The Use of Multivariate Analysis in the Characterization of Satellite Tracking Systems in Highway Freight Transportation*

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Abstract

The objective of this paper is to analyze the use of satellite tracking systems by trucking companies in São Paulo City, Brazil, considering their growing importance to the transport sector. Multivariate analysis is used to explain the simultaneous relations among the variables. As the data are qualitative, correspondence analysis is used to indicate the existence of well defined groups. Subsequently, companies with similar behavior concerning the use of tracking systems are classified through cluster analysis.

Resumo

Objetivou-se analisar o uso dos sistemas de rastreamento por satélite no transporte rodiviário de cargas na cidade de São Paulo em função de sua crescente importância no setor de transporte. Para explicar as relações simultâneas entre as variáveis, foi escolhida a análise multivariada. Como os dados eram qualitativos, a análise de correspondência indicou a existência de grupos bem definidos. Posteriormente, foi utilizada a análise de conglomerados para classificar as empresas que apresentavam comportamentos semelhantes quanto ao uso dos sistemas de rastreamento.

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1. Introduction.

Access to information has been a fundamental aspect facilitating the efficient organizational structure of institutions. In this sense, the use of more precise on-line information provides a huge differential for both public and private entities to make effective decisions.

To expand the employment of new technologies in the current information age, according to Tigre, Rovere and Fagundes (1995), industries involved with information and telecommunications have been joining forces, creating the new field of information technology (IT).

This tendency has important implications in Brazil, as observed by Silva (1995, p.28), in an analysis of the impact of information technologies on Brazilian agriculture. This author states that, "investments in basic science and the creation of technological infrastructure are, once again, fundamental. Obviously we are not speaking of building new roads to expand the agricultural frontier, nor the construction of new silos or warehouses. Instead, we are speaking of telecommunications infrastructure - telephone, radio, satellites, etc. – and data storage ..."

The trucking industry is one of the key sectors of the Brazilian economy, and among the IT advances of greatest relevance to this industry is fleet management using satellite tracking systems. The logistics and security applications of this new technology have proven of great value.

Up through mid-1997 there were ten options for satellite tracking in the Brazilian market: Cargosat, Combat, Controlsat, Logiq (which left the market in 1998), Motorola, Omnisat, Radiotrack, Satcom, Teletracker and Trucksat (desactivated in 1997). According to Reis (1997), these systems had three basic functions: communication between vehicles and base stations; on-line location of vehicles; and fleet control regarding such factors as fuel level, speed, cargo temperature, doors ajar, hitchhikers, etc.[1].

To analyze and understand the interrelationships of all the variables simultaneously, efficient operational statistical tools, available in computational packages, can be used, such as multivariate analysis. We must mention that to evaluate qualitative data, correspondence analysis, although not yet a multivariate technique widely disseminated in studies of this nature, allows relevant information to be extracted and subsequently grouped by means of cluster analysis.

Seeking a better understanding of the importance and potential for growth of this new technology in the highway transport sector, the main objective of this article is to apply multivariate analysis to assess the influence of various types of satellite tracking systems on trucking firm users that have headquarters or branch offices in the city of São Paulo.

2. Correspondence Analysis.

According to Hair et al. (1995), correspondence analysis is one of the most recent techniques developed to analyze non-linear relationships and data with categorical responses (measured in nominal terms, such as: low, reasonable and high), which is the case for the variables analyzed in this study. Correspondence analysis seeks to

[1]For more information on the caracteristics of satellite tracking systems, as well as analysis of the investments required for such technology, see Anefalos (1999).

group highly correlated variables, thus reducing the number of predictive variables of the model (Hair et al., 1995).

Greenacre (1984) and Benzécri (1992), state that other methods should be used, such as analysis of regression, discriminants or clusters, to complement correspondence analysis.

From a mathematical and computational standpoint, correspondence analysis can be considered fairly straightforward, because it is more geometrical than statistical in nature, and hence is more appropriate for drawing up perception maps of the relationships among the variables (Greenacre, 1984; Hair et al., 1995).

