THE MEASUREMENT OF INTERINDUSTRY LINKAGES WITH DATA ANALYSIS METHODS

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ABSTRACT

The main aim of this paper is to identify the structure of production sectors and to highlight the interindustry dependencies of Greek economy. First of all, based on the input – output tables, we use input – output analysis to create the proper tables which describe the characteristics of the Greek economic system.

The data analysis methods (Correspondence analysis and Hierarchical Cluster Analysis) are applied in order to determine the key sectors of the Greek economy and the reason which characterize them important. These methods reveal to us the structural relationships among the economic sectors, taking into account at the same time, the interdependencies and interrelations of the economic sectors.

Keywords: Input – Output, Interindustry Linkages, Data Analysis, Hierarchical Cluster Analysis, Correspondence Analysis.

1. Introduction

As it is known, the economy is an interdependent system, which structure analysis, it is particularly important regarding the investigation in national level. The significance of structure in the economy includes two basic ideas: from one point of view the heterogeneity of elements that composes the total economy and from other point, the interdependence of these elements *(interindustry linkages)*, which are quite importantly mainly connected among them.

The measurement of the interindusty linkages has a long history within the field of input-output analysis. The purpose of this measurement is to find the inter-industrial linkages of a particular industry to other industries and to the sectoral structure of an economy. Two methods, which were developed by Rasmussen (1956) and by Chenery and Watanabe (1958), have been used most widely for the measurement of such interindusty linkages (Dietzenbacher, 1991; Tzouvelekas, 2002; Adamou, 2004; Andreosso-O'Callaghan and Yue, 2004).

Since these pioneering works, many others have been proposed for the measurement of linkage coefficients. In the 1970s, these traditional measures were widely discussed and several adapted forms were put forward (Yotopoulos and Nugent, 1973; Laumas, 1976; Riedel, 1976; Jones, 1974; Schultz, 1977). More recently, linkage analysis methods have again attracted increasing attention from input-output analysts (Cella. 1984; Clements, 1990; Heimler, 1991; Mattas and Shresta, 1991; Sonis et.al., 1995; Dietzenbacher and van der Linden, 1997). With regard to the measurement of linkage coefficients, a few different methods have been presented so far (Andreosso-O'Callaghan and Yue, 2004).

In two earlier papers, (Papadimitriou, 1987; Burtschy and Papadimitriou, 1991) as well as (Hoen, 2001) have proposed the use of cluster analysis, in order to investigate the interindusty linkages.

In the present article, we use first of all, input – output analysis methods to create the proper tables, which describe the characteristics of any economic system. Then, the data analysis methods (Correspondence Analysis and Hierarchical Cluster Analysis) are applied in order to determine the key sectors of the Greek economy and the reason which characterize them important. These methods reveal to us the structural relationships among the economic sectors, taking into account at the same time, the interdependencies of the economic sectors.

2. Methodology

The input-output table which is used in this study is taken from the National Statistical Service of Greece, it is for the year 2000 and it is aggregated in 30 sectors. In our analysis we use 29 sectors, because of the zero values the sector P: Private households with employed persons, is excluded.

For the examination of backward linkages we use the $(I\text{-}A)^{-1}$, (Leontief inverse matrix), where the elements in columns denotes the share of the inputs to the sectors in rows. For the examination of forward linkages we propose the $(I\text{-}B)^{-1}$, (Ghosh inverse matrix) or (supply driven model) (Augustinovics, 1970; Jones, 1976; Dietzenbacher, 1991; Adamou, 1995), where the elements in columns denotes the share of outputs to the sectors in rows.

For the aim of data analysis the sectors in rows of the tables are considered as objects and the columns as variables. Because our objective is to determine and clarify, the relative place of sectors as for the inputs (backward linkages) or the outputs (forward linkages) that we study, we categorize the data of each matrix, according to the law of proportional distribution (Lukas, 2004; Markos; 2006; Menexes, 2006). Thus, in the $(I\text{-}A)^{-1}$matrix, the nine (9) sectors with the smaller values for each variable (inputs) constitute the 1st category – group (sectors with low inputs), the 3rd category – group (sectors with the high inputs) include the ten (10) sectors with the bigger values, while the remainder ten (10) sectors constitute the 2nd category – group (sectors with medium input) (Tzimos and Papadimitriou, 2005).

