

PUBLIC AND PRIVATE INVESTMENT IN A VECTOR ERROR CORRECTION MODEL: EMPIRICAL EVIDENCE FROM TURKEY

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Abstract

This study investigates the dynamic interaction between public and private investment in Turkey. To this end, because the variables in question are cointegrated, a vector error correction representation of private investment is employed. Variance decomposition and impulse responses are derived from the VECM to analyze the relationship between public and private investment. The empirical findings indicate that while real GDP has an accelerator impact, real public investment has a detrimental effect on the investment activities of private sector in Turkey.

Keywords: Public investment, private investment, vector error correction model.

Öz

Vektör Hata Düzeltme Modeli ile Kamu ve Özel Sektör Yatırımları: Türkiye Örneği

Bu çalışma, Türkiye’de, kamu ve özel sektör yatırımları arasındaki dinamik ilişkiyi incelemektedir. Bu amaçla, söz konusu değişkenler arası eşbütünleşme olduğundan, özel sektör yatırımları için bir vektör hata düzeltme modeli (VECM) uygulanmıştır. Kamu ve özel sektör yatırımları arasındaki ilişkiyi analiz etmek için, varyans ayrıştırması ve etki-tepki fonksiyonları VECM’den elde edilmiştir. Ampirik bulgular, Türkiye’de, reel gayri safi milli hasılanın özel sektör yatırımları üzerindeki hızlandırıcı etkisini ortaya çıkarırken, reel kamu yatırımlarının ise dışlayıcı etkisi olduğunu göstermektedir.

Anahtar Sözcükler: Kamu yatırımları, özel yatırımlar, vektör hata düzeltme modeli.

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I. INTRODUCTION

Until late 1980s, the macroeconomic literature on fiscal policy had given little attention to the impact of government investment decisions. The demand side effect of government expenditures has been the focus of the researchers who have examined whether an expected or an unexpected fiscal policy measure has a permanent effect on real output by analyzing the relationships among real output, government spending and/or debt, consumption and other aggregate demand variables (e.g., Barro, 1981; Kormendi, 1983; and Aschauer, 1985). However, the importance of separating out different types of government expenditure has now been incorporated into the literature because of the argument that government spending that represents public investment expenditure can have a different impact on the productivity of private capital than government consumption expenditures (see for examples, Deno, 1988; Aschauer, 1988, 1989a and 1989b; Munnell, 1990, Barro 1990, Easterly and Rebelo, 1993; Holtz-Eakin, 1994). More specifically, the argument is that government investment spending may also exert supply-side effects. This point differs from the new-classical position, which asserts that a rise in public expenditure is expected to increase aggregate demand, giving rise to the expected prices and wages. As a result, aggregate supply shifts to the left, offsetting the expansionary effect of public expenditure on output. However, if agents anticipate a rise in aggregate supply due to an increase in public expenditure that is correlated with the productivity of private inputs, public capital has also a supply-side impact (Erenburg, 1993: 831-832). This argument emanates from the notion that the provision of public goods and services, in particular public infrastructure, complements private investment, increasing the productivity of private inputs and thus stimulating economic growth. Starting with Ram (1986) and followed by the analysis of Aschauer (1989a and 1989b), there have been numerous empirical and theoretical studies during the last decade that focus on the effects of public investment on output and productivity, and hence on the relationship between public and private investment (e.g., Khan and Reinhart, 1990; Ramirez, 1994; Cashin, 1995; Erenburg and Wohar, 1995; Odedokoun, 1997; Khan and Kumar; 1997; Ghali, 1998; Ramirez, 2000). Nonetheless, the empirical studies using panel and single country data yielded rather inconsistent results. This may mean that public capital may have different effects depending on the institutional and structural characteristics of the nations under consideration. Therefore, applying recently developed time series techniques to the data from a developing country, Turkey, this study attempts to investigate the question of whether there is a complementary impact of public investment on private investment. To this end, this paper employs a vector error correction representation (VECM) of private investment, a multivariate cointegration method developed by Johansen (1988, 1992) and Johansen and Juselius (1990). The advantage of this time series approach is that the empirical

model of private investment is not constrained to a specific structural interaction between the variables of interest. Instead, this methodology lets the data determine whether there are any long run interactions that the variables may have.

Applying this methodology to the data from Turkey over the period 1968-1998, the results indicate that public investment has a detrimental effect on private investment behavior. In addition to Introduction and Conclusion, this paper is organized as follows. Section II, from the theoretical perspectives, discusses several opposing effects that public investment may have on private investment and so on the overall economic performance. Section III presents the model and method. Empirical results are documented in section IV.

