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EXAMINING THE CROSS-INDUSTRY RELATIONS IN THE GREEK ECONOMY DURING THE ECONOMIC CRISIS USING I-O ANALYSIS

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Abstract
The crisis that the Greek economy went through during the decade 2010-2020 had certain characteristics, which are worth studying, since they can be exploited in the future. The structural characteristics and weaknesses of the Greek economy are mentioned in the literature among the main factors that caused the economic crisis or did not allow a quick "exit" from it. The effectiveness of the interventions that seek to stimulate economic development depends to a large extent on the understanding of the general characteristics of the economy and mainly of the interconnections of the productive sectors. The study of some of the structural characteristics of the Greek economy during the 2nd period of the crisis, i.e. the period 2015-2020, is the aim of this article. Initially, the evolution of some basic macroeconomic features of the Greek economy is analyzed. Then, occurred structural changes during the above period are calculated using the Input-Output (I-O) Tables of the years 2015 and 2020, which provide a satisfactory framework for describing the interconnections between productive sectors of an economy. The analysis of the structural elements of the Greek economy during the period of the economic crisis can provide important information to be used for a successful future implementation of economic development policies. In particular, the information provided by the I-O Analysis is particularly important, since it satisfactorily describes the interconnection and operation of the productive sectors of the economy.
Keywords: Greek economic crisis, Cross-industry relations, Input-Output Analysis, economic changes, structural changes

1. INTRODUCTION

The recent economic crisis in Greece has resulted in a large loss of social welfare, as indirectly reflected in key macroeconomic figures. Characteristically, in the decade 2009 to 2019, the reduction of the real

GDP amounted to 23.6%, while the unemployment rate in the same period increased from 7.8% to 19.3% (ELSTAT, 2020; ELSTAT, 2024). The fiscal constraints and economic austerity imposed had the expected effect of lowering demand and causing a deep recession, resulting in high unemployment, having reached in 2013 to an unthinkable 27.5% (ELSTAT, 2020).

During the period 2008-13 the Greek economy went through a period of dramatic economic contraction in which output fell by around 1/4 and unemployment exceeded 25%. After a brief resurgence in the economy in 2014, the following year was economically volatile. During the first half of 2015, economic confidence was significantly affected when there was intense political uncertainty regarding the repayment of the Greek debt, while the Greek economy entered a new cycle of recession in the second half of the same year. Afterwards, there was a stabilization and after 2018 the Greek economy showed evidence of permanent growth (ELSTAT, 2020; ELSTAT, 2024). The economic crisis has affected all regions of the country, to a larger or smaller extent, depending on the structure of their economy. More generally, this crisis has led to changes in the structure of the Greek economy, its productive patterns and the way the economy operates (Pnevmatikos et al., 2019; Polyzos and Tsiotas, 2020).

After a sharp recession for about ten years in the wake of the global financial crisis, the Greek economy started to recover in 2019. The Covid-19 pandemic in 2020 interrupted the economic recovery, bringing it back into deep recession, but gradually the Greek economy is entering a growth trajectory, which is expected to be continued in the coming years (ELSTAT, 2024).

Regarding the causes of the economic crisis in Greece and the strategies that have been implemented to achieve economic growth, many analyses have been made and various and often conflicting opinions have been expressed (Kouretas and Vlamis, 2010; Christodoulakis, 2013; Galenianos, 2015; Spinthiropoulos et al., 2021; Karamouzis et al., 2022; Hardouvelis and Magginas, 2022). Most of them conclude that achieving sustainable development requires changes in public-private sector relations, investment mobility, the internal interconnections of the economy and the strengthening of outward-facing activities. The aforesaid require reversals in development and industrial policy, based on structural changes or reforms and modernization of production standards, that is, the structure and mode of operation of the economy (Galenianos, 2015; Spinthiropoulos et al., 2021; Karamouzis et al., 2022; Hardouvelis and Magginas, 2022).

As in every economic crisis, so in the case of the Greek economic crisis, changes occurred in the structure of the economy, which related to the processes of organizing productive activities and functional interconnections of the productive sectors. These changes reflect the evolution of the structure of the economy and the degree of interdependence of its productive sectors, while indirectly reflecting

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technological changes and changes in final demand. An investigation of changes in the way production activities are organized and interdependent can be achieved by exploiting information contained in input-output tables (Polyzos and Tsiotas, 2020; Miller and Blair, 2022).

An economic growth or recession is usually reflected in the evolution of key macroeconomic data. Thus, in times of economic recession or crisis, the macroeconomic elements vividly illustrate the size of the crisis and its main characteristics. For the Greek economic crisis, some key macroeconomic elements have been selected, for which their evolution during the period from 2010 to 2022 is illustrated in the next section.

Over the time, the changes in the production process show distinct features of the development processes and the mechanism at work, while allow the configuration of economic planners the most appropriate development strategy for the economy. In an economy, the changes that will be generated by a certain economic sector on other sectors will be “backward linkage” and “forward linkage”. The backward linkage effect measures the dependence of a specific sector on other sectors from which it purchases inputs; whereas the forward linkage effect measures the dependency of other sectors on a specific sector to supply outputs which they use as inputs in their production processes (Miller and Blair, 2022).

Input-output (I-O) analysis is useful for studying these inter-sector linkages, since it evaluates economic sectors and their relationship to the rest of the economy as well as providing a mechanism for identifying “key” sectors. A key sector is one whose output growth will promote growth in other sectors via its inter-sector linkages. In the economy, a key sector provides a channel for launching developmental program to stimulating economic production through its inter-sectors linkages (Polyzos and Sofios, 2008; Polyzos and Tsiotas, 2020; Miller and Blair, 2022). In general, I-O Analysis has been established as a very useful tool of economic and regional science and is used to analyze the impacts on the sectors of an economy at national, regional and local level, following investment actions or other economic changes.

Technological coefficients are the key elements of I-O Analysis, while researchers report that technological coefficients remain stable for a period of 5-10 years. Longer periods require adjustment of technological coefficients tables. The main factors affecting the stability of technological coefficients can be cited as the technological changes, changes in production process, price changes, changes in trade pattern, start-ups and other random factors (Miller and Blair, 2022).

In a previous article (Polyzos and Tsiotas, 2020), the evolution of some fundamental macroeconomic elements of the Greek economy was studied and the key structural changes that have occurred during the period from 2010 to 2015 were detected using the corresponding I-O Tables. In this article, the analysis of the structural changes of the Greek economy is continued for the period 2015-2020, using

macroeconomic data and the I-O Tables of this period. This article attempts a historical comparison for the above-mentioned period of the economic production structure of the Greek economy using Input-Output relationships.

The remainder of the paper is organized as follows: In section 2, the values of the main macroeconomic parameters that directly and indirectly reflect the performance of the Greek economy during the economic crisis are analyzed. Then the main relationships and indicators that will be used to investigate the structural changes that have been observed in the Greek economy in 2015-20 will be described. These indicators are calculated using the National I-O Tables of the Greek economy for the years 2015 and 2020. Finally, in the last section, conclusions are drawn regarding the changes in the Greek economy during the period under review, which result from the preceding analysis.

2. KEY MACROECONOMICS OF THE GREEK ECONOMY DURING THE PERIOD OF CRISIS

The starting point of the Greek economic crisis is placed in the middle of 2008 and is related to the inability of the Greek public to borrow at low interest rates from the international markets and the subsequent inability to repay the public debt (Kouretas and Vlamis, 2010; Hardouvelis and Vayanos, 2023). The crisis was reinforced by other factors, such as the structural weaknesses of the Greek economy, the lack of fiscal policy flexibility as a member of the euro zone, the low competitiveness, the lack of productive investments etc. Some of these factors are endogenous related to the structure of the Greek economy, the prolonged macroeconomic imbalances that the Greek economy faced and the credibility problem of macroeconomic policy. Other factors are exogenous connected with the financial turmoil implications and the delayed Europe's reaction to the Greek economic crisis (Christodoulakis, 2013). The crisis is considered to have ended in 2018 with the completion of the 3rd "Memorandum" or in September 2019, with the complete lifting of capital controls that had been imposed (Hardouvelis and Magginas 2022).

