.28	66.89	68.37	69.25	69.29	2.03
Fujian	75.41	76.10	76.82	77.51	77.41	77.78	77.67	77.52	0.39
Jiangxi	77.99	78.85	79.39	80.15	78.49	81.43	81.84	81.87	0.70
Shandong	64.99	66.61	67.62	68.41	69.10	69.63	70.07	70.67	1.20
Henan	51.12	53.47	54.88	56.30	57.56	59.42	61.58	61.71	2.73
Hubei	66.66	67.39	68.80	67.18	66.30	64.75	71.01	69.49	0.60
Hunan	80.63	78.93	80.86	81.76	82.22	82.47	82.07	82.26	0.29
Guangdong	65.49	63.72	61.98	60.07	59.49	60.76	60.60	60.68	–1.08
Guangxi	57.81	57.47	57.98	57.43	57.19	56.31	56.26	56.36	–0.36
Sichuan	44.49	45.00	45.45	45.86	46.31	46.83	47.26	47.28	0.87
Guizhou	29.68	27.65	33.39	32.35	32.97	33.27	33.63	33.77	1.86
Yunnan	37.34	37.85	40.25	39.58	41.30	43.54	44.71	45.29	2.79
Tibet	n.a	n.a	n.a	n.a	72.94	72.99	65.63	74.11	n.a.
Shaanxi	35.67	36.44	37.37	38.16	38.73	39.49	37.94	37.96	0.89
Gansu	24.57	24.93	25.42	25.85	26.26	25.63	26.96	27.09	1.40
Qinghai	29.99	30.27	30.21	30.39	30.26	30.06	29.85	31.08	0.51
Ningxia	32.74	33.25	37.01	34.24	34.25	34.46	34.86	41.30	3.37
Xinjiang	92.99	91.46	89.43	90.06	89.56	88.87	90.83	91.64	–0.21

Sources: Calculated from the *China Rural Statistical Yearbook* (SSB, various years).

Table C.9 Rural electricity consumption, 1990–97 (hundreds of millions of kilowatts)

Province	1990	1991	1992	1993	1994	1995	1996	1997	Annual growth rates (%)
Beijing	18	20	14.4	17	17.2	20.2	20.2	25.1	4.86
Tianjin	16.5	18.1	21.8	23.1	25.1	32.5	35.8	33	10.41
Hebei	58.8	65.5	78.1	85.1	101.8	118.5	150	161.3	15.51
Shanxi	26	30	34	38	41.5	46.1	48.7	54.5	11.15
Inner Mongolia	11	11.7	12.2	13.5	15.5	16.7	16.7	17.7	7.03
Liaoning	47	54.8	63.5	73.7	72.7	81.6	89	96	10.74
Jilin	16.8	18.2	19	19.8	21.5	21.5	22.1	22.6	4.33
Helongjian	17.6	20.3	21	22	23	23.5	24.3	26.1	5.79
Shanghai	32.5	40	40.1	50	54.2	52.3	62.5	65.8	10.60
Jiangsu	105.3	121.5	146.5	169.2	206	238.2	252.2	263.1	13.98
Zhejiang	69.4	84	98	115.4	147	169.2	181	190.1	15.48
Anhui	23.6	26	29.9	27.8	32.2	37.4	36.4	43.1	8.98
Fujian	20.4	23.4	26.9	29.2	36	45.7	50	57.8	16.04
Jiangxi	16	16.8	18.3	22.1	23.5	26.6	29.1	30.8	9.81
Shandong	75.7	84.2	100.2	106.6	132.3	147.3	152.4	169.5	12.20
Henan	46.9	52.1	59.6	61.1	72.6	85.1	103.7	118.3	14.13
Hubei	27.2	27.8	30.9	33.4	40.8	47.4	50.6	55.4	10.70
Hunan	23.4	25.8	27.7	30	33	37.6	38.9	41.7	8.60
Guangdong	57.8	73.9	101.2	128.9	175.6	187.5	205	244	22.84
Guangxi	12.6	15.1	17	19	20.8	23.6	25.2	27.1	11.56
Sichuan	44	48	52.3	59.6	69.7	78.8	82.6	81.1	9.13
Guizhou	6.1	4.7	6.1	5.4	6.7	7.9	7.9	11.1	8.93
Yunnan	12.2	13.9	15.4	16.8	19.4	20.7	25	28.3	12.77
Tibet	n.a.	n.a.	n.a.	n.a.	n.a.	0.2	0.18	0.17	n.a.
Shaanxi	29.2	28.6	32.6	36.1	40.8	44.6	45.8	50.5	8.14
Gansu	14.2	19.1	20.4	21.8	22.8	21.4	30.3	25.6	8.78
Qinghai	1.5	1.5	1.6	1.9	2.2	2	2.1	2.1	4.92
Ningxia	3.9	4.5	4.9	4.8	5.4	5.6	6.5	7.3	9.37
Xinjiang	10.5	12	13.1	13.8	14.4	16.2	17.8	20.8	10.26

Sources: *China Rural Statistical Yearbook* (SSB, various years).
Note: N.a. means not available.

