EPTD DISCUSSION PAPER NO. 94

AGRICULTURAL RESEARCH AND URBAN POVERTY IN INDIA

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September 2002

ABSTRACT

Using a similar analytical approach to a study in China, this paper analyzes the impact of agricultural research on urban poverty reduction in India. State level data from 1970 to 1995 were used in the empirical analysis. It is found that in addition to its large impact on rural poverty reduction, agricultural research investments have also played a major role in the reduction of urban poverty. Agricultural research investments increase agricultural production, and increased production in turn lowers food prices. The urban poor often benefit proportionately more than the non-poor since they spend 50-80% of their income on food. Among all the rural investments considered in this study, agricultural research has the largest impact on urban poverty reduction per additional unit of investment. The results from this study are similar to earlier findings for China.

Today, urban poverty still accounts for one quarter of total poverty in India, and this share is expected to rise in the future. Policymakers cannot afford to be complacent about this trend and continued investments are still needed to keep food prices low. Among all government policy instruments, increased agricultural research is still the most effective way to achieve this objective.

KEYWORDS: developing countries, India, agricultural research, urban, poverty, food price
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AGRICULTURAL RESEARCH AND URBAN POVERTY IN INDIA

Shenggen Fan[1]

1. INTRODUCTION

The debate on the role of agricultural research in poverty alleviation dates back to the green revolution in South Asia and Mexico in the late 1960s (Pinstrup-Andersen and Hazell, 1985). A general consensus has emerged that not only did research-led technology prevent widespread starvation; it also contributed to significant national economic growth and saved huge areas of forest, hillsides and other environmentally fragile lands from conversion to agriculture. For example, the green revolution contributed to more than a doubling of the aggregate food supply in Asia over a 25-year period. More importantly, it achieved this output increase with only a 4 percent increase in the net cropped area (Rosegrant and Hazell, 2000). There is also a large empirical literature on the economic returns to agricultural research investment in developing countries. Alston et al. (2001) reviewed 292 studies (more than 1886 rates of return estimates) and obtained an average rate of return of 100 percent to agricultural research investment with a median rate of return of 48 percent.

Fan, Hazell and Thorat (2000) were the first to directly link agricultural research to rural poverty reduction. Their results for rural India indicate that agricultural research has the largest productivity impact of all kinds of government investments included in their study. This growth impact has also trickled down to the rural poor. In fact,

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agricultural research has the second largest impact on rural poverty reduction in India, second only to investments in rural roads. Using provincial-level data for China, Fan, Zhang, and Zhang (2002) reached a similar conclusion that agricultural research has the largest productivity effect on agricultural production, and also has the second largest poverty impact in rural China. Only investments in rural education have a larger poverty impact.

The links between agricultural research and food price benefits for consumers have also been quantified, using the consumer surplus as a welfare measure (Akino and Hayami 1975; Mellor 1975; Scobie and Posada 1978; and Pinstrup-Andersen 1979). But little work has been done on quantifying the impact of agricultural research on urban poverty reduction, despite the fact that rapid urbanization is increasing the incidence of urban poverty in developing countries (Haddad et al. 1999; Ravillion 2000). Fan, Fang, and Zhang (2002) were the first to develop a model formally linking agricultural research with urban poverty reduction and applied it to China. This paper uses India as a case to reinforce the findings of the China case study. But the India case has its own merits. First, India is largely a market-driven economy, in contrast to the centrally-planned economy practiced by China until the late 1970s. The distorted nature of food prices in China makes it difficult to fully capture the impact of agricultural research on urban poverty reduction by lowering urban food prices. Second, despite considerable success reducing poverty, India today still has more than 70 million urban poor, accounting for one third of India's total poor. India also accounts for a large share of the total global urban poor (more than 40%). Developing a national strategy to prevent further increases in urban poverty is more urgent than ever.

