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MONETARY STABILIZATION POLICY AND THE INVENTORY CYCLE MODEL

WITH AN EMPIRICAL INVESTIGATION OF STYLIZED FACTS FOR GREECE

By

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Abstract

The growth of knowledge about monetary phenomena over the last fifteen years or so has been enormous. The aim of this paper is to investigate stylized facts of inventory investment and output for the Greek economy and to analyse the effectiveness of monetary economic policy in relation to the inventory cycle model of Hillinger. (JEL E32, E5)

1. Introduction

The business cycle has often been declared dead. To cite but one recent example, there was much confidence among economists of the 1920's that a new era of perpetual prosperity had dawned (Haberler 1963). Haberler penned these words in 1962, just at the time when yet another era of supposedly perpetual steady growth was being proclaimed. The specter of economic instability was assumed to have been removed through the art of "fine tuning".

Since the advent of the oil crisis, instability has been the dominant feature of the world economy and the profession is gingerly beginning to remove the taboo on the use of the word cycle.

The aim of this paper is first to investigate stylized facts of inventory investment and output for the Greek economy during the period 1960-1990 and second to analyse the effectiveness of monetary economic policies in relation to

* The author would like to thank Pr, Dr. C. Hillinger for general assistance with the paper.

the inventory cycle model of Hillinger (1987). Hillinger believes that there is such an idea, and that it is in fact the same which explains the simplest periodic movement in phusics - that of the *frictionless pendulum*. The duration of the oscillation of the pendulum is proportional to its inertia. Though the world inertia is not customary in economics, the idea that major macro-economic variables are resistant to changes in their flow rates is commonplace. For this phenomenon there are a host of well-known economic and technological reasons. It is the very function of incentories to smooth output in the face of demand fluctuations. The inertia of output in the theory furnishes the explanation of the inventory cycle.

Similarly, plans for investment in plant and equipment are long-range and not changed significantly in a short time interval. This inertia explains in our view, the equipment cycle.

2. The Real Model

At the heart of the various cycle models is the following simple mechanism: Let (K') be the desired stock of capital (however determined) and (K) the actual stock. We postulate that investment (I) is determined by

$$DI = a\,(K' - K); \qquad a>0 \tag{1}$$

Since DK = I we can write equivalenty

$$DK^2 = a\,(K' - K) \tag{2}$$

The simplicity of this formulation makes it very useful for theoretical analysis. Since DK has the dimension of a reta of shange or velocity, DK^2 is an accelaration and a is of course the coefficient of accelaration. The reciprocal $b= {}^1/_a$ is the coefficent of *inertia.*

The solution is a simple harmonic oscillation with period (p)

$$p = \frac{2\pi}{\sqrt{a}} \tag{3}$$

in K, around an equilibrium path determined by K' (Hillinger 1987). In terms of inertia, *the period is an increasing function of the coefficient of inertia.*

Analyzing the inventory cycle, the business sectors is viewed as an analogous to a single manufacturing firm, in which inventories K_i have the buffer function of smoothing production, Y, relative to final sales Z.

For our formulation of the production decision we use the simple accelarator hypothesis. Firms increase/decrease their production rate if their inventories are low/high with reference to a desired level. Production being the inflow to the stock of inventories, has the dimension of investment or rate of change of stock. The derivative DY has the dimension of a second derivative of the stock. It follows that in making DY dependent on the stock, we have an accelarator formulation.

The model is:

$$DY = a_{YK}(K'_i - K_i)\,; \quad a_{YK} > 0 \tag{4}$$

where: K' is the desired stock

The allocation of Y takes the form

$$DK_i = Y - Z \tag{5}$$

which states that everything which is produced and not sold must be added to inventories.

It remains to specify how total demand is determined. Total demand is determined by an adjustment equation, a_{zy} is the adjustment coefficient, with the assuption that the desired rate of the total demand is equal production Y. It must be remembered that we are dealing with a stationary economy for which in equilibrium the propensity to demand is unity. It thus makes sence to assume $Z' = Y$, where Z' is the desired demand.

$$DZ = a_{ZY}(Y - Z)\,; \qquad a_{ZY} > 0 \tag{6}$$

The models is:

$$\begin{aligned} DY &= a_{YK}(K'_i - K_i) \\ DK_i &= Y - Z \\ DZ &= a_{ZY}(Y - Z) \end{aligned} \tag{7}$$

In order to analyse the dynamics of the system, we use the transformations:

$$\begin{aligned} V &= K'_i - K_i \\ W &= DK_i = Y - Z \end{aligned} \tag{8}$$

The transformed system is

$$DV = -W \tag{9}$$
$$DW = a_{YK}V - a_{ZY}W$$

The corresponding characteristic equation is:

$$x^2 + a_{ZY}x + a_{YK} = 0 \tag{10}$$

which has the roots

$$x_1x^2 = ½ \{ -a_{ZY} \pm (a_{ZY}^2 - 4a_{YK}) \} ½ \tag{11}$$

We see that the system is stabilized by a_{ZY}. The faster the response in demand to a change in income, the more stable the model. In conclusion, the amplitude of the dynamic model is damped, depending on the coefficient a_{ZY}.

