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IFPRI Discussion Paper 00716

September 2007

Investment, Subsidies, and Pro-Poor Growth in Rural India

Shenggen Fan, International Food Policy Research Institute
Ashok Gulati, International Food Policy Research Institute
and
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Development Strategy and Governance Division

and

New Delhi Office

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IFPRI's research, capacity strengthening, and communications work is made possible by its financial contributors and partners. IFPRI gratefully acknowledges generous unrestricted funding from Australia, Canada, China, Denmark, Finland, France, Germany, India, Ireland, Italy, Japan, the Netherlands, Norway, the Philippines, Sweden, Switzerland, the United Kingdom, the United States, and the World Bank.

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Published by

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ABSTRACT

This paper reviews the trends in government subsidies and investments in and for Indian agriculture; develops a conceptual framework and model to assess the impact of various subsidies and investments on agricultural growth and poverty reduction; and, presents several reform options with regard to re-prioritizing government spending and improving institutions and governance.

There are three major findings. First, initial subsidies in credit, fertilizer, and irrigation have been crucial for small farmers to adopt new technologies. Small farms are often losers in the initial adoption stage of a new technology since prices of the agricultural products are typically being pushed down by greater supply of products from large farms, which adopted the new technology. But as more and more farmers have adopted HYV, continued subsidies have led to inefficiency of the overall economy. Second, agricultural research, education, and rural roads are the three most effective public spending items in promoting agricultural growth and poverty reduction during all periods. Finally, the trade-off between agricultural growth and poverty reduction is generally small among different types of investments. As for agricultural research, education, and infrastructure development, they have large growth impact and a large poverty reduction impact.

Several policy lessons can be drawn. Agricultural input and output subsidies have proved to be unproductive, financially unsustainable, environmentally unfriendly in recent years, and contributed to increased inequality among rural Indian states. To sustain long-term growth in agricultural production, and therefore provide a long-term solution to poverty reduction, the government should cut subsidies of fertilizer, irrigation, power, and credit and increase investments in agricultural research and development, rural infrastructure, and education. Promoting nonfarm opportunities is also important. However, simply reallocating public resources is not the full solution. Reforming institutions can have an equal, if not larger, impact on future agricultural and rural growth and rural poverty reduction.

Keywords: Rural poverty, agricultural growth, investment, subsidies, India

1. INTRODUCTION[1]

There is a raging debate going on in India about the reasons why the growth rate in Indian agriculture declined since the 1990s, especially during the last several years (see Alagh 2004; Bhalla 2004; and Gulati 2004). The underlying causes of this deceleration are not very clear. Various reasons have been suggested, ranging from the declining trend in public-sector investments in agriculture to the adverse impact of trade liberalization resulting from the collapse in world prices of major agricultural products. One common strand in the debate concerns the neglect of public-sector investments since the 1980s (GOI [Government of India] 2004). Promises have often been made in various government publications that the trend of declining public-sector investments in agriculture will be reversed, but these promises remain largely unfulfilled. Another strand in the debate, one that is increasingly coming into focus, concerns the rising level of subsidies (in real terms) given to agricultural inputs, especially power, canal irrigation, fertilizers, and credit. The subsidies on food through the public procurement, stocking, and distribution system are also increasing (GOI 2004).

So the real issue is not only that government expenditure on food and agriculture is decreasing, but also how it is being allocated and what impact it has on agricultural growth and poverty reduction in rural areas. If the government had a billion rupees to spend on agriculture, should it spend the money on agricultural subsidies or agricultural investments (and on what type of investments), if the objective is to get maximum returns from each billion rupees spent? Answering this question is the purpose of this paper.

The paper aims to (1) review the trends in government subsidies and investments in/for Indian agriculture, (2) empirically estimate the relative impact of various subsidies and investments on agricultural growth and poverty reduction, and (3) present, in the light of these results, a few reform options to re-prioritize government spending and improve institutions and governance in order to enhance use of limited resources.

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2. PUBLIC INVESTMENTS AND SUBSIDIES

This section will review the trends in public investments that are targeted to improve agricultural productivity in long run through accumulation of public capital and subsidies that are supposed to increase farmers' production directly.

Public Investments in and for Agriculture

In the strict definitional sense of the term, public investments in agriculture are often equated with public-sector gross fixed capital formation (GFCF) in agriculture, as defined in the National Accounts Statistics (NAS) of the Central Statistical Organisation (CSO) of India. By this definition, which uses the asset-based approach as well as the industry-of-use approach, public-sector GFCF in agriculture comprises primarily (almost 90 percent) the irrigation projects undertaken by the Departmental Commercial Undertakings. The Non-Departmental Commercial Undertakings contributes a minor amount through irrigation, horticulture, livestock, and development of state farms.

Going by this definition of public investments in agriculture, it is worth noting that the share of GFCF in total investments (capital formation) in agriculture was less than one-fourth (24 percent to be exact) for the triennium average of 2000-01 to 2002-03 (GOI 2004, 167), and that this share has decreased over the years. In the early 1980s, for example, the share of the public sector and private sector (including household sector) in gross capital formation in agriculture was roughly equal, but by the early 2000s, the share of the private sector was three times larger than the share of the public sector at 1993-94 constant prices (Gulati and Bathla 2002). Not only has the share of the public sector in gross capital formation decreased, but it is ironic that it has decreased even in absolute terms. This overall decline has been the focus of major debate in the country because many assume it to be the main cause behind the slow down in agricultural growth and, thereby, in the reduction of rural poverty.

The problem with this definition is that it does not capture the full scale of public-sector investments or expenditures that have significant influence on the growth of agriculture. We know from past experience, especially during the Green Revolution period, that government expenditures in agricultural research and development (R&D), rural roads, education, and so on are perhaps as important as public expenditures on irrigation. This dual effect on agriculture is often expressed as the famous dichotomy of investments *in* agriculture and investments *for* agriculture (Dantwala 1986). Recognizing the effects of multiple factors, many researchers have tried to construct their own series of capital formation *for* agriculture, depending upon the purpose at hand. They have extended the definition to include expenditures under many headings, ranging from power supplied to rural areas, roads, R&D, and sometimes even investments in the fertilizer industry (see the details of this debate in Chand 2000; Fan, Hazell, and Thorat 2002; Gulati and Bathla 2002, Annexure IV; GOI 2003).

In an earlier study, Fan, Hazell, and Thorat (2002) constructed their own series of public expenditures to explain the growth of agriculture, and concluded that the success of the Green Revolution was due largely to government expenditures in irrigation and electricity, agricultural R&D, and rural infrastructure. In recent years, however, we have seen a steady decline in these public expenditures, whichever way we look at them: as public-sector capital formation *in* agriculture or *for* agriculture (GOI 2003). As a share of agricultural gross domestic product (GDP), these investments declined from more than 10 percent during 1981-83 to 5 percent during 1998-2000 (Landes and Gulati 2004). In contrast, however, Fan, Hazell, and Thorat's (2002) expenditure series—one of the most comprehensive series constructed because it includes rural education—shows a decline in overall public expenditure in agriculture as a share of agricultural GDP up to 1992, but some pick up thereafter, though the rate of growth is very low compared to earlier decades.

