AGGREGATE INVESTMENT FUNCTION IN GREECE (1958 - 1982)

By
Dr E. VARELAS*

I. INTRODUCTION

The investment expenditure plays an important role in the economic development of any country, because the change in the future productive capacity of the economy depends on the present level of investment expenditure. In this paper I will examine the demand for investment goods which constitutes the second major component in total demand after the demand for consumption goods. I will concentrate on tde aggregative investment activity of the economy as a whole, without considering explicity the wide diversity of capital goods.

The investment function which I will use in the present paper is essentially based on the flexible accelerator principle including as explanatory variable changes in stock of previous period. Since the number of regression coefficients is one less than the number of parameters, the function is not identified. Estimating the rate of depreciation of the capital stock, I can then estimate direct using OLS/ALS and 2SLS methods the proposed investment function.

In the next section, I will try to present briefly the main theoretical considerations on investment in the international bibliography and also the specification of the gross private investment function which I will use in the present work. In the third section I will present the estimation findings themselves, produced by applying the OLS/ALS and 2SLS/A2SLS methods. In the fourth section I will discuss those results in the light of the economic theory and I will compare my

* Agricultural Bank of Greece, Research and Planning Division.

results with equivalent results of other similar works. Finally, I will summarize the main conclusions of this chapter.

II. SPECIFICATION OF THE INVESTMENT FUNCTION

The two main strands of economic hypothesis are built round the neoclassical theory of investment hehaviour and the accelerator relationship. The difference between these two theories is regarding assumptions about factor substitutability and malleability of capital. If capital is only imperfectly maleable we have to specify asymétrie effects or price change or by specifying separate investment functions for each type of capital equipment. This is a Utopian alternative because data do not exist on the purchase and sale of every piece.

The neoclassical theory of investment developed by Jorgenson (1963) and others can be summarized as follows : The standard Jorgenson assumptions are a) that the firm is assumed to maximize the present value of future net revenues subject to a production function, b) that the firm is assumed to produce under conditions of perfect competition and c) that the capital depreciates at a constant rate. The actual investment expenditure at any given time a distributed lag function of current and past orders, or changes in desired capital stock. The reduced form of Jorgenson's model is :

$$(1.1.)\ \gamma(Z)\ [I_t - \delta K_{t-1}] = J(Z) \Delta \left(a \frac{PY}{c}\right)_t$$

where c is the implicit rental value of capital services, δ is the depreciation rate, ρ is the price of the product, γ (Z) and j (Z) are two finite polynomials in (Z) and (Z) being the lag operator.

Briefly, Jorgenson's model relies on strong assumptions concerning the production function in order to oôtain a simple intuitely appealing functional form relating capital stock to its determinants.

The flexible accelarator (or partial adjustment) assumes that the adjustment process is not instantaneous between desired and actual capital, so that :

$$(1.2.)\ K_t - K_{t-1} = (1-\lambda)\ (K^*_t - K_{t-1})\quad 0\ \lambda<1$$

where K^*_t is the desired capital stock in time t, K_{t-1} is the actual capital stock at time t and t- 1 and λ is a constant parameter, (Nerlove 1960, Stome- Rowe 1960, Helliwell 1976). This formulation implies that there may be rapid changes or even discontinuous jumps in the investment rate if there are such changes in K*t. What is actually observed, however, is not a high degree of short-run volatility, but rather a cyclical movement during which the actual capital stock is sometimes above and sometimes below its equilibrium value. I believe that investment theory is relatively unsatisfactory. This is due to the multitude of the arguments which explain the desired capital stock. Although there are disagreements in the various theories with respect to the factors which affect the desired capital stock. To begin with we can take up a Harrod model with an equilibrium capital output ratio β, and to compture the disequilibrium aspects of the investment process we combine it with a partial adjustment framework. Returning to the context of investment in physical capital, there are two main groups of variables which have been considered as relevant determinants of K*t. The use output or of expected sales in place of actual sales and the use of financial variables. The desired capital stock which I will use in the present paper includes output, changes in stock lagged once and real iterest rate. The changes in stock has been introduced lagged once, because I believe that on increase in inventories at (t-1) period implies a reduction of desired capital at the period t. Everything which is produced and not sold must be added to inventories. Firms increase/decrease their capital stock if their inventories at (t- 1) period are low/high relative to a desired level. Assuming that desired level is equal actual level, the changes in inventories reflect the short-run situation of total demand. The proposed investment function has following form :