Among the applications of this analysis, we can mention the following:

- Guttman[2] (1971), cited by Greenacre (1984), who studied the main worries of adult Israelis;
- Meimaris[3] (1978), cited by Benzécri (1992), who sought to show the relationships between the socio-economic origin of students and the careers they chose;
- Golveia[4] (1978), cited by Benzécri (1992), who studied competition among various Brazilian industries to evaluate the development of the specialized equipment market over a five-year period.

According to Crivisqui (1993), correspondence analysis can be classified as simple or multiple. In simple correspondence analysis (SCA) there are only two categorical variables, while in multiple correspondence analysis (MCA) there are more than two, i.e., the latter

[2] Guttman, L. Measurement as structural theory. Psychometrick, v. 36, p.329–347, 1971.

[3] Meimaris, M. Statistique de l'enseignement en Grèce: étude des différents établissements d'enseignement supérieur suivant l'origine socioprofissionelle de leus étudiants. Cahiers de l'Analyse des Données, v.3, n.3, 355–365, 1978.

[4] Golveia, V. Brazil's imports of industrial equipment: their evolution from 1971 to 1975. CAD, v.3, n.3, p.307–317, 1978.

is a generalization of the former. In general, this type of analysis permits the study of I individuals described by J qualitative variables, expressed by modalities (each question can be related to a variable and the responses to the modalities). Hence, it is essential to define these three components (individuals, variables and their modalities), and these modalities must be mutually exclusive, i.e., only one modality of each variable can be related to each observation.

In simple correspondence analysis it is possible to visualize the components by means of contingency tables, called T Tables, which relate the variables two-by-two, as shown in Chart 1.

Chart 1. Structure of a Contingency Table (T Table) with I modalities of variable L and J modalities of variable C.

Variable L	Variable C (modalities)					Total
(Modalities)	1	...	j	...	J	
1	n_{11}	...	n_{1j}	...	n_{1J}	$n_{1.}$
...	...	...	...	...	...	...
i	n_{i1}	...	n_{ij}	...	n_{iJ}	$n_{i.}$
...	...	...	...	...	...	...
I	n_{I1}	...	n_{Ij}	...	n_{IJ}	$n_{I.}$
Total	$n_{.1}$	...	$n_{.j}$	...	$n_{.J}$	$n_{..}$

Source: Crivisqui (1993, p.14)

In this table, n_{ij} is the number of individuals who possess modality i of variable L and modality j of variable C; $n_{i.}$ is the i-th element of the table margin, which corresponds to the number of individuals that have modality j of variable C; $n_{..}$ is the sum of all the tables cells, and thus corresponds to the total number of individuals observed.

Using this table, Crivisqui & Batista (1998) showed it was possible to arrive at a table of relative frequencies, called an F Table, obtained by dividing each cell by $n_{..}$, as shown in eq.(1).

$$f_{ij} = \frac{n_{ij}}{n_{..}} \tag{1}$$

where:

f_{ij}: frequency relative to the total number of observations of the i-th individual (representing modality j of variable C).

Each of these tables can be visualized in graphical displays, where the information from their rows and columns is represented by means of the following coordinates: row points, where each row of the table represents one point of a graph; column points, where each column of the table represents one point on another graph. The distances between the row points (or column points) are obtained based on information from the contingency table, as shown by eq. (2) and eq. (3).

$$d_{(i,i')} = \sqrt{\sum_{j=1}^{J} (n_{ij} - n_{i'j})^2} \qquad \forall i, i' \tag{2}$$

where:

$d_{(i,i')}$: distance between two row elements of the table;

n_{ij}: element ot the i-th row of the j-th column;

$n_{i'j}$: element of the i'-th row of the j-th column.

$$d_{(j,j')} = \sqrt{\sum_{i=1}^{I} (n_{ij} - n_{ij'})^2} \qquad \forall j, j' \tag{3}$$

where:

$d_{(j,j')}$: distance between two row elements of the table;

n_{ij}: element ot the i-th row of the j-th column;

$n_{ij'}$: element of the i-th row of the j'-th column.