Following this example we categorize the elements of the inverse matrixes and we create two new matrixes, with categorical data, one for the investigation of backward linkages (29X29) and one for the forward linkages (29X28). The second matrix has one less column because of the sector L (Public administration and defence; compulsory social security) has only zero values.

Then, we transform them to logical matrixes with 1 and 0 elements where the twenty nine (29) initial variables of the categorized $(I\text{-}A)^{-1}$matrix after they were split in three attributes, created the eighty seven (87) attributes (Figure 1), that are the columns of the logical matrix with elements 0 and 1. The logical matrix of the categorized $(I-B)^{-1}$ matrix has eighty-four (84) columns (Figure 2).

«insert Figure 1 here»

«insert Figure 2 here»

With the logical matrixes are nominated the attributes that characterize the sectors of economic activity, contrary to the initial tables where the sectors are characterized by the inputs or outputs. Also the logical matrixes participate in the algebraic action with the same weight, as well as the sum of their elements is constant and equal with twenty nine (29) as same as the total of sectors (Tzimos and Papadimitriou 2005).

3. Backward Linkages

3.1 Hierarchical Cluster Analysis

Main characteristic of this method is that an achieved analysis will be supposed that it leads to clusters, for which the observations in each cluster to be as long as it becomes more homogeneous, but also comparing observations of different clusters differ considerable among them.

In the Hierarchical grouping method the number of clusters is not known beforehand. The methods function hierarchical with the significance that they begin using each observation as a cluster and in each step they link in clusters the observations that are found more "near".

The significance of distance and resemblance is a basic one in the Hierarchical Classification, as well as in the other methods of Data Analysis. Two observations that resemble between them, have relatively similar honours, in other words they have very small distance. The aim of Hierarchical Classification is to create clusters through which the observations abstain little, while the observations of different clusters abstain among them enough (Tzimos, 2006).

In the cases that we don’t know beforehand the important characteristics, it is preferable to follow the algorithm of Hierarchical Classification (CAH). This begins with each observation as a group and links then in clusters the sectors that are more near, creating successively superior clusters, according to the criteria where are involved all the characteristics that were used for the description of initial objects (Papadimitriou, 2005).

We apply initially the method of Hierarchical Cluster Analysis with which we create homogenous groups of sectors. So that the sectors they differ considerably among them, in order the attributes that contribute in the characterization and split of clusters created to be sought and determined, without a priori affair in the initial table (Papadimitriou, 2005; Drosos, 2005;).

In the dendrogram of Cluster Analysis (Figure 3) we observe that the initial node 57 is split into two clusters 56 and 52. This split is owed to the supremacy of cluster 52 against cluster 56 as for the low inputs. Cluster 52, includes 7 sectors (24% of total economy) which are (M: Education, K: Real estate, renting and business activities, DL: Manufacture of electrical and optical equipment, DM: Manufacture of transport equipment, DK: Manufacture of machinery and equipment n.e.c, DF: Manufacture of coke, refined petroleum products and nuclear fuel and CA: Mining and quarrying of energy producing materials).

«insert Figure 3 here»

Thanks to algorithm of Hierarchical Cluster Analysis, we have the possibility to know the characteristics of the cluster groups. These sectors are characterized mainly from low inputs of products and services of the sectors A: Agriculture, hunting and forestry, DB: Manufacture of textiles and textile products, G: Wholesale and retail trade; repair of vehicles and household goods, DA: Manufacture of food products, beverages and tobacco, DG: Manufacture of chemicals, chemical products and man-made fibres, E: Electricity, gas and water supply, I: Transport, storage and communication and DF: Manufacture of coke, refined petroleum products and nuclear fuel.