3. Stylized Facts of Inventory Investment and Output for Greece

The main purpose of this chapter is to analyze the data to get information about cyclical components.

The model of data analysis (Cl. Hillinger, 1986) can be described in the following way:

(A) Gross Domestic Product (GDP) is decomposed into the two aggregated categoris, i.e. Inventory Investment (II), and the Residual Demand (ED).

$$GDP = II + RD \tag{12}$$

(B) Each of these time series, x(i), i= II, RD, GDP, is decomposed into a trend component and three periodic functions: a long equipment cycle, a cycle of medium duration, and a short inventory cycle.

As first step of data analysis, the secular growth must be removed. This trend component T(i) has the form of a simple polynomial in time.

$$T(i) = \sum_j c_{ij}t^j \tag{13}$$

$$i = 1, \ldots, 3;$$
$$j = 1, \ldots, n;$$
$$t = 1, \ldots, m,$$

where m is the sample size and n the order of trend-polynomials. The last parameter n was determined by the first maximum of adjusted R-squares of all the polynomials from zero to a maximum order. The best-fit-criterion is a partical procedure which gives good results in most cases (J. G. Hayes, 1970).

Besides, it can be shown that the cycles are not very sensitive regarding the polynomial order chosen, as long as it is greater than (or equal to) two. Linear trends should be only used if the secular trend of a time series has exactly this form (K. Hung Chan, J. C. Hayya and J. Keith Ord, 1977; C. R. Nelson and H. Kang, 1981). First the trends were estimated by ordinary least square method (OLSQ). The deviations from trend

$$\hat{x}_i (t) = x_i (t) - \hat{T} (t) \tag{14}$$

are then tested for cyclical components.

The business cycles z_{ij} are proposed to have the form of cosine function

$$z_{ij} (t) = a_{ij} \cos (w_{ij} t + e_{ij}) \tag{15}$$

$$i = 1, \ldots, 3; \quad j = 1, \ldots, n,$$

where the parameters a_{ij} are the amplitudes, w_{ij} the frequewnces, and e_{ij} the phases. The periods of the cycles are determined by $p_{ij} = 2\pi / w_{ij}$. The nonlinear least square estimation of all the parameters requires the minimization of the following function S_i relating the a_{ij}, w_{ij}, and e_{ij}:

$$\min S_i (a_{ij}, w_{ij}, e_{ij}) = \Sigma_t [x_i (t) - \Sigma_j a_{ij} \cos (w_{ij}{}^t + e_{ij})]^2 \tag{16}$$

$$t = 1, \ldots, m; \quad j = 1, \ldots, n; \quad i = 1, \ldots, 3.$$

The data analysis briefly described above was applied to Greek data for the period 1960 to 1990. All series are annual data at 1970 prices.

Before turning to the cyclical analysis, it is instructive to examine how much of the movement in the time series can be attributed to the trend functions.

Looking at Table 1, the high fit of the trends may perhaps be astonishing. But it must be regarded that trends even of a very simple form, like linear trend,

TABLE 1

Orders and R-squares of fitted trend-polynomials

	Order	adj. R-square
Inventory Investment	3	0.589
Residual Demand	3	0.997
Gross Domestic Product	3	0.996

Source: National Statistical Service of Greece. All Series are annual data at 1970 prices.

explain a great part of a time series, if this contains a monotonically increasing component. Besides, the R-square is growing, if you add new observations, and is therefore not a good measure of the economic importance of the growing component.

Table 1, in which all adjusted R-squares are reported, shows that inventory investment was much less explained by the trend component than the order series.

The role of inventories in economic fluctuations was often underestimated, because changes of invetories account for only 1-2 percent of GDP. Blinder (1981) has calculated on the basis of US data, that inventory investment accounts in some historical business cycles for about 70 percent of declines in GNP during recessions and for about 37 percent of all quarterly changes in GNP (M. Abramovitz, 1951). In conclusion, one stylized fact is:

Inventory investment is *the most,* residual demand *the least* volatile component of GDP.