Amongst various types of government spending *for* agriculture, agricultural R&D appears to be the most critical for promoting farm yields. Public agricultural research expenditure increased from Rs 1.6 billion in 1964, measured in 1995 prices, to Rs 7.1 billion in 1990, at an average annual growth rate of 5.8 percent. As a result, the national agricultural research system released many new technologies. The adoption of high-yielding varieties jumped from almost zero farmers in the mid-1960s to more than 50 percent of farmers in 1990. But adoption increased very little after 1990. In 1995 government spending in agricultural R&D increased only marginally above 1990, to Rs 7.3 billion. As a percentage of agricultural GDP, public agricultural research spending increased from 0.21 percent in 1964 to 0.50 percent in 1987. After 1987 it stagnated, and even dropped to 0.43 percent in 1995. This percentage is very low when compared with the 2-4 percent share in developed countries, and even lower than the 0.75 percent average share for developing countries.

Public expenditure on irrigation too has been critical for agricultural growth in the past. Massive investments in dams, reservoirs, and canal networks through multipurpose river valley schemes, especially during the first three decades after independence, appear to have paid off well given that the seeds of the Green Revolution sprouted in the areas where these investments were made. But during the 1980s and 1990s, public expenditure on irrigation declined consistently (measured at constant prices). While the costs of creating additional irrigation through major and medium-sized surface-irrigation schemes went up, the resources to complete these schemes shrank. As a result, the growth in area irrigated through publicly funded schemes slowed down, creating severe shortages of irrigation water on the one hand and a large number of unfinished irrigation projects on the other. In 1996-97 the GOI introduced the Accelerated Irrigation Benefits Programme (AIBP) and in 2002 a Fast Track Programme in order to help states complete pending irrigation schemes quickly through central loans and grants. So far, success has been modest. As public expenditures have generally declined, private-sector investments in minor irrigation, primarily ground water, have increased. Despite irrigation investment over the years, roughly three-fifths (60 percent) of India's gross cropped area remain dependent on rains.

In addition to investments that are directly targeted towards agriculture, like R&D and irrigation, there are also investments in education, health, and infrastructure that contribute to growth in agricultural production and even more to poverty reduction in rural areas. The literacy rate in rural India has increased steadily from 23 percent in 1970 to 40 percent in 1995. In 1970, only 34 percent of the villages in rural India had access to electricity. But in 1995, this percentage had increased to almost 90 percent. It is difficult to separate the rural share of overall government investment, but overall investments in education and electricity have slowed down in recent years. A strong urban bias has probably caused rural areas to suffer even more from the recent stagnating or declining investment trends (Fan, Thorat, and Rao 2004).

Input Subsidies

Input and output subsidies in Indian agriculture have increased over the last two decades. Food subsidies alone increased by more than 10 times (at current prices) between 1990-91 and 2004-05 (GOI 2004, 94), while the wholesale price index for all commodities roughly doubled during this period (food subsidies therefore increased by more than 5 times in real terms). The components of this increase include rising minimum support prices, accumulation of huge stocks of grains (touching 64 million metric tons in July 2002), and the increasing economic cost of operations of the Food Corporation of India.

In this paper we focus only on input subsidies. The sources of input subsidies are diverse. Different levels of government (central, state, and local) can provide direct financial support to input industries, parastatal and private input traders, and farmers. The government can also design policies that subsidize inputs indirectly, such as those related to trade and marketing. Subsidies can be disaggregated further into those for fertilizer, credit, irrigation, and power. The data we use here are estimated by Fan, Thorat, and Rao (2004) following the methodology developed by Gulati and Narayanan (2003).

Accordingly, fertilizer subsidy is measured basically as the difference between the import parity price and what the farmer actually pays, multiplied by the total consumption of fertilizers. The underlying rationale is that fertilizer is largely a tradable commodity and therefore its relevant price under a free trade scenario would be the import parity price. The subsidy estimated on this basis is very different from what is shown in government budgets, which is primarily the difference between the cost of production of fertilizers under the Retention Pricing Scheme and what the farmer pays.

Measured in 1993 constant prices, government budget support for fertilizer increased from Rs 2.6 billion in 1976 to Rs 80 billion in 2000, an increase of more than 30 times in 24 years (Fan, Thorat, and Rao 2004). Only after 1998 did government support for fertilizer stabilize at Rs 80 billion per year. As a percentage of overall GDP, fertilizer subsidy increased from 0.07 percent to 0.61 percent between 1976 and 2000. The fertilizer subsidy budget increased at a faster rate than the total subsidy budget of the central government. As a result, its share in total central government subsidy outlays increased from 6.3 percent to more than 50 percent between 1976 and 2000. As a percentage of agricultural GDP, the fertilizer support budget increased from 0.19 percent to 2.7 percent during the same period. This share is more than 5 times larger than government spending on agricultural R&D.[2]

An important question is whether the central government fertilizer subsidy is distributed equitably across crops, states, and farm classes. Singh (2004) has analyzed this issue, measuring equity in terms of shares of different farm classes, crops, and states in total fertilizer use, and per hectare fertilizer use on different size farms. His study shows that paddy and wheat farmers are the main beneficiaries of fertilizer subsidy, followed by cotton and sugarcane farmers. Paddy and wheat growers consume 35 percent and 19.3 percent of total fertilizers, respectively, whereas cotton and sugarcane growers consume 5.8 and 5.5 percent of total fertilizers, respectively. Fertilizer use per hectare is also higher for paddy and wheat when compared to other crops. Paddy and wheat use 79.7 kilograms (kg) and 85.32 kg of fertilizer per hectare, whereas coarse cereals and other crops use 28.8 kg and 42 kg per hectare, respectively.

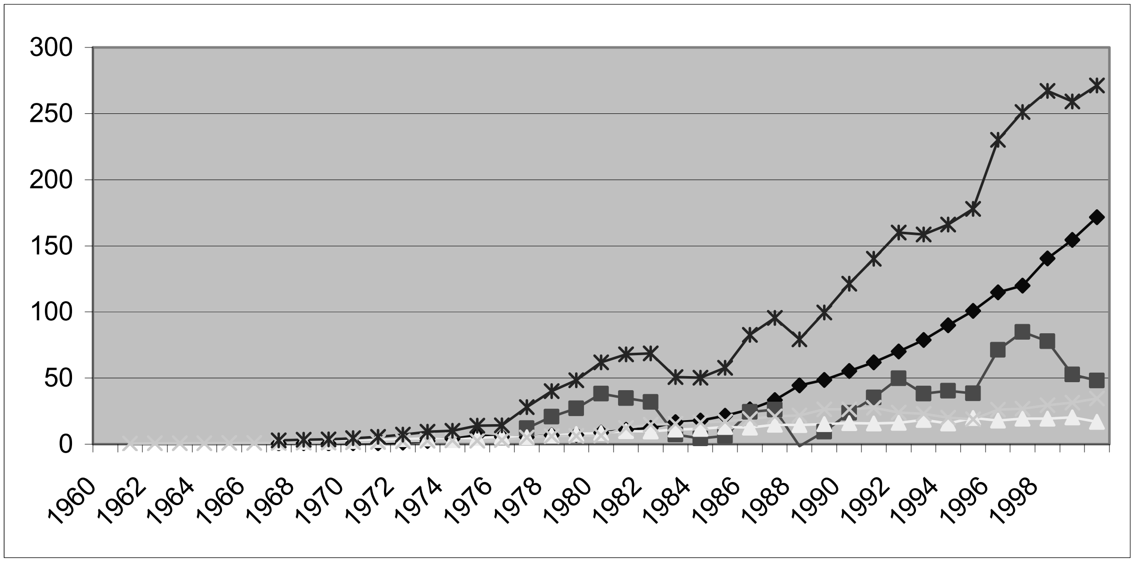
But not all government budget support goes to farmers; a large proportion ends up with the domestic fertilizer industry. On the basis of import parity prices of fertilizers, about 67.5 percent of the fertilizer subsidy went to farmers over the last two decades. If one adjusts for the pricing of gas as per the Kelkar Committee's recommendations, farmers' share of the fertilizer subsidy drops to roughly 50 percent (Gulati and Narayanan 2003). Based on this measure, fertilizer subsidy increased substantially between 1976 and the mid-1990s (Figure 1a). After the mid-1990s, the subsidy declined mainly because the international price of fertilizer declined; but the government budget support remained almost at the same level in real terms.

