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The Effect of a Free Market Price Mechanism on Total Factor Productivity: The Case of the Agricultural Crop Industry in Greece

by

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CONTENTS

LIST OF TABLES

ABSTRACT

The Common Agricultural Policy of the European Communities has traditionally been characterized by a plethora of subsidies and income support policies. This phenomenon has been typical in Greece well before 1981, the year that she officially joint the EC. Taking into account the argument that such policies in general hinder the development of agriculture, this paper investigates the effects of a hypothetical price liberalization policy on Total Factor Productivity in the agricultural crop industry of Greece. The maximum likelihood estimates of the specified LISREL model suggest that if agricultural markets were liberalized, TFP growth would have more than quintupled during 1974-1989 on average.

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* This paper derives from earlier work on the Greek agricultural sector, some first results of which were presented at the Panhellenic Agricultural Congress, held in Thessaloniki, 11-12 December 1992. The author gratefully acknowledges helpful comments by participants of that Congress, the Agricultural Production and Technological Adjustment Session.

1. INTRODUCTION

Before accession to the European Communities (EC), Greece used to support her agricultural sector by using a variety of means, among which the most important were minimum price guarantees, direct subsidies to farmers, subsidies on inputs, export promotion incentives, import restrictions and low interest rates. After accession, in 1981, these policies were replaced by Common Agricultural Policy (CAP) market interventionism and the budget of the agricultural fund EAGGF. Although CAP policies are different from the previous regime regarding the emphasis given to various products, in essence they are consistent with a fully market-interventional policy system. It has often been argued in economic development literature, but also in political parties' debates that such policies have in general hindered the development of agriculture. In the Greek particular case, Mergos (1991, p. 18) argues "...to the extent that subsidies have blurred or distorted price incentives, they had a negative impact on output". Furthermore, the gradual reformation of CAP towards a scheme that is centered on "more market" and "less intervention" is already under way. Thus, policy makers should obtain quantitative evidence of the pros and cons of market liberalization before they address detailed policies for the sector.

Focusing on the question of the possibility of relaxing the existing interventional policies, this paper investigates the effects of a hypothetical price liberalization policy on Total Factor Productivity (TFP) growth of the agricultural crop industry in Greece. Crops versus animal production has been selected because Greece has a comparative advantage in this agricultural sub-sector.

TFP figures for the agricultural sector or any of its sub-sectors are not officially available. The National Statistical Service of Greece does not compile partial productivity or TFP indices for any sector or sub-sector of the Greek economy. Thus, this paper first compiles TFP indices by utilizing the Divisia and Tornquist methodology. The data that the paper uses come from official publications of the OECD, the EuroStat, the Commission of EC, and the Agricultural Bank of Greece (ATE). The time period considered is 1974-1989.

The purpose of the paper is methodologically achieved by following the LISREL (LInear Structural RELations) approach (Joreskog and Sorbom, 1984, 1989, Hayduk, 1987, Bollen, 1989). Within this approach a MIMIC (Multiple Indicator Multiple Cause) model is developed, estimated and evaluated. The maximum likelihood estimates of the model suggest that if agricultural crop markets were liberalized, TFP growth would have more than quintupled during the examined 1974-1989 on average. This finding implies that the establishment of a free-market mechanism in agriculture may lead to the development of the sector.

On the other hand the following are observed:

1. During 1974-1980, the pre-CAP period, a 10% increase in inputs has lead to a

6.8% increase in output.

2. During 1981-1985, a post-CAP transition period, a 10% decrease in inputs has lead to 1.2% increase in output.

3. During 1986-1989, a full post-CAP period, a 10% decrease in inputs has lead to a 0.4% decrease in output.

According to these results the rates of growth of inputs and outputs suggest smaller productivity gains during the post-CAP period, which may imply a relatively unfavorable distribution of CAP interventional policies for Greece. Another possibility may be that the post-CAP period may be too short to draw reliable conclusions.

