Macroeconomic Uncertainty and Sectoral Output Performance: Empirical Evidence from Greece

Constantinos P. Katrakilidis and Nikolaos Tabakis*

Abstract

This paper provides an empirical investigation of the links between macroeconomic uncertainty and sectoral output using Greek data. Uncertainty is considered in three distinct components, namely the inflation uncertainty, the exchange rate uncertainty and the output uncertainty. The results highlight the differences in sectoral responsiveness and the importance of a stable macroeconomic environment.

Key Words: *sectoral growth, macroeconomic uncertainty, VAR, Granger-causality, variance decompositions*

JEL classification: C32, C53, O52, E32

Introduction

Recent economic literature dealing with the determinants of growth, introduces a new element which may affect significantly growth, namely macroeconomic uncertainty. It is generally accepted that in an environment characterised by macroeconomic uncertainty economic agents become more likely to make mistakes or to incur large transaction costs. Furthermore, it would seem intuitive that uncertainty would depress capital formation and, in turn the rate of economic growth. The direct or indirect impacts of uncertainty on growth is a topic of obvious concern for policy makers and has attracted considerable interest in both theoretical and empirical literature (Lucas and Prescott, 1971; Bernanke, 1983; Kormendi and Meguire, 1985; Pindyck, 1991; Ramey and Ramey, 1991 and 1995; Aizenman and Marion, 1993; Ferderer, 1993; Pindyck and Solimano, 1993; Leahy and Whited, 1996; Brunetti and Weder, 1998).

The objective of this paper is not to investigate the causes of structural change, such as technical progress, changes in relative prices, factor accumulation, etc. Instead, the paper takes account of the dynamic interactions between the two traditional sectors of the economy (i.e. agriculture and industry) and attempts to identify the sectoral patterns of behaviour over time. Within this context, we provide a thorough empirical investigation of the links between macroeconomic uncertainty and growth using Greek data series. Besides, the paper attempts a step further by considering macroeconomic uncertainty in three distinct components, namely the inflation uncertainty, the exchange rate uncertainty and the output uncertainty.

---

* **Correspondence address:** Constantinos P. Katrakilidis, Department of Economics, Aristotle University of Thessaloniki, P.O. Box 213, 54006 Thessaloniki, Greece, Tel.: 003-0310-996-467, Fax: 003-0310-996-426, e-mail: katrak@econ.auth.gr
Nikolaos M. Tabakis: Technological Educational Institute of Thessaloniki, Department of Farm Management

The results indicate that the two traditional sectors respond differently to macroeconomic uncertainty, a fact which has to be seriously considered by the policy makers in order to achieve balanced rates of sectoral growths.

The rest of the paper is organised as follows: Section 2 discusses the methodological and technical issues. Section 3 reports the empirical findings and finally, section 4 provides some concluding remarks.

Methodological Issues

The Uncertainty Variables

As set out previously, the aim of this paper is to examine whether possible sources of uncertainty causes impacts on growth. In this direction, we concentrate on three types of uncertainty, which are all meant to measure the uncertainty regarding government policy.

a) The inflation uncertainty

High inflation has been found to be associated with increased uncertainty regarding future inflation (Heitger, 1985; Ball, 1992; Golob, 1994). In fact, decisions regarding consumption and investment are affected given that they are dependent on the formation of expectations regarding prices. Economic agents, in order to avoid the risks arising from inflation uncertainty may put off or postpone their decisions regarding capital formation thus causing negative effects on real output growth.

b) The exchange rate uncertainty

Endogenous growth theory associates positively the development of international trade with economic growth through the expansion of the effective size of markets, the international knowledge spillovers, the elimination of redundancy in the research sector, the international competition, etc. (Tharakan, 1999). However, in an open economy the development of international trade presupposes large investments in export capacity. When economic agents cannot predict accurately the exchange rate in the future, they may alter or put off their investment decisions and turn to less risky domestic activities. Thus, exchange rate uncertainty causes negative impacts on international trade which in turn leads to the deterioration of economic growth.

c) The output uncertainty

Output uncertainty influences negatively investment decisions and consequently economic growth (Ramey and Ramey, 1995; Guiso and Parigi, 1998). The volatility of output growth is taken here to represent output uncertainty. Increased output uncertainty, makes price signals less informative about the relative profitability of investment across sectors, likely hampering investment decisions, thus affecting growth adversely.

d) Political instability

We do not include in the empirical analysis political instability since we intent to investigate exclusively the economic sources of macroeconomic uncertainty.

