Physical Infrastructure and Land Productivity: A District Level Analysis of Rural Orissa

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The present study analyzes the effectiveness of rural physical infrastructure on land productivity. Physical Infrastructure includes irrigation, electricity, transportation and communication. The final selection of the items in each category has been made on the basis of a priori study and regression through backward elimination. It is a novel attempt by the Principal Component Analysis, to construct infrastructure index at district level for Orissa. This study observes asymmetry in the spread of physical infrastructure across the three major regions of the state. The analysis also explores that land productivity is low in the Kalahandi-Bolangir-Koraput (KBK) belt and in certain districts of the Western-Central Orissa, in comparison to the Coastal Orissa. This may be ascribed to the underdevelopment of infrastructure. All the two variable regressions of land productivity on individual infrastructure items—irrigation and electricity, except road density, are significant. The overall physical infrastructure index is highly significant in raising land productivity. The elasticity coefficients obtained from log-linear models are less than unity, but significant. The study attributes this inelasticity to the base and scale effects. This finding from the state of Orissa reinforces the significance of non-price factors in agriculture, which has strong policy implications.

Introduction

A recent study has shown that the net farm income is growing at about 1% per annum, which is not enough to keep pace with the inflation (Sen and Bhatia, 2004). As a consequence, the farmers as a lot are distressed. This situation should change sooner, rather than later. Agriculture should grow.

How can agriculture grow? Economists are divided over the issue. There are two distinct views in this regard. Firstly, government should give price support (read subsidies) to agricultural inputs, viz., fertilizer, irrigated water, seeds, implements, etc., and secondly,

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government should strengthen the rural infrastructure—irrigation, rural roads, rural electrification, storage and processing, rural credit, marketing and so on. The two views are to some extent complementary, but to a great extent contradictory. These are complementary as a mix of the two approaches may place agriculture in a better space. However, considering the resource constraints, in one hand, and the huge demand magnitude, on the other, we cannot opt for both the options simultaneously. When the matter of choice arises, economists have no other alternative, but to take one of the two sides. So, the debate between the relative effectiveness of the price and the non-price factors on agricultural growth is long-standing.[1] Chalking out the suitable strategy is crucial for agricultural growth as well as for poverty alleviation.

Furthermore, in the World Trade Organisation (WTO) arrangement, Indian agriculture has been exposed to the global competition. The role of price-support has been severely constrained. The trading rules are being rewritten. It is likely to change the settings of the world agriculture, having significant implications for developing countries like India. Therefore, it is necessary for India to assess the likely implications of such global changes and accordingly plan her agricultural strategies, with a view to maximize gains from the new setup under the WTO.

Agricultural productivity has many aspects—land productivity, labor productivity and total factor productivity. 'Land' is a basic factor, which has its special significance. However, in order to accommodate the rising population, availability of land for cultivation is on the decline. The onslaught of ruthless industrialization has made the situation more complicated.[2] Raising land productivity is, therefore, crucial.

Similarly, rural infrastructure has many dimensions—rural physical, social and financial infrastructure. The present study attempts to analyze the effectiveness of rural physical infrastructure on land productivity. The specific objectives of the study are: a) to analyze interregional disparity in physical infrastructure *vis-à-vis* land productivity and b) to examine the effect of physical infrastructure on land productivity. The state of Orissa has been taken as the case study of the present analysis. Considering that above 80% of the population is living in rural areas, where agriculture is the mainstay, the state of Orissa is a fit case for the present analysis.

Review of Literature

Agricultural productivity can be defined as a measure of efficiency, with which an agricultural production system employs land, capital and other resources. The measurement of the growth of agricultural productivity involves a number of issues like the choice of period, the selection of cut-off points for different sub-periods, estimation of growth parameters and proper interpretation of results. These points have been taken up in a number of studies made earlier (Minhas, 1966; Narain, 1977; and Vaidyanathan, 1980).

1 Please see Desai B M and Namboodiri N V (1997).

2 Establishment of Special Economic Zones (SEZs) in agricultural land, land acquisition for industries and onset of contract farming are some recent examples of this complicated situation.