The crisis had significant negative effects mainly on many macroeconomic parameters of the Greek economy, such as GDP, GAV, investments, unemployment, productivity, the trade balance, the level of well-being, etc. (Economakis et al., 2015). The combination of these effects caused a wave of immigration, social unrest and changes in the way of life of the Greeks.

The economic crisis in Greece was considered more profound and lasting than in other European Union countries due to the structure and general characteristics of the Greek economy, which favored the emergence of the crisis (Dudin et al., 2016). The productive base of the Greek economy was weak as it was relied, in contrast to other European countries, on sectors such as tourism, shipping and construction,

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i.e., sectors affected first and foremost by the crisis. Greece suffered from deteriorating competitiveness as unit labor costs increased relative to international standards, causing exports to drop and current account deficits to worsen. In addition, Banks were operated at an unprecedented rate of credit expansion, both domestically and internationally, that along with other large Greek companies were exposed to an international crisis with high risks (Mavridis, 2018; Hardouvelis and Vayanos, 2023).

To illustrate the course of the economic crisis in Greece, as well as the effectiveness of the measures taken, the evolution of some key macroeconomic parameters will be presented using data from ELSTAT (2024) relating to the period 2008-2023.

The debt-to-GDP ratio is an important indicator that compares a country's public debt to its gross domestic product (GDP). Otherwise, a comparison of a country's debt-to-GDP ratio and a consideration of its evolution reliably depict the country's ability to repay its debts. This ratio can also be interpreted as the number of years it would take to pay off the debt if GDP were devoted entirely to paying off the debt. Figure 1 illustrates the evolution of three important relevant to debt macroeconomics: (a) the evolution of Debt as a percentage of GDP, (b) the rate of change of Debt and (c) the rate of change of GDP.

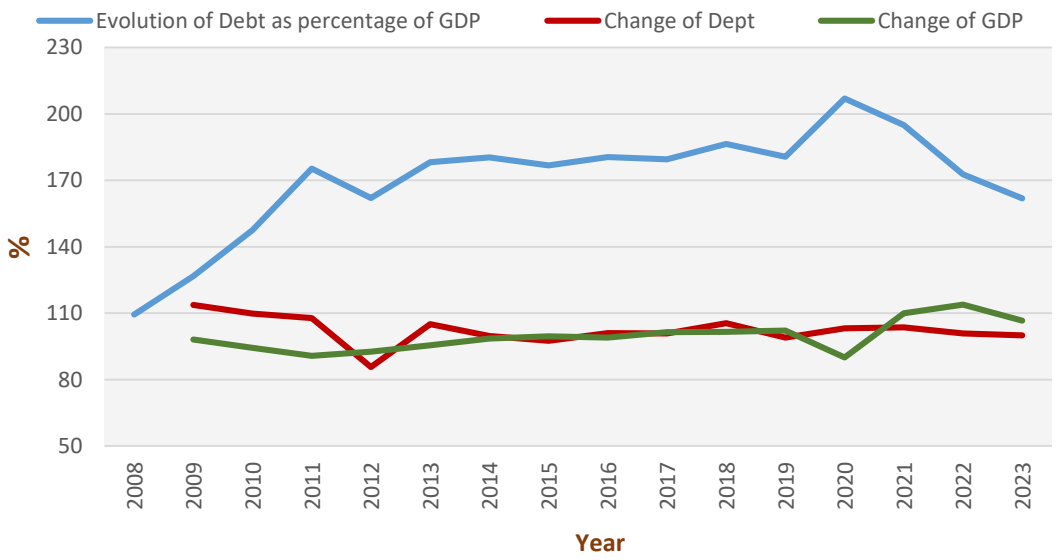

FIGURE 1 - EVOLUTION OF DEBT AS A PERCENTAGE OF GDP, THE RATE OF CHANGE OF DEBT AND THE RATE OF CHANGE OF GDP (DATA SOURCE: ELSTAT, 2024).

During the first three years of the crisis, debt-to-GDP ratio increased due to the decrease in GDP and the increase in debt. The rate then stabilized until 2019, increased in 2020 and showed sharp downward trends after 2021 due to GDP growth. Regarding the evolution of debt and GDP, the debt is stable in all the years of the crisis, while the GDP shows stabilization in the first years of the crisis and then increases.

Figure 2 illustrates the evolution of Unemployment Rate (%) for Total Population, while Figure 3 illustrates the evolution of the number of employed and unemployed during the period of the economic crisis. From the two figures it is evident the large increase in unemployment until 2014, a result of the decline in GDP and economic recession and its gradual decline thereafter.

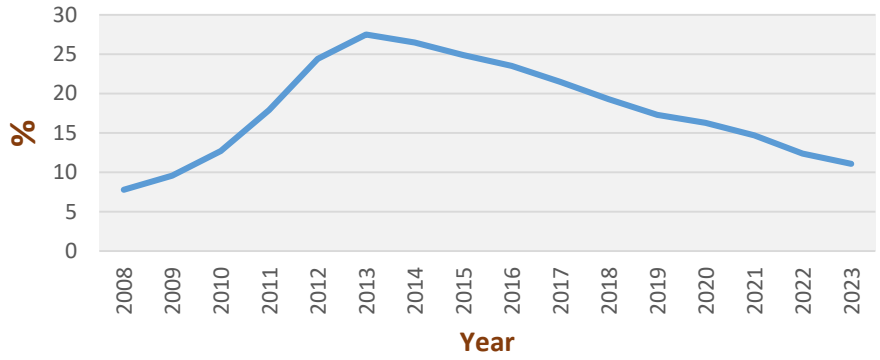

FIGURE 2 - EVOLUTION OF UNEMPLOYMENT RATE (%) FOR TOTAL POPULATION (DATA SOURCE: ELSTAT, 2024).

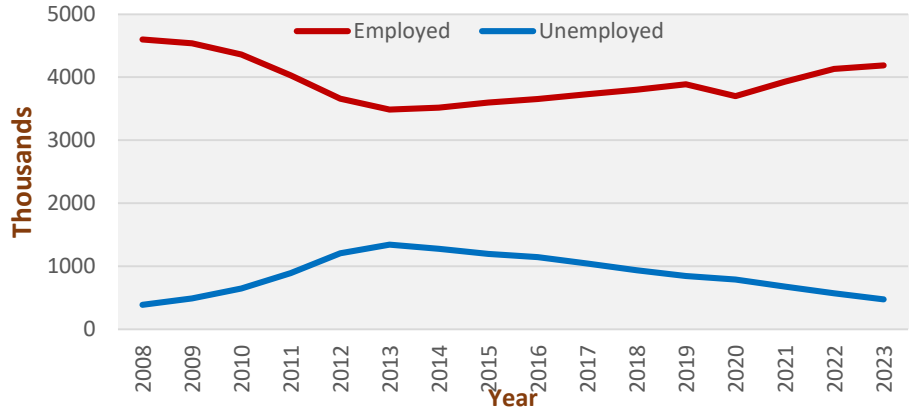

FIGURE 3 - EVOLUTION OF EMPLOYED AND UNEMPLOYED (DATA SOURCE: ELSTAT, 2024).

The main question that arises after a consideration of Figure 2 and Figure 3 concerns the reasons for the decrease in unemployment and whether it is due to the increase in consumption or investment. Also, if when GDP increases, the efficiency of the economy improves, new technology is adopted, and the economy becomes more competitive. The Greek debt crisis and Greece's recourse to the financial support mechanism at the time of the global economic crisis raises questions about the structural characteristics of the Greek economy.