To better represent the elements of a contingency or relative frequency table, according to Crivisqui & Batista (1998), the contents are compared in terms of row profiles ($f_{i|C_j}$, which is the proportion of the i-th sub-population that represents modality j of variable C) and of column profiles ($f_{j|L_i}$, the proportion of the j-th sub-population that represents modality i of variable L). To neutralize the distortions of a contingency table, the chi-squared (or Benzécri) distance is used, which is a weighted Euclidean distance, to evaluate two row or column profiles, as shown in Chart 2.

Chart 2. Formulas for the Row and Colum Profiles Obtained from Contingency and Relative Frequency Tables.

	Table		Chi-squared distance
Profile	Contingency	Relative frequency	between two profiles
Row	$f_{i\|C_j}=\frac{n_{ij}}{n_{i.}}$	$f_{i\|C_j}=\frac{f_{ij}}{f_{i.}}$	$d_{(i,i')}=\sqrt{\sum_{j=1}^{J} \frac{1}{f_{.j}} \left(\frac{f_{ij}}{f_{i.}}-\frac{f_{i'j}}{f_{i'.}}\right)^2}$
	$\forall i \in I, \forall j \in j$	$\forall i \in I, \forall j \in J$	$\forall i,i' \in I$
Column	$f_{j\|L_i}=\frac{n_{ij}}{n_{j.}}$	$f_{j\|L_i}=\frac{f_{ij}}{f_{.j}}$	$d_{(j,j')}=\sqrt{\sum_{i=1}^{I} \frac{1}{f_{i.}} \left(\frac{f_{ij}}{f_{.j}}-\frac{f_{ij'}}{f_{.j'}}\right)^2}$
	$\forall i \in I, \forall j \in J$	$\forall i \in I, \forall j \in J$	$\forall j,j' \in J$

Source: Crivisqui & Batista (1998, p.27 and 37)

In order to compare the point-profiles, another method is used – inertia – which assigns a weight (or mass) to each point as its relative position changes. In this fashion, the information from a relative frequency table "can be read in terms of dispersion of the mass-points in relation to a reference point" (Crivisqui, 1993, p.75).

According to Crivisqui & Batista (1998, p. 48–49), "the inertia (or dispersion) of a cloud of points in relation to any point m is equal to the sum, for all the points, of the product of the weight associated with each point and the squared distance of each point to a point m" (m is any point in the space taken as a reference), as shown by eq.(4).

$$I_m = \sum_{i=1}^{I} p_i d^2_{(i,m)} \quad \forall i \in I \tag{4}$$

where:

I_m: inertia of the cloud of points in relation to m, with the set of points-profiles represented by $I = \{1, 2, \ldots, i\}$;

p_i: weight (or mass) associated with each point i;

$d_{(i,m)}$: distance between each point i and m.

According to Crivisqui & Batista (1998), the construction of point clouds in relation to point G (the center of gravity or centroid or mean vector of the coordinates of the elements) enables analysis of the shape of this cloud and its graphical representation, since this point has a minimum inertia value.

In this new reference system, the point-profiles are expressed quantitatively by factors and are represented in the factorial spaces (or axes) by coordinates (Crivisqui, 1993).

Considering the quantitative variables (factors), the variance of a cloud of points can be represented by eigenvalues based on the sum of the inertias on each factorial axis, i.e., they reproduce "part of the relationship observed between the variables on each factorial axis" (Crivisqui, 1993, p.138), as show by eq. (5).

$$s_\alpha^2 = \sum_{i=1}^{I} p_i \left[F_\alpha(i)\right]^2 \quad \forall\alpha = 1, 2, \ldots, p \tag{5}$$

where:

s_α^2: variance of factor α, where $\alpha = 1, 2, \ldots, p$;

p_i: weight associated with each point i, where $i = 1, 2, \ldots, I$;

$F_\alpha(i)$: factorial coordinate of the i-th row of the T Table on factorial axis α.