The paper is organized as follows. We first review historical trends in agricultural research investment, technology development, and productivity growth in Indian agriculture, followed by a brief discussion of changes in urban poverty. Second, a conceptual framework and model are developed and adapted for the analysis of how agricultural research affects the urban poor, and the estimation procedures and results are discussed. We then conclude with some policy implications.

2. AGRICULTURAL RESEARCH, TECHNOLOGY, PRODUCTIVITY

Government spending on agricultural research in India has increased significantly over the past four decades, but not without substantial year-to-year variations (Table 1). Investment in agricultural research was quite modest during the 1960s, ranging from 1.6 to 1.9 billion Rupees (all values in 1995 prices). During the 1970s, expenditures on agricultural research increased dramatically to 4.0 billion Rs around 1980, more than doubling in the decade. This was the period when many agricultural universities and national research institutions were set up (Evenson, Rosegrant, and Pray, 1999). These were the driving force behind the green revolution that more than doubled the yields of rice and wheat within a decade. During the 1980s, research expenditures continued to increase to 7 billion Rs in 1990. But in the 1990s, research expenditure increased only modestly to 7.3 billion Rs by 1995, which is worrying given their importance to national food security and poverty alleviation.

As a percentage of agricultural gross domestic product (AgGDP), agricultural research investment was relatively low at 0.20% during the 1960s, but it increased dramatically to more than 0.40% in the 1970s. In the 1980s, the percentage continued to rise, to a peak of 0.50% in 1987. But the percentage has gradually declined to below 0.43% in recent years. This indicates that government investment in agricultural research has increased in absolute terms over the past decade, but has declined relative to the size of the agricultural sector.

One of the most significant changes in Indian agriculture in recent decades has been the widespread adoption of high-yielding varieties. During the green revolution of the 1970s, the crop area planted to high-yielding varieties (HYVs) for five major crops (rice, wheat, maize, sorghum, and pearl millet) increased from about 20 percent to 40 percent (Table 2).[3] Even after the green revolution, the percentage of the crop area planted with HYVs continued to increase. It reached 53 percent by 1990, and 59 percent by 1995. This has been one of the major engines of productivity growth in Indian agriculture.

As a result of the rapid adoption of new technologies and improved rural infrastructure, agricultural production and factor productivity have both grown rapidly in India. For all India, agricultural production grew at 2.11 percent per annum between 1970 and 1995 (Table 2). In the 1970s, production growth was comparatively low, growing at an average annual rate of only 1.95 percent. In the 1980s, it grew at 3.82

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[3] High-yielding varieties (also referred to as modern varieties) are those released by the Indian national agricultural research system and the international agricultural research centers. The yields of these varieties are usually substantially higher than those of traditional varieties. The percentage of cropped areas with HYVs is calculated as the ratio of areas planted with HYVs for 5 major crops (rice, wheat, maize, sorghum, and pearl millet) to the total cropped areas of these five crops.

percent per annum, a much higher growth rate than most other countries achieved during the same period. Since 1990, production growth has slowed, growing at only 2.09 percent per annum.

Total factor productivity for India grew at an average annual rate of 0.69 percent between 1970 and 1995 (Table 2). In the 1970s, total factor productivity grew at 1.37% per annum. But it grew fast in the 1980s, at 1.99 percent per annum. Since 1990, total factor productivity growth in Indian agriculture has declined, at a rate of –0.59 percent per annum.

Table 1--Agricultural research expenditures in India, 1964-95

	Research Expenditures a/		Research Intensity Ratio b/
	million 1990 Rs	*million 1990 PPPs*	%
1964	1,629	378	
1965	1,581	367	0.21
1966	1,869	434	0.25
1967	1,590	369	0.18
1968	1,684	391	0.19
1969	1,879	436	0.20
1970	1,902	441	0.20
1971	1,886	438	0.21
1972	1,973	458	0.22
1973	1,741	404	0.17
1974	2,504	581	0.26
1975	3,178	737	0.33
1976	3,471	805	0.38
1977	3,965	920	0.38
1978	4,407	1,022	0.43
1979	4,148	962	0.45
1980	3,982	924	0.38
1981	4,128	958	0.39
1982	4,292	995	0.41
1983	4,695	1,089	0.40
1984	4,978	1,155	0.43
1985	4,572	1,061	0.39
1986	5,115	1,186	0.44
1987	6,011	1,394	0.50
1988	6,517	1,512	0.48
1989	6,507	1,509	0.46
1990	7,085	1,643	0.48
1991	6,873	1,594	0.46
1992	6,754	1,567	0.44
1993	7,280	1,689	0.44
1994	7,246	1,681	0.42
1995	7,293	1,692	0.43

