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A GRANGER - CAUSALITY ANALYSIS ON THE PUBLIC DEFICIT - MONEY SUPPLY RELATIONSHIP: SOME EVIDENCE FOR GREECE

By

Christos Alexakis , Yannis Panagopoulos** , Aristotelis Spiliotis***

Abstract

An issue which has attracted the attention of many monetarist economists is the relationship between public debt and the money stock. The question addressed in this paper is what theoretical and empirical basis is there for the beliefs that public sector deficits will result in an expansion of money supply. In our analysis we used the Lutkepohl and Reimers version of the Johansen cointegration approach in order to investigate the relationship between public deficit and money supply in the Greek economy. Our results give support to a strong relationship between the public deficit and the broad money supply (M3), suggesting that the Greek financial system was operating with a high degree of monetization for the period under examination **(JEL** Classification: E52, C50).

1. Introduction

The determinants of the public sector deficit are usually perceived as lying largely outside the monetary sphere. However, one issue which has attracted the attention of many monetarist economists is the relationship between public debt and the money stock. It has been argued that a strong increasing effect on the money supply, caused by an increase in the public deficit (debt), is primarily absorbed by an equivalent change in the balance

* University of Athens, Department of Economics, & Ministry of Development.

** Athens Stock Exchange (A.S.E.), Training Center.

***Diethniki Mutual Fund Company, National Bank of Greece.

of payments (deficit) and then by a change in the domestic credit. The question addressed in this paper is what logical and empirical basis is there for the beliefs that public sector deficits will result in an expansion of the money supply?

2. The theoretical framework and previous empirical work

Monetization refers to the process by which an increase in government deficit leads to an increase in the money supply. This occurs when the debt is purchased by the banking system - either by the central bank or the commercial banking system. If government debt is taken into the commercial banks' portfolios then their reserve assets increase, unless this increase is offset by other transactions. This allows the commercial banks to expand their lending activity to the private sector and hence increase the money stock. If the central bank wishes the commercial banks to purchase government bonds and treasury bills then it provides the commercial banks with the necessary cash reserves to do so. Therefore the central bank increases its liabilities and hence the money supply expands (Jackson, 1990).

In the framework where monetary policy decisions are made independently of fiscal decisions, the monetary authorities, through the relevant credit policy decisions, determine the level of government debt purchases by the non-banking private sector, while the fiscal authorities are left to finance the residual. In contrast, if monetary policy is passive, with respect to fiscal policy decision, then the level of government debt purchases are directly linked to the deficit since the full amount of it must be financed by the monetary authorities. An accounting relationship that may reflects the relationship between the money stock and the public debt can be presented as follows:

Change of the money stock = [Public debt-Debt to the non-bank public + Change of the bank lending to the private sector + Balance of payments].

At this point, assuming that interest rates are constant, an increase in public sector borrowing will initially be accompanied by an equivalent increase in the money stock since borrowing from the banking system is the residual source of public sector finance. However, in the long run it is hardly plausible to assume that the public will simply passively accept the bank deposits which are brought into being by the public sector borrowing.

As Savage (1980) noted *"the private sector will wish to maintain a balance between different assets in its portfolios"*.

Sargent and Wallace (1981) demonstrated that a permanently higher government deficit must eventually be accommodated by an increase in the monetary base. According to the above authors, in the long - run, the growth of the money stock is governed by the public sector deficit. In contrast, Middleton, 1981, argued that it would be wrong to assume that because of the identity relationship a given increase in the PSBR (Public Sector Borrowing Requirements) would produce the same amount of increase in the size of the broad money supply, or that there is any close relationship, year by year, between them. This line of argument is based on the fact that different public expenditure and tax measures, which have the same effect on the public debt, could have different effects on real demand and hence on the private sector's savings, investment and money holdings.

It is widely accepted (Johnson, 1972) that a full equilibrium must be characterized by a balanced external account (on the implicit assumption of zero growth), otherwise the resulting financial flows will disturb the equilibrium of the private sector.

Similarly, in the budget constraint literature, it is argued that an equilibrium must be maintained at the balanced government position otherwise the financing of the budget will again disturb the stock equilibrium of the private sector (see Currie, 1976).

