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The Impact of Public Investment on Economic Growth in Pakistan

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This paper explores the role of public investment in the process of economic growth, in the context of Pakistan's economy, using the vector autoregressive approach (VAR). Based on theoretical considerations, the model also includes private investment and public consumption besides public investment. The results show that growth is largely driven by private investment and that no strong inference can be drawn from the effects of public investment and public consumption on economic growth.

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1. INTRODUCTION

A growing body of literature including recent extensions of the neo-classical growth model as well as the theories of endogenous growth has underlined the role of public investment in economic growth [see, for example, Kormendi and Meguire (1985); Romer (1986); Lucas (1988); Grier and Tullock (1989); Barro (1991); Levine and Renelt (1991); Rebelo (1991); Mankiw, Romer, and Weil (1992); Barro and Lee (1993); Fischer (1993) and Barro and Sala-i-Martin (1999)]. It is, however, noteworthy that the question whether or not public investment has a beneficial impact on economic growth is far from settled. One strand of literature takes a positive view of public investment and argues that public investment stimulates private sector productivity thereby increasing economic growth [see, for instance, Arrow and Kurz (1970); Barro (1990)]. According to this view, the importance of public investment in determining long term economic growth stems from the fact that it not only generates positive spillovers in the economy through the provision of education, health, basic scientific research and physical infrastructure, but may also crowd in private investment thereby enhancing economic growth. Other studies raise questions about the efficiency of public investment on the one hand and its relationship with private investment on the other, and argue that public investment

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may not necessarily have a favourable impact on economic growth [see, Khan (1996); Devarajan (1996), among others]. In the absence of a clear theoretical relationship between public investment and economic growth, the issue is essentially an empirical one.

This study empirically examines the relationship between public investment and economic growth in the context of Pakistan's economy. Section 2 provides a review of literature. Data and methodology are discussed in Section 3, whereas empirical results are reported in Section 4. Section 5 concludes the discussion.

2. REVIEW OF LITERATURE

The role of public investment in the process of economic growth has been the subject of enquiry of a growing body of both theoretical and empirical literature. The starting point for both strands of literature is the notion that actions taken by governments have considerable effect on macroeconomic performance. For example, the level of public investment may affect both private investment and the long-term rate of growth. The fact that public investment is largely non-excludable and non-rival in consumption suggests spillover effects, and this is emphasised by the endogenous growth models including Romer (1986) and Barro and Salai-i-Martin (1999). These models allow for the possibility of external effects through which public investment can have an effect on economic growth.[1]

Empirical studies have used various approaches to investigate the role of public investment in the process of economic growth. Using a production function approach, Ebert (1986), Costa, *et al.* (1987) and Deno (1988) find public investment to be a significant input in the production process and private and public investments to be complementary, rather than substitutes. Milbourne, Otto and Voss (2003), using an extension of Mankiw, Romer and Weil's augmented Solow-Swan growth model, examine whether public investment has a distinct role as a determinant of economic growth. The study considers both the predictions of the model in steady state and in transition to steady state. For the steady state model, there is no significant effect from public investment on the level of output per worker. Using standard ordinary least squares (OLS) methods for the transition model, it observes a significant contribution to economic growth from public investment. When instrumental variables methods are used, however, the associated standard errors are much larger and the contribution of public investment is statistically insignificant.

In an influential study, using annual data for the period 1949 to 1985 for the United States, Aschauer (1989a) finds a strong positive relationship between productivity and the ratio of the public to the private capital stock. Aaron (1990) and Tatom (1991) question the findings of Aschauer on the basis of non-stationarity of

[1]Recall that public investment (fiscal policy) does not affect the steady state growth rate in neoclassical growth models.

the time series data which may yield spurious correlation between the public capital stock and output growth. Sturm and De Haan (1995) argue that if Aschauer's model is estimated in first differences—which is necessary as the variables used are neither stationary nor cointegrated—the model produces only ambiguous results. However, as pointed out by Munnell (1992), first differencing also has its problems as it does not allow the estimation of the underlying long-term relationship between production and factor inputs. Duggal, *et al.* (1995) argue that first differenced equations generate a priori implausible labour and capital output elasticities, and that this is enough to question the ability of first differenced equations to capture the long run relationships.