This paper is organized as follows: Section two presents the compilation of TFP-growth indices. Section three includes the development, specification, estimation and evaluation of the MIMIC model which makes explicit the relationship between TFP growth and liberalization policy in Greece's agricultural crop industry. The final section summarizes the results.

2. COMPILATION OF TFP-GROWTH INDICES

Theory

The compilation of TFP-growth indices is based on the traditional theory of TFP measurement, which is formulated according to the main modelling principles of famous researchers of the field (Solow, Jorgenson and Griliches, Denison, Kendrick). According to their model, TFP growth is identified with shifts in the production function, which are perceived as changes in the efficiency of production. Thus, the basic assumption is a production function with the conventional neoclassical curvature properties relating the maximum possible output Y, the flows of services of k inputs X_k which are combined to produce Y, and the state of technology represented by time - an increase in time leads to technology improvements arising from disembodied technical change. A constant returns to scale postulate facilitates exposition, but is not crucial (Morrison, 1986). Within this framework, TFP growth equals the difference between real output growth and an index of the growth rates of factor inputs.

The conventional theory, briefly outlined thus far, assumes that producers are in long-run equilibrium, while the transformation of the capital stock into flows presupposes an under- or over-utilization of capacity, which reflects the condition of a short-run equilibrium. This distinction between the long-run and short-run is introduced into the analysis by assuming capital to be a quasi-fixed factor - fixed in the short-run and variable in the long-run. See Berndt and Fuss (1986). Furthermore, capacity utilization is defined as the ratio of actual output Y to capacity output Y_0. At capacity level of output, Y_0, the short-run and the long-run unit cost curves are at their minimum.

According to the above growth accounting framework, TFP is negatively related to output prices and positively related to input prices. If p denotes input prices and q denotes output prices, Y is output and X represents inputs, the following dual relationships hold:

$$TFP = p/q \quad \text{and} \quad TFP = Y/X \tag{1}$$

The relationships (1) result from the main accounting identity $Yq = Xp$.

TFP-Growth Indices

Based on the above theoretical framework and following the Divisia approach and its discrete-time Tornquist approximation, TFP growth is defined as follows:

$$TFP = \sum w_{it}[\log Y_{it} - \log Y_{i,t-1}] - \sum v_{jt}[\log X_{jt} - \log X_{j,t-1}] \tag{2}$$

where Y is output, X is input, w_{it} denotes the relative share of output i at time t in total value

of output, vjt denotes the relative share of input j at time t in total cost. The weights w and v are arithmetic averages of the relative shares in the two periods. The productivity growth index described by formula (2), often called translog or Tornquist, has been used by many authors including Cristensen and Jorgenson (1970), Jorgenson and Griliches (1967, 1972), the U.S. Bureau of Labor Statistics (see Mark and Waldorf, 1983, p.15), and more recently by Thirtle and Bottomley (1992).[1]

The calculation of the output index, based on formula (2), utilizes annual output data published in the OECD (1990, pp. 168-169 and 170-171, 1991, pp. 170-171 and 172-173) "Economic Accounts for Agriculture". This data cover 14 groups of agricultural crop products and eight groups of crop inputs, presented in Table 1. This current value data is transformed into volume data by utilizing the corresponding producer prices and input prices taken from the EuroStat (1986, pp. 142-143 and 180-181, 1989, pp. 158-159 and 202-203).

TABLE 1
Crop Product Categories (P1-P14) and Intermediate Consumption Categories (C1-C8)

P1	Grains	C1	Seeds
P2	Paddy rice	C2	Fertilizers
P3	Pulses	C3	Plant protection products
P4	Root crops	C4	Pharmaceutical products
P5	Industrial crops	C5	Energy and lubricants
P6	Fresh vegetables	C6	Maintenance and repair
P7	Fresh fruit	C7	Services
P8	Citrus fruit	C8	Other intermediate
P9	Grapes		
P10	Wine		
P11	Table olives		
P12	Olive oil		
P13	Nursery plants		
P14	Other		

[1]. In a recent paper, Diewert (1992) proves that the Fisher ideal productivity index, Pr_F, described by the following formula (3), is superior to formula (2) from both viewpoints, the test approach to index numbers and the economic approach (the assumption of optimizing behavior is taken into account) to productivity indexes.

$$Pr_F \equiv Q_F/Q^*_F \qquad (3)$$

where Q_F is the output index, given by $Q_F \equiv [Q_L\ Q_P]^{1/2}$, Q^*_F is the corresponding input index, and Q_L, Q_P denote Laspeyres and Paasche indices, respectively.