India was one of the first developing countries that introduced a rural credit scheme to help poor farmers overcome cash constraints for agricultural production. The Rural Credit Survey Committee report of the early 1950s recommended financial support for cooperatives, establishment of primary agricultural credit cooperatives (PACS), the strengthening of the cooperative credit structure, and the nationalization of the banking system. With the introduction of high-yielding varieties, there was a substantial increase in the demand for credit from cooperatives, which were the only official providers of agricultural credit at that time. With the nationalization of 14 major commercial banks in 1969, commercial banks entered the agricultural credit scene. In 1975, Regional Rural Banks (RRBs) were created to provide agricultural

[2] In 2000, the central government spent Rs 13.7 billion on agricultural research measured in 1993 price (Jha and Pal 2004).

credit to targeted districts with a weak credit base. As a result of this focus on credit, the share of agriculture in total credit disbursed by commercial banks increased quickly from 3 percent in 1967 to 15 percent in 1985. The share of credit provided by the RRBs also increased rapidly and averaged 11.4 percent of total agricultural credit by 1989. By the early 1990s, 50 percent of total agricultural credit came from commercial banks.

Figure 1a. Input Subsidies in Indian Agriculture, 1993 Billion Rs



Sources: Fan, Thorat and Rao, 2004.

Credit subsidies are calculated as interest subsidies (the difference between commercial rates and the rate farmers receive) plus defaulted loans to agriculture. At the national level, the volume of the credit subsidy increased at a yearly rate of 11.24 percent during 1960-1999. However, the growth rates varied considerably across decades. During the 1960s, credit subsidies grew at a rate of 12.62 percent per year; during the 1970s the rate of increase doubled, averaging 22 percent a year. The growth rate in credit subsidies dropped to 7.31 percent in the 1980s and further down to 4.74 percent in the 1990s (Figure 1).

Irrigation subsidies are calculated as the difference between the total operation and maintenance (O&M) costs and the total revenue in the irrigation sector. From 1966 to 1999, the level of irrigation subsidy, which includes major, medium, and minor irrigation schemes, increased quite dramatically, at 7.6 percent per year. The rate of increase was higher during the 1960s (20 percent), compared with the 1970s (10 percent) and the 1980s (5 percent) (Figure 1a). During the 1990s, the growth rate in irrigation subsidies decreased significantly to only 1 percent per year. Himachal Pradesh and Jammu and Kashmir had the highest subsidy per agricultural population, while Assam and Maharashtra had the lowest.

The agricultural sector in India consumed 29 percent of the power generated in 1999, but contributed to only 3.36 percent of the total electricity sales revenue. This pattern has been stable over the last two decades and, as such, industrial and commercial consumers of electricity have cross-subsidized power consumption of the agricultural sector (Gulati and Narayanan 2003). This is true for almost all states in India. For example, in 2000-01, the average revenue tariffs from power supply to agriculture was 28.42 paise (100 paise equals one rupee) per kilowatt-hour, whereas the estimated average cost of supply to others in the power sector was 303.86 paise per kilowatt-hour. Thus, agriculture received a subsidy of 275.44 paise for every kilowatt-hour it consumed. By contrast, the average revenue tariff for industrial and commercial consumers was 360.23 and 341.20 paise per kilowatt-hour, respectively.

The power subsidies are estimated using the following procedure (Gulati and Narayanan 2003). The total costs of the power sector are reported in the State Budget and the Finance Account and include capital outlays as well as assistance to the electricity board, subsidies, and grants-in-aid. The total revenue expenditure includes collection of taxes and duties on consumption and sale of electricity, as well as the revenue expenditure on power, but excludes interest payment by the government.

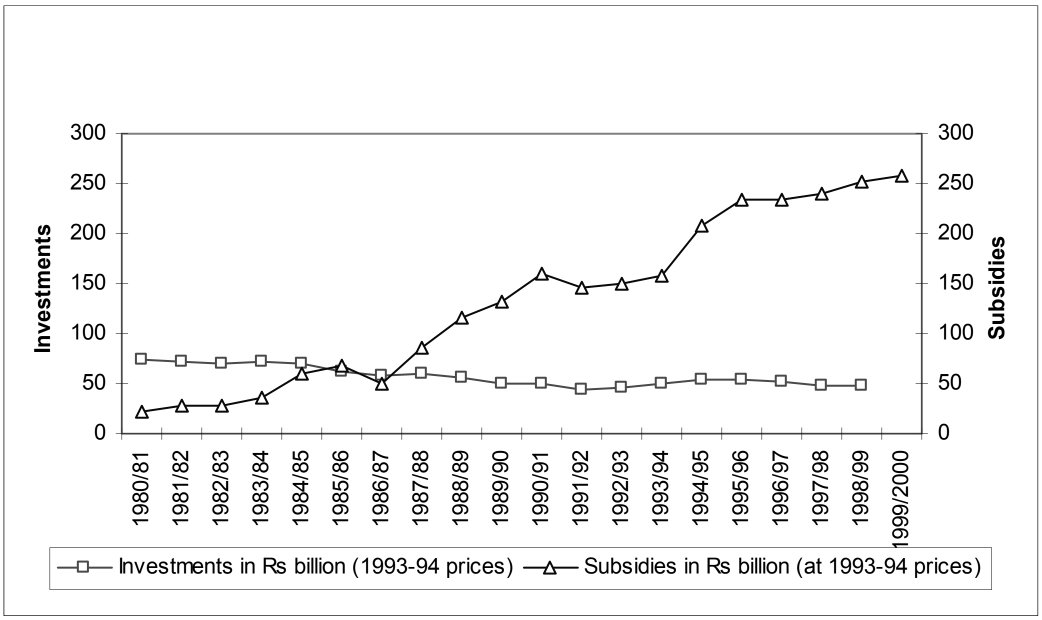
The unit subsidy for agriculture is calculated as the unit cost of supplying electricity to all sectors subtracted by the electricity tariff charged to agriculture. The total electricity subsidy to agriculture is simply the total agricultural electricity consumption multiplied by the unit subsidy for agriculture. For the years prior to 1980 we use the 1980 rate (in real terms), because tariff rates for agriculture by state are unavailable.

Overall, power subsidies to the agricultural sector grew at an annual rate of 19.7 percent between 1966 and 1999. However, the rate of growth has been uneven over time: a rising trend is clearly observed in Figure 1a. Power subsidies grew rapidly, from an annual average rate of 7.2 percent in the 1960s to 38.5 percent in the 1970s. The rate of increase declined to 19.7 percent in the 1980s. In the 1990s, it fell further to 11.9 percent per year. Power subsidies have been unevenly distributed among states.

