EPTD DISCUSSION PAPER NO. 71

PUBLIC INVESTMENT AND REGIONAL INEQUALITY IN RURAL CHINA

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ABSTRACT

This paper develops a method for decomposing the contributions of various types of public investment on regional inequality and applies the method to rural China. Public investments are found to have contributed to production growth in both the agricultural and rural non-agricultural sectors, but their contributions to regional inequality have differed by type of investment and the region in which they are made. All types of investment in the least-developed western region reduce regional inequality, whereas additional investments in the coastal and central regions worsen regional inequality. Investments in rural education and agricultural R&D in the western region have the largest and most favorable impacts on reducing regional inequality.

CONTENTS

Public Investment and Regional Inequality in Rural China

Xiaobo Zhang and Shenggen Fan*

1. INTRODUCTION

There has been a long debate on the role of public investment in economic growth (Aschauer, 1989; Barro, 1990; Munnell, 1992; Tatom, 1993; Gramlich, 1994; Holtz-Eakin, 1994; Evans and Karras, 1994; Garcia-Mila *et al*., 1996). Public investments can be allocated to various public goods, such as research and development (R&D), infrastructure, and education. Different public goods have different characteristics and externalities and may, therefore, have different impacts on growth and equity. However, most theoretical and empirical studies focus on either just one type of public investment or on total public investment, and ignore differences among alternative types of public investments. Using just one type of public investment often leads to overestimation of its returns (Antle, 1988; Griliches, 1988), while using aggregate government investment masks important policy information about which public investments deserve highest priority.

Apart from their role in growth, different types of public investments are also key instruments for governments to use in reducing regional inequality (World Bank, 1994).

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But apart from Martin (1999) and Jacoby (2000), there have been few studies that attempt to investigate both the regional equity and growth impacts of public investments. Jacoby (2000) found that investments in rural roads have a positive impact on growth but an ambiguous effect on regional inequality in rural Nepal. Using a two-region endogenous growth model, Martin (1999) explored the link between road infrastructure and regional inequality. Since both studies do not consider other public investments besides roads, they have limited relevance for policy makers who must choose between different types of investments as well as investment levels.

In this study, we develop a framework to assess the impact of various forms of public investment on growth and regional inequality using China as an example. The key hypothesis we want to test is that different types of public investment have different impacts on regional inequality. We will consider six major types of public investment in this study --- roads, education, electrification, telephones, irrigation, and agricultural R&D.

There are two reasons to choose China as an example. First, the Chinese economy has grown rapidly over the past two decades at an average annual rate of about 10 percent while regional inequality has increased significantly (SSB, 1998). Second, because of huge regional differences in geography and resource endowments, China has made significant public investments in some regions in an attempt to overcome natural constraints and reduce regional inequality. The dramatic increase in regional inequality despite rapid growth and an active public investment strategy in China provide a good test for our hypothesis. Since the rural population still accounts for over 60 percent of the total population in China, and since most of the poor are concentrated in rural areas, we focus our study on the rural sector. Although there are numerous studies that attempt to describe and explain China's regional inequality (Lyons, 1991; Tsui, 1991; Yang, 1999; and Kanbur and Zhang, 1999), previous studies have not systematically examined the role of public investment in changing regional inequality.

One constraint to assessing the distributional impact of public investment is the lack of a suitable analytical framework to decompose the contributions of production factors and public investment on regional inequality. In the literature, inequality is decomposed based on either exogenous population groups or income sources (Shorrocks, 1982, 1984). The distributional effect of production factors and public investment cannot be directly analyzed with these frameworks, hence we develop a new approach based on Shorrocks' decomposition methods.

The paper is organized as follows. Section 2 describes recent trends in growth and regional inequality in China. Section 3 develops our conceptual framework. Section 4 provides our estimates of the agricultural and non-agricultural production functions needed to decompose the sources of regional inequality. A simulation is conducted in section 5 to evaluate the marginal impacts of public investments on inequality amongst three regions. Section 6 highlights our conclusions and policy implications.

