I J A B E R, Vol. 14, No. 1, (2016): 311-327

OUTPUT DETERMINATION IN AN ANNUAL MACRO-ECONOMETRIC MODEL-PARTIAL ADJUSTMENTS TO DEMAND AND SUPPLY CHANGES

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Abstract: *In an annual macro-econometric model it can be argued that in the determination of real production both demand and supply play a significant role. Even if there is unutilized capacity, the adjustment of production as a respond to a change in demand could not be totally completed, as it is implied with the Keynesian equilibrium condition but only partly. On the other hand, productive capacity can change and this has a certain effect in the real production to the extent that this additional capital equipment will be used within the year. This work proposes the specification of a relation of output determination in which elements of both supply and demand are included. The extent of their effect on production is estimated statistically by a relation of partial adjustments of real production to changes in demand as well as in supply. Policy simulations of a simple model for the Greek economy, which incorporates an adjustment relation of output determination, are compared with those of a similar model in which the macroeconomic Keynesian relation of equilibrium is included. The proposed model gives more plausible results compared to the usual Keynesian model. More specifically, the increase of public expenditure does not appear to have as strong effect on production as in the Keynesian model where the adjustment of production to changes in demand are fully completed within a year. The reduction of interest rate, leads to a greater increase in production with the proposed model due to the increased effect of investments through both the demand and the supply while the short-run model does not incorporate the effect of supply on production.*

Keywords: *Macroecomic model, Output determination, Short-run and long-run relations, Adjustments, model closure, Macroeconomic identities, Macroeconomic demand - Supply output determinants.*

1. INTRODUCTION

In specifying an annual macroeconomic model it is usually taken into consideration either the short-run or the long-run period only. The case of medium-run period, as it is the year, is not usually considered as a period during which elements of

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both short-run and long-run character coexist. Productive capacity is possible to change and contribute to changes in production together with changes in utilization of existing productive capacity.

In this article an effort is made to incorporate short-run and long-run elements in the determination of production when constructing a macro-econometric model. The introduction of investments into the model is meant to play its dual role both as a component of demand and as an addition to productive capacity augmenting production. At the same time the short–run character of the period dictates the introduction of adjustment mechanism both on the side of demand and on the side of supply. The extent to which the adjustments are realized should be left to be determined statistically by the historical data.

2. THE VARIETY OF STRUCTURES IN THE EXISTING MACROECONOMIC MODELS

In certain annual models, for the determination of real production, the period of a year is considered on the one hand as so short-run that only Keynesian relations of demand (consumption, investment, inventory change, imports and exports) are used as determinants of the production. In other words, during one year a given and not fully utilized productive capacity "reacts" so as to satisfy the level of demand as it is formed by its exogenous components and the multiplier. On the other hand, the period of the year is considered long enough so that all required adjustments of production to the changes of demand are completed (See e.g. Jouganatos, 1992; Karadeloglou and Koutsouvelis 1996;Merlevede, 2003: UN–WEFM-, 2014) *i.e.* supply below full capacity is taken to fully satisfy demand whatever its changes.

In other cases, the production is determined only with long-run relations. It is set equal to demand so that some part of demand is determined as a residual (usually the change in stocks) ensuring the macroeconomic identity (See Petrochilos, 1989: Côté, *et al*, 2003 - FOCUS model).

Other annual models (see *e.g.* Fanning and Bradley, 1981; Commission of the European Communities, 1993) include short-run relations for demand and income determination (mainly of Keynesian character) and at the same time they include long-run relations for determining potential output (see. DRI model, in Côté, *et.al.* 2003). Dreger C. and Marcellino M. (2006) in their macro econometric model for the Euro economy separate supply and demand sides were specified estimating potential output in the supply side using a Cobb–Douglas production function. However, "the model is demand driven in the short run. Actual GDP is equal to the sum of the demand components". In OECD's INTERLINK models (Richardson, 1988),

"actual output is determined as the product of "normal output" and the utilization rate, with stock building determined residually by identity". Normal output is determined by the production functions and the existing factor level. In IMF's MULTIMOD III models (Laxton, *et.al.*, 1998), capacity output is determined as a relation to 2 factor inputs through a Cobb-Douglas production function, a constant growth rate of total factor productivity and exogenous labour supply. In his article on Macro econometric Models for India (Krishnamurty, 2002), suggested that " Manufacturing' may be either demand-constrained or resource-constrained" *i.e.* demand may be either in excess or in short of the capacity output and ex-post production will be identified with the smaller of these. In this sense, the level of activity switches between two regimes. He further argues that this approach would be superior to the one in which "only aggregate demand or only aggregate supply" operates.