Modelling Uncertainty - The GARCH methodology

The empirical analysis employs the GARCH technique to model the uncertainty variables. Chou (1988) argues in favour of GARCH models on the grounds that they are capable of capturing various dynamic structures of conditional variance, of incorporating heteroscedasticity into the estimation procedure, and of allowing simultaneous estimation of several parameters under examination.

If ε denotes the innovations in the mean for a specific stochastic process, y(t), and h a time-varying, positive, and measurable function of the time t-1 information set, then the GARCH(p,q) model proposed by Bollerslev (1986) suggest that:

$$h^2(t) = \omega + \sum_{i=1}^{q} \alpha(i)\varepsilon^2(t-i) + \sum_{i=1}^{p} \beta(i)h^2(t-i) = \omega + \alpha(L)\varepsilon^2(t) + \beta(L)h^2(t) \tag{1}$$

with

$$0 < \alpha(L) + \beta(L) < 1. \tag{2}$$

Condition (2) ensures stationarity of the conditional volatility. Iterative maximum likelihood techniques are used to estimate the parameters of the GARCH model.

Generalized Forecast Error Variance Decomposition

The forecast error variance decomposition provides a decomposition of the variance of the forecast errors of the variables in a VAR model at different time horizons. In this research paper, we use the generalized forecast error variance decomposition which for the i-th variable in the VAR is given by (Pesaran and Pesaran, 1997)

$$\psi_{ij,N} = \frac{\sigma_{ii}^{-1} \sum_{k=0}^{N} (\mathbf{e}_j' \mathbf{A}_k \mathbf{\Sigma} \mathbf{e}_i)^2}{\sum_{k=0}^{N} \mathbf{e}_i' \mathbf{A}_k \mathbf{\Sigma} \mathbf{A}_k' \mathbf{e}_i}, \tag{3}$$

where $\mathbf{\Sigma}$ is the covariance matrix of the shocks $\mathbf{u}_t$ in the considered VAR; $\mathbf{e}_i$ is the selection vector defined by $\mathbf{e}_i=(0,0,\ldots 0,1,0,\ldots 0)'$ (1 is the i-th element); and $\mathbf{A}_k$, k=0,1,2,… are the coefficient matrices in the moving-average representation of the VAR model.

$\psi_{ij,N}$ measures the proportion of the variance of the N-step forecast errors which is explained by conditioning on the non-orthogonalized shocks, u_{it}, $u_{i,t+1}$, …, $u_{i,t+N}$, but explicitly to allow for the contemporaneous correlations between these shocks and the shocks to the other equations in the system.

Empirical analysis

The Model and data

The relationship between sectoral growth and the considered sources of macroeconomic uncertainty is explored within a vector autoregressive (VAR) framework. Our sectoral growth VAR model includes the agricultural and industrial output, both in logarithms and denoted by LY and LI respectively, the inflation uncertainty (UP), the exchange rate uncertainty (UE), the agricultural output uncertainty (UY) and the industrial output uncertainty (UI).

In such a case, the vector of the variables involved in the VAR system is

$$\mathbf{x}_t' = \left[\Delta LY_t \quad \Delta LI_t \quad UP_t \quad UE_t \quad UY_t \quad UI_t; \text{ deterministic variables } \right].$$

The empirical analysis covers the period 1974-2000 and econometric estimates have been obtained based on monthly data transformed in logarithmic form. Thus, i) for the case of the inflation uncertainty we employed monthly data on the consumer price index (LP) (1990=100), ii) for the exchange rate uncertainty we used monthly data on the real effective exchange rate (LE) (1990=100), while iii) for the industrial output uncertainty the monthly index of manufacturing production (LI) (1990=100) was considered. Last, for the construction of the agricultural output uncertainty, due to the unavailability of monthly data, the annual index of agricultural production (LY) (1990=100) was employed, which was next interpolated to monthly frequency with the respective method provided by the RATS econometric package. As sources for our data we employed IFS and FAO statistical databases.