Now, let's look at the cyclical components detected in the deviations from polynomial trend. Table 2 contains all of the estimated parameters and t-statistics. The t-statistics show that the most parameters are significant with SN levels of 90 or more percent, where the frequencies are much more significantly estimated that the other parameters.

The unusual feature that the standard errors of estimated frequency parameters are much smaller that those of the other parameters, can be intui-

TABLE 2
Estimated Parameters of the Periodic Functions and their t-Statistics in Brackets

	1st cycle $i = 1$	2nd cycle $i = 2$	3rd cycle $i = 3$
Inventory Investment	$R^2 = 0.57$		
a_i	4765.4 (4.58)	3206.2 (3.13)	2830.8 (2.70)
w_i	0.6172 (17.9)	1.227 (22.5)	1.611 (32.8)
e_i	-2.849 (7.89)	-1.977 (5.54)	-3.586 (4.53)
p_i	10.18	5.12	3.9
R^2_i	0.27	0.29	0.09
Residual Demand	$R^2 = 0.79$		
a_i	2622.6 (2.80)	3829.3 (4.24)	2175.8 (2.43)
w_i	0.892 (12.0)	1.098 (27.0)	2.066 (22.9)
e_i	-5.511 (1.09)	-2.884 (5.82)	-1.930 (1.98)
p_i	7.04	5.72	3.04
R^2_i	0.34	0.27	0.16
Gross Domestic Product	$R^2 = 0.78$		
a_i	5896.1 (4.63)	3671.5 (2.87)	3074.3 (2.48)
w_i	0.8149 (17.9)	1.83 (15.2)	1.653 (33.9)
e_i	-3.883 (1.28)	-1.896 (2.02)	-3.330 (3.72)
p_i	7.71	5.8	3.8
R^2_i	0.53	0.16	0.12

tevely explained, considering how a simple harmonic function is represented by spectral density function. It is mathematically descripted by Delta function and shown as a very sharp peak, whereas the amplitude parameter has not such great influence. The correct expression of asymptotic covariance matrix for our estimation problem is given by A.M. Walker (1971).

During the period examined, 1960-1990, three cycles have been detected in all time series. The periods of the long, socalled equipment cycles vary between 10.2 and 7.7 years, while the duration of the short inventory cycles lies in the range of 3.1 to 3. years.

The variation in cycle period is not very high, if we bear in mind that the empirical investigation was made on the basis of only 31 annual data. In Table 2, the simple R-squares of each cycle are also collected, in order to be presented as a yardstick of how much of the variance of every time series was explained by one cycle alone. The small difference between the sum of simple R-squares and the multiple R-squares indicates that the correlation of estimated cosine functions was not very high, so that we can have confidence in the empirical results.

It is a little surprising that the long cycle dominates the fluctuations in all data series, while the short one has the relatively smallest explanation power. The medium cycle is important above all in inventory ivestment.

Apart from the good fit on the basis of statistical criteria, a visual inspection of the diagrams shows that the curves fitted to the data depict in general correctly turning points for all economic magnitudes. The wide difference in total amplitude between the cycles before 1974 and those of more recent years seen in Figures 1-3 seems rather puzzling. This possibly indicates an increased instability related to international economic factors and the structure of the Greek economy.

Structure may include concepts like: (a) the open character of the economy, (b) the existence of a significant underground economy, (c) the large percentage of small scale industry and its difficulty to keep up at high technological level.

4. The Role of Money-Stabilization Policy an Overview

Up till now we have dealt with a model in which only real variables appear. We have implicitly assumed either that prices are constant, or that all monetary magnitudes have been deflated by price indexes. The analysis of economic policy itself forces us to pay some attention to nominal magnitudes since economic policy is directly formulated in relation to such variables as nominal government expenditure of the nominal money supply.

The most common simplification made in the context of monetary analysis and on which we also want to make, is that there is only a single financial asset namely money. In reality, however, even after aggregating over very broad categories of assets, it seems that we are still left with three very broad categories of instruments, namely: money, regarded as the non-interest bearing medium of exchanges; bonds, regarded as a negotiable interest bearing financial instrument;

the liabilities of the private sector to the banks. It is not immediately obvious that in evaluating economic policies, it is sufficient to pay attention only to how these policies influence the stock of money, and to leave out of consideration how the magnitudes or other financial instruments are altered. For some purposes it is clearly not possible to ignore the other instruments. In particular, building investment is highly sensitive to interest rate changes, such as those induced by open-market operations.

