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A MULTIVARIATE DATA ANALYSIS OF LOGISTICS STRUCTURE AS A FACTOR OF COMPETITIVENESS

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ABSTRACT

The importance of logistics structure to economies is becoming increasingly significant and in order to support the economic growth based on exports, governments have sought to constantly improve the quality of logistics infrastructure of their countries, ensuring and promoting competitiveness of its production internationally. The consensus is that the logistics structure forms a vital link in the entire chain of trade, contributing to the international competitiveness of a country. This study aims to characterize the country as its logistics structure and relationship of this result to the promotion of competitiveness for them by relevance participation in world trade. To reach that goal the methodological procedure was performed a literature search and analysis of secondary data. Initially, through the identification and validation of data for countries and hence the application of multivariate data analysis methods to measure dimensions that allow such classification, planning, and especially the identification of dimensions of logistics infrastructure components in terms of promotion competitiveness.

Keywords: logistics structure; multivariate data analysis; competitiveness.

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1. INTRODUCTION

An important dimension of the infrastructure's contribution to economic growth is highlighted by the World Bank (2008) as the utility associated with the infrastructure of the countries for allowing the occurrence of agglomeration economies. From the competitive point of view, different types of investment in infrastructure are important to different countries at different stages of development. Investment in basic public services and local public goods are important to provide the basis for the density of small towns. Transport infrastructure is an additional requirement for the rapid growth of medium-sized cities, and large cities require more spatially oriented investments in, for example, housing with affordable prices to overcome divisions related to the presence of slums.

Aligned with these issues, we can highlight the productive potential and competitiveness of national industries and products associated with the existing logistics structure in the country. Such structure could be responsible for supporting existing competitive advantages and even the enhancement of trade, internal and external, given its ability to influence the efficiency and costs of transport. As seen, in addition to representing an important factor able to influence and promote economic growth, logistics structure also has a great potential to generate competitiveness for industries and countries.

According to the World Economic Forum definition (Porter *et al.*, 2007) competitiveness can be defined as the set of institutions, policies and factors that determine the level of productivity of a given place. Taking productivity as a basic measure, the concept of competitiveness encompasses connotations that include both the level of economic growth as the potential for sustained growth. Competitive economies not only produce more income they are also more likely to grow faster over the medium and long terms.

The concept of competitiveness of cities, however, is controversial. Some economists such as Krugman (1996) have questioned to what extent it makes sense to apply the term "competitiveness" to entities other than companies. It is true that countries do not compete with each other as private companies; in fact, in most cases, the wealth of cities is created by the private sector, and are private companies that must compete in local, national and global levels.

However, the location is still relevant and some countries offer better conditions than others for private companies to be more competitive. To become more disputing, companies depend on a favorable local environment that encourages competition and innovation. Governments can and should pursue policies to improve the local business environment, which, in turn, raises the level of income of the inhabitants. The countries, in this sense, compete with each other to provide a better business environment able to attract competitive private companies.

If countries are to provide a better business environment, decision makers need to understand the factors that private companies consider important and fundamental role of governments. Among these, the logistics structure is extremely important for the composition of productivity criteria and, consequently, for business environment and opportunities as a competitive advantage factor.

The importance of logistics structure for national economies is becoming increasingly significant (Cullinane *et al.,* 2005) and in order to support economic growth, governments have sought to constantly improve the quality of logistics infrastructure to their countries, ensuring and promoting the competitiveness of its production internationally. The consensus is that the logistics infrastructure forms a vital link in the entire chain of trade, contributing to the international competitiveness of a country (Tongzon, 1989; Chin; Tongzon, 1998).

The continuous measurement of the logistical structure and its consequent contribution in generating efficiency and productivity in terms of global exchange is very important in improving the understanding of the logistics factor contributions to the economic growth.

In this context, this paper aims to categorize countries given its logistical structure and relate this result to its respectively competitiveness promotion terms by share in world trade. Initially, through the identification and validation of countries data and, consequently, by the application of multivariate analysis methods to measure items that allow such classification, rating and, especially, to identify the items of the logistical structure components in terms of competitiveness promotion.

2. LOGISTICS STRUCTURE AS FACTOR OF COMPETITIVENESS

According to Filho (2001), the concept of logistics is defined as the process of planning, implementing and controlling efficiently, at the right cost, the flow and storage of raw materials, stock during production and finished goods, from the point of origin to the final consumption.

The historical development of the logistics' concept dates back to periods that make reference the construction of the pyramids in Egypt or the first missions on the seas by the Mayans. However, the implementation of logistics as a term linked to the management, competitiveness and productivity was better adjusted from the military logistics which has as goals the deployment of troops, food, weapons and equipments. According to Lovelock (1996), throughout history, wars have been won and lost by the power and capacity of logistics. During World War II, the logistics

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played a role key in the invasion of Europe by Allied Forces. In the beginning of 1991, during the Gulf War, the United States and its allied, through logistics process, moved in a few months, half million people and supplies, more than 2.3 million tons of equipment, along 12,000 km.

