EPTD DISCUSSION PAPER NO. 84

HOW PRODUCTIVE IS INFRASTRUCTURE? NEW APPROACH AND EVIDENCE FROM RURAL INDIA

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ABSTRACT

There have been competing arguments about the effect of public infrastructure on productivity in the literature. Level-based regressions generally show a much higher return to public capital than private capital, while difference-based regressions tend to find insignificant or even negative effects. To help reconcile this debate, this paper proposes that researchers should first test for causality in their data to check for length of lagged relationships and the existence of reverse causality, as a critical step before specifying a final model and estimating procedure on the relationship between the stock of capital and productivity growth. A newly developed system GMM method of estimation is proposed for this purpose. Second, a new method of estimating the relationship between the capital stock and productivity in level form is proposed that controls for possible endogeneity problems arising from reverse causation. These methods are illustrated using a unique set of pooled time-series, cross-section data for India. It is shown that infrastructure development in India is productive with an estimated impact lying between those obtained from level-based and difference-based estimates.

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HOW PRODUCTIVE IS INFRASTRUCTURE? NEW APPROACH AND EVIDENCE FROM RURAL INDIA

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1. INTRODUCTION

Many developing countries have invested heavily in rural areas. These investments have resulted in significant improvements in rural infrastructure, technology, and education with the result that agricultural production and productivity have grown much faster than population growth in many developing countries (Binswanger et al. 1989; Antle 1984). Rapid growth in agricultural productivity has also led to significant trickle down benefits for the rural poor (Fan, Hazell, and Thorat 2000).

Despite these successes, the relationship between the stock of public capital and productivity growth remains controversial from a macroeconomic perspective in the general literature (Gramlich 1994). This debate arises in large part from differences in the methodology used in assessing the impact of public capital. Using aggregate time-series or panel data measured in level rather than change or difference form, a number of studies have found a positive link between public capital (especially infrastructure) and productivity growth and have reported rates of return to public capital far exceeding those to private capital (Aschauer 1989; Munnell 1992). Critics have pointed out that there are a number of econometric problems with this approach because variables measured in level form have common trends and measurement errors. Moreover, these statistical problems may be compounded by endogeneity problems when there is reverse causation between productivity growth and levels of capital formation.

To avoid these econometric problems, other researchers have used some form of differencing method. In contrast to the high rates of return to public capital obtained in prior studies, these studies suggest an insignificant or negative relationship between the capital stock and productivity growth (Tatom 1993; Holtz-Eakin 1994; Evans and Karras 1994; Garcia-Mila et al. 1996). But these studies in turn are suspect because the use of difference methods can destroy any long-term relationship in the data, leaving only short term impact to be captured in the model (Hsiao 1986; Munnel 1992). Since there are often long lags between investment and productivity growth, then jettisoning these relationships *ex ante* is not justified.

In an attempt to help reconcile this debate, this paper proposes the following. First, researchers should test for causality in their data to check for length of lagged relationships and the existence of reverse causality, as a critical step before specifying a final model and estimating procedure on the relationship between the stock of capital and productivity growth. For this purpose we suggest using a newly developed system GMM method of estimation. Second, we propose a new method of estimating the relationship between the capital stock and productivity in level form that controls for possible endogeneity problems arising from reverse causation. We also illustrate the proposed methods using a unique set of pooled time-series, cross-section data for India[1].

The paper is structured as follows. In the next section, we outline our causality test strategy for a panel data set and undertake an empirical test of the relationship between infrastructure capital and productivity in rural India. In Section 3 we estimate the impact

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[1] The literature on the puzzle of productivity and public capital has primarily focused on developed countries so far. Among those studies on developing countries, Canning (1999) has evaluated the returns to public capital in both lower-income and higher-income countries using cross-country data, while Binswanger et al. (1993) and Fan, Hazell, and Thorat (2000) have estimated the returns for a particular developing country.

of increases in the capital stock on productivity growth in India. Our conclusions comprise Section 4.

