

Growth Accounting: A European Comparison

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Abstract

Our method decomposes output growth to its components for Cyprus, Greece and the Euro area. The period covered is 1996 to 2011. Our results, especially after 2008 suggest that Greece has a negative TFP growth rate, while Cyprus and the Euro area averages appear to be close to zero. With respect to output decomposition, we observe that in the period 2008-2011, there is a dramatic decline in the contribution of TFP and labor growth in both the Euro area and Greece. Both contributed negatively in output growth and this is the reason for the reduction of output growth. In Cyprus a decline in the labor and TFP contribution is also observed. But only labor growth has a negative contribution. TFP growth still has a positive contribution (close to 7%) but it decelerates. The contribution of capital growth is positive and capital appears to have a small acceleration. Output growth would have been worse if capital didn't accelerate.

Keywords: total factor productivity, output decomposition, economic growth.

1. Introduction

Growth Accounting provides a useful framework for analyzing observed output growth into components associated with changes in factor inputs and a Residual (Total Factor Productivity or Productivity) reflecting technical change and other elements. The Growth Accounting framework is empirically motivated and can be seen as a first attempt to understand the long-term growth process. The Growth Accounting framework does not rely on any ex ante implications of any theoretical framework and therefore does not aim to give explanations of the underlying forces of growth such as preferences, institutions and economic policies.

The history of Growth Accounting is very old starting in the 1930's with Paul Douglas, Tinbergen (1942) and others (see Griliches 1996 for a historical note) but the basics were presented by Solow (1957) Kendrick

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(1961) Denison (1962) and Jorgenson and Griliches (1967). More recently, among many others, Erwin Diewert (1976) has formalized the theory by integrating index number theory, production theory and national accounts.

Productivity is the residual growth of output not explained by measured input growth and it is directly unobservable. Total factor productivity growth reflects phenomena such as advances in general knowledge, the advantages of particular organizational structures or management techniques, reductions in inefficiency and reallocations of resources to more productive uses. Productivity growth means more output is produced for given inputs and this means more income is available to be distributed. Slow productivity growth is more likely to generate conflicting demands for distribution of income.

The paper decomposes value added growth into the contributions from total factor productivity, capital and the labor supply in the period from 1996-2011, emphasizing on the pre and after 2008 crisis periods, for Cyprus, Greece and a number of European countries, specifically the Euro area. Our results, especially after 2008, suggest that Greece has a negative TFP growth rate, while Cyprus and the Euro area (EA) averages appear to be close to zero. A similar picture emerges with respect to labor productivity. Capital deepening appears to be small in all countries under investigation. With respect to output decomposition, we observe that in the period 2008-2011, there is a dramatic decline in the contribution of TFP and labor growth in both the EA and Greece. Both contributed negatively in output growth and this is the reason for the reduction of output growth. In Cyprus, a decline in the labor and TFP contribution is also observed, but only labor growth has a negative contribution. TFP growth still has a positive contribution (close to 7%) but it decelerates. The contribution of capital growth is positive and capital appears to have a small acceleration. Output growth would have been worse if capital didn't accelerate.

2. Growth accounting framework

Growth models typically provide a theoretical framework for understanding the fundamental determinants of economic growth and the consequences of economic policies for long-run growth. Growth accounting may be viewed as a first step towards such an understanding. It essentially implies breaking down observed real GDP growth into the contributions from pertinent factors growth such as labor, capital and technology.

We have a production function:

$$Y = F(K, L, t)$$

where Y is the quantity of output, K is the capital input, L is the labor input and t is the level of technology (TFP).

Differentiating with respect to time and dividing by Y , rearranging in terms of growth rates we obtain the rate of TFP change \hat{T} as the residual. We also assume that firms maximize profits and then the social marginal products must be equal to the observed factor prices. Therefore:

$$\hat{T} = \hat{y} - s_K \hat{k} - s_L \hat{l}$$

where $(\hat{})$ denotes growth rate and s are the output shares of capital and labor.