Cluster 56 considered as node is split into clusters 54 and 55. Cluster 54 includes 12 sectors (41% of total economy) which are O: Other community, social and personal service activities, N: Health and social work, L: Public administration and defence; compulsory social security, J: Financial intermediation, H: Hotels and restaurants, DC: Manufacture of leather and leather products, DG: Manufacture of chemicals, chemical products and man-made fibres DN: Manufacturing n.e.c., DA:

Manufacture of food products, beverages and tobacco, I: Transport, storage and communication, B: Fishing, and A: Agriculture, hunting and forestry.

These sectors are characterized of high product inputs from the sectors, DA: Manufacture of food products, beverages and tobacco and B: Fishing also of low product input from the sectors DL: Manufacture of electrical and optical equipment, A: Agriculture, hunting and forestry and DA: Manufacture of food products, beverages and tobacco.

The rest 10 sectors (35% of total economy) are the most important for the Greek Economy because they have high effect to the other sectors as they characterized of high product inputs from the sectors G: Wholesale and retail trade; repair of vehicles and household goods, DD: Manufacture of wood and wood products, DE: Manufacture of pulp, paper, paper products; publishing and printing, DH: Manufacture of rubber and plastic products, DB: Manufacture of textiles and textile products, E: Electricity, gas and water supply, CB: Mining and quarrying except energy producing materials, F: Construction, DJ: Manufacture of basic metals and fabricated metal products and DI: Manufacture of other non-metallic mineral products.

The main characteristics of them are the high inputs form the sectors E: Electricity, gas and water supply, J: Financial intermediation, DH: Manufacture of rubber and plastic products and the medium inputs from the sector O: Other community, social and personal service activities.

3.2 Correspondence Analysis

The Hierarchical Cluster Analysis is one useful method to see which sectors are strongly interrelated, when no specific sector is given in advance, but without ordinance. To avoid this problem, we use the Correspondence Analysis which answers this question.

As we see in next figure 4, in the first factorial axis we have in ordinal positions from right to left, the sectors CA, DK, DF, DM, DL, M, E, with the low inputs which characterize them. These sectors are the same as in node 52 of the Hierarchical Cluster Analysis. In the other side of this axis we have all the rest sectors with the most important characteristics.

«insert Figure 4 here»

In the second factorial axis (Figure 5) we observe the split of node 56. From the right to left side we have the sectors N, O, H and L, with the inputs which characterize them. In the left side we have the sectors DI, DJ, CB which are mostly contributed in the creation of this axis.

«insert Figure 5 here»

4. Forward Linkages

4.1 Hierarchical Cluster Analysis

In the following figure 6, we observe three clear groups of sectors (clusters). The initial node 57 (where included all sectors) is split first to the 53 and then to the 56 node. Cluster 53, includes 9 sectors (31% of total economy) which are the sector L: Public administration and defence; compulsory social security, N: Health and social work, DC: Manufacture of leather and leather products, M: Education, B: Fishing, H: Hotels and restaurants, F: Construction, A: Agriculture, hunting and forestry and DA: Manufacture of food products, beverages and tobacco. These sectors are characterized of low outputs mainly to the sectors DF: Manufacture of coke, refined petroleum products and nuclear fuel, DI: Manufacture of other non-metallic mineral products, DJ: Manufacture of basic metals and fabricated metal products, DK: Manufacture of machinery and equipment n.e.c. and to the sector DM: Manufacture of transport equipment.

«insert Figure 6 here»

Cluster 56 considered as node is split into clusters 51 and 55. Cluster 51 includes 9 sectors (31% of total economy) which are CA: Mining and quarrying of energy producing materials, E: Electricity, gas and water supply, J: Financial intermediation, DH: Manufacture of rubber and plastic products, DJ: Manufacture of basic metals and fabricated metal products, DE: Manufacture of pulp, paper, paper products; publishing and printing, DG: Manufacture of chemicals, chemical products and man-made fibres, DF: Manufacture of coke, refined petroleum products and nuclear fuel and G: Wholesale and retail trade; repair of vehicles and household goods.

These sectors are the most important in Greek economy for the year 2000, because they are characterized of high outputs to the other sectors, mainly to the DD: Manufacture of wood and wood products, DE: Manufacture of pulp, paper, paper products; publishing and printing, DA: Manufacture of food products, beverages and tobacco, DF: Manufacture of coke, refined petroleum products and nuclear fuel, DG: Manufacture of chemicals, chemical products and man-made fibres and to the sector DH: Manufacture of rubber and plastic products.