2. CAUSALITY TEST IN A PANEL

There are two reasons to conduct a causality test before estimating the productivity impact of infrastructure capital. First, such test may be necessary to ensure that there is a causal relationship between these two variables to avoid spurious regressions. Second, a test to determine the direction of the causal relationship is also important because if a reverse relationship exists, the ordinary least squares technique will yield inconsistent estimates of the parameters (Gramlich 1994; Jimenez 1995).

To date, most causality tests have used time-series data.[2] However, time-series data are rarely available for many years and it is difficult to control for measurement errors and omitted variable problems. To overcome these problems, we apply a newly developed system GMM technique for panel data to conduct the causality test. The system GMM method can help reduce the estimation bias often inherent in a panel data set when lagged dependent variables are used as regressors. Our study differs from previous studies on the panel causality tests developed by Holtz-Eakin et al. (1988) by including initial conditions as additional instruments to improve estimation accuracy.

To illustrate, assume that there are *N* cross-sectional units observed over *T* periods. Let *i* index the cross-sectional observations and *t* the time periods. Assume further the existence of an individual effect α_i for the i^{th} cross-sectional unit. The model is:

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[2] Tatom (1993) has conducted a causality test for productivity and infrastructure capital using time-series data and finds a two-way impact. Holtz-Eakin and Schwartz (1995) found a one-way impact of infrastructure on productivity growth.

$$y_{it} = a_0 + \sum_{e=1}^{m} a_e y_{it-e} + \sum_{k=1}^{n} \boldsymbol{b}_k x_{it-k} + \boldsymbol{h}_i + u_{it} \ , \qquad (1)$$

where i=1, …, N; t=m+2, …, T; the á’s and â’s are parameters; and the lag lengths *m* and *n* are sufficient to ensure that u_{it} is a stochastic error. While it is not essential that *m* equals *n*, we follow typical practice by assuming that they are identical.[3] The test of whether *x* causes *y* is simply a test of the joint hypothesis that $\boldsymbol{b}_1 = \boldsymbol{b}_2 = ... = \boldsymbol{b}_n$ are all equal to zero. If this null hypothesis is accepted, then it means that *x* does not cause *y*. To account for the individual effects, the intercept is often allowed to vary with each unit in a panel analysis, which is represented as $\boldsymbol{h}_i$ in (1).

When the number of cross-sectional units (N) is much larger than the number of time periods (T), the nonstationarity problem commonly seen in time-series data can be attenuated (Holtz-Eakin et al. 1988).[4] But in a dynamic panel model, including an individual effect together with a lagged dependent variable generates biased estimates for a standard LSDV (least squares dummy variable) estimator especially when N is much larger than T (Hsiao 1986). A common way to deal with this problem is to take the first difference as shown in (2) and exploit a different number of instruments in each time period using either an instrument variable estimator or a GMM estimator as an estimation method (Holtz-Eakin et al. 1988 and 1989; Arellano and Bond 1991).

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[3] Constraining the lag lengths to be equal simplifies the problem by reducing greatly the number of potential combinations of lag lengths for the right-hand side variables, and hence commensurately reducing the number of tests that have to be performed. A consequence of this strategy is that some variables may appear with more lags than are truly" nonzero. Because these variables have zero coefficients, their presence does not affect the behavior of the system. Thus, the only cost to this strategy is some loss in efficiency.

[4] When T is larger than N or T increases faster than N, the nonstationarity problem may cause estimation bias with standard methods. Unit root and cointegration tests are usually needed to identify the nonstationarity problem. For recent development in this area, please see papers collected in a special issue of *Oxford Bulletin of Economics and Statistics* (Vol. 61, November 1999) and a review by Baltagi and Kao (2000).

$$\Delta y_{it} = \sum_{e=1}^{m} a_e \Delta y_{it-e} + \sum_{e=1}^{m} \boldsymbol{b}_e \Delta x_{it-e} + \Delta u_{it} \ , \qquad (2)$$

