Measuring Technological Change in Greece

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ABSTRACT. This paper uses the Growth Accounting methodology to estimate technological change, as well as labor and capital productivity in the various sectors of the Greek economy over the period 1988–1998. The results show that the technological level, as measured through annual growth in Total Factor Productivity, has remained practically unchanged. Meanwhile, technological change accounts for about 40% of economic growth, which is slightly lower compared with the relative performance of other O.E.C.D. countries. Finally, our main findings are, in general terms, consistent with estimates by other researchers.

Keywords: technological change, T.F.P., sectors, S&T policy, Greece

JEL Classification: O30, O52, O40

1. Introduction

The economic importance of technology is great: "The difference between rich nations and poor nations is not [...] that the rich have more money than the poor, but that rich nations produce more goods and services. One reason they can do so is because their technology is better; that is, their ability to control and manipulate nature and people for productive ends is superior" (Mokyr, 1990, preface). If some nations, or sectors of economic activity, have been superior—in terms of economic growth—compared to others it is, at least partly, due to their technological superiority. Indeed, economic research has consistently shown that technological progress is a major driving force of long-term economic growth (e.g. O.E.C.D., 1996, p. 53; Tassey, 2004, p. 165).

The purpose of the paper is to present estimates of total factor productivity (T.F.P.) change which accounts for technological change, as well as estimates of labor and capital productivity, by sector of economic activity. We use the *Growth Accounting* methodology for the case of Greece, over the period 1988–1998, when data are available.

The remainder of the paper is structured as follows: Section 2 presents some key figures about the Greek economy and discusses the research question; section 3 sets out the methodological framework; section 4 presents the empirical results, while section 5 offers policy insights; finally, section 6 concludes the paper.

2. Economic growth and technological change in Greece: The research question

Greece has one of the least developed economies in the European Union (E.U.).[1] Agriculture was the driving force behind the Greek economy. During the first half of the 20th century, the economy depended on the export of agricultural products and had a performing shipping industry. Also, remittance sent home from Greeks working abroad was a major source of income. Natural resources are limited and there are some deposits only in the case of nonferrous metals. Fossil fuels are in short supply, expect for lignite, whereas oil production is limited. The country became more industrialized after World War II and the government policies were conducive for industrialization, while foreign aid grew considerably. Also, the country's great heritage is well preserved and tourism has become a booming industry, especially after the 2004 Olympic Games.

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The Greek economy performed poorly from about 1970 to 1995, during which it was the poorest in the E.U. Part of the explanation lies with the collapse of macroeconomic policy that took the form of large fiscal deficits and high inflation rates. Also, reduced rates of capital formation, the shock of entry in the E.U. and the presence of structural rigidities are regarded as contributors to the economic slowdown. But the deteriorating performance is also attributed to the country's poor economic institutions, such as competitiveness of its tradable goods (Bosworth and Kollintzas, 2001).

Now, Greece has a mixed capitalist economy with a strong participation of the public area. The country became a full member of the E.U. in 1981 and its economy has improved over the last decades in the run-up to its entry into the Economic and Monetary Union (E.M.U.) in 2001 as a result of a major effort to reverse the macroeconomic situation. More precisely, the public deficit was cut from 16% of G.D.P. in 1990 to 1.8% in 1999, while inflation was reduced from 20% in 1990 to about 3% in 2000. These improvements lead to the acceleration in the growth of G.D.P. Also, Greece engages in free trade with its European partners and benefits from E.U. funds. Major challenges remaining include the reduction of unemployment and restructuring of the economy.

Greece is also the most easterly country within Western Europe, and the gradual enlargement of the E.U. to the East will create a new allocation of resources and factors such as know-how and productivity will play a decisive role for competitiveness. In this context, the measurement of technological change for Greece, by sector of economic activity, is of great interest since the country constitutes an original member of the O.E.C.D., and an old member of the E.U. Also, it ranks very high among E.U. countries in output growth since 1995 (European Commission [E.C.], 2000, p. 30). However, despite its high growth rates, Greece has long been viewed as one of the laggards within the E.U. In fact, it ranked last among E.U. members in R&D expenditures (E.C., 2000, 2003) and very low in terms of growth in T.F.P. (e.g. O'Mahony, 2002, p. 9).