Recent developments in econometrics have allowed the researchers to not only examine the extent to which variables are non-stationary, but also whether they grow together over time and converge to their long-run relationship, that is, whether they are cointegrated. This approach is followed by Lynde and Richmond (1993a, 1993b). They apply an error correction model (ECM) to capture the non-stationarity of the data. Using an ECM approach also introduces dynamics in this framework. The standard behavioural approach assumes that all endogenous variables adjust to their equilibrium level within one period, which is implausible. Furthermore, Sturm and Kuper (1996) report severe autocorrelation using the standard behavioural approach, and show that this can be overcome by adopting an ECM representation within a translog cost function.

Khan (1996) explores the relative importance of public and private investment in promoting economic growth for a large group of developing countries. The results of the study show that private and public investment have a differential impact on economic growth, with private investment having a much larger impact than public investment. Also, significant regional variations are found in terms of the effects of public and private investment. Devarajan, Swaroop, and Zou (1996) focus on the composition of public expenditure and show that whereas current public expenditure has positive and significant growth effects, the effect of capital component of public expenditure on per-capita growth is negative.

A number of empirical studies have adopted the vector auto-regressive (VAR) approach to examine the relationship between government investment and economic growth. By imposing as little economic restrictions as possible, this modelling technique tries to solve some of the problems inherent in the production and behavioural approaches. An advantage of VAR models is, for instance, that no a priori causality directions are imposed or other identifying conditions derived from economic theory are needed. Indirect effects of public investment are also taken into account. Using the VAR approach, Sturm (1998) finds that infrastructure investment positively influences output in the Netherlands, and using the same approach to analyse the dynamic effects of public investment for six industrial countries, Mittnik and Neumann (2001) establish that public investment tends to exert a positive influence on GDP. Furthermore, they find no crowding-out effect between public investment and private investment. Navy (2002) examines the relationship between economic growth, public investment and private investment using VAR methodology. Based on annual time series data for Pakistan, the analysis suggests that public investment has a positive impact on private investment, and that economic growth drives both private and public investment as predicted by the accelerator-based models.

3. DATA AND METHODOLOGY

We pursue the VAR approach to investigate the relationship between public investment and economic growth. The VAR methodology is preferred in this study for at least two reasons. First, it avoids any *a priori* restrictions on the variables appearing in the VAR and captures the forward-looking nature of investment spending. Second, the VAR methodology allows the study of both long run equilibrium relationship and short run dynamics within a unified framework of co-integration and error-correction modelling, due to Engle-Granger, Johansen (1988) and others.

The VAR consists of four variables i.e. public investment (IG), private investment (IP), public consumption (CG), and GDP (Y). Data on these variables in real terms for the period from 1973 to 2004 are obtained from various issues of the Economic Survey. Both public investment and private investment capture physical capital formation which is considered as one of the most important determinants of economic growth. The dis-aggregation of investment into public and private components not only allows estimation of the impact of the two types of investment on economic growth, but also sheds light on the question of whether or not public investment crowds out private investment. This question has received wide attention in the literature. In line with a number of earlier studies on economic growth, most notably Kormendi and Meguire (1985) and Grier and Tullock (1989), public consumption is also included in the analysis. It is generally argued that public consumption can either promote or impede the process of economic growth depending on the nature of such expenditures. For instance, expenditure on the provision of public goods would foster growth only if it does not divert resources from other productive uses.