For the first-difference equation (2), suitably lagged endogenous variables can be used as instruments. For example, if u_{it} are not serially correlated with each other, then for time t = m+2, ($y_{i1}, y_{i2},..., y_{im}$) are uncorrelated with y_{im+2} and therefore can be used as valid instruments at time m+2. Similarly, the instruments for time period T are ($y_{i1}, y_{i2},..., y_{i(T-2)}$). For the whole period, the instrument matrix for the differenced equation (2) is:

$$Z_i^D = \begin{pmatrix} y_{i1} & y_{i2} & \ldots & y_{im} & 0 & 0 & \ldots & 0 & \ldots & 0 & 0 & \ldots & 0 \\ 0 & 0 & \ldots & 0 & y_{i1} & y_{i2} & \ldots & y_{i(m+1)} & \ldots & 0 & 0 & \ldots & 0 \\ . & . & & . & . & . & & . & & . & & & . \\ . & . & & . & . & . & & . & & . & & & . \\ 0 & 0 & \ldots & 0 & 0 & 0 & \ldots & 0 & \ldots & y_{i1} & y_{i2} & \ldots & y_{i(T-2)} \end{pmatrix} \quad (3)$$

This matrix has T-m-1 rows and $\sum_{j=m}^{T-2} j$ columns.

However, it is found that estimations on first-differenced equations produce unsatisfactory results in both simulation and empirical studies (Mairesse and Hall 1996). Blundell and Bond (1998) proposed a system GMM method by combining the first-differenced and level equations and show it has a relatively better performance. In addition to the above instruments for the first-differenced equations, the system GMM method also takes into account instruments available for the levels equation (1). Because ($\Delta y_{i(m+1)},..., \Delta y_{i(T-1)}$) are uncorrelated with ($y_{i(m+2)},..., y_{iT}$), they can be used as instruments for levels equations (1) from period m+2 to T.

In order to fully exploit these instruments, the equations in first differences and equations in levels corresponding to the period m+2, …, T are stacked as system equations for GMM estimations as follows:

$$y_i = W_i \boldsymbol{d} + u_i \ , \qquad (4)$$

where ä is a parameter vector including the á's and â's;

y_i is defined as $(\Delta y_{i(m+2)},\ldots,\Delta y_{iT}, y_{i(m+2)},\ldots, y_{iT})$, and W_i includes the lagged endogenous and predetermined variables in terms of both differences and levels.

The instrument matrix for the combined differenced and levels equation (4) is:

$$Z_i = \begin{pmatrix} Z_i^D & 0 & \ldots & 0 \\ 0 & \Delta y_{i(m+1)} & \ldots & 0 \\ . & . & & . \\ 0 & 0 & \ldots & \Delta y_{i(T-1)} \end{pmatrix} \qquad (5)$$

If there are regressors other than lagged endogenous variables uncorrelated with individual effects á's and the error terms, these regressors can be used as instruments together with the above Z_i.

Using these instruments and following the estimation strategy outlined by Blundel and Bond (1998)[5], the coefficients for the lagged dependent variables and predetermined variables can be estimated for the purpose of causality tests.

The estimation was based on a pooled time-series (1971 to 1994) and cross-sectional (290 districts) data set from rural India with a total of 6,960 observations. The

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[5] We use a Gauss program "DPD98" to conduct the regressions (see Arellano and Bond, 1998 for details).

data were mainly compiled from official publications of the Indian central and local governments.[6]

Agricultural productivity growth is measured through a total factor productivity (TFP) index that is the ratio of total output to total input. The Törnqvist-Theil index (a discrete approximation to the Divisia index) is used to construct TFP growth.[7] The infrastructure variable is road density measured as the length of roads in kilometers per thousand square kilometers of geographic area. All the variables used in the analysis are in natural logarithm form.

Figure 1 graphs the relationship between TFP and road density after regional fixed effects have been eliminated. It appears there is a positive correlation between TFP and road development, but this needs not be a causal relationship.

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[6] The data set was compiled by IFPRI in collaboration with the National Center for Agricultural Policy Research, New Delhi, and Jawaharial Nehru University, New Delhi.