For the indirect calculation of a country's international competitiveness, the balance of payments is usually used. The international trade profile of a national economy or otherwise the international competitiveness of an economy is reflected in its performance in international trade.

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Figure 4 illustrates the evolution of Imports, Exports and Trade Balance during the aforementioned period. A sharp drop in Imports during the early years of the crisis is evident, while Exports show a small but steady upward trend. Regarding the trade balance, it increases during the first and last years of the crisis, while it decreases in the period 2014 to 2019. A trade surplus is an indication of an economy that is a net creditor to the rest of the world. Conversely, a trade deficit reflects an economy that is a net debtor to the rest of the world, since it invests and consumes more than it saves from its own resources and is consequently forced to use resources from other economies to cover its domestic needs.

The main conclusions emerging from a consideration of Figure 4 are the following:

- In the period 2009-2012, a significant improvement was noted in the current account balance, due to the large reduction of the trade deficit. The negative for the economy is that this improvement was based primarily on the reduction of imports, due to the significant contraction of national income and by extension internal demand, and secondarily on the progress made in terms of export performance due to the improvement in the competitiveness of the economy.

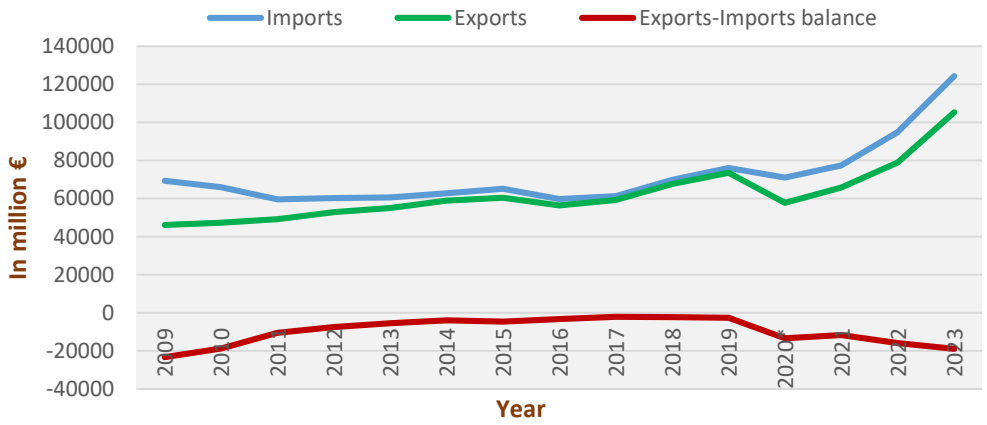

FIGURE 4 - IMPORTS, EXPORTS AND TRADE BALANCE (DATA SOURCE: ELSTAT, 2024).

- In the period 2013-2019, the trade deficit moved to historically low levels (-1.6% of GDP per year), gradual recovery of the relative competitiveness of the economy and stabilization of the trade deficit at levels close to 2 billion €. On the contrary, in the period 2020-2022 there was a significant increase in the trade deficit, reaching 20 billion € in 2022.
- Finally, to highlight the great importance of productivity in economic growth, Figure 5 calculates the relationship between Gross Value Added and Labor Productivity with elements of the Greek economy from 2009 to 2023. As can be seen in this figure, the two economic parameters show a high correlation, which leads to the conclusion that the improvement of productivity is positively related to the increase of the product of the economy.

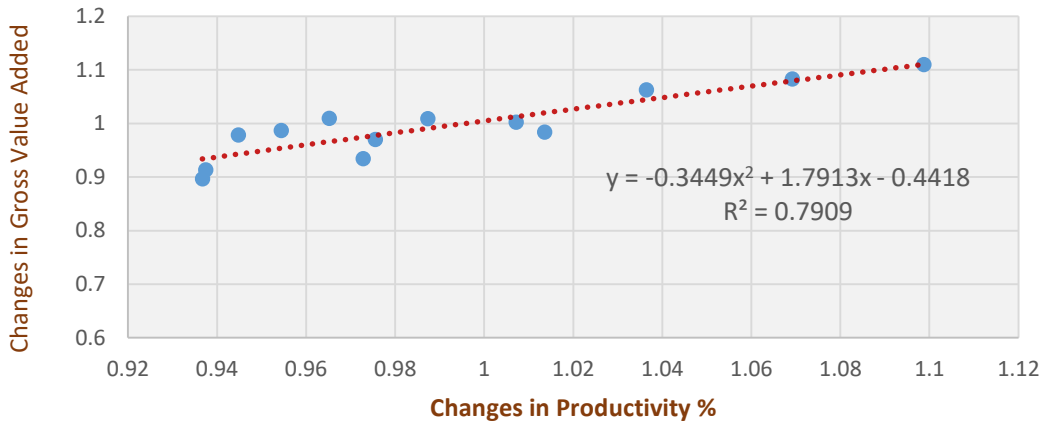

FIGURE 5 - CORRELATION BETWEEN CHANGES IN PRODUCTIVITY AND CHANGES IN GROSS VALUE ADDED (GVA).

3. ANALYSIS OF STRUCTURAL CHANGES IN GREEK ECONOMY DURING THE PERIOD 2015-2020.

3.1. Estimation of key sectors

(a) The Leontief model

The strength of domestic sectoral productive linkages and consequently the competitiveness of a national economy can be estimated using I-O Analysis (Economakis et al., 2015). The basic equation of the I-O methodology in the form of tables is the following (Miller and Blair, 2022):

$$X=(I-A)^{-1}Y=LY \quad (1)$$

where: X is the $n\times1$ vector of final product, I is the $n\times n$ Identity matrix, A is the $n\times n$ matrix of technological coefficients or direct requirements, and Y is the $n\times1$ vector of final demand.

The matrix A includes technological coefficients (a_{ij}), which show the number of units of one sector's output that are required to produce one unit of another sector's output and they are estimated by the formula $a_{ij}=x_{ij}/X_J$, $[\forall i,\ j\varepsilon(1,..n)]$, where: x_{ij} is the flow from sector i to sector j, and X_j is the total output of sector j. Technological coefficients, therefore, represent the structure of production cost, that is, the production technology used (Polyzos and Sofios, 2008; Economakis et al., 2015; Miller and Blair, 2022).

Matrix $L=(I-A)^{-1}$, which is also known as the "*Leontief matrix inverse",* expresses the intensity of the intersectoral relations of the economy. The element b_{ij} of $L=(I-A)^{-1}$ measures the additional product which will be produced by a domestic sector i if the output of j is increased by one monetary unit (Polyzos and Sofios, 2008; Miller and Blair, 2022).

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(b) The Ghosh model

A different version of presenting the financial activity of a system is the Ghosh-type model, that was introduced in 1958 by Ghosh, as an alternative approach to Leontief's I-O analysis (Miller and Blair, 2022). In Ghosh's approach, the output of each sector is related to the primary inputs or final payments. In this form of the model, output flows from each sector in fixed proportions to the other sectors, in contrast to the fixed ratios of inputs to each sector from the others that applies to the Leontief model. That is, while Leontief's model links the distribution of final demand to production requirements, Ghosh's model links the cross-sectoral distribution of output to value added, respectively.

Corresponding to the Leontief model, and with the same conditions that apply to the inverse matrix (I-B), it follows that:

$$X=V(I-B)^{-1}=VG \quad (2)$$

where: $G=(I-B)^{-1}$, which is known as the "*Ghosh matrix inverse*".

The element g_{ij} of $G=(I-B)^{-1}$ is estimated by the formula $g_{ij}=x_{ij}/X_i$, $[\forall i, j \varepsilon (1,..n)]$, where: x_{ij} is the flow from sector *i* to sector *j*, X_i is the total gross output or total outputs of the sector *i* has been interpreted as measuring the total value of production that comes about in sector *j* per unit of primary input in sector *i*.