(1.3.) $It = \beta_0 + \beta_1 Qt + \beta_2 Kt-, + \beta_3 \Delta IN_{t-1} + \beta_4 r_t$

where It : gross investment, Qt : output, ΔINt-i : changes in stock, r_t : real interest rate defined as rt = it - Pt, it : nominal interest rate, Pt : inflation rate.

I use the gross investment variables in the proposed investment function, instead of the net investment one, because I think that investment decisions are made with respect to total capital expenditure whether they are used for purposer of replacement or expansion. Following Keynes position, I am introducing the real interest rate in the investment function, because the interest rate, as a cost factor, affects investment activity. The data which I used in fitting the investment function are relevant to the gross privare investment expenditure excluding investment in ships and changes in inventories and to the gross private investment including investment in ships. Also I used data with respect to gross national product, and to the interest rate, (National Accounts of Greece Nr, 23, Bank of Greece 1950- 1983). I assume that individuals do not suffer from money illusion and so all the above variables are expressed at constant 1970 prices.

TABLE 1

GROSS PRIVATE INVESTMEΣT (1958 – 1982)

I_t	C_0	Q_t	K_{t-1}	$i_t = (r_t - P_t)$	ΔINV_{t-1}	R^2	D-W	P
1 OLS	−8.845 (−3.792)	0.42081 (16.793)	(−0.09489 (−10.492)	−53.546 (−3.213)	−0.3404 (−2.508)	0.9847	1.7692	
ALS	−5.892 (−2.158)	0.40917 (14.832)	−0.09872 (−9.953).	−59.742 (−4.812	−0.4321 (−3.102)	0.9817	1.9857	0.087 (1.125)
2 OLS	(−10.347 (−5.982)	0.43682 (18.602)	−0.09881 (−12.046)		−0.4486 (−2.572)	0.9862	2.5277	
ALS	−9.948 (−5.128)	0.42399 (17.321)	−0.09327 (−10.748)		−0.4327 (−2.782)	0.9854	2.4987	0.0821
3 OLS	−7.1582 (−3.122)	0.43897 (15.843)	−0.09375 (−11.711)	(−41.873 (−2.187)	−0.3879 (−2.971)	0.9875	1.873	
ALS	−6.1817 (−4.753)	0.411827 (12.237)	−0.09561 (−9.238)	−45.663 (−3.019)	−0.4017 (−3.152)	0.9871	2.013	0.0916 (0.915)
4 OLS	−9.2189 (−3.122)	0.4375 (9.189)	−0.09931 (−10.735)		−0.4855 (−3.008)	0.9849	9.935	
ALS	−9.8535 (−5.281)	0.4228 (10.173)	−0.09841 (−10.543)		−0.50182 (−3.748)	0.9851	1.925	0.0885 (1.017)

TABLE 2

I_t	C_0	Q_t	K_{t-1}	$i = (r_t - p_t)$	$\Delta INVt_{t-1}$	R^2	DW.	
5	−8.743	0.40989	−0.09528	−50.142	−0.3241	0.9883	1.715	
2SLS	(−3.542)	(12.717)	(12.842)	(−2.121)				
A2SLS	−6.711	0.4099	−0.09717	−53.818	−0.3957	0.892	1.812	0.093
	(−2.105)	(12.615)	(10.532)	(−4.313)	(−1.987)			(0.883)

Equations 1 and 2 are the «flexible accelerator» investment functions excluding investment in ships operating overseas and changes in inventories.