Unless Greece can begin to do better, it will probably continue to languish at the bottom of the E.U. distribution. After stabilizing the macroeconomic environment, the next stage for Greece is to accelerate the rate of increase in technological change. In this context, the E.C. report suggests that Greece should give high priority to taking measures to increase technology diffusion and stimulate technology financing (E.C., 2000, p. 31).

Obviously, the identification of poorly performing sectors of economic activity within the Greek economy could have significant implications for policy makers. For instance, the analysis pinpoints the industries, the performance of which is poor and needs enhancement, in case the Greek government decides to stimulate technological change for some industries. On the other hand, the Greek government might wish to subsidize technology in a certain industry and in this case, our analysis indicates the annual growth rate of each industry's technological level. Consequently, the topic of this paper is important and timely given the position of Greece at the periphery of the E.U.

3. Methodological framework

A central problem in examining technological change and one that makes it difficult to define or characterize it is that it takes many different forms (Rosenberg, 1982: 3). The most useful common denominator underlying its multitude of forms is that it constitutes any change in the application of knowledge that can make it possible to produce (i) a greater volume of output from a given amount of resources, (ii) a qualitatively superior output, or (iii) a completely new output (Mokyr, 1990, p. 6; Jones, 1993, p. 190; Rosenberg, 1982, p. 3). Technology constitutes a very crucial determinant of an economy's competitiveness, however its direct quantification is difficult and it is usually estimated indirectly using a production function (O.E.C.D., 1996).

The quantitative changes which an economy in the process of economic growth undergoes have been subject of numerous studies by economists. The use of an aggregate production function and its limitations are well understood by now, yet the methodological framework continuous to be a popular one. The empirical investigation is based on *Growth Accounting*.[2] In *Growth Accounting*, growth in a single country is decomposed using a production function into a part explained by growth in factor inputs and another part (i.e. the Solow residual), which is attributed to technological change, and is called Total Factor Productivity (T.F.P.). The basic framework can be extended in other ways (see, for example, Denison, 1967; Mankiw *et al.*, 1992), the most common of which is to consider different types of capital and labor (Romer, 1996, p. 26). Growth accounting has been applied to numerous cases in the last two decades (see Denison, 1985; Jorgenson, 1988; Griliches, 1988; Baily and Gordon, 1988; O'Mahony, 1992; Page, 1994; Young, 1994; Michaelides *et al.*, 2005) with very satisfactory results.[3]

The most commonly used production function in empirical investigations using aggregate data is the unrestricted Cobb-Douglas production function (Thirlwall, 2001, p. 181).[4] We assume a Cobb-Douglas production function with two inputs (capital and labor) and Hicks-neutral technological progress.[5] So, production at time t is given by:

$$\begin{aligned} &Y(t) = A(t) \cdot L(t)^{a} \cdot K(t)^{\beta} \\ &Y(t) > 0,\ L(t) > 0,\ K(t) > 0, \\ &A(t) > 0,\ \alpha > 0,\ \beta > 0. \end{aligned} \tag{1}$$

The notation is standard: Y is output, L labor, K capital and A the level of technology. Meanwhile, a and b are the parameters of the original Cobb-Douglas production function, expressing the elasticities of output with respect to labor and capital, respectively,[6] which have to be empirically estimated (Dornbusch and Fischer, 1993, p. 873). From Equation (1) we get Equation (2) which allows us to estimate technological change, indirectly (see e.g. Thirlwall, 2001, p. 181):[7]

$$\begin{aligned} \dot{A}/A = \frac{\partial A(t)}{\partial t}\cdot\frac{1}{A(t)} = \frac{\partial Y(t)}{\partial t}\cdot\frac{1}{Y(t)} \\ - \alpha\frac{\partial L(t)}{\partial t}\cdot\frac{1}{L(t)} - \beta\frac{\partial K(t)}{\partial t}\cdot\frac{1}{K(t)}. \end{aligned} \tag{2}$$