In addition to the above approaches, growth in Total Factor Productivity (TFP) has been a focal point of research in recent agricultural growth analysis. The TFP is computed as the ratio of the output index to the input index. It is also termed as the residual factor because it represents that part of the growth of net output, that is not accounted for by the growth of basic factor inputs such as land, labor and capital (Dholakia and Dholakia, 1993; and Rosegrant and Evenson, 1995). However, a study on TFP needs time-series data for a reasonable longer period and the analysis should go through rigorous tests for causality and autocorrelation problems.[3]

An exploratory study indicates the substantial growth potential in Eastern India, which are now characterized by extreme poverty and suffer from socio-economic structures, inhibiting growth (Rao and Deshpande, 1986). The report of the Committee on Agricultural Productivity (RBI, 1985) states that, "the basic strategy for inducing intensive agricultural practices in Eastern India has to be through infrastructure development". Unless improved through investment of adequate capital on such programs, the scope for technological progress will remain limited. This proposition needs empirical verification.

The World Development Report, 1994, which has drawn the attention of the economists by putting the fact that there is a direct relationship between infrastructure and economic development. The Report observes that good infrastructure raises productivity and lowers production costs. Though a good number of studies have been carried out across countries subsequently, only limited studies have been undertaken on the functioning and effectiveness of infrastructure in the Indian context. Amitabh and Rajan (1995), Nair (1995), Raghuraman (1995), and Ramanathan (1997) have discussed the problems in the various infrastructural sectors of India. However, these studies have not done any empirical examination of the impact of infrastructure on the economic growth.

Some recent studies have dealt directly with the infrastructure and economic development (Elhance and Lakshmanan, 1988; Gowda and Mamatha, 1997; Datt and Ravallion, 1998; Lall, 1999; Sahoo and Saxena, 1999-2000; and Ghosh and De, 2004). However, the effect of infrastructure has been studied on the overall productivity and pattern of development of an economy. Very few studies (Binswanger *et al*., 1993; Wanmali *and* Ramasamy, 1995; Bhatia, 1999; and Zhang and Fan, 2001) have analyzed the progress and economic effects of rural infrastructure on the growth in agriculture.

Zhang and Fan (2001) found that rural infrastructure development has a significant and positive impact on growth in productivity. Using a panel data set at district level in rural India from 1971 to 1994, they have conducted a causality test to investigate the relationship between technology and infrastructure. It is found that infrastructure development and productivity often affect each other in the long-run but not in the short-run.

Bhatia (1999) has attempted to build a state-wise composite index of rural infrastructure and examine the relationship between rural infrastructure development and the levels of

[3] It is noteworthy here that Orissa has undergone an administrative re-setup in years 1992 and 1993, creating 30 districts (in three phases) out of the existing 13 districts at that time. There was difficulty in finding comparable time-series data on the different aspects of our study. Hence, a cross-sectional analysis was preferred.

production and growth in agriculture. Although the study has chosen the items of infrastructure meticulously, yet the attempt to assign weights arbitrarily and subjectively can be contested. The study also ignores the categorization and the analysis of the infrastructural items as well as their relative effectiveness on agricultural productivity.

Using district-level time-series data and sophisticated econometric techniques to identify the factors influencing private agricultural investment and output, Binswanger *et al.* (1993) found that the availability of adequate rural infrastructure including roads, electricity, banks and education, plays an overwhelming role in determining private investment, input and output decisions.

Development of rural infrastructure plays a key part in generating agricultural growth and disseminating the benefits of agricultural growth to all the sectors of the economy. Growth of rural infrastructure improves the mobility of commodities, services, people and information in rural areas. This allows for an increase in specialization, commercialization, technology transfer, investment, rural resource utilization, and government outreach (Wanmali *et al.*, 1995). However, there are several studies examining the effect of different individual items of infrastructure on agricultural productivity (Barnes and Binswanger, 1986; and Dhawan, 1988). The present study is an attempt to contribute to this area of research from a different perspective.

Concepts, Methodology and Database

The present study is a lagged cross-sectional study based on secondary data, collected from different published sources like Statistical Abstracts of Orissa (2002 and 2005); Economic Survey (various issues), Agricultural Census of Orissa (1995); District Statistical Hand Books of Orissa (2001). These are the latest available sources which could provide our requisite data on a compatible form.

The study assumes that infrastructure items take time to influence productivity. Therefore, a lagged analysis is preferred. The productivity related terms have been measured for the year 2001-2002, whereas the infrastructure factors have been taken for the year 2000-2001.