According to Santos (2005), the logistical expertise was used in a more systematic way in the art of war, "making it an advantage for those who could implement more effective strategies of movement and deployment of troops". Over the years, the logistics was improved in many ways. In the early XVII century, in France, was introduced, for the first time, the logistics' concept in the war. And one of the first men in the world to use the logistic strategy was Alexander "The Great", according to Filho (2001), "which with an army of 35,000 men came to slaughter the enemies' armies of up to 60,000 men, losing only 110 men".

According to Ballou (2006), few authors had already started a more detailed discussion on logistics before the 1950's and, in this way, there weren't many opportunities for the executive officers to learn and practice the concepts of logistics.

In fact, studies and practices of physical and logistics distribution have taken more intensity in the 1960's and 1970's. In this period, the logistics costs were high, according to Hesket *et al.* (1973), the logistic cost was estimated at 15% of the US GDP. This scenario attracted the attention of many researchers as Drucker (1962), which presented the development of logistics as the most promising and necessary at that time.

Currently, as presented by Fleury *et* Hijjar (2008), using logistics is to know all its own variables and control them so that they could fit on its own type of service. Transport is the main logistics activity - but not the only one, also handling in the factory courts is part of the logistics activity. An efficient logistics should pay attention to the management of information in order to achieve better results; and the proper administration of logistics is a matter of economic and financial survival.

According to Petraglia *et al.* (2009), transportation can be classified into five essentially categories, which are the following: rail, road, water, pipeline and air transportation. In the logistics process, the choice of the best mode of transport (modal) depends on the product to be transported and modal limitations, impacts the costs significantly. For example, the pipeline is a modal with cost low, but the suitable products are limited, as is limited the pipeline system coverage; the air modal is not as limited as the pipeline, however, its freight cost is very high; water transport has the feature to handle large volumes; the rail and road modals are the ones which practically concentrate most cargos, differences of goods loaded on these modals are not great.

A key factor in integrated logistics is the transport management. By any economic, political and military view, transport is, unquestionably, the most important industry in the world (Ballou, 2006).

According to Hutt *et* Speh (2000), transport is usually the largest logistics expense and, considering the impact of the continuing rise in fuel costs, its importance is likely to increase.

As presented by Larranaga (2003), all developments associated with globalization, have brought new challenges, such as market competitiveness. The globalization of supply chains, increased diversity of products offered and the growth in consumer demand level lead companies to meet their logistics needs with agility, consistency and flexibility at the lowest possible cost.

3. METHODOLOGY

3.1. Data analysis

To achieve the goal proposed, methodological procedure used was literature review and analysis of secondary data. The literature review consisted of books, periodicals, journal articles, technical reports released by the World Bank and some papers. As for the documentary research, were used documents and data available on websites as per IBGE, IPEADATA, Brazil's Central Bank, Penn World Table and World Bank. The literature review was used to give the theoretical deepening and the documentary research, through the data, to prove the studied hypotheses. The used leading indicators, to analyze the logistic structure in the country, were the level of each modal activity, the installed structure, the cost and consumption of fuel, quantitative of the categorized vehicles, and logistics performance indicators. The economic variables were represented by the level of production activity, competitiveness through market prices, terms and cost of exchanges and the potential foreign trade. The used database was from 2010 given the availability of the above data.

For the data analysis were used the techniques of multivariate analysis, which is a statistical analysis that works with measures - attributes - multiple of one or more samples of individuals, taken generally as a single measurement system, ie, consider the general interconnection of random variables simultaneously.

The "individual" term refers to the basic unit on which is performed a certain number of measurements and are attributed a certain number of descriptions. This so, in the multivariate analysis there is - always - individuals with their own attributes, for example, regions and its variables.

Here we will take a closer look to the Main Component Analysis (MCA) and the Grouping Models (Cluster Analysis).

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The MCA method is used in order to explain the structure of variance and covariance of a random vector composed of p random variables, obtained by linear combinations of k original variables (Manly, 1986). In other words, the aim is to reduce the number of explanatory variables (attributes) from a set of individuals to a small number of indexes called main components (as by construction k < p), with the characteristic of being uncorrelated.

It is elaborated a set of orthogonal variables (statistically independent) Z1, Z2, ... Zk from a linear combination of the original observed variables (attributes) X1, X2, ... Xk. The Zk components are calculated so that the first component Z1 groups and summarizes the largest portion of the variance, and so on. The idea is, as k < p, with a small number of components we could be able to explain a much larger number of variables/attributes, only depending on the level of correlation between them.

The Main Component Analysis (MCA) reduces the number of observed variables to a smaller number of main components which accounts for most of the variance of the observed variables. The total amount of variance in MCA is equal to the number of observed variables in the analysis. In the MCA, the observed variables are standardized, for example, mean = 0, standard deviation = 1, matrix diagonals = 1. The first identified main component represents most of the variance in the data. The second component represents the second most of the variance in the data and is not correlated with the first component and so on. Components representing maximum variation are maintained while other components that represent a non-relevant amount of variance are not kept. The eigenvalues indicate the amount of variance explained by each component, while vectors are the weights used to calculate the scores of the components.

