9. The Effect of Public Expenditure on Private Investment: An Empirical Application

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1. Introduction

If we would like to trace the starting point of the literature concerning the relationship between public and private spending then we have to mention the early work of Baily (1971), but also the later research on the topic of Buiter (1977). These studies examined the effect of government spending [1]on private investment. Till then it was believed that fiscal variables, like public infrastructure investment expenditures, do not affect private decision concerning investment expenditures.

Thereafter a series of articles on the issue emerged. It seems that the importance of government expenditure for the private investment of the economy was for long time ignored, and once the issue was mentioned there was an immediate booming response from economists. Initially the research agenda concentrated on the effectiveness of fiscal measures by empirically testing the Ricardian Equivalence Hypothesis (REH thereafter). The specific hypothesis was investigated by the pioneer research of Barro (1974), Kormendi (1983) and Feldstein (1982). Their empirical estimations leaned in favour of REH.

Later on another research channel emerged, this time the topic was to examine the nature of the relationship between private investment and various measures of public spending. In many occasions the outcomes of this research were controversial and were coming in contrast with each other in terms of their imposed restrictions and their implications. While the hypothesis of substitutability between private and public spending seems to be confirmed by the research of Barro(1981), Baily(1971) and Monadjemi(1993), the hypothesis of complementarity is strongly advocated by the research of Aschauer(1989), Erenburg(1993), Karras(1994) and Erenburg and Wohart(1995).

The aim of this chapter is to investigate whether there is a correlation between various measures of public expenditure and private investment. Subsequently, we test for the direction of the causation among these variables. For doing so in the first stage of our analysis we implement tests for the statistical properties of our data set, in the second stage we investigate whether a long run relationship exist among the variables of our model, and in the last stage the short run dynamics among them are reported.

2. Developments of public and private investment in Greece

In Greece public expenditure as per cent of GNP rose from 27% in 1960 to 48.2% in 1990, and so one may think that there should be no shortfalls in public capital stock. However, although the total public sector expenditure was rising, public capital was decreasing as a result of the stable reduction of public investment that negatively affected the production base of the economy. The most recent big reduction of public investment occurred in the period 1987-1990. Public investment as percent of GNP fell from 6.9% in the period 1982-1987 to 4.7% in the period 1987-90. It was the stabilisation programme of 1985, intending to cover government budget deficits, that caused the specific reduction in investment. Moreover, it is common practice in the economic policy making to curve expenditure in public investment whenever the government faces difficulties in financing its budget. The curtailment of public investment expenditure was expected to act together with a prudent management of the rest of the public expenditures in order to stabilise the economy. But, while public investment was decreased, the public expenditure on goods and services together with the transfer payments remained at enormously high levels (see Table 1).

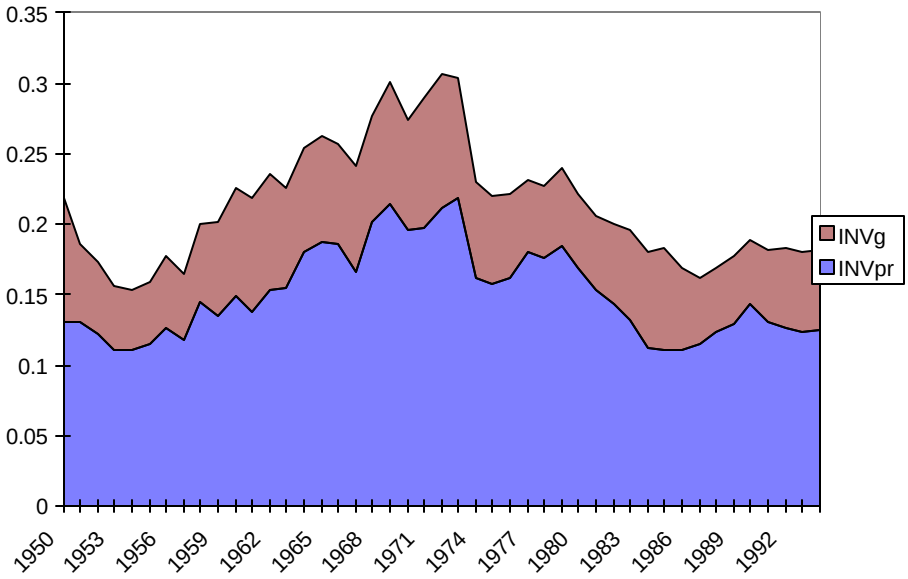
Table 1: The Structure of Greek Public Expenditure, 1958-1990 (percentages).