a/ Agricultural research expenditures were obtained from the State Planning Commission, Government of India. The GDP deflator was used to deflate expenditures to 1995 prices. We then used the1995 exchange rate based on purchasing power party (PPP) to convert expenditures into 1995 international dollars.

b/ The agricultural research intensity ratio is defined as agricultural research expenditure as a percentage of agricultural GDP.

Table 2--Agricultural technology, production and productivity growth in India, 1970 – 95

	HYV Adoption	Production Growth	Productivity Growth	Urban Food Price Index
	%	%	%	%
1970	21	100	100	100.00
1971	24	100	99	98.88
1972	23	93	92	n.a
1973	25	97	98	101.23
1974	26	101	100	102.44
1975	29	114	113	n.a.
1976	31	105	103	n.a.
1977	34	115	112	n.a.
1978	36	119	114	97.37
1979	37	119	113	n.a.
1980	41	120	112	n.a.
1981	40	127	116	n.a.
1982	43	125	110	n.a.
1983	41	135	118	97.31
1984	45	131	114	n.a.
1985	44	141	120	n.a.
1986	46	133	114	n.a.
1987	48	136	114	95.33
1988	47	152	130	95.78
1989	53	168	134	95.78
1990	53	152	121	n.a.
1991	57	152	119	95.78
1992	56	153	118	94.44
1993	57	156	118	96.02
1994	64	165	118	n.a.
1995	59	n.a.	n.a.	n.a.
Annual Growth Rate (%)				
1970-79	6.25	1.95	1.37	
1980-89	3.10	3.82	1.99	
1990-95	2.10	2.09	-0.59	
1970-95	4.19	2.11	0.69	

Sources: HYV (high yielding variety), production and productivity growth data are from Fan, Hazell, and Thorat, (1999). Food price index is from the Indian Statistical Abstract.

3. URBAN POVERTY

In the early 1970s, both rural and urban poverty rates were high with 57% of the rural population and 47% of the urban population living under the poverty line (Table 3). Due to the high growth in agriculture, the rural poverty rate declined to 45% by the mid-1980s. The urban poverty rate also declined to 36%. In addition to growth in urban income, the decline in real food prices relative to nonfood prices may have played a large role in this reduction. From the mid-1980s to 1987, rural poverty continued to decline to 39%, but urban poverty changed very little. The reduction in rural poverty during this period is mainly due to the development of rural nonfarm employment and increases in rural wages. The so-called "trickle down" benefits of agricultural growth for the rural poor were almost nonexistent since both agricultural production and productivity growth was largely stagnant. The impact of agricultural growth on urban poverty through lower food prices was also absent.

There was a relatively rapid reduction in rural and urban poverty during the second half of the 1980s. The rapid increases in agricultural production and productivity is the major reason behind this reduction in rural poverty. The growth in agricultural production and productivity may have also contributed to urban poverty reduction by keeping food prices low. If fact, the relative food price index dropped by 2 percentage points during this period.

In summary, whenever there is higher growth in agricultural production and productivity, rural poverty declines. But it is also true that urban poverty falls when agricultural growth is high.