In certain cases, while the actual product is determined within the model, the potential product is determined exogenously[1]. The difference between potential and actual product, determines the degree of utilisation of productive capacity, which in its turn influences prices, demand and production.

Another category of annual models is only of long-run character representing productive potential with the real production. They include either a production function (see *e.g.* Christodoulakis and Kalyvitis, 1995) or relations of production to certain factors such as exports (See *e.g.* Fanning and Bradley, 1981).

3. THE ADJUSTMENTS TOWARDS EQUILIBRIUM

It should be observed that, adopting one only side from those mentioned previously and in particular in the case of short-run model of simple Keynesian approach, the implicit as sumptionis that during one year the potential supply-production side does not play any role in the economy.

In an annual macroeconomic model it can be argued that elements of both short-run and long-run character exist. That in the determination of real production both demand and potential supply factors contribute.

It can be accepted that:

- the period of one year is short enough so that changes in production as are sponse to changes in demand could not be totally (as it is implied with the Keynesian equilibrium condition) but only partially completed. Uncertainty, imperfections of information, lack of perfect mobility and other factors is possible not to allow a complete adjustment of production to a change in demand within a year. Finding the appropriate labor force and its full utilization can in many instances require a period longer than a year (training of new

comers, obtaining of skills, establishing the required associated infrastructure etc). In addition, existing productive capacity can constrain a rapid adjustment of production to the changes in demand.

- the period of one year is long enough so that productive capacity can change and this has a certain effect in the real production, among others because part of this additional capital equipment will be used and create its own demand (classical view). It can be accepted that, the adjustment of production to changes in productive capacity could not be realized completely but only part of it. If some producers had planned and installed additional productive capacity relative to the previous year they will increase their production facilitated by additional demand, but the increase in production will not correspond fully to the additional productive capacity due to imperfections, the uncertainty they face and demand constraints.

In this work it will be attempted to take into consideration the above arguments proposing the specification of a relation determining production in which elements of both long-run and short-run will be included. The extent of their effects will be estimated statistically with partial adjustment relations of the actual production to both changes in demand and changes in potential supply.

The adjustments which take place in an economy have been represented by a number of specifications (error correction mechanisms, partial adjustment models etc). Houthakker and Taylor (1970), applying adjustment relations to exports proposed the adjustment of export quantities according to the relation.

$$\Delta Y = \delta(Y^d - Y_{t-1}) \tag{3.1}$$

Where Y stands for the realized quantity of exports and Y^d, stands for the demanded quantity during the current period.

This relation express market conditions where the change in demand constitutes the main constraint of the realized exports, as could be the case for a small open economy, but a number of factors do not allow the full adjustment of exports to this change in demand.

In another article afterwards, Browne(1982), proposed the adjustment of export quantities according to the relation.

$$\Delta Y = \gamma(Y^s - Y_{t-1}) \tag{3.2}$$

Where Y^s the supplied quantity of exports during the current period.

This relation express market conditions where the change in supply constitutes the main constraint of the realized exports but a number of factors do not allow the full adjustment of exports to this change in supply.

This procedure could be applied to the formation of total production in the economy as a result of adjustments in changes of total demand or/and total potential supply.The relation determining production in an annual macro economic model should include elements of both restrictive sides (demand and supply) on the base of the following arguments:

- During a period of, say, 30 years the there are alterations with respect to the main constraining factor for any change in production (potential supply constraint or demand constraint).
- During the period of one year, a part of the productive sector could be mainly affected by a change in demand (with or without supply restrictions) and another part could be mainly affected by the new installed capacity (with or without demand restrictions).
- Instead of determining arbitrarily the short-run and the long-run period as well as the extent of the adjustments, the historical data are left to determine statistically the extent of the adjustments that take place.