Furthermore, production exhibits constant returns to scale and we can link the labor productivity with total factor productivity growth. Labor productivity growth depends on TFP growth plus the capital deepening, i.e. the growth rate of per capita capital:

$$\hat{\ell} = \hat{T} + s_K(\hat{k} - \hat{l})$$

Overall, growth accounting provides a suitable framework for identifying individual factors of growth and summarizing them in a convenient way, but the caveats in using the framework need to be borne in mind. There are three main assumptions underlying this framework and any violation of any of these assumptions leads to biased technical change measures. This might require estimating econometrically the production or the associated cost function. These three assumptions are that:

- the production function specified exhausts all inputs of production,
- the technology exhibits constant returns to scale, and
- inputs are paid their socially observed marginal products.

3. Empirical implementation

The method to decompose output growth to its components is applied to European countries. For our methodology one needs data for the prices and quantities of both the output and the inputs. We obtained relevant data from several publications of Eurostat and the European Commission.

The data cover the period 1995 to 2011. All prices are expressed in constant Euros of year 2000. The measure is billions of Euros.

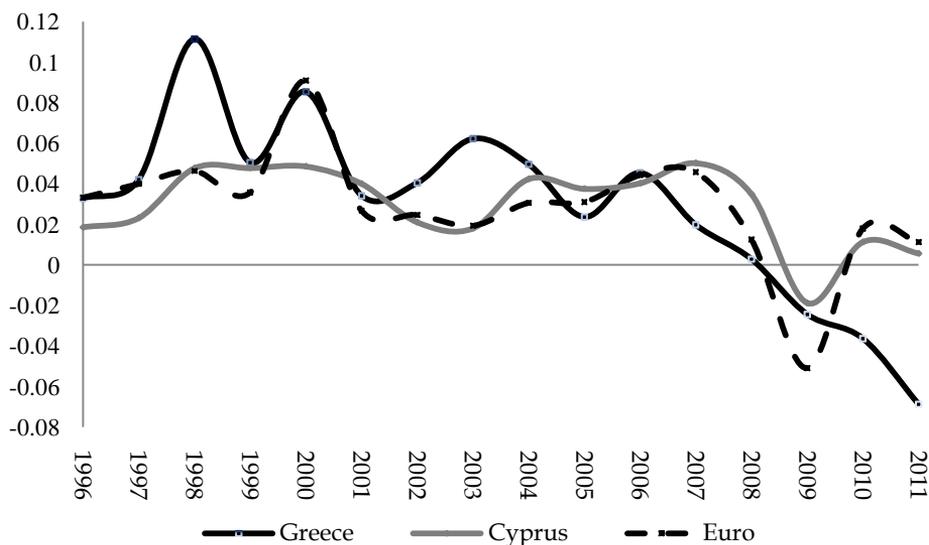
We collected data for Cyprus, Greece and all countries included in the EA (17 countries aggregated to obtain the results for the EA). The variables used for our analysis are: Value Added in current prices and constant 2000 prices, Employees (total and self employees) Total hours worked (man hours for total and for self employees) Investment in current prices and in 2000 prices and Compensation of employees.

For the construction of the output variable, we used the value added in current prices (used as the value of output, VY_{it}) along with the value added in constant prices (considered as the quantity of output). For labor, necessary data were the price and quantity of labor. The compensation of employees was used as the value of labor, adjusted to include the self employees. Having the value of labor and hours worked (again adjusted to include the self employees) the price of labor was obtained, which was transformed in order to be expressed in 2000 prices. Combining labor price and labor value one can derive the quantity of labor in 2000 prices.

Investments, in current and constant prices, were used in order to construct the capital stock. The value of capital was obtained using the value added in current prices and the value of labor. The perpetual inventory method was followed with a constant depreciation rate of 5% to get the quantity of capital. For the initial value (initial period $t = 0$) of the quantity of capital we used the initial capital stock obtained from the European Commission data.

Using the above data, the growth rates of output, labor and capital were obtained. With respect to output growth (Figure 1) Cyprus followed the EA output growth rate, and slightly above, until 2010. After 2010, the output growth rate in Cyprus appears to be below the EA growth rate. Greece, after 2008, experiences an ongoing decrease of its output growth rate. Specifically, the average output growth rates for the period 1996-2011 are: Cyprus 2.92%, EA 2.87% and Greece 2.94%. Before 2008, Cyprus sustained a growth rate around 3.5%, close to the EA average, while Greece had a growth rate around 4%. After 2008, Greece has a negative growth rate of -3.2%, while Cyprus and the EA both have a growth rate close to zero.