2. GROWTH AND REGIONAL INEQUALITY IN CHINA

During the past two decades, Chinese agriculture has experienced phenomenal economic growth. This rapid growth followed the policy reforms of the early 1980s has stimulated numerous studies analyzing the sources of this growth (e.g. McMillian *et al.,* 1989; Fan, 1991; Lin, 1992; and Fan and Pardey, 1997). Following the traditional growth accounting approach (Solow, 1957; Denison, 1962), most of these studies attempted to analyze the impact of institutional changes in addition to increases in the use of inputs on production growth during the reform period (from the end of the 1970s to the beginning of the 1990s).

Fan and Pardey (1997) were the first to point out that omitted variables such as agricultural R&D investment would bias the 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 rapid production growth, in addition to inputs and institutional changes. They found that ignoring the R&D variable in the production function leads to a significant overestimation of the impact of institutional change.

In addition to R&D investment, government investments in roads, electrification, education, and other public goods and services in rural areas may have also contributed to the rapid growth in agricultural production. Omitting these variables will also likely bias the estimates of the production function for Chinese agriculture.

Despite the phenomenal development of the rural non-farm sector in China, very few researchers have analyzed the sources of growth of this increasingly important sector. The only exception is Fan, Zhang, and Robinson (1999), in which they decomposed the sources of growth into growth in capital and labor. But they failed to include public investment directly as a source of growth. One of the motivations of this study is to include these public investment variables when estimating the production functions for agriculture and non-agriculture, and to calculate the differential impact of these investments on regional inequality.

Another feature of the Chinese economy is that the gains from the policy reforms have not been evenly distributed across regions. The difference in the growth rates between the coastal and inland regions has been as high as 3 percentage points during the past two decades and regional inequality for China as a whole has increased significantly (Kanbur and Zhang, 1999). China has implemented a coast-biased development policy with a large portion of public investment concentrated in the coastal region. It is legitimate to speculate that the skewed distribution of public investment might be an important factor behind the increase in regional inequality.

In order to better analyze these issues, we divide China into three zones: the east or coastal zone which includes Hebei, Liaoning, Shandong, Jiangsu, Zhejiang, Fujian, Guangdong, and Guangxi provinces; the central zone comprising Shanxi, Inner Mongolia, Anhui, Jiangxi, Henan, Hubei, and Hunan provinces; and the west zone comprising all remaining provinces. Tibet is excluded due to 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 1 compares key characteristics of the three zones in 1978 and 1995, using the western region as a base. Labor productivities in the agricultural and non-agricultural sectors were higher in the coastal and central regions than in the western region in 1978. In addition, the productivity gaps between the western and other regions increased significantly between 1978 and 1995. For instance, the difference in agricultural labor productivity between the coastal and western zones rose from 1.03 to 1.76.

Table 1–Characteristics of the Coastal and Central Regions Relative to the Western Region

Year and Characteristics	Coastal	Central
1978		
Agricultural GDP / Labor	1.03	1.12
Rural non-agricultural GDP / Labor	1.53	1.29
Capital/Labor		
for agricultural production	0.69	0.55
for non-agricultural production	1.20	1.75
Road density	2.97	1.93
Education level	1.79	1.27
Electrification	1.46	1.45
Phone (rural communication)	2.26	1.52
The portion of irrigated area	1.54	1.12
Agricultural R&D per capita	0.40	0.41
1995		
Agricultural GDP / Labor	1.76	1.50
Rural non-agricultural GDP / Labor	1.74	1.55
Capital/Labor		
for agricultural production	1.13	0.98
for non-agricultural production	3.20	1.37
Road density	3.97	1.84
Education level	1.24	1.24
Electrification	3.37	1.36
Phone (rural communication)	10.43	2.43
The portion of irrigated area	1.46	1.02
Agricultural R&D per capita	0.78	0.53

Sources: Authors' calculations based on the data from SSB publications.

Notes: 1.The coastal zone includes the following provinces: Hebei, Liaoning, Shandong, Jiangsu, Zhejiang, Fujian, Guangdong, and Guangxi. The central zone contains Shanxi, Inner Mongolia, Anhui, Jiangxi, Henan, Hubei, and Hunan. The remaining provinces are classified as the western zone. Tibet is excluded due to the lack of data. Hainan is included in Guangdong Province.