	Goods and Services		Public Investment		Transfer Payments		Total Expenditure
Years	Exp.	GNP	Exp.	GNP	Exp.	GNP	GNP
1958-66	47.5	11.3	24	5.7	28.4	6.7	23.8
1967-73	42.5	12.2	24.3	7	33.2	9.5	28.7
1974-81	46.7	15.3	16.6	5.5	37.7	12.8	33.7
1982-87	41	19.3	14.5	6.9	44.5	21	47.2
1988	46.7	17.5	12.9	4.9	47.7	18	46.1
1989	49.3	20	12.2	4.8	45.5	18.4	46.9
1990	45.2	20.2	9.9	4.4	50.5	22.6	48.23

Source: National Accounts of Greece (ESYE) and Bank of Greece.

Furthermore, in Diagram 1 we can observe the gradual dwindling of public investment and the big fall of private investment (as % of GNP), which especially occurred in the eighties at a time when public deficit started to soar to an unprecedented level. Clearly, the diagram reveals that the large budget deficits in the eighties were actually covered by reductions in public investments instead of introducing austerity to all public expenditures, including popular expenditures like public transfer payments. The diagram indicates that it might exist a causal link between the fall of private investment and the prolonged reduction of government investment.

Diagram 1: Private and Public Investment (% of GDP) in Greece

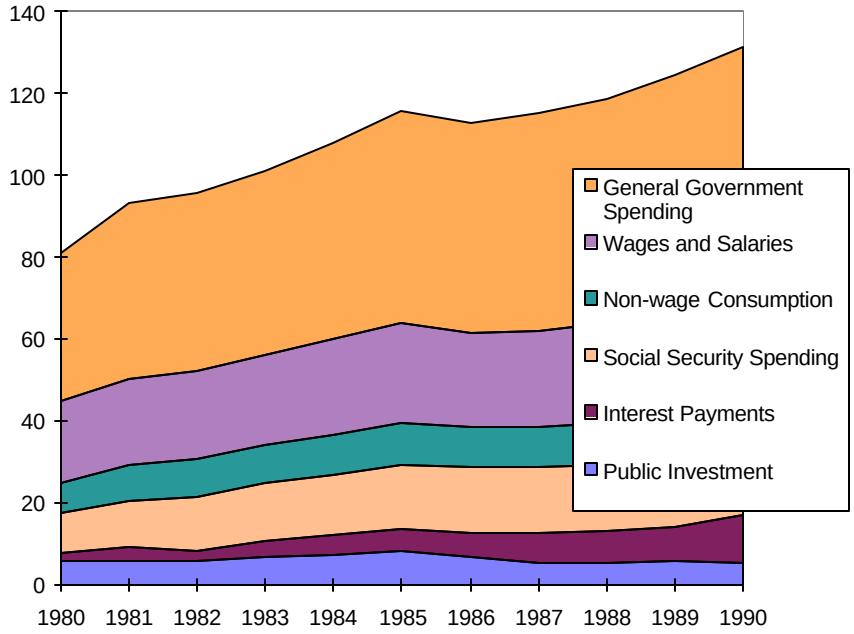


Note INVg is government investment, and INVpr is private investment.
Source: National Accounts, ESYE.

After all, policy makers believed that the social-economic returns on public investment could take a long time to be realised. They were thinking that if, indeed, there is a positive effect from government investment to private investment, this is expected to take place in the long-run[2]. It seems that policy makers criterion for implementing public investment was primarily determined by the extent that it could be used to reward voters for their loyalty. And, since in most of the cases public investment took time to show its effects on peoples' life, it was becoming inactive in every pre-election period, when an immediate reward to the voters was required.

In diagram 2 the components of general government spending can be observed. In the period 1980-90 the public investment fluctuated bellow 5% of GDP, while generally government spending and its disaggregated components, wages, salaries, and the social security payments dramatically rose. Diagram 2 reveals the preference of government in the eighties for high expenditures on goods, services and social security spending.

Diagram 2: General Government Spending (per cent of GDP).



Source: National Statistical Office of Greece, National Accounts.