The focus on money as the only relevant financial instrument appears empirically to produce good results in explaining inflation rates. The question of the extent to which changes in the nominal quantity of money influence real magnitudes has been much and inclusively debated. One reason why we will use the simplification to a single financial instrument is that we do not attempt an empirical test of the model.

Given that money is the only financial instrument to be considered, we must specify how the quantity of money is caused to be changed. As elaborated in any introductory text in economics, we know that changes in the money supply come about in the first instance as a result of changes in high powered money which can serve as a reserve asset of the banking system and subsequently through the expansion of bank loans based on these reserves.

One simplification which we will make in order to avoid dealing with a higher order differential equations, is that we will neglect the lag between a change in reserves and the completion of the responce of the banking system.

Bank reserves are changed as a result of a government deficit. In fact, when there are no chances in borrowed reserves and no open market operations, as we will assume throughout, then the rate of change of reserves is equal to the government deficit. Because of the operation of the deposit multiplier, the total expansion of the money supply will be a multiple of the deficit. Formally we assume that the money supply changes according to the following equation:

$$DM = a_m (G - T) + b_m \qquad a_m > 1 \tag{17}$$

where G is Government expenditure and T Government revenue

The parameter a_m corresponds to the deposit multiplier in convention a analyses of monetary expansion and is applied to the high powered money introduced into the economy by the deficit. The parameter b_m represents changes in the money supply due to open market operations.

If money is the only asset we are considering, then we should focus on the *money stock, not on its current rate of change, as determined by the fiscal* variables, as the basic magnitude influencing behavior. From (17) we see that:

$$M = a_m \int (G - T) + \int b_m \tag{18}$$

which is nothing but the formal statement of the fact that the current money stock is the sum of its past changes. In particular, in taking account of the money stock we are implicitly taking account of the sum of all past government deficits.

In macroeconomic models we do not consider explicitly aggregation over commodities, we produced as though there is a single good Q with price P, and hence with monetary value PQ. We assume that, both for transaction purposes and as a form of holding part of their wealth, individuals desire to hold an amount of cash equal to some fraction of their income.

$$M^* = m\ PY \qquad m>0 \tag{19}$$

Since any nominal quantity of money can become the desired quantity for an appropriate price level, we might conjecture that it really does not matter what the nominal quantity is, that prices will simply adjust themselves to an appropriate level. What is the mechanism which leads prices to change until the actual quantity of money is equal to the desired quantity? It is simply the macroeconomic equivalent of the elementary microeconomic consideration that firms will lower their prices if they wish to increase their sales. This situation will generally obtain when they have excess capacity. Conversely, if demand is greater that what can be produced with full or normal capacity utilization, so that it becomes impossible or very costly to supply, then the incentive for raising prices exists.

Let $x = K^*/ K$ be the rate of capacity utilization; we assume:

$$\frac{DP}{P} = a_p\ (x - 1) \qquad a_p>0 \tag{20}$$

That unemployment will have in a way similar to capacity utilization is plausible. When there is slack demand, all the economic resources will be under-utilized. The simplest relationship between the rate of unemployment u, and x is that they are linearly related. If capacity utilization is abnormally high, we have short-run equilibrium of the unemployment rate greater than the equilibrium (or frictional) unemployment rate. This situation is compatible only with a rising inflation rate. In the short-run a government may be able to achieve a value of $x>1$ by means of an aggresive inflationary policy. But this cannot continue, since in time, the inflation rate would tend to infinity, it would become prohibitively expensive to hold cash, and the monetary system would disintegrate with the economy returning to a primitive varter system.

Even apart from the monetary aspect, it is doubtful for how long a government can by means of fiscal and monetary policy keep $x>1$. The attempt to do so removes the economy from equilibrium and activates the cyclical mechanisms. We are confident that the broad outlines of this analysis are correct, regardless of the validity of the detailed specification of our equations. The present state of the world economy, evidencing both pronounced cyclical fluctuations and high, inflation rates, is a monument to the misguided stabilization policies, which economists successfully sold to policy makers in the course of the last three decades.

What is the task of aggregate economic policy? We believe that it is: (1) to *reduce* cyclical fluctuations to a minimum; (2) to maintain an acceptable inflation rate. This rate can, in our view, be best defined as the zero rate of a constant price level, since we do not believe in *any* permanent association between inflation and employment. Structural unemployment should be clearly recognised as a microeconomic problem and eliminated from consideration in the macroeconomic context.