Once the government budget constraint is consistent in the context of a open economy under a regime of fixed or managed float exchange rates, there is no reason to assume that the economy will tend to a balanced external account. Mckinnon (1969) argues that, government deficits can be consistent with an equilibrium in the private sector of the economy, if at the same time, a trade balance deficits drains off the supply of new financial assets that is created. Therefore, a government may acquire reserves continuously without disturbing the private sector's equilibrium, provided that it runs a budget surplus/deficit equal to a balance of payments surplus/deficit and provided that overseas governments in aggregate are willing and able to acquiesce by running a corresponding aggregated budget deficit.

Taking into account all the different arguments about the relationship between the money supply and the public deficit we could argue that the strength of the above relationship depends crucially on the specific institutional

framework under consideration and the way in which monetary authorities act in relation to the fiscal authorities, and, in a more general sense, how the monetary authorities react to changes of the public debt.

In this case we are dealing with a highly and strictly regulated monetary system (the Greek monetary system). During the period of the 1970s and early 1980s funds were allocated at administratively set interest rates through a quite complicated reserve/rebate system of bank credit. Also, commercial banks were required to invest a certain fraction of their total deposits in government treasury bills, that fraction being 40 percent as late as 1990. However, between 1980 and 1987, financial liberalization evolved gradually. Deregulation of the Greek monetary system then accelerated, following the 1987 Report of the Committee for the Reform and Modernization of the Greek financial system. In the 1990s most of the credit restrictions have been removed and the above mentioned investment requirement was gradually reduced during 1991-1993, and in May 1993 it was abolished .

It is worth noting that in an investigation of the above consideration by the Treasury and Civil Committee, 1981; a wide range of witnesses, including Friedman, Kaldor, Laidler, and Hahn agreed that there was no clear strong direct link between the PSBR and the monetary growth in the UK (see Cobham, 1991, p. 59-60). This conclusion seems to be supported by the empirical evidence as well (see Kaldor, 1970; 1980; Parkin, 1975; Akhtar and Wilford, 1979; Savage, 1980; Jackson, 1990).

However, the above work has been criticized by Cobham (1980). Cobham, working on quarterly data for the period 1963-1979, show that Savage's findings were highly weakened when the data were seasonally adjusted and deflated. Additionally, even using a rather naive approach to the periodization of UK macroeconomic policy, Cobham found considerable evidence of structural shifts in the relationship between the PSBR and money growth.

The UK discussion of how the public deficit should be inflation-adjusted was initiated by Taylor and Threadgold (1979) further developed by Miller (1982; 1985) and more recently by Begg (1987). The main idea is that the "real" value of the public debt is relevant for private portfolio preferences. Several sophisticated inflation-adjustment processes have been suggested, but it may be worth noting that even this turns out to perform poorly in this type of regressions.

A number of empirical studies have been carried out for the US economy. Niskanen (1978) found that the Federal deficit does not appear to have any significant influence on the money stock. Barro (1977; 1978) like Niskanen could non find a positive significant relationship between public debt and the money supply. However, the above results have been strongly criticized by Hamburger and Zwick (1981) who used a modified definition of the Federal deficit and found that US public sector deficit has a positive significant effect on the money stock. Allen and Smith (1983) using the change in the public sector deficit rather than the current period public deficit and the monetary base instead of the money stock, found a positive and significant impact of the public debt on the growth of the monetary base.

Finally, concerning the Greek experience, in an indirect test Dogas (1992) found that public deficit exerts an influence on inflation. Additionally, Hondroyiannis and Papapetrou (1994), in their empirical investigation, examined the existence of a long - run relationship between budget deficit and inflation and they concluded that there is *"a bi-directional causality between the two variables"*.

3. Econometric methodology and empirical results

In this study we try to test the direction of causality between the public deficit and some different monetary aggregates (e.g. monetary base, narrow money supply and broad money supply), of the Greek monetary system. More specifically, we can include the above hypotheses in the following formulations:

$DEF=f_1$ (Lagged Log MB) or Log $MB=g$, (Lagged DEF) (Al)

$DEF=f_2$ (Lagged Log Ml) or Log $M1=g_2$ (Lagged DEF) (A2)

$DEF=f_3$ (Lagged Log M3) or Log $M3=g_3$ (Lagged DEF) (A3)

where DEF stands for public deficit, Ml stands for narrow money supply, M3 stands for broad money supply and MB stands for monetary base.