In the Ghosh model, row and column sums in the output inverse, $G=(I-B)^{-1}=[g_{ij}]$ were given interpretations parallel to those in the Leontief quantity model. Row sums, $\sum_{j=1}^{n} g_{ij} = g_{i1} + \cdots + g_{in} = (\partial x_1/\partial v_i + \cdots + \partial x_n/\partial v_i)$, were taken to represent the effect on total output throughout all sectors of the economy that would be associated with a monetary unit change in primary inputs for sector *i*. This is the supply-side model's analog to an output (or demand) multiplier – a column sum in L.

These supply model row sums were termed input (or supply) multipliers. Also, column sums, $\sum_{i=1}^{n} g_{ij} = g_{1j} + \cdots + g_{nj} = (\partial x_j/\partial v_1 + \cdots + \partial x_j/\partial v_n)$, were interpreted as the total effect on sector *j* output if there were a monetary unit change in the supply of primary factors for each of the *n* sectors in the economy. These column sums were the supply-side model's parallel to the row sums of L in the demand model (Miller and Blair, 2022).

Both the Leontief and Ghosh models have been criticized because of the way they handle the role of some key variables. In Ghosh model, for instance, output depends on value-added and a change in a given sector's value-added will rise output everywhere with no need for additional value-added in the rest

of sectors. There is more output overall but value-added is not affected by this change. In Leontief model, output depends on final demand and any change in final demand (e.g., consumption) will raise output everywhere but this will not get reflected in any additional demand for final demand, even though overall there is more output and income around. The conclusion is that consumption is insensitive to income, something that goes against the basic principles of economics (Manresa and Sancho, 2012).

(c) Linkages in Input-Output Models

From the above equations, which describe the structure of the I-O model, production by a particular sector has two kinds of economic effects on other sectors in the economy. An increase of output of sector *j* will result in an increase of demands from sector *j* on the sectors whose goods are used as inputs to production in *j*. The term "backward linkage" is used to indicate this kind of interconnection of a particular sector with those ("upstream") sectors from which it purchases inputs.

Moreover, an increase of output in sector *j* means that additional amounts of product *j* are available to be used as inputs to other sectors for their own production. The term "forward linkage" is used to indicate this kind of interconnection of a particular sector with those ("downstream") sectors to which it sells its output (Miller and Blair, 2022).

Matrices A and B incorporate indicators of backward and forward linkages and cross-sectoral output relations. These indicators describe the degree of interdependence of the economic activities of an economy, that is, how much the product of the sectors will increase in response to changes in final demand or primary inputs, respectively. Differently, tables $(I-A)^{-1}$ and $(I-B)^{-1}$ are the multiplier matrices through which the backward linkages and forward multiplicative interactions of changes in demand or primary inputs to the economy as a whole are estimated respectively (Polyzos and Sofios, 2008; Polyzos and Tsiotas, 2020; Miller and Blair, 2022). Multipliers derived from I-O Tables are particularly important to assess the effects of changes in final demand on the output of each industry, on income, employment, etc.

Approaches have been proposed to quantify such backward and forward linkages or the "connectedness" of an economy, as well as to identify the "key" or "leading" sectors in this economy. As "key" or "leading" are defined the most connected sectors and, in some sense, they are the most "important".

In a simple form, a measure of the strength of the backward linkage of sector *j* is given by the sum of the elements in the j_{th} column of the direct input coefficients matrix, namely:

$$BL(d)_j = \sum_{i=1}^{n} a_{ij} \qquad (3)$$

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To measure both direct and indirect linkages in an economy, column sums of the matrix L=[l_{ij}], were proposed as a total backward linkage measure, that are output multipliers. So, for sector *j* we have:

$$BL(t)_j = \sum_{i=1}^{n} l_{ij} \quad (4)$$

To normalize the measure given in equation (4), the following formula has been proposed and used in empirical studies:

$$\overline{BL}(t)_j = \frac{\sum_{i=1}^{n} l_{ij}}{(1/n)\sum_{i=1}^{n}\sum_{j=1}^{n} l_{ij}} \quad (5)$$

In formula (4) the overbar suggests a normalized measure.

To measure direct forward linkage, formulas was proposed, based on matrices A and L. These formulas have been viewed with skepticism, because they are generated by a peculiar stimulus – a simultaneous increase of one unit in the gross outputs of every sector in the case of A_i and an increase of one unit in the final demands of every sector in the case of L_i (Oosterhaven, 1988; Hu and McAleer, 2004; Oosterhaven, 2012; Miller and Blair, 2022).

This questioning led to the use of the Ghosh model as more appropriate to measure forward linkages. Thus, the parallels to (3) and (4) for direct forward linkages are:

$$FL(d)_i = \sum_{j=1}^{n} b_{ij} \quad (6)$$

$$FL(t)_j = \sum_{j=1}^{n} g_{ij} \quad (7)$$

Again, to normalize the measure given in equation (7), the following formula has been proposed and used in empirical studies:

$$\overline{FL}(t)_j = \frac{\sum_{j=1}^{n} g_{ij}}{(1/n)\sum_{i=1}^{n}\sum_{j=1}^{n} g_{ij}} \quad (8)$$

From the above relationships, it follows that, sectors with a normalized interconnection index (backward and forward linkages) greater than one, have stronger branch interconnections (backward and forward, respectively), than those with a normalized interconnection index smaller than one.

Otherwise, if $\overline{BL(t)}_j > 1$, then an increase in the final demand of sector *j* by one unit will cause a greater change in the output of the economy than the average change that would be caused by the corresponding change in any other sector. Accordingly, if $\overline{FL(t)}_j > 1$, a unit increase in the output of industry *i* will cause an increase in the economic activity under consideration above the average corresponding increase due to a unit change in any other sector.

(d) "Leading" or "Key" sectors in Greek economy during the period 2015-2020

"Leading" or "key" sectors of an economy in the I-O model are the sectors that have simultaneously forward and backward linkages, as given by the normalized equations (5) and (8), greater than the average of all sectors of the economy. Identifying the leading or key sectors can be related to the size of production, employment, wages, or any other size investigated through I-O model (Allaudin, 1986; Oosterhaven, 2003; Lenzen, 2003).

Identifying the leading sectors of an economy facilitates the investigation of the magnitude of the effects of changes in supply and demand on a sector's output. Otherwise, it is easier to identify sectors with greater integration and diffusion of the endogenous dynamic feedback of the economy, as they are linked to the effects of changes in demand (backward linkages) and supply (forward linkages) (Polyzos and Tsiotas, 2020). A sector is considered to have a leading role in an economy when forward linkages and backward linkages indices are higher than unity. Conversely, a sector is considered to be non-leading if forward linkages and backward linkages indices are lower than unity. The higher the level of backward and forward linkages of a sector, the greater its contribution to strengthening the coherence of the production model and to the diffusion of an endogenous dynamic feedback of the economy through changes in supply and demand (Economakis et al., 2015; Miller and Blair, 2022).

Forward and backward linkages quantify the interactions between different sectors or, in other words, quantify the "coherence" of the economy. The sectors of the economy that are most interconnected are also the most important, in the sense that they are the ones that contribute, to a greater extent, to strengthening the internal dynamics of the economic system. Furthermore, it should be noted that sector linkages also act as a mechanism for technological diffusion between industries and for workers to move up the learning curve.

In particular, those sectors characterized by a high technological level "motivate", through backward linkages, their suppliers to develop the *know-how* needed in order to respond to the increased technological specifications demanded by buyers. Similarly, technologically advanced industries transfer *know-how* to their customers through the input products that the latter procure from the former.