Integration Analysis

Unit root nonstationarity of the involved variables is tested by using the methodology proposed by Dickey-Fuller (1981). Table 1 reports the unit root test results. The hypothesis of a unit root is rejected for all the series in first differences at the 5% significance level. Therefore, the above variables should be used in first difference form. Further, the importance of the unit root properties of a series has to do with policy implications as well. If a series is stationary (or I(0); integrated of order zero), then a shock to the series only has a transitory effect, and the series returns to path it would have taken if the shock had not occurred. If a series is non-stationary (or I(1); integrated of order one), then the effect of a shock is permanent. Hence, and according to the results in Table 1, shocks to sectoral output levels would have permanent effects (they are both I(1)), while shocks to sectoral output growth rates would have transitory effects (they are found I(0)).

Table 1. Augmented Dickey-Fuller (ADF) Unit Root Tests

Variables	Levels	
	Without Trend	With Trend
LP (8)	-1.363	0.559
LE (4)	-2.725	-2.363
LI (8)	-1.197	-1.460
LY (6)	-2.282	-1.585
	FirstDifferences	
	Without Trend	With Trend
ΔLP (7)	-5.759	-5.960
ΔLE (3)	-12.448	-12.525
ΔLI (7)	-7.618	-7.591
ΔLY (5)	-5.874	-6.177

1) The number of lags (indicating in the parentheses in the first column), used for the calculation of the ADF statistics, is based on the Schwarz Bayesian Criterion (SBC) provided by Microfit.
2) The critical values from Fuller (1976), for the respective degrees of freedom and the 5% level of significance, are -2.87 and -3.42 for the non-trended and trended case, respectively.

Generating the Uncertainty Variables

Having established the stationarity properties of the examined variables, we proceed with generating the uncertainty variables through ARIMA modelling. More specifically, for the inflation rate, the exchange rate, the industrial output and the agricultural output we constructed the respective ARIMA structures
inflation rate: ΔLP (2, 1, 0)
exchange rate growth: ΔLE (1, 1, 0)
industrial output growth: ΔLI (1, 1, 0)
agricultural output growth: ΔLY (2, 1, 0).

Next, the distributional properties of the residuals obtained from the ARIMA models were investigated. The measurement of the kurtosis statistic tests the acceptance or the rejection of a normal distribution characterising the behaviour of certain economic variables. Under the null hypothesis, an economic variable is normally distributed. As shown in Table 2, the kurtosis statistics for the distribution of the residuals from the corresponding ARIMA models, indicate the rejection of the normality hypothesis in all cases.

Table 2. Distributional Properties of the Residuals from the ARIMA Models

Variables	Kurtosis	ARCH test		
		Lag length (q)	Test statistic *LM=TR²*	p-value
$\hat{u}_{\Delta LP}$	4.069	4	9.669	0.046
$\hat{u}_{\Delta LE}$	10.844	1	4.656	0.031
$\hat{u}_{\Delta LI}$	4.045	4	14.813	0.005
$\hat{u}_{\Delta LY}$	6.685	4	18.490	0.001

The general form of the tested model is

$$\hat{u}_t^2 = a_0 + a_1\hat{u}_{t-1}^2 + a_2\hat{u}_{t-2}^2 + \ldots + a_q\hat{u}_{t-q}^2 + v_t.$$

With a sample of T residuals, under the null hypothesis of no ARCH errors, the test statistic TR^2 converges to a X_q^2 distribution (Enders, 1995).

Having detected absence of normality in the distribution of the residuals, we proceed with testing for the presence of possible ARCH effects. The results, also reported in Table 2, confirm the presence of ARCH effects for ΔLP, ΔLE, ΔLI and ΔLY, and thus, the analysis proceeded with the estimation of the conditional variances of the series, properly specified to proxy the respective uncertainty variables, by means of the GARCH technique.