Apparently the Greek macro-economic policy was characterised by myopic planning as much as public investment is concerned. The long-run perspective was always absent in the decision procedure of the public sector. In many cases governments' decision of implementing a specific investment project was the outcome of a strong pressure of a group of people that shared the same interests and had the same objectives. Christodoulakis (1994) emphasises the decisive role that these groups of people had for the adverse development of the economy. The result of this decision making was that public investment did not follow a specific macro-economic plan in order to support and enhance the inherent competitive abilities of the economy. Public investment was rather serving the interests of an ailing part of the economy, that having lost its viability to survive turned to the public sector for rescue. A characteristic example was the creation of the Organisation for Restructuring Problematic Enterprises in the early eighties. The scope of the specific organisation was to nationalise and then to revive firms with excess debts. This was supposed to happen through investment in more advanced technologically production procedures. Alas, what actually took place was to burden even more the

government budget and to increase the public consumption expenditures for wages, salaries and pensions.

3. Theoretical Model

The previous section has provided descriptive indications of a possible link that might exist between private and public investment. One could further suspect that there might exist a causal relationship between them. The objective of this chapter is to empirically investigate the possible relationship between public and private spending. This requires to bring many pieces together in a rather complex puzzle. Erenburg and Wohar (1995) suggested that the correlation between public and private investment may be due to more than one reasoning; it might be the case: (a) that public investment causes private investment or the other way around, (b) that public and private investment are causally independent and their observed correlation is explained by other variables that affect them and (c) that public and private investment are mutually causal. One has to test for these different causal relationships, accepting the one that can be empirically established as the most plausible.

There exist various theoretical specifications that attempt to model private and public investment spending in the literature. Aschauer (1989) opted to use a neoclassical framework where private investment is assumed to be a function of marginal product of capital, government investment and of government consumption expenditure. Monadjemi (1993) used an open-economy macro model to examine the effects of fiscal policy on private investment expenditure. Other methodological approaches are the accelarator-cash flow investment model and the securities valuation-cash flow (see Erenburg and Wohar (1995). The innovation of the current chapter does not rest on challenging the above aforementioned theories or offering an alternative theoretical specification. The innovation of this chapter lies on a vigorous empirical analysis that would allow us to interpret the causal relationship that might exist between public and private spending. We adopt therefore a transformation of Aschauer's (1989) model in which elements of the accelerator model in line with Monadjemi's (1996) work are incorporated. Private investment (I) is therefore a function of real output (GDP), real non-financial corporate profits (Π), real government investment (I_g) and government consumption expenditure(C_g).

$$I_t = I(GDP_t, \Pi_t, I_{gt}, C_{gt}) \quad (1)$$

A linear transformation of the above function in logs can be written as follows:

$$\ln I_t = \alpha + \beta_1 \ln GDP_t + \beta_2 \ln \Pi_t + \beta_3 \ln I_{gt} + \beta_4 \ln C_{gt} + \varepsilon_t \quad (2)$$

where ln means that the variables are expressed in logs, and ε_t is the error term. The main criticism on the empirical estimations of equation 2 emerges from the standard regression techniques that do not take into consideration stochastic trends in the underlying data generating processes of the time series. Nonstationary time series

result to spurious regressions that do not allow statistical interpretation of the estimations. In a preliminary stage therefore we implement tests for the existence of unit root in our time series (existence of unit root implies that the time series are not stationary), and subsequently we apply the Johansen (1992) cointegration technique in order to examine whether there is a long run co-movement of the variables of equation 2. That is to say we test whether our time series are cointegrated.

Johansen (1992) method allows us to test for the existence of more than one cointegration relationships. The specific method treats all the variables of equation 2 as endogenous without imposing restrictions. In this way problems caused by the possible endogeneity of some of the variables are handled. However an a-priori knowledge of the theory is essential since testing for cointegration in a multivariate system of equations does not imply that a meaningful economic relationship will be derived.

A vector X_t of n potentially endogenous variables is set. This vector is modelled by a vector error correction model (VECM thereafter). In specific the derived data generating process takes the following form:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + ... + \Gamma_{\kappa-1} \Delta X_{t-k-1} + \Pi X_{t-\kappa} + \varepsilon_t \qquad (3)$$

where X_t is (5x1) vector of the variables lnI_t , $lnGDP_t$ lnΠt lnIgt lnCgt. Π is a (5x5) matrix and εt is a (5x1) vector of white noise errors. The matrix Π contains information on the long run adjustment while Γ_i contains information on the short run adjustment to changes in X_t.[3]

Since the VECM is reduced form that includes a system of equations with a common set of lagged regressors on the right hand side, it is not efficient to estimate (3) using OLS. Johansen (1992) develop a technique that allows to obtain maximum likelihood estimations for the components of the multivariate system of equations. Testing for cointegration is essentially defining the rank of Π matrix. This means that the number of linearly independent columns of the Π matrix gives the number of cointegration relationships. After testing for long-run relationships between the variables of equation 2 our next step is to use an unconstrained VAR in order to reveal their causal relationship and the direction of causality.