2. All numbers are expressed as ratios of the corresponding value for the western region.

Not only has the gap in labor productivity increased, but also has the disparity in input use. For example, the capital labor ratio for non-agricultural production was 20 percent higher in the coastal zone than in the western zone in 1978. By 1995, this difference has increased to 220 percent. The most notable gap is the difference in the number of rural telephones per rural resident among zones. In 1978, the coastal region had 126% more telephones per capita than the western region, and this gap increased to 943% by 1995. Comparing public capital stocks among different regions, only the gaps in education and irrigation levels have narrowed between the western and coastal regions. In comparison, the differences in public capital stocks between the coastal and western regions have changed rather modestly. It appears that the increased disparity in output levels among regions might have been caused in large part by differences in public investment. However, we need a more formal model to quantify the contributions of various investments on overall inequality.

3. CONCEPTUAL FRAMEWORK

We assume that each region has the same agricultural and non-agricultural production functions at a given time but that they lie at different points on the production surfaces. Following standard procedures in the literature, we assume that the agricultural and non-agricultural production functions are of Cobb-Douglas form, with *k* conventional inputs and *m* public inputs as follows:

$$Y = A\prod_{i=1}^{k} X_i^{b_i} \prod_{j=1}^{m} P_j^{g_j} \qquad (1)$$

where Y = total Gross Domestic Product (GDP),

A = intercept,
X_i = conventional inputs such as labor, capital, and land,
P_j = public investments such as roads and R&D,
$\boldsymbol{b}_i$ = output elasticity with respect to conventional input i,
g_j = output elasticity with respect to public investment j.

The logarithmic form of equation (1) is given by:

$$y = a + \sum_{i=1}^{k} b_i x_i + \sum_{j=1}^{m} g_j p_j + e \, , \tag{2}$$

where lower cases indicate logarithms. An error term $\boldsymbol{e}$ 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 (2) can be decomposed as:

$$\begin{aligned} \boldsymbol{s}^2(y) &= \sum_{i=1}^{k} \mathrm{cov}(y, \boldsymbol{b}_i x_i) + \sum_{j=1}^{m} \mathrm{cov}(y, \boldsymbol{g}_i p_j) + \mathrm{cov}(y, \boldsymbol{e}) \\ &= \sum_{i=1}^{k} \boldsymbol{b}_i \, \mathrm{cov}(y, x_i) + \sum_{j=1}^{m} \boldsymbol{g}_j \, \mathrm{cov}(y, p_j) + \mathrm{cov}(y, \boldsymbol{e}) \\ &= \sum_{i=1}^{k} \boldsymbol{b}_i \, \mathrm{cov}(y, x_i) + \sum_{j=1}^{m} \boldsymbol{g}_j \, \mathrm{cov}(y, p_j) + \boldsymbol{s}^2(\boldsymbol{e}), \end{aligned} \tag{3}$$

where $\boldsymbol{s}^2(y)$ is the variance of y and cov(y, $\bullet$) represents the covariance of y with other variables. Since all the right-hand side variables in equation (2) are not correlated with the error term, the covariance of y and $\boldsymbol{e}$ is equal to the variance of $\boldsymbol{e}$. Considering that y is already in logarithmic form, $s^2(y)$ is a standard inequality measure known as the logarithmic variance (Cowell, 1995). It has the property of invariance to scale. According to Shorrocks (1982), the covariance terms on the right-hand-side of (3) can be regarded as the contributions of the factor components to total inequality.

Using estimates from (2) and applying the above decomposition method from (3), we are able to quantify the contributions of various public investments on regional inequality in agricultural GDP and non-agricultural GDP. Moreover, it is also possible to calculate the impact of public investments on regional inequality in total GDP. For this purpose, we assume a Cobb-Douglas aggregation over sectors, and then regress the logarithms of agricultural GDP and non-agricultural GDP on the logarithm of total GDP as follows:

$$y = a_1 y_1 + a_2 y_i \qquad (4)$$

where y, y_1, and y_2 are GDP, agricultural GDP, and non-agricultural GDP in logarithms, respectively; and a_1 and a_2 are the elasticities of y_1 and y_2 with respect to y. After estimating y_1 and y_2 based on (2), we can substitute the estimates into the aggregate GDP function (4) and then decompose the contributions of different inputs and investments on inequality in total GDP, again using equation (3).