A GARCH(0, 1), a GARCH(1, 1), a GARCH(1, 1) and a GARCH(1, 1) model were obtained, via the Box-Jenkins identification approach, to account for inflation uncertainty, the exchange rate uncertainty, the industrial output uncertainty and the agricultural output uncertainty respectively. The estimations of the GARCH models are reported in Table 3. The estimated coefficients in all equations obey the stationarity rule, i.e., their sum is less than unity.

Table 3. GARCH Models

Variable	Order (p, q)	$h_t^2 = \alpha_0 + \sum_{i=1}^{q}\alpha_i u_{t-i}^2 + \sum_{j=1}^{p}\beta_j h_{t-j}^2$
UP	(0, 1)	$h_t^2 = \underset{(0.00000575)}{0.0000567} + \underset{(0.07799)}{0.20988}\,u_{t-1}^2$
UE	(1, 1)	$h_t^2 = \underset{(0.00000649)}{0.0000366} + \underset{(0.12434)}{0.26640}\,u_{t-1}^2 + \underset{(0.08589)}{0.69273}\,h_{t-1}^2$
UI	(1, 1)	$h_t^2 = \underset{(0.0000719)}{0.0001609} + \underset{(0.13561)}{0.27531}\,u_{t-1}^2 + \underset{(0.20460)}{0.46665}\,h_{t-1}^2$
UY	(1, 1)	$h_t^2 = \underset{(0.0000945)}{0.0003836} + \underset{(0.24234)}{0.56514}\,u_{t-1}^2 + \underset{(0.08380)}{0.20813}\,h_{t-1}^2$

The numbers in parentheses indicate the asymptotic standard errors

The VAR Models

Having estimated the uncertainty variables, we next estimated the growth functions following VAR specifications to avoid possible simultaneity problems. In particular, we proceed the econometric analysis performing a VAR system which involves the series ΔLY_t, ΔLI_t, UP_t, UE_t, UY_t, UI_t. We do not proceed with cointegration analysis since the set of endogenous variables consists of series with different order of integration, i.e. the output series are I(1) while the uncertainty series are all by definition I(0). The selection of the lag-length for the estimated VAR was based on Sims (1980) Likelihood Ratio (LR) methodology. More particularly, LR tests suggested 3 lags. For the shake of saving space, only relevant results with respect to the output equations are reported in Table 4. In particular, we perform the results of Granger-causality tests applied on each group of lagged explanatory variables as well as the sum of the respective coefficients to confirm the theoretical consistency of the signs.

More specifically, Table 4 presents the test results from the two estimated output equations. With respect to the agricultural output, the inflation uncertainty and the output uncertainty variables are found to cause strong impacts on the sectoral growth, while exchange rate uncertainty and industrial output uncertainty are statistical insignificant. Next, in the case of the industrial output, the results, reported in the lower part of Table 4, reveal that inflation uncertainty and agricultural output uncertainty affect the behaviour of the sectoral output, while exchange rate uncertainty and industrial output uncertainty exhibit weaker causal effects (at the 10% level of significance). The coefficients in both equations are theoretically consistent.

Variance Decompositions Analysis

The variance decompositions of the output growth variable is reported in Tables 5 and 6. More specifically, each table reports the percentage of the variance of the k-month ahead forecast error of the variables that is attributable to each of the shocks for k=12, 36 and 60. We consider a 12-months ahead time horizon as short-run, a 36-months ahead time horizon as medium-run and a 60-months ahead horizon as long-run.

In the case of agriculture, we observe that only inflation uncertainty and agricultural output uncertainty efficiently explain the sectoral growth variance in all time horizons. In particular, inflation uncertainty explains a 28.1% in the short-run, a 31.7% in the medium-run and a 31.3% in the long-run. The respective percentages for the agricultural