In the following section we will analyse macroeconomic policies in relation to the first objective. It is clear that in an inflationary environment, a policy optimal with respect to (1) may not be optimal in respect to (2). To find a policy which is optimal relatively to both criteria is a problem in optimal control theory. We wish to avoid these complexities and limit ourselves to a consideration of the effects of some simple monetary policies on cyclical stability.

5. Stabilization Policy and the Inventory Cycle

For our analysis we use the simplest stationary model of the inventory cycle with a constant desired inventory stock (K_i'). Into this model we introduce the actual and the desired quantity of real balances, M and M'. A basic assumption which we are making in order to keep the model linear, is that it is possible to formulate a regulatory policy directly, in relation to M and M'. A simple assumption which can be made regarding M' is that it is proportional to Y.

$$M' = mY \tag{21}$$

but this assumption does not play any direct role in the analysis. All that is required for our purposes is that M', however determined, can be measured by the authority responsible for stabilization policy.

The model for stabilization policy relative to the inventory cycle takes the following form:

$$DY + a_{YK}(K_i' - K_i) + a_{Ym}(M - M')$$

$$DK_i = Y - Z \qquad (22)$$

$$DZ = a_{ZY}(Y - Z) + a_{Zm}(M - M')$$

The speed of adjustment parameters are usually assumed to be all positive. An above equilibrium quantity of real balances makes it easier to finance both production and demand, the magnitude of these effects being given by the coefficients a_{Ym} and a_{Zm}. We see that in our formulation the relevant policy variable is the excess of actual over desired real balances which we denote by:

$$\overline{M} = (M - M') \qquad (23)$$

we will analyse 3 alternative policies:

1. The *accommodative policy* defined by

$$\overline{M} = 0 \qquad (24)$$

This policy corresponds to the real bills doctrine, now mainly of historical interest, according to which the central bank should supply whatever quantity of money is required for the needs of trade.

2. The *flow-disequilibrium policy*

$$\overline{M} = m_Z(Y - Z) \qquad (25)$$

In the context of this policy, excess real balances are set at a level proportional to the short fall of demand relative to its current equilibrium level. In an alternative interpretation, this policy can be considered to counteract the potentially depressive effect of a rise in investories.

3. The *stock equilibrium policy*

$$\overline{M} = m_s(K_i' - K_i) \qquad (26)$$

Since inventories can be presumed to have a depressing effect on the economy, excess real balances are proportional to the excess of inventories over the equilibrium evel. In the following paragraphs we will look at the implications of these policies for the stability of the system.

Under the accomodative policy (11) becomes:

$$DY = a_{YK} (K_i' - K_i)$$
$$DK_i = Y - Z \qquad (27)$$
$$DZ = a_{ZY} (Y - Z)$$

which is the mathematical equivalent of a not monetary model, but with a slightly different set of assumptions than we have encountered thus far.

The model corresponding to the flow disequilibrium policy is

$$DY = a_{YK} (K_i' - K_i) + a_{Ym} m_Z (Y - Z)$$
$$DK_i = Y - Z \qquad (28)$$
$$DZ = a_{ZY} (Y - Z) + a_{Zm} M_Z (Y - Z)$$

The characteristic equations is

$$x^2 - (a_{Ym} m_Z - a_{Zm} m_Z - a_{ZY}) x + a_{YK} = 0 \qquad (29)$$

with roots

$$x_1, x_2 =$$
$$= ½ \{ (a_{Ym} m_Z a_{Zm} m_Z - a_{ZY}) \pm [(a_{Ym} m_Z - a_{Zm} m_z - a_{ZY})^2 - 4a_{YK}]^{½}\}$$

Relative to the accommodative policy, the flow dissequilibrium policy is seen to yield ambiguous results. On the demand side, the policy is additive to the already stabilizing parameter a_{ZY}. The effect on production, contained in the term a_{Ym} m_Z destabilizing. The net effect on stability of this policy depends on the numerical values of the parameters.

The relevant model for the stock disequilibrium policy is

$$DY = a_{YK} (K_i' - K_i) + a_{Ym} m_K (K' - K_i)$$
$$DK_i = Y - Z \qquad (30)$$
$$DZ = a_{ZY} (Y - Z) + a_{Zm} m_K (K_i' - K_i)$$

The associated characteristic equations is

$$x^2 + a_{ZY}x + (a_{YS} + a_{Ym}\, m_K - a_{Zm}\, m_K) = 0 \qquad (31)$$

which has the roots

$$x_1, x_2 =$$
$$= \tfrac{1}{2} \{ - a_{ZY} \pm [a_{ZY}^2 - 4\,(a_{YS} + \alpha_{Ym}\, m_K - a_{Zm}\, m_K)\,]^{1/2} \}$$

We have the surprising result, that regardless of the parameter values associated with this policy, there is no effect on stability at all, only the period is influenced.