The meaning of the information represented in the factorial plane (defined by pairs of axes: 1 and 2, 1 and 3, and so on) is interpreted through the following components: the eigenvalue associated with axis α, the relative contribution of the point-profiles for the inertia along a factorial axis, the relative contribution of a distance factor from a point-profile to the centroid. Such components are described in more detail in the next sections.

It is important to stress that in correspondence analysis there is a division between active and supplementary variables. The principal (or active) variables appear in the contingency tables and are effectively used in the analysis. The supplementary ones are excluded from the calculation of the marginal totals (rows and columns). Although these excluded variables do not influence the construction of the factorial planes (i.e., do not interfere in the dimension of the eigenvalues, in the coordinates and in the contributions of the active variables), they can furnish additional information on the relationships among the elements analyzed (Benzécri, 1992).

- Eigenvalue associated with axis α

By construction, the eigenvalue for axis 1 must be greater than that for axis 2, and so on ($\lambda_1 \geq \lambda_2 \geq \lambda_3 \geq \lambda_4 \ldots$). In general, their values help define the ideal number of factorial planes, since the eigenvalues that are greater than or equal to the mean eigenvalue must be considered (according to Benzécri, 1992, below this value generally the percentage of inertia falls off regularly). This is expressed in eq. (6).

$$\lambda_\alpha = s_\alpha^2 = \sum_{i=1}^{I} p_i \left[F_\alpha(i)\right]^2 \quad \forall \alpha = 1, 2, \ldots, p \tag{6}$$

where:

λ_α: eigenvalue associated with axis α, where $\alpha = 1, 2, \ldots, p$.

Nevertheless, this author warns that the interpretation of successive factors must be carried out until some meaning for the associations among the variables can be established.

•Relative contribution of the point-profiles to the inertia along a factorial axis

Based on the values observed for this component, one may identify whether there are balanced contributions or few points along axis α, as shown by eq. (7):

$$CTR_\alpha(i) = \frac{p_i \left[F_\alpha(i)\right]^2}{\lambda_\alpha} \quad \forall i \in N(I) \tag{7}$$

where:

$CTR_\alpha(i)$: relative contribution of point i to the inertia of axis α;

$N(I)$: point cloud.

•Relative contribution of a factor to the distance from a point-profile to the center of gravity

Crivisqui (1993) states that this contribution is interpreted as the square of the correlation coefficient between two row points (or between two column points). In this fashion, one can say it measures the quality of the representation of the distance from point i to the origin of axis α, since as this relative contribution increases, it reflects a better association of a point profile i on a factorial axis α, as shown by eq. (8):

$$COR_{\alpha}(i) = \cos^2(w) = \frac{[F_{\alpha}(i)]^2}{d^2(i,0)} \tag{8}$$

where:

$COR_{\alpha}(i)$: relative contribution of a factor;

$\cos^2(w)$: square of the cosine of angle w;

$d(i,0)$: distance from a point profile to the origin of the factorial axis.

In the study of factorial analysis of multiple correspondence, according to Escofier & Pagès (1992), p qualitative variables ($p > 2$) are used, which can by displayed in 2×2 tables. The set of all possible 2×2 tables can be expressed in a single table, called a Burt Table, whose procedures are the same as factorial analysis of single correspondence described at the start of this section. The main characteristics of such tables are: they are symmetrical and contain in their diagonal the frequency of each of the modalities of the p variables under study (see Chart 3).