When we aggregate these four subsidies, we see that total input subsidies increased from Rs 3 billion in 1966 to Rs 271 billion in 1999 (all in 1993 prices), an increase by 90 times during the last three decades (Figure 1a). In the 1960s, irrigation accounted for more than 50 percent of the total subsidies, credit accounted for 30 percent, and power for the rest. During the second half of the 1970s, fertilizer subsidy became dominant, accounting for more than 50 percent of the total. Since 1982, power subsidy has taken the largest share. In 1999 it accounted for 64 percent of total input subsidies in Indian agriculture.

Three issues come to the fore from the above analysis: (1) the volume of subsidies increased substantially during this 34-year period (1966-1999). The rate of increase, however, was higher for power (19.6 percent per year) and credit (11.2 percent per year) than for irrigation and fertilizer (about 5.5 percent and 7.6 percent, respectively). (2) The rate of change in the amount of subsidies was uneven over time. Overall, subsidies on all four inputs increased at a much faster rate during the 1960s and the 1970s. In the next two decades, subsidy growth for these inputs slowed down, partly because the international price of fertilizer declined (and yet government support for fertilizer remained high). (3) Subsidy distribution across states has been extremely unequal and has only become more so over time. This last point is investigated in more detail below.

Figure 1b. Input Subsidies (Fertilizer, Power, and Canal Irrigation) and Public Investments in Agriculture, 1980-2000



There exists great variation of input subsidies across states (Figures 2a, 2b, and 2c). As a percentage of agricultural GDP, Madhya Pradesh, Gujarat, Andhra Pradesh, Punjab, and Tamil Nadu received the most subsidies in 1997-99, ranging from 15 to 21 percent. Assam, Kerala, and West Bengal received among the least, often less than 5 percent. In terms of subsidies per hectare of cropped land, Tamil Nadu, Punjab, Gujarat, and Andhra Pradesh were among the top recipients, receiving anywhere from Rs 2,600 to 3,300 per hectare. Assam and Orissa received the least: less than Rs 500 on a per hectare basis. However, when subsidies are calculated per agricultural person, the picture is quite different, showing the largest variation across states. In 1997-1999, each individual in Punjab's agricultural population benefited from input subsidies by almost Rs 1,500 (1993 prices), while agricultural Assamese benefited by only Rs 43, a 35-fold difference. In general the western states, including Punjab, Haryana, and Gujarat, benefited the most, topping the national average, while the eastern states, including Assam, Bihar, and Orissa, benefited the least per agricultural person. This strongly implies that input subsidy policy may have increased inequality within agriculture across states.

Distribution of Input Subsidies across States, 1997-99 (1993 prices)

Figure 2a. Input Subsidies as Percentage of Agricultural

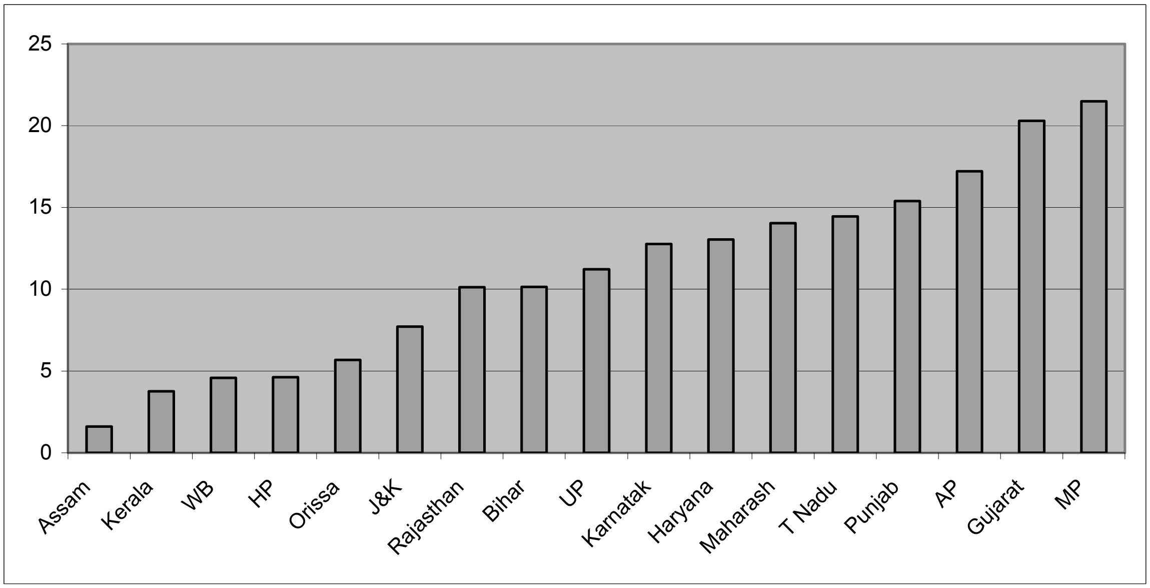


Figure 2b. Input Subsidies, Rs per Hectare of Cropped Land

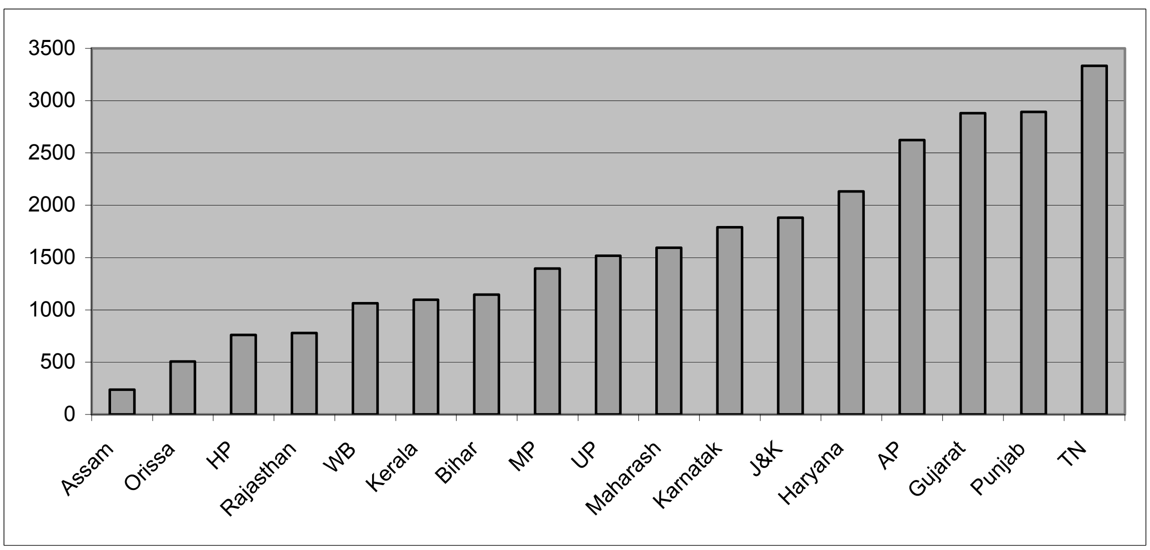
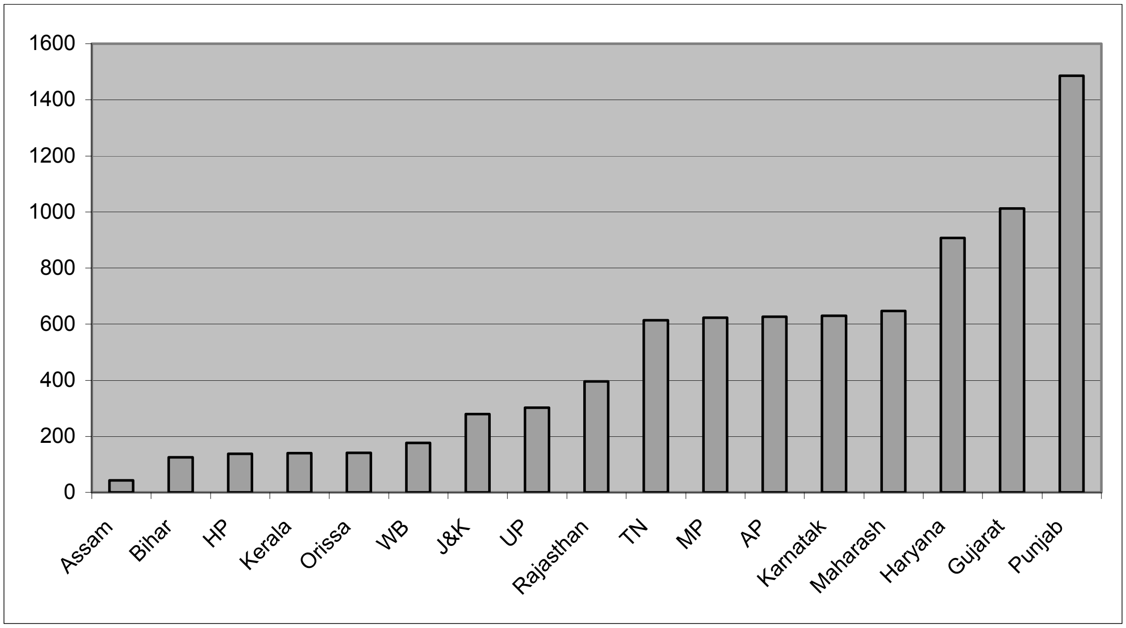