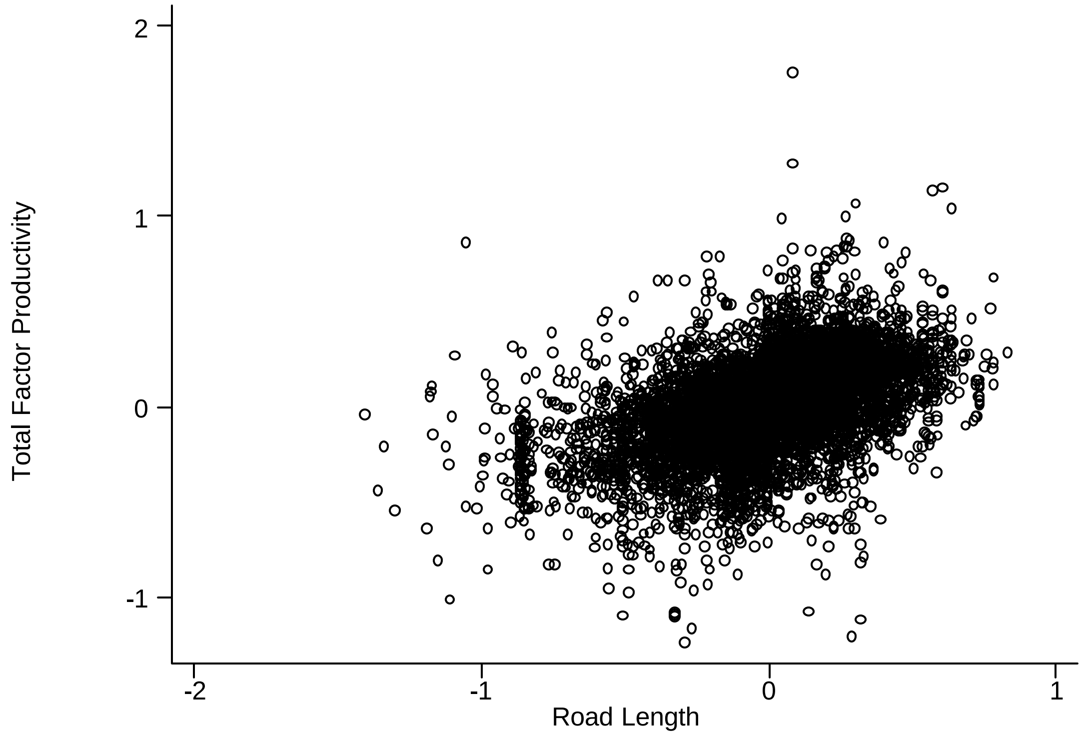
[7] The TFP growth index is constructed as follows:

$$\ln TFP_t = \sum_i 0.5*(S_{i,t} + S_{i,t-1})*\ln(Y_{i,t}/Y_{i,t-1}) - \sum_i 0.5*(W_{i,t} + W_{i,t-1})*\ln(X_{i,t}/X_{i,t-1})$$

Where $lnTFP_t$ is the log of the total factor productivity index; $S_{i,t}$ and $S_{i,t-1}$ are output *i*'s share in total production value at time *t* and *t-1*, respectively; and $Y_{i,t}$ and $Y_{i,t-1}$ are quantities of output *i* at time *t* and *t-1*, respectively. Farm prices are used to calculate the weights of each crop in the value of total production. $W_{i,t}$ and $W_{i,t-1}$ are cost shares of input *i* in total cost at time *t* and *t-1*, respectively; and $X_{i,t}$ and $X_{i,t-1}$ are quantities of input *i* at time *t* and *t-1*, respectively. Thirty crops (rice, wheat, *jowar*, *bajra*, maize, *ragi*, barley, gram, other pulses, groundnut, sesame, linseed, rapeseeds and mustard, castorseed, safflower, nigerseed, coconut, soybeans, sunflower, potato, tapioca, sweet potato, banana, cashewnut, coffee, jute, sugarcane, onion, and fruits) and three major livestock products (milk, chicken, and sheep and goat meat) are included in total production. Farm prices are used to calculate the output shares.