Prior to estimating a multivariate VAR, the stationarity properties of the data are investigated using tests for the existence of unit roots. If individual variables in the VAR turn out to be unit root processes, it is possible that the variables share a common stochastic trend, i.e. they are cointegrated. Tests for cointegration are carried out by using the Johansen's testing procedure. This method proceeds with the specification of the following VAR of order p:

$$y_t = A_1 y_{t-1} + \dots\dots\dots + A_p y_{t-p} + \varepsilon_t \quad \dots \quad \dots \quad \dots \quad \dots \qquad (1)$$

where y_t is k-dimensional vector of non-stationary variables, and ε_t is a vector of white noise residuals. By using the first difference operator Δ, the above VAR can be rewritten as:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p} T_i \Delta y_{t-i} + \varepsilon_t \qquad \dots \quad \dots \quad \dots \quad \dots \qquad (2)$$

The rank of matrix Π determines the number of linear combinations of y_t that are stationary processes. If the rank of the matrix is r, Π can be factored as $\alpha\beta'$, where the elements of α are the adjustment parameters in the error-correction model, and β contains the cointegrating vectors. Johansen derives two test statistics for testing the cointegrating rank. The first is the maximum eigenvalue test, which tests the null hypothesis of r cointegrating vectors against the alternative of $r + 1$ vectors. This test utilises the $r + 1^{st}$ largest eigenvalue in the following likelihood ratio:

$$\lambda_{\max} = -T \ln(1 - \lambda_{r+1}) \qquad \dots \quad \dots \quad \dots \quad \dots \quad \dots \qquad (3)$$

The second test statistic, known as the trace statistic, provides a test for a more general alternative hypothesis ($r \leq n$) and is computed as:

$$\lambda_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \lambda_i) \qquad \dots \quad \dots \quad \dots \quad \dots \quad \dots \qquad (4)$$

If the variables in the VAR turn out to be cointegrated, the error correction modelling approach (restricted VAR) is adopted to determine the direction of causation between public investment and economic growth. The error correction model unifies both the short run dynamics and long run equilibrium relationships among the variables. More specifically, the statistical significance of the adjustment parameters α would provide evidence of long-run causality, whereas the joint significance of lagged first differences in the restricted VAR would indicate short run causality.

4. EMPIRICAL RESULTS

The empirical work proceeds by conducting DF-GLS and KPSS tests for stationarity for the four variables, in their logarithmic form. The DF-GLS has been found to be particularly suitable for small samples in view of its better power in smaller sample sizes. As an additional test for stationarity, the KPSS test has been used, which tests the null hypothesis of stationarity instead of the null of a unit root. The results of both these tests (Table 1) show that all the variables are non-stationary in their levels. To ascertain the order of integration, unit root tests are performed on variables in their first differences, and these results show that all the variables are integrated of order 1.

Table 1

Unit Root Tests

Variable	DF-GLS		KPSS	
	Without Trend	With Trend	Without Trend	With Trend
Y	–0.85	–2.89	0.74	0.18
Δ*Y*	–1.40	–4.72	0.41	0.11
IG	–1.44	–1.82	0.55	0.19
Δ*IG*	–4.77	–4.74	0.39	0.31
CG	0.18	–1.11	0.67	0.19
ΔCG	–6.24	–6.69	0.28	0.11
IP	0.57	–2.90	0.74	0.17
Δ*IP*	–4.61	–4.82	0.50	0.35

Notes: The 5 percent MacKinnon critical values are –1.95 (0.463) and –3.19 (0.146) respectively for without trend and with trend cases for DF-GLS (KPSS) tests. (*) denotes rejection of the null hypothesis of unit root (stationarity) for the DF-GLS (KPSS) tests. Δ denotes first difference.

Since all the variables are non-stationary in their levels, the Johansen's cointegration tests are applied to determine whether or not the variables have a long run equilibrium relationship. This procedure allows testing for the number of cointegrating relationships (*r*) in the VAR. Based on various lag length selection criteria including Final Prediction Error (FPE), Akaike Information Criterion (AIC), and Schwarz Criterion (SC), a lag length of 1 is chosen for the VAR. An important issue in testing for cointegration is the choice of deterministic terms in the VAR, and this has been accomplished by using a procedure expounded by Johansen (1992), known as the *Pantula Principle*. This procedure involves running a series of joint hypotheses about the number of cointegrating relationships as well as the presence of deterministic terms in the VAR. In particular, three models are estimated: the first model (Model 2) assumes no linear trend in the levels of data and includes an intercept in the cointegration relation; the second (Model 3) assumes linear deterministic trend in the levels of data; and the third (Model 4) allows the existence of a trend term in the cointegration relation. This is followed by running sequential tests from the most restrictive model ($r = 0$, Model 2) to the least restrictive model ($r = 3$, Model 4) and selecting a model for which the null hypothesis is not rejected in the first instance.