The great advantage of multivariate techniques over traditional econometrics is given when the explanatory variations (independent) of the equation to be adjusted made significant autocorrelation (which creates multicollinearity and predictable rejection of the significance of the estimated parameters). By this technique, the variables obtained by MCA method are orthogonal, presenting zero correlation. Moreover, it is not necessary to assume normal distribution and design the cloud's gravity center points observed in the origin coordinate (0,0); on the contrary, the orthogonal projection of the origin will focus on the gravitational center of the point cloud, without the need to assume normality and asymptotically.

The Factor Analysis is another classic multivariate method, similar to the main components, but a more generic tool which allows "(...) the rotation of the axes (factors) that summarize the information in the data matrix whose purpose is to facilitate its analytical interpretation, as well as the establishment of non-orthogonal axes representing the mutual relationship between interdependent factors" (Haddad *et al*., 1989). Factor analysis is used to discover relating to a set of data, being the rotation of each vector (variable) on the factors, the factor weights. Its most common use is in the hierarchy of variables in a given space base, particularly in urban analysis.

Finally, the classification methods, or cluster analysis, have as their goals dividing into subsets, the possible most similar, sets of elements (individuals), so that such elements belonging to a same group are similar with respect to the characteristics (attributes) which are measured in each element.

In other words, clustering methods can be characterized as any statistical procedure which, using a finite and multidimensional set of information, classifies its elements in internally homogeneous small groups, allowing generate significant aggregate structures and develop analytical typologies. Such methods can be hierarchical – with parts sequences on increasingly broad classes – and not hierarchical - partitioned into fixed number categories (Barouche *et* Saporta, 1982).

The classification of individuals occurs in homogeneous groups, with minimum intra-category variability and maximum inter-category - allowing to create taxonomies, typologies, reducing the number of dimensions to be examined and enabling a more direct understanding of the inherent characteristics of the information.

3.2. Research data

For data analysis we used data from the World Bank, IBGE, IPEADATA, Brazil's Central Bank, Penn World Table, World Economic Forum and World Bank for each country for the year 2011. The variables were referred to logistics structure and level of economic activity as shown in Table 1. The abbreviations presented will be used from now on in this study.

To meet the proposed objectives, were selected 109 countries which provided information about the selected data. Countries, divided by geographical groups are presented in Table 2.

4. RESULTS

As presented, the data used contains 109 countries for each of the 10 variables presented logistics, so the initial matrix has performed with 109 lines of countries and 10 columns categorized as logistic variables. Table 2 presents the mean, median and standard deviation for each variable logistics.

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Table 1. Analysis variables

Categories	Variables	Abbreviation
Logistics Variables	Merchant Marine (total ships with 1.000 GRT or over)	MM
	Motor vehicles (per 1,000 people)	MV
	Cost to export (US$ per conteiner)	CE
	Railways density (km of road per 100 sq. km of land area)	RD
	Road density (km of road per 100 sq. km of land area)	ROD
	Waterways density (km of road per 100 sq. km of land area)	WD
	Paved Roads (% of total roads)	EP
	Airports density (paved and not paved per 100 sq. km of land area)	AD
	Pump price for diesel fuel (US$ per liter)	CDIESEL
	Pump price for gasoline (US$ per liter)	CGASOL
Economics Variables	Global Competitiveness Index	GCI
	Trade (% do GDP)	TRD
	GDP (current US$)	PIB

In order to prevent that the principal component analysis model emphasizes more variables with higher standard deviation and therefore with greater variance, since the variables have different units of measure, they were standardized so that they have the same weight in the analysis.

The Principal Components Analysis were kept the first four components (with Eigenvalues> 1), which represent 72.4% of total variance, a discussion on the number of components kept in Principal Component Analysis can be found in Wichern *et* Johnson (1992). The result obtained with the aid of SPSS 8.0, is shown in Table 3. The values shown in columns are coefficients of the main components related to each of the variables presented. The Eigenvalues represent the variance of each principal component of all variables.

Components with high "eigenvalues" contain a higher common variance between the observed variables, those with lower or "eigenvalues" negative are removed from the solution. Various procedures and factorial retention criteria have been developed. The criterion of Kaiser-Guttman, better known as eigenvalues> 1, allows rapid and objective assessment of the number of factors to be retained. The logic behind the Kaiser-Guttman criterion is simple: each held factor presents an eigenvalue which refers to the total variance explained by this factor. The total sum of the eigenvalues is always equal to the number of items used in the analysis. Thus, a component with eigenvalue <1 presents a total variance explained smaller than a single item. Since the purpose of factor analysis is to reduce a number of variables observed in a smaller number of factors, only factors with eigenvalues> 1 are retained (Floyd *et* Widaman, 1995).