4. DATA AND EMPIRICAL RESULTS

DATA

A panel data set including 25 provinces over the period 1978-1995 was constructed from various governmental data sources. We divided total rural GDP into agricultural GDP and rural non-agricultural GDP to reflect differences in their underlying production structures. Both nominal GDP and real GDP growth indices for various sectors are available from *The Gross Domestic Product of China* (State Statistical Bureau (SSB), 1997a). The data sources and method of construction of national GDP estimates were published by the State Statistical Bureau (SSB, 1997b). This publication indicates that the SSB has used the U.N. standard SNA (system of national accounts) definitions to estimate GDP in Mainland China for the period of 1952-95. This is the first time that the SSB has published historical GDP information at the province level for such a long period of time. We assume prices were the same for all provinces in 1980. Under this assumption, real GDP estimates for the whole period can be derived from nominal GDP data for 1980 and the published annual growth rates in real GDP.

In the empirical analysis, we consider both agriculture and non-agriculture production. Our specification of the agricultural production function includes conventional inputs (land, labor, and capital) and public investment goods such as roads, education, irrigation, electrification, rural telephones and agricultural R&D capital generated by government investment. Additionally, we include annual rainfall to reflect regional differences in natural production conditions. Our specification of the non-agricultural production function includes all the same variables except land, irrigation, agricultural R&D, and rainfall.

Since the data sources for the above input variables can be found in Fan, Zhang, and Zhang (2000), we only briefly introduce the definitions of these variables. Labor is measured in stock terms as the number of persons at the end of each year. Capital stocks are calculated based on gross capital formation and annual fixed asset investment and adjusted with appropriate price index and depreciation rates. Land refers to arable land area. The average years of schooling among the rural population is used as the measure of education. The irrigation variable is expressed as the ratio of irrigated area to total arable land. Roads are measured in density form, i.e. road length in kilometers per thousand square kilometers of geographic area. Electricity and rural telephones are the average electricity consumption and number of rural telephones per rural resident.

The R&D variable is measured in stock form, and is defined as a function of past government expenditures on agricultural R&D. For simplification, we assume that the R&D stock follows a polynomial distributed lag (PDL) of degree 2. Based on available data and econometric tests, the lag length is set at 17 years. This means we only need estimate three parameters to obtain all the parameters of a 17-year lag structure. For additional details on the method, see Davidson and MacKinnon (1993).

RESULTS

Agricultural and non-agricultural GDP functions were estimated based on equation (2). Year and region dummies were included in the equations to capture time and region-invariant fixed effects. The estimated coefficients are reported in Table 2. Most of the coefficients for the year and region dummy variables (which are not reported in the table) are statistically significant. The adjusted R^2s for the agricultural and non-agricultural GDP functions are high at 0.966 and 0.949, respectively, implying good fits.

All the coefficients in the estimated agricultural GDP function are positive and, except for roads, are all statistically significant at the five percent confidence level. The summation of the coefficients for conventional inputs – labor, capital and land, is 0.993, suggesting constant returns to scale. In China, labor is abundant and land is scarce, hence one should expect that the elasticity of land would be larger than that of labor. This is confirmed in Table 2; the elasticity of land is 0.56 while the elasticity of labor is 0.36. The coefficient for irrigation - a land-enhancing technology - is also significant at 0.318. These results are consistent with the induced innovation hypothesis (Hayami and Ruttan, 1985).