Figure 2c. Input Subsidies, Rs per Agricultural Person



3. EFFECTS OF PUBLIC INVESTMENTS AND SUBSIDIES

Analytical Approach and Model

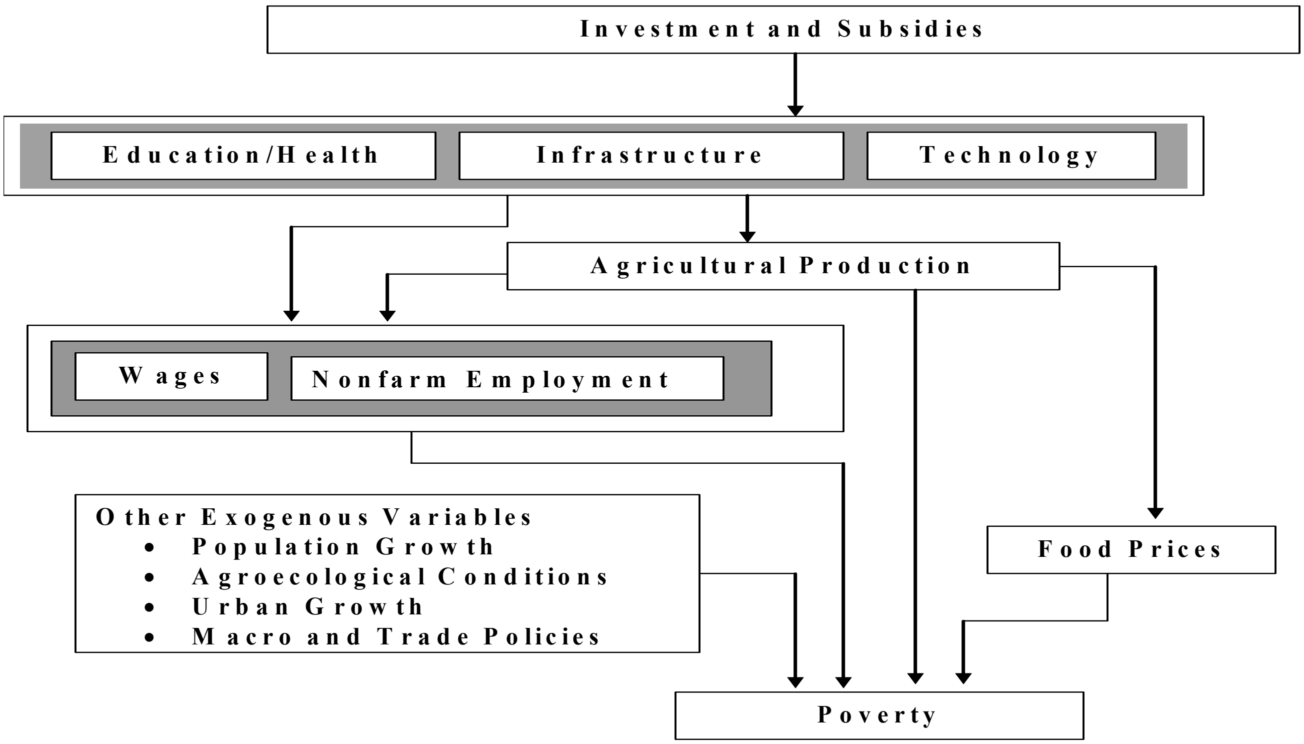
Model

In a previous study, Fan, Hazell, and Thorat (2002) used state-level data from 1951 to 1993 to estimate the marginal returns of different types of government spending on agricultural growth and poverty reduction. The impact of government spending on poverty was estimated by analyzing linkages across agricultural growth, the development of the rural nonfarm economy, and rural wages. However, that study was unable to offer analysis by different time periods due to limited data, and it did not distinguish between impacts arising from investments and subsidies. But to prioritize future government spending, we need to analyze impacts over time and from different types of expenditures.

Therefore, we use a multi-equation system to estimate the effects of government investment and subsidies on poverty, and a full information maximum likelihood method for the estimation technique. The system of 10 equations includes a poverty equation that is a function of agricultural growth, changes in wages, nonfarm employment, and food prices. These equations further endogenize equations of agricultural growth, rural wages, nonfarm employment, and food prices, and these latter equations are linked to forms of public capital, such as agricultural research investment, improvements in roads, electricity, education, and irrigation. Finally a set of equations model the relationships between government spending and public capital. The relationships described by these equations are also shown in Figure 3.

(1) *POVERTY = f1 (AY, AWAGES, NFE, TT)*
(2) *AY = f2 (LAND, FERT, ROADS, LITE, IRRI)*
(3) *AWAGES = f3 (UGDPP, AY, ELECT, ROADS, LITE)*
(4) *NFE = f4 (UGDPP, AY, ELECT, ROADS, LITE)*
(5) *TT= f5 (AY, WFPI, UGDPP)*
(6) *FERT= f6 (FERTS, CRS, RDS, IRS, ELECT)*
(7) *IRRI = f7 (IRI)*
(8) *ELECT= f8 (ELECS)*
(9) *ROADS= f9 (ROADI)*
(10) *LITE= f10 (EDUI)*

Figure 3. Model Relationships between Public Spending and Poverty



Equation (1) models the determinants of the rural poverty rate (*P*), which is defined as the percentage of rural residents under the poverty line. The explanatory variables include agricultural labor productivity (*AY*), agricultural wages (*AWAGES*), the percentage of nonagricultural employment (*NFE*), and the terms of trade (*TT*). Agricultural labor productivity is included in the poverty equation to proxy agricultural income as agriculture is still the dominant source of income for most rural residents in India. Wages are the second most important source of income after agricultural production for Indian rural residents. Together, rural wages and rural nonfarm employment capture the impact of nonfarm activities on poverty reduction. The terms of trade variable measures the rural poverty impact of the changes in agricultural prices relative to nonagricultural prices. It is hypothesized that in the short run, the poor may suffer from higher agricultural prices because they are usually net buyers of foodgrains.