Table 3--Poverty in India, 1970 - 95

	Rural Poverty	Urban Poverty	Urban Poor	Rural Poor	Share of Urban Poor
	%	*%*	*million*	*million*	*%*
1970	57.61	47.16	51.69	256.53	16.77
1971	54.84	44.98	51.12	248.99	
1972	n.a.	n.a.	n.a.	n.a.	n.a
1973	55.36	45.67	55.97	260.99	17.66
1974	55.72	47.96	61.07	267.46	18.59
1975	n.a.	n.a.	n.a.	n.a.	n.a
1976	n.a.	n.a.	n.a.	n.a.	n.a
1977	n.a.	n.a.	n.a.	n.a.	n.a
1978	50.60	40.50	59.95	259.54	18.77
1979	n.a.	n.a.	n.a.	n.a.	n.a
1980	n.a.	n.a.	n.a.	n.a.	n.a
1981	n.a.	n.a.	n.a.	n.a.	n.a
1982	n.a.	n.a.	n.a.	n.a.	n.a
1983	45.31	35.65	62.36	253.06	19.77
1984	n.a.	n.a.	n.a.	n.a.	n.a
1985	n.a.	n.a.	n.a.	n.a.	n.a
1986	n.a.	n.a.	n.a.	n.a.	n.a
1987	38.81	34.29	67.73	232.36	22.57
1988	39.60	35.65	72.55	241.10	23.13
1989	39.06	36.60	76.71	241.77	24.09
1990	34.30	33.40	72.06	215.79	25.03
1991	36.43	32.76	72.72	232.89	23.79
1992	40.00	33.50	74.36	259.76	22.26
1993	36.66	30.51	71.63	241.73	22.86
1994	41.00	33.50	80.88	274.36	22.77
1995	37.15	28.40	70.54	252.15	21.86

Sources: Rural and urban poverty rates are from Datt (1998), and the number of rural and urban poor was calculated by the author using rural and urban population data from FAO (2002).

4. ECONOMETRIC MODEL

To analyze the links between agricultural research and urban poverty, we developed an econometric model in which an agricultural production function, price determination function, and urban poverty equation were estimated. This is because agricultural research investments affect poverty through changes in food prices, it is difficult to capture this link using a single equation approach.

$$(1) \qquad TFP = h(RDE, RDE_{-1}, \ldots RDE_{-2}, RDE_{-I}, IR, ROADS, PVELE, LITE, GCSHEL, GERDEV, GCSSL, RAIN)$$

$$(2) \qquad FP = g(TFP, GDP, POP, WPI, S)$$

$$(3) \qquad UP = f(FP, M, GINI, Z)$$

Equation (1) models the determination of TFP growth in agriculture. The TFP growth index is the ratio of an aggregated output index to an aggregated input index. The following variables are included in the equation: current and lagged government spending in agricultural research and extension (RDE, RDE_{-1},... RDE_{-i}); percentage of irrigated cropped area in total cropped area (*IR*); literacy rate of the rural population (*LITE*); road density (*ROADS*); percentage of villages electrified (*PVELE*), capital stocks of government investments in health (*GCSHEL*), rural development (*GERDEV*), and soil and water conservation (*GCSSL*); and annual rainfall (*RAIN*). The first seven variables should capture the productivity-enhancing effects of technologies, infrastructure, education, and other government spending in rural areas. The rainfall variable should capture weather effects. Inclusion of other public goods and government spending variables will avoid overestimating the effects of agricultural research, and will allow comparing the effects of these public investments with agricultural research.

Equation (2) models the determination of food prices (*FP*). Food prices are measured as a ratio of food prices to nonfood consumer prices. Growth in agricultural productivity (*TFP*) increases the supply of agricultural products and hence is expected to contribute to lower food prices. Per capita GDP (*GDP*) and population size (*POP*) are used to capture demand-side factors in the food markets. Food prices in India may have also been affected by international market prices (*WPI*), although during most of the study period the share of imports and exports in total domestic consumption was small, often less than 3%. Variable *S,* which consists of a set of state dummies, is intended to capture the effect of all other factors on changes in food prices.