II. COMPLEMENTARITY AND SUBSTITUTABILITY EFFECTS OF PUBLIC INVESTMENT

There are several channels through which public capital might have an impact on the productivity of private capital (see, for examples, Barth and Cordes, 1980, Aschauer (1989a, b; Ramirez, 1994). For instance, public capital investment in economic and social infrastructure is likely to be complementary to private investment. Through investment in roads and highways, power plants, communications, and schools, public infrastructure expenditures can have strong effects on the productivity of private capital and economic growth. Such infrastructure investments are likely to increase the rate of return to private sector investments, which leads private agents to seek new investment avenues and thus to make more capital investment.

On the other side of the coin, however, public capital investment may crowd out private investment if they compete for the same financial and physical resources, increasing their costs while reducing their availability to private sector. Especially in developing countries, public investments made by heavily subsidized and inefficient state economic enterprises are likely to displace private investment because governments in developing countries are inclined to finance these investments through printing press, external and internal indebtedness. Also, if public investment raises the level of aggregate capital formation beyond the level anticipated by private agents, it could lead to an ex ante reduction in private investment while, ex post, private agents reallocate their resources accordingly.

It is also possible to use a neo-classical production function modified to incorporate public capital to formally analyze the hypotheses about the potential impact of public investment on private investment (Barth and Cordes, 1980; Ramirez, 1994; Ghali, 1998):

$$Y = f [N, K_p, K_g] \quad (1)$$

$$f_1, f_2 > 0; f_{11}, f_{22} < 0; f_{12} > 0; f_3 > \text{ or } < 0; f_{23} > \text{ or } < 0; f_{13} > \text{ or } < 0$$

where Y is the level of real output; N is employment; K_p is the stock of private capital; K_g is the stock of public capital.

By including the public capital stock as a separate input to the production function, holding everything else constant, an increase in public investment brings about three distinct effects. First, in the case where the public capital stock is productive and complements the private capital stock, a *ceteris paribus* increase in the public capital stock raises output in the same way as private inputs ($f_3 > 0$). In addition, it indirectly increases private investment and output by raising the marginal productivity of the private capital stock ($f_{23} > 0$) relative to the user cost of capital. Moreover, it stimulates output through its positive impact on the marginal productivity of labor. Second, if public and private capital are direct substitutes then an increase in public investment (primarily owing to the operations of state-owned enterprises) generates a positive direct effect on output, but a negative indirect effect on productivity of private inputs that could offset any positive effect, under the condition that $[(f_3 + f_{13}) + f_{23} - f_{12}] < 0$. Finally, if public capital is independent of private capital formation, a *ceteris paribus* increase in public investment creates a direct positive effect on output. This is the case where one treats public capital as additive into the production function.

At this juncture, the overall effect of public capital on private investment is ambiguous and complex because as mentioned above there are competing roles that public investment plays. The issue at hand appears to be an empirical rather than a theoretical one.

III. THE MODEL AND METHODOLOGY

III.1. Vector Error Correction Representation of an Investment Model

According to the flexible accelerator model, capital stock is proportional to the changes in the level of output. The cost of capital does not enter into the model because of the underlying assumption of the fixed-proportions production function in which capital-output ratio remains constant. Modifying the flexible accelerator model by incorporating public capital, demand for private capital can be expressed as the following,

$$K_p = F(Y, K_g) \quad (2)$$

Since there is no officially published data on depreciation rate or capital stocks for Turkey over the periods under study, the data on public (RGI) and private investment (RPI) are to be used for empirical purposes. Output, Y, is proxied by real GDP (RGDP). Thus, the following vector autoregressive model (VAR) is employed to examine the dynamic interaction between public and private investment;

$$X_t = A(L)X_t + U_t \quad (3)$$

where X_t is a vector of three variables, (RGI, RGDP, RPI)', A(L) is an (3×3) polynomial matrix and L is the lag operator. U_t is a vector of random disturbances with mean zero and variance Σ .