Equations 3 and 4 are the «flexible accelerator» investment functions including investment in ships operating overseas and excluding changes in inventories.

III. ESTIMATION OF THE INVESTMENT FUNCTION

In the present section, I will try to estimate the proposed previously investment function without taking into account the investment in ships operating overseas, therefore assuming the last category of investment as being exogenous, because these are not determined by the usual economic variables. Following that, I will relax the above assumption and I will try to estimate the gross private investment function including investment in ships.

Table 1 presents the results on the above mentioned investment functions using the OLS and ALS methods. It can be seen in table 1 that all the estimates of the coefficients of the variables obtained by the OLS and ALS methods are statistically significant at 5 per cent level and the ceoefficients of determination are very high. More than 98 % of the variation of the investment expenditure is explained by the involved variables in the function Moreover the signs of the estimated coefficients of the parameters are the expected ones taking into account the economic theory on the investment function. Table 1 reveals that the autocorrelation of the distrurbance terms is insignificant. Therefore the results of table 1 obtained by the OLS method are acceptable. However, the application of the OLS/ALS method to the signle investment function, which belongs to a system of simultaneous equations, presupposes that there is no joint dependence of investment and explanatory variables. Of course the latter is no true, because the economic relationships are reliable to simultaneous interdependence. Consequentlly, the result estimates by OLS/ALS methods are incosistent and biased. In order to get more reasonable results, I estimated again the same investment function using 2SLS/A2SLS method. To estimate with 2SLS/A2SLS method I have used following model :

(3.1) $I_t = F(Q_t, r_t, A_i N_{t-1} K_{t-1})$

(3.2) $Q_t = I_t + X_t$

where X are all other exogenous variables for the identity including changes in stocks and investment in ships. It can be seen from table 2 that the estimates of the parameters obtained by the 2SLS and A2SLS methods are significantly different from zero at 5 % level and also that their signs are the expected ones. Moreover, table 2 reveals that there is no significant autocorrelation. So, the equation estimated by the 2SLS method is accepted.

To analyze the results of the investment function estimated in this paper we must have an estimation of the depreciation rate. Gross investment is equal net investment plus replacement investment. The standard assumption is that repla-

TABLE 3
Estimation of depreciation rate (1958 – 1982)

Method	Dependent Variable	Constant	Kt–1	R2	DW	P
OLS	1) Dt	–	0.01925 (240.30)	0.9982	0.5031	
OLS	2) Dt	–339.108 (4.785)	0.01960 (110.8)	0.9984	1.7732	
ALS	1')Dt	–	0.01919 (108.2)	0.9981	1.5632	0.7655 (5.798)
ALS	2')Dt	–146.83 (3.682)	0.01943 (55.4)	0.9943	1.7213	0.4781 (1.098)

TABLE 4

Marginal Propencities to invest with respect to current output, previous inventories, interest rate and elasticities.

Method	Equation	m.p.i. with respect to current output		m.p.i. with respect to inventory investment		λ	m.p.i. with respect to real interest rate		Elasticity with respect to output		Elasticity with respect to previous inventory investment		Elasticity with respect to real interest rate	
		Short run	Long-run	Short run	Long run		Short run	Long run	Short run	Long run	Short-run	Long-run	Short run	Long-run
OLS	1	0.42081	0.47521	-0.3404	-0.38441	0.88551	-53.546	-60.469	2.792	3.1535	-0.0998	-0.1127	-0.0885	-0.10003
2SLS	5	0.40989	0.463089	-0.3241	-0.36616	0.88512	-50.142	-56.649	2.719	3.0730	-0.0987	-0.1113	-0.0829	-0.0937
OLS	2	0.43682	0.49549	-0.4486	-0.50885	0.88159	–	–	2.898	3.2880	-0.0998	-0.1132	–	–
OLS	3	0.43897	0.49509	-0.3879	-0.43749	0.88664	-41.873	-47.226	2.9128	3.285	-0.1021	-0.1151	-0.0692	-0.07813

cement demand of depreciation is proportional to the existing stock at (t-1) period. (3.3) $D_t = S(Kt_{-1})$

Table (3) presents the results of the depreciation functions using the above form (3.3) obtained by the OLS and ALS methods, with constant term and without constant term (equations 1 and 2 respectively).

