A LINEAR PROGRAMMING APPROACH TO SOME POLICY PROBLEMS IN GREECE

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I. INTRODUCTION

This paper is an application of the Linear Programming (LP) approach to some policy problems in Greece. The discussion concerning the LP approach is to reveal what the main constraint to higher economic growth in Greece is.

Using the reduced form coefficients of an econometric model* of the Greek economy which emphasizes the monetary sector, the results would seem to give support to the importance of the balance of payments constraint (i.e. the import constraint).

II. STRUCTURE OF THE LP MODEL

The objective of the following LP model is to maximize

* The structure of the model is described in a Ph. D. thesis submitted to the University of Kent at Canterbury (1980). The model consisting of 53 equations is estimated by 2SLS principal components method for the period 1958-1974 and is designed to reflect the impact of alternative monetary and fiscal policies. The capital stock and the labour force are considered as given. In detail, explanation of the movements of consumer expenditure brings into the picture income variables, and these in turn produce price variables which are dependent on the money supply. Investment expenditure also brings into the picture credit variables which are dependent on deposit variables which in turn are dependent on income and on interest rates. Finally tax receipts depend upon both tax rates, and the tax base. 1 owe my thanks to R.J.D. Hill for the valuable suggestions on the content of this paper.

$$R = \sum_{i=1}^{n} b_i X_i \qquad (1)$$

where R=GNP=Gross National Product

bi=objective constants (the reduced form coefficients of the policy variables).

Xi=Policy variables controlled by the authorities

n=number of policy variables

Equation (1) is maximized subject to a series of constraints

$$\sum_{j=1}^{n} a_{ij} \leqslant c_i \quad i=1,2,\ldots,m \qquad (2)$$

where aij=coefficient constrants

Ci=constraint constants

m=number of constraints

The procedure we follow involves getting the submatrix from the reduced form coefficients that concern the policy variables, and using it in the following way. Maximize the Gross National Product Variable[1] subject to a set of constraints such as, for example that the policy instruments must not exceed a certain value or that the price level must not exceed a specific value determined by political and social criteria and other economic constraints like import constraints. Each of the constraints expressed in terms of the policy variables will change the solution of the LP programme except when the constraint is redundant.

The policy variables we use are represented in the order that they appear (see Definition of Variables in APPENTIX A). The range of the assumed changes in the policy variables is one unit for all policy variables except for the rates of indirect and direct taxation, the ratio of obligatory deposits of commercial banks and the ratio of obligatory treassury bills held by commercial banks which are assumed to change by 0.01.

Looking at the relevant row of the GNP of the reduced form coefficients

1. We note that exactly the same procedure can be applied to any other endogenous variable in the model. However, we have chosen one target (i.e. GNP) to which we have applied the LP technique, that is the most important target variable tor development purposes.

(see Table 1) we can see that the rates of indirect and direct taxation, the government expenditure variable and the Bank's of Greece credit supply variable are among the most powerful policy instruments. Concerning the interest rate policy variables, we observe that the most powerful of them is the one on credits to manufacturing.

Finally we should point out that in the present article more emphasis should be given on the study of alternative parameter assumptions than on the results obtained with any particular set of parameters.

III. EXPERIMENTS WITH THE L.P. MODEL AND THEIR POLICY IMPLICATIONS

We examine the following cases considering :

a. Different (realistic) values of the policy variables in the appropriate constraints.

b. A variable number of constraints (see Table 1).

In case 1 we included all the policy instruments constraints. The maximum value of GNP is 602566 millions drachmas (m.d.). This is achieved by fixing fine policy instruments at their maximum permitted values and equating the values of the other policy instruments to zero. However, this value of GNP is associated with a high value of imports which consequently effects the balance of payments.

Case 2 is more realistic since it is similar to case 1 but we have also imposed an import constraint. The results show the importance of imports in expanding GNP. Analytically in case 2(a) the maximum value of GNP is 369511 m.d; this is achieved by fixing the values of eleven policy variables. In cases 2(b) and 2(c) we condsidered realistic values of the policy variables for short-run planning.