Table 3. Total vector of the coordinates - Analysis of the principal components

Variables	PC1	PC2	PC3	PC4
Merchant Marine	0.004	0.086	0.558	0.004
Motor vehicles	0.547	0.125	-0.088	0.508
Cost to export	-0.010	-0.099	-0.533	-0.028
Paved Roads	0.504	0.100	-0.066	0.030
Road density	0.558	-0.087	0.032	0.012
Railways density	0.365	0.698	-0.117	0.010
Waterways density	0.028	-0.040	0.614	0.017
Airports density	0.002	0.678	-0.033	-0.024
Diesel Cost	0.024	0.026	0.012	-0.615
Gasoline Cost	0.019	0.020	0.011	-0.601
Eigenvalues	**1.939**	**1.163**	**1.042**	**1.021**
Variance %	**37.60%**	**13.50%**	**10.90%**	**10.40%**
Cumulative variance %	**37.60%**	**51.10%**	**62.00%**	**72.40%**

Given the characteristics of the components presented in Table 2, the first component maintains 37.60% of the information contained in the data (measured by the variance). The table of coefficients measure the correlations between the variables and components. In this way the first component will provide an index presenting high values for countries with higher relevance for the variables MOTOR VEHICLES, PAVED ROADS AND ROAD DENSITY.

The second component is highly correlated with the variables RAILWAYS DENSITY and AIRPORTS DENSITY. The third component increases as the variables MERCHANT MARINE and WATERWAYS DENSITY ROUTES increases and the variable COST TO EXPORT decreases. Similarly the fourth component form is positively influenced by MOTOR VEHICLES and negatively by DIESEL COST and GASOLINE COST.

Table 2. Summary of collected data

	MM	MV	CE	EP	ROD	RD	WD	AD	CDIESEL	CGASOL
Mean	209.61	271.74	1238.85	56.71	67.86	2.23	0.76	0.08	1.28	1.40
Median	31.00	188.21	1100.00	57.01	29.85	0.81	0.41	0.04	1.26	1.42
Std Deviation	583.16	233.24	635.61	32.69	87.24	2.95	1.65	0.14	0.56	0.55

Source: World Bank (2008)

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By observing all components it is possible to sort them by analysis groups as the most significant variables for each and according to common characteristics of prominent variables, naming them as these characteristics. Table 3 shows the groups already properly named according to the information of the estimated components.

Table 4. Analysis groups according to estimated components

Components	Groups
PC1	Roads and Vehicles
PC2	Railways and Airports
PC3	Waterways, merchant marine and cost to export
PC4	Cost of fuel and potential consumption by the fleet

In order to sort the countries according to analysis variables, Table 5 presents the best and worst ten countries ranked as a result of index estimated based on principal component analysis, taking into account the obtained factor loadings and standardized data for countries, as well as the classification of Brazil in each category.

In the first component, it is possible to verify the classification of countries for the criterion that considers the road density, paved roads and motor vehicles as the most relevant factors, in this sense, countries such as Luxembourg, Germany and Switzerland are highlighted because they have almost their entire roads paved, while Belgium and Netherlands by the high density of roads in their territory. Belgium has the highest roads extension per 100 sq. km throughout the sample of countries analyzed in this paper.

The second component highlights countries like Singapore mainly by airports density in its territory, the other prominent countries such as Germany, Czech Republic, Switzerland, Luxembourg and Belgium have their positions influenced by the railways density their territory .

In the third and fourth component, there is a more heterogeneous formation across countries, especially by highlighting features related to logistics structure of countries outside Europe. In the third component, countries such as Panama and China are highlighted for their significant merchant marine, the largest of the sample of countries, and low cost to export. Vietnam is highlighted by the low cost to export associated with a relevant waterways density in its territory. Countries like Netherlands and Belgium are highlighted mainly by the waterways density in its territory, the largest respectively in the entire sample of countries.

The fourth component highlights countries such as Kuwait, Qatar, Bahrain, Saudi Arabia and Venezuela mainly by the low cost of fuel (diesel and gasoline) presented, Venezuela and Saudi Arabia have the lowest gasoline and diesel liter costs of entire sample countries. The United States are highlighted as top ten in this classification mainly by the potential consumption of its fleet, one time the country has the largest fleet of vehicles across the sample of countries according to the criteria analyzed, i.e. for every 1,000 people.

Table 5. Ranking of the estimated index for countries - Top Ten, Brazil and Portugal

Ranking	Roads and Vehicles	Railways and Airports	Waterways, merchant marine and cost to export	Cost of fuel and potential consumption by the fleet
1	Belgium	Singapore	Panama	Kuwait
2	Luxembourg	Germany	Netherlands	Qatar
3	Netherlands	Czech Republic	Vietnam	Bahrain
4	Germany	Switzerland	China	Saudi Arabia
5	Switzerland	Luxembourg	Belgium	Venezuela, RB
6	Czech Republic	Belgium	Indonesia	Iran, Islamic Rep.
7	Singapore	United Kingdom	Malaysia	Iraq
8	Italy	Denmark	Cambodia	Oman
9	Slovenia	Israel	Singapore	United States
10	France	Slovak Republic	Philippines	Malaysia
Brazil	***84º***	***86º***	***77º***	***33º***
100	Nigeria	Iraq	Slovakia	Hungary
101	Mozambique	Kyrgyzstan	Ethiopia	Italy
102	Kenya	Myanmar	Mongolia	Senegal
103	Cambodia	Cameroon	Venezuela	Sweden
104	Cote d'Ivore	Switzerland	Uruguay	Venezuela
105	Tanzania	Sudan	Botswana	Netherlands
106	Bolivia	Cote d'Ivore	Iraq	United Kingdom
107	Cameroon	Botswana	Kyrgyzstan	Israel
108	Mongolia	Ethiopia	Kazakhstan	Norway
109	Ethiopia	Mongolia	Zimbabwe	Turkey

By analyzing the first two components, "ROADS AND VEHICLES" and "RAILWAYS AND AIRPORTS," there is a predominance of European countries among those who presented better results for the calculated index; this result implies better conditions and greater density of roads, railways and airports in their respective territories.

