**The Determinants of Labour Productivity in the Greek Economy**

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Decomposition techniques are widely used to detect and evaluate the relative importance of determinants that identify the changes of a specific variable. The aim of this paper is to investigate the impact effect in labour productivity changes, using Index Decomposition Analysis (IDA) and Structural Decomposition Analysis (SDA). Both methods are applied to the Greek economy, over the period 1995-2010, at a sectoral level. Although IDA and SDA approaches are used to assess the driving forces of labour productivity, there are significant differences between them. IDA is based on index number theory and expresses simple relationships using aggregate data and SDA is based on input-output analysis and expresses complex interindustry relationships using analytical data in matrix form. In this paper, both decomposition techniques are adapted to generate a framework to identify the potential sources which affect the formation of labour productivity and to determine significant differentiation in productivity level between sectors of economic activity.

Keywords: Structural Decomposition Analysis, Index Decomposition Analysis, Labour Productivity, Greek economy

1. **Introduction**

Τhe Greek economy growth rate during the period 1995–2009 had better performance than more of the developed EU countries. The convergence indicator of the country compared with EE-15 stood at 84.5% in 2008, while from 2009 shows a steady decline about 8% a year. However, despite the positive growth rate, since 2007 the large public sector deficit and the chronic deficit in the current account are the strong destabilizing factors of the Greek economy (Bank of Greece, 2012). Specifically, the cumulative reduction in annual GDP growth rate for the period 2008-2011 reached 13.2%, while for the period 2007-2011 amounted to 17.2%. The budget deficit despite continuous budgetary measures in 2011 stood at 10.6% of GDP from 15.5% in 2009[[1]](#footnote-1) (Eurostat). In the same time, the unemployed persons in 2011 are approximately 1,000,000 (≈ 20% of active population) from 450,000 in 2008 (7.8% of active population). The doubling of unemployment rate (2009-2011) reduced also the real wages by 11.5% in the whole economy and by 9.2% in private sectors in 2010-2011 (OECD, 2011). The annual deflator of GDP in 2010 stood at 2.6% versus 1.3% in 2009, while for 2011 and 2012 provided a further reduction of 0.3% and 0.4%, respectively. This indicates that the economy has begun a gradual adjustment of prices at the new lower level of output and employment. But the competitiveness gap to be covered by the country is very important. During the period 2001-2009 Greece lost cumulatively the 22.7% of competitiveness, compared with the countries of the euro area. However, in 2010 the competitiveness has improved by 3.2% and by 3.6% in 2011. Thus the period 2001-2011, the competitiveness gap has fallen in 14.5%, respectively. Additional, the country is facing a slowdown in long-term trend in labor productivity observed from 2009. In Greece in 2010-2011, labor productivity fell by 7.6% compared with the 35 most developed countries. In fact, the decline in productivity, the loss of competitiveness, the reduction of fixed capital investment, the reducing demand, the increasing of the underemployment capacity and the rising proportion of long-term unemployed has led to a shrinking economy's potential growth rate from 1.75% in 2005-2008 to a negative size in 2011 (Bank of Greece, 2012). Given the negative circumstances for the Greek economy the aim of this research is to investigate the factors that influence the formation labor productivity in the long-term. There is no doubt that it is the leading factor of economic growth. The paper is organised as follows: Section II provides the theoretical framework; Section III contains the methodology; Section IV describes the empirical estimation for the Greek economy and Section V concludes.