. Conclusions

Traditionally, macroeconomics has attempted to explain the potential output and the deviations from it. Growth and business cycle theories contain essential insights for the explanation of these phenomena. As the result of this empirical investigation of Greek data we have found an equipment cycle, a medium cycle and an inventory cycle explain most of the variation around the statistical trend in GDP and its components so that we have some further arguments for the traditional model of several superposing business cycles (J. A. Schumpeter, 1939).

The empirical results are very interesting insofar as the about same frequency parameters could be found by Cl. Hillinger (1986) in ten industrialized OECD countries. The business fluctuations are without doubt an international phenomenon whose occurance in Greek economy is not astonishing, because of the greate dependence on capital and industrial transfer from abroad.

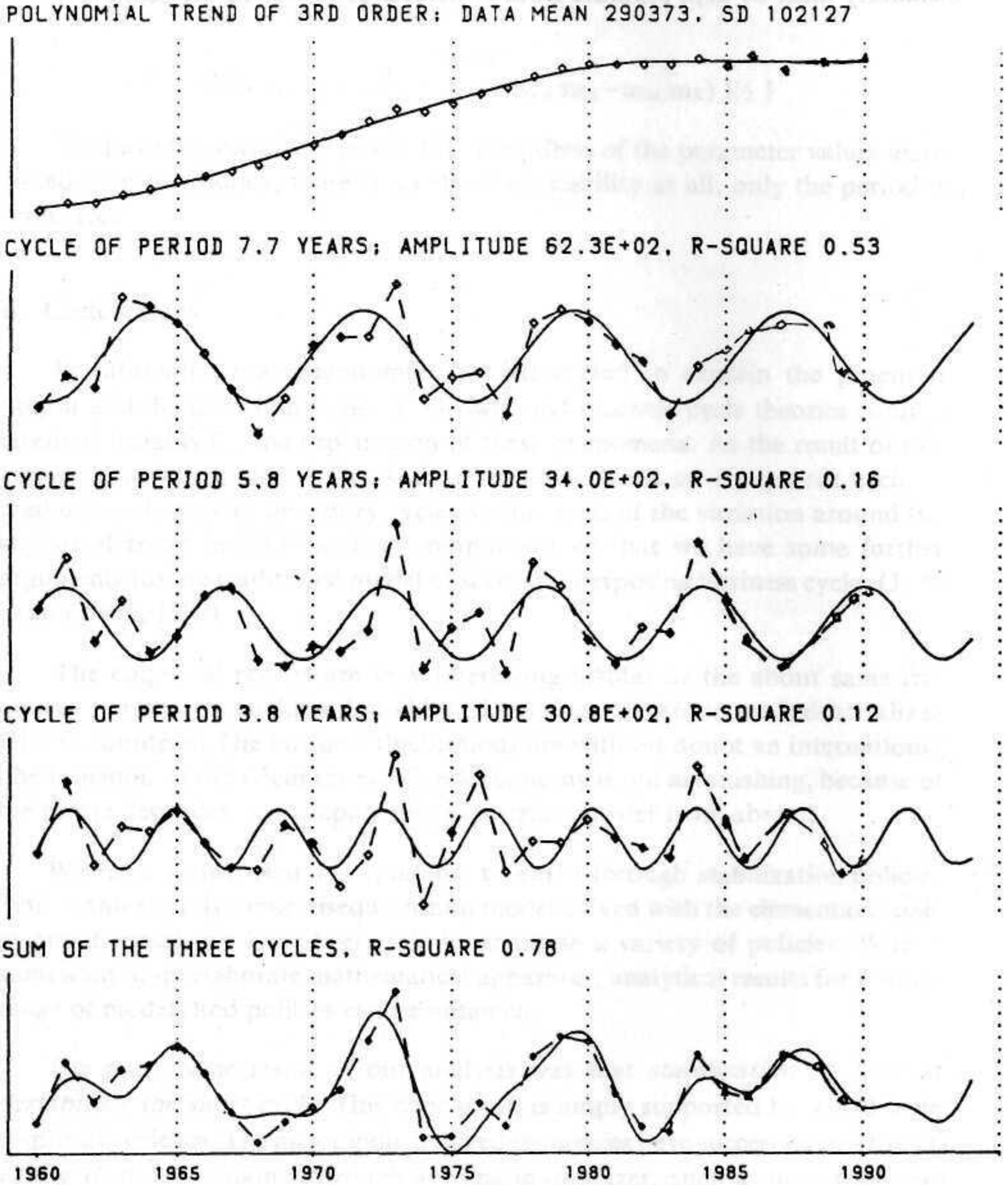
We have shown that it is possible to carry through stabilization policies in the context of dynamic disequilibrium models. Even with the elementary tools at our disposal, we have been able to analyse a variety of policies. With a somewhat more elaborate mathematical apparatus, analytical results for a wider range of models and policies can be obtained.