The second equation is a labor productivity function. Land *(LAND)* and fertilizer *(FERT)*, on a per worker basis, are included as conventional inputs. To capture the impact of government interventions on productivity and production growth, we also include the following variables in the equation: the percentage of cropped area sunder irrigation *(IRRI)*, the literacy rate of the rural population (*LITE*), and road density (*ROADS*). Although agricultural research and rural electrification could be added to the explanatory variables, they are highly correlated with fertilizer, and therefore are excluded from the equation. Instead, we will include these variables in the fertilizer demand equation.

Equation (3) is a wage determination function. Rural wages are determined by agricultural labor productivity *(AY)*, electrification *(ELECT)*, roads *(ROADS)*, and literacy rate *(LITE)*. The impact of improved roads on wages is often ignored when specifying a wage determination equation. Ignoring this effect is likely to lead to an underestimation of the impact of government spending on poverty, since wage increases induced by improved rural roads can be potentially large, benefiting workers in their agricultural and nonagricultural activities. We also include urban GDP growth (*UGDPP*) to control for the effects of urban labor demand on rural wages.

Equation (4) determines nonagricultural employment. Similar to the wage equation, it is modelled as a function of urban GDP growth *(UGDPP),* agricultural labor productivity *(AY)*, rural roads *(ROADS)*, electrification *(ELECT),* and education *(LITE)*. Improved roads should help farmers to set up small nonfarm businesses and to market their products. Improved roads and education also help farmers to find jobs in towns.

Equation (5) determines the terms of trade. Growth in agricultural production increases the aggregate supply of agricultural products, and therefore reduces agricultural prices. Lower prices will help the poor if they are net buyers of grains. A world price index of rice, wheat, and corn *(WFPI)* is included in the equation to capture the impact of international markets on domestic agricultural prices. In addition to agricultural labor productivity *(AY)*, we also include urban GDP growth *(UGDPP)* in the equation to capture the demand side effects on agricultural prices.

Equation (6) models fertilizer use in agriculture. It includes government subsidies in fertilizer (*FERTS)*, subsidies in credit *(CRS)* and irrigation *(IRS)*, agricultural research *(RDS)*, and electrification *(ELECT)*. Many of these variables affect agricultural production through fertilizer use. For example, improved irrigation and new seeds from agricultural research would increase farmers' demand for fertilizer use. A variety of evidence shows that modern seeds would not have performed as well without fertilizer and irrigation.

Equation (7) models the relationship between government investment in irrigation *(IRRI)* and the percentage of the cropped area under canal irrigation *(IRI)*. Since nearly all canal irrigation results from government investment, we use the cropped area under canal irrigation as a proxy for public irrigation.

Equation (8) models agricultural electricity consumption *(ELECT)* as a function of government subsidies in agricultural electricity *(ELECS)*. Ideally, we should also include capital investment in generating electricity for agriculture in the function. However, electricity is generated by the power sector. Thus, it is difficult to separate the use of capital between the agricultural and the nonagricultural sectors. Second, agricultural electricity consumption is only a small portion of overall power use.

Therefore, the use of electricity for agriculture will not be affected by overall power investment. However, as the charge rates for the agricultural sector is much lower than the rates for the nonagricultural sector, power subsidies in the agricultural sector (estimated as the difference between rates for agricultural use and nonagricultural use) should be an important factor in determining the amount of electricity used in agriculture.

Equations (9) and (10) model the relationships of the stock of improved roads and education as functions of their past investments.

Specification Tests and Estimation Procedure

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

Numerous studies have examined the impact of public spending on growth and poverty reduction. One significant feature of the literature is the use of a single-equation approach. There are at least two disadvantages to this method. First, many poverty determinants, such as production or productivity growth, prices, wages, and nonfarm employment, are generated from the same economic process as poverty. In other words, these variables are also endogenous variables. Ignoring this characteristic leads to biased estimates of the poverty effects. Second, certain economic variables affect poverty 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 therefore very difficult to capture these different effects using a single-equation approach.

In our estimation, all endogenous variables that appear on the right-hand side of equations (1) to (10) are lagged for one year. This has two advantages. First, it allows weak exogeneity of the endogenous variables. Second, since every equation has its own predetermined variables, the model is identified, which means it is possible to obtain an estimate of each parameter.

Before proceeding to the estimation, it is important to test the model specification. One important test is the test of endogeneity of the exogenous variables, which include various subsidy and investment variables, world food price, and urban per capita GDP. Since India is a small importing and exporting country for most of its agricultural commodities, it is a price taker in the international food market. Therefore, there is hardly a need to test for the endogeneity of the world food price variable. The one-year lagged per capita urban GDP variable is used in the wages, nonfarm employment, and agricultural price determination equations. Therefore, they can be considered predetermined and weakly exogenous, and will not impact the estimated parameters unless there is a serial correlation. The variables that are potentially most problematic are government investment and subsidies. For these variables we use the Durbin-Wu-Hausman test to decide whether they are indeed exogenous. Two variables, education investment and fertilizer subsidies, are found to be endogenous after testing. These two variables were replaced with instruments, which are the fitted values when they are regressed on all the truly exogenous variables. The estimated results are shown in Tables 1 to 5.

Results of Model Estimation

In the estimated poverty equations, agricultural labor productivity and rural wages are negatively correlated with rural poverty in all decades, although in the case of rural wages this relationship is not significant (at 95 percent) for the two earlier decades (Table 1). Nonfarm employment is also negatively correlated with poverty, but only in the 1980s and 1990s. Agricultural terms of trade (relating agricultural and nonagricultural prices) is negatively correlated with poverty for the first three decades (although only in the 1980s is this significant at 95 percent), but then positively correlates with poverty in the 1990s (significant at 95 percent). Thus, as these results show, higher relative prices of agricultural commodities appear to have benefited the poor in earlier decades, especially during the 1980s, but then harmed them in the 1990s. Such a result raises a tough question: what factors could be behind this shift in the relation between terms of trade and poverty? Although a more robust answer would require further probing and analysis, at this stage we can only conjecture that the increasing role of nonagricultural activities in the livelihoods of the poor may be the cause of the shift, or the very structure of agricultural price increases may have shifted the relationship, reflecting the possible dominance of foodgrain prices in the 1990s. These findings also suggest that as Indian agriculture has developed the relationships between poverty on the one hand and nonfarm employment and agricultural terms of trade on the other may have undergone a structural change.

Table 1. Estimated Poverty Equation

Time Period	AY	AWAGES	NFE	TT
1960s	-0.387	-0.133		-0.030
	(-3.37)*	(-1.55)		(-1.27)
1970s	-0.368	-0.262		-0.124
	(-7.14)*	(-6.13)*		(-1.29)
1980s	-0.509	-0.181	-0.211	-0.119
	(-13.42)*	(-4.83)*	(-3.15)*	(-2.14)*
1990s	-0.481	-0.132	-0.1123	0.240
	(-11.45)*	(-2.03)*	(-3.28)*	(3.98)*
R^2=0.874				

Notes: The dependent variable is the percentage of rural population under the poverty line.
Figures in the parentheses are t-values. Asterisk indicates significant at the 5% level.