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Consequently, the sectors that have strong forward and backward linkages and at the same time are characterized by high scientific and organizational know-how, based on the criteria we set above, in addition to their contribution to the coherence of the domestic production model, also act as technological diffusion mechanisms. In relation to the ones mentioned above, the examined sectors are classified as follows:

TABLE 1 - CLASSIFICATION OF BACKWARD AND FORWARD LINKAGE RESULTS

		Forward Linkage	
		Low ($\overline{FL(t)} < 1$)	High ($\overline{FL(t)} > 1$)
Backward Linkage	High ($\overline{BL(t)} > 1$)	Key sector (Leontief)/Dependent on inter-sector supply	Key sector/Generally dependent
	Low ($\overline{BL(t)} < 1$)	No Key sector/Generally independent	Key sector (Ghosh)/Dependent on inter-sector demand

These assumptions are used to identify the leading sectors of the Greek economy. With data for two or more time periods, a table of this sort for each period will give one indication of the evolution of the economy. Sectors that can be characterized as leading or key sectors are particularly important in product formation and can be determinants of economic growth and improved competitiveness. Using the I-O tables of the years 2015 and 2020 of the Greek economy, the forward and backward linkages are estimated and the leading or key sectors. With the results from the estimations, the correlation scatter plots in Figure 6 and Figure 7 are constructed.

The position of each production sector in Figure 6 and Figure 7 can reveal its characteristics. The productive sectors in the “upper-right” part of the figures can be characterized as “leading or key sectors”. These sectors for the year 2015 are: Wood and products of wood and cork, except furniture; articles of straw and plaiting materials, Other professional, scientific and technical services, veterinary services, printing and recording services, advertising and market research services, etc. For the year 2020 the key sectors are: Advertising and market research services, services auxiliary to financial services and insurance services, architectural and engineering services; technical testing and analysis services, basic metals, fabricated metal products, except machinery and equipment, printing and recording services, etc. The general conclusion drawn from Figure 6 and Figure 7 is that there has been a slight increase in the number of key sectors, as well as a diversification of them, but no significant changes in the “hierarchy” of the leading sectors of the Greek economy over the period 2015-2020.

In the “lower-left” part of the figures are the “no leading or key sectors”, that are generally independent. These sectors do not differ significantly in the examined period, while there is a slight decrease in their

number and are as follows: Services provided by extraterritorial organizations and bodies, services of households as employers, undifferentiated goods and services produced by households for own use, other transport equipment, education services, motor vehicles, trailers and semi-trailers, computer, electronic and optical products, Imputed rents, etc.

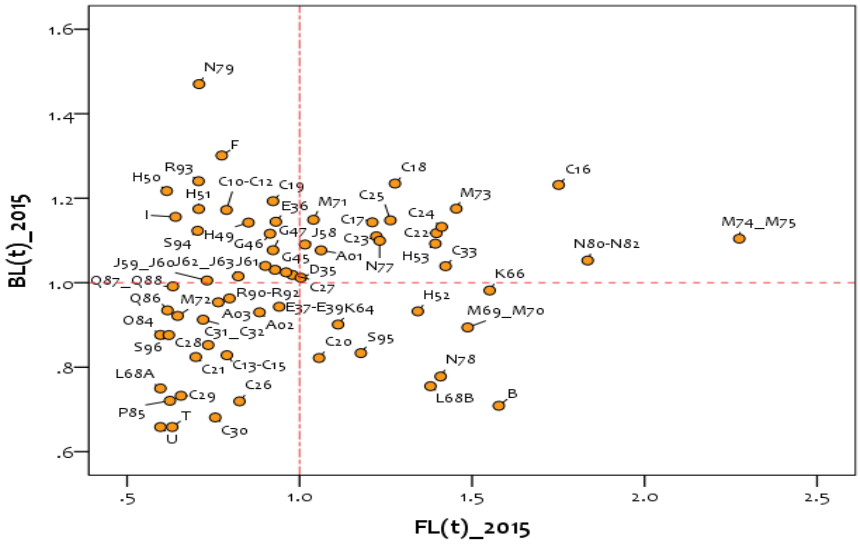

FIGURE 6 - CORRELATION SCATTER PLOT OF FORWARD LINKAGES [$\overline{FL(t)}$] AND BACKWARD LINKAGES [$\overline{BL(t)}$] OF THE GREEK ECONOMY FOR THE YEAR 2015

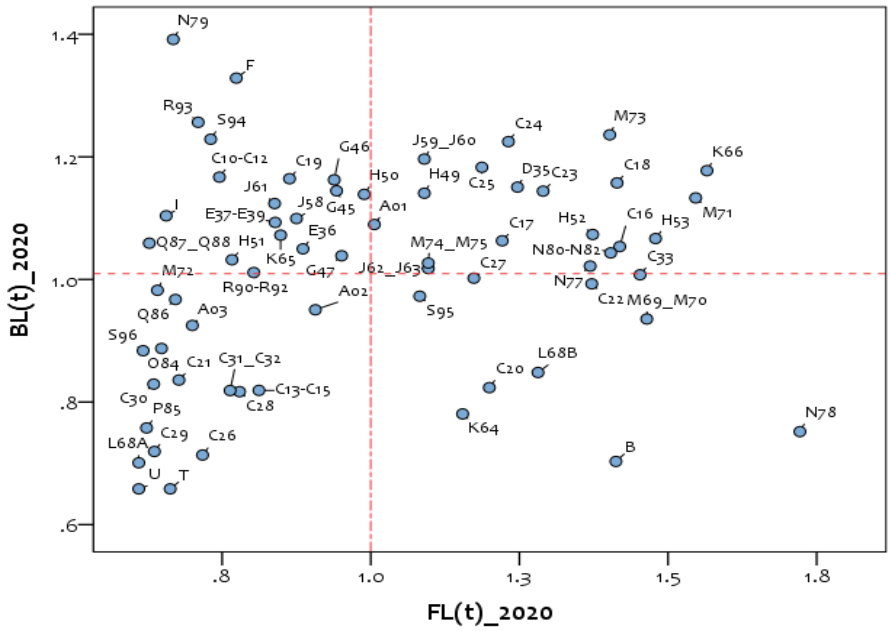

FIGURE 7 - CORRELATION SCATTER PLOT OF FORWARD LINKAGES [$\overline{FL(t)}$] AND BACKWARD LINKAGES [$\overline{BL(t)}$] OF THE GREEK ECONOMY FOR THE YEAR 2020

The "lower-right" and "upper-left" parts of the figures include the sectors with strong Forward and Backward Linkages, respectively. From the figures, small changes can be observed in the intensity of the

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interaction of the sectors, as it is reflected in the values of $\overline{FL(t)}$ and $\overline{BL(t)}$, without a significant change in the sectors belonging to these categories.

3.2. Assessment of the production techniques

The differences in the production structure of the Greek economy over the period considered can be compared using the technological coefficients of I-O Analysis (Bekhet, 2009; Polyzos and Tsiotas, 2020). This index is a measure of the comparability of production techniques on a sector-by-sector basis and is estimated from the sum of absolute differences in coefficients ("absolute column measure") divided by an "average column total" for two years, PT_j. The former is the ratio of the sum of absolute differences of all the coefficients of the j_{th} column vector of these tables, divided by the arithmetic mean of all coefficients in the two tables. The latter is the median value of the former. Specifically, the PT_j index can be estimated from the equation:

$$PT_j = 2[(\sum_{i=1}^{n} |a_{ij0} - a_{ij1}|)]/[\sum_{i=1}^{n} (a_{ij0} + a_{ij1})] \quad (9)$$

where: a_{ij0} is the technological coefficient of the reference year, and a_{ij1} is the technological coefficient for the comparator year.