The third component "WATERWAYS, MERCHANT MARINE AND COST TO EXPORT" stand out countries such as Panama, by a significant merchant marine, as well as Vietnam, by the density of waterways in its territory, and Malaysia, China and Singapore due to the low cost to export their production. Many of these countries combine strengths associated with this component in more than one variable, such as Malaysia and Vietnam, which stand out among the five countries with the lowest cost to export and at the same time, with the highest density of waterways from the sample analyzed.

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The fourth component "COST OF FUEL CONSUMPTION AND POTENTIAL BY FLEET", highlights countries with low cost of fuel, which highlights middle eastern countries that composes the vast majority of the top ten classified, and with great potential for consumption by the representativeness of the motor vehicle density, representing the consumption potential, as in the United States case.

From the scores obtained by principal component analysis, it was possible to perform a sorting analysis through cluster analysis. The purpose of this analysis is to identify clusters of countries with common characteristics when grouped by the estimated components, as seen above, were determined according to coefficients presented in Table 3 and classified as outlined in Table 4. For the Cluster Analysis solution was used Ward method and Euclidean distance. The representation dendrogram obtained by applying the method to those obtained indices is shown in Figure 1.

With this result countries were divided into four analysis groups, by the dendrogram you can view the division into four groups is very well defined, involving countries by common characteristics, and generating groups containing 25, 21, 24 and 39 countries respectively. To facilitate the visualization of the groups and their characteristics, Table 6 shows the composition of the groups, with the countries belonging to each, and the mean values found for each classification context.

By observing the conditions for the cluster of countries, can be interpreted common features revealed by the average of the calculated rates. The first group considered countries with relevant averages in relation to the cost of fuel and potential for fleet consumption, i.e. in this group are related countries with low cost of diesel and gasoline and / or a relevant density of motor vehicles in use. In addition, the group 1 has a lower density of roads, smaller proportion of paved roads, low density airports, railroads and waterways in its territory. Other characteristic features of this group are represented by the lack of competitiveness in the cost to export as well as a inexpressive merchant marine. For the first group, a composition observed most notably is the representation of South America, Africa and the Middle East countries.

Among the member countries of this first group it's possible to view some competitive advantage in terms of logistics infrastructure through the cost of fuel and/or the density of the fleet, however the absence of structural potential associated with other modes of transport also indicate countries with a concentration of the flow of production in a single modal, in this case we observe the predominance of road transport over the others, certainly with greater vascularization and density than the others.

The group 2 presents countries with relevant averages in a combined form in relation to cost of fuel, potential consumption by the fleet, merchant marine, greater waterways density and lower cost for export. That is, the composition of the second group is related to countries with representative for one or more variables in a combined form on both featured components. For this group it is possible to observe a greater closeness of the indexes for all components, i.e. countries have good indicators for roads density and paved roads, as well as density of airports and