4. Data And Empirical Estimations

The data set is derived from various sources. Private investment is defined as real fixed investment in non residential equipment and structures. It is obtained from the Greek Ministry of National Economy. Public investment includes public expenditures on equipment structures and it is measured in real terms. The source of public investment is also the Ministry of National Economy. Government consumption is derived by subtracting the real government investment from total purchases of goods and services that includes wage and salaries, non wage consumption and social security payment. Output is measured as real GDP and it is derived from the National Accounts of Greece published by the National Statistical Office, ESYE. The series for

real non financial corporate profits are taken from the European Statistics, various issues. The time period of our data set is from 1950-1994. Augmented Dickey-Fuller (ADF) and Phillips-Peron (PP thereafter) tests are implemented to test whether the our time series have a deterministic or otherwise a stochastic trend. Table 3 reports ADF and PP test both in levels and first differences.

Table 3: Unit Root Tests

	ADF(1 lag)	ADF(2 lags)	PP(1 lag)	PP(2 lags)
Variables				
I	-0.87	-1.10	-0.83	-0.85
GDP	O.96	0.33	0.76	0.74
P	-1.05	-3.06	-1.50	-1.62
Ig	-1.75	-1.74	-1.45	-1.54
Cg	-2.16	-1.93	-1.24	-1.27
DI	-4.51**	-4.22**	-6.10**	-6.10**
DGDP	-4.51**	-2.88	-7.50**	-7.47**
D P	-6.67**	-6.61**	-7.03**	-7.02**
DIg	-4.60**	-3.73*	-5.77**	-5.81**
DCg	-7.09**	-4.60**	-4.80**	-4.87**

An asterisk indicates significance at 5% level, while two asterisks indicate significance at 1% level. The critical values are from Dickey-Fuller.
Source: Author's Estimations.

The above Table provides evidence in favour of the existence of one unit root in the time series of equation 2, indicating that they are integrated of order 1, I(1). A way to treat this problem is to test for cointegration. Essentially cointegration describes whether a linear combination among different variables exist. Thus even when the variables are nonstationary it is possible to derive a long-run equilibrium among them without suffering from the statistical problems of spurious estimation of the underlying regression model. We opt to use Johansen (1992) cointegration test as the most appropriate way to deal with equation 2 where it might be the case that more than one variables are endogenous.[4]

The time series of our analysis seem to have an inherent drift. A restricted constant in the multivariate system that allows a non-zero drift in the unit root process seems, therefore, to be an adequate way to treat our time series. Our next step is to choose the lag value of the multivariate system of equations. By setting the lag length equal to 2 we ensure that the residuals of the system are white noise.

Having specified the appropriate model and lag value for the underlying data generating process we can subsequently test whether the Π matrix has reduced rank. That is to find whether $r \leq (n-1)$ cointegration vectors exist in β matrix.

Table 4 presents the maximum likelihood eigenvalue statistics. The null hypothesis is that there is no cointegration relationship, so r = 0. It becomes clear from the table that the null hypothesis is rejected at 1% level (see Osterwald-Lenum (1992) for critical values). The estimated likelihood ratio tests and eigenvalues indicate that there are two cointegration vectors. There are, therefore, two long-run relationships between the variables of equation 2.

Table 4: Johansen's Maximum Likelihood Method Test for Cointegration Relationship (number of lags = 2).

Ho: rank=r	Eigenvalue	Likelihood Ratio Test	5% Critical Value	1% Critical Value	No of CEs
r = 0	0.543	91.01	68.52	76.07	None**
r< = 1	0.504	58.12	47.21	54.46	At most 1 **
r<=2	0.339	28.64	29.68	35.65	At most 2
r<=3	0.223	11.19	15.41	20.04	At most 3
r<=4	0.013	0.589	3.76	6.65	At most 4

An asterisk indicates significance at 5% level, while two asterisks indicate significance at 1% level.
Source: Author's Estimations.