Five inputs (labor, land, fertilizer, tractors and animals) are included. Labor input is measured as total female and male labor (including both family and hired) engaged in agricultural production. A conversion ratio of 0.7 has been used to convert female labor to its male labor equivalent. Land is measured as net cropped area; fertilizer input is measured as the total amount of nitrogen, phosphate, and potassium used; tractor input is measured as the number of four-wheel tractors (including both private- and government-owned); and animal input is measured as the number of draft animals (total buffalos). Wages of agricultural labor are used as the price of labor; rental rates of tractors and animals are used for their respective prices; and the fertilizer price is calculated as a weighted average of the prices of nitrogen, phosphate, and potassium. The land price is measured as the residual of total revenue net of measured costs for labor, fertilizer, tractors, and bullocks.

Figure 1—TFP and Road Density



CAUSALITY TEST RESULTS

For any causality test, the lag length is an important issue. Ideally, we should specify an arbitrarily long initial lag length. However, a considerably long lag length poses overindentification and estimation problems. According to Holtz-Eakin *et al*. (1988), the lag length should be less than 1/3 of the total time period; otherwise, the covariance matrix cannot be correctly estimated due to over identification problem. Therefore, we set the maximum lag length as 7.

Table 1 presents the causality test results between productivity and infrastructure development with lag length ranging from one to seven years.

Table 1--Causality tests on TFP and road density, rural India

	TFP							Road Density						
Road(-1)	-0.034	-0.010	-0.235	-0.024	-0.110	-0.090	-0.054	0.981**	1.074**	1.047**	1.055**	1.030**	1.005**	1.116**
	(0.023)	(0.147)	(0.152)	(0.150)	(0.135)	(0.142)	(0.144)	(0.005)	(0.061)	(0.062)	(0.064)	(0.055)	(0.053)	(0.050)
Road(-2)		-0.027	0.301*	0.301*	0.148	0.112	0.061		-0.091	-0.046	-0.053	-0.026	0.004	-0.092
		(0.139)	(0.167)	(0.166)	(0.152)	(0.159)	(0.158)		(0.061)	(0.069)	(0.071)	(0.064)	(0.063)	(0.063)
Road(-3)			-0.104**	-0.057	-0.073	-0.063	-0.062			-0.017	-0.011	-0.007	-0.015	-0.031
			(0.042)	(0.062)	(0.066)	(0.067)	(0.069)			(0.018)	(0.023)	(0.025)	(0.033)	(0.022)
Road(-4)				-0.038	-0.080	-0.094*	-0.102*				-0.005	0.026	0.040	0.040
				(0.039)	(0.057)	(0.056)	(0.055)				(0.012)	(0.024)	(0.027)	(0.027)
Road(-5)					0.060*	0.049	0.034					-0.035*	-0.034	-0.045*
					(0.036)	(0.046)	(0.054)					(0.020)	(0.035)	(0.025)
Road(-6)						0.020	0.025						-0.008	-0.020
						(0.048)	(0.062)						(0.019)	(0.018)
Road(-7)							0.037							0.026*
							(0.042)							(0.015)
TFP(-1)	0.653**	0.437**	0.345**	0.326**	0.327**	0.297**	0.292**	0.007	0.008	0.013	0.016	0.016	0.022*	0.002
	(0.037)	(0.032)	(0.037)	(0.037)	(0.038)	(0.043)	(0.045)	(0.008)	(0.010)	(0.010)	(0.012)	(0.011)	(0.012)	(0.010)
TFP(-2)		0.225**	0.305**	0.321**	0.331**	0.367**	0.369**		0.001	-0.002	-0.005	-0.006	-0.008	-0.013*
		(0.025)	(0.037)	(0.036)	(0.036)	(0.038)	(0.041)		(0.006)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)
TFP(-3)			0.115**	0.120**	0.135**	0.160**	0.151**			-0.003	-0.004	-0.007	-0.003	-0.007
			(0.029)	(0.029)	(0.032)	(0.031)	(0.034)			(0.006)	(0.006)	(0.006)	(0.008)	(0.005)
TFP(-4)				0.012	-0.030	-0.017	-0.013				0.001	0.003	0.004	-0.010**
				(0.017)	(0.017)	(0.018)	(0.018)				(0.001)	(0.007)	(0.008)	(0.005)
TFP(-5)					0.090**	0.050**	0.087**					-0.009	-0.022**	0.007
					(0.015)	(0.014)	(0.017)					(0.006)	(0.010)	(0.005)
TFP(-6)						0.034**	0.063**						0.005	0.012**
						(0.016)	(0.015)						(0.063)	(0.004)
TFP(-7)							-0.091**							0.007**
							(0.016)							(0.004)
Wald tests p-value	0.131	0.195	0.023	0.043	0.003	0.002	0.010	0.400	0.627	0.565	0.643	0.345	0.061	0.000