Table 2. Estimated Labor Productivity Equation

Time Period	LAND	FERT	LITERACY	ROADS	IRRI
1960s	0.506	0.056	0.150	0.06	0.341
	(6.38)*	(1.32)	(2.68)*	(0.66)	(2.02)*
1970s	0.506	0.087	0.30	0.029	0.250
	(13.04)*	(3.65)*	(4.42)*	(1.87)*	(3.72)*
1980s	0.532	0.122	0.251	0.023	0.293
	(14.28)*	(5.33)*	(2.90)*	(1.88)*	(4.82)*
1990s	0.532	0.289	0.190	0.091	0.221
	(15.73)*	(8.66)*	(3.61)*	(4.85)*	(3.82)*
R2=0.806					

Notes: The dependent variable is agricultural GDP per rural inhabitant. Figures in the parentheses are t-values. Asterisk indicates significant at the 5% level.

Table 3. Estimated Wages Equation

Time Period	AY	NSDPP	ROADS	LITERACY
1960s	0.571	-0.070	0.225	-0.269
	(3.30)*	(-0.15)	(3.05)*	(-1.09)
1970s	0.353	-0.110	0.191	-0.151
	(3.36)*	(-1.21)	(5.63)*	(-1.22)
1980s	0.255	0.075	0.042	0.341
	(4.42)*	(-1.24)	(1.48)	(2.43)*
1990s	0.386	0.029	0.030	0.126
	(4.63)*	(0.44)	(1.03)	(2.84)*
R2=0.548				

Notes: The dependent variable is rural daily wages. Figures in the parentheses are t-values. Asterisk indicates significant at the 5% level.

Table 4. Estimated Rural Nonfarm Employment Equation

Time Period	NSDPP	ROADS	LITERACY	ELECT
1960s	-0.281	0.020	0.355	0.023
	(-0.22)	(0.37)	(1.88)*	(0.60)
1970s	-0.178	0.075	0.377	0.033
	(-1.23)	(3.43)*	(5.26)*	(1.89)*
1980s	-0.102	0.010	0.559	0.090
	(-1.29)	(0.46)	(7.19)*	(3.17)*
1990s	0.289	0.112	0.257	-0.070
	(5.10)*	(4.18)*	(2.79)*	(-1.49)
R2=0.727				

Notes: The dependent variable is percentage of rural labor engaged in nonfarm activities. Figures in the parentheses are t-values. Asterisk indicates significant at the 5% level.

Table 5. Estimated Fertilizer Demand Equation

Time Period	FERTS	CREDITS	IRS	ELECT	RDS
1960s	0.384	0.004	0.11	0.236	0.133
	(3.42)*	(0.04)	(3.12)*	(4.01)*	(1.69)
1970s	0.602	0.0608	0.07	0.101	0.081
	(9.97)*	(1.83)*	(1.46)	(3.36)*	(1.87)*
1980s	0.079	0.32	0.15	0.240	0.542
	(1.79)*	(5.35)*	(0.67)	(8.65)	(10.11)*
1990s	0.36	0.25	-0.114	0.230	0.042
	(5.61)*	(4.27)*	(-1.89)*	(3.32)*	(1.16)
R2=0.932					

Notes: The dependent variable is fertilizer use per acre. Subsidies on fertilizer, credit and irrigation are also expressed on a per acre basis. Figures in the parentheses are t-values. Asterisk indicates significant at the 5% level.

Estimated results from Tables 2 to 5 also suggest: (1) over time fertilizer use and road density appear to have an increasing impact on agricultural labor productivity; (2) rural wages are increasingly affected by literacy rates, but decreasingly affected by road density; (3) urban growth has increasing impact on nonfarm employment (although there is no evidence of change in the positive effects of literacy on nonagricultural employment); (4) there is some evidence that agricultural terms of trade are affected only negatively by agricultural growth from the 1980s onwards, and only weakly by urban growth and world prices (but the direction of these relations changes as the weakly negative effects of urban GDP growth become weakly positive from the 1980s onwards, and the weakly positive effects of world prices become weakly negative during the same period); and (5) irrigation subsidies have a decreasing impact on fertilizer use. Together these changes in estimated coefficients (and in their levels of significance) suggest increasing integration of the economy, with increasing importance of nonagricultural employment for wages (from [2] and [3] above) and of rural–urban linkages (from [3] and [4] above); they also suggest increasing efficiency in the use of purchased (fertilizer) inputs (from [1] and [5] above).

The policy implications of these structural changes can be investigated further by examining the marginal growth and poverty reduction effects of different types of government investment and subsidies over the four decades of the study period.

Marginal Returns in Growth and Poverty Reduction

The marginal impact and elasticity of different types of government subsidies and expenditures on rural poverty can then be obtained by differentiating the equations with their estimated coefficients. These returns are calculated for four decades: 1960s (1967-70), 1970s (1971-79), 1980s (1980-89), and 1990s (1990-97). Marginal effects are expressed as: (1) production (rupees per unit of spending in 1999) and (2) poverty (number of poor brought out of poverty per unit of spending in 1999). For example, the returns to investments in irrigation are measured as rupees of additional production (or the number of persons brought out of poverty) for every additional million rupees spent on irrigation. These measures provide useful information for comparing the relative benefits of additional units of expenditure on different types of investment items in different regions. They can also guide priorities for government expenditures to further increase agricultural production and reduce rural poverty.

Table 6 details the estimated marginal effects of different types of government expenditure in each decade, in terms of impact on agricultural GDP and poverty reduction. Considering first the estimated returns to agricultural GDP, in the 1960s most investments and subsidies generated returns that were both significantly greater than zero and larger than their costs.[3] In particular, road and education investments had estimated benefit-cost ratios of 6 to 9. Agricultural research investments and subsidies on irrigation, fertilizer, and credit yielded benefits that were 2 to 4 times the amount spent. This was the period when HYVs, fertilizer, and credit were being promoted as a high payoff technology package. Irrigation investments and subsidies and power subsidies yielded the lowest returns in this period, though returns to irrigation investment and subsidies were estimated as more than double spending.

In the 1970s, the returns to most of these subsidies and investments declined, with the exception of agricultural R&D and education. Road investments and fertilizer subsidies, however, remained good value for money (with returns of 300 percent or more). Estimated returns to irrigation investments and subsidies and to power and credit subsidies fell to 200 percent or less. By the 1980s, returns to fertilizer subsidies had fallen to below 100 percent, but returns to agricultural R&D continued to rise. Although returns to road and educational investments had fallen, they remained "good buys" along with irrigation investments and credit subsidies (estimated returns to these had risen). By the 1990s only agricultural R&D and road investments continued to yield estimated returns of more than 300 percent. Estimated net returns to irrigation investments and education were low but still positive, whereas credit, power, and fertilizer subsidies had negative net returns, and subsidies on irrigation had no significant impact on agricultural production at all.