In case 3 we included the same constraints as in case 2, but instead of an import constraint we imposed a price constraint (i.e. we do not allow the rate of change of prices to increase more than 25% in case 3(a) and 7% in case 3(b). The price constraint was found to be redundant in case 3(a). However, in case (b) in which we restricted the rate of inflation to less than 7.89% the price constraint became effective. In fact the slack variable of the price constraint is zero in case 3(b) while in case 3(a) is positive. So in an effort to achieve a reduction of the inflation from 7.89 % to 7 %[2] the GNP has to fall from 602566 m.d. to 541737 m.d.

2. Ceteris paribus the values of the other policy instruments. -. ..

TABLE 1

A sub-matrix of impact multipliers
(2SLS reduced form coefficients of the model)

	$(C_g + I_g)$	T^{ind}	T^{dir}	r^A	$r_{sig \cdot d}$	$r_{sav \cdot d}$	$r_{t \cdot d}$	$r_{p \cdot S \cdot d \cdot}$	$r_{tr \cdot b}$	$(r_{red} - r_{tr \cdot b})$	r_M	RR	Tb^{RR}	$(r_{imp} - r_{sav})$	Cr^{BG}
G_{NP}	4,38	—654486	—176948	—1228	—372	700	66	1113	—525	—310	—2257	—7387	—3087	191	11.02
P_{GNP}	0.0006	—3.191	—2.358	—0.017	—0.058	—0.023	0.0009	0.01	—0.007	—0.004	—0.03	—0.104	—0.04	0.003	0.00015
I_{mp}	0.95	—142364	—38489	—267	—81	152	14	242	—114	—67	—491	—1607	—671	42	2.39

TABLE 2 (Cont.)

Linear programming problems

Case 1

Max GNP

Subject to the constraint that			the results from the above program are:		
$(C_g + I_g)$	$\leqq$	100000	$(C_g + I_g)$	= 100000	$S_1 = 0$
$r_{sav.d}$	$\leqq$	10	$r_{sav.d}$	= 10	$S_2 = 0$
$r_{p.s.d.}$	$\leqq$	11	$r_{p.s.d}$	= 11	$S_3 = 0$
$(r_{imp} - r_{sav.d})$	$\leqq$	7	$(r_{imp} - r_{sav.d})$	= 7	$S_4 = 0$
Cr^{BG}	$\leqq$	13000	Cr^{BG}	= 13000	$S_5 = 0$
$r_{t.d}$	$\leqq$	11	$r_{t.d}$	= 11	$S_6 = 0$
T^{ind}	$\leqq$	0.25	T^{ind}	= 0	$S_7 = 0.25$
T^{dir}	$\leqq$	0.13	T^{dir}	= 0	$S_8 = 0.13$
r^A	$\leqq$	7.5	r^A	= 0	$S_9 = 7.5$
$r_{tr.b}$	$\leqq$	10.5	$r_{tr.b}$	= 0	$S_{10} = 10.5$
$(r_{red} - r_{sav.d})$	$\leqq$	4	$(r_{red} - r_{sav.d})$	= 0	$S_{11} = 4$
r_M	$\leqq$	13	r_M	= 0	$S_{12} = 13$
RR^{cb}	$\leqq$	0.25	RR^{cb}	= 0	$S_{13} = 0.25$
Tb^{RR}	$\leqq$	0.40	Tb^{RR}	= 0	$S_{14} = 0.4$
$r_{sig.d}$	$\leqq$	1	$r_{sig.d}$	= 0	$S_{15} = 1$

With optimum value of the maximizing function being Max GNP = 602566

TABLE 2 (Cont.)