By imposing the restriction of two cointegration vectors we get the following normalised parameter estimates of our model from the maximum eigenvectors:

Table 5: Cointegration Equations

$$\ln I_t = \underset{(0.09232)}{0.271 \ln \Pi_t} + \underset{(0.07147)}{0.861 \ln I_{gt}} + \underset{(0.03746)}{0.085 \ln C_{gt}}$$

and

$$\ln GDP = \underset{(0.06738)}{0.047 \ln \Pi_t} + \underset{(0.05216)}{0.544 \ln I_{gt}} + \underset{(0.02734)}{0.111 \ln C_{gt}}$$

Note: standard errors in parenthesis.
Source: Author's Estimations.

The normalised parameter estimates from Table 5 show the significant and positive effect that government investment spending, lnI_{gt}, has on private investment, lnI_t , and GDP of the Greek economy. The effect of government consumption expenditure, lnC_{gt}, on private investment is also positive, however not significant at 5% level, but quite smaller in magnitude compared with the one of government investment. This results may imply the importance of providing basic infrastructure projects to the private sector of the economy as a way to create the appropriate economic environment that prompts private incentives to invest. Private corporate

profits, Π, have a positive impact on private investment as it was expected by the accelerator investment theory.

Although the above analysis shows that there are long run relationships between the variables of model (3), it does not reveal the direction of their causal relationship. Our main interest is to examine the dynamic interactions between private investment and government spending. We adopt therefore Sims (1980) and (1990) vector autoregression model (VAR) and we estimate variance decomposition (VDC) and impulse response functions (IRF). By doing so we will be able to comment on the different dynamic relationships.

Before proceeding in the presentation of IRF and VDC we should mention that the ordering of the variables of our model may considerably alter the outcomes of the analysis. Different recursive structures of the VAR correspond to different choices of ordering. Sims (1980 and 1990) emphasises this point; in particularly variables that are listed earlier in the VAR contemporaneously influence the variables that are listed latter, while the opposite does not hold. Therefore a suitable way of ordering variables is to list first the exogenous followed by the endogenous variables. This essentially requires an a-priori theoretical knowledge of the model that is empirically estimated. The ordering of the variables is, therefore, $\ln C_{gt}$, $\ln I_{gt}$, $\ln \Pi_t$, $\ln GDP_t$ and $\ln I_t$. Standard deviation confidence bounds are also reported in order to test the significance of the responses.[5] The time period of the IRF function spread is over twenty years, which is long enough to capture the dynamic interactions between public spending and the remaining variables of the VAR.

A linear trend is present in the unconstrained VAR, acting as an approximation of the inherent trend of the underlying data generating process of our data set.[6] We set the lag value of the VAR equal to three.[7] Toda and Yamamoto (1995) suggest that standard asymptotic theory still applies in a VAR, even when the variables of the model are known to be nonstationary, as long as the order of integration of the underlying data generating process does not exceed the chosen lag length of the model. Their finding implies that using nonstationary time series in a VAR is applicable once p + d lags have been selected, where p is the true lag length of the model and d is the order of integration of the variables. Knowing that the order of integration of our variables is one and that p = 2, we estimate a VAR(3).

Diagram 3 reports the response of each variable of the VAR to its own innovation and to the innovations of other variables. The cointegration analysis indicates that there is a positive long-run relationship between private investment and government investment, the IRF seems to confirm this relationship. From the last raw of the diagram it becomes clear that the effect of one standard deviation shock of government investment on private investment is positive and significant for a period of twelve years. The peak response of private investment to government investment takes place after eight years, and converges towards the equilibrium thereafter. On the other hand the response of government investment to private investment's innovation is estimated equal to zero for the whole period. Effectively this outcome

confesses that there exist a complementary relationship between private and public investment, with the direction of causality running from the latter to the former. Approximately, the response of private investment to one standard deviation shock of public capital stock is 0.05% per annum, implying that a one 1% increase in government investment's innovation causes a 0.05% increase in private investment. The evidence, therefore, points out that there is a crowding in effect from government to private investment.[8] The response of private investment to profit and gross output is also found to be positive as it is expected by the theory, though only for the first 6 years.