FIGURE 1
Output growth (1996-2011)



In Figure 2, we observe that before 2008, all countries seemed to have increasing capital growth rates. After 2008, the capital growth rates have been decreasing; specifically in Greece the rate becomes negative. Before 2008, Cyprus seemed to be below the EA, while after 2008 the picture changed. The growth rates for Cyprus and Greece for the whole period appear to be below the EA average. Specifically Cyprus had 1.3%, Greece 0.4% and the EA 1.6%. The same scenario seemed to exist before 2008 with Cyprus and Greece having lower capital growth rates than the EA (Cyprus 1%, Greece 0.5% and EA 1.7%). After 2008 things appears to change with Cyprus having higher capital growth rates than the EA averages (Cyprus 2% and Euro 1.2%). Greece remained below EA and close to zero, 0.16%. Disinvestment is observed in both Greece and the EA.

With respect to labor growth (Figure 3) we observe that before 2008 (1996-2007) there existed large variation in both Greece and Cyprus, but the growth rates were positive on average. After 2008, we observe a reduction in the labor growth rates (they become negative) in Greece, Cyprus and the EA. In 2011, Cyprus and the EA manage to achieve a positive, but close to zero, labor growth rate, while in Greece the negative growth rates continue. Here we refer to adjusted labor input, meaning that the self employees are also included in our analysis (follow the ECB report). From 1996 to 2011, labor input in Cyprus increased by a modest average rate of 2.1%. Greece had growth rates close to zero while in the EA labor growth

was below Cyprus, recording a 0.6% average growth. Before 2008, Cyprus had average growth rates of 1.7%, Greece and EA close to 1%, while after 2008 negative growth rates are observed in Greece -2%, a close to zero for the EA and 0.7% in Cyprus.

FIGURE 2

Capital growth (1996-2011)

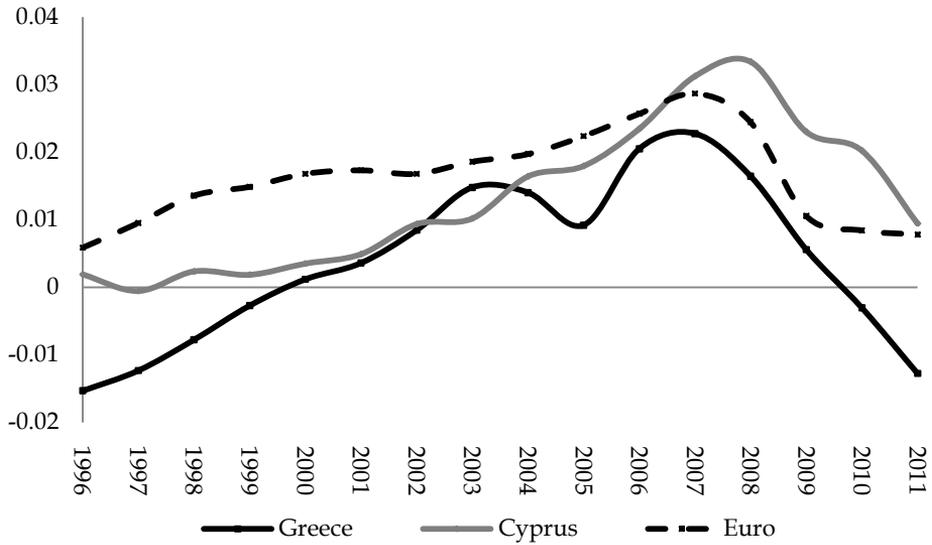
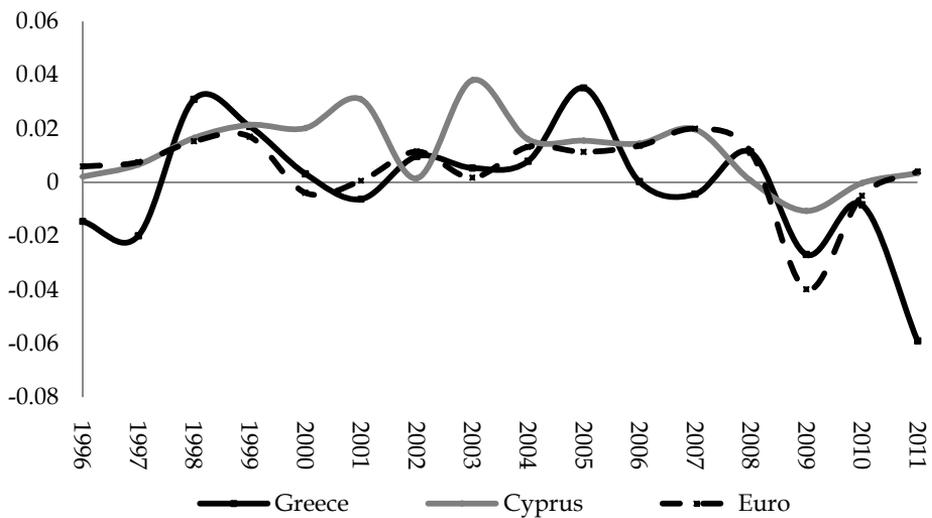