Table 4. VAR Analysis

Dependent variable ΔLY				
Regressors	Sum of coefficients	Granger causality tests: Hypotheses tested	LR-statistic	p-values
ΔLY(t-i)	0.212			
ΔLI(t-i)	1.659			
UP(t-i)	-15.602	Lagged UP do not Granger-cause ΔLY	17.018	0.000
UY(t-i)	-2.864	Lagged UY do not Granger-cause ΔLY	15.316	0.000
UE(t-i)	-5.267	Lagged UE do not Granger-cause ΔLY	6.562	0.104
UI(t-i)	4.632	Lagged UI do not Granger-cause ΔLY	2.748	0.201
R^2=0.845				
Diagnostic tests (LM version)				
LM=1.736(0.189), RESET=0.390(0.532), NO=2.394(0.302), HE=0.190(0.663)				
Dependent variable ΔLI				
Regressors	Sum of coefficients	Granger causality tests: Hypotheses tested	LR-statistic	p-values
ΔLY(t-i)	0.183			
ΔLI(t-i)	-0.268			
UP(t-i)	-14.022	Lagged UP do not Granger-cause ΔLI	13.368	0.001
UY(t-i)	-0.861	Lagged UY do not Granger-cause ΔLI	18.473	0.000
UE(t-i)	-1.320	Lagged UE do not Granger-cause ΔLI	5.426	0.064
UI(t-i)	-2.270	Lagged UI do not Granger-cause ΔLI	3.165	0.098
R^2=0.934				
Diagnostic tests (LM version)				
LM=1.118(0.731), RESET=0.294(0.771), NO=0.418(0.811), HE=1.205(0.272)				

LM is a serial correlation test, RESET is a functional form test, NO is a normality test, and HE is a heteroscedasticity test. Numbers in parentheses denote p-values output uncertainty are 29.8%, 27.8% and 28.1%. Similarly, the industrial output uncertainty is found to exert insignificant impacts on agricultural output, explaining a 12.2% in the short-run, a 13.1% in the medium-run and a 13.5% in the long-run.

The above performance has not been found in line with that of the industrial output growth. More particularly, in the short-run, all the explanatory factors are insignificant. In the medium-run, we observe a raise in the explanatory power of the industrial output uncertainty (20.2%) and that of the inflation uncertainty (24%). With regard to the long-run, industrial output uncertainty explains the 20.2% and last, inflation uncertainty the 27.7%. The explanatory power of exchange rate uncertainty ranks moderate (about 16.4%) in both medium-run and long-run horizons.

Table 5. Forecast Error Variance Decomposition for Variable ΔLY

Forecast horizon	Percentage of variance of error due to innovations in					
	ΔLY	ΔLI	UP	UY	UE	UI
12	20.521	5.287	28.075	29.810	4.119	12.188
36	14.141	7.699	31.699	27.793	5.553	13.115
60	13.614	8.094	31.312	28.071	5.378	13.531

Table 6. Forecast Error Variance Decomposition for Variable ΔLI

Forecast horizon	Percentage of variance of error due to innovations in					
	ΔLY	ΔLI	UP	UY	UE	UI
12	18.778	41.925	12.172	8.487	7.610	11.028
36	8.239	15.794	23.957	15.594	16.182	20.234
60	7.446	14.741	27.744	13.474	16.435	20.160

Concluding Remarks

This paper has attempted to provide empirically a thorough re-investigation of the dynamic interactions between the traditional sectors of the economy and macroeconomic uncertainty using Greek data. Uncertainty has been considered in three distinct components, namely the inflation uncertainty, the exchange rate uncertainty and the output uncertainty.

The econometric analysis used GARCH techniques to model the uncertainty variables while the detection of causal effects running from the considered sources of uncertainty towards the growth rates of the two traditional economic sectors has been traced out within VAR modelling, and by applying Granger-causality tests and variance decomposition analysis.

The main conclusions drawn from the econometric analysis are as follows:

i. The results derived from integration analysis provide interesting insights into the time series properties of the sectoral output data, indicating that shocks to output levels have permanent effects while shocks to the sectoral growth series have transitory effects.
ii. The overall macroeconomic uncertainty seems to cause more strong impacts on the growth of the agricultural sector.
iii. Agricultural sector is sensitive in aggregate macroeconomic uncertainty, by the same about percentages, all over the examined horizons, while the industrial sector is less sensitive in the short-run, becoming more sensitive, though less than agriculture, in the medium and long-run time horizon.
iv. Among the sources of macroeconomic uncertainty, inflation uncertainty together with the respective sectoral output uncertainty variable explain the major part of the growth behaviour in both sectors, while exchange rate uncertainty is responsible for a rather weaker influence and only on the industrial output growth. However, hereafter the negative effects of the exchange rate uncertainty together with inflation uncertainty are expected to gradually eliminate due to the adoption of the Euro. Towards this direction, Dinopoulos and Petsas (2000) present evidence that a fixed exchange rate area will add to the stability of the Greek economy in general and generate higher rates of growth though at the cost of serious income disparities.