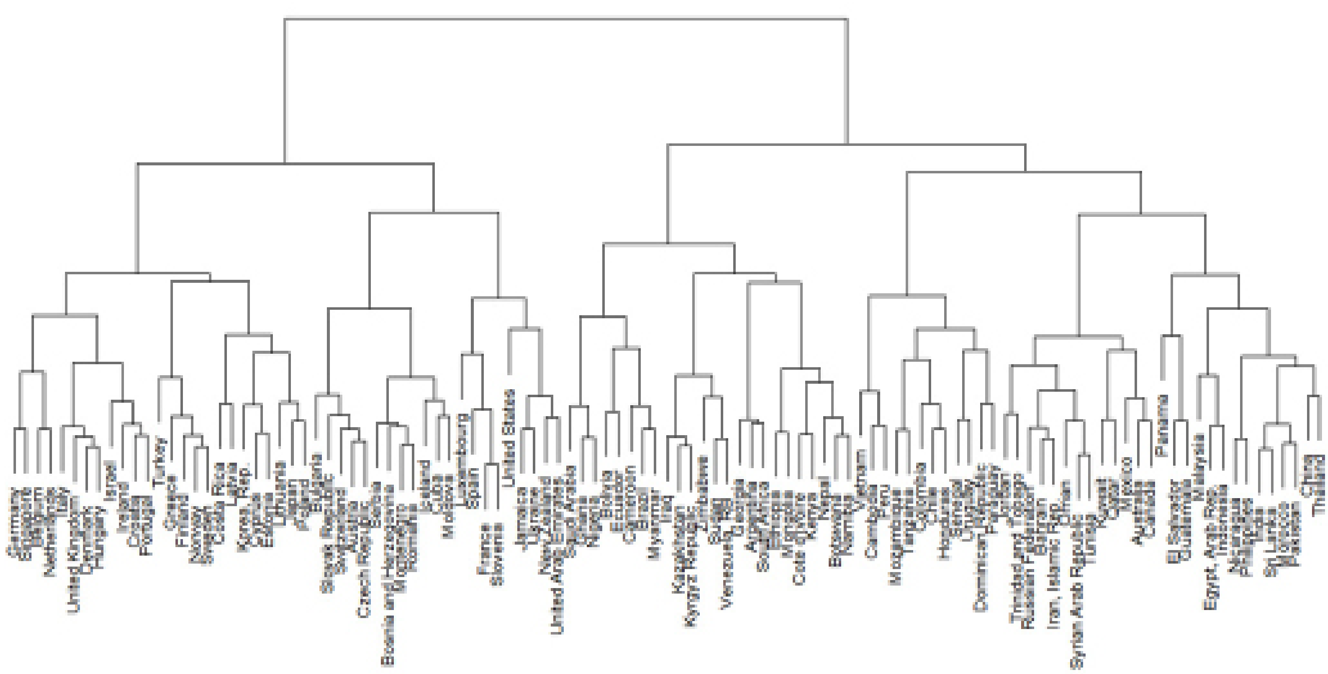

Figure 1. Hierarchical Cluster for countries as a result of factor loadings obtained in the principal component analysis
Source: The authors own.

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railways, particularly when compared to the first group, but without doubt most notably than those initially presented. For group 2 it can be seen that, despite the homogeneity observed for results of the indices, the group performs very heterogeneous in the composition of countries, with representatives from all regions considered in this paper.

Group 3 presents countries that combine significant results for the components of roads and vehicles; Airports and Highways; and to a lower level, but still considerable, the cost of fuel and potential consumption by the fleet. Members of the third group have a lower density of waterways in its territory, a merchant marine less expressive and/or lack of competitiveness in the cost to export. Most of countries members in the third group are European representatives, with an emphasis on the United States and the United Arab Emirates as members.

The fourth group analyzed is predominantly European, with the inclusion of countries representing Asia such as Japan, South Korea and Singapore. The fourth group has a lower average observed for the potential consumption by the fleet and/or a less competitive fuel costs. However, the fourth group has better structural conditions observed for its waterways, merchant marine, roads density, a higher proportion of paved roads, higher density of airports and railroads as well as presenting competitiveness in costs to export compared to the third group.

The third and fourth group highlighted countries that have representative indices for more than one component, this result refers to the distribution of logistics structure in these countries in more than one transport modal, where besides the quality associated with the conditions necessary for road transport, indicate better distribution of railways and airports, and in some cases, such as members of the fourth group, associated to a larger waterway structure.

Regarding the presented results, it should be noted that better transport structures contributes to logistics costs throughout the supply chain, thus it would be reasonable that countries seek conditions to combine or even integrate transport modes in order to promote the flow of production, as well as easy access throughout its territory. By seeking these conditions, countries could not only meet the needs of their companies and citizens, but also to promote the competitiveness of their goods and services inside and outside their territories.

In order to verify these conditions, an indicator was designed considering the position observed for each country, for each of the four components estimated. Intuitively, it was possible to find a general ranking for countries, called here only as a general logistics structure index.

The graphs in Figures 2 and 3 show the relationship of general logistics structure index with Trade and the Global Competitiveness Index. In both cases we observe a positive association between the variables, which could indicate that countries with better conditions observed for their logistics structures tend to have better results in terms of trade, measured by the representativeness of the corresponding GDP to the total value of trade realized by the country, as well as better conditions of competitiveness, measured by the global competitiveness index. The value of the correlation coefficient is respectively 0.57 and 0.68 for the total value of trade and global competitiveness index.

By quadrants of the graphics is also possible to categorize countries according to the variables considered, the highest incidence of the countries in lower left and upper right quadrants contribute to the view that the logistics structure is positively correlated with its trade and competitiveness results, suggesting the existence of a positive correlation between the variables, a fact proven earlier.

Table 6. Cluster results and respective averages for each topic

G	Countries	Roads and Vehicles	Railways and Airports	Waterways, merchant marine and cost to export	Cost of fuel and potential consumption by the fleet
1	Argentina, Bolivia, Botswana, Brazil, Cameroon, Cote d'Ivoire, Ecuador, Ethiopia, Georgia, Ghana, Iraq, Kazakhstan, Kenya, Kyrgyz Republic, Mongolia, Myanmar, Namibia, Nepal, Nigeria, Saudi Arabia, South Africa, Sudan, Venezuela and Zimbabwe	22,17	18,54	27,00	76,13
2	Australia, Bahrain, Cambodia, Canada, Chile, China, Colombia, Dominican Republic, Egypt, El Salvador, Guatemala, Honduras, India, Indonesia, Iran, Jordan, Kuwait, Malaysia, Mexico, Morocco, Mozambique, Nicaragua, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Qatar, Russian Federation, Senegal, Sri Lanka, Syrian Arab Republic, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Uruguay and Vietnam	40,67	42,82	69,64	67,23
3	Austria, Bosnia and Herzegovina, Bulgaria, Cuba, Czech Republic, France, Iceland, Jamaica, Luxembourg, Moldova, Montenegro, New Zealand, Romania, Serbia, Slovak Republic, Slovenia, Spain, Switzerland, Ukraine, United Arab Emirates and United States	82,19	83,48	28,52	50,05
4	Belgium, Costa Rica, Croatia, Cyprus, Denmark, Estonia, Finland, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Rep., Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Singapore, Sweden, Turkey and United Kingdom	86,04	85,08	81,28	23,16