Linear programming problems

Case 2

Max GNP

Subject to the constraint that

	case (a)	case (b)	case (c)
$(C_g + I_g)$	$\leq$ 100000	$\leq$ 100000	$\leq$ 100000
$r_{sav.d}$	$\leq$ 10	$\leq$ 10	$\leq$ 10
$r_{p.s.d}$	$\leq$ 11	$\leq$ 11	$\leq$ 11
$(r_{imp} - r_{sav.d})$	$\leq$ 7	$\leq$ 7	$\leq$ 7
Cr^{BG}	$\leq$ 13000	$\leq$ 13000	$\leq$ 13000
$r_{t.d}$	$\leq$ 11	$\leq$ 11	$\leq$ 11
T^{ind}	$\leq$ 0.25	$\leq$ 0.25	$\leq$ 0.25
T^{dir}	$\leq$ 0.13	$\leq$ 0.13	$\leq$ 0.13
r^A	$\leq$ 7.5	$\leq$ 7.5	$\leq$ 7.5
$r_{tr.b}$	$\leq$ 10.5	$\leq$ 10.5	$\leq$ 10.5
$(r_{red} - r_{sav.d})$	$\leq$ 4	$\leq$ 4	$\leq$ 4
r_H	$\leq$ 13	$\leq$ 13	$\leq$ 13
RR^{cb}	$\leq$ 0.25	$\leq$ 0.25	$\leq$ 0.25
Tb^{RR}	$\leq$ 0.4	$\leq$ 0.4	$\leq$ 0.4
$r_{sig.d}$	$\leq$ 1	$\leq$ 1	$\leq$ 1
Imports	$\leq$ 60000	$\leq$ 120000	$\leq$ 100000

The results from the above programs are.

	case (a)		case (b)		case (c)	
$(C_g + I_g)$	= 100000	$S_1 = 0$	100000	$S_1 = 0$	100000	$S_1 = 0$
$r_{sav.d}$	= 10	$S_2 = 0$	10	$S_2 = 0$	10	$S_2 = 0$
$r_{p.s.d}$	= 3.774	$S_3 = 7.226$	11	$S_3 = 0$	11	$S_3 = 0$
$(r_{imp} - r_{sav.d})$	= 0	$S_4 = 7$	0	$S_4 = 7$	0	$S_4 = 7$
Cr^{BG}	= 13000	$S_5 = 0$	13000	$S_5 = 0$	13000	$S_5 = 0$
$r_{t.d}$	= 11	$S_6 = 0$	11	$S_6 = 0$	11	$S_6 = 0$
T^{ind}	= 0.25	$S_7 = 0$	0.0165	$S_7 = 0.2335$	0.1569	$S_7 = 0.0931$
T^{dir}	= 0.13	$S_8 = 0$	0	$S_8 = 0.13$	0	$S_8 = 0.13$
r^A	= 0	$S_9 = 7.5$	0	$S_9 = 7.5$	0	$S_9 = 7.5$
$r_{tr.b}$	= 10.5	$S_{10} = 0$	10.5	$S_{10} = 0$	10.5	$S_{10} = 0$
$(r_{red} - r_{sav.d})$	= 0	$S_{11} = 4$	0	$S_{11} = 4$	0	$S_{11} = 4$
r_H	= 13	$S_{12} = 0$	13	$S_{12} = 0$	13	$S_{12} = 0$
RR^{cb}	= 0.25	$S_{13} = 0$	0.25	$S_{13} = 0$	0.25	$S_{13} = 0$
Tb^{RR}	= 0	$S_{14} = 0.4$	0	$S_{14} = 0.4$	0	$S_{14} = 0.4$
$r_{sig.d}$	= 1	$S_{15} = 0$	1	$S_{15} = 0$	1	$S_{15} = 0$
Imports	= 80000	$S_{16} = 0$	120000	$S_{16} = 0$	100000	$S_{16} = 0$

With optimum value of the maximizing function being

	case (a)	case (b)	case (c)
Max GNP	369511	55[illegible]405	46[illegible]

TABLE 2 (Cont.)

Linear programming problems

Case 3

Max GNP

Subject to the constraint that

	case (a)	case (b)
$(C_g + I_g)$	$\leq$ 100000	$\leq$ 100000
$r_{sav.d}$	$\leq$ 10	$\leq$ 10
$r_{p.s.d}$	$\leq$ 11	$\leq$ 11
$(r_{imp} - r_{sav.d})$	$\leq$ 7	$\leq$ 7
Cr^{BG}	$\leq$ 13000	$\leq$ 13000
$r_{t.d}$	$\leq$ 11	$\leq$ 11
T^{ind}	$\leq$ 0.25	$\leq$ 0.25
T^{dir}	$\leq$ 0.13	$\leq$ 0.13
r^A	$\leq$ 7.5	$\leq$ 7.5
$r_{tr.b}$	$\leq$10.5	$\leq$10.5
$(r_{red} - r_{sav.d})$	$\leq$ 4	$\leq$ 4
r_M	$\leq$ 13	$\leq$ 13
RR^{cb}	$\leq$0.25	$\leq$ 0.25
Tb^{RR}	$\leq$0.4	$\leq$ 0.4
$r_{sig.d}$	$\leq$ 1	$\leq$ 1
$\hat{P}_{GNP}$	$\leq$ 75	$\leq$ 7