In our analysis, the Lutkepohl and Reimers version of the Johansen approach will be implemented in order to exploit the relationship between the public deficit and the money supply in the Greek monetary system. We believe that this econometric technique will give more robust results in our investigation and consequently we will be able to end with some more valid

conclusions. The examined period is 1975(1) to 1994(2), using quarterly data collected from the Monthly Statistical Bulletin, Bank of Greece.

The Lutkepohl and Reimers (1992) methodological approach of causality follows by principles of co-integration in bivariate VAR systems, in a step by step basis. In the first step, we re-parametrize two bivariate vector autoregressive processes of order ρ [VAR(p)] to get the corresponding Johansen's (1988) error-correction (EC) forms. Sims tests for VAR specification were applied next, in order to define the lag length (p) of each of our bivariate error-correction systems. Then, with the help of the Johansen tests, the number of the existing co-integrating vectors (e.g. r=0,1,2) will be defined. Moreover, the number of the existing co-integrating vectors will also transform our initial bivariate error-correction systems accordingly. To these reparametrized and transformed Granger - causality bivariate VAR systems, Wald tests will be implemented in order to define the direction of possible causality .

*The Bivariate **VAR** System*

According to the Lutkepohl and Reimers (1992) theoretical presentation, we assume the existence of the following bivariate vector autoregressive process of order ρ [VAR(p)]:

$$[Z_t] = \sum_{i=1}^{p} [\alpha_{11,i}\ \alpha_{12,i}]\ [Z_{t-i}] + u_t \qquad (1)$$

$$[X_t] \qquad [\alpha_{21,i}\ \alpha_{22,i}]\ (X_{t-i}]$$

where Z_t and X_t, are the two time series variables and $u_t = (u_{1t}, u_{2t})'$ is the bivariate white noise process with zero mean and nonsinglular covariance matrix Σ_u.

Reparametrasing (1), by subtracting $(Z_{t-1}, X_{t-1})'$ from both sides of the system and by rearranging the variables, we can get the Johansen's (1988) error-correction (EC) form of the process:

$$[\Delta Z_t] = \sum_{i=1}^{p-1} \Gamma_i\ [\Delta Z_{t-1}] - \Pi\ [Z_{t-p}] + u_t \qquad (2)$$

$$[\Delta X_t] \qquad [\Delta X_{t-i}] \qquad [X_{t-p}]$$

where

$\Gamma_i = -(I_k - A_1 - A_2 - ...A_i)$, i=1, ..., p-1

and $\Pi = I_k - A_1 - A_2 - ..A_p$

Here $A_i = [a_{11,i}\alpha_{12,i}]$ i=1, ..., p.

$[\alpha_{21,i}\ \alpha_{22,i}]$

The rank of the matrix Π, say r, will transform process (2) accordingly. More analytically, as Lutkepohl and Reimers (1992) say, *"for r — 1 the two variables Z_t, X_t are co-integrated in the sense of Engle and Granger (1987). If r = 0 then Π = 0 and the system is stationary in first differences. At the other extreme end, if r = 2, Π is non singular and the system is stationary in levels (without taking differences)".*

The two likelihood ratio tests (the Trace and Maximal Eigenvalue tests), from the Johansen's (1988) methodology, can be implemented next for defining the co-integrated rank of the matrix Π of process (2) and therefore the nature of our causality tests.

Our first empirical step is the specification of the lag length of our three alternative bivariate VAR systems (the LQMB, DEF bivariate VAR system as well as the LQM1, DEF and the LQM3, DEF bivariate VAR systems).

The Lag Length Selection for the Bivariate VAR Systems

The lag length selection criterion which was chosen to be applied to the three different bivariate VAR systems is Sims (1980) likelihood ratio test. This criterion is also suggested by Hall. The general idea of this process is *"to test one VAR system against a more general VAR. This is to say we may test whether a fourth order VAR is in fact a valid restriction on a fifth order VAR, and so on". (Hall 1991).*

Table 1 gives the results of Sims (1980) likelihood ratio test implementation to our three alternative bivariate VAR systems.