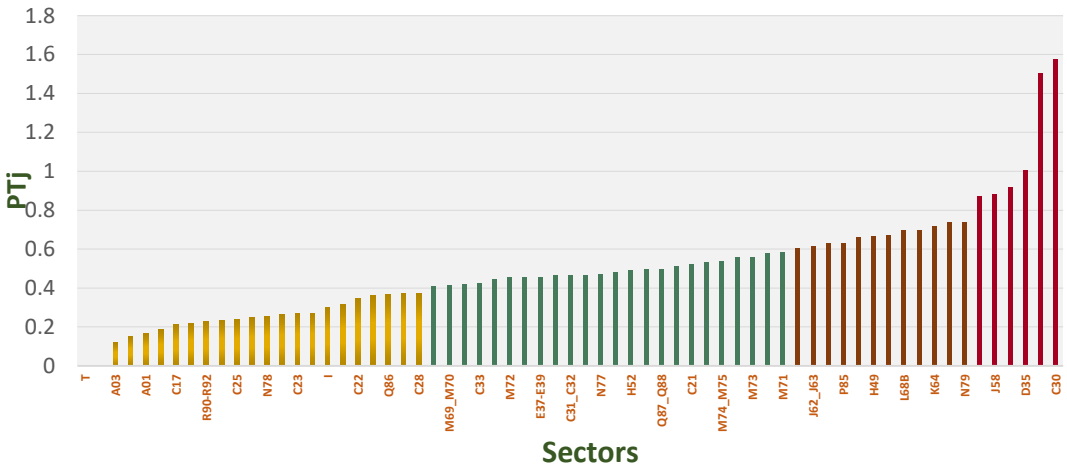

FIGURE 8 - VALUES OF PT_J INDEX ESTIMATED BY USING EQUATION (9)

From equation (9) it follows that the index PT_j values range from 0 to 2 ($0 < PT_j < 2$). In particular, when the PT_j index equals zero ($PT_j = 0$), the production techniques are completely identical in the two periods considered, while when the PT_j index equals two ($PT_j = 2$), the production techniques have the highest level of measurable difference. According to Chenery and Watanabe (1958), the value $PT_j = 0.80$ can be used as a "borderline". If $PT_j < 0.80$, the production techniques used in both cases (base year and

comparator year) are approximately the same or there are *no* significant differences. The indices of "Comparison of production techniques" will then be calculated to identify the differences in the productive structure of the Greek economy over the period considered. These indices are calculated using equation (9) and the results are shown in Figure 8.

Changes in production techniques can be distinguished into four categories. In the 1st category belong the sectors with small changes ($0 < PT_j < 0.40$), in the 2nd category the sectors with bigger changes ($0.40 < PT_j < 0.60$), in the 3rd category the sectors with even bigger changes ($0.60 < PT_j < 0.80$) and, finally, in the 4th category the sectors with big changes ($0.80 < PT_j < 1.60$). The values in Figure 8 show that there were no major changes in production techniques in most sectors, as the values of the PT_j index are relatively small. The sectors with the highest index values ($PT_j > 0.80$) are: Publishing services, motion picture, video and television program production services, sound recording and music publishing; programming and broadcasting services, imputed rents, electricity, gas, steam and air-conditioning, water transport services and other transport equipment.

The general conclusion, however, that can be drawn from a general overview of the values in Figure 8, is that in the period 2015 to 2020 there were no significant changes in the production techniques of the Greek economy in most of the production sectors. This reinforces the aspect that during a 5-year period there are no significant changes in the production process of enterprises.

3.3. Comparability in Intermediate Use

A useful approach to the problem is the examination of the degree of similarity between two I-O tables in the intermediate use of a good. Similarity between I-O tables for two years (base year 0 and comparator year 1) in the intermediate use of commodity *i* by industry *j* can be analyzed by comparing the intermediate use in the comparator table that would be necessary, using the input coefficients in the base table, with the actual level of use in the comparator table. The comparison could be done for sector *i* by multiplying the production levels of the economy in the table of the comparator year with the input coefficients (along the row) of the reference table year and dividing this sum by the total intermediate use of sector *i* of comparator year, IU_i (Bekhet, 2009; Polyzos and Tsiotas, 2020). This measure can be expressed as follows:

$$IU_i = \left(\sum_{j=1}^{n} a_{ij0} X_{j0}\right) / \left(\sum_{j=1}^{n} a_{ij1} X_{j1}\right) \quad (10)$$

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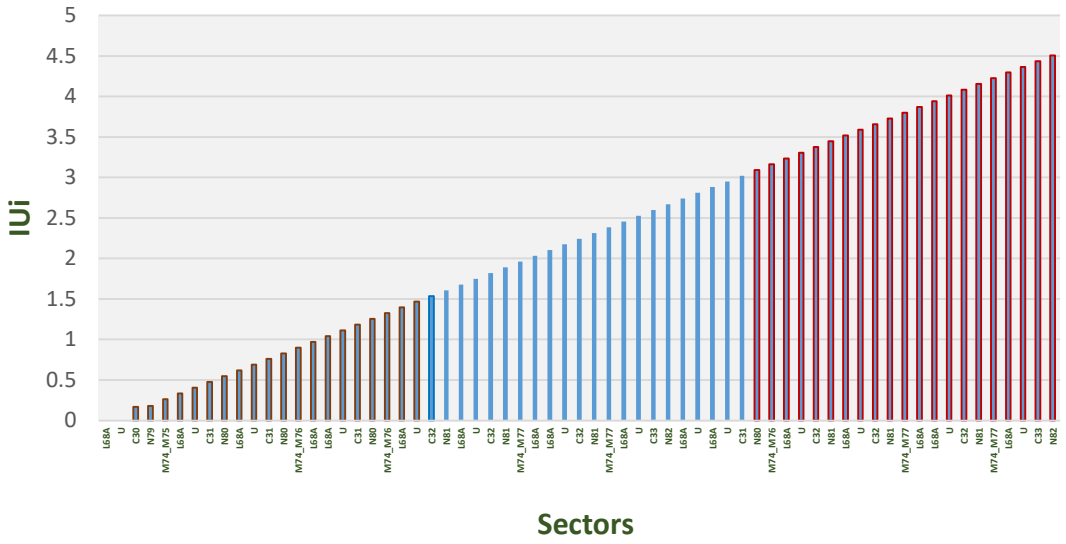

FIGURE 9 - VALUES OF IU_J INDEX ESTIMATED BY USING EQUATION (10)

The values of IU_i are affected by the patterns of intermediate use in the base year, while in the case the value of IU_i is close to 1, the similarity of the technical production between the two I-O tables will be large. Deviation of the value of IU_i from 1 may be due to various factors, such as input substitution without compensating for value variations, or conceptual differences in the definition of the products or sectors.

Then, the indices of comparison on intermediate use IU_i for the two years (reference year 2015 and comparator year 2020) are calculated. The results are shown in Figure 9, where it can be observed that a lot of indicator values are $IU_i < 0.75$ and $IU_i > 1.25$, implying a relatively large deviation from 1.

In order the effect of the table used as the base table in calculating the ratio of overall comparison to be reduced, a mixed base can be used (Bekhet, 2009). The ratio of overall comparison with a mixed base of different output level, *OC*, may be expressed as follows:

$$OC = \frac{\left[\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij0}x_{j1}\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij0}x_{j0}\right]^{1/2}}{\left[\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij1}x_{j1}\sum_{i=1}^{n}\sum_{j=1}^{n} a_{ij1}x_{j0}\right]^{1/2}} \quad (11)$$

The estimation of the index of the overall comparison by applying relation (11), gives *OC* = 1.021, which shows not very large changes for the considered period.

3.4. Changes in Gross Outputs

Another useful approach is the structural decomposition analysis (SDA), in which the gross output changes are estimated between two time periods for which I-O data are available. Using superscripts 0

and 1 for the two different years (0 earlier than 1), differences in the gross output vectors for those two years are estimated as follows (Miller and Blair, 2022):

$$\Delta X = \frac{1}{2}(\Delta L)(Y^0 + Y^1) + \frac{1}{2}(L^0 + L^1)(\Delta Y) \quad (12)$$

The term $\frac{1}{2}(\Delta L)(Y^0 + Y^1)$ quantifies the output that would be needed to satisfy old (year-0) demand with new (year-1) technology and the output needed to satisfy old demand with old technology. So, this term can be called *the effect of technology change*. The term $\frac{1}{2}(L^0 + L^1)(\Delta Y)$ has a similar kind of interpretation and can be called *the effect of final demand change*.