Turning now to consider the poverty reduction impacts of different types of government spending in different decades, Table 6 shows estimated number of people lifted out of poverty per million Rs spent. Results follow the same broad pattern as that for agricultural GDP growth, with a few (generally minor) differences. Thus, across all decades the estimated costs of reducing poverty by spending on roads, agricultural R&D, and education were relatively low (although educational cost rises in the 1990s). Fertilizer subsidies are estimated to have been effective at reducing poverty in the two earlier decades, but

[3] The coefficients of the labor productivity function are used in calculating the returns in agricultural GDP. These coefficients should be the same as the agricultural GDP function if constant returns to scale are assumed.

subsequently appear to have been highly ineffective. Credit subsidies were effective in the 1960s and 1980s. Power subsidies were never a good buy.

These results have significant policy implications: most importantly, they sow that spending government money on investments is surely better than spending on input subsidies. And within different types of investments, spending on agricultural R&D and roads is much more effective at reducing poverty than putting money in, say, irrigation.

Table 6. Returns in Agricultural Growth and Poverty Reduction to Investments and Subsidies

	1960s		1970s		1980s		1990s	
	returns	rank	returns	rank	returns	rank	returns	rank
Returns in Agricultural GDP (Rs per Rs spent)								
Road Investment	8.79	1	3.8	3	3.03	5	3.17	2
Educational Investment	5.97	2	7.88	1	3.88	3	1.53	3
Irrigation Investment	2.65	5	2.1	5	3.61	4	1.41	4
Irrigation Subsidies	2.24	7	1.22	7	2.28	6	n.s.	8
Fertilizer Subsidies	2.41	6	3.03	4	0.88	8	0.53	7
Power Subsidies	1.18	8	0.95	8	1.66	7	0.58	6
Credit Subsidies	3.86	3	1.68	6	5.2	2	0.89	5
Agricultural R&D	3.12	4	5.9	2	6.95	1	6.93	1
Returns in Rural Poverty Reduction (Decrease in number of poor per million Rs spent)								
Road Investment	1272	1	1346	1	295	3	335	1
Educational Investment	411	2	469	2	447	1	109	3
Irrigation Investment	182	5	125	5	197	5	67	4
Irrigation Subsidies	149	7	68	7	113	6	n.s.	8
Fertilizer Subsidies	166	6	181	4	48	8	24	7
Power Subsidies	79	8	52	8	83	7	27	6
Credit Subsidies	257	3	93	6	259	4	42	5
Agricultural R&D	207	4	326	3	345	2	323	2

4. POLICY LESSONS

This study constructed a data series at the state level over the last several decades on investment and subsidies in and for Indian agriculture, based a which an econometric model was constructed and estimated to quantify the impact of various government investment and subsidies on agricultural growth and poverty reduction by different decade. The following conclusions can be drawn from the study:

(1) The success of the Green Revolution during the late 1960s and 1970s indicates that pre-conditions may have been important to the outcome. India had already invested heavily in irrigation, electricity, roads, and human capital prior to the Green Revolution. Without these investments, the Green Revolution may not have spread as fast as it did, even with the advent of new technologies such as high-yielding varieties.

(2) Initial subsidies in credit, fertilizer, and irrigation helped farmers, especially the smallholders, to adopt the new technologies. Small farms are often losers in the initial adoption stage of a new technology because the increased supply of agricultural products from large farms that have benefited from new technologies pushes prices down.

(3) Agricultural research, education, and rural infrastructure are the three most effective public-spending items for promoting agricultural growth and poverty reduction throughout the periods under study. In contrast, in more recent years, input subsidies (including fertilizer, electricity, credit, and irrigation) yielded very low marginal returns in both agricultural growth and poverty reduction, despite their large impact in earlier decades.

(4) The trade-off between agricultural growth and poverty reduction is generally small among different types of public spending. Investments in agricultural research, education, and infrastructure development all have large impacts on economic growth and poverty reduction.

Several policy lessons can be drawn from this study. First, for the last two decades, we have seen a declining trend in government investment in the agricultural sector and an increasing trend in government subsidies. These subsidies, including those on fertilizer, irrigation, power, and credit, amounted to about 2 percent of the national GDP and 8-10 percent of agricultural GDP (Gulati and Narayanan 2003). These outlays are in direct competition with more long-term capital investment in roads, rural education, and agricultural research. To sustain long-term growth in agricultural production and therefore achieve a long-term solution to poverty reduction, the government should cut subsidies and increase investments in agricultural R&D, rural infrastructure, and education.

Second, the role of nonfarm employment in poverty reduction has become increasingly significant over time. It will become even more so in the future, as the average size of Indian farms decrease. These small farms may be efficient in terms of land productivity, but not in terms of labor productivity, which has greater impact on farmers' incomes. Promoting greater off-farm opportunities and migration from rural to urban areas (particularly to small cities) is inevitable if we are to increase average farm size in order to increase labor productivity and farmers' incomes. But over the last two decades, growth in the nonfarm sector has not been ideal. The nonfarm share of rural employment has increased only marginally, from 20 percent in the 1970s to less than 30 percent today.[4] Reforms in the power sector, along with reforms in investment provisions for agro-processing, could unleash a sort of revolution in nonfarm activities in rural areas, substantially boosting nonfarm employment.

Third, India's success during the Green Revolution came from political will: the government was strongly committed to making the food supply more secure. Today, political will is equally important for reforming public policy in agriculture and reducing input and output subsidies. These subsidies have been unproductive, financially unsustainable, and environmentally unfriendly, and have contributed to increased inequality among rural Indian states. They have also crowded out more productive government spending in agricultural R&D, rural roads, and education. But simply reallocating public resources is not the only solution. Public institutions must be reformed. These reforms can have an equal, if not larger, impact on future agricultural and rural growth and rural poverty reduction.

[4] This contrasts sharply with China, where the percentage of nonfarm employment in total rural employment increased from 7 percent in 1978 to more than 40 percent in 2003.

APPENDIX: DEFINITION OF PUBLIC INVESTMENT VARIABLES

Government expenditure data by state were obtained from *Finances of State Governments*, various issues, published by the Reserve Bank of India. All expenditures were deflated into 1960/61 prices using a national GDP deflator. Expenditures include both revenue (for maintenance) and capital (investment) account.

Agricultural R&D. Agricultural R&D expenditure includes government expenditure on agricultural research and extension.

Rural roads. We used the share of the length of rural roads in the length of total roads to calculate the expenditures for rural roads, assuming that the cost per unit of rural roads is one-fifth that of urban roads. This differential cost of roads can be supported by the World Bank Road Information System, which provides unit costs for World Bank-funded road projects across different countries, including India. In China this ratio is 8.3. If the China ratio was used, the road effects would be 66 percent higher.

Rural electricity. The share of agriculture in total electricity consumption is used to estimate the capital investment for agricultural electricity.

Rural education. There is no separate account of government expenditures for rural and urban areas in state government financial statistics. We used the following regression procedure to determine the ratio of cost per capita between rural and urban areas. Total education expenditures at the state level = rural population *per capita education cost in rural areas + urban population* per capita education cost in urban areas. All variables are known except for the per capita education cost in rural and urban areas. Using the state-level data from 1967 to 1999, we can estimate econometrically these two unknown parameters. The estimated results show that per capita education cost in urban area is 4.72 times greater than per capita cost in rural areas. Using this differential, we calculated the rural education cost at the state level.

Stock of public capital. The monetary stocks of public capital variables are calculated using the following procedure:

(11) $$K_t = I_t + (1-\delta)\mathrm{K}_{t\text{-}1}.$$

Here, K_t is the capital stock in year t, I_t is gross capital formation in year t, and δ is the depreciation rate (10 percent).

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