4. SPECIFYING THE RELATION OF INCOME DETERMINATION IN A MACROECONOMIC MODEL

The relation of income-product determination can include an adjustment mechanism of the form presented by the relations (1) and (2). More specifically based on the previous arguments the following adjustment relation for income-product determination are proposed:

$$\Delta Y = \gamma(Y^s - Y_{t-1}) + \delta(Y^d - Y_{t-1}) \tag{4.1}$$

The change of production is the result of partial adjustment to the additional potential supply relative to the production of the previous period given additional demand and the partial adjustment to the additional demand relative to the production of previous period with given additional supply.

Relation (3.1) can take the form:

$$\Delta Y = \gamma Y^s + \delta Y^d - (\gamma + \delta) Y_{t-1} \tag{4.2}$$

Y^s will be determined by a production function, which in a period of high unemployment rate as it was the period of the last 30 years could be represented by a simple relation:

$$Y = f(K)$$

Where K the capital stock

Thus, if a linear production function[2] is adopted and if the current net fixed investments (ITNETR) are distinguish, from the rest of capital stock[3], the following relation holds:

$$Y^s = a_1 * K_{t-1} + a_2 * ITNETR \quad (4.3)$$

where K_{t-1} the capital stock at the end of the previous year and ITNETR Net Real Fixed Investments (where the index t is omitted the current period is meant)

Y^d will be determined by:

$$Y^d = CTR + ITR + XTR - MTR \quad (4.4)$$

Where CTR = total consumption, ITR = total investments, XTR = exports and MTR = imports.

Substituting (4.3) and (4.4) into (4.2) the following relation is derived

$$\Delta Y = \gamma a_1 * K_{t-1} + \gamma a_2 * ITNETR + \delta * (CTR + ITR + XTR - MTR) - (\gamma + \delta) * Y_{t-1}$$

If ITR = ITNETR + DEPR + INVR, where DEPR = depreciations and INVR Changes in inventories

$$\Delta Y = \gamma a_1 * K_{t-1} + (\gamma a_2 + \delta) * ITNETR + \delta * (CTR + DEPR + INVR + XTR - MTR) - (\gamma + \delta) * Y_{t-1} \quad (4.5)$$

5. AN APPLICATION BASED ON A SIMPLE MODEL FOR THE GREEK ECONOMY

5.1 Specification of a Simple Model

The proposed specification of a small model for the Greek economy will include the relation of adjustments mentioned previously. The function of this model will be compared to that of a similar model except that it will include the Keynesian macroeconomic equilibrium relation.

All variables (except the IRLN) are in constant prices

Private consumption *(YDR = Real Disposable Income)*

$$CPR = f(YDR) \quad (5.1)$$

Dosposable income *(GDPMR = GNP at market prices, NCTNITDT = net trasfers + net' indirect taxes + direct taxes*)

$$YDR = GDPMR - NCTNITDT \quad (5.2)$$

Total consumption *(CGR = Public consumption)*

$$CTR = CPR + CGR \quad (5.3)$$

Private investments, *(IRLR=Real interest-rate)*

$$IPR = f(GDPMR, IRLR) \tag{5.4}$$

Real interest-rate (IRLN = *nominal interest-rate, pch(PGDP) = percentage change of GNP deflator)*

$$IRLR = IRLN - pch(PGDP) \tag{5.5}$$

Total investments *(IGR = public investments)*

$$ITR = IPR+IGR \tag{5.6}$$

Net investments *(DEPR = Depreciation)*

$$ITNETR = ITR-DEPR-INVR \tag{5.7}$$

Total Imports *(PMT = imports prices, PGDP = GNP deflator)*

$$MTR = f(GDPMR, PMT, PGDP) \tag{5.8}$$

Total Exports *(YW = world Income, PXT = Prices of exports)*

$$XTR = f(YW, PGDP, PXT) \tag{5.9}$$

Relation of adjustments towards equilibrium

Proposed model

(K_{t-1} capital stock end of previous period, INVRF = voluntary change in inventories, *XTR = exports and MTR = imports)*

$$\Delta GDPMR = f(K_{t-1}, ITNETR, (CTR + DEPR + INVRF + XTR - MTR), GDPMR_{t-1} \tag{5.10a}$$

Model for comparison

$$GDPMR = CTR + ITR + XTR - MTR \tag{5.10b}$$

The definitions of variables' symbols are given in Annex A,

5.2 Estimation of the Functions of the Models

Specifying and estimating the functions of the model based on Error Correction Mechanism (ECM) have been extensively adopted in the literature (see Mallick, S.K., 2004 and Maddala G. 1992). ECM is suggested as a means to cope with non-stationary issues as dictated by co-integration theory (see Hendry, 1995).