Equation (3) models the determinants of urban poverty (*UP*)[2]. Urban poverty is expected to be positively relate to food price increases relative to nonfood prices (*FP)* and to inequality in urban incomes (GINI), and negatively related to the per capita income of urban residents (*M*). Variable *Z* (which comprises year and province dummies) is included to capture the effects of all other omitted variables.

5. DATA AND MODEL ESTIMATION

DATA

State level data from 1970 to 1995 were used in the model estimation. Most of the data are taken from the official sources of the Indian Government (Fan, Hazell and Thorat, 2000).

The head-count ratio data used in this analysis were constructed by Datt, and are published in a World Bank publication (World Bank 1997). Datt used the poverty line originally

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[2] To simplify the presentation, we have omitted to include subscripts to indicate observations in year t and at the province level. The variables with subscript "-1,...-j" indicate lagged observations for years *t-1*,...*t-j*.

defined by the Planning Commission, and more recently endorsed by the same agency, which is based on a nutritional norm of 2,400 calories per person per day. It is defined as the level of average per capita total expenditure at which this norm is typically attained, and is equal to a per capita monthly expenditure of Rs 57 at October 1973-June 1974 all-India urban prices. The mean income and Gini coefficients are also taken from Datt (1998).

Our measure of total factor productivity growth has already been defined. But because of concerns that the measure of TFP used may be sensitive to the cost data used in aggregating inputs, a primal approach was also tried. By first estimating a production function for Indian agriculture using district level data, production elasticities for key inputs like land, labor, fertilizer, machinery, and animals were obtained and then used to construct an estimate of TFP growth at the state level. The results were similar to those obtained by using the cost shares (a dual approach). But the dual approach is preferred here because the elasticities used in the primal approach do not vary by states.

The road density variable is defined as the length of road per unit of geographic area. Education is measured as the literacy rate, defined as the percentage of literate people in the total rural population above 7 years old. The irrigation variable is defined as the percentage of the total cropped area under irrigation. The electrification variable measures the percentage of all villages that have access to electricity. These variables were aggregated from district level data, which were obtained from the Planning Commission through the National Center for Agricultural Policy and Economics Research, New Delhi.

The food price variable is measured as the change in food prices relative to nonfood prices in urban areas. GDP and population data are from World Bank database (2002). The world food price index is a weighted average price index for rice, wheat, and maize in the international market, and the international prices of these commodities are taken form FAO (2002).

Functional Form and Estimation Technique

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

Lags and Distributions of R&D Investments

Government investments in R&D can have long lead times in affecting agricultural production, as well as long-term effects once they kick in. One of the thornier problems to resolve when including agricultural research investments in a production function concerns the choice of an appropriate lag structure. Most past studies use stock variables which are usually weighted averages of current and past government expenditures on R&D. But what weights and how many years lag should be used in the aggregation are currently under hot debate.[3] Since the shape and length of these investment lags are largely unknown, we use a free form lag structure in our analysis, i.e., we include current and past government expenditures on R&D in the production function. Then we use statistical tools to test and determine the appropriate length of lag for R&D expenditure.

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 many economists (Greene 1993). In this report, we simply use the adjusted R^2. The optimal lag length is determined by the length of lag that maximizes the adjusted R^2. The *AIC* is similar in sprit to the adjusted R^2 in that

[3]Alston *et al*. (1998) argue that research lags may be much longer than previously thought, perhaps even infinite. But this argument may be less relevant for most developing countries since their national agricultural research systems are much younger and their research tends to be more applied and hence has shorter useful life.

it rewards goodness of fit, but it penalizes for the loss of degrees of freedom. The lag determined by the adjusted R^2 approach is 13 years.

Another problem related to the estimation of the lag structure is that the independent variables (*RDE*, RDE_{-1}, RDE_{-2}, ... and RDE_{-i}) are often highly correlated, making the estimated coefficients statistically insignificant. Several ways of tackling this problem have been proposed. The most popular approach 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*. In this study, we use *PDLs* of 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 equations system with the *PDLs* and appropriate lag length for research investment.