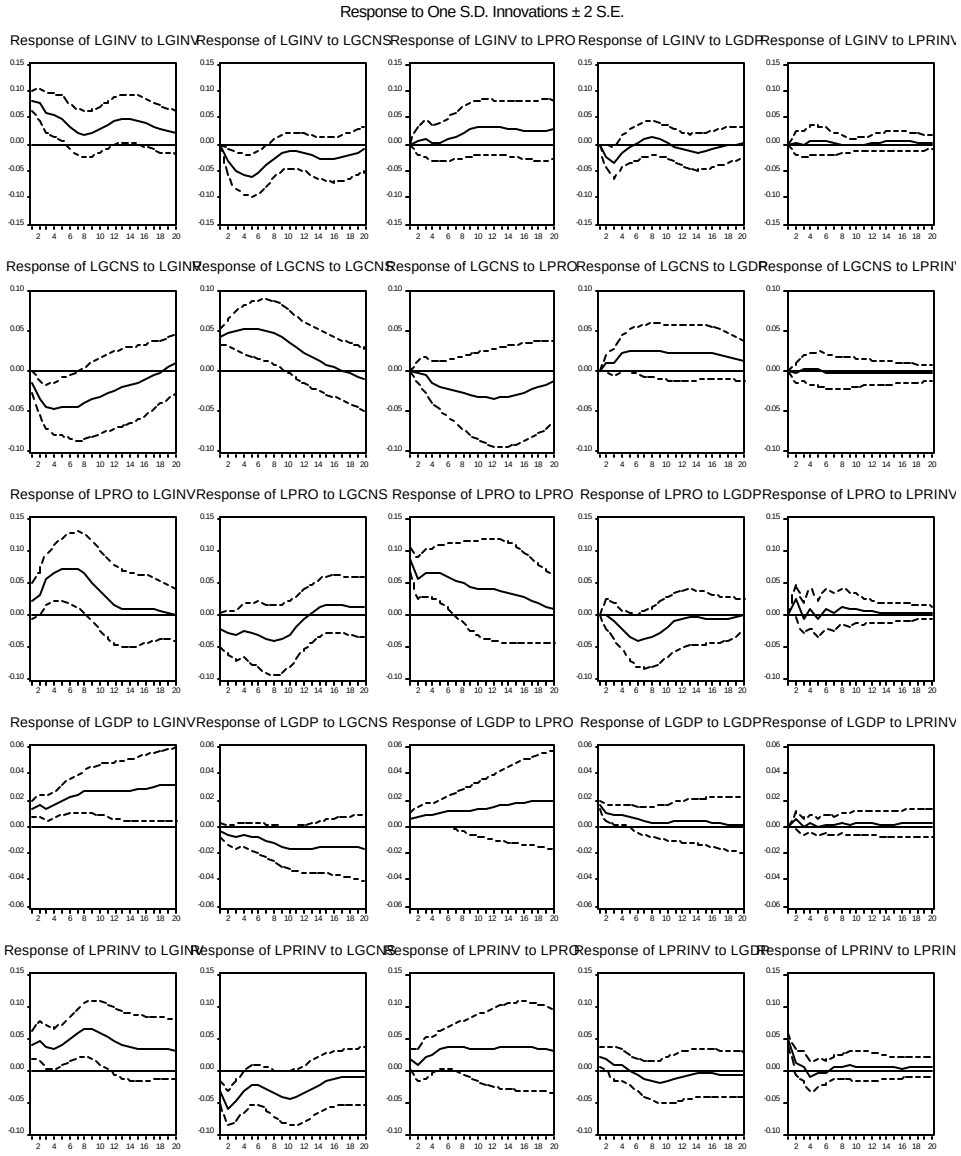
Diagram 3 also shows that the response of private investment to innovations of government consumption expenditures is negative over the whole period. This implies that actually there is some kind of substitution between private investment and government spending, but only in the case that the latter is defined as government consumption expenditures. Karras (1994) shows that as the size of the government increases the relationship between private investment and public spending changes from complementary to substitutable. It may be argued that this is mainly the outcome of an increase of government expenditures for wages and for salaries of public employees, which captures the biggest share of public consumption expenditures. In the descriptive section we have seen that in the late seventies and throughout the eighties there was an enormous increase in government transfer payments and salaries in Greece, while government investment was curtailed at the same period. Unavoidably private investment started to decline following the short-sighted economic policies. The present empirical analysis reveals that this development was severely harmful for private investment. Investors tend to abandon their plans once they realise that the necessary level of public capital stock is not provided. In Greece becomes apparent that the dramatic reduction of government investment is one of the causes of the observed slow down in private investment.