The stationary condition of all endogenous variables of the model as provided by their correlogram in the form that they have been used in the estimation process suggests that the ECM specification in this particular case is quite appropriate for coping with the problem of stationarity. An effort was made to estimate the

functions with fully-modified OLS (FM-OLS) procedure as proposed by Phillips and Hansen (1990). The equations gave very close results to the simple OLS estimation. It should be noted that a system estimator is not expected to be superior (see Dreger and Massimiliano, 2007). However, instrumental variables methods have also been tried. The model with OLS estimations have been statically simulated and the forecasts have been used in the place of endogenous regressors. Again the results were quite close to those with OLS estimations.

The estimates of behavioural functions and the related statistical tests are given in Annex B.

The estimated functions seem to be satisfactory from the point of view of statistical tests. As it can be seen, both the signs and the statistical significance of the coefficients are satisfactory with the exception of the export function.

For the estimation of the production relation 5.10a, of the proposed model, the first differences of the variables in the initial specification were taken for 3 reasons. The first differences exempt the functions from the unitary root of their variables, limit the degree of autocorrelation in the functions and replaces the capital stock (which it is difficult to calculate) with the variable of net investments (since ΔK=ITNETR). As it can be seen in Annex B, both the signs and the statistical significance of the coefficients are satisfactory. Moreover,the function does not present a problem of autocorrelation.The estimated relation taken from Annex B is presented below.

$$D(D(GDPMR)) = 0.1091^* ITNETR(-1) + 0.2197^* D(CTR + XTR + DEPR + INVRFF - MTR) + 0.6244^* D(ITNETR) - 0.7520^* D(GDPMR(-1)) - 5459.13^* D10 - 5785.32^* D11$$

The adjustment coefficient of production to the additional demand (δ) is estimated to be 0.2197. The adjustment coefficient of production to the additional (potential) supply (γ) is estimated to be 0.5323 (0.7520-0.2197). The coefficient of capital stock (α_1) is estimated to be 0.2050 (0.1091/0.5323). Finally the coefficient of current investment (α_2) is estimated to be 0.7603 [(6244-0.2197)/0.5323]. The adjustment function (5.10a) leaves the data to estimate the extent the adjustments allowed by the period of one year[4]. The time series used are given in Annex C.

5.3 Comparisons of Base Lines

The purpose of this section is not to test the forecasting accuracy of either model but to compare the relative accuracy of the 2 alternative models. Their explanatory power is compared with respect to the baseline scenario using the Mean Absolute Percentage Error -MAPE which is defined as:

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\frac{|Y_t - Y_t|}{Y_t}$$

The result for the period 1990 – 2013 is MAPE = 9.83% for the simple Keynesian model and MAPE = 5.57% for the proposed model. In terms of explanatory power it seems that the proposed model presents a slightly better performance.

5.4 Comparisons of Policy Scenarios

The comparison will be made with 2 policy exercises: afiscal policy scenario of public consumption increase and a monetary policy of interest-rates decrease.

The comparisons were made taking the percentage differences of each policy scenario from the baseline scenario. Both scenarios were taken applying dynamic simulation for the period 1990-2013. The changes of the corresponding policy variables (public consumption and interest rate) were made the year 1990 and were retained up to the end of the period.

5.4.1Increase of public consumption by 20%

The policy simulations of the models are given in Table 5.1.

As it could be expected, in the model of short-run Keynesian character the effect of an increase of public expenditure, due to the complete adjustment of production to the changes in demand, seems quite extensive showing an average percentage deviation of production from the baseline scenario for the period 1990 – 2013 of 10.55%. The proposed model presents a more moderate (compared with the short-run Keynesian) increase of production with an average deviation of 8.15% for the same period. If the consequences of a public deficit are ignored (as it is the case with the models examined), a positive effect on the production could be expected but not to the extent implied by the Keynesian model.