The rest 11 sectors (38% of total economy) are characterized by medium outputs mainly to the sectors DD: Manufacture of wood and wood products, DE: Manufacture of pulp, paper, paper products; publishing and printing, DF: Manufacture of coke, refined petroleum products and nuclear fuel, DA: Manufacture of food products, beverages and tobacco, DH: Manufacture of rubber and plastic products and DH: Manufacture of rubber and plastic products. These sectors are CB: Mining and quarrying except energy producing materials, DD: Manufacture of wood and wood products, DN: Manufacturing n.e.c., DI: Manufacture of other non-metallic mineral products, DB: Manufacture of textiles and textile products, DK: Manufacture of machinery and equipment n.e.c., DL: Manufacture of electrical and optical equipment, DM: Manufacture of transport equipment, I: Transport, storage and communication, O: Other community, social and personal service activities and K: Real estate, renting and business activities.

4.2 Correspondence Analysis

In the first factorial axis (Figure 7) which represent the first split we observe ordinary placed from right to the left the sectors L, H, DC, B, N, M, DA and F with the low outputs to the other sectors which characterize them.

«insert Figure 1 here»

In the second factorial axis (Figure 8) we observe the spit of the node 56 to the 51 and 55. From right to left we have ordinary placed the sectors E, J, DH and CA with the characteristics which are the high outputs to other sectors and from the other side of 2nd axis we see the sectors DI, DK, DM, O and I, with the attributes (medium outputs) which mostly contributed in the creation of this axis.

«insert Figure 8 here»

5. Conclusion

Regarded as the study of relationship and interdependency among the sectors is important to economic growth, we used Data Analysis methods to identify the interindustry linkages for the Greek economy.

Firstly, we applied the method of Hierarchical Cluster Analysis, to create homogeneous groups of sectors which have the same characteristics. With this method we have the possibility to know which attributes grouping the sectors together. The sectors with high inputs (backward linkages) or outputs (forward linkages) have high effects to other sectors (which characterize them) so they are the most important for the whole economy.

Finally, with the use the Correspondence Analysis we distinguish in the factorial axes the sectors in ordinary position together with their attributes.

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ANNEX

A.1 FIGURES

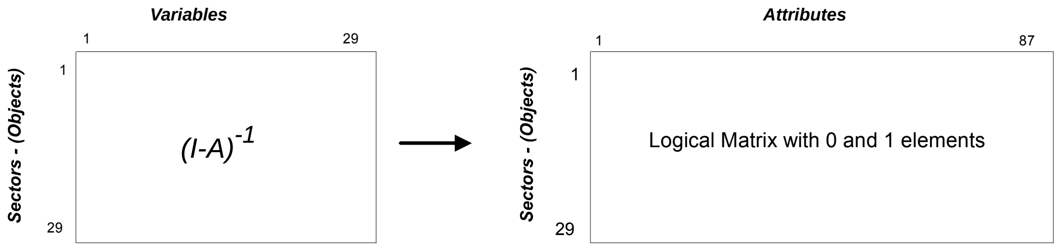

Figure 1. Leontief Matrix Transformation (Inputs)