It can be observed from this table, that equation 1 without constant term is misspecified. So, finally I accept equation 2 estimated by the OLS method, since the autocorrelation in the disturbance terms is insignificant. Therefore, the of-ficient of depreciation which I found directly is $\delta = 0.01960$. Geronimakis (1964) has estimated the depreciation rates, and the average useful lifetime of capital corresponding to various sectors in Greece. Particularly, he found that the depreciation rate corresponding to buildings is 1.5 %, 7 % for machinery, 1 % for other equipment and 5 % for all the other capital goods. The average depreciation rate for the manufacturing sector has been estimated by him to be arrount 5.6-5.9 %. The above percentage implies that the useful lifetime of all capital assets in Greek manufacturing is near to 16-18 years. On the other hand, Krengeland Mertens (1966) suggested that the depreciation rates estimated by Geronimakis are lower than those found in other international works.

The coefficient of depreciation which I found is close to that found by Katos (1978) and slightly smaller than that estimated by Adelman and Chenery (1966).

Table (4) shows the short and long-run marginal propensities to invest with respect to the various explanatory variables estimated by the OLS and the 2SLS methods and the corresponding elasticities in each case. As one can see in table (4) the estimates of the coefficients obtained by the OLS method are very close to those obtained by the 2SLS method. It may be observed in Table (4) the great importance of the output. The short-term marginal propensity to invest with respect to current output is 0.40989. The marginal effect of the previous changes in stocks on the present investment is -0.3241. The negative sign is also consistent with the investment theory under the assumption that an increase in demand relative to increase in supply implies on reduction of net capital stock. The importance of gross national product as explanatory variable in the aggregate investment function supports the profits hypothesis if we take into account that the output could be considered as a proxy of profits.

The significance of the lagged capital stock is evidence that there is some «hysteresis» in the reaction of the enterpreneours and also that there is a technical lag between the ordering and purchase of capital goods (echo effect). Zonrilos and Brisimis (1978) found that the influence of the past investment expenditure is relatively strong, i.e. 0.7684, and it is very close to my estimation $\lambda = 0.8851$.

The interest rate affect the investment decisions of the enterprieneours. The interest rate taken as the opportunity cost, affects negatively the investment activity. This finding reveals that in the Greek economy the financing of capital goods depends also on the money market.

The demand for investment goods is elastic with respect to output and it is inelastic with respect to previous changes in stocks and real interest rates.

Tsoris (1976) in his model estimated private investment function excluding ships. His «best» investment equation included as explanatory variables the annual change in the GDP in real terms, the total long-run credit flow at constant 1958 prices and the capital inflows for business lagged one year. In contrast to my results, he found that the income variable was statistically insignificant, while the size of the coefficient of the lagged capital stock was wrong. Zonsilos and Brisimis (1978) using in their econometric model for the Greek economy, an investment function found that the marginal effect of the current interest rate exerts stronger effect on the gross private investment compared with my estimation. In view of international findings concerning the investment function I would like to mention that in many econometric studies the interest rate is largely neglected. (Klein and Goldberger 1969). Moreover, De Leew (1962) supports that the association of interest rates and capital spending by manufacturers is not so common a finding of recent studies.

Table (4) presents the numerical estimates of the coefficients of the variables included in equation (2) and (3) of table (1). As one can see the mearginal effects of the included variables in equation (2) are higher than those found in equation (1), since the last form of the investment equation also includes the interest rate as an explanatory variable of the investment activity, and then, this variable absorbs some of the effects of the other variables in equation (2). As a consequence the vales of the estimated elasticities of investment with respect to the various explanatory variables are higher in the case of equation (2), than those estimated by the proposed investment equation.