FIGURE 3

Labor growth (1996-2011)



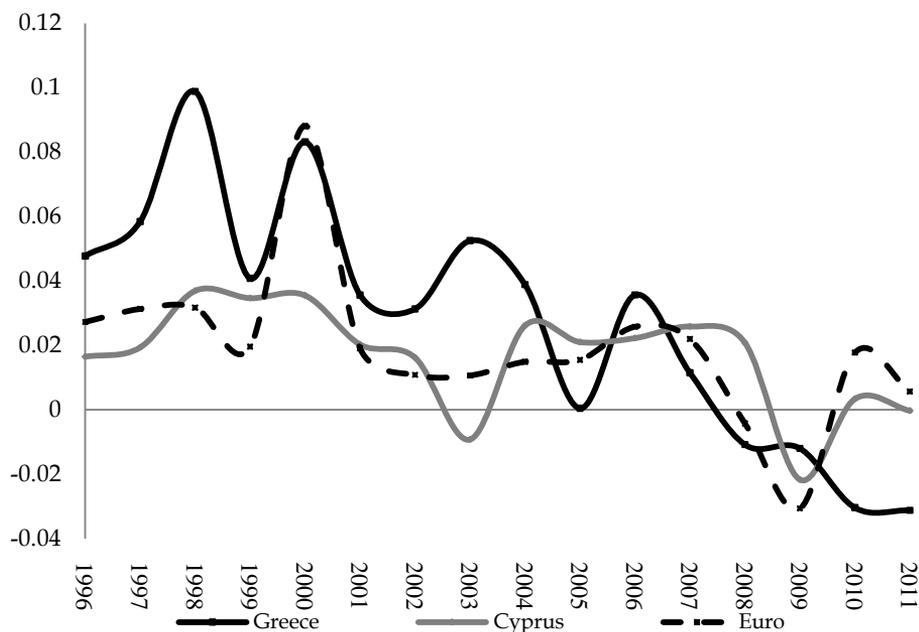
4. Results

4.1 TFP and labor productivity

Figure 4, shows that TFP growth for Cyprus was positive throughout the period, slightly below the EA average (Cyprus 1.67%, Greece 2.82%, EA 1.91%). After 2008, the average growth for Cyprus was around zero (0.06%) whereas Greece and the EA recorded negative rates of 2.1% and 0.3% respectively. On average, for the period 2008-2011 Cyprus appears to be more competitive than Greece and the EA. However, after 2010 the TFP growth rate in Cyprus is lower than the EA average, therefore it is losing competitiveness relative to the EA (TFP growth rates for EA become positive). Greece had a negative growth rate which remains negative until 2011.