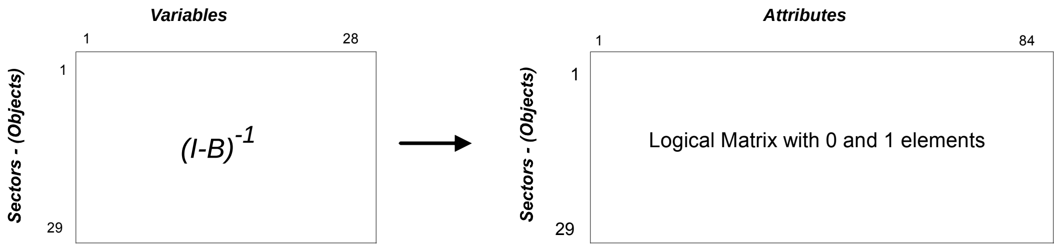

Figure 2. Ghosh Matrix *Transformation (Outputs)*

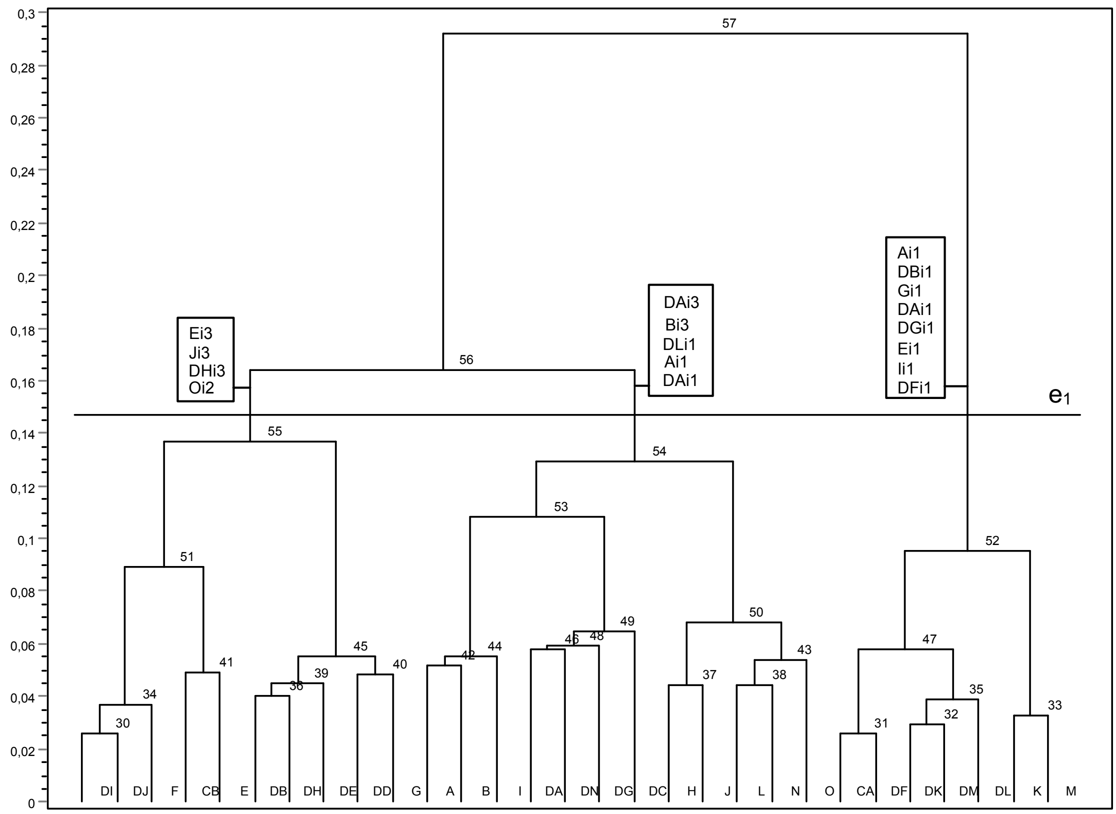

Figure 3. Cluster Dendrogram of Backward Linkages

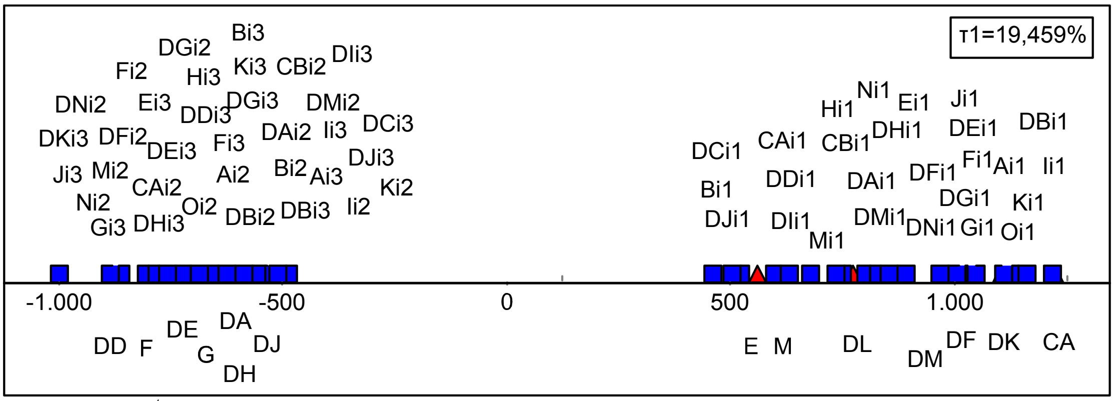