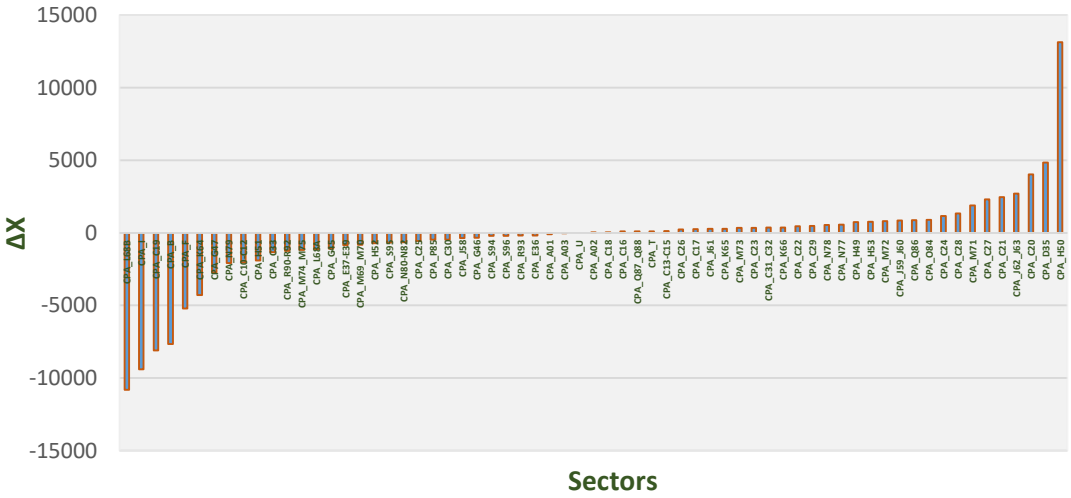

FIGURE 10 - VALUES OF ΔX INDEX ESTIMATED BY USING EQUATION (12)

By applying equation (12) for the years 2015 (year-0) and 2020 (year-1), the gross output changes for the Greek economy are obtained and the results of the calculations in ascending order, from smallest to largest, are shown in Figure 10. This figure shows the sectors with a negative change in gross output in the aforementioned period, as well as the sectors with a positive change. It is worth noting that the total GDP change of the gross output is equal to -23236 million €.

3.5. Output Multipliers

An output multiplier for sector *j* is defined as the total value of production in all sectors of the economy that is necessary to satisfy a dollar's worth of final demand for sector *j*'s output (Miller and Blair, 2022). The output multiplier for each sector is calculated from the sum of the b_{ij} elements of the corresponding

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Leontief inverse matrix column (Polyzos and Tsiotas, 2020). By using formula (13), the output multiplier is:

$$PM_j = \sum_{i=1}^{n} l_{ij} \tag{13}$$

where: PM_j is the output multiplier of sector j and l_{ij} are the elements of the Leontief's matrix L.

These indicators along with the following will be estimated using data from the National I-O Tables of 2015 and 2020. The productive content of each sector and its code are displayed in the Appendix. Using the data of intersectoral exchanges for the years 2015 and 2020, the output multipliers PM_j are then calculated from equation (13) and the final PM_j results and the multipliers differences ($PM_{j,2020} - PM_{j,2015}$) by sector are shown in Figure 11.

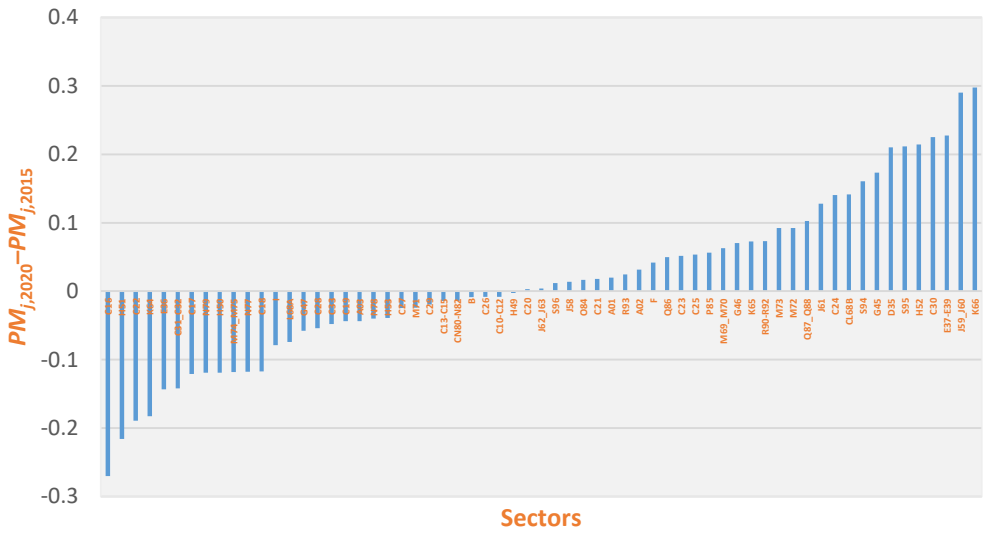

FIGURE 11 - THE CHANGES IN THE MULTIPLIER VALUES $PM_{j,2020} - PM_{j,2015}$

The conclusion that emerges from a look at Figure 11 is that, in some sectors the output multipliers have declined, while in others they have increased. In general, there have been no notable changes in the output multipliers, while the total for the year 2015 is 98.74 and for the year 2020 is 99.65.

4. CONCLUSIONS

The analysis carried out in the previous sections highlighted some of the main characteristics of the Greek economy for the period 2015-2020 and some key changes occurred. More generally, developments as well as changes concerning the structural characteristics of an economy, as they are indirectly reflected

in the interconnections of its productive branches, are linked to the ability of the economy to be more efficient and produce more product. Under a general consideration of the above results, it appears that the economic crisis did not significantly affect the production process of many sectors of the economy and there were no significant changes in their structure.

There have been no significant technological changes, as reflected in the relevant indicators calculated, with the result that the endogenous capacity of industries to generate additional output, employment and income has not been improved. However, some of the leading sectors are identified, as well as other sectors with growth prospects, which can form the core of planned development policies. It is pointed out that the time period studied is relatively short, so that no significant changes in the functioning of the economy are expected.

The final conclusions of the previous analysis can be summarized as follows:

(a) The evolution of the main macroeconomic indicators presented in section 2 indirectly showed a satisfactory effectiveness of the economic policy implemented to deal with the crisis, since the indicators in question appear to be stabilizing or improving. Macroeconomic data led to the conclusion that the Greek economy showed signs of a steady but slow recovery during the period under review. Some macroeconomic data improved, while some others, such as the trade balance, reveal the low competitiveness of the economy. The significant structural problems made the Greek economy particularly vulnerable to changes in the external environment.

(b) No significant technological changes are observed, as reflected in the relevant indicators calculated, with the consequence that the endogenous capacity of the sectors to generate additional output, employment and incomes is not improved. However, some leading sectors can be identified, which can be found at the “core” of the planned development policies, but also other sectors with growth prospects can emerge.

(c) There were no significant changes in the production techniques in most of the production sectors. This reinforces the aspect that during a 5-year period there are no significant changes in the production process of enterprises.

(d) The absence of significant technological changes resulted in the maintenance of the production process of the sectors of the economy. The modernization of the production process would improve the efficiency of individual branches and ultimately the efficiency of the entire economy.

(e) The variability of technological coefficients was limited, a finding that emerges from a consideration of similarity indices. Also, the comparison of the indicators of production techniques and indicators of

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comparison of the intermediate use did not show significant changes in the structure of the Greek economy. The changes in output multipliers were relatively small, many of them positive and many negative, while the overall effect did not change appreciabl

REFERENCES

Alauddin, M. (1986), Identification of Key Sector in the Bangladesh Economy: A Linkage Analysis Approach, *Applied Economics,* 18, pp. 421-442.