FIGURE 4

Total factor productivity growth (1996-2011)

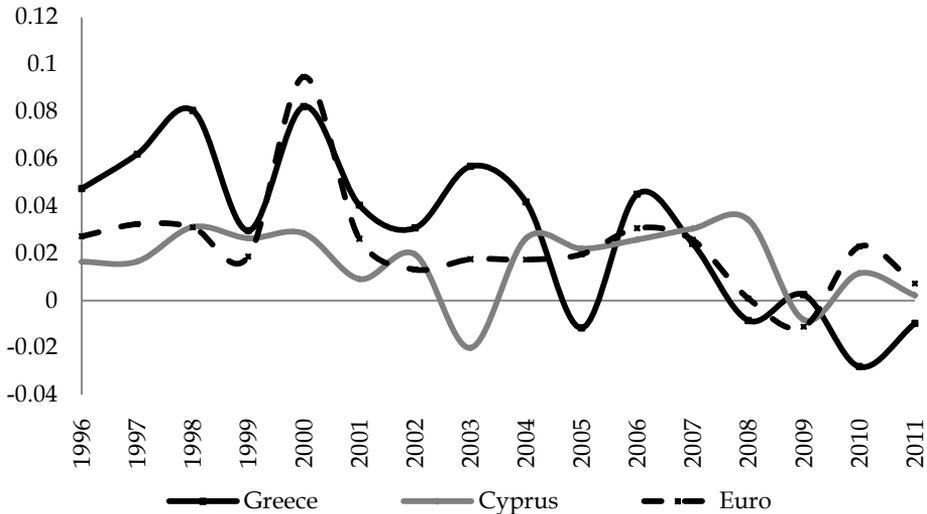


Labor productivity growth (Figure 5) during the period 1996-2011 in Cyprus was on average around 1.7%, while for Greece was around 3% and for the EA 2.3%. Before 2008, labor productivity growth ranged at the same levels, with Cyprus having lower rates than the EA and Greece. After 2008,

labor productivity rates for both Cyprus and the EA dropped nearly close to zero while for Greece they became slightly negative.

FIGURE 5

Labor productivity growth (1996-2011)



Capital deepening (Figure 6) in Cyprus on average contributes 0.02% (close to zero) to labor productivity. The corresponding numbers for Greece and the EA are 0.22% and 0.43% (again close to zero). During the years just before the crisis, the contribution of capital deepening to labor productivity was very small for all countries, especially for Cyprus for which the contribution was very close to zero. After 2008, the same situation continued, i.e. small and positive contribution of capital deepening to labor productivity.

4.2 Output growth decomposition

The measure of output is value added, which basically includes capital and labor. These two components, along with total factor productivity, explain the increases/decreases in output growth. In Tables 1 and 2 (see also graphs in the Appendix) we present the results for the decomposition of output in Cyprus, Greece and the EA for the period 1996-2011 and sub periods 1996-2001, 2002-2007 and 2008-2011.

FIGURE 6
Capital deepening (1996-2011)

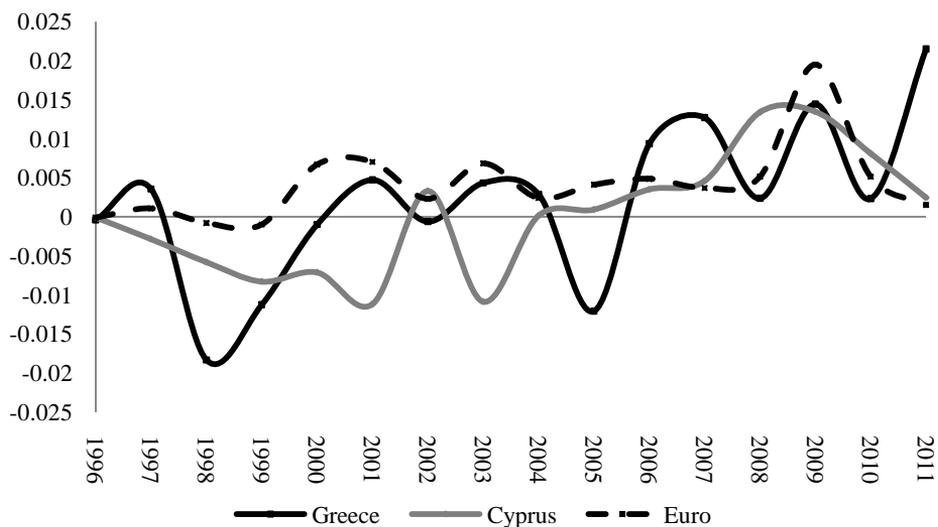


TABLE 1

Output growth decomposition (average growth rates, %)