Estimation Results

The estimated model is presented in Table 4. Since we used double-log functional forms, the estimated coefficients are in elasticity form. The estimated agricultural productivity function (equation (1)) confirms that agricultural research, improved roads, irrigation, access to electricity, and education all contributed significantly to agricultural production over the sample period. The coefficient reported for agricultural R&D is the sum of the past 13 years coefficients from the *PDLs* distribution. The significance test is the joint *t* test of the three parameters of the *PDL*.

The estimated food price equation (equation (2)) indicates that increases in agricultural output do exert a strong downward pressure on food prices with an elasticity of 0.231. Per capita GDP and total population size have positive, but statistically insignificant impacts on agricultural prices. World food prices have a significant impact on domestic food prices, indicating that domestic urban food prices are linked with the international market.

The estimated poverty equation 3 shows that food prices have a very significant impact on urban poverty. For every one percent decline (increase) in food prices, urban poverty is reduced (increased) by 0.35%. Growth in per capita income has also contributed significantly to rapid reductions in urban poverty while a worsening income distribution in urban areas has worked to increase urban poverty.

Table 4--Estimates of the Simultaneous Equation System

(1)	TFP	=	-0.026	+	0.255 TRDE	+	0.215 IR	+	0.242 ROADS	+	0.062 PVELE	+	0.708 LITE	+	0.012 GCSHEL	
			(-0.78)		(1.82)*		(1.83)*		(2.43)*		(0.60)		(1.95)*		(0.39)	
				+	0.022 GERDEV	+	0.0015 GCSSL	+	0.272 RAIN							R^2=0.301
					(0.63)		(0.37)		(5.47)*							
(2)	FP	=	0.025	-	0.231TFP	+	0.112 GDP	+	0.034 POP	+	0.271 WPI					R^2=0.363
			(2.22)*		(-3.03)*		(1.56)		(1.67)		(8.03)*					
(3)	UP	=	7.07	-	1.637 M	+	1.003GINI	+	0.350 FP							R^2=0.911
			(21.15)*		(-23.89)*		(15.15)*		(1.78)*							

Note: The estimated first equation is from Fan *et al*, 2000. Asterisks indicate statistical significance at the 5% level. The coefficient for RDE is the sum of the coefficients for the past 13 years, and the *t-value* of the coefficient is the joint *t-value* of the coefficients for the past 13 years.

6. CONTRIBUTION OF AGRICULTURAL RESEARCH TO URBAN POVERTY REDUCTION

By totally differentiating equations (1) - (3), the impact of government investment in agricultural R&D in year *t-i* on poverty at year *t* can be derived as:

$$(4)\quad dUP/dRDE_{-i} = (\partial UP/\partial FP)\,(\partial FP/\partial Y)\,(\partial Y/\partial RDE_{-i}).$$

By aggregating the total effects of all past government expenditures on R&D over the lag period, the sum of marginal effects is obtained for any particular year. This is equivalent to the marginal impact of a change in the "stock" of R&D investment at time t, where the stock *RS* is measured as:

$$RS_t = a_t RE_t + a_{t-1} RE_{t-13} + \ldots, + a_{t-13} RE_{t-13},$$

and a_{t-i} coefficients are the estimated parameters in the production function (equation 1).

The estimated elasticity of urban poverty to agricultural research is –0.021. That is, for every one percent increase in agricultural research investment, urban poverty declines by 0.021%.

Using this elasticity and the values of the relevant variables for specific periods of time, we can calculate the number of poor urban people raised above the poverty line for an additional 1 million *Rs* increase in the stock of agricultural research investment. Similarly, we can calculate the total number of urban poor who were lifted out of poverty each year as a result of actual investments in agricultural research. The results are shown in Table 5.