5.4.2Reduction of Nominal Interest Rates by 20%

As it can be seen in Table 1, in the model of Keynesian orientation the effect of a reduction of interest-rate on the production is positive as it would be expected but since this effect is caused only by demand its extent is limited reaching around 1.49% on average. In the proposed model in which not only the demand but also the potential supply influence the changes of production, an increase relative to the basic scenario of the order of 2.40% can be seen for the period as a whole. Such a development would be expected since in the proposed model the investments function with their dual role both as an element of demand and as an element that increases the productive capacity.

Table 1
Policy Simulations: Percentage differences from the basic scenario

Increase	Short	90	91	92	93	94	95	96	97	98	99	00	01	
Average	-run													
of public	Keyn	9.4	6.4	7.2	7.9	8.1	8.1	7.8	9.2	9.1	9.5	10.9	10.9	
consum-	esian	02	03	04	05	06	07	08	09	10	11	12	13	
ption by		11.8	11.6	12	12.2	12.6	12	12.4	12	12.8	12.8	13.6	12.9	10.55
20%	Prop	90	91	92	93	94	95	96	97	98	99	00	01	
	osed	6.6	5.2	5.4	5.9	6.1	6.0	5.9	6.4	6.9	7.0	8.1	8.2	
		02	03	04	05	06	07	08	09	10	11	12	13	
		8.5	8.8	9.0	9.2	9.8	9.6	9.9	9.8	10.2	10.6	11.2	11.3	8.15
Reduct	Short	90	91	92	93	94	95	96	97	98	99	00	01	
ion of	-run	2.1	2.3	2.4	2.5	2.5	2.1	1.8	1.8	1.7	1.7	1.5	1.4	
nominal	Keyne	02	03	04	05	06	07	08	09	10	11	12	13	
interest	sian	1.2	1.1	1.1	1.0	1.0	0.9	1.0	0.8	0.9	1.0	1.0	1.0	1.49
rates														
by 20%	Prop	90	91	92	93	94	95	96	97	98	99	00	01	
	osed	1.7	2.1	2.3	2.5	2.6	2.3	2.2	2.2	2.4	2.3	2.4	2.3	
		02	03	04	05	06	07	08	09	10	11	12	13	
		2.2	2.3	2.3	2.3	2.5	2.3	2.5	2.3	2.6	2.8	3.1	3.2	2.40

CONCLUSION

The relation determining production which is proposed to include adjustments of both the supply side and the demand side was tried in a macroeconomic model which is compared with a model of short-run character. The comparisons were made implementing 2 alternative policy simulations, that is, increase of public expenses, and reduction of nominal interest-rate.

The results of dynamic simulations showed, in both cases of policy simulations that the proposed model in which the adjustment relation was included seems to provide more plausible results.

The increase of public expenditure does not appear to have as strong effect on production as in the Keynesian model where the adjustment of production to changes in demand are fully completed within a year.

The reduction of interest rate, leads to a greater increase in production with the proposed model than with the short-run Keynesian model due to the increased effect of investments both through the demand and the supply in the proposed model while the short-run model ignores the effect of supply.

Notes

1. It is usually estimated by joining the peak points of the sample.
2. We could adopt a non linear function but this would complicate the analysis.

3. On the one hand it could have a different coefficient from the rest of the capital stock, on the other hand only part of investments could be used in production.
4. While the proposed model does not distinguish the short-run from the long-lasting period the model to be compared has a short-run character. Comparisons with long-run character models have been made with analogous conclusions which resulted from the fact that in this models the production is determined only by the supply.

References

Browne F. (1982), 'Modeling Export Prices and Quantities in a Small Open Economy', *The Review of Economic and Statistics,* 64: 346-347.

Christodoulakis N, Kalyvitis S. (1995), *Likely Effects of CSF 1994-1999 on the Greek economy, an ex ante Assessment Using an Annual Four sector Macro econometric Model*. Center of Planning and economic research, Athens.