Similarly, the rates of growth of labor productivity (l) and capital productivity (k), can also be calculated (see Romer, 1996, p. 26), as well as the percentage of economic growth by sector of economic activity, which is attributed to technological progress (p) (see Thirlwall, 2001, p. 189).[8] The rates of growth of labor productivity and capital productivity, respectively, are given by:

$$1 = \frac{\partial Y(t)}{\partial t}\cdot\frac{1}{Y(t)} - \frac{\partial L(t)}{\partial t}\cdot\frac{1}{L(t)} \tag{3}$$

$$k = \frac{\partial Y(t)}{\partial t}\cdot\frac{1}{Y(t)} - \frac{\partial K(t)}{\partial t}\cdot\frac{1}{K(t)}. \tag{4}$$

4. Empirical results

The significance of the factors entering the production function of the various sectors of economic activity in Greece is tested using the available data collected from the publications of the National Statistical Service of Greece (2001, 2002). However, their industry classification was not identical to the classification used by O.E.C.D. (see Table III, Appendix). The data available is on an annual basis and covers the period 1988–1998. The regressions are based on the log-linear form of the Cobb-Douglas production function with two inputs, i.e. capital and labor, Hicks-neutral technological progress and are estimated with the aid of the Ordinary Least Squares (O.L.S.) methodology (see Table II, Appendix), which is the standard procedure for estimating the Cobb-Douglas production function (see, for example, Mankiw *et al.*, 1992; Andrikopoulos, 2000; Stewart, 2005).[9]

The signs of the estimated coefficients are consistent, except for one case, with the implied hypotheses ($a > 0$, $b > 0$) and are statistically significant, in most cases. The regressions account, in most cases, for a high percentage of the variability of output in the various sectors of economic activity in Greece, which, given the inevitable imperfections in this sort of data, is very satisfactory (Mankiw *et al.*, 1992, p. 408).[10]

Continuously, the estimated parameters (a, b), the rates of growth in output ($\dot{Y}/Y$), labor ($\dot{L}/L$), capital ($\dot{K}/K$), labor productivity (l), capital productivity (k), total factor productivity ($\dot{A}/A$) and the percentage of output growth by sector of economic activity that is attributed to technological progress (p), are calculated (Table I).

A first conclusion that can be drawn is that for the great majority of sectors, T.F.P. remains, practically, unchanged (on average, equal to

Table I
Growth rate in output, labor, capital, labor productivity, capital productivity, total factor productivity and technology participation for Greece by sector, 1988–1998

Sector	a	b	$a + b$	$\dot{Y}/Y$	$\dot{L}/L$	$\dot{K}/K$	l	k	$\dot{A}/A$	p
1	0.170	0.048	0.218	0.0077	0.0285	0.0804	−0.0208	−0.0726	−0.001038	0.13402
2	0.350	0.146	0.498	−0.0098	0.0137	−0.0513	−0.0234	0.0416	−0.006996	0.71760
3	0.610	0.014	0.625	0.0175	0.0389	−0.2418	−0.0214	0.2592	−0.002823	0.16172
4	0.233	1.203	1.437	−0.0102	−0.0058	−0.0062	−0.0044	−0.0040	−0.001356	0.13288
5	0.708	0.047	0.756	−0.0045	0.0176	−0.2803	−0.0220	0.2759	−0.003619	0.83168
6	0.529	0.436	0.965	0.0389	0.0571	0.0305	−0.0182	0.0085	−0.004586	0.11779
7	0.762	0.856	1.619	0.0077	0.0470	−0.0153	−0.0393	0.0230	−0.015005	1.93907
8	−0.37	0.554	0.187	0.0013	0.0279	0.0265	−0.0265	−0.0252	−0.003124	2.34710
9	1.674	0.532	2.206	0.0230	0.0291	−0.0416	−0.0061	0.0646	−0.003523	0.15310
10	0.389	0.797	1.187	−0.0107	0.0961	−0.0657	−0.1069	0.0549	0.004195	0.38961
11	1.066	0.114	1.182	0.0176	0.0395	−0.2367	−0.0220	0.2543	0.002582	0.14688
12	0.112	0.230	0.343	0.0109	0.0010	0.0404	0.0100	−0.0295	0.001499	0.13733
13	0.591	0.028	0.620	0.0371	0.0508	0.2188	−0.0137	−0.1817	0.000775	0.02088
14	0.502	0.467	0.970	0.0381	0.0390	0.0250	−0.0009	0.0131	0.006803	0.17855
15	0.013	0.376	0.391	0.0436	0.0566	0.1172	−0.0130	−0.0736	−0.001392	0.03195
16	0.035	0.573	0.609	0.0816	0.0490	0.1510	0.0326	−0.0694	−0.006718	0.08228
17	0.503	0.475	0.979	0.0529	0.0479	0.0748	0.0050	−0.0219	−0.006768	0.12801
18	0.074	0.554	0.629	0.0883	0.0593	0.1491	0.0290	−0.0608	0.001281	0.01451
19	0.419	0.126	0.546	0.0728	0.1110	0.3973	−0.0383	−0.3246	−0.023959	0.32933
20	0.585	0.461	1.047	0.0557	0.0442	0.0759	0.0115	−0.0202	−0.005236	0.09401
21	0.524	0.105	0.630	0.0683	0.0713	0.4156	−0.0030	−0.3474	−0.012934	0.18945
									−0.003902	0.39418