Country/ Area	Period	Output growth	TFP growth	Labor contribution	Capital contribution
Cyprus	1996-2011	2.921	1.674	0.728	0.520
	1996-2001	3.758	2.720	0.940	0.098
	2002-2007	3.485	1.705	1.070	0.710
	2008-2011	0.820	0.057	-0.105	0.868
Greece	1996-2011	2.944	2.818	-0.054	0.180
	1996-2001	5.943	6.080	0.125	-0.262
	2002-2007	4.019	2.841	0.482	0.697
	2008-2011	-3.165	-2.107	-1.127	0.068
EA-17	1996-2011	2.867	1.909	0.291	0.667
	1996-2001	4.544	3.619	0.408	0.516
	2002-2007	3.256	1.662	0.676	0.918
	2008-2011	-0.234	-0.285	-0.464	0.515

TABLE 2
Growth acceleration /deceleration (average growth rates, %)
Difference from previous period

Country/ Area	Period	Output	TFP	Labor	Capital
Cyprus	1996-2001	-	-	-	-
	2002-2007	-0.273	-1.015	0.130	0.612
	2008-2011	-2.665	-1.648	-1.175	0.158
Greece	1996-2001	-	-	-	-
	2002-2007	-1.924	-3.239	0.356	0.959
	2008-2011	-7.184	-4.948	-1.608	-0.628
EA-17	1996-2001	-	-	-	-
	2002-2007	-1.288	-1.957	0.268	0.401
	2008-2011	-3.490	-1.947	-1.141	-0.403

During the period 1996-2011, output growth in Cyprus was 2.9%, which is very close to the EA average. TFP growth has been the most important contributor to that growth rate, explaining more than half of growth rate. Labor also made a significant contribution, while the remainder was accounted for the capital. As regard to the EA, TFP growth was also the most important contributor, explaining around 70% of the growth rate. Capital had a significant contribution whereas labor contribution was rather small.

It is interesting to see what happened the years before and after the economic crisis. Before 2008 Cyprus managed to sustain a growth rate of around 3.5% which again was close to the EA average rate, while Greece had a growth rate of around 4%. After 2008, Greece had a negative growth rate of 3.2% while Cyprus presented slightly positive rates, in contrast with the EA countries which had marginally negative growth rates. It seems that labor is the major drive force behind the reduction in the growth of output during the period 2008-2011.

Specifically, during 1996-2011, TFP growth contributes positively on average to output growth in Greece, the EA and Cyprus, explaining about 95%, 66% and 57% of growth respectively. For Cyprus, second comes the contribution of labor, which explains about 25% of output growth, and last is the capital whose contribution is around 18%. There is a different picture in Greece and the EA. In the EA, capital contributes about 23% and labor

10%, while in Greece capital explains 6% and labor has a negative contribution, therefore pushing output growth downwards.

During the period 1996-2001, output growth again was mostly explained by TFP growth in all countries. Capital growth was still important in the EA but less important in Cyprus where labor contributed about 25%. In Greece, capital and labor had a very small contribution with capital having a negative one.

The period 2002-2007 was characterized by a slowdown in TFP contribution in all countries. Both capital and labor growth increased their contribution in all countries.

Finally, after 2008 (2008-2011) the EA had a slightly negative growth rate (-0.23%) Greece had a negative growth rate of -3.17% and Cyprus had a slightly positive growth rate about 0.82%. In the EA we had a dramatic decline in the contribution of TFP and labor growth (both contributed negatively in output growth and this is the reason for the reduction of output). The reduction would have been higher if capital growth was not positive (notice though that capital decelerated). In Greece, a dramatic decline in the contribution of labor and TFP growth was also observed. Both have been decelerated and caused the negative output growth. Capital growth had a small positive contribution close to 2% of the output growth.

In Cyprus, we also had a decline in the labor and TFP contribution, but only labor growth had a negative one. TFP growth still had a positive contribution (close to 7%) but it decelerated. The contribution of capital growth was positive and capital appeared to have a small acceleration. Output growth would have been worse (even more negative) if capital had not accelerated.

5. Conclusion

Growth Accounting provides a useful framework for analyzing observed output growth into components associated with changes in factor inputs and total factor productivity. It is an empirical tool useful as a first approximation in order to understand long-run economic growth.