The results from the above programs are.

	case (a)		case (b)	
$(C_g + I_g)$	= 100000	S_1 = 0	89027	S_1 = 10373
$r_{sav.d}$	= 10	S_2 = 0	10	S_2 = 0
$r_{p.s.d}$	= 11	S_3 = 0	11	S_3 = 0
$(r_{imp} - r_{sav.d})$	= 7	S_4 = 0	0	S_4 = 7
Cr^{BG}	= 13000	S_5 = 0	13000	S_5 = 0
$r_{t.d}$	= 11	S_6 = 0	11	S_5 = 0
T^{ind}	= 0	S_7 = 0.25	0	S_7 = 0.25
T^{dir}	= 0	S_8 = 0.13	0	S_8 = 0.13
r^A	= 0	S_9 = 7.5	7.5	S_9 = 0
$r_{tr.b}$	= 0	S_{10}=10.5	0	S_{10}=10.5
$(r_{red} - r_{sav.d})$	= 0	S_{11}= 4	0	S_{11}= 4
r_M	= 0	S_{12}=13	0	S_{12}=13
RR^{cb}	= 0	S_{13}= 0.25	0.25	S_{13}= 0
Tb^{RR}	= 0	S_{14}= 0.40	0	S_{14}= 0.4
$r_{sig.d}$	= 0	S_{15}= 1	1	S_{15}= 0
$\hat{P}_{GNP}$	= 7.89	S_{16}=17.109	7	S_{16}= 0

With optimum value of the maximizing function being

	case (a)	case (b)
Max GNP	602556	541937

TABLE 2 (Cont.)

Linear programming problems

Case 4

Max GNP

Subject to the constraint that

	case (a)	case (b)	case (c)
$(C_g + I_g)$	$\leq$ 100000	$\leq$ 100000	$\leq$ 100000
$r_{sav.d}$	$\leq$ 10	$\leq$ 10	$\leq$ 10
$r_{p.s.d}$	$\leq$ 11	$\leq$ 11	$\leq$ 11
$(r_{imp} - r_{sav.d})$	$\leq$ 7	$\leq$ 7	$\leq$ 7
Cr^{BG}	$\leq$ 13000	$\leq$ 13000	$\leq$ 13000
$r_{t.d}$	$\leq$ 11	$\leq$ 11	$\leq$ 11
T^{ind}	$\leq$ 0.25	$\leq$ 0.25	$\leq$ 0.25
T^{dir}	$\leq$ 0.13	$\leq$ 0.13	$\leq$ 0.13
r^{A}	$\leq$ 7.5	$\leq$ 7.5	$\leq$ 7.5
$r_{tr.b}$	$\leq$ 10.5	$\leq$ 10.5	$\leq$ 10.5
$(r_{red} - r_{sav.d})$	$\leq$ 4	$\leq$ 4	$\leq$ 4
r_M	$\leq$ 13	$\leq$ 13	$\leq$ 13
RR^{cb}	$\leq$ 0.25	$\leq$ 0.25	$\leq$ 0.25
Tb^{RR}	$\leq$ 0.4	$\leq$ 0.4	$\leq$ 0.4
$r_{sig.d}$	$\leq$ 1	$\leq$ 1	$\leq$ 1
Imports	$\leq$ 100000	$\leq$ 80000	$\leq$ 140000
$\dot{P}_{GNP}$	$\leq$ 6	$\leq$ 6	$\leq$ 20