Selection of Items for Physical Infrastructure

Physical infrastructure includes several factors like irrigation, electricity, communication network, transportation, storage and processing and so on. The present study has explored all such factors of physical infrastructure for their possible inclusion. However, a preliminary survey of secondary data from all the available sources indicates that the development of infrastructures like storage and processing in the state is too scanty and incompatible for a statistical analysis. The study has taken irrigation, electricity, transportation and communication for the investigation. Each factor, as such, has different dimensions. For example, irrigation can be taken either as gross irrigated area or as net irrigated area, and either in absolute or in relative form. All such dimensions have been taken and the final selection of the items of physical infrastructure has been made on the basis of a priori study and regression, through backward elimination. The details of finally selected items have been explained in Table 1.

Table 1: Categorization of Rural Infrastructure

Category of Infrastructure	Factors Taken	Variables Taken	Abbreviationof Variables
Physical	Irrigation	Percentage of gross irrigated area to gross cropped area	PGIA
	Electricity	Percentage of rural households with electricity connection	PHHELCT
	Transportation	Density of rural roads per thousand hectare of net sown area	RURDEN PHHTELCN
	Communication	Percentage of rural household with telephone connection	
Note: Weighing Method: Principal Component Analysis (PCA).			

Concepts and Definitions

PGIA[4] *= (Gross irrigated area/Gross cropped area)100*

Gross Irrigated Area (GIA) = *Kharif* + *Rabi* irrigated areas

Gross Cropped Area (GCA) = *Kharif* + *Rabi* cropped areas

PHHELCT = (Rural households having electricity connection/Total number of houses) 100

Rural electrification is supposed to be critical for providing other necessary infrastructure such as communication for bringing rural areas quickly to higher levels of development.

RURDEN = Total length of rural roads in kilometer/Net Sown Area in '000 hectare

All types of roads excluding national highways and state highways and district roads have been included in our measurement of rural roads. Specifically, these include: Classified village roads, forest roads, Panchayat Samiti roads, and Gram Panchayat roads. Density per '000 hectare of NSA, represents availability of road *vis-à-vis* agricultural land.

PHHTELCN = (Total number of rural households having telephone connection/ Total number of rural households)100

Measuring Agricultural Productivity and Related Terms

Productivity has different measures. The present analysis takes into account land productivity (*LNDPDVTY*) only.

LNDPDVTY = Value of output (O)/Gross Cropped Area (GCA) in hectares,

i.e., $O = \sum_{j=1}^{n} Q_j P_j$, where Q_j = quantity of j^{th} output, P_j = price of j^{th} output

[4] The study could not collect data on crop-wise use of irrigation. It has been assumed that data on PGIA for all crops are applicable for the 13 selected crops in the present study, without any change. However, due care has been taken while analysing the data.

The study has taken 13 crops, which are placed in five major categories as follows:

a) Cereals: rice—autumn; winter, summer—maize, ragi, and wheat;

b) Pulses: green gram, black gram, and horse gram;

c) Oil Seeds: ground nut, mustard, and sesamum;

d) Vegetables: potato; and

e) Other crops: jute, sugarcane.

It is noteworthy that output has been measured in nominal terms. The weighed average prices per quintal of these outputs for the reference year 2000-2001 have been taken for this purpose.

Normalization and Preparation of Composite Index[5]

Since the units of measurement of the selected factors are different, they give rise to problems of aggregation and comparison. So, the items have been normalized by dividing (column-wise) standard deviations to make them unit-free. Unit free measurement of different factors is essential for developing a composite index.

Contrary to the conventional methods of indexation, the present study employs the Principal Component Analysis (PCA) of the well-known Factor Analysis in order to prepare the Physical Infrastructure Development Index (*PIDI*).[6] This infrastructure index is a linear combination of the unit free values of the chosen individual factors,

$$Index_i = \Sigma W_i X_{ki}$$

where $Index_i$ = Index of the i^{th} district, W_k = Weight of the k^{th} factor, and X_{ki} = Unit free value of the k^{th} factor for the i^{th} district.

Modelling

The effects of physical infrastructure on productivity have been studied with help of the following linear and double-log models:

$$LNDPDVTY_i = \beta_0 + \beta_1 PIDI_i + u \qquad ...(1)$$

$$LnLNDPDVTY_i = \delta_0 + \delta_1 \; Ln \; PIDI_i + v \qquad ...(2)$$

where i represents i^{th} district, β_k and δ_k; (k = 0, 1) are the regression coefficients, while β_1 is the respective marginal function with respect to the concerned infrastructure index, δ_1 is the (partial) elasticity of the dependent variable with respect to *PIDI*; u and v are the error terms.