Chart 3. Structure of a Burt Table with p variables of n individuals

		1st Variable (modalities)			j-th Variable (modalities)					p-th Variable (modalities)					Margin
		1	(...)	k_1	k_{j-1}	(...)	j	(...)	$k_{j-1}+k_j$	k_{p-1}	(...)	p	(...)	k	
1st Variable (modalities)	1	n_1	0	0	...	...	n_{1j}	...	...	...	...	n_{1p}	...	...	pn_1
	(...)	0		0								⋮			⋮
	k_1	0	0	n_{k1}											pn_{k1}
J-th Variable (modalities)	$k_{j-1}+1$				$n(k_{j-1}+1)$		0					$n(k_{j-1}+1)p$			$pn(k_{j-1}+1).$
	(...)	⋮										⋮			.
	j	n_{j1}	......	......	0	......	$n_{j\cdot}$	......	0		......	n_{jp}	......		pn_j
	(...)	⋮										⋮			.
	$k_{j-1}+k_j$								$n(k_{j-1}+k_j)$			$n(k_{j-1}+k_j)$			$pn(k_{j-1}+k_j).$
p-th Variable (modalities)	$K_{p-1}+1$									$n(k_{p-1}+1).$		0			$pn(k_{p-1}+1).$
	(...)														
	p	n_{p1}					np_j			0		$np.$		0	pn_p
	(...)														
	k									0				n_k	pn_k
Margin		pn_1 . ... pn_{k1}			....		$pn_j.$		.. ...			pn_p		pn_k	p^2n

Source: Crivisqui (1993, p.230)

3. Cluster Analysis.

The cluster analysis is a multivariate technique that seeks to group individuals based on similarities or distances, i.e., generally the proximity of items is indicated by some type of distance and the variables are grouped based on correlation coefficients or measures of association (Dillon & Goldstein, 1984; Johnson & Wichern, 1992).

According to the same authors, among the similarity coefficients used in this analysis, Euclidean distance stands out. It is generally preferred for grouping analyses because it contains sample variances and covariances in its formula, as shown by eq. (9):

$$d\,(\mathrm{x},\mathrm{y}) = \sqrt{(\mathrm{x}-\mathrm{y})'\,\mathrm{A}\,(\mathrm{x}-\mathrm{y})} \tag{9}$$

where:

$d\,(\mathrm{x},\mathrm{y})$: Euclidean distance between sample observations contained in vectors x and y;

x: column vector that contains p observations of an item: $\mathrm{x} = [x_1, x_2, \ldots, x_p]'$;

y: column vector that contains p observations of another item: $\mathrm{y} = [y_1, y_2, \ldots, y_p]'$;

A: inverse matrix of the matrix of variances and covariances of the sample.

Besides the choice of an adequate measurement of similarity, the type of computational algorithm used is also very important. Among the best-known techniques, we can mention: hierarchical, where the groups are separated into various levels with no a priori knowledge of the number of clusters or the initial division; and non-hierarchical partitions, where the groups are formed by some specific criterion, thus requiring definition of the number of groupings or the initial division (Sharma, 1996).

Among hierarchical methods, there are those that facilitate grouping, especially: agglomerative ones (such as nearest neighbor, centroid, Ward), which first group the most similar objects; and divisive hierarchical ones (such as automatic interaction detection), which initially divide the objects into two well-distinguished subgroups (Dillon & Goldstein, 1984). The results of these methods are shown graphically in the form of a two-dimensional diagram (dendrogram or classification tree).

Among the agglomerative methods, that of the centroid uses the distance between the mean values of the observations of the variables to obtain the Euclidean distance between two groupings. In the nearest neighbor method, the distance between clusters is defined as the distance between the nearest elements (Dillon & Goldstein, 1984; Hair *et al.*, 1995).

The Ward method is based on grouping individuals within clusters based on the error sum of squares (ESS), as specified in eq.(10). At each stage this sum is minimized based on the combination of the two groupings from the previous stage. Another characteristic of this method is the joining of clusters that have a small number of observations (Hair *et al.*, 1995).

$$ESS = \sum_{j=1}^{k} \left(\sum_{i=1}^{n_j} X_{ij}^2 - \frac{1}{n_j} \left(\sum_{i=1}^{n_j} X_{ij} \right)^2 \right) \tag{10}$$

where:

ESS: error sum of squares;

X_{ij}: characteristic value (trace) of individual i conglomerate j;

k: total number of clusters at each stage;

n_j: number of individuals in cluster j.