1. **Theoretical Framework**

The purpose of this paper is to examine the long-term of labor productivity changes in the Greek economy over the period 1995-2010. Using input-output Structural Decomposition Analysis (SDA) and Index Decomposition Analysis (IDA), we break down the productivity changes into the changes of its determinants for the both methods, respectively **(**Rose and Casler, 1996). In particular the determinant effects are distinguished to: i) labour effect, using as factor inverse of the size of employment in working time, for both techniques ii) structural effect expressed through Leontief’s inversed matrix in SDA method and sectors' production shares in IDA method and iii) volume effect expressed by final demand and gross output, respectively. These methods have been used in many social science fields over the past decades to quantify fundamental sources of change in various economic variables (Chen and Wu, 2008). Hoekstra and Bergh (2003) have compared IDA and SDA from their fundamental differences and similarities, applying also an example. According Hoekstra **and Bergh** (2003): “SDA uses the input–output model and data to decompose changes in indicators, while IDA uses only sector level data… The two methods have developed quite independently, which has resulted in each method being characterized by specific, unique techniques and approaches. Generally speaking, the literature on IDA has extensively studied the implications of index theory and the specification of the decomposition, whereas the SDA literature has focused attention on distinguishing a large number and specific determinant effects”. Between SDA and IDA there are many differences, but “the main difference is on the model being used. SDA uses the input–output framework while IDA uses only aggregate sector information” (more analytically Hoekstra **and Bergh,** 2003; Liu Fengling, 2004). In summary, “some of the determinant effects that can be distinguished in SDA and IDA are different. SDA uses a greater amount of data and a more complex economic model, which allows for a more detailed analysis of technological and final demand effects. However, IDA remains a popular tool precisely because the data that it requires are relatively abundant. As a result, the IDA literature is characterized by greater detail of time periods and countries investigated” (Hoekstra **and Bergh,** 2003). But according to the results and numerical findings a careful choice of approach is needed i.e. in IDA studies, a number of methods have been proposed by researchers but there still exist several methodological problems in the literature (more analytically: Liu Fengling, 2004, pp xiv; 9-12).

SDA, is defined as the analysis of economic change by means of a set of comparative static changes in key parameters in an input–output table (Rose and Chen, 1991; Rose and Casler, 1996). In the traditional IO accounting framework most studies employ decomposition analysis starting from two major effects: the changes in technical coefficients and the changes in final demand (Hoekstra and Bergh 2003, Chen and Wu, 2008). Recent developments of this method proposed alternative approaches for exploring the various decomposition forms (Chen and Wu, 2008). Additionally, in this context, numerous others variable as capital, labour, energy and materials (KLEM model) have been incorporated. In this context, especially in relation to employment[[2]](#footnote-2), the method has found several applications (see Fernandez-Vazquez *et al.,* 2008). On the other hand IDA, is essentially an analytical tool designed for quantifying the driving forces influencing changes in an aggregate indicator (Liu Fengling, 2004, pp 11; 18-90). The works related with the IDA technique concerning variety of factors i.e. energy or environmental studies or others determinants is very strong (i.e. Ang and Zhang, 2000). In summary, both techniques have advantages and disadvantages, (see also Hoekstra and Bergh, 2003). In this context SDA and IDA are applied, in the same time, for the estimation of the structural and quantitative determinants effect of labour productivity changes for the Greek economy. In this study, SDA and IDA proceeds by examining the effects of three major variables (endogenous variable) on labour productivity changes. Initially for the SDA: labour, Leontief’s inverse matrix and final demand, and then for the IDA: labour, the sectoral production shares in economy and the output.

1. **Methodology**

For the estimation of the contribution of productivity’s determinants in its formation, we use the additive forms of SDA and then we transform appropriately the basic equation to adapt IDA techniques, constructing two comparable approaches. These approaches are developed according to Los and Dietzenbacher (1998), De Haan (2001),, Hoekstra and Bergh (2003) and Belegri-Roboli and Markaki (2010).

Gross labour productivity by sector of economic activity is calculated by the formula:

(1)

Where:

: gross productivity of labour by sector

: gross output by sector

: sectoral employment in hours

In matrix form, equation (1) can be transformed to:

(2)

where:

: vector of sectoral labour productivity

: vector of sectoral gross outputs

: vector of sectoral labour in working hours

Using the approach of input-output analysis, the output vector can be expressed as follow (see also Belegri-Roboli et al, 2011):

(3)

where:

: inversed Leontief matrix

y: vector of sectoral final demand

Substituting (3) to (2) we have:

(4)

If we set and =S, then

(5)

The annual change in labour productivity (Δπ), can be described in a simple input-output model as a linear additive function of economic growth in terms of changes in the inversed of employment (ΔL), changes in the economic production structure (ΔS) and changes in final demand (ΔY):

6)

where the symbol **Δ** expresses the first difference operator.