[5] In case of normalization of factors by dividing standard deviation (σ), the standard deviations of all the normalised factors become unity. The variability of the factors reduces. One advantage is that the β-coefficients and the partial regression coefficients will be equal and if the regress is also normalized then the β-coefficients will also be equal to the zero-order correlation coefficients.

[6] Factor analysis attempts to identify underlying variables or factors that explain the pattern of correlations within a set of observed variables. Factor analysis is often used in data reduction, by identifying a small number of factors, which explain most of the variance observed in a much larger number of manifest variables. PCA is one of the approaches of factor analysis. In the PCA approach, the first principal component is the linear combination of weighed items, which explains the maximum of variance across the observation at a point in time. Here, the sole objective of the weighing mechanism is to explain the maximum variance for all individual indicators taken together, across the districts and at a point in time.

Land productivity has also been regressed on individual items of physical infrastructure and the results have been interpreted. The software Statistical Package for Social Sciences (SPSS) has been used for principal component and regression analysis.

Results and Analysis

Preparation of Infrastructure Indices

As per the PCA, only the principal components having eigenvalues over 1 have been extracted. Thereby, two principal components are selected (Table 2). The study observed that the first principal component explains about 54% of variance in the taken normalized factors (not given in Table 2). Then, the Bartlett's criterion had been applied to make a further scrutiny to ascertain whether or not to take, only the first principal component or both the principal components. The Bartlett Criterion suggests that the first principal component can be taken convincingly.

Table 2: Component Matrix[a]

Component	*PGIA*	*PHHELCT*	*PHHTELCN*	*RURDEN*
1	0.684	0.957	0.877	–7.64E–02
2	–0.109	–6.965E–03	0.179	0.985

Note: Extraction Method: Principal Component Analysis.
a. 2 components extracted.

Sources: i) Primary Census Abstract (Census of India 2001-Orissa) for PHHELCT and PHHTELCN; ii) Statistical Abstracts of Orissa, 2002 and 2005 for PGIA and RURDEN.

The loadings (0.684, 0.957, 0.877, –0.0764) in the first principal component have been taken as weights of the normalized factors.

So, $PIDI = 0.684\,PGIA + 0.957\,PHHELCT + 0.877\,PHHTELCN + (-)\,0.0764\,RURDEN$

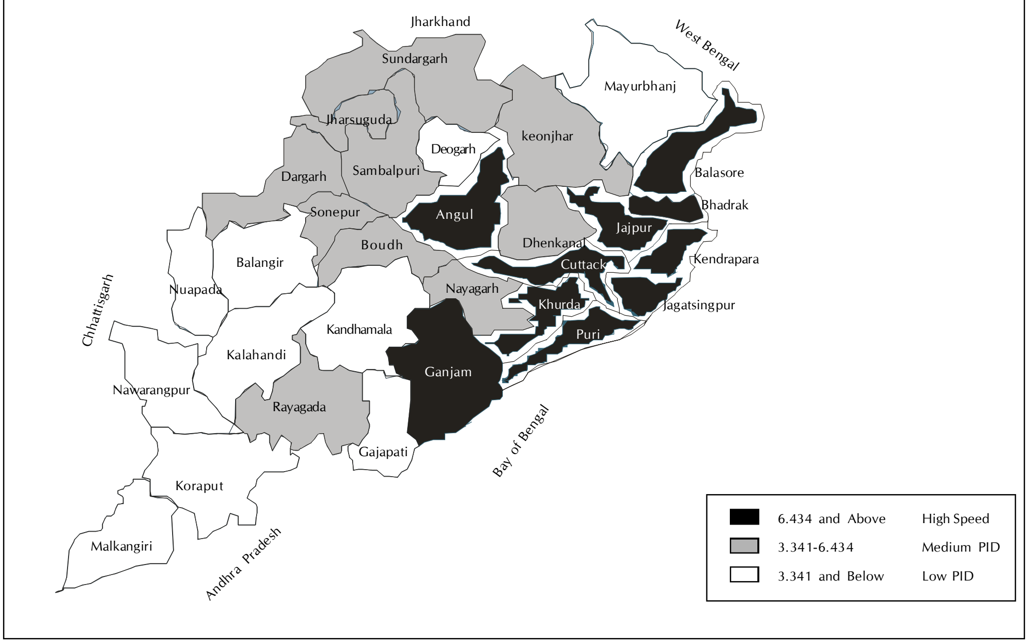
District-Wise Ranking

All the 30 districts of the state have been ranked on the basis of *PIDI* and *LNDPDVTY*. The details of such ranking have been presented in Table 3. The analysis divides all the 30 districts of the state in terms of *PIDI* as high, medium and low. There are ten districts in each category. A relative categorization of physical infrastructure and land productivity as such has been presented in the form of Map 1 and Map 2 respectively.