Each additional million Rs increase in the 1970 stock of agricultural research investment lifted 196 urban people out of poverty. This figure had declined to 72 people by 1995. Given actual levels of investment in agricultural research, then 1.21 million urban people were lifted out of poverty in 1970 and 1.70 million in 1995. This suggests that although marginal impact of agricultural research on urban poverty reduction is declining, the total number of rural poor lifted out of poverty by agricultural research actually increased over time.

Table 5: Impact of agricultural research on urban poverty

	Number of Poor Reduced per Million Rs (1995 price)	Total Number of Poor Reduced (million)
1970	196.26	1.21
1971	215.87	1.32
1973	229.58	1.30
1974	166.07	1.35
1978	102.47	1.46
1983	103.03	1.57
1987	85.10	1.66
1988	73.73	1.56
1989	74.52	1.57
1990	69.99	1.61
1991	69.49	1.55
1992	79.86	1.75
1993	64.61	1.52
1994	68.66	1.61
1995	72.11	1.70

The results obtained here for the urban poor are quite comparable with similar calculations by Fan, Hazell and Thorat (2000) of the impact of agricultural research investments on the rural poor (Table 6). For example, for every one million Rs increase in the stock of agricultural research investment, 84.5 rural people were raised out of poverty in 1995. The large impact on rural poverty arises not only from the direct impact of increased agricultural productivity on the poor, but also from indirect nonfarm employment effects.

Among all types investments in rural areas, agricultural research has the largest impact on urban poverty, almost three times higher than road investments, which have the second largest impact. The total poverty effect (combining both rural and urban poor) of agricultural research investment is also the largest. For every additional one million Rs spent on agricultural research, 157 poor people are lifted above the poverty line. Road investments have almost as a large an impact; each additional one million Rs spent raises 152 poor people above the poverty line.

Table 6--Number of urban and rural poor reduced per million Rs, 1995

	Urban Poor	Rural Poor	Total Poor
Agricultural R&D	72.11	84.5	156.61
Irrigation	7.31	9.7	17.01
Rural Roads	28.39	123.8	152.19
Rural Education	7.43	41	48.43
Rural Electricity	1.44	3.8	5.24
Soil and Water Conservation	5.15	22.6	27.75
Rural Development	5.87	25.5	31.37
Rural Health	4.55	17.8	22.35

Note: The relationships between government investments and physical stocks for different types of government spending were taken from Fan, Hazell, and Thorat (2000). These relationships are used to calculate the marginal returns for poverty reduction.
Source: The figures on the rural poor taken from Fan, Hazell and Thorat (2000); the figures on the urban poor are the author's calculations.

7. CONCLUSIONS

This study has estimated the impact of agricultural research investments on urban poverty in India using time series and cross-state data and an econometric modeling approach. The model explicitly tracks the causal links between agricultural research investments and subsequent production increases in agriculture, and how this impacts on food prices and the incidence of urban poverty. The results show that agricultural research has played an important role in reducing urban poverty in India. Without investments in agricultural research, urban poverty in India would be much higher today. Each one million Rs increase in the stock of agricultural research investment raises about as many urban people as rural people above the poverty line.

With rapid urbanization, agricultural research will still need to play a key role in supplying adequate food at affordable prices to ensure that urban and rural poverty remain low.

But since 1990, agricultural research investment in India has stagnated. By 1997, government investment in agricultural research as a percentage of agricultural GDP was only about 0.4%. This is extremely low when compared with 2-3% in many developed countries, and is even lower than the average of 0.5% for all developing countries. One result of this stagnation in investment was that both rural and urban poverty declined at a slower rate in the 1990s than in the 1970s and 1980s.

Today, the urban poor account for a quarter of India's total poor. It is projected that more than half the Indian population will reside in urban cities by 2030 and the poor will be urbanized faster than the general population (Ravallion, 2001). India has made great success in feeding its large and growing population and in reducing both rural and urban poverty during recent decades through government investments in agricultural research, rural infrastructure, and education. But India cannot afford to be complacent. Continued government support for these investments is still needed, otherwise food insecurity, malnutrition, poverty, and social conflict will shadow India for a long time to come.

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