From equation (6), following Los and Dietzenbacher (1998), and De Haan (2001) method for the calculation of SDA forms without residuals, we derive the decomposition forms for the labour productivity changes into the three examined determinants between two points in time, (0) and (1). The IO-SDA expressions are as follows:

(7.1)

(7.2)

(7.3)

(7.4)

(7.5)

(7.6)

The first term in each equation corresponds to changes in labour expressed in working time. The second term involves changes in production technology, expressing in different terms the strength of sectoral interrelations or the indirect effects. The third term reflects changes in final demand (Wolff, 2006; De Haan, 2001; Belegri and Markaki; 2010).

Using Hoekstra and van der Bergh (2003) approach who calculated forms of IDA equations comparable to SDA forms; we transform equation (1) as follows:

(8)

where is the gross output of the economy.

Again, setting and using a difference equation to express the annual change in labour productivity, we estimate that:

(9)

According to equation (9), the annual change in labour productivity (Δπ), can be described as a linear additive function of economic growth in terms of changes: in production structure (), in the inversed of employment (), and in total production (). In analogy with the previous analysis, the decomposition equations resulting using IDA methods can be described as follows:

(10.1)

(10.2)

(10.3)

(10.4)

(10.5)

(10.6)

Although equations (5) and (8) have different theoretical concept, there are significant similarities between the difference equations (6) and ((9).

For both equation and consequently for the corresponding forms of decompositions, the determinant, which express the *employment effect*, is common.

* Both equations use a determinant factor to express the changes in production structure. For the SDA forms the *structure effect* is estimating by ΔS -which includes changes in the intersectoral relationships, while for IDA forms is estimated using -which includes only changes in sectoral production.
* The terms in SDA forms and in IDA, although they are referring to different economic terms, both have the significance of expressing the *volume effect* -the change in the volume of the production.

Equations (7.1)-(7.6) and (10.1)-(10.6) include all SDA and IDA forms respectively. From each equation we obtain a different value for each of the determinants and its contribution to the changes of labour productivity. For the comparison of the finding we implement the calculation of the average contribution of each factor taking into account all six equations, for both SDA and IDA methodologies. The comparison of the findings will show possible quantitative divergence between the two methods for this specific empirical application.

1. **Data**

The proposed methodology will be applied to the Greek economy (1995-2010). For the estimation of the results we use the domestic input-output tables for Greece of years 2005 and 2010 published by Eurostat[[3]](#footnote-3) using the revised sector’s classification NACE Rev.2[[4]](#footnote-4) in 62 sectors. We also use the domestic input-output table of the year 2000 (available from Eurostat in NACE Rev.1 classification) which is transformed to NACE Rev.2 classification. Using RAS methodology we created a complete time series of input-output tables. Data for output, employment in working time and final demand by sector (NACE Rev.2) are provided from Eurostat[[5]](#footnote-5). All monetary variables are expressed in constant prices (2000).

1. **Results**

The processing of the results from the application of equations (7.1) - (7.6) and (10.1)-(10.6) was completed by computing the average of each determinant, for both equation forms. For the presentation of the results we selected the 20 most important sectors of the economy which produce 79% of total output and employee 78% of total employment. The selected sectors and their share to total output and employment (in persons and working hours) along with the sectoral labour productivity for the year 2010 are presented in Table 1 (Appendix).

From Table 1 it should be noted the particularly high value of labor productivity in sectors C19 (Manufacture of coke and refined petroleum products) and L (Real estate activities). These high values ​​must be interpreted based on the product composition of each industry-specific institutional features of the country and the international prices, factors that are independent of the economic characteristics embodied in the two models examined here (For a detailed investigation of issues arising during the calculation of labour productivity see ECB, 2006). Therefore, these two sectors are excluded from the presentation since the specific approach required for this analysis exceeds the scope of this research.

For each sector of the economy, changes in variables and the effect of each determinant factor (structure effect, employment effect, volume effect) are calculated for each year. Table 2 (Appendix) and Figure 1 (Appendix) are showing the total change in each industry displays for the entire period 1995-2010.