The most basic result of our analysis was that *stabilization of demand destabilises the short cycle.* This conclusion is amply supported by world wide empirical evidence. The major industrialized economies have succeeded in *stabilizing demand,* mainly through automatic stabilizers such as unemployment insurance and progressive income taxation which stabilize dipisable income. The short cycle, however, - inventory investment - has never been as prominently in evidence world wide as currently.

Finally, it is important at all times to keep in mind that problems of cyclical instability must be kept separate from structural problems of the economy.

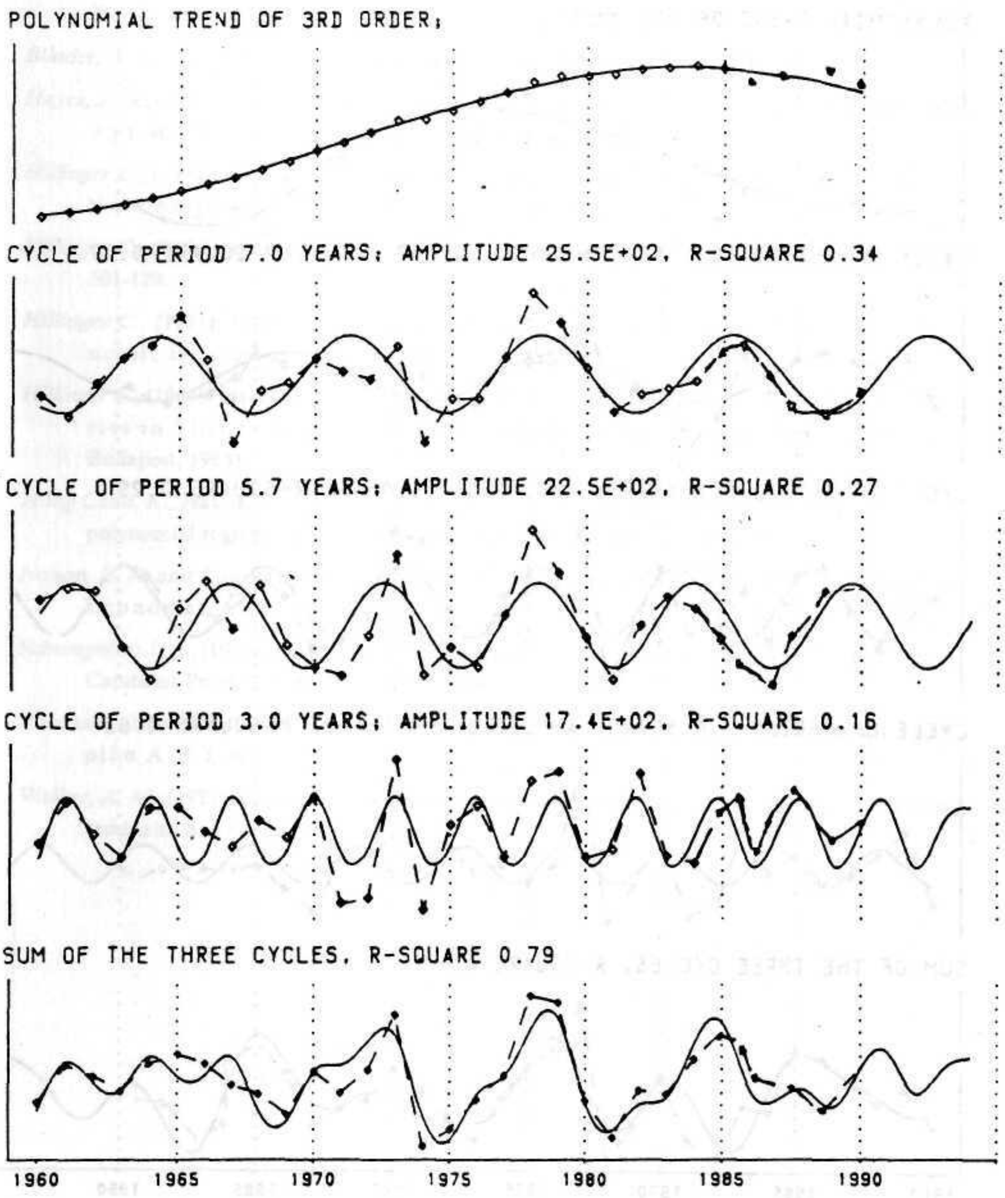
Appendix

Figure 1
Gross Domestic Product



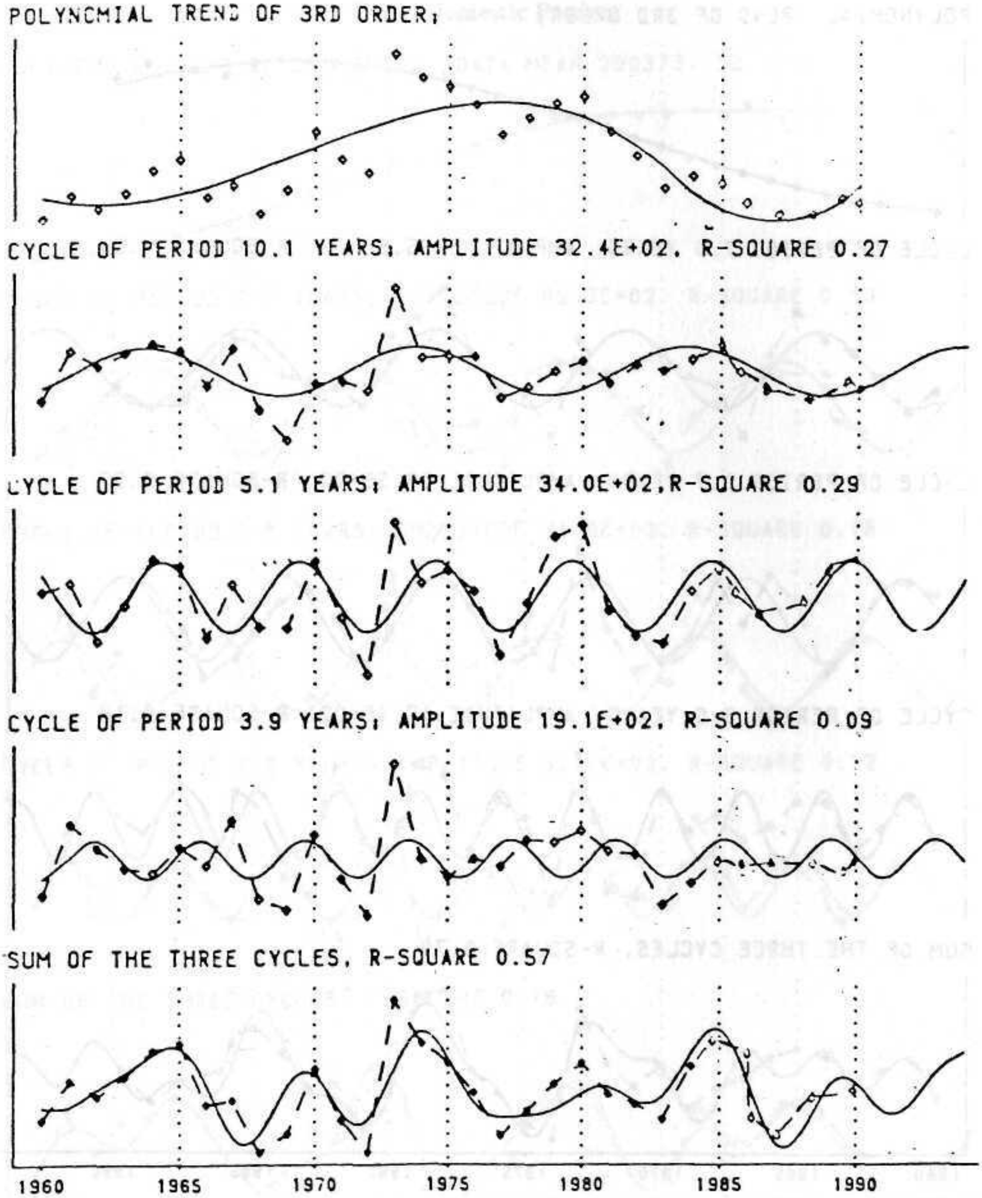
GREECE ANNUAL DATA AT 1970 PRICES

Figure 2
Residual Demand



GREECE ANNUAL DATA AT 1970 PRICES

Figure 3
Inventory Investment



GREECE ANNUAL DATA AT 1970 PRICES

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