III.2. Testing for Cointegration

Before testing for cointegration, unit root tests are carried out to determine the order of integration of the variables in question. To this end, the augmented Dickey-Fuller (ADF) and Phillips and Perron (PP) tests are performed both on the levels and the first differences of the variables. Both the ADF and PP unit root tests use the various specifications of the following regression,

$$\Delta x_t = \alpha + \beta x_{t-1} + \lambda t + \sum_{s=1}^n \gamma_s \Delta x_{t-s} + \varepsilon_t \quad (4)$$

where x_t is the variables of interest, ε_t is the disturbance term and t is a time trend. Assuming that each of the variables contains a unit root in levels, but not in the first differences, one can proceed to determine the number of cointegrating vectors among the variables in question. Johansen (1988, 1991) suggested a method to test for cointegration by considering the following p variable VAR model,

$$X_t = \mu + \sum_{i=1}^k \theta_i X_{t-i} + \eta_t \quad (5)$$

where X_t is ($p \times 1$) vector of the variables in question, which is a (3×1) vector in our case. η_t is the disturbance term assumed to be an i.i.d Gaussian process with mean zero and variance Ω . Although these variables are individually nonstationary, if there are linear combinations of these variables that are stationary, then they form a meaningful and stable long run relationship. Thus exploiting the notion that they are cointegrated, one may re-parameterize equation (5) to obtain the following vector error correction representation (VECM),

$$\Delta X_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + \eta_t \quad (6)$$

where Γ s are estimable parameters. Π is the long run parameter matrix whose rank determines the long run relationship between the variables. When the variables are integrated of order one and are cointegrated, Π is not a full rank, meaning $0 < \text{rank}(\Pi) < p$. The rank of $\Pi = r$, indicating the number of cointegrating vectors. Based on the maximum likelihood estimation method, Johansen (1991, 1992) developed two test statistics to determine the r : the trace test and maximum eigenvalue test. The first entertains the hypothesis that the number of cointegrating vector is at most equal to r while the second tests the hypothesis that the number of cointegrating relationship is equal to r . Moreover, if the series are cointegrated, it is shown that Π matrix can be decomposed as $\alpha\beta'$, with α and β both $(p \times r)$ matrices. β is the matrix of r cointegrating vector and α is the matrix of adjustment coefficients that show the speed at which the disequilibrium closes up in each short run period and so the variables move together toward the long run equilibrium.

IV. EMPIRICAL RESULTS

Using equation (4), the ADF and PP unit root tests are carried out sequentially; namely, with and without intercept and/or deterministic trend¹. Akaike and Schwarz information criteria are used to determine the lag length of the augmenting term. Table 1 presents the results. Each variable is nonstationary in levels and stationary in first differences, suggesting that the variables of interest are each integrated of order one, $I(1)$. Accordingly, the Johansen test for cointegration is performed to see if there exist any linear combinations of the variables that have a common stochastic trend. Since the Johansen test is quite sensitive to the lag length selected, Akaike's Final Prediction Error (AFPE) criterion is used to determine the proper lag length.

Table-1: Testing for Unit Root

Variables	ADF stat.	PP stat.
RPI	-0.89	-0.98
RGDP	-1.73	-1.49
RGI	-3.23	-2.61
Δ RPI	-5.02	-6.28
Δ RGDP	-6.33	-5.95
Δ RGI	-3.99	-4.60

Note: MacKinnon critical value at 5% is -3.57

The AFPE criterion suggests two lags be chosen. The results of the Johansen test are reported in Table 2.

Table-2: Testing for Cointegration

H ₀	H ₁	Trace stat.	95% CV	H ₀	H ₁	λ Max	95% CV
r=0	r≥0	32.54*	29.68	r=0	r>0	21.53*	20.97
r≤1	r≥1	11.01	15.41	r≤1	r=1	10.29	14.07
r≤2	r≥2	0.71	3.76	r≤2	r=2	0.71	3.76
Coefficients of Cointegrating Vector and Coefficients of Adjustment							
	RPI	RGDP		RGI			
β'	1.00	-0.42 (0.038)		2.73 (0.451)			
α	-0.29 (0.128)	-1.08 (0.304)		-0.28 (0.071)			

Note: * shows significant cases at 5% level. Figures in parentheses are standard errors.