Labour productivity, as indicated by Table 2 and Figure 1, is increasing in all sectors except the A01 (Crop and animal production, hunting and related service), where it shows a decrease of 0.38 € per working hour[[6]](#footnote-6). The largest growth occurs in sectors J61 (Telecommunications), H50 (Water transport) and D (Electricity, gas, steam and air conditioning supply) and the increase is 130.202, 128.885 and 111.160 € per working hour, respectively[[7]](#footnote-7).

According to the results of input-output analysis and the application of SDA technique, the structure effect is positive for 11 of the 18 sectors. The largest positive effects are observed in sectors J61 (Telecommunications) where the increasing effect reaches 31.23€ per working hour, M71 (Architectural and engineering activities; technical testing and analysis) where the effect is 24.21€ per working hour and in K64 (Financial service activities) where the positive impact is 23.94€ per working hour. The highest negative effects are observed in sectors C10-C12 (Manufacture of food products; beverages and tobacco) where the decreasing effect reaches -13.27€ per working hour, G45 (Wholesale and retail trade and repair of motor vehicles and motorcycles) where the effect is -3.25€ per working hour and in H49 (Land transport and transport via pipelines) where the positive impact is -1.36€ per working hour.

The employment effect as resulting from SDA forms is positive for 6 of the 18 sectors. The largest positive effects are observed in sectors J61 (Telecommunications) where the increasing effect reaches 35.96€ per working hour, H50 (Water transport) where the effect is 24.27€ per working hour and in D (Electricity, gas, steam and air conditioning supply) where the positive impact is 20.41€ per working hour. The highest negative effects are observed in sectors C24 (Manufacture of basic metals) where the decreasing effect reaches -29.02€ per working hour, M71 (Architectural and engineering activities; technical testing and analysis) where the effect is -23.29€ per working hour and in K64 (Financial service activities) where the positive impact is -14.6 € per working hour.

The volume effect as estimated in the SDA concept is positive for all sectors. The largest positive effects are observed in sectors H50 (Water transport) where the increasing effect reaches 104.59€ per working hour, D (Electricity, gas, steam and air conditioning supply) where the effect is 86.01€ per working hour and in J61 (Telecommunications) where the positive impact is 63.01€ per working hour. The lowest effects are observed in sectors G47 (Retail trade) where the decreasing effect reaches 6.07€ per working hour, I (Accommodation and food service activities) where the effect is -5.79€ per working hour and in A01 (Crop and animal production, hunting and related service) where the negative impact is -0.015€ per working hour.

According to the results of the application of IDA technique, the structure effect is positive for 11 of the 18 sectors**.** The largest positive effects are observed in sectors J61 (Telecommunications) where the increasing effect reaches 57.09€ per working hour, H5 (Water transport) where the effect is 50.55€ per working hour and in D (Electricity, gas, steam and air conditioning supply) where the positive impact is 24.08€ per working hour. The highest negative effect are observed in sectors C10-C12 (Manufacture of food products; beverages and tobacco) where the decreasing effects reaches -27.31€ per working hour, A01 (Crop and animal production, hunting and related service activities) where the effect is -10.01€ per working hour and in I (Accommodation and food service activities) where the negative impact is -8.37€ per working hour.

The employment effect as resulting from IDA forms is positive for 6 of the 18 sectors. The largest positive effects are observed in sectors J61 (Telecommunications) where the increasing effect reaches 34.56€ per working hour, D (Electricity, gas, steam and air conditioning supply) where the effect is 19.50€ per working hour and in H49 (Land transport and transport via pipelines) where the positive impact is 7.20€ per working hour. The lowest effects are observed in sectors C24 (Manufacture of basic metals) where the decreasing effect reaches -31.85€ per working hour, M71 (Architectural and engineering activities; technical testing and) where the effects is -20.19€ per working hour and in A01 (Crop and animal production, hunting and related service) where the negative impact is -16.42€ per working hour.

The volume effect as estimated in the IDA concept is positive for all sectors. The largest positive effects is observed in sectors H50 (Water transport) where the increasing effect reaches 91.29€ per working hour, C24 (Manufacture of basic metals) where the effect is 55.94€ per working hour and in D (Electricity, gas, steam and air conditioning supply) where the positive impact is 49.58€ per working hour. The lowest effects are observed in sectors A01 (Crop and animal production, hunting and related service) where the decreasing effect reaches 6.55€ per working hour, G47 (Retail trade) where the effect is 5.75€ per working hour and in H49 (Land transport and transport via pipelines) where the positive impact is 4.71€ per working hour.