Commission of the European Communities (1993), *HERMES: Harmonized Econometric Research for Modeling Economic Systems*. North-Holland.

Côté D, Kuszczak J, Lam J.-P., Liu Y, and Amant P. (2003), *A Comparison of Twelve Macroeconomic Models of the Canadian Economy*, Bank of Canada, Technical Report No 94.

Dreger, Ch. and Marcellino M. (2007), 'A macroeconometric model for the Euro economy', *Journal of Policy Modeling,* 29: 1-13.

Fanning C., Bradley J. (1981), 'Twenty-Five tears of Modeling the Irish economy – Retrospect and prospects',*Journal of Statistical and Social Inquiry Society of Ireland*, 24(4).

Granger, C.W.J. and Newbold, P., (1974), 'Spurious Regressions in Econometrics', *Journal of Econometrics*, 2: 111-20.

Hendry, D., (1995), *Dynamic Econometrics*, Oxford: Oxford University Press.

Houthakker H and Taylor L. (1970), *Consumer Demand in the United States, Cambridge*. Harvard University Press.

Jouganatos G.A. (1992), *The Development of the Greek Economy 1950–1991*, Greenwood Press, Westport, Connecticut.

Karadeloglou P., Koutsouvelis P. (1996), *Macroeconometric Model KEPE-LINK (MYKL)*, Center of Planning and Economic Research.

Krishnamurty K. (2002), 'Macroeconometric Models for India: Past, Present and Prospects', *Economic and Political Weekly*, 37(42): 4295-4308.

Laxton D., Isard P.,Faruqee, H, Prasad E, and Turtelboom B (1998), MULTIMOD Mark III The Core Dynamic and Steady-State Models, *IMF occasional Paper* 164.

Maddala G. (1992), *Introduction to Econometrics*, Second Edition, Prentice Hall International Edition.

Mallick, S.K. (2004), 'A dynamic macroeconometric model for short-run stabilization in India', *Applied Economics,* 36(3): 261-276.

Merlevede, B., Plasmans, J. and Aarle, B. (2003), 'A small macroeconomic model of the EU accession countries', *Open Economies Review*, 14: 221–250.

Petrochilos G.A. (1989), *Foreing direct investment and the development process*, Avebury, Aldershot.

Phillips, P. and.Hansen, B. (1990), 'Statistical Inference in Instrumental Variables Regression with I(1) Processes', *Review of Economic Studies*, 57: 99-125.

Richardson, P. (1988), '*The structure and simulation properties of OECD's INTERLINK model', OECD Economic Studies,* 10: 57-122.

UN, (2014), DESA, *Development Policy and Analysis Division, Global Modeling Tools,*The World Economy Forecasting Model (WEFM), URL:http://www.un.org/en/development/desa/policy/un_gpm.shtml, Accessed on October 2014.

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APPENDIXB: ESTIMATIONS OF THE BEHAVOURAL FUNCTIONS OF THE MODEL

Private consumption CPR

D(CPR) = - 7374.91 + 0.5378 * D(YDR) + 0.2767 * YDR(-1) - 0.2596 * CPR(-1) - 6880.93 * D12

(-1.84) (7.74) (2.50) (-2.51) (-2.44)

R-squared	0.766
Durbin-Watson stat	1.430
Prob(F-statistic)	0.000

Private investments IPR

D(IPR) = 0.5847*D(GDPMR)-18899.23*D(IRLR)+ 0.1171*GDPMR(-1)-19034.612*IRLR(-1)-0.6420*IPR(-1) +

(7.87) (-1.14) (4.75) (-1.90) (-5.20)

6364.37*D07

(2.92)

R-squared	0.758
Durbin-Watson stat	2.344

Total Imports MTR

D(MTR) = -12597.60 + 0.5360*D(GDPMR) - 20450.82*D(PMT/PGDP) + 0.1993*GDPMR(-1)

(2.17) (7.09) (-2.15) (3.08)

- 2815.44*PMT(-1)/PGDP(-1) - 0.3377*MTR(-1) + 7850.52*D00 - 12745.77*D09

(-1.39) (-2.88) (3.39) (-5.21)