Another interesting finding of the IRF analysis is the negative relationship between government consumption and government investment as it is indicated by the negative response of the former to a one standard deviation shock of the latter. The economic interpretation is that within the bounds of a very small public budget government investment was competing for the same resources with government consumption. The result is not difficult to be conceived, government investment was sacrificed every time that government faced fiscal imbalances.

Table 6 presents the VDC estimations. These results come in agreement with the ones reported by the IRF, and provide further evidence favouring the importance of government investment in explaining the variation of private investment. Specifically, 44% of private investment's forecast error variance after twenty years is explained by government investment's disturbances. This figures implies that a quite subastantial part of the variation of private investment is explained by government investment, pointing out the importance of the latter for the former. On the other hand a very small part of the variation of government spending is explained by private investment.

Part of private investment's forecast error variance, 24% after twenty years, is explained by disturbances of government consumption expenditures. However, the explained variation of private investment due to public consumption is rather small compared to the one of public investment, implying the significance of the later for private investment and thus the growth of the Greek economy.

Diagram 3: Impulse Response Functions



Note: where LPRINV is lnI, LGDP is lnGDP, LPRO is lnΠ, LGCNS is lnCg and LGINV is lnIg.

Source: Author's Estimations.

Table 6: Variance Decomposition of the VAR(3).

Variance Decomposition of LGINV:

S.E.	LGINV	LGCNS	LPRO	LGDP	LPRINV
1	0.081	100.0000	0.000000	0.000000	0.000000
			0.000000		
5	0.183	62.32067	30.86726	0.467649	6.018270
			0.326145		
10	0.212	53.28321	35.54948	5.591369	5.236273
			0.339666		
15	0.250	54.04011	29.48629	11.20066	4.920759
			0.352175		
20	0.270	52.63386	28.43650	14.12090	4.402801
			0.405944		

Variance Decomposition of LGCNS:

S.E.	LGINV	LGCNS	LPRO	LGDP	LPRINV
1	0.045	8.799831	91.20017	0.000000	0.000000
			0.000000		
5	0.147	33.97238	56.80463	2.514854	6.561387
			0.146756		
10	0.217	31.98540	49.27588	8.832306	9.812802
			0.093612		
15	0.243	29.19914	42.66699	15.50227	12.52978
			0.101824		
20	0.251	27.64043	40.07929	17.64340	14.49738
			0.139497		

Variance Decomposition of LPRO:

S.E.	LGINV	LGCNS	LPRO	LGDP	LPRINV
1	0.093	6.003196	6.016715	87.98009	0.000000
			0.000000		
5	0.209	32.02275	8.858911	53.23578	4.097276
			1.785279		
10	0.296	37.02898	11.86089	41.28656	8.453617
			1.369953		
15	0.310	34.73249	11.62697	44.39546	7.929577
			1.315500		
20	0.315	33.84377	12.23490	44.75128	7.827901
			1.342152		

Variance Decomposition of LGDP:

S.E.	LGINV	LGCNS	LPRO	LGDP	LPRINV
1	0.021	36.00589	1.965046	6.414793	55.61427
			0.000000		
5	0.049	52.88282	8.364807	13.41593	23.89424
			1.442199		
10	0.085	62.08503	14.19776	14.13190	8.858831
			0.726471		
15	0.116	60.68747	17.02078	16.47306	5.274066
			0.544619		
20	0.146	60.34345	16.55950	19.13791	3.473194
			0.485946		

Variance Decomposition of LPRINV:

S.E.	LGINV	LGCNS	LPRO	LGDP	LPRINV
1	0.075	26.85526	20.32817	4.928644	6.964896
			40.92303		
5	0.148	33.68125	40.18349	10.12743	3.838051
			12.16977		
10	0.229	45.68320	29.32014	15.76188	3.908996
			5.325781		
15	0.270	44.81868	27.90404	20.01269	3.296869
			3.967726		
20	0.291	44.89226	24.70764	23.80582	3.104512
			3.489761		

Ordering: LGINV LGCNS LPRO LGDP LPRINV

Source: Author's Estimations.