In sum, the results highlight the negative effects of macroeconomic uncertainty on sectoral growth and argue for stronger efforts, on the part of the authorities, towards a stable macroeconomic environment if aiming at higher rates of economic growth.

References

Aizenman, J. and Marion, N.P. (1993) Macroeconomic Uncertainty and Private Investment, Economics Letters, **41**, 207-210.

Ball, L. (1992) Why Does High Inflation Raise Inflation Uncertainty?, Journal of Monetary Economics, **29**, 371-388.

Bernanke, B. (1983) Irreversibility, Uncertainty and Cyclical Investment, Quarterly Journal of Economics, **98**(1), 85-106.

Bollerslev, T. (1986) Generalized Autoregressive Conditional Heteroscedasticity, Journal of Econometrics, **31**, 307-327.

Brunetti, A. and Weder, B. (1998) Investment and Institutional Uncertainty: A Comparative Study of Different Uncertainty Measures, Weltwirtschaftliches Archiv, **134**, 513-533.

Chou, R. (1988) Volatility Persistence and Stock Valuations: Some Empirical Evidence Using GARCH, Journal of Applied Econometrics, **3**, 279-294.

Dickey, D.A. and Fuller, W.A. (1981) Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root, Econometrica, **49**, 1057-1072.

Dinopoulos, E. and Petsas, I. (2000) Greece and the Euro. Paper presented at the 7th International Congress of the Economic Society of Thessaloniki, Economic and Financial Developments in the Era of the Euro, October 2000, Kavala, Greece.

Enders, W. (1995) Applied Econometric Time Series, John Wiley & Sons Inc., New York.

Ferderer, J.P. (1993) The Impact of Uncertainty on Aggregate Investment Spending: An Empirical Analysis, Journal of Money, Credit, and Banking, **25**, 30-48.

Fuller, W.A. (1976) Introduction to Statistical Time Series, J. Wiley & Sons Inc., New York.

Golob, J.E. (1994) Does Inflation Uncertainty Increase with Inflation, Federal Reserve Bank of Kansas City, Economic Review, **79**, 27-38.

Guiso, L. and Parigi, G. (1998) Investment and Demand Uncertainty, Mimeo, Banca d' Italia.

Heitger, B. (1985) Bestimmungsfactoren Internationaler Wachstumsdifferenzen, Weltwirtschaft, **1**, 49-69.

Kormendi, R. and Meguire, P. (1985) Macroeconomic Determinants of Growth: Cross-Country Evidence, Journal of Monetary Economics, **16**, 141-163.

Leahy, J. and Whited, T.M. (1996) The Effects of Uncertainty on Investment: Some Stylized Facts, Journal of Money, Credit, and Banking, **28**, 64-83.

Lucas, R.E. and Prescott, E.C. (1971) Investment Under Uncertainty, Econometrica, **39**, 659-681.

Pesaran, M.H. and Pesaran, B. (1997) Working with Microfit 4.0: Interactive Econometric Analysis, Oxford University Press, Oxford.

Pindyck, R.S. (1991) Irreversibility, Uncertainty and Investment, Journal of Economic Literature, **29**(3), 1110-1148.

Pindyck, R. and Solimano, A. (1993) Economic Instability and Aggregate Investment, Working Paper, WPS 1148, Word Bank, Washington.

Ramey, G. and Ramey, V.A. (1991) Technology Commitment and the Cost of Economic Fluctuations, NBER (Cambridge, MA), Working Paper No. 3755.

Ramey, G. and Ramey, V.A. (1995) Cross-Country Evidence on the Link Between Volatility and Growth, American Economic Review, **85**, 1138-1151.

Sims, C.A. (1980) Macroeconomics and Reality, Econometrica, **48**, 1-48.

Tharakan, J. (1999) Economic Growth and Exchange Rate Uncertainty, Applied Economics, **31**, 347-358.