−0.39%), over the time period 1988–1998. This finding is, roughly speaking, consistent with estimates, for the total economy, by other researchers, such as O'Mahony (1992), who also found that T.F.P. growth rate hovers around 0%, (i.e. 0.75%) but over a slightly different period, i.e. 1989–1999.[11]

Also, the (University of) Groningen Growth and Development Center (G.G.D.C.) Total Economy Growth Accounting publishes annual growth rates for Greek T.F.P., and a simple calculation yields a growth rate equal to 0.43%, over the period 1988–1998. Moreover, a similar study by Bosworth and Kollintzas (2001), after a simple calculation, yields a T.F.P. growth rate of about 0.13% over the 1988–1998 period. Finally, according to O.E.C.D. (1996, p. 60), the T.F.P. growth rate for the total economy in Greece is equal to −0.30% which practically matches our estimation (−0.39%). Obviously, all these figures use slightly different methodologies (or data) and yield slightly different results. However, they all seem to confirm the main conclusion of this paper, i.e. that in the late 1980s and for the great part of the 1990s, Greek T.F.P. remained, practically, unchanged.

On average, the annual growth rates in output, labor and capital among sectors are positive and equal to 2.99%, 4.38%, and 4.11%, respectively. On the contrary, the average annual growth rates in productivity of labor and capital among sectors are, equal to −1.39%, and −1.12%, respectively.

As far as the contribution of technology to economic growth is concerned, its average value among sectors is equal to 39%, which is slightly lower compared with the relative performance of other O.E.C.D. countries (O.E.C.D., 1996, p. 58).

Concentration on performance at the economy wide level hides interesting variations at more detailed sector levels. For instance, the great majority of sectors experience slightly negative annual rates of growth of T.F.P. with the exception of sectors 10–14 and sector 18 that experience slightly positive annual growth in T.F.P. The fastest decline in T.F.P. is experienced by sectors 19, 7, 21, while the slowest decline is experienced by sector 14.

Also, sectors 8, 7, 5, 2, 10, 19 are highly dependent on technological change when the rates of economic growth are concerned. On the other hand, sectors 18, 13, 15, 16 and 20, do not show any significant dependence. Finally, fifteen (15) out of twenty-one (21) sectors of the Greek economy experience decreasing returns to scale, while in most of them the elasticity of labor is larger than that of capital.

At this point, we should stress the fact that all estimates of T.F.P. are subject to a margin error and the production function estimate is obviously contingent on an estimate of the capital stock (Stikuts, 2003). In other words, the methodology we used is popular and appropriate, but it should be treated with caution since, the parameters *a* and *b*, and the capital stock are estimated figures, and therefore, there is some uncertainty in their estimation. Obviously, a figure such as Greek T.F.P. is an estimate and not a firm, precise measure.

5. Discussion and policy implications

Given the fact that technology is critical for productivity and economic growth (Tassey, 2004, p. 166), the T.F.P. estimates are important policy variables, as well. Thus, our investigation has direct relevance for policy issues for Greece. For instance, in case the Greek government decides to enhance technological change, it could choose the ‘‘construction’’ industry, which yielded the highest T.F.P. growth. In case it wishes to support the weakest economic sectors, our analysis pinpoints the industries, the performance of which is poor and needs enhancement. In such a case, the Greek government could chose the ‘‘petroleum and coal products’’ industry.