Note: One and two asterisks indicate that estimates are significant at the 10% and 5% significance levels, respectively. Figures in the parentheses are standard errors. The estimations reported in this table include year dummies.

The Wald test for the null hypothesis that road development has no effect cannot be rejected until the lag length is more than two. It seems the impact of infrastructure development on TFP might not be instantaneously exerted. The result confirms the findings by Canning and Pedroni (1998) that the casual impact of road development on productivity exists as a long run rather than a short run relationship.

In the equations for TFP, similar results can be observed. When lag length is less than six years, we cannot observe a significant impact of TFP on road development. The p-value of the Wald test becomes significant if a six-year or seven-year lag is considered. This result suggests a possible long-run induced effect of productivity growth on infrastructure development. This might be because a fast growing region requires better infrastructure conditions and therefore more investment. On the other hand, the central government may target infrastructure investment to the high productivity regions because of higher growth potentials. The relatively short lag length of roads on TFP indicates investment in infrastructure has a more immediate impact on TFP, which in turn leads to more investment in infrastructure development in the longer run.

Because of multicollinearity problems among the lagged variables, the causality test cannot distinguish whether infrastructure development has a positive or negative effect on long-run productivity growth. Some have argued that public provision of infrastructure may crowd out private investment and generate negative effects on growth. Therefore, the sign and magnitude of the productivity effect of infrastructure development is still an empirical question subject to test. This issue will be discussed in the next section.

3. PRODUCTIVITY EFFECT OF INFRASTRUCTURE DEVELOPMENT

As shown in the previous section, the two-way causality correlation indicates that higher productivity regions may have more resources to spend on infrastructure than lower productivity regions, resulting in a greater stock of infrastructure capital and therefore contributing to regional divergences. In addition, the government may target its resources to high potential areas (Fan, Hazell, and Haque 2000). Taken together, the two-way causality and regional targeting may create endogeneity and heterogeneity problems that yield inconsistent estimates when using ordinary least squares to estimate the impact of infrastructure on productivity.

To control for the heterogeneity problem, we use district dummy variables to capture the regional-specific fixed effects. To account for nationwide shocks due to such factors such as macroeconomic and trade policy, we also add year-specific intercepts in our analysis. The year dummies will eliminate any common countrywide effects on the TFP variable. In addition to the fixed effects, we also include a rainfall variable and the adoption of high-yielding varieties to avoid any omitted variable problems and to model the productivity effect of these two variables.

The long-run impact of roads on TFP shown in the causality test justifies using levels instead of differences in estimation. We consider the following function as the starting point for our analysis:

$$tfp_{it} = \beta_1 road_{it} + \beta_2 HYV_{it} + \beta_3 rain_{it} + \gamma_t + \eta_i + v_{it} \qquad (6)$$

where tfp_{it}, $road_{it}$, HYV_{it}, and $rain_{it}$ refer to the logarithm of total factor productivity, road density, the proportion of cropped areas planted to high yield varieties, and annual rainfall in district *i* at year *t*, respectively. The error term is represented as v_{it}. As stated earlier, it is highly likely that the road variable is correlated with the error term v_{it}.

Table 2 presents the estimation results for various model specifications. Regression (1) is in difference form and is estimated by the least squares dummy variable (LSDV) method.