A comparison between the results of the two different techniques shows significant differences between the values ​​of determinants. Even the results on the employment effect, ie the only determinant that is similar in both models, differ significantly. However, the difference in the case of the employment effect is much smaller than the differences of the other two determinants. These results demonstrate that, despite the similarities in the models described in the mathematical description, the fact that their construction involves different theoretical models, leads to entirely different results[[8]](#footnote-8).

However, you can observe a range of sectors such as: G47 (Retail trade), M71 (Architectural and engineering activities; technical testing and analysis), O (Public administration and defense; compulsory social security), P (Education) and Q86 (Human health activities), where the application of both methodologies leads to quite similar results, without major deviations.

It is also important for the economic performance of the economy to emphasize that the volume effect is stronger in both models than the influence of the other two determinants.

Finally, for the 6 of the 18 sectors the employment effect is larger than the structure effect for both methods. As shown in Table 2, these sectors are: C10-C12 (Manufacture of food products; beverages and tobacco products), D (Electricity, gas, steam and air conditioning supply), G45 (Wholesale and retail trade and repair of motor vehicles and motorcycles), H9 (Land transport and transport via pipelines), H50 (Water transport) and J51 (Telecommunications). From the sectors under investigation, we can draw the conclusion that the structure effect impacts the tertiary sector more than the secondary.

1. **Conclusions**

The aim of this paper was to investigate the determinants of labour productivity growth, over the period 2000-2008, by sector of economic activity in the Greek economy. The approach of the subject was made by two different decomposition techniques, which however contain as determinants variables with similar economic concepts. In this way, for both SDA and IDA methodologies the determinants of labor productivity reflect: the structure effect, the employment effect and the volume effect.

The most interesting results are: First, the positive impact of volume effect for all the sectors under investigation. Second, structure effect is more significant in the tertiary sector. Third, the disparity of the results shows that the methods in question   offer different evaluating possibilities for the changes in economic activity.

To conclude, a comparative study using SDA and IDA techniques for several countries taking into account structural differences is a fine example for future investigation.

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Appendix

Table 1: Selected sectors and their main characteristics (2010)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | NACE Rev.2 | Share of Output (% of total) | Share of Employment in Hours (% of total) | Share of employment in Persons (% of total) | Labour Productivity (Euros per hour, in constant 2000 prices) |
| A01 | Crop and animal production, hunting and related service activities | 3.01% | 10.77% | 10.17% | 7.97 |
| C10-C12 | Manufacture of food products; beverages and tobacco products | 4.66% | 2.85% | 2.70% | 46.57 |
| C19 | Manufacture of coke and refined petroleum products | 3.70% | 0.15% | 0.15% | 715.66 |
| C24 | Manufacture of basic metals | 1.59% | 0.44% | 0.45% | 102.71 |
| D | Electricity, gas, steam and air conditioning supply | 2.52% | 0.44% | 0.46% | 161.74 |
| F | Construction | 7.36% | 7.23% | 7.05% | 29.00 |
| G45 | Wholesale and retail trade and repair of motor vehicles and motorcycles | 1.72% | 2.24% | 2.11% | 21.91 |
| G46 | Wholesale trade | 6.78% | 7.64% | 7.49% | 25.27 |
| G47 | Retail trade | 3.91% | 12.68% | 11.74% | 8.78 |
| H49 | Land transport and transport via pipelines | 2.22% | 2.98% | 2.88% | 21.21 |
| H50 | Water transport | 4.40% | 0.90% | 0.93% | 139.70 |
| I | Accommodation and food service activities | 5.37% | 7.75% | 6.71% | 19.73 |
| J61 | Telecommunications | 3.08% | 0.54% | 0.60% | 161.34 |
| K64 | Financial service activities, except insurance and pension funding | 2.89% | 1.65% | 1.73% | 49.89 |
| L | Real estate activities | 7.95% | 0.10% | 0.10% | 2312.89 |
| M69\_M70 | Legal and accounting activities; activities of head offices | 1.89% | 2.29% | 2.25% | 23.46 |
| M71 | Architectural and engineering activities; technical testing and analysis | 1.55% | 1.56% | 1.57% | 28.30 |
| O | Public administration and defence; compulsory social security | 7.09% | 8.45% | 9.10% | 23.88 |
| P | Education | 3.39% | 3.63% | 5.57% | 26.59 |
| Q86 | Human health activities | 3.93% | 4.30% | 4.60% | 26.02 |