R-squared	0.863
Durbin-Watson stat	1.440
Prob(F-statistic)	0.000

Total exports XTR

D(XTR) = -15409.52*D(PXT(-1)/PGDP(-1)) + 0.2330*D(YWN) - 559.73*PXT(-2)/PGDP(-2) + 0.0243*YWN(-1) +

(-1.2483) (1.0321) (-0.7792) (0.9429)

4693.13*D99 - 10140.03*D09

(2.2890) (-3.7203)

R-squared	0.566914
Durbin-Watson stat	1.271002

Gross Domestic Product GDPMR (for the proposed model)

D(D(GDPMR)) = 0.1091 * ITNETR(-1) + 0.2197 * D(CTR + XTR + DEPR + INVRFF - MTR)
(2.31) (1.85)
+ 0.6244 * D(ITNETR) - 0.7520 * D(GDPMR(-1)) + -5459.13 * D10 + -5785.32 * D11
(5.11) (-5.45) (-2.06) (-2.11)

R-squared 0.627898
Durbin-Watson stat 2.500913

APPENDIX C:TIME SERIES OF THE VARIABLES OF THE MODELS

YEAR	*CGR*	*CPR*	*CTR*	*DEPR*	*GDPMR*	*IGR*	*INVR*
1980	21179	72173	93352	10221	117341	1914	3080
1981	22623	71680	94303	10430	115518	2314	2752
1982	22160	74109	96269	10884	114209	2249	2634
1983	22958	75663	98621	11424	112978	2863	831
1984	23573	75952	99525	11576	115249	3479	2403
1985	24478	76340	100818	11882	118141	3706	2743
1986	24210	75210	99420	12007	118753	3284	3736
1987	24264	77214	101478	12055	116070	2577	1419
1988	22929	81890	104819	11915	121047	2925	3002
1989	24167	87037	111204	12016	125647	2938	2659
1990	24312	89317	113629	11973	125647	2821	2427
1991	23947	91898	115845	12764	129542	3308	3278
1992	23229	93987	117216	13261	130449	3736	2460
1993	23833	93268	117101	13389	128362	3539	2309
1994	23571	95081	118652	14238	130929	3567	2554
1995	24891	100503	125394	15260	133678	4187	2961
1996	25111	98723	123834	15938	136830	3487	2646
1997	25869	101852	127721	16456	141807	4686	3301
1998	26393	104675	131068	17161	146575	4570	3196
1999	26956	108896	135852	17783	151589	5278	3299
2000	31166	109373	140539	18309	158377	5840	4268
2001	31398	114806	146204	19389	165023	5985	4134
2002	33666	120252	153724	20240	170702	5933	1330
2003	33373	124189	157479	23756	180848	6594	4112
2004	34547	128952	163422	24899	188746	7125	2852
2005	34937	134725	169662	23636	193050	5479	1302

2006	36017	140595	176612	24859	203682	7039	4052
2007	38575	145644	184176	25881	210884	7432	45
2008	37559	151852	189436	27003	210431	8288	2279
2009	39398	149476	188924	28863	203830	6003	-3767
2010	35988	140138	176116	31873	193754	4484	-642
2011	34129	129321	163421	33651	179986	3303	591
2012	31783	117273	148950	38182	167436	3330	896
2013	30474	110237	140552	43261	160981	3571	2234