Table 2–Estimated Production Functions for Agricultural GDP and Rural Non-agricultural GDP

Variables	Agricultural GDP	Rural Non-agricultural GDP
Labor	0.364**	0.500**
	(0.042)	(0.041)
Capital	0.068**	0.506**
	(0.017)	(0.041)
Land	0.561**	
	(0.039)	
Road	0.012	0.138**
	(0.026)	(0.037)
Education	0.340**	0.366**
	(0.089)	(0.172)
Electricity	0.055**	0.128**
	(0.027)	(0.040)
Telephone	0.110**	0.241**
	(0.017)	(0.033)
Irrigation	0.318**	
	(0.025)	
Research	0.030**	
	(0.013)	
Rainfall	0.225**	
	(0.027)	
Adjusted R^2	0.966	0.949

Note:

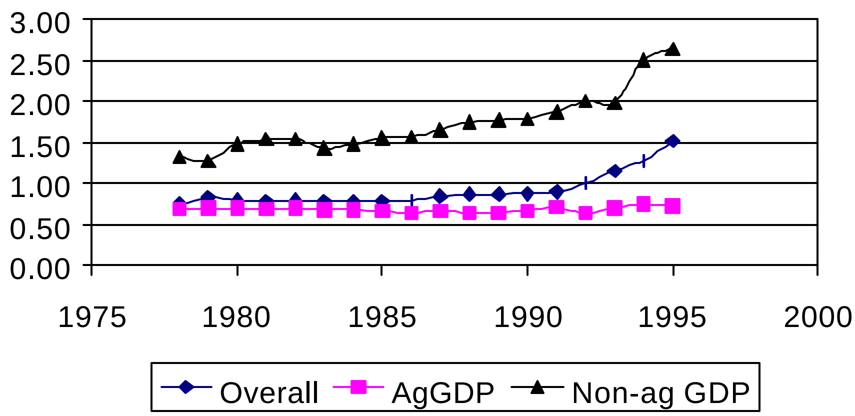
1. All variables are in logarithms. Two regional dummies were included in the model, but the results are not reported here.
2. * and ** indicate statistical significance at the 10% and 5%, respectively. Figures in parentheses are standard errors.

Among the six types of public investment goods, education and irrigation have the largest and second largest output elasticities. The elasticities for roads and agricultural R&D are relatively small.

Turning to the rural non-agricultural GDP function, all the coefficients are significant and positive. The sum of the coefficients for the conventional inputs (capital and labor) is also about one, suggesting that there are no economies or diseconomies of scale. Education is the most significant contributing public investment to rural non-agricultural GDP. Rural telephone services and roads have the second and third largest effects on non-agricultural output.

Figure 1 shows the time paths of regional inequality in agricultural GDP, rural non-agricultural GDP, and total GDP from 1978 to 1995. Regional inequality in agricultural GDP did not change much over this period, but inequality in non-agricultural GDP doubled. Inequality in total GDP doubled from 0.751 in 1978 to 1.510 in 1995, and this was almost entirely due to worsening inequality in non-agricultural GDP. This confirms similar findings by Rozelle (1994).

Figure 1 Regional Inequality from 1978 to 1995



Given the estimated coefficients for the two GDP functions, we can now apply the inequality decomposition method outlined in equation (3). Tables 3 through 5 report the contributions of each factor in share form to regional inequality for agricultural GDP, non-agricultural GDP and total GDP, respectively.

TABLE 3–Contributions of Input Factors to Regional Inequality in Agricultural GDP