Data on labor is taken from the Commission of the EC "The Agricultural Situation in the Community" various reports, and is expressed in annual work units (agricultural work done by a full-time worker in one year).

Data on capital stock distinguish the following four categories: buildings, other construction works, machinery, and transport equipment. It is taken from Skoutzos and Matheou (1991). Their capital stock data base, which extends as back as 1950, is officially used by the Greek government, as well as by private research institutions and individual analysts. The capital input is compiled as a Tornquist index based on the above four capital stock categories. The difficulties for the transformation of capital stock data into flow-of-services data is well known even for advanced economies, where a plethora of "good" data is available. This paper adjusts the capital stock index for capacity utilization following the previously described theoretical framework of distinguishing between the long-run and the short-run equilibrium. Thus, it is assumed that $Y=Y_0$, leading to a quasi-rent Z of the agricultural capital stock. Z is non-parametrically estimated and the factor shares are accordingly adjusted.

Data on compensation of employees, and subsidies and production taxes is also taken from the OECD "Economic Accounts for Agriculture". This data, together with data on depreciation, rent and other payments, and interest (also included in OECD "economic Accounts for Agriculture"), are used to obtain the input shares in total cost, and also to get the final output indices in factor-cost prices.

3. The MIMIC Model

The specification of the MIMIC model used in this paper has the following matrix form:

Measurement Model

$$\begin{bmatrix} LIB \\ PPEC \\ TFP \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} L^* \\ TFP^* \end{bmatrix} + \begin{bmatrix} \epsilon_1 \\ \epsilon_2 \\ \epsilon_3 \end{bmatrix}$$

Structural Model

$$\begin{bmatrix} L^* \\ TFP^* \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ \beta & 0 \end{bmatrix} \begin{bmatrix} L^* \\ TFP^* \end{bmatrix} + \begin{bmatrix} \gamma_1 & 0 \\ 0 & \gamma_2 \end{bmatrix} \begin{bmatrix} PI \\ PPG \end{bmatrix} + \begin{bmatrix} \zeta_1 \\ \zeta_2 \end{bmatrix}$$

or in equation form:

$$LIB = L^* + \varepsilon_1 \quad (4)$$

$$PPEC = L^* + \varepsilon_2 \quad (5)$$

$$TFP = TFP^* + \varepsilon_3 \quad (6)$$

$$L^* = \gamma_1 PI + \zeta_1 \quad (7)$$

$$TFP^* = \beta L^* + \gamma_2 PPG + \zeta_2 \quad (8)$$

where LIB denotes a liberalization proxy variable defined as the multiplication of the percentage time structure of industrial crops industry in Greece and the producer price index of the EC. The selection of industrial crops has been based on its dynamic development during the examined period in terms of both value and volume. In particular, this group of products has grown by over 20% during the last five years in both value and volume terms. Thus, the proxy variable for liberalization combines both, expected change in structural

characteristics of the crop sub-sector in Greece, and European price change, which can be considered as expressing competitive conditions much closer than the Greek price changes. PPEC is the producer price index of the EC. LIB and PPEC are indicators of L^* which denotes the "true" but unobserved liberalization of agricultural markets. PI is the input price index of agricultural production, and PPG is the producer price index for crop output in Greece. The ε's are composite error terms including mainly measurement errors and differences between the theoretical constructs and empirical proxies. The ζ's are classical error terms.