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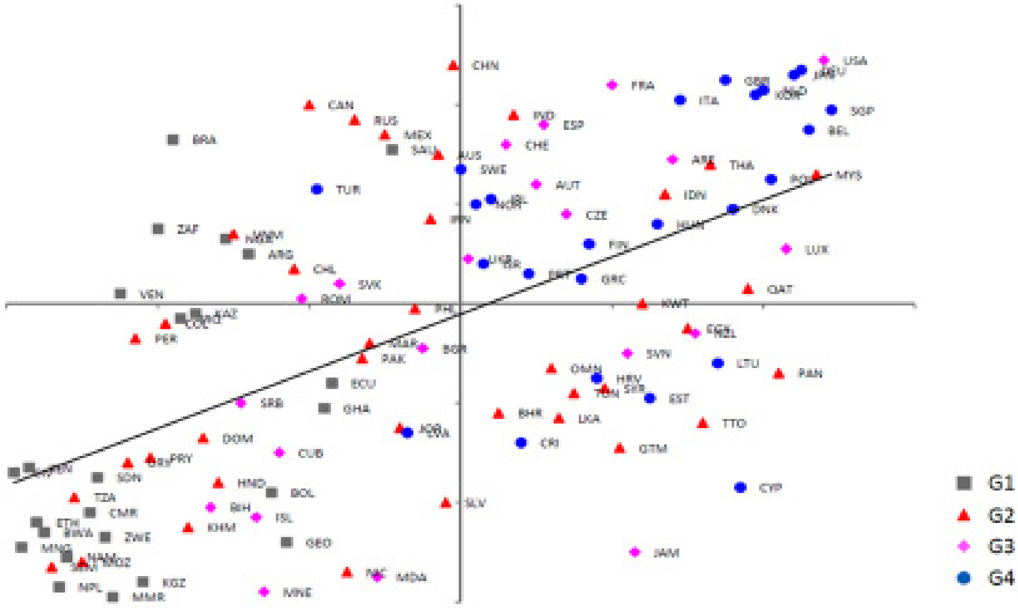

Figure 2. General Logistics Structure (Horizontal Axis) and Trade (Vertical Axis)
Legend: Members of (results of Table 5)
Source: *Trade and GCI obtained from World Bank – Countries abbreviations*

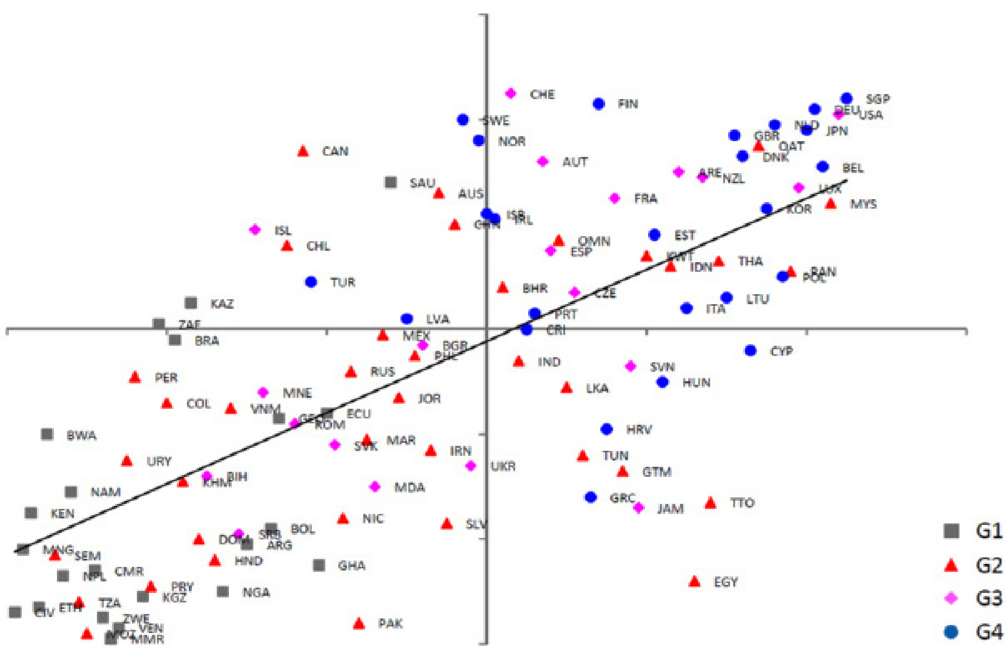

Figure 3. General Logistics Structure (Horizontal Axis) e Competitiveness (Vertical Axis)[1]
Legend: Members of (results of Table 5)
Source: *Trade and GCI obtained from World Bank - Countries abbreviations*[2]

1 - Countries such as Iraq, Syria, Sudan and Cuba were not included in this graph because the World Bank does not calculate the Global Competitiveness Index for these countries.