Our method decomposes output growth to its components for Cyprus, Greece and the EA. The period covered is 1996 to 2011. Our results, especially after 2008, suggest that Greece has a negative TFP growth rate, while Cyprus and the EA averages appear to be close to zero. A similar picture emerges with respect to labor productivity. Capital deepening appears to be small in all countries under investigation.

With respect to output decomposition, we observed that in the period 2008-2011, there was a dramatic decline in the contribution of TFP and labor growth in both the EA and Greece. Both contributed negatively to output growth and this is the reason for the reduction of output growth. The reduction would have been higher if capital growth was not positive (notice though that capital decelerated). In Cyprus, a decline in the labor and TFP contribution was also observed, but only labor growth had a negative contribution; TFP growth still had a positive contribution but it decelerated. The contribution of capital growth was positive and capital appeared to have a small acceleration. Output growth would have been worse if capital had not accelerated.

Appendix

A.1. Output Growth Decomposition

FIGURE 7

Output growth decomposition (2002-2007)

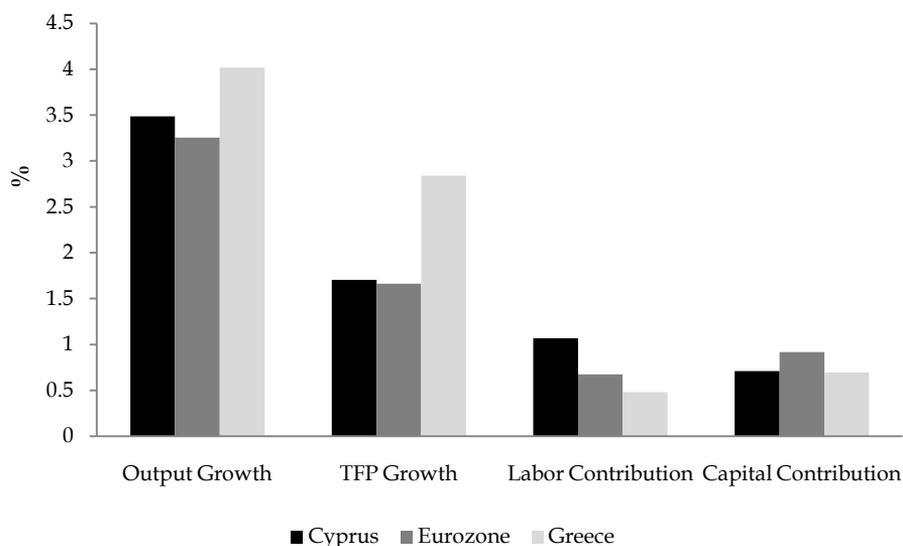
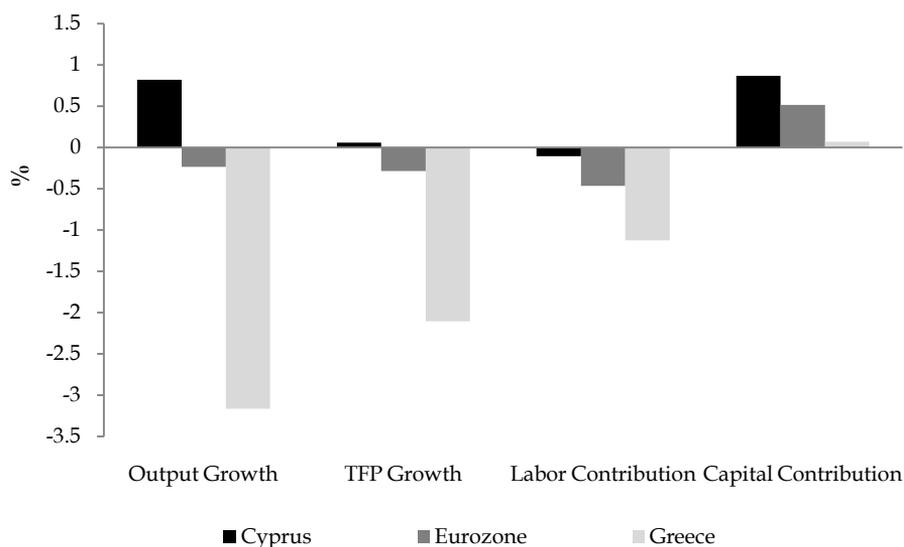


FIGURE 8

Output growth decomposition (2008-2011)

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