The study has attempted to find similitude between *LNDPDVTY* and *PIDI*. It is observed that most of the coastal districts have occupied the top positions in land productivity. However, Gajapati, which is a poor performer in infrastructure has also got a position in the high productive category. On the contrary, a good performer in infrastructure, the Angul district, comes in the low land-productivity category.

The discrepancy is more severe in the case of Khurda district. While this district occupies the 1st rank in *PIDI*, its rank in *LNDPDVTY* is one among the lowest, i.e., 25th rank (Table 3). So, although the study indicates, more or less, a positive relationship between *PIDI* and *LNDPDVTY*, it is still sketchy and needs some further scrutiny.

Map 1: Disparity in Physical Infrastructure



Map 2: Distribution of Land Productivity in Orissa

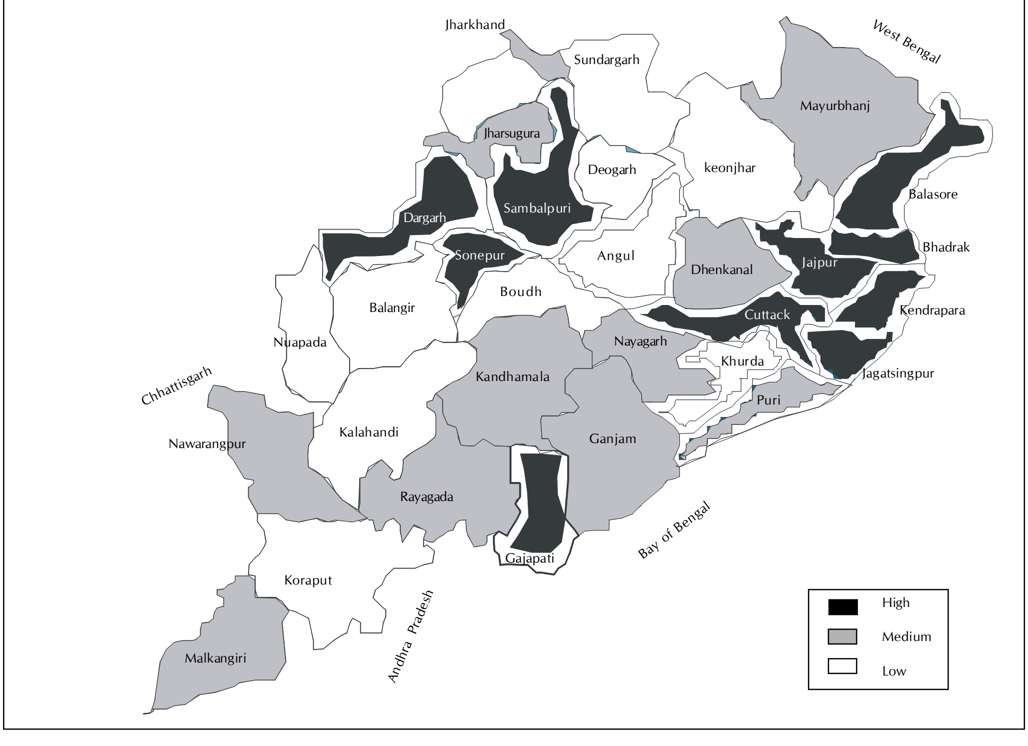


Table 3: Positions of Districts in Infrastructure *vis-à-vis* Land Productivity					
S. No.	District	*PIDI*	Rank in *PIDI*	*LNDPDVTY*	Rank in *LNDPDVTY*
1.	Angul	6.434	10	2280.74	24
2.	Balasore	6.562	9	4606.05	9
3.	Baragarh	6.356	11	6108.06	2
4.	Bhadrak	7.299	5	5535.58	4
5.	Bolangir	2.833	26	1492.54	29
6.	Boudh	3.783	19	1992.24	26
7.	Cuttack	8.438	2	7088.00	1
8.	Deogarh	1.948	29	2354.35	23
9.	Dhenkanal	5.588	13	2930.02	20
10.	Gajapati	3.430	21	5244.06	6
11.	Ganjam	7.257	6	4138.90	13
12.	Jagatsingpur	7.011	7	5857.36	3
13.	Jajpur	7.810	4	5095.81	7
14.	Jharsugura	5.048	16	3189.26	18
15.	Kalahandi	3.234	24	1983.99	27
16.	Kandhamala	2.335	28	3721.31	16
17.	Kendrapara	6.818	8	5403.19	5
18.	Keonjhar	3.819	18	2430.90	22
19.	Khurda	9.671	1	2274.52	25
20.	Koraput	3.247	23	4202.00	11
21.	Malkangiri	2.933	25	2577.57	21
22.	Mayurbhanj	3.300	22	3544.50	17
23.	Nawarangpur	1.688	30	3156.90	19
24.	Nayagarh	5.202	15	3726.62	15
25.	Nuapada	2.822	27	1119.56	30
26.	Puri	8.092	3	4143.58	12
27.	Rayagada	3.431	20	3730.44	14
28.	Sambalpur	6.183	12	5040.49	8
29.	Sonepur	5.330	14	4466.21	10
30.	Sundargarh	4.411	17	1769.14	28
Sources: i) PIDI has been compiled; ii) LNDPDVTY from Statistical Abstracts of Orissa, 2002 and 2005; and Agricultural Census of Orissa, 1995.					

Analysis of Correlation Coefficients