Year	Inequality Coefficient	Capital	Labor	Land	Education	Irrigation	Roads	R&D	Elec.	Phone	Public Investment[1]
1978	0.681	0.053	0.370	0.371	0.049	0.069	0.008	-0.012	0.002	-0.007	0.110
1979	0.697	0.052	0.371	0.334	0.032	0.097	0.008	-0.011	0.005	-0.007	0.124
1980	0.695	0.052	0.369	0.324	0.027	0.104	0.007	-0.011	0.003	-0.007	0.124
1981	0.680	0.053	0.367	0.340	0.027	0.097	0.007	-0.010	0.007	-0.003	0.125
1982	0.702	0.052	0.363	0.325	0.021	0.101	0.007	-0.009	0.005	-0.002	0.124
1983	0.680	0.052	0.366	0.331	0.023	0.105	0.007	-0.009	0.000	0.002	0.128
1984	0.677	0.052	0.362	0.338	0.025	0.104	0.007	-0.011	0.000	0.002	0.126
1985	0.661	0.052	0.364	0.344	0.028	0.097	0.008	-0.012	0.001	0.004	0.127
1986	0.633	0.052	0.369	0.348	0.031	0.094	0.007	-0.012	0.005	0.004	0.130
1987	0.665	0.050	0.353	0.340	0.034	0.093	0.007	-0.012	0.002	0.005	0.129
1988	0.632	0.051	0.362	0.352	0.044	0.093	0.007	-0.011	0.003	0.004	0.140
1989	0.641	0.047	0.361	0.340	0.041	0.096	0.007	-0.008	0.006	0.005	0.147
1990	0.666	0.045	0.358	0.348	0.043	0.091	0.007	-0.004	0.006	0.003	0.147
1991	0.707	0.044	0.342	0.333	0.042	0.086	0.007	0.001	0.014	0.005	0.154
1992	0.635	0.046	0.360	0.348	0.044	0.089	0.007	0.006	0.017	0.006	0.169
1993	0.697	0.047	0.339	0.332	0.036	0.087	0.007	0.009	0.013	0.007	0.158
1994	0.741	0.046	0.322	0.321	0.040	0.083	0.007	0.010	0.062	0.009	0.211
1995	0.727	0.049	0.322	0.319	0.038	0.087	0.008	0.012	0.064	0.013	0.221

[1] The public investment column is the summation of the columns for education, irrigation, road, R&D, electricity, and telephones.

TABLE 4–Contributions of Input Factors to Regional Inequality in Non-agricultural GDP

Year	Inequality Coefficient	Capital	Labor	Education	Roads	Electricity	Phone	Public Investment[1]
1978	1.320	0.358	0.600	0.063	0.054	0.006	0.020	0.144
1979	1.271	0.370	0.581	0.052	0.054	0.017	0.029	0.153
1980	1.480	0.353	0.605	0.045	0.044	0.018	0.032	0.140
1981	1.534	0.351	0.592	0.044	0.043	0.028	0.041	0.155
1982	1.542	0.346	0.596	0.038	0.044	0.035	0.040	0.158
1983	1.429	0.383	0.569	0.034	0.046	0.039	0.037	0.157
1984	1.473	0.390	0.562	0.034	0.047	0.035	0.038	0.153
1985	1.556	0.381	0.563	0.033	0.048	0.039	0.038	0.158
1986	1.559	0.389	0.550	0.034	0.049	0.040	0.041	0.165
1987	1.646	0.391	0.540	0.037	0.047	0.041	0.048	0.173
1988	1.743	0.385	0.527	0.044	0.046	0.040	0.061	0.191
1989	1.767	0.386	0.519	0.042	0.047	0.041	0.071	0.200
1990	1.786	0.389	0.517	0.041	0.047	0.036	0.076	0.200
1991	1.873	0.387	0.504	0.040	0.046	0.040	0.087	0.213
1992	2.006	0.389	0.489	0.039	0.045	0.044	0.099	0.227
1993	1.981	0.400	0.496	0.034	0.046	0.048	0.081	0.209
1994	2.505	0.364	0.439	0.033	0.044	0.048	0.170	0.295
1995	2.639	0.365	0.427	0.030	0.044	0.052	0.178	0.305

[1] The public investment column is the summation of the columns for education, electricity, and telephones.