The most commonly used of the non-hierarchical techniques is the k-means method. In this algorithm, each item is grouped in relation to the nearest centroid, i.e., a partition is sought with the lowest error component (E), defined by eq. (11), by conducting individual exchanges of groupings until the value of E stops falling (Dillon & Goldstein, 1984).

$$E\left[P\left(n,k\right)\right]=\sum_{i=1}^{n}D\left[i,l\left(i\right)\right]^{2} \tag{11}$$

where:

$P\left(n,k\right)$: partition where each of the n individuals is allocated to each of the k clusters;

$l\left(i\right)$: cluster containing individual i;

$D\left[i,l\left(i\right)\right]$: Euclidean distance between individual i and $l\left(i\right)$.

This method performs much better when the initial division uses hierarchical methods, showing that hierarchical and non-hierarchical methods should be considered complementary instead of alternative[5] (Sharma, 1996).

According to Crivisqui (1998), the classification algorithm of Ward can be used to select the optimal number of classes (groups), through interpretation of the dendrogram, based on the coordinates of the factorial planes from correspondence analysis. The composition of each of the classes can be obtained using the non-hierarchical k-means method.

[5]The cluster analysis, according to Sharma (1996), can be indicated for some situations: to identify similar cities that can be used to test products; to identify voting groups that have the same political inclinations, among others.

In this fashion, grouping analysis can be applied subsequently to the correspondence analysis for each of the questions raised in the field in order to group companies (or systems used by them) that have similar characteristics. Hence, in this study we obtained quantitative variables (factors, which explain the inertia of the point cloud) based on multiple correspondence analysis. After interpretation, these factors were used to describe the companies by means of analysis of groupings.

4. Characterization of the Use of Satellite Tracking Systems in Highway Freight Transportation

This work studies primary users (trucking firms), which theoretically have received the main impacts of this new technology. From these companies we selected those active in highway freight transport since this sector has the greatest number of users of satellite tracking systems according to information from the principal suppliers of this service in Brazil.

We chose only those highway freight transporters with headquarters or branch offices in the city of São Paulo, since the state of São Paulo (at the time of the study, November 1997) had some 49% of Brazilian trucking firms (followed by Paraná with 13% and Santa Catarina with 12%). Within the state of São Paulo, the city of São Paulo has the greatest number of such firms (around de 30%), followed by the city of Santos, with 7%, and Guarulhos, with 6%.

We chose a random sample of 26 firms from a list of users of tracking systems[6]. Interviews were conducted at the start of 1998 based on a questionnaire (see Annex I), utilizing three groups of active (or characteristic) categorical variables: greatest impact caused

[6]For more information on the main economic characteristics of the companies sampled, see Anefalos (1999).

by use of the systems; principal actions taken by the firms to adapt to the systems; and greatest benefits obtained by use of tracking systems.

In characterizing the companies, we used the same supplementary variables (percentage of trucks equipped with tracking, time of use of the system and annual company revenue) for each of the groups of active variables, since they were the sole ones available to assist the analysis. Hence, these three supplementary variables were essential for the analysis of each of the groups, permitting more efficient comparison of the data extracted from the active variables and interpretation of the factors[7].

In all the analyses described below we used the multiple correspondence analysis (CORMU) module of the SPAD computational program, v. 3.5 (CISIA, 1998).

4.1. Main Financial Impacts

To describe the principal effects of the tracking systems on the trucking firms, comparing their predominant characteristics and relating those that presented homogenous behaviors, we analyzed 9 active variables (characteristics) and the 3 supplementary variables described in Section 4.

Through projection of point profiles in line (coordinates) in each factorial plane (formed by the coordinates of two axes), a correspondence can be established between modality groups and tracking systems.

To identify how many factorial axes must be considered in interpreting the data, we used information from the eigenvalues. One can

[7] Although only the analyses of each of the groups of variables were related separately, in Anefalos (1999) one can also find results of joint cluster analysis, based on the factors obtained in the multiple correspondence analysis for each of the three groups of variables.

see from the histogram (see Annex 2) that the percentage of inertia diminishes regularly after the third factorial axis, indicating it would be reasonable to interpret only the first three factorial axes.