Figure 4. 1st Factorial Axis of Backward Linkages

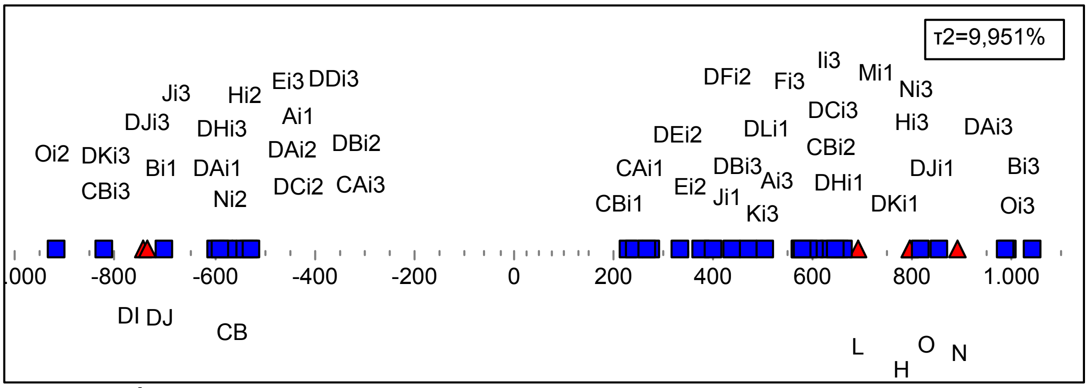

Figure 5. 2nd Factorial Axis of Backward Linkages

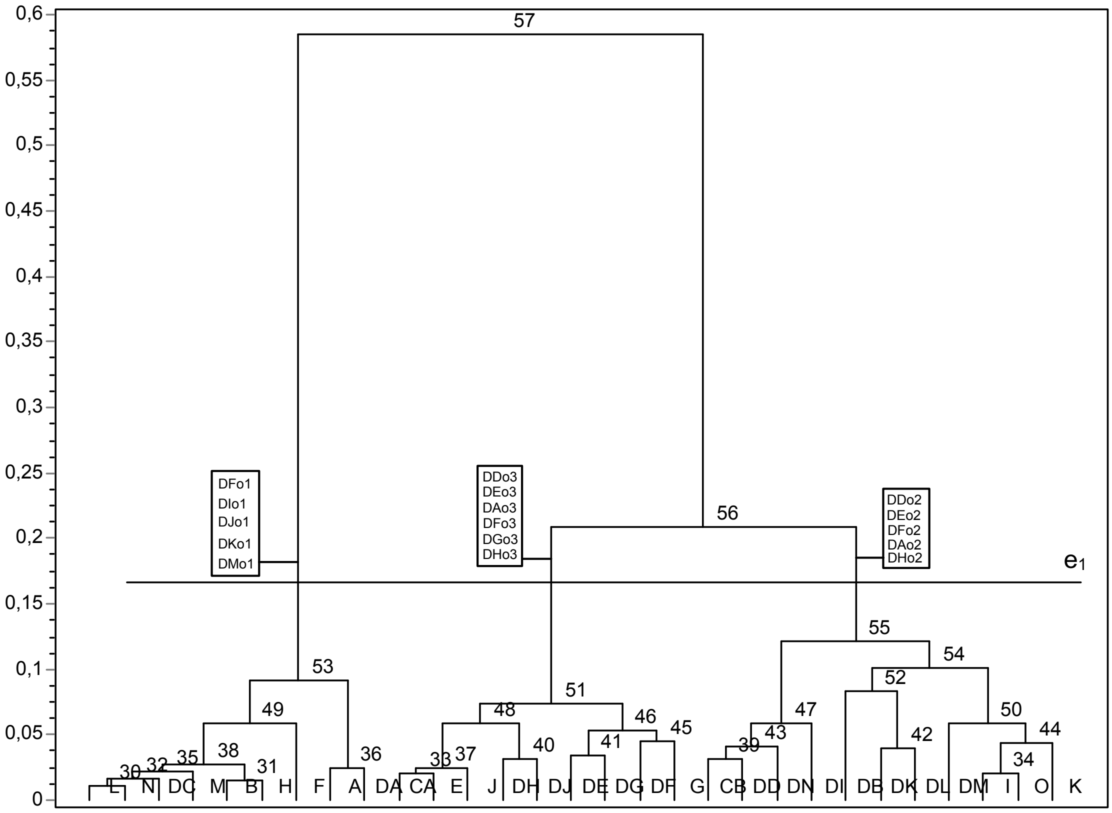