TABLE 5–Contributions of Input Factors to Regional Inequality in Total GDP

Year	Inequality Coefficient	Capital	Labor	Land	Education	Irrigation	Roads	R&D	Elec.	Phone	Public Investment[1]
1978	0.751	0.085	0.389	0.276	0.042	0.082	0.013	-0.010	-0.010	0.004	0.121
1979	0.822	0.083	0.368	0.267	0.030	0.082	0.012	-0.009	-0.008	0.008	0.115
1980	0.791	0.090	0.390	0.262	0.026	0.085	0.013	-0.007	-0.007	0.006	0.116
1981	0.783	0.092	0.384	0.268	0.027	0.085	0.013	-0.007	-0.003	0.010	0.125
1982	0.796	0.095	0.382	0.261	0.023	0.085	0.013	-0.007	-0.001	0.009	0.122
1983	0.783	0.100	0.377	0.275	0.027	0.074	0.014	-0.006	0.006	0.006	0.121
1984	0.773	0.109	0.381	0.268	0.028	0.077	0.015	-0.008	0.007	0.005	0.124
1985	0.779	0.131	0.403	0.248	0.029	0.076	0.017	-0.008	0.010	0.006	0.131
1986	0.789	0.140	0.401	0.238	0.033	0.069	0.018	-0.008	0.013	0.009	0.135
1987	0.842	0.146	0.394	0.225	0.036	0.063	0.018	-0.008	0.013	0.010	0.132
1988	0.866	0.159	0.401	0.211	0.044	0.058	0.020	-0.006	0.016	0.018	0.150
1989	0.867	0.164	0.409	0.204	0.043	0.060	0.021	-0.005	0.016	0.018	0.153
1990	0.873	0.163	0.405	0.211	0.045	0.057	0.021	-0.002	0.013	0.024	0.158
1991	0.892	0.172	0.406	0.196	0.046	0.058	0.022	0.001	0.016	0.032	0.175
1992	0.999	0.190	0.404	0.167	0.044	0.048	0.023	0.003	0.020	0.044	0.183
1993	1.154	0.216	0.400	0.130	0.039	0.040	0.027	0.003	0.024	0.037	0.170
1994	1.273	0.237	0.396	0.106	0.039	0.035	0.029	0.003	0.030	0.126	0.262
1995	1.510	0.221	0.380	0.105	0.036	0.032	0.028	0.004	0.027	0.116	0.243

[1] The public investment column is the summation of the columns for education, irrigation, road, R&D, electricity, and telephones.

The contributions of the three conventional inputs (capital, labor, and land) to regional inequality in agricultural GDP have declined, while the contributions of most public investments, especially R&D, electrification, and telephones, have increased. Public investment's total contribution to regional inequality in agricultural GDP increased from 0.110 in 1978 to 0.221 in 1995.

The results are similar for changes in regional inequality in non-agricultural GDP (Table 4). Capital and labor have contributed little to worsening inequality, while public investment in electricity, telephones and in total has worsened regional inequality. Public investment's contribution to regional inequality in non-agricultural GDP increased from 0.144 in 1978 to 0.305 in 1995.

Turning now to total GDP, capital's contribution to worsening regional inequality increased from 0.085 in 1978 to 0.221 in 1995, even though its shares in the inequality of agricultural GDP and non-agricultural GDP changed little (Table 5). This is probably due to a structural shift in capital from agricultural to non-agricultural 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, have accounted for a decreasing share of overall inequality. The contributions of roads, agricultural R&D, electricity, and telecommunications have increased significantly. All this suggests that public investment has pursued a regionally biased strategy over the past two decades. As discussed earlier, the coastal region has enjoyed the most favorable investment from the government.

5. MARGINAL EFFECTS OF PUBLIC INVESTMENT ON INEQUALITY

Using the estimated coefficients in Table 2 and 1995 values for all relevant variables, we are able to calculate the marginal impacts of different types of public investments on regional inequality. Table 6 reports the percentage changes in regional inequality in agricultural GDP, non-agricultural GDP, and total GDP, as a result of a 1 percent increase in each type of public investment (measured in physical units) within a particular region. Two results are of special interest. First, additional investments of all types in the western areas reduce regional inequality. Additional education in the western region is much more effective in reducing regional inequality in agricultural, non-agricultural and total GDP than any other investment (with elasticities of –0.221, -0.268, and -0.277, respectively). Irrigation has the second largest impact on regional inequality in agricultural GDP with an elasticity of –0.204. For non-agricultural production, development of the rural telephone system in the western region is another important way of reducing regional inequality.

Second, if the government's current coast-biased development strategy continues, regional disparities will worsen. The positive numbers in the second column of Table 6 indicate that additional public investment of all types in the coastal area will worsen regional inequality. A 1 percent increase in education, telephones and electricity in the coastal area will lead to a 0.185, 0.084, and 0.041 percent increase, respectively, in overall regional inequality. Compared to the western and coastal regions, the marginal effects of public investment in the central region on inequality are less striking.