Table 2 reports the results of the sequential tests for the number of cointegrating relations corresponding to various assumptions about the presence of deterministic terms in the VAR. The results confirm the presence of one cointegrating vector, indicating the existence of a long-run equilibrium relationship among output, public investment, private investment and public consumption. The estimated relationship is as follows:

$$\ln y = -3.47 - \underset{(0.12)}{0.12 \ln I_g} + \underset{(0.10)}{0.97 I_p} + \underset{(0.13)}{0.04 \ln C_g} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Table 2

Johansen's Cointegration Tests

	Model 2	Model 3	Model 4
		λ-Trace	
r = 0	83.84184	69.92973	80.16679
	(0.00)	(0.0011)	(0.0012)
r = 1	49.74335	28.87321*	39.36421
	(0.0007)	(0.0636)	(0.1084)
r = 2	20.42196	14.93662	20.77260
	(0.0475)	(0.0605)	(0.1893)
r = 3	6.487048	5.152660	6.938408
	(0.1563)	(0.0232)	(0.3510)
		λ-Max	
r = 0	34.09849	34.05652	40.80258
	(0.0089)	(0.0064)	(0.0034)
r = 1	29.32139	13.93659*	18.59161
	(0.0044)	(0.3702)	(0.3335)
r = 2	13.93491	9.783961	13.83419
	(0.0990)	(0.2265)	(0.2655)
r = 3	6.487048	5.152660	6.938408
	(0.1563)	(0.0232)	(0.3510)

Note: Figures in parenthesis are MacKinnon-Haug-Michelis (1999). *P*-values for the hypothesised number of cointegrating vectors (*r*), and * signifies acceptance of the null hypothesis in the first instance.

Where figures in parentheses are standard errors. The above equation shows that both private investment and public consumption positively influence output. However, public consumption turns out to be insignificant. Public investment has a negative sign, though it is insignificant. The negative impact of public investment on economic growth is in line with Devarajan, *et al.* (1996), who argue that public investment can have potentially negative effects on economic growth perhaps because of inefficient and unproductive nature of such investments.

The next step is the estimation of vector error-correction model, which can be used to ascertain the direction of causation in a multivariate context. The vector error-correction model captures the short run dynamics of the system as well as adjustment towards long run equilibrium. Hence, these models are widely used to test for the presence of both short run and long run causality.

Table 3 reports the results of the χ^2-tests for the joint significance of lagged independent variables (columns 2–5) in the vector error correction model as well as the significance of the error correction terms (column 6). The results show the presence of long run causality from public investment, private investment, and public

Table 3

Causality Tests based on Vector Error Correction Model

Dependent Variable	Lagged Y	Lagged IG	Lagged CG	Lagged IP	EC Term
Y	–	1.08	1.17	1.06	–0.06*
		(0.30)	(0.28)	(0.30)	(–1.79)
IG	1.05	–	4.44*	6.24*	–0.28
	(0.31)		(0.04)	(0.01)	(–1.16)
CG	1.11	0.09	–	0.10	0.42*
	(0.29)	(0.76)		(0.75)	(2.18)
IP	2.83*	0.92	0.69	–	0.75*
	(0.09)	(0.34)	(0.40)		(5.92)

Figures in parentheses are *p*-values for χ^2-tests and *t*-statistics for the error-correction terms.
* Denotes significance at 5 percent.

consumption to economic growth. The reverse long run causality is also indicated in the case of public consumption and private investment. It is interesting to note that there is no evidence of short run causality from any variable to economic growth. However, there is evidence of short run causality from public consumption and private investment to public investment in that order, while controlling for other variables. There is also a feedback relationship from economic growth to private investment in the short run, other variables being controlled for. These results show that growth is largely driven by private investment and that no strong inference can be made about the effects of public investment and public consumption on economic growth.