YEAR	*IPR*	*IRLN*	*IRLR*	*ITNETR*	*ITR*	*MTR*	*NCTNITDTR*	*PGDP*
1980	27102	0.179		18795	29016	17634	22050	0.057
1981	23873	0.179	-0.037	15758	26187	18815	16673	0.069
1982	23094	0.192	-0.080	14460	25343	18309	15242	0.088
1983	24091	0.192	-0.014	15531	26954	18796	15610	0.106
1984	19098	0.223	0.004	11001	22577	18366	15308	0.130
1985	20982	0.231	0.041	12806	24688	19141	12860	0.154
1986	21431	0.232	0.043	12708	24714	21849	18544	0.184
1987	20745	0.240	0.087	11268	23322	22240	19110	0.212
1988	20998	0.242	0.075	12008	23922	23096	11960	0.247
1989	22446	0.238	0.093	13368	25384	25509	8082	0.283
1990	23695	0.288	0.081	14543	26516	27631	9082	0.341
1991	24335	0.292	0.094	14879	27643	29228	12996	0.409
1992	22943	0.272	0.124	13417	26679	29530	12367	0.469
1993	22074	0.266	0.122	12224	25613	29725	11088	0.537
1994	21257	0.238	0.126	10585	24824	30185	12290	0.597
1995	22958	0.194	0.071	11884	27145	32858	-1267	0.670
1996	20182	0.161	0.088	7730	23669	35140	7746	0.719
1997	25470	0.129	0.061	13699	30155	40055	12884	0.768
1998	24957	0.134	0.082	12366	29527	43754	19840	0.808
1999	27468	0.122	0.092	14963	32746	50914	26516	0.832
2000	31598	0.104	0.070	19129	37438	58597	34192	0.860
2001	32923	0.079	0.048	19519	38908	59274	32466	0.887
2002	33466	0.064	0.030	19159	39399	58532	34026	0.917
2003	40093	0.058	0.019	22931	46687	60267	33811	0.953
2004	38453	0.059	0.030	20679	45578	63682	35369	0.982
2005	35843	0.059	0.040	17686	41322	62741	33929	1.000
2006	43003	0.067	0.043	25183	50042	69712	38681	1.024

2007	49081	0.072	0.039	30632	56513	79820	42805	1.058
2008	42374	0.072	0.025	23659	50662	80537	40791	1.108
2009	31979	0.057	0.034	9119	37982	64262	29808	1.134
2010	30347	0.065	0.054	2958	34831	60298	36846	1.147
2011	25807	0.076	0.066	-4541	29110	55871	37285	1.159
2012	20604	0.072	0.075	-14248	23934	48176	31622	1.155
2013	18758	0.069	0.090	-20932	22329	45606	32572	1.131

YEAR	*PMT*	*POP*	*PXT*	*XTR*	*YDN*	*YDR*	*YWN*
1980	0.112	9642	0.099	15822	5915	95291	10952
1981	0.129	9730	0.121	17153	7554	98845	11204
1982	0.159	9790	0.147	14329	9157	98967	10995
1983	0.185	9847	0.178	13491	10753	97368	11268
1984	0.230	9896	0.204	14967	13165	99941	11690
1985	0.271	9934	0.234	15242	16592	105281	12133
1986	0.292	9964	0.263	17810	19329	100209	14258
1987	0.313	9984	0.286	18867	21935	96960	16354
1988	0.354	10004	0.320	18466	28398	109087	18353
1989	0.406	10039	0.365	18825	34740	117565	19284
1990	0.461	10089	0.423	18172	41274	116565	22428
1991	0.518	10200	0.482	18921	49393	116546	23499
1992	0.582	10314	0.531	20817	57886	118082	24614
1993	0.625	10368	0.579	20277	65612	117274	25279
1994	0.659	10426	0.629	21774	73667	118639	27113
1995	0.709	10478	0.683	22427	88614	134945	30126
1996	0.745	10531	0.722	23209	95611	129084	30892
1997	0.767	10583	0.748	27859	100330	128923	30759
1998	0.797	10681	0.779	29322	103789	126735	30561
1999	0.801	10878	0.793	34641	103238	125073	31758
2000	0.892	10917	0.857	39527	111984	124185	32731
2001	0.919	10934	0.890	39522	122724	132557	32527
2002	0.926	10922	0.912	36205	129841	136676	33811
2003	0.923	10910	0.926	37262	144371	147037	37978
2004	0.943	10898	0.947	43712	154985	153376.9	42748
2005	1.000	10886	1.000	44807	159121	159121	46255
2006	1.035	10874	1.033	46739	170654	165000.8	50059

2007	1.060	10862	1.060	50066	179211	168079.1	56440
2008	1.118	10851	1.106	50898	188461	169640.5	61848
2009	1.105	10839	1.085	41015	194644	174022.3	58623
2010	1.161	10827	1.145	43142	182565	156907.8	64020
2011	1.237	10815	1.207	43283	171658	142700.9	70896
2012	1.288	10803	1.240	42536	164883	135813.6	72106
2013	1.268	10791	1.224	43300	153555	128409.4	73982