Table 6–Changes in Regional Inequality as a Result of Additional Public Investments in Each Region

Public Investment	Coastal	Central	Western
Agricultural GDP			
Roads	0.004	0.003	-0.005
Education	0.137	0.086	-0.221
Electricity	0.022	0.014	-0.033
Telephones	0.043	0.027	-0.068
Irrigation	0.127	0.080	-0.204
R&D	0.018	0.011	-0.027
Rural Non-agricultural GDP			
Roads	0.033	0.002	-0.036
Education	0.251	0.018	-0.268
Electricity	0.064	0.004	-0.068
Telephones	0.129	0.009	-0.138
Total Rural GDP			
Roads	0.018	0.009	-0.028
Education	0.185	0.093	-0.277
Electricity	0.041	0.021	-0.062
Telephones	0.084	0.042	-0.125
Irrigation	0.052	0.026	-0.078
Agricultural R&D	0.007	0.003	-0.010

Note: The table measures the percent change in regional inequality as a result of a 1% increase in each type of public investment within each region. All calculations take 1995 as the base year.

We can regress each public investment variable against historical government expenditure data following the method developed by Fan, Zhang, and Zhang (2000) to obtain a dynamic relationship between the stocks of public goods and past government expenditures. Based on the above information in Table 6 and the estimated stock-expenditure relationships, we can further calculate the marginal returns of an additional 100 Yuan (about $12) of public investment per rural resident in each of the three regions on changes in regional inequality (Table 7).

Table 7–The Marginal Impact of Public Investments by Region on Regional Inequality

Public Investment	Coastal	Central	Western
Agricultural GDP			
Roads	0.041	0.053	-0.063
Education	2.147	2.965	-9.147
Telephones	2.155	0.863	-0.862
Electricity	0.266	0.347	-0.703
Irrigation	0.725	0.660	-1.288
Agricultural R&D	10.995	9.351	-4.938
Rural Non-agricultural GDP			
Roads	1.294	0.171	-1.745
Education	13.960	2.204	-39.461
Electricity	2.778	0.401	-5.055
Telephones	23.011	1.036	-6.193
Total Rural GDP			
Roads	0.432	0.408	-0.820
Education	6.231	6.899	-24.722
Telephones	9.032	2.884	-3.413
Electricity	1.092	1.126	-2.791
Irrigation	0.637	0.464	-1.058
Agricultural R&D	6.245	3.715	-7.401

Note: The entries in the table are the percentage change in regional inequality as a result of an additional 100Yuan investment (about $12) per capita public investment in a specific region. Calculations are based on the most recent year for which data are available, except for telephones that are based 1988 to 1993 averages.

A positive figure in Table 7 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 a reduction in 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. Education has the largest impact of any investment, and again additional investment in the western region reduces regional inequality, whereas additional education investments in the central and coastal regions worsen regional inequality. These results are true for agricultural, non-agricultural and total GDP. Additional investments in agricultural R&D and rural telephones also have large impacts on regional inequality, and follow much the same pattern as investments in education.

6. CONCLUSIONS

This paper provides a method for decomposing the distributional consequence of various types of public investment on regional inequality, and applies the method to rural China. Using a provincial level data set for the period 1978 to 1995, a model was estimated that enables the impacts on regional inequality of different types of public investments in each of three regions to be quantified.

Conventional and public inputs have positively affected the growth in both agricultural and non-agricultural production, but have played different roles in contributing to changes in overall inequality. In general, the government has pursued a coast-biased investment strategy, and this has been an important factor contributing to the rapid increase in regional inequality.

Regional variations in the impact of public investments on regional inequality are large. Increasing public investment in the less-developed western region will lead to a decline in regional disparity. In contrast, if the government continues to favor the coastal region in its investment strategy, then regional disparities will widen further. The magnitude of the impact of different types of public investment differs as well. Among the six types of public investment considered in this paper, additional investments in education and agricultural R&D in the western region are the two most powerful ways of reducing regional inequality.

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