IV. CONCLUSIONS

The main conclusions of this paper are :

1. The estimated private investment function gave satisfactory results. The explanatory variables included in the aggregate investment function, that is the output, the previoues changs in stocks, as well as the interest rate significantly affected the investment decisions.

2. The importance of the interest rate variable revealed that the financing of the capital goods in Greek economy depends also on bank lending system.

3. The importance of the previous changes in stocks variable revealed that firms increase/decrease their capital stock if their previous inventories are low/ high relative to desired level.

4. The annual depreciation rate for the total economy, which I found to be close to 2 %, is similar to that estimated by other economists.

5. The elasticities (short - and long-run) of the investment with respect to output appeared quite high.

REFERENCES

Adelman, I., and H.B. Chenery, (1966), «Foreign aid and development : The case of Greece», *Review of Economics and Statistics*.

Boatwright, B.D., and J.R. Eaton, (1972) ; «The estimation of investment functions for manufacturing industry in the United Kingdom», *Econometrica*.

Boot, J.C.G., and G.M. De Wit, (1960), «Investment demand : an empirical contribution to the aggregation problem», *International Economic Review*.

Chenery, H.B., (1952), «Overcapacity and the accleration principle», *Econometrica*.

De Leeuw, F., (1962), «Demand for Capital Goods», *Econometrica*.

Eckaus, R.S., (1953). «The acceleration principle reconsidered» *Quarterly Journal of Economics*.

Eisner, R., and M.I. Nadiri, (1968), «Investment behaviour and neoclassical theory», *Review of Economics and Statistics*.

Evans, M.K., (1967), «A Study of Industry Investment Decisions» *Review of Economics and Statistics*.

Gehrels, F., and S. Wiggins, (1957), «Interest rates and manufactures fixed Investments», *American Economic Review*.

Geronimakis, S. I., (1964), The evolution of Investment in Greece after the War (1948-62), Ministry of Coordination, Athens.

Gould, J.P., (1968), «Adjustment Costs in the Theory of Investment of the Firm», *Review of Economic Studies*.

Greenberg, E., (1964), «A Stock-Adjustment Investment Model», *Econometrica*.

Helliwell, J.H., (1976), *Aggregate Investment*, Readings - Penguin.

Jack, A.B., (1966), «The capital expenditure function», *Manachester School*.

Jorgenson, D. W., (1963), «Capital theory arid Investment Behaviour», *American Economic Review*.

Katos, A.V., (1977), Structural relationships of the Greek Economy and Growth Perspectives, Thessaloniki, Greece.

Klein, L. R., (1950), *The Keynesian Revolution*, London : Macmillan, Co, Ltd.

Klein, L.R., (1950), and A.S. Goldberger, (1969), An Econometric Model of the United States : 1929-1952, Amsterdam : North-Holland Publishing Co.

Klein, L.R., (1950), and Y. Shinnai, (1963), «An Econometric Model of Japan, 1930-59», *Iinternational Economic Review*.

Krengel, R., and D. Mertens, (1966), Fixed Capital stock and futnre investment requirements in Greek manufacturing, Center of Planning and Economic Research, Athens.

Lund, P.J., (1971), Investment : *The Study of an economic aggregate*, San Francisco : HoldenDay.

Meyer, J.R., and E. Kuh, (1955), «Acceleration and related theories of investment : an empirical enquiry», *Review of Economics and Statistics*.

Smyth, D., (1964), «Empirical evidence of the acceleration principle», *Review of Economic Studies*.

Tinbergen, J., and JJ. Polak, (1950), *Dynamics of Business Cycle*, London : Routledge and Kegan Paul.

Tsoris, N., (1976), Econometric Studies of Greece, Athens, Plato PudlishingCo.

Zonzilos, N.G., and S.N. Brissimis, (1978), «Investigation of the effectiveness of the monetary and fiscal policies in a simple model of the Greek economy», *Sρoudai*, no. 1.