Besides this, we also obtained the coordinates and contributions relative to the point profiles and of each factor relative to each of the modalities and to each of the companies, so as to distinguish groups of modalities and of systems based on their greatest relative contributions. The graphs related to the three axes can be constructed based on the coordinates of the point profiles as follows: axes 1 and 2, axes 1 and 3 and axes 2 and 3.

Because the first and second factorial planes best related the modalities from the variables and the systems used by the companies, we concluded that four groups can be delineated by means of correspondence analysis.

Based on the coordinates obtained in this analysis combined with the grouping of the set of tracking systems, we conducted a more careful study of the groups, through cluster analysis, to give a clearer representation of the location of each company in the groups.

We compared the tracking systems based on the set of characteristics observed by means of calculating the Euclidean distances between individual points in the three-dimensional hyperspace (referring to the 3 first factorial axes). To classify the systems, we primarily used the Ward method (ascending hierarchical classification) to choose the optimal number of classes.

Thus, we divided the set of individual points into 4 classes by means of a non-hierarchical method (k-means). The final composition of each class (group) and the most influential modalities in each class confirmed the analyses of the factorial planes realized through correspondence analysis (see Chart 4)[8].

[8] Annex 2 presents some intermediate results, both from correspondence analysis (histogram

Chart 4. Description of the Groups (Classes)
formed by cluster Analysis of Question 3.

Groups (classes)	Companies[1]	Most characteristic modalities (variable/impact)
1	A,C,E,G,I,J,K, L,M,N,T,V,X	Sales/none; number of clients/none; quantity sold/none; final price of service sold/none; selling expenses/none
2	U	–
3	H,Q,W,Y	Number of clientes/neither strong nor weak;quantity sold/ neither strong nor weak; gross profit/neither strong nor weak
4	B,D,F,O,P,R,S, Z	Number of clients/very strong; gross profit/no score rate of return on investment/no score

Source: Data from the study.

[1]List of transport firms as to use of tracking systems: A (Combat); B to G (Controlsat); H (Controlsat + Combat); I (Logic); J (Motorola); K (Multisat); L to Z (Omnisat); W (Teletracker); Y (Teletracker + Omnisat + Controlsat).

First Group

In the first group, the great majority of companies had yearly revenue between US$ 1 and 99 million and used only satellite systems (among them, Controlsat, Logiq and Omnisat). Almost half of them had used the system between 4 and 12 months, and the other half from 2 to 3 months on trucks of their own fleets and some on aggregate vehicles (which are outsourced vehicles with fixed routes, permitting them to be treated as part of the company fleet).

Despite the differences in time of use of the tracking systems, in general there were a small number of trucks so equipped (between 5 and 21), which in a certain form explains the absence of financial effects from use of the systems as related by cluster analysis

of profile of eigenvalues, graph of first factorial plane) and cluster analysis (table to obtain the number of classes by the Ward method) relative to the main financial effects from adoption of the systems by the companies.

(sales, number of clients, selling expenses, final price of service sold), described in the second group of the first factorial plane for correspondence analysis. Added to this fact, it must be pointed out that there were two cases in which implementation of the systems was only possible because the clients paid, excluding them from any of the effects described previously.

Besides this, one of the companies from this group stated that tracking was merely an additional tool, thus justifying the absence of impacts on its selling expenses, and that the prices of its services had been reduced due to increased competition in the market, with no influence from the tracking systems.

Second Group

The second group contains only one company[9], which had used the Omnisat system for 2 years on its entire fleet, specialized in hauling pharmaceutical products. Due to the economic situation during these years, sales had fallen, but with regular growth in selling expenses due to use of the tracking system.

Third Group

The third group is characterized by companies that use tracking on all their trucks, whether own fleet, aggregates, or third-party vehicles (sporadically contracted), since all of them were very concerned with security, carrying high-value cargo both within the city limits for collection and on the highways for transfer to headquarters

[9] It must be stressed that the formation of this group, with only one company, was due to the large contribution of modalities of low frequency in the first factorial plane. According to Crivisqui (1993), these modalities are in general related in the first factorials and indicate the presence of rare cases, and one can opt for their use as supplementary modalities. As their inclusion as an active