The above MIMIC model includes 15 sample moments and 11 free parameters to be estimated. These are the three coefficients, the five variances of the error terms, and the variance-covariance matrix of the exogenous variables PI and PPG.

A price liberalization policy will lead to lower output prices and a restructuring of output towards higher income-elasticity products. Also, other structural effects, like a reduction in farm fragmentation resulting in increased economies of scale, may appear. Thus, liberalization of agricultural markets is expected to lead to higher productivity and higher agricultural incomes.

Summary statistics of the variables of the model are presented in Table 2.

TABLE 2
Summary Statistics of the Endogenous and Exogenous
Observed Variables of the MIMIC Model (4)-(8)
Logarithmic Changes

Obs = 14 Variable	Mean	Std. Dev.	Min.	Max.
LIB	0.1017	0.0847	-0.0160	0.2874
PPEC	0.0689	0.0581	0.0073	0.2191
TFP	0.1163	0.4475	-0.6142	0.9761
PI	0.1595	0.0408	0.0981	0.2469
PPG	0.1620	0.0327	0.0947	0.2070

The maximum likelihood estimates of the model parameters are presented in Table 3.

TABLE 3
Maximum Likelihood Estimates of the MIMIC Model (4)-(8)
under the Assumption of Orthogonality of Disturbances*

Parameter	Estimate	Parameter	Estimate
β	5.7661	$var\varepsilon_1$	0.0047
	(4.4794)		(0.0022)
γ_1	0.3957	$var\varepsilon_2$	0.0018
	(0.3617)		(0.0013)
γ_2	-6.3734	$var\varepsilon_3$	0.1460
	(3.5849)		(0.0804)
$var\zeta_1$	0.0018		
	(0.0014)	R^2(LIB) = 0.2831 R^2(TFP*)	= 0.9374
$var\zeta_2$	0.0070	R^2(PPEC) = 0.5108 R^2(L*)	= 0.1265
		R^2(TFP) = 0.4337	

θ^2 (prob. 0.068, df 5)

prob: probability level
df : degrees of freedom
* numbers in parentheses are standard errors

As Table 3 shows, the maximum likelihood estimates of the MIMIC model have the expected signs according to the theoretical framework presented previously and are significant at the 10% level at least. The estimate of β is 5.7661, implying that a hypothetical liberalization of agricultural markets has lead to a more than five times increase of TFP on average. Also the effect of input and output prices on TFP growth have the expected sign. Regarding the estimates of variances, it is worth noticing that the variance of ε_3 is strongly significant at the 5% level, implying that "true" TFP growth, TFP*, is affected by other variables except liberalization and output prices. R&D expenditures may be one of them. Also, as one can judge from the estimated variances of ε_1 and ε_2, both LIB and PPEC are "good" indicators of the unobserved liberalization variable. Moreover, the chi square statistic shows an acceptable fit for the model.

4. CONCLUSIONS

This article has investigated the effects of a hypothetical price liberalization policy on the crop sub-sector of Greek agriculture within the framework of a LISREL MIMIC model. The time period considered was 1974-1989. The maximum likelihood estimates of the model have suggested that the followed interventional policies of CAP characterized by a plethora of subsidies and income support policies have hindered the development of the agricultural sector of Greece, why not of the rest of the European countries. The estimate of the direct effect of liberalization on TFP growth is 5.7661, implying that if market liberalization was prevailing, TFP growth would have been more than five times greater than it actually was during 1974-1989.

On the other hand, by examining the relationship between inputs and output in the crop sub-sector, and distinguishing three time sub-samples, namely: (1) 1974-1980: pre-CAP period, (2) 1981-1985: post-CAP transition period, and (3) 1986-1989: full post-CAP period, the following are observed:

A 10% increase in inputs has lead to: 6.8% increase, 1.2% increase, and 0.4% decrease in output for each of the three sub-periods respectively. As noted in the introduction, this may imply a relatively unfavorable distribution of CAP policies for Greece or the Mediterranean region.

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