It is important to understand the degree of correlation between land productivity and the different items of physical infrastructure. It is observed that land productivity is significantly correlated to *PGIA* and *PHHELCT* ($r_{LNDPDVTY,\ PGIA} = 0.558$, $r_{LNDPDVTY,\ PHHELCT} = 0.498$). Though positive correlation exists between *LNDPDVTY* and *PHHTELCN*, the correlation is not significant ($r_{LNDPDVTY,\ PHHTELCN}$ = 0.302, *p*-value is 0.105). However, contrary to the general notion, the correlation between *LNDPDVTY* and *RURDEN* is found to be negative ($r_{LNDPDVTY,\ RURDEN}$ = –0.149). It has also been assigned negative weight in the making of *PIDI*. It is observed that mild negative correlation between *RURDEN* and other items of physical infrastructure exists. This implies that there is lack of synchrony in the development of rural roads *vis-à-vis* other physical infrastructure items. The districts, particularly Cuttack, Bhadrak, Baragarh, Jagatsinghpur and Jajpur, where land productivity is higher, have lower road density. These districts are otherwise better positioned in irrigation, rural electrification and rural telecommunication.

Effect of Individual Infrastructure Items

In order to assess the impact of individual infrastructure items on land productivity, *LNDPDVTY* has been regressed on each of the individual physical infrastructure items separately. Both linear and log-linear models have been fixed for this purpose. The linear model explains the absolute effect, whereas the log-linear model is useful in understanding the elasticity of *LNDPDVTY,* with respect to a particular infrastructure factor. It is noteworthy, that the independent variables have been modified into absolute terms before applying log-linear models, so that the slope coefficients can be interpreted as elasticity coefficients. The results are summarized in Table 4 and Table 5.

Irrigation

The R^2 values in Table 4 show that irrigation explains around 31% of variation in land productivity. If gross irrigated area increases by one unit, i.e., by 1%, then land productivity, on an average, increases by Rs. 44.20 and this increase is found as significant. The high value of the intercept indicates that there are other factors, which are also important in determining land productivity in the state.

Table 4: Regression Results of Two-Variable Linear Models

Independent Variables Model	***PGIA* (1)**	***PHHELCT* (2)**	***PHHTELCN* (3)**	***RURDEN* (4)**
Constant	2258.76	2423.04	2466.26	4317.41
Slope Coefficient	44.20	70.91	795.73	–16.39
SE of Slope Coefficient	12.41	30.31	422.01	20.557
t-stat. of Slope Coefficient	3.56	2.34	1.89	–0.797
p-value	0.00	0.027	0.07	0.432
R^2	0.31	0.16	0.11	0.022
Adjusted R^2	0.29	0.13	0.08	–0.013
N	30	30	30	30

Note: Dependent Variable: *LNDPDVTY.*

Source: Compiled by the author from the sources as stated in Tables 2 and 3.