The results from the above programs are:

	case (a)		case (b)		case (c)	
$(C_g + I_g)$	= 87488	S_1 = 12511	99070	S_1 = 930	100000	S_1 = 0
$r_{sav.d}$	= 10	S_2 = 0	10	S_2 = 0	10	S_2 = 0
$r_{p.s.d}$	= 0	S_3 =11	0	S_3 =11	11	S_3 = 0
$(r_{imp} - r_{sav.d})$	= 0	S_4 = 7	0	S_4 = 7	7	S_4 = 0
Cr^{BG}	= 13000	S_5 = 0	13000	S_5 = 0	13000	S_5 = 0
$r_{t.d}$	= 11	S_6 = 0	11	S_6 = 0	11	S_6 = 0
T^{ind}	= 0.0037	S_7 = 0.2463	0.2214	S_7 = 0.0286	0	S_7 = 0.25
T^{dir}	= 0.13	S_8 = 0	0.13	S_8 = 0	0	S_8 = 0.13
r^{A}	= 7.5	S_9 = 0	7.5	S_9 = 0	0	S_9 = 7.5
$r_{tr.b}$	=10.5	S_{10}= 0	10.5	S_{10}= 0	0	S_{10}=10.5
$(r_{red} - r_{sav.d})$	= 0	S_{11}= 4	0	S_{11}= 4	0	S_{11}= 4
r_M	= 13	S_{12}= 0	13	S_{12}= 0	0	S_{12}=13
RR^{cb}	= 0.25	S_{13}= 0	0.25	S_{13}= 0	0	S_{13}= 0.25
Tb^{RR}	= 0.40	S_{14}= 0	0.40	S_{14}= 0	0	S_{14}= 0.40
$r_{sig.d}$,	= 1	S_{15}= 0	1	S_{15}= 0	0	S_{15}= 1
Imports	= 100000	S_{16}= 0	80000	S_{16}= 0	130700	S_{16}=9300
$\dot{P}_{GNP}$	= 6	S_{17}= 0	6	S_{17}= 0	7.891	S_{17}= 12.109

With optimum value of the maximizing function being

	case (a)	case (b)	case (c)
Max GNP =	461292	369492	602556

Finally case 4 is similar to case 1, but we have also imposed both import and price constraint. The results revealed again the dominance of the import constraint. However, in case 4(c) the slack variable of the import constraint takes a value which is not equal to zero because of the restrictive value of the government expenditure constraint.

On the other hand the price constraint became a non redundant constraint at a rate of inflation of less than 7.89 %[2]. So the price constraint is not an obstacle in the expansion of the GNP unless we want to keep the rate of inflation at this level.

Obviously the above mentioned results are dictated by the structure of the model.

IV. CONCLUSION

The discussion concerning the linear programming approach reveals that the main obstacle to higher economic growth in Greece is the balance of payments; this indicates the importance of the import constraint in expanding GNP and that the price constraint does not constitute a serious obstacle in the effort to maximize GNP. So in an effort to expand GNP in the future, the authorities must be aware of the repercussions of this expansion of GNP on the balance of payments rather than on the rate of inflation (though this depends on the value they attach to lower inflation).

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APPENTIX A

DEFINITION OF VARIABLES

Policy Instruments

1. (Gg+Ig. Government consumption plus government investment at constant 1970 prices.

2. T^{ind} Ratio of total indirect taxes to private consumption.

3. T^{dir} Ratio of total direct taxes on income to National Income.

4. r^{A} Interest rate on credits to farmers.

5. $r_{Sig}.d$ Interest reate on sight deposits.

6. $r_{sav}.d$ Interest rate on savings deposits.

7. rt-d Interest rate on time deposits.

8. $rp._{s}.,j.$ Interest rate on postal savings deposits.

9. rtr-b Interest rate on treasury bills.

10. $(r_{red}-r_{Sav}\cdot d)$ Bank of Greece rediscount interest rate minus interest rate on savings deposits.

11. r_{M} Weighted average interest rate on credits to bills discount, working capital, handicraft and long term credit.

12. RR Ratio of obligatory deposits of commercial banks with the Bank of Greece to bills discounted credit plus working capital credit plus trade credit supplied by commercial banks for the years (1966 - 1974).

13. Tb^{RR} Ratio of obligatory treasure bills held by commercial banks to total sight and savings deposits with commercial banks.

14. (rimp-r_{S}av-d) Interest rate on credits to trade supplied by commercial banks minus interest rate on savings deposits.

15. Cr^{BG} Flow of supply of credit of Bank of Greece and of Government deflated by PGDP.

Endogenous variables

1. GNP Gross National Product at constant 1970 prices.

2· PGNP Percentage rate of growth of the implilit Gross National Product price index.

3. I_{mp} Imports of goods and serviçces deflated by the import price index.