Table 2--Estimation results of the productivity impact of infrastructure, rural India

	(1) Difference (LSDV)	(2) Level (LSDV)	(3) Level (GMM)	(4) Level + r (LSDV)	(5) Level + r (GMM)
Road	0.019	0.078**	0.048**	0.069**	0.043**
	(.035)	(0.040)	(0.009)	(0.017)	(0.007)
HYV	0.044**	0.061**	0.053**	0.044**	0.073**
	(0.009)	(0.013)	(0.002)	(0.006)	(0.002)
Rainfall	0.100**	0.035**	0.053**	0.037**	0.050**
	(0.014)	(0.014)	(0.003)	(0.005)	(0.001)

Note:
1. One and two asterisks indicate that estimates are significant at the 10% and 5% significance levels, respectively. Figures in the parentheses are standard errors.
2. LSDV stands for lease square dummy variable estimators. Column (1) includes only year dummies and all other columns include both year and district dummies.
3. One and two asterisks indicate that estimates are at the 10% and 5% significance levels, respectively.
4. The system GMM method uses historical values of the TFP and road variables with a lag up to 10 years and the current values of HYV and rainfall as instrumental variables.

The coefficient for roads is positive at 0.019 but is statistically insignificant. Because regressions in difference form reflect a short-run relationship, this result is not surprising given our earlier findings from the causality test that roads do not have an immediate causality effect on TFP.

In regression (2), we estimate a level equation using the LSDV estimator. Both regional and year dummies are included. The productivity effect of roads is now high at

0.078 and is statistically significant. However, this regression is probably subject to estimation bias due to the endogeneity problem inherent in the road variable as shown in the causality test. Because road development is endogenous as shown in the causality test, a GMM approach is applied to overcome the endogeneity problem for equation (6). To be specific, historical values for TFP and roads up to period t-3, the current values for HYV and rainfall, and the dummy variables are used as instruments for the GMM estimation. Compared to the conventional instrumental variable estimator, the GMM method allows us to use more initial conditions and historical values as instruments, therefore having better estimation efficiency. Regression (3) presents the GMM estimation results with the endogeneity problem being taken into account. The coefficient for the road variable drops to 0.048 but it is still much larger than in regression (1) and remains statistically significant.

To further justify the rationale of not taking differences in the regression, we estimate a level equation with first-order autocorrelation using LSDV to check the autocorrelation coefficient r. If r is equal or close to 1, then differencing is required, otherwise not. Regression (4) reports estimation results with first-order correlation. The autocorrelation is significant at 0.454, far from 1, suggesting that it is not necessary to take the first difference. With autocorrelation being considered, the coefficient for roads declines from 0.078 to 0.069.

This level regression may also be subject to an endogeneity problem from reverse causality. Using the autocorrelation coefficient obtained from regression (4), we first take a quasi-difference to transform all the data series to eliminate the serial correlation in the error term and then apply the GMM method to overcome the endogeneity problem. This two-stage estimation is asymptotically consistent (Greene, 1993). The coefficient for roads in regression (5) is significant at 0.043, less than that without autocorrelation being adjusted or endogeneity being eliminated.

The implication of using all the historical information for productivity and road variables as instruments in the GMM method is that governments can utilize all the available information prior to time t in making investment decisions. In sum, the results in Table 2 consistently show that infrastructure development has a positive effect on productivity growth. The actual magnitude of the effect may be lower after adjusting for autocorrelation and endogeneity problems than that for the standard two-way effects model. But it is definitely much higher than those from the differenced estimation approach.

4. CONCLUSIONS

In the first part of the paper, we conducted a causality test to investigate the relationship between technology and infrastructure using a panel data set at the district level in rural India from 1971 to 1994. The test allows for individual effects, and is estimated by applying a dynamic system GMM estimator to the autoregression equations. It is found that infrastructure development and productivity often affect each other in the long term but not in the short run. This finding has important implications for evaluating infrastructure investments.

In order to examine the magnitude of the productivity impact of infrastructure, we further explored different model specifications. In general, a model in levels yields positive and larger effects, while a model in differences gives insignificant results. This is consistent with findings in the literature. Because the autocorrelation coefficient is below one, estimation in differences cannot be justified in our Indian data set. After further controlling for autocorrelation and accounting for possible endogeneity problems, we find that the magnitude of relationship decreases slightly. Nevertheless, infrastructure development has a significant and positive impact on growth in productivity.

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