TABLE 1

Sims tests of the order of the VAR specification[6] 1975Q1 - 1994Q2

General VAR vs	Restricted VAR	Likelihood Ratio	Selected VAR*
DEF & LQMB variables			
VAR(2)	VAR(1)	4,05	VAR(1)
VAR(3)	VAR(2)	24,87	
VAR(4)	VAR(3)	11,58	
VAR(5)	VAR(4)	32,46	
VAR(6)	VAR(5)	8,19	VAR(5)
VAR(7)	VAR(6)	8,72	
DEF & LQM3 variables			
VAR(2)	VAR(1)	7,64	VAR(1)
VAR(3)	VAR(2)	11,67	
VAR(4)	VAR(3)	11,61	
VAR(5)	VAR(4)	30,53	
VAR(6)	VAR(5)	7,66	VAR(5)
VAR(7)	VAR(6)	5,37	
DEF & LQM1 variables			
VAR(2)	VAR(1)	9,55	VAR(1)
VAR(3)	VAR(2)	29,47	
VAR(4)	VAR(3)	16,08	
VAR(5)	VAR(4)	24,56	
VAR(6)	VAR(5)	7,68	VAR(5)
VAR(7)	VAR(6)	8,77	

Note: The critical values for the tests are: $X^2(4)=9,5$ for 5% and = 11,1 for 2,5%.
* Between VAR(5) AND VAR(1) we select the VAR(5) specification following model selection criteria like the Akaike criterion.

According to the results of Table 1, the VAR(5) case is chosen as the appropriate lag length for our three vibariate relations . More analytically, in all the examined cases the likelihood ratio test (L.R.) qualifies VAR(1) & VAR(5) bivariate systems. Then, with the help of *Akaike* criterion, the VAR(5) option is chosen as the selected VAR case in all our systems. The next step will be to proceed to the application of the Johansen (1988) tests (the Trace and Maximal Eigenvalue tests), for defining the co-integrated rank, r, of the matrix Π of process (2).

The Johansen Results

The likelihood ratio test statistic, the trace test, for the hypothesis that there are at most r co-integrating vectors is:

$$-2\ 1n\ Q\ =\ -T\ \sum_{i=r+1}^{N} 1n\,(1-\hat{\lambda}_i)$$

where $\hat{\lambda}_i$ correspond to the N-r smallest Eigenvalues.

As an alternative to the above test, Johansen also considers another LR statistic for testing that there are r versus r+1 co-integrating vectors, the maximal Eigenvalue test. This LR test is:

$$-2\ 1n\ (Q:\ r/r+1)\ =\ -T\ (1-\hat{\lambda}_{r+1})$$

For both the trace and maximal Eigenvalue tests, critical values have been tabulated by Osterwald-Lunum (1990).

In Table 2, we report the likelihood ratio (Johansen) results concerning the LQMB & DEF, the LQM1 & DEF and the LQM3 & DEF variables.

TABLE 2

The Johansen Results[7] (for VAR's lag length, k=5) 1975Q1 - 1994Q2

Hypothesis H_0	**H_1**	**Eigenvalues**	**Likelihood Ratio**	**5% Critical Value**
DEF & LQMB variables				
The Trace Tests				
r=0	r ≥ 1	0.07	8,42	17,95
r ≤ 1	r=2	0.033	2,54	8,17
The Maximal Eigenvalue Tests				
r=0	r=1	0.07	5,87	14,90
r ≤ 1	r=2	0.033	2,54	8,17
DEF & LQM1 variables				
The Trace Tests				
r=0	r ≥ 1	0.09	7,57	17,95
r ≤ 1	r=2	0.001	0.11	8,17
The Maximal Eigenvalue Tests				
r=0	r=1	0.09	7.45	14,90
r 1	r=2	0.001	0.11	8,17
DEF & LQM3 variables				
The Trace Tests				
r=0	r ≥ 1	0.19	19.61	17,95
r ≤ 1	r=2	0.062	4.56	8,17
The Maximal Eigenvalue Tests				
r=0	r=1	0.19	15,05	14.90
r ≤ 1	r=2	0.062	4.56	8,17