2 - Argentina (ARG), Australia (AUS), Austria (AUT), Bahrain (BHR), Belgium (BEL), Bolivia (BOL), Bosnia and Herzegovina (BIH), Botswana (BWA), Brazil (BRA), Bulgaria (BGR), Cambodia (KHM), Cameroon (CMR), Canada (CAN), Chile (CHL), China (CHN), Colombia (COL), Costa Rica (CRI), Cote d'Ivoire (CIV), Croatia (HRV), Cuba (CUB), Cyprus (CYP), Czech Republic (CZE), Denmark (DNK), Dominican Republic (DOM), Ecuador (ECU), Egypt, Arab Rep. (EGY), El Salvador (SLV), Estonia (EST), Ethiopia (ETH), Finland (FIN), France (FRA), Georgia (GEO), Germany (DEU), Ghana (GHA), Greece (GRC), Guatemala (GTM), Honduras (HND), Hungary (HUN), Iceland (ISL), India (IND), Indonesia (IDN), Iran, Islamic Rep. (IRN), Iraq (IRQ), Ireland (IRL), Israel (ISR), Italy (ITA), Jamaica (JAM), Japan (JPN), Jordan (JOR), Kazakhstan (KAZ), Kenya (KEN), Korea, Rep. (KOR), Kuwait (KWT), Kyrgyz Republic (KGZ), Latvia (LVA), Lithuania (LTU), Luxembourg (LUX), Malaysia (MYS), Mexico (MEX), Moldova (MDA), Mongolia (MNG), Montenegro (MNE), Morocco (MAR), Mozambique (MOZ), Myanmar (MMR), Namibia (NAM), Nepal (NPL), Netherlands (NLD), New Zealand (NZL), Nicaragua (NIC), Nigeria (NGA), Norway (NOR), Oman (OMN), Pakistan (PAK), Panama (PAN), Paraguay (PRY), Peru (PER), Philippines (PHL), Poland (POL), Portugal (PRT), Qatar (QAT), Romania (ROM), Russian Federation (RUS), Saudi Arabia (SAU), Senegal (SEM), Serbia (SRB), Singapore (SGP), Slovak Republic (SVK), Slovenia (SVN), South Africa (ZAF), Spain (ESP), Sri Lanka (LKA), Sudan (SDN), Sweden (SWE), Switzerland (CHE), Syrian Arab Republic (SYR), Tanzania (TZA), Thailand (THA), Trinidad and Tobago (TTO), Tunisia (TUN), Turkey (TUR), Ukraine (UKR), United Arab Emirates (ARE), United Kingdom (GBR), United States (USA), Uruguay (URY), Venezuela, RB (VEN), Vietnam (VNM) and Zimbabwe (ZWE).

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In both graphs it is possible to observe the division between the groups established in Table 5, as the distribution of countries by quadrants. Members of the Group 1, group of which Brazil is a member, are more concentrated in the lower left quadrant, linking low logistics structure with low competitiveness or trade. The opposite occurs for the sample countries of the group 4, concentrated in the upper right quadrant, by presenting a clear evidence of the occurrence of high logistics infrastructure with high competitiveness or trade. The countries in groups 2 and 3 are distributed among the quadrants without strong concentration evidence characterized by the formation of the quadrants.

5. CONCLUSION

In the approach used in this paper for index construction, two multivariate data analysis techniques were used, the Cluster Analysis and Principal Component Analysis. In many cases it may be interesting to take advantage of the highly descriptive power of these two techniques to interpret the resulting index.

In the applications presented in this paper, four components were chosen for construction of the index due to its variance, furthermore, has been shown the consistency of the results of the two techniques in both applications. In fact, the index obtained ordered groups presented by Cluster Analysis.

The estimated indexes were named according to their characteristics and allowed the classification of countries across all categories. The clustering allowed the formation of common groups with distinct characteristics observed by averages of associated components. From a general index, it was estimated a ranking for the countries and each component weights, it was possible to relate the logistical structure of countries with trade and competitiveness indicators, such analysis proved relevant both for the results obtained as to the importance of logistics structure in the generation of productive and commercial competitiveness of countries.

In general, it can be highlighted the logistics structure and the combination of modals in the flow of production and territory interconnection of European countries, as well as noted great potential associated with the cost of fuel for Middle Eastern countries and low cost for export of Asian countries. In the division by clusters was possible to identify structural factors that promote integration in the use of transportation modals mainly by countries with better logistics structures.

Best logistics structure conditions and factors that allow the integration of transport modals, strongly contribute to reduce the logistics costs throughout the supply chain. In order to verify this relationship, it was observed that the conditions of the logistical structure, associated with its use in an integrated manner, can promote commercial and productive competitiveness for countries.

The graphical analysis enabled visualization of a positive association between competitiveness and trade variables with the logistic structure of countries. This result confirms the hypothesis proposed by this paper and encourages further research in order to investigate beyond the relations between these variables, such the identification of determinant factors and causal relationships between them.

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