Table 2: Results of SDA and IDA methodologies

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | SDA | | | IDA | | |
|  | Total change of labour productivity | Structure Effect | Employment Effect | Volume Effect | Structure Effect | Employment Effect | Volume Effect |
| A01 | -0.380 | 3.010 | -3.405 | 0.015 | -10.009 | 3.083 | 6.546 |
| C10-C12 | 8.686 | -13.287 | 2.700 | 19.273 | -27.305 | 3.959 | 32.032 |
| C24 | 36.233 | 17.743 | -29.023 | 47.513 | 12.150 | -31.853 | 55.937 |
| D | 111.160 | 4.675 | 20.409 | 86.076 | 42.081 | 19.499 | 49.579 |
| F | 5.989 | -0.980 | -8.169 | 15.138 | -6.676 | -8.653 | 21.319 |
| G45 | 7.432 | -3.253 | 0.638 | 10.047 | -6.268 | 0.636 | 13.064 |
| G46 | 20.714 | 6.121 | -11.123 | 25.716 | 17.885 | -10.467 | 13.297 |
| G47 | 5.256 | 0.836 | -1.653 | 6.073 | 1.164 | -1.659 | 5.751 |
| H49 | 14.811 | -1.361 | 7.703 | 8.469 | 2.901 | 7.200 | 4.710 |
| H50 | 128.885 | 0.024 | 24.274 | 104.586 | 50.549 | -12.956 | 91.292 |
| I | 2.032 | 1.293 | -5.047 | 5.786 | -8.377 | -5.377 | 15.787 |
| J61 | 130.202 | 31.226 | 35.958 | 63.018 | 57.090 | 34.562 | 38.550 |
| K64 | 16.279 | 23.940 | -14.660 | 6.999 | -1.305 | -16.423 | 34.006 |
| M69\_M70 | 9.852 | 3.866 | -9.586 | 15.572 | 9.111 | -8.820 | 9.562 |
| M71 | 14.686 | 24.209 | -23.289 | 13.766 | 26.019 | -20.119 | 8.786 |
| O | 8.904 | 0.000 | -4.158 | 13.062 | 0.176 | -4.295 | 13.022 |
| P | 13.396 | -0.142 | -0.865 | 14.403 | 1.429 | -0.968 | 12.935 |
| Q86 | 7.854 | -0.058 | -5.334 | 13.246 | -2.370 | -4.431 | 14.655 |

Figure 1: The determinants of Labour Productivity Changes, using SDA and IDA techniques, 1995-2010

1. This is positive element for the Greek economy because it stops the adverse debt dynamic. [↑](#footnote-ref-1)
2. i.e. Skolka, 1989; Forssell,1990; Wolff, 2006; [↑](#footnote-ref-2)
3. <http://epp.eurostat.ec.europa.eu/portal/page/portal/esa95_supply_use_input_tables/data/workbooks> [↑](#footnote-ref-3)
4. More about NACE Rev.2 classification and the transition from NACE Rev.1: <http://epp.eurostat.ec.europa.eu/portal/page/portal/nace_rev2/introduction> [↑](#footnote-ref-4)
5. <http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database> [↑](#footnote-ref-5)
6. This change consists with a decrease by 4.55% [↑](#footnote-ref-6)
7. The percentage changes are 13.99% for sector J61, 92.26% for sector H50 and 68.73% for sector D. [↑](#footnote-ref-7)
8. For a more accurate picture of the economy seems necessary to investigate the results by sector of economic activity. This large-scale analysis exceeds the capabilities of this presentation. However, the sectoral results for both methods are available. [↑](#footnote-ref-8)