The first two bivariate cases produced the same results concerning the co-integration rank of matrix Π, say r. More specifically, no co-integrating vector was traced (e.g. r=0). This implies that there is no long - run relationship between public deficit (DEF) and narrow money supply (QM1) as well as between public deficit and monetary base (QMB). For these two cases the existence of a short-run relationship remains to be exploited, later on. On the contrary, for the third case (LQM3 & DEF variables), one co-integrating vector was traced (e.g. r=1). This implies a long-run relationship between public deficit and broad money supply. This result is a first step for the clarification of the causality between public deficit (DEF) and broad supply (QM3) at the examined time period. In other words, up to this stage we do not whether changes in public deficit produce corresponding changes in broad money supply or the other way round. This question will be resolved with the help of the error-correction two stage Granger-Engle methodological approach (E.C.—tests).

Our next step will be to trace for the existence of any **short - run relationship** [effects] between the first two bivariate systems (LQMB & DEF and LQM1 & DEF) as well as the direction of the long-run causality and the short-run effects in the third one (LQM3 & DEF). Wald tests will be implemented for the determination of the short - run causalities between all sets of variables (DEF & LQMB, DEF & LQM1 and DEF & LQM3 accordingly).

The Wald - Test for Granger - Causality

As we have already mentioned, the number of the existing co-integrating vectors (e.g. r=0, 1, 2), will accordingly transform the nature of our Granger - causality bivariate error-correction systems. Wald tests will then be applied (in order to define the direction of causality in the three sets of variables).

According to Toda and Phillips (1991, Collorary 1.1. and Theorem 2) the Wald Likelihood ratio test (λ») has an asymptotic X^2 (p) distribution[3], if the co-integration rank of matrix Π is equal to one or two (e.g. **r=l** or 2). Furthermore, as Lutkepohl and Reimers (1992) say, *"if r=0, the VAR coefficients may be estimated in first differences and the resulting Wald statistic for testing Granger - causality has an asymptotic X^2 (p-1) distribution"*.

As we also analysed in advance, when r=0 (as in our first two systems) the Granger - causality bivariate systems will have no error-correction terms (as Π=0) even though there are formulated at the first difference. The

results of Table 3 are the products of the Wald test implementation on our first two VARs, under the restriction of no co-integrating vector, r=0.

TABLE 3

Wald - tests for Granger - Causality° (only for short-run causality)
1975Q1-1994Q2

Hypothesis H_0	Co-integration rank (r=0)
DEF does not cause LQMB	5,28
LQMB does not cause DEF	1,95
Note: The critical values for the tests are: $X^2(4)$= 11,14 for 2,5% and 9,49 for 5% when **r=0**	
DEF does not cause LQM1	13,34
LQM1 does not cause DEF	1,76
Note: The critical values for the tests are: $X^2(4)$=11,14 for 2,5% and = 9,49 for 5% when **r=0**	

From the results of Table 3 two inferences are emerging: Firstly, there is no short-run relationship between public deficit (DEF) and monetary base (QMB) and secondly, changes on public deficit "preceded of corresponding changes on narrow money supply and not the opposite.

Regarding the third VAR (DEF & LQM3), Table 4 presents the results of the Granger-Engle two stage approach (in other words, the two error correction tests) under the restriction of one co-integrating vector, r=1. in other words, we are searching which of the two variables precedes the other, in the long-run.

A feedback result between budget deficit and broad money supply is produced regarding to their long-run relationship. This result is inferred because in both E.C. tests the error correction term (R_1) turned out to be statistically significant.

Finally, the results on the short-run causality among these two variables are presented at Table 5 (with the implementation of the Wald test).