The implementation of a sectoral science and technology (S&T) policy should focus the effort on specific carefully selected sectoral fields of high economic interest. For instance, sectors (10)–(14) seem to constitute a good choice since they demonstrate relatively satisfactory T.F.P. growth rates combined with a low dependence on technologically induced economic growth. In case these sectors could be gradually transformed into ‘‘technology—intensive’’ sectors, the result would be satisfactory.

However, despite having implemented a successful program for stabilizing the macroeconomic environment, Greece is still in the process of developing an effective strategy for promoting technological progress. It has no well defined areas of comparative advantage in the international sphere, and it has no sector like the export-oriented electronics in Ireland, for instance, that could serve as the driving force behind economic growth (Bosworth and Kollintzas, 2001). If the country is not going to use its tradable goods as the driving source for growth, it will probably need to develop an upgrading of domestic industries based on technological advancement and innovation.

Of course, following O.E.C.D, in Greece certain characteristics of the S&T system, such as the small size of the research community, the dispersion of the research effort to multiple sectors and themes, the weak communication among laboratories, as well as between the research and production systems, seem to constitute a handicap to the dissemination of knowledge based information and, thus, to technology transfer.

The state effort for the implementation of a science and technology (S&T) policy is shared by several authorities.[12] No major reform has been introduced since 1985 concerning the legal framework whereas the national S&T policy has, traditionally, been supported by E.U. funds. Undoubtedly, international co-operation and E.U. programs consist an important channel of technology transfer to the country. Universities account for the great majority of absorption of the program funding, while industrial participation remains low.[13] However, the needs of European competitiveness in research and technology change rapidly and make co-operation between researchers and enterprises essential for the successful completion of the projects and the exploitation of the results.

Evaluation of the efficiency of research projects should be integrated in the policy formulation. More precisely, the new programs should contribute to new technological activities generating competitive advantage, and assist research teams to commercialize the results. The programs have to motivate the business sectors in increasing their contribution to R&D expenditure (see Belegri-Roboli and Michaelides, 2005).

It should also aim at raising awareness of entrepreneurs and managers on the use of technologies and increasing the skills and the number of qualified personnel employed in business. Opportunities should be provided for the transfer of technology in terms of integration of skilled researchers into the S&T system. Moreover, the monitoring of the science and technology labor market should be organized on a more systematic basis, i.e. an effort should be undertaken for the identification of skill gaps in the Greek S&T field.

As far as it concerns the Greek universities, the greater part of their R&D activities is financed by the Ministry of National Education. Research programs should aim at upgrading their research equipment, encouraging young graduates to integrate research teams, and improving the linkages of the universities with other elements of the S&T system, especially the users of research results (see Caloghirou *et al.*, 2001).

Finally, there should be a concentration of future funding on the most promising fields of science and technology, while a monitoring and evaluation procedure should lead to the most successful financial schemes having the greatest relevance to the specificities of the Greek S&T system. The restructuring and the expansion of the existing infrastructure should be carried out selectively on the basis of expert studies. We believe that the results of this study could be utilized for the feedback of the policy formulation procedure and could contribute to the efficient allocation of future funds.

6. Conclusion

The present paper used the *Growth Accounting* methodology to estimate technological change, as well as labor and capital productivity, in the various sectors of the Greek economy in the 1988–1998 time span. The results showed that, in general terms, the technological level, as measured through annual growth in Total Factor Productivity, has remained, practically, unchanged. Meanwhile, technological change accounts for about 40% of economic growth, which is slightly lower compared with the relative performance of other O.E.C.D. countries. Our findings are, in general terms, consistent with estimates by other researchers.

The main policy guidelines suggested can be summarized in the following: enhancement of co-operation between research organizations and production units, encouragement of technology transfer from abroad to Greek firms, reinforcement of the innovation process, restructuring of the existing R&D institutions, assessment of the training needs of the Greek human capital, development of specialized training programs in new technologies, and providing incentives for applied post-graduate research.