Table 5: Regression Results of Two-Variable Log-Linear Models				
Independent Variables Model	**GIA (1)**	***HHELCT* (2)**	***HHTELCN* (3)**	***RURDEN* (4)**
Constant	5.69	5.97	6.59	8.66
Slope Coefficient	0.22	0.21	0.19	–0.15
SE of Slope Coefficient	0.10	0.09	0.09	0.22
t-stat. of Slope Coefficient	2.14	2.313	2.05	–0.67
p-value	0.04	0.03	0.05	0.51
R^2	0.14	0.16	0.13	0.02
Adjusted R^2	0.11	0.13	0.10	–0.02
N	30	30	30	30

Note: Dependent Variable: *LNDPDVTY*.

Source: Compiled by the author from the sources as stated in Tables 2 and 3.

The slope coefficients in Table 5 are the elasticity coefficients. The elasticity of *LNDPDVTY* with respect to irrigation is 0.22. It is pertinent to note here that *LNDPDVTY* has been regressed on Gross Irrigated Area (GIA), not on Percentage of Gross Irrigated Area (*PGIA*). The analysis observes that a 1% increase in GIA, increases land productivity in agriculture by 0.22%. This is inelastic but significant (*p*-value = 0.04).

Rural Electrification

The analysis observes electricity in rural areas (*PHHELCT*), as another critical input in raising the productivity of land. It paves way for mechanization and modern agricultural practices. Irrigation, to a certain extent, depends upon the availability of electricity in rural areas. The present study finds that electricity explains about 16% variation in *LNDPDVTY*. If an additional 1% household avails electricity, then land productivity increases by Rs. 70.91, which is significant at 5% level (Table 4).

With a view to assess the elasticity of *LNDPDVTY* with respect to household availing electricity (*HHELCT*), we have regressed *LNDPDVTY* on *HHELCT*, not on *PHHELCT*. The study observes that land productivity increases by 0.21%, if one more per cent of rural households gets electricity. This elasticity coefficient is statistically significant (Table 5).

Rural Telecommunication

Telecommunication is considered as an important part of rural physical infrastructure. It augments connectivity accessibility to technology and extension. However, the present analysis shows that the slope coefficient of *LNDPDVTY* with respect to *PHHTELCN* is not significant at 5% level, but it is significant at 7%. It is estimated that a 1% increase in rural household-owning telephone connection, increases land productivity by Rs. 795.73 (Table 4).

The study observes that the elasticity of *LNDPDVTY* with respect to *HHTELCN* is estimated as 0.19. This elasticity is found significant at 5% level.

Rural Road and Land Productivity

The existence of negative correlation between land productivity and rural road density (*RURDEN*) has been stated earlier. The regression results also confirm the same. It is observed that neither the slope nor the elasticity coefficient of *LNDPDVTY* with respect to *RURDEN* is significant (Table 4 and Table 5). Rather, the analysis reveals that rural road density has negative impact on land productivity, which needs to be interpreted cautiously. This finding is in conformity with our PCA and correlation analysis. The study observes that some districts such as Cuttack, Jagatsinghpur, Bhadrak, Jajpur and Balasore, where land productivity is relatively higher, have low density of rural road per net sown area. Some districts, where arable areas are relatively lower such as Deogarh, Anugul and Boudh, have got higher ranks in *RURDEN*. It may be interpreted in two ways. First, these districts are relatively better performers in other infrastructure items which overshadow their inadequacy in road infrastructure. Second, the net sown areas are higher in these districts in comparison to the length of rural roads in these districts. Both these points explain, what seems to be a paradox otherwise. However, it is not pertinent to state that rural road is a negative factor in the productivity of land. Had there been supportive well-connected rural road network, in addition to irrigation, electricity and communication in rural areas, the reality might have been different.

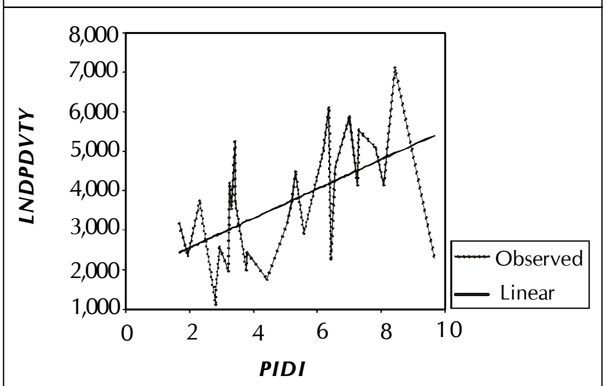
It is noteworthy, that the dependent variable *LNDPDVTY* has been expressed in value terms, which has taken values in thousands. So, the values of Standard Errors (SEs) in the linear regression model, except in case of *PHHTELCN*, may not be considered as high. Besides, the values of SEs have been reflected in the computations of *t*-ratios and R^2. In the present study, the number of cases taken for the analysis is 30, i.e., the number of districts in the state, which is given.