Bekhet H. A. (2009), Decomposition of Malaysian Production Structure Input-Output Approach, *International Business Research*, 2(4), pp. 129-139.

Chenery, H.B., Watanabe, T. (1958), International Comparisons of the Structure of Production, *Econometrica*, 26(4), pp. 487-521.

Christodoulakis N. (2013), From Grexit to growth: on fiscal multipliers and how to end recession in Greece, *National Institute Economic Review*, 224, pp. R66-R76.

Dudin M. N., Gayduk V. I., Sekerin V. D., Bank S. V., Gorohova A. E. (2016), Financial Crisis in Greece: Challenges and Threats for the Global Economy, *International Journal of Economics and Financial Issues*, 6(5), pp. 1-6.

Economakis G., Markaki M., Anastasiadis A. (2015), Structural Analysis of the Greek Economy, *Review of Radical Political Economics*, Vol. 47(3), pp. 424–445.

Galenianos M. (2015), *The Greek Crisis: Origins and Implications*, Research Paper No 16, Hellenic Foundation for European and Foreign Policy (ELIAMEP), Athens.

Hardouvelis G., Magginas N. (2022), Restarting the Greek Financial Sector: A Comprehensive Set of Proposals, Dianeosis policy report, May, Available, in Greek, at: https://www.dianeosis.org/wpcontent/ uploads/2022/ 05/banking-and- finance-in- Greece.pdf.

Hardouvelis G., Vayanos D. (2023), The Greek Economic Crisis and the Banks, GreeSE Paper No. 180, Hellenic Observatory Papers on Greece and Southeast Europe, London School of Economics.

Hellenic Statistical Authority - ELSTAT (2016), *Input – Output Tables, 2010,* Piraeus.

Hellenic Statistical Authority - ELSTAT (2022), *Input – Output Tables 2015,* Piraeus.

Hellenic Statistical Authority - ELSTAT (2022), *The Greek Economy*, Piraeus.

Hellenic Statistical Authority - ELSTAT (2024), *The Greek Economy*, Piraeus.

Hellenic Statistical Authority - ELSTAT (2024), *Input – Output Tables, 2020,* Piraeus.

Hu B., McAleer M. (2004), Input Output Structure and Growth in China, *Mathematics and Computers in Simulation*, 64, pp. 193-202.

Kouretas G., Vlamis P. (2010), The Greek Crisis: Causes and Implications, *Panoeconomicus*, vol. 4, pp. 391-404.

Lenzen, M. (2003), "Environmentally important paths, linkages and key sectors in the Australian economy", *Structural Change and Economic Dynamics*, 10(6), pp. 545–572.

Manresa A., Sancho F. (2012), Leontief versus Ghosh: two faces of the same coin, Working Papers XREAP2012-18, Xarxa de Referència en Economia Aplicada (XREAP).

Maris G., Sklias P., Maravegias N. (2022), The political economy of the Greek economic crisis in 2020, *European Politics and Society*, Vol. 23(4), pp. 447–467, https://doi.org/10.1080/23745118.2021.1895552.

Mavridis S. (2018), "Greece's Economic and Social Transformation 2008–2017, *Soc. Sci.,* 7, pp. 2-14; doi:10.3390/socsci7010009.

Miller, R., Blair P. (2022), *Input–Output Analysis, Foundations and Extensions*, 3nd Edition, Cambridge University Press.

Oosterhaven J. (1988), On the Plausibility of the Supply-driven Input-output Model, *Journal of Regional Science*, 28, pp. 203-217.

Oosterhaven, J. (2003), *On the Definition of Key Sectors and the Stability of Net Versus Gross Multipliers,* 50th North American Congress of the RSAI, November, Philadelphia.

Oosterhaven J. (2012), Adding Supply-Driven Consumption Makes the Ghosh Model Even More Implausible, *Economic Systems Research*, vol. 24(1), pp. 101-111.

Polyzos S., Sofios S. (2008), Regional multipliers, Inequalities and Planning in Greece, *South Eastern Europe Journal of Economics*, 6(1), pp. 75-100.

Pnevmatikos T., Polyzos S., Tsiotas D. (2019), Assessing the structural changes in the Greek Economy for the period prior to economic crisis, *Regional Science Inquiry*, XI(3), pp. 69-82.

Polyzos S., Tsiotas D. (2020), Measuring Structural Changes of the Greek Economy during the period of Economic Crisis, *Management Research and Practice*, Vol. 12(2), pp. 5-24.

Spinthiropoulos K., Tsiatsiou E., Garefalakis A., Chaitidis G., Stavropoulou E. (2021), Greek Economic Crisis Management Program and its Impact on Public Employees' Earnings: A case series and Literature Review, Polish Journal of Management Studies, vol. 24(2), pp. 431-448.

APPENDIX

Table A1: The productive sectors of the Greek economy

Code	Economic (Productive) sector
A01	Products of agriculture, hunting and related services
A02	Products of forestry, logging and related services
A03	Fish and other fishing products; aquaculture products; support services to fishing
B	Mining and quarrying
C10-C12	Food products, beverages and tobacco products
C13-C15	Textiles, wearing apparel and leather products
C16	Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials
C17	Paper and paper products
C18	Printing and recording services
C19	Coke and refined petroleum products
C20	Chemicals and chemical products
C21	Basic pharmaceutical products and pharmaceutical preparations
C22	Rubber and plastics products
C23	Other non-metallic mineral products
C24	Basic metals
C25	Fabricated metal products, except machinery and equipment
C26	Computer, electronic and optical products
C27	Electrical equipment
C28	Machinery and equipment n.e.c.
C29	Motor vehicles, trailers and semi-trailers

Code	Economic (Productive) sector
C30	Other transport equipment
C31-C32	Furniture; other manufactured goods
C33	Repair and installation services of machinery and equipment
D35	Electricity, gas, steam and air-conditioning
E36	Natural water; water treatment and supply services
E37-E39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
F	Constructions and construction works
G45	Wholesale and retail trade and repair services of motor vehicles and motorcycles
G46	Wholesale trade services, except of motor vehicles and motorcycles
G47	Retail trade services, except of motor vehicles and motorcycles
H49	Land transport services and transport services via pipelines
H50	Water transport services
H51	Air transport services
H52	Warehousing and support services for transportation
H53	Postal and courier services
I	Accommodation and food services
J58	Publishing services
J59-J60	Motion picture, video and television programme production services, sound recording and music publishing; programming and broadcasting services
J61	Telecommunications services
J62-J63	Computer programming, consultancy and related services; information services
K64	Financial services, except insurance and pension funding
K65	Insurance, reinsurance and pension funding services, except compulsory social security
K66	Services auxiliary to financial services and insurance services
L68B	Real estate activities without imputed rents
L68A	Imputed rents
M69-M70	Legal and accounting services; services of head offices; management consulting services
M71	Architectural and engineering services; technical testing and analysis services
M72	Scientific research and development services
M73	Advertising and market research services
M74-M75	Other professional, scientific and technical services; veterinary services
N77	Rental and leasing services
N78	Employment services
N79	Travel agency, tour operator and other reservation services and related services
N80-N82	Security and investigation services; services to buildings and landscape; office administrative, office support and other business support services
O84	Public administration and defence services; compulsory social security services
P85	Education services
Q86	Human health services
Q87-Q88	Social work services
R90-R92	Creative, arts and entertainment services; library, archive, museum and other cultural services; gambling and betting services
R93	Sporting services and amusement and recreation services
S94	Services furnished by membership organisations
S95	Repair services of computers and personal and household goods
S96	Other personal services
T	Services of households as employers; undifferentiated goods and services produced by households for own use
U	Services provided by extraterritorial organisations and bodies