Based on our findings, we agree with the E.C. report suggesting that Greece should give high priority to taking measures to increase technology diffusion and stimulate technology financing (E.C., 2000, p. 31), given the incorporation of other countries in the European Union financial area. Although some European countries report increasing T.F.P. (O'Mahony, 1992), the lack of comparability in methodology and time period hampers multi-country analyses of technological change. The measurement of technological change for other European countries is of great interest and could be a good example for future investigation.

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Notes

1. According to Maddison (1995), in 1950 Greece was the poorest of the current members of the E.U.-15. Over the next two decades, it was the fastest growing economy and its standard of living exceeded that of Ireland and Portugal. However, since 1973, it has been characterized by the lowest rate of growth and has fallen back to being the poorest country in the E.U.-15 (Bosworth and Kollintzas, 2001).
2. Growth accounting was pioneered by Abramovitz (1956) and Solow (1957) and aimed at explaining the determinants of growth worldwide, after World War II.
3. For instance, Young (1994) used the growth accounting methodology to argue that rapid growth of Taiwan, Singapore,

South Korea and Hong Kong was mainly due to increasing labor-force and investment, and not to technological progress. Also, growth accounting has been extensively used for the study of the slowdown in productivity in the United States since the 1970s.

4. Despite its extensive use and its considerable success in modeling economic growth, the Cobb-Douglas production function presents some theoretical shortcomings, one of which is the fact that it considers as homogenous the production and labor expanded originating from different sectors and skills. For a brief review of the model's theoretical limitations see Thirlwall (2001, pp. 185–187), which are, however, of limited practical character, as the author himself implies (ibid., p. 187).

5. The assumption of (Hicks-) neutral technological progress is, according to the empirical literature, a very reliable one (Thirlwall, 2001, p. 187).

6. The *Growth Accounting* framework is based on the assumption that the rate of change in output depends on the growth in labor, capital and technological change, as well as on the typical assumption that factor prices are equal to social marginal products for capital and labor, respectively. However, some scholars—even Solow himself in his 1957 paper—argue that it is not always possible to isolate technological progress from capital formation.

7. Note that if: (i) $\alpha + b = 1$, then there are constant returns to scale, (ii) $\alpha + b < 1$, decreasing returns to scale and (iii) $\alpha + b > 1$, increasing returns to scale (see e.g. Thirlwall, 2001, p. 182).

8. In the econometric model presented, one could account for the differences in the quality of the factor inputs by disaggregating them into quality classes. These issues could be addressed by using a production function representing different qualities of input factors (see Barro, 1998). For example, L could be viewed as a vector that specifies the quantities of labor of various types, categorized by educational attainment. In a similar vein, the variable K could be distinguished between short lived and long lived capital. Unfortunately, this sort of data is not available by sector of economic activity for the Greek economy, concerning the variable K. As far as the variable L is concerned, better data are available. However, this sort of empirical investigation for the case of Greece, by sector of economic activity, did not yield statistically significant results, implying that the different qualities of labor do not contribute, in a (statistically) significant way, to the variability of total output, by sector of economic activity. In other words, the different qualities of labor do not constitute explanatory variables of the total output. This fact implies that the labor expanded originating from different sectors and skills behaves in a "homogeneous" way, and should be attributed to the very low level of differentiation of labor quality in Greece.

9. Despite its extensive and widespread use the O.L.S. regression is, traditionally, associated with certain disadvantages (see, for instance, Griliches and Mairesse, 1995; Barro, 1998, etc). Some alternatives to O.L.S. have been proposed (see for example, Olley and Pakes, 1996; Barro, 1998; Levinsohn and Petrin, 2003), including numerical methodologies and non-linear instrumental variables. However, despite being promising, these highly technical approaches have not been fully exploited till now, and the research is still ongoing.

10. The remaining part is attributed to inevitable errors and other factors possibly affecting growth, which are not included in the typical production function. For instance, various authors have provided evidence for the importance of human capital in growth in income. See, for instance, Mankiw *et al.* (1992), Azariadis and Drazen (1990).