5. Conclusion

In the present chapter a transformation of neo-classical and cash-flow investment model is used in order to empirically investigate the relationship between private investment and various government expenditures. Our main findings profess that there is a crowding in effect from government investment to private investment, while the latter does not affect the former. Gross output and profits are also found to have a positive effect on private investment. Although government consumption expenditure has a positive, but very small in magnitude, effect on private investment in the long run, it does not seem to exhibit the same effect once the dynamics of the model are estimated. Apparently, the IRF shows that the response of private investment to government consumption expenditure is negative. This empirical evidence comes in line with the earlier work of Aschauer (1989) and Monadjemi (1993), not supporting the neutrality hypothesis of fiscal policy.

In terms of economic policy the outcomes of the present analysis may further explain what is considered to be by many economists one of the greatest fallacies that Greek economy fell into in the seventies and in the eighties. Government investment expenditure was constantly reduced during this period, while a government consumption spree was launched. Having found strong indications that there exist a negative relationship between the private investment and government consumption expenditure it is not peculiar that in the Greece private investment dramatically drop.

Fiscal policy may indeed has something to offer to the development of the Greek economy. But what it has been experienced in the past is that enormous increases in government consumption expenditure have less to give compared with government investment. After all it might be the case, as it is suggested by the results of the present study, that government consumption expenditures by negatively affecting private investment do not contribute to the growth of the economy.

Notes

1 Although we may expect that public investment can increase domestic demand through a Keynesian multiplier, it was believed in Greece that this increase is well below the one that can be achieved by direct transfer payments to unemployed and pensioners. Having in mind the main economic concept of the eighties in the country ,regarding the beneficial effects of an increase in demand on output, is not peculiar the incredible increase of transfer payments at that time.

2 More analytically, the system (3) takes the form:

Model (4)

$$\begin{bmatrix} \ln I_t \\ \ln GDP_t \\ \ln \Pi_t \\ \ln I_{g_t} \\ \ln C_{gt} \end{bmatrix} = \sum_{i=1}^{k-1} \begin{bmatrix} \Gamma_{i11}\Gamma_{i12}\Gamma_{i13}\Gamma_{i14} \\ \Gamma_{i21}\Gamma_{i22}\Gamma_{i23}\Gamma_{i24} \\ \Gamma_{i31}\Gamma_{i32}\Gamma_{i33}\Gamma_{i34} \\ \Gamma_{i41}\Gamma_{i42}\Gamma_{i43}\Gamma_{i44} \\ \Gamma_{i51}\Gamma_{i52}\Gamma_{i53}\Gamma_{i54} \end{bmatrix} * \begin{bmatrix} \Delta(\ln I)_{t-i} \\ \Delta(\ln GDP)_{t-i} \\ \Delta(\ln \Pi)_{t-i} \\ \Delta(\ln I_g)_{t-i} \\ \Delta(\ln C)_{t-i} \end{bmatrix} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \end{bmatrix} [\beta_1\beta_2\beta_3\beta_4\beta_5] \begin{bmatrix} \ln I_{t-k} \\ \ln GDP_{t-k} \\ \ln \Pi_{t-k} \\ \ln_{g_{t-k}} \\ \ln Cg_{t-k} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix}$$

The matrix Π can be decomposed into $\Pi = \alpha\beta'$, where the matrix $\alpha=[\alpha_1,\alpha_2,\alpha_3,\alpha_4,\alpha_5]$ is a (5xr) adjustment matrix, representing the speed of adjustment to disequilibrium. The matrix $\beta=[\beta_1,\beta_2,\beta_3,\beta_4,\beta_5]$ is a (1x5) cointegration matrix of long-run coefficients, such that $\beta' X_{t-k}$ represents up to (n-1) cointegration relationships, which ensure that the matrix X_t converges to the long run steady state solution.

3 As the criticism in the relevant literature implies there is an element of uncertainty as much as the causal relationship between private investment and public capital spending is concerned. Thus, unless all the endogenous variables appear on the left-hand side of the estimated equations, the lost information causes inefficiency (see R.Harris(1995)).

4 If the confidence interval include the zero line or the bounds are very wide then the response of a variable to disturbances is considered to be insignificant.

5 Evidence is provided in the present paper, DF, ADF and Phillips -Peron unit root tests, in favour of the argument that the time series of our analysis are rather first difference stationary than trend stationary. A linear trend in VAR model therefore may be an approximation of our time series underlying data generating process. Our results do not considerably differ, depending on whether a trend is included or not.

6 The results of the unconstrained VAR models are not reported, since it is not of our main interest in the present analysis.

7 Aschuaer(1989) and Monadjemi (1996) find also evidence in favour of crowding in using data for US and Australian economies, respectively.

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