Table C.10 Share of nonfarm employment in total rural employment, 1980–97 (%)

Province	1980	1985	1990	1995	1997
Beijing	13.08	52.58	55.24	59.88	59.49
Tianjin	11.97	46.49	47.60	52.38	54.10
Hebei	7.65	20.43	24.58	33.34	38.00
Shanxi	8.14	29.37	29.61	33.35	34.34
Inner Mongolia	6.48	8.46	11.25	14.66	15.41
Liaoning	13.64	28.16	27.14	31.54	32.25
Jilin	9.05	11.18	11.91	14.85	15.35
Helongjian	9.97	13.03	13.81	17.70	15.86
Shanghai	19.06	58.66	70.00	71.53	70.03
Jiangsu	13.77	34.44	38.48	44.42	44.28
Zhejiang	8.09	32.30	34.32	45.36	47.29
Anhui	2.98	12.53	16.44	25.53	26.54
Fujian	6.05	19.83	23.76	32.35	34.70
Jiangxi	4.50	16.27	17.32	28.51	29.73
Shandong	7.03	21.42	25.10	29.96	30.41
Henan	5.59	12.76	17.64	25.58	27.71
Hubei	7.12	19.67	18.83	26.59	29.02
Hunan	5.61	15.32	13.12	23.27	25.25
Guangdong	5.71	23.56	30.95	44.68	36.41
Guangxi	2.68	6.05	10.11	20.44	21.77
Sichuan	3.93	10.56	13.41	23.14	27.12
Guizhou	1.89	5.99	8.33	14.16	16.01
Yunnan	2.79	8.64	8.76	11.06	12.23
Tibet	2.08	4.67	5.29	5.96	6.95
Shaanxi	5.90	15.52	16.78	20.80	22.08
Gansu	2.86	20.19	16.78	23.80	24.47
Qinghai	2.03	10.90	11.92	13.69	14.37
Ningxia	4.63	9.88	11.66	15.45	17.67
Xinjiang	4.09	7.01	7.59	9.25	9.58

Source: *China Rural Statistical Yearbook* (SSB,various years).

Table C.11 Rural poverty incidence, 1985–96 (%)

Province	1985	1986	1987	1991	1996
Beijing	0	0	0	0.1	0.8
Tianjin	0	0	0	0.3	0.3
Hebei	4.9	11.2	5.8	13.4	3.9
Shanxi	4.1	6.8	10	17	7.5
Inner Mongolia	10.6	38	1.3	13.7	9.3
Liaoning	6.5	6	0	4.4	2.9
Jilin	0	0	0	8.7	4.7
Helongjian	14.1	1.3	1.3	14.3	6.7
Shanghai	0	0	0	0.1	0.1
Jiangsu	0	0	0	4.1	0.1
Zhejiang	4.5	2.3	0	3.6	0.1
Anhui	5.1	2	0.8	27.8	2.7
Fujian	6.3	5.2	0	1.4	0.5
Jiangxi	12.1	6	27.9	0.3	0.7
Shandong	2.3	0	0	4.1	1.9
Henan	24.9	28.7	16.7	21.7	4.3
Hubei	3.7	5.4	2.5	9	2.7
Hunan	12.6	9.4	1.4	3.1	1.5
Guangdong	0	1	0	0.3	0.2
Guangxi	22.2	19.7	11.7	7	6.4
Sichuan	35.1	21.6	15.5	11.2	7
Guizhou	36.8	38.3	32.7	23.5	12.8
Yunnan	41.3	42.4	36	17.3	22.9
Tibet	n.a.	n.a.	3.8	11.6	10.1
Shaanxi	41.6	31.5	16.7	18	17.5
Gansu	43.9	35.6	15.5	29	22.7
Qinghai	5	1.7	1.7	17.8	17.7
Ningxia	53	49.9	50.7	22.7	18.5
Xinjiang	0.9	2.4	0.2	16.3	27.4

Source: World Bank 2000a.

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