TABLE 4

The error correction tests 1975Q1 - 1994Q2

Depended variable	ΔDEF	ΔLQM3
C	178.5	-0.01
	(1.60)	(0.95)
R(-1)	-0.99	-1.11
	(-2.13)	(-3.62)
ΔDEF(-1)	-0.72	9.28E-6
	(-1.61)	(0.71)
ΔDEF(-2)	-0.47	3.30E-6
	(-0.72)	(0.15)
ΔDEF(-3)	-0.46	-1.34E-6
	(-0.68)	(-0.05)
ΔDEF(-4)	-0.008	2.50E-6
	(-0.01)	(0.99)
ΔDEF(-5)	0.52	4.41E-6
	(1.17)	(2.14)
ΔLQM3(-1)	86.19	1.20
	(0.07)	(4.35)
ΔLQM3(-2)	-1383.7	0.19
	(1.17)	(1.32)
ΔLQM3(-3)	-200.0	-0.42
	(0.14)	(-2.39)
ΔLQM3(-4)	1548.5	-0.18
	(1.23)	(-1.48)
ΔLQM3(-5)	214.4	0.23
	(0.15)	(1.69)
D2	-261.9	0.003
	(-1.89)	(0.35)
D3	-194.4	0.03
	(-1.85)	(4.13)
D4	-371.2	-0.003
	(-3.57)	(-0.41)
R2	0.87	0.53
DW	1,89	2.04

TABLE 5

Wald - tests for Granger - Causality (only for short-run causality) 1975Q1 - 1994Q2

Hypothesis H_0	Co-integration rank (r=1)
DEF does not cause LQM3	13,35
LQM3 does not cause DEF	2,46
Note: The critical values for the tests are: $X^2(5)$= 12,83 for 2,5% and = 11,1 for 5% when **r=1**	

From the results of Table 5 it is obvious that in the short-run changes on public deficit (DEF) produced corresponding changes on broad money supply (QM3) and not the opposite.

4. Concluding comments

Our empirical findings suggest that there is a strong relationship between the public deficit and the broad money supply (M3). The results of the Johansen and the error correction tests support the idea that a strong feedback relationship exists between the public deficit and the money supply in the long run. Additionally, checking for any short run dynamics, Granger causality revealed to run from the public deficit to the broad money supply (M3) which implies that changes in the public borrowing requirements were matched by changes in the money supply.

The above outcome reflects the fact that for the most of the period under investigation the Greek commercial banking system was highly and strictly regulated. In addition, despite the deregulation process which took place at the late 80's and 90's commercial banks continue to show strong preference investing in government bonds and treasury bills, enjoying highly profitable interest rates spreads (the difference between cost reserves rates and public debt interest rates) at zero risk.

Moreover, the fact that the M3 monetary variable was proved to be the crucial one and in a close feedback relationship with public deficit, exactly reveals its role as the vehicle of the monetization process. For accurately, commercial banks "absorbed" increases of public deficit allowing them to increase their reserves assets. Therefore their lending activities were expanded to the private sector increasing, as a result, the money stock. This increase is expected to be better "caught" through the broad money supply - M3 variable - instead of the narrow one - Ml variable. This happens because the first one is a better representative of the private sector's money holdings, especially for this part of money stock which is directly related to the credit money.

Finally, the overall results quite clearly support the view that the Greek financial system was operating with a high degree of monetization at least for the period under examination.

Notes

1. For an extensive analysis of the Greek institutional framework see Spiliotis 1992, Ch II.

2. See Ericsson and Sharma (1996), Alogoskoufis (1995) and Soumelis (1995) for recent overviews.

3. It is important to underline that we are only consider VAR processes as a good approximation of the unknown process. In other words, if the true process has a VARMA presentation then the whole analysis is under question.

4. The selection of a VAR(5) model is also preferable, as an autoregressive presentation, because it helps us to avoid problems of testing the null vector unit root hypothesis.

5. P is the number of restrictions which are tested when a Wald test is applied. It is also the lag length of the corresponding bivariate VAR system [e.g. VAR(p)].

6. This test is: (T-C) (LOG/Σ_r/-log/Σ_u/) where Σ_r and Σ_u are the restricted and the unrestricted covariance matrices and T is the number of observations. This is asymptotically distributed as a x with degrees of freedom equal to the number of restrictions. C is a correction to improve small sample properties: Sims (1980, p. 17). The win-RATS 32 (1995) econometric package was used for producing the above results.

7. The Johansen results were calculated with the help of MFIT 3.0(1993) econometric package.

8. The Wald-tests for Granger-causality were calculated with the help of Eviews-version 2.0 (1995) econometric package.

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