Figure 6. Cluster Dendrogram of Forward Linkages

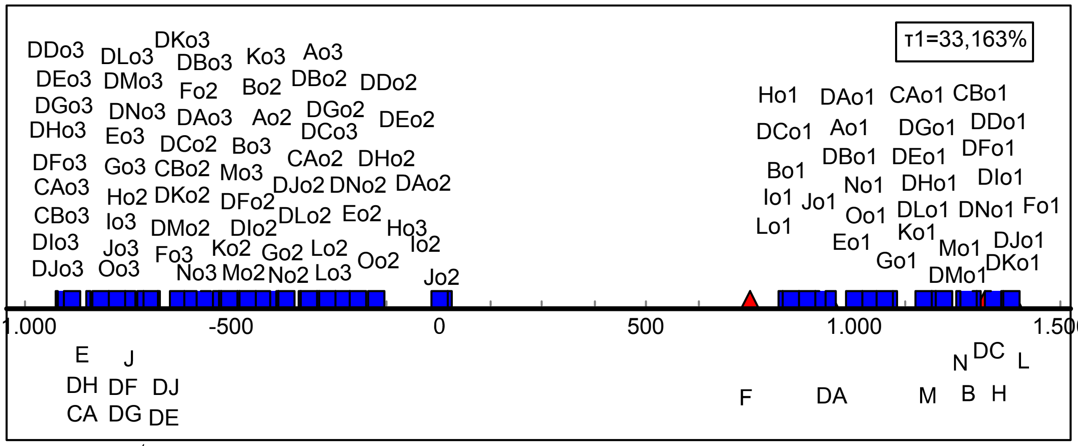

Figure 7. 1st Factorial Axis of Forward Linkages

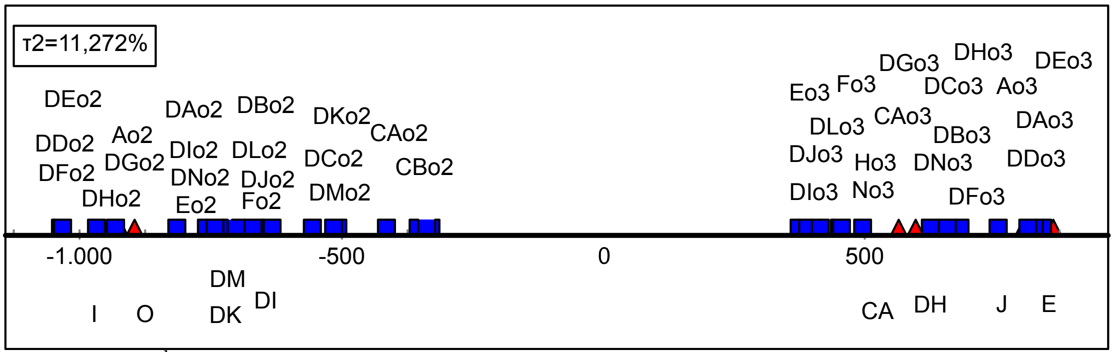

Figure 8. 2nd Factorial Axis of Forward Linkages