Overall Physical Infrastructure and Land Productivity

The analysis develops a composite index of physical infrastructure (*PIDI*) as a remedial measure for the multicollinearity problem. Besides these, developing a composite index of physical infrastructure has a number of advantages like studying regional disparity, understanding the overall impact of rural physical infrastructure on the productivity of land. Studying regional disparity is beyond the scope of the present analysis.

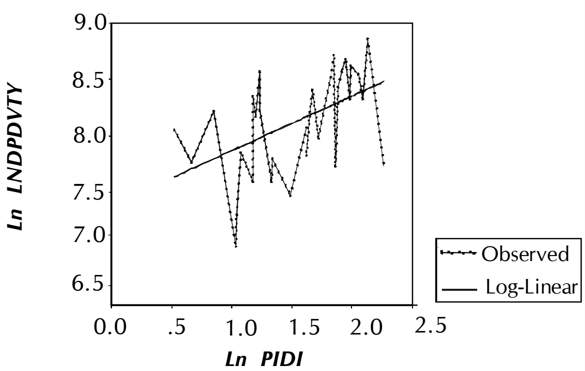
With a view to assess the overall impact of rural physical infrastructure on productivity of land, *LNDPDVTY* has been regressed on *PIDI*. The fitting model has been presented graphically. Figure 1 depicts the fitting of the linear model and Figure 2 presents the fitting of the log-linear model. It is clear from the figures that there is neither any conjectural fallacy nor any flaw in selecting these models.

Figure 1: Linear Model of *LNDPDVTY* on *PIDI*



The regression results of the overall regressions of the linear and the log-linear models have been presented in Table 6. The study observes that about 27.6% variation in land productivity is explained by

Figure 2: Log-Linear Model of *LNDPDVTY* on *PIDI*



PIDI. The overall regression is observed as highly significant. The model, therefore, confirms that physical infrastructure has a significant effect in raising land productivity. The analysis observes that when *PIDI* increases by one unit, i.e., one point, *LNDPDVTY* increases by Rs. 370.98. It is to be remembered that the value of *PIDI* is units free score, not any absolute quantity.

Table 6: Regression Results

Independent Variables	Linear Model	Log-Linear Model
Constant	1,823.334	7.386
Slope Coefficient	370.975	0.484
t-statistic	3.296	2.997
p-value of *t*	0.003	0.006
R^2	0.276	0.243
Adjusted R^2	0.250	0.216
N	30	30

The t-value in the log-linear model is also significant. The coefficient of determination R^2 in this model is 0.243 and the adjusted R^2 is 0.216. The slope coefficient in this model (the elasticity term) states that a 1% increase in PIDI increases land productivity by 0.484%. This is inelastic but significant. The inelasticity may be attributed to base and scale effects as land productivity has been expressed in value terms. So, *LNDPDVTY* in the present analysis are 4 or 5-digit values, whereas *PIDI* has got only single digit values. This indicates that even a small percent rise in *LNDPDVTY* with respect to 1% rise in *PIDI* is statistically highly significant, which is confirmed by the *p*-values of the *t*-statistics in Table 6.

Conclusion

This study observes that there is vertical inequality in the spread of physical infrastructure. All the two variable regressions of *LNDPDVTY* on individual infrastructure items such as irrigation and electricity, except road density are significant. The overall physical infrastructure index is highly significant in raising land productivity. The elasticity coefficients obtained from log-linear models are less than unity, but significant. The study attributes this inelasticity to the base and scale effects. This finding from the state of Orissa reinforces the significance of non-price factors in agriculture, which has strong policy implications. The findings of the present study also establish the observations of erstwhile studies made by Barnes and Binswanger, 1986; Desai and Namboodiri, 1997; Bhatia, 1999; and Sahoo and Saxena, 1999-2000.

The analysis explores that land productivity is low in the Kalahandi-Bolangir-Koraput (KBK) belt and certain districts of the Western-Central Orissa. This may be ascribed to underdevelopment of rural infrastructure. The formation of KBK plan and Western Orissa Council by the government, therefore, has established ground. However, a time-bound delivery system needs to be worked out. Besides, certain region-specific measures need to be initiated.

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