It is important to note that the error correction term in the equation for public consumption is insignificant while in the output equation it is not highly significant. Therefore, both output and public consumption appear to be weakly exogenous. This warrants some further empirical tests including tests for zero restrictions in the cointegration equation as well as the possibility of cointegration between private investment and public investment taking output and public consumption as exogenous variables.[2] Table 4 provides a test of zero restrictions on the coefficients of output and public consumption in the cointegration equation [Equation 5], and the results confirm that zero restrictions are binding.

In the next step, both the rank test and maximum eigenvalue test indicate the presence of two cointegrating relationships between private investment and public investment while treating output and public consumption as exogenous variables (Table 5). Following convention, we choose the relationship associated with the

[2]We are thankful to an anonymous referee for this observation, and for suggesting the additional econometric tests.

Table 4

Tests of Zero Restrictions

Hypothesised No. of CE(s)	Restricted Log-likelihood	LR Statistics	Degrees of Freedom	Probability
1	198.5566	0.984202	2	0.611340
2	205.8696	0.294617	1	0.587277
3	210.9089	NA	NA	NA

NA indicates restriction not binding.

Table 5

Cointegration Rank Test (Trace)

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistics	0.05 Critical Value	Prob.**
None*	0.550708	37.16749	15.49471	0.0000
At most 1*	0.303301	11.56484	3.841466	0.0007

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level.
*Denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon-Haug-Michelis (1999) *p*-values.

Cointegration Rank Test (Maximum Eigenvalue)

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistics	0.05 Critical Value	Prob.**
None*	0.550708	25.60265	14.26460	0.0000
At most 1*	0.303301	11.56484	3.841466	0.0007

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level.
*Denotes rejection of the hypothesis at the 0.05 level.
**MacKinnon-Haug-Michelis (1999) *p*-values.

maximum eigenvalue, and the estimated relationship is as follows (figure in parentheses is standard error):

$$\ln I_p = 11.76 - \underset{(0.10)}{0.13} \ln I_g \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Though the coefficient of public investment is insignificant, the negative sign seems to suggest that public investment crowds out private investment. This result is somewhat surprising in view of the widely held belief that public investment complements private investment by creating, for example, better infrastructure that is conducive for private sector activity. However, as Aschauer (1989b) argues, the relationship between public investment and private investment depends on two opposing forces. On the one hand public capital may raise the national investment rate above the optimal level chosen by private agents, thus necessitating a decline in private investment as agents adjust their portfolios to achieve intertemporal optimality. On the other hand, public capital may attract private investment by contributing to an increase in its rate of return. So the net impact of public investment on private investment would depend on which of these two opposing forces dominate.

5. CONCLUDING REMARKS

This study has analysed the role of public investment in the process of economic growth in the context of Pakistan's economy. The question whether or not public investment has a beneficial impact on economic growth is far from settled in the theoretical and empirical literature. One strand of literature takes a positive view of public investment and argues that public investment stimulates private sector productivity thereby increasing economic growth. Other studies raise questions about the efficiency of public investment and argue that public investment may not necessarily have a favourable impact on economic growth. Empirical studies have come up with generally inconclusive evidence on the relationship between public investment and economic growth.

Our empirical results indicate that growth is largely driven by private investment and that no strong inference can be made about the effects of public investment and public consumption on economic growth. Public investment has a negative though insignificant impact on output, and this raises some concern about the efficiency of public investment. As Devarajan, *et al.* (1996) argue, public investment may have deleterious consequences owing to misallocation of resources towards unproductive capital expenditures. On the question of whether or not public investment has a favourable impact on private investment, our results indicate that public investment crowds out private investment. This seems contrary to the popular view that public investment has a complementary relationship with the private investment. However, as Aschauer (1989b) has observed, this relationship may be reversed if public investment leads to an intertemporal reallocation of resources by the private sector that may in turn necessitate a decline in private investment. These results, however, need to be interpreted with caution not least because of the statistically insignificant effect of public investment. Future research that explicitly builds on micro foundations may shed more light on the role of public investment on economic growth on the one hand, and on the relationship between public and private investment on the other.

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