11. The slightly different figures estimated are due to: (a) the different time period investigated (b) the fact that in this paper the production functions are estimated by sector of economic activity and not for the total economy as in O'Mahony (1992), (c) O'Mahony's (1992) hypothetical assumption of constant returns to scale whereas in our study the unrestricted model was estimated, (d) O'Mahony (1992)'s hypothetical assumption that the values of a and b equal labor's and capital's share of value added, respectively, and were not estimated empirically, as in this paper.

12. These authorities include the General Secretariat for Research and Technology (G.S.R.T.) and the Ministry of National Education.

13. The institution of venture capital enterprises was established in Greece so as to support high technology or innovation investments. However, financial organizations and the market have not exploited till now the incentives provided for the promotion of technologically promising productive activities.

Appendix

Table II

Regression results Cobb-Douglas production function for Greece by sector, 1988–1998

Sector	$\ln A(t)$	t-stat	a	t-stat	b	t-stat	R^2	SE	DW-stat
1	11.728	11.332	0.170	1.163	0.048	0.559	0.48	0.041	2.84
2	5.852	2.127	0.350	1.753	0.146	1.657	0.36	0.049	1.04
3	6.703	2.086	0.610	2.687	0.014	0.505	0.80	0.032	2.14
4	− 7.047	− 1.020	0.233	1.223	1.203	2.152	0.70	0.027	2.64
5	4.075	1.579	0.708	2.781	0.047	3.453	0.63	0.040	1.97
6	0.863	0.338	0.529	2.686	0.436	1.550	0.86	0.072	1.67
7	− 6.646	− 0.313	0.762	1.451	0.856	0.719	0.29	0.116	1.76
8	9.305	3.821	− 0.37	− 1.223	0.554	1.529	0.24	0.033	1.75
9	− 13.258	− 3.707	1.674	8.058	0.532	5.026	0.90	0.027	2.49
10	− 2.946	− 0.795	0.389	3.452	0.797	4.312	0.70	0.071	2.50

Table II
(Continued)

Sector	$\ln A(t)$	*t*-stat	*a*	*t*-stat	*b*	*t*-stat	R^2	SE	DW-stat
11	−0.635	−0.191	1.066	3.929	0.114	2.964	0.72	0.039	2.39
12	8.336	5.768	0.112	1.687	0.230	3.847	0.65	0.023	2.56
13	5.529	5.804	0.591	5.949	0.028	1.150	0.93	0.030	2.54
14	0.392	0.097	0.502	1.791	0.467	1.166	0.80	0.051	1.21
15	9.418	35.902	0.013	0.335	0.376	16.737	0.99	0.011	2.29
16	5.343	5.779	0.035	0.293	0.573	12.180	0.99	0.037	1.68
17	0.442	0.167	0.503	0.872	0.475	1.361	0.94	0.052	0.54
18	4.764	2.461	0.074	0.279	0.554	4.178	0.91	0.093	1.66
19	7.124	6.353	0.419	4.472	0.126	7.152	0.99	0.026	1.78
20	−0.757	−0.449	0.585	2.324	0.461	3.473	0.98	0.032	1.71
21	5.679	2.894	0.524	3.047	0.105	3.233	0.95	0.047	1.44

Table III
Sector classification

Sector	Description	I.S.I.C.rev.2
1	Agriculture, forestry and fishing	1
2	Mining	2
3	Food, beverages and tobacco	31
4	Textiles, apparel and leather	32
5	Wood products and furniture	33
6	Paper, paper products and printing	34
7	Petroleum and coal products	353 + 354
8	Industrial chemicals, rubber and plastic products	351 + 352 − 3522 + 355 + 356
9	Non-metallic mineral products	36
10	Iron and steel, non-ferrous metals	371 + 372
11	Metal products	381
12	Shipbuilding and other transport, motor vehicles, aircraft, electrical apparatus, non electrical apparatus, professional goods, other manufacturing	382 − 3825 + 383 + 3832 + 3841 + 3842 + 3844 + 3849 + 3843 + 3845 + 385 + 39
13	Electricity, gas and water	4
14	Construction	5
15	Wholesale and retail trade	61
16	Hotels and restaurants	62
17	Transport, storage and communication	71 + 72
18	Finance and insurance	81
19	Real estate and business services	82
20	National defense and public administration	–
21	Communication, social and personal services	9

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