According to both the trace and maximum eigen value statistics, the results indicate the presence of one cointegrating vector among the variables at 5 % significance level. The lower panel of Table 2 shows the normalized coefficients of cointegrating vector and of the coefficients of adjustment. As seen, all error correction coefficients are statistically significant, indicating that all variables respond to the disequilibrium. Thus, none of the variables can be regarded as weakly exogenous. Also, since there is no strong theoretical rationale suggesting the direction of causality among the variables in question, imposing long-run zero identifying restrictions is not reasonable. Given that there is no statistical and theoretical weak or strong exogeneity, the study takes another approach to drawing a casual interpretation from the VECM estimates. Following the studies by Orden and Fisher (1993) and Monadjemi and Huh, (1998) that use a Choleski type of contemporaneous identifying restriction, impulse response functions (IRF) and variance decompositions (VD) are derived to examine the long run dynamic relationships among the variables. Since the choice of a specific order of the variables determines the recursive structure of the model, and so may affect the results, it is important to place the variable that may be viewed as exogenous in the first order. This enables the exogenous variable to simultaneously affect endogenous variables, but not to be affected by them.

Accordingly, the study uses the ordering of RGI, RGDP, and RPI to generate the IRF and VD. Using the variables in this order assumes that the variables RGDP and RGI have simultaneous impact on RPI. However, different orderings of the variables such as RPI, RGDP, RGI and RGI, RPI, RGDP are also used to check the robustness of our results to different ordering of the variables, which yields quite similar results. Table 3 reports the VD results. The

VD coefficients show the relative importance of the variables in explaining the forecast error variance of private investment. An examination of the first two columns of Table 3 indicates that, compared to the RGI, the RGDP plays a more substantial role in determining the forecast error variance of private investment dynamics. This can be taken as evidence that there is a strong accelerator effect of the real GDP on private investment.

Table-3: Variance Decomposition of Real Private Investment

Years Ahead	RGI	RGDP	RPI
1	0.521	67.735	31.743
2	0.625	70.240	29.134
3	9.751	55.738	34.509
4	15.598	51.843	32.557
5	17.478	54.601	27.919
6	23.921	50.101	25.977
7	27.391	46.787	25.821
8	27.490	46.666	25.842
9	28.073	45.590	26.336
10	28.906	44.346	26.746

Furthermore, to see the direction of the impacts of RGDP and RGI, the impulse responses are derived and presented in Figure 1. The IRF reveals the dynamic responses of private investment to a one standard deviation innovation of RGDP and RGI. The response of private investment to a shock is considered negative (positive) if it lies below (above) the zero line. As seen from the figures, while the responses of RPI to RGDP are positive, those to RGI are negative, a result that is in line with the theoretical predictions discussed earlier. These findings suggest that real GDP has an accelerator effect on private investment, whereas public investment substitutes for private investment in Turkey.

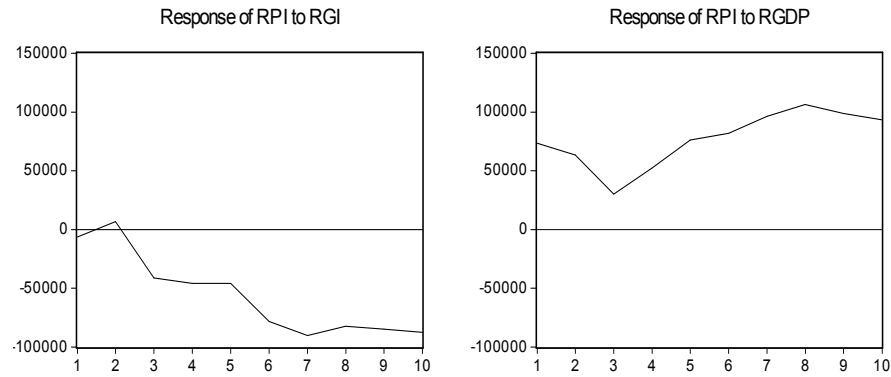


Figure-1: Response of RPI to One Standard Deviation Shock

CONCLUSION

In an attempt to examine the role of public investment in determining private investment in Turkey, this study employs multivariate time series techniques. Finding that the variables of interest are nonstationary in the levels, but are stationary in the first differences enables us to specify a vector error correction model that is helpful to investigate the dynamic interactions between public and private investment. Application of this method to data from Turkey over the 1968-1998 periods shows that public investment inhibits the investment activities of private sector. This provides some support for the IMF-sponsored reforms adopted by Turkey in early 1980s in which the primary objective was to reduce the role of public sector, but to promote private sector by establishing a more market-oriented environment. Further, the results reveal that there is a substantial accelerator impact of the real GDP on private investment, a result that is consistent with virtually all empirical studies.

NOTES

¹ The data on public and private investment and GDP spanning from 1968 to 1998 are taken from Economic and Social Indicators: 1950-2003, State Planning Organization (Jan-2004 issue). All variables are converted into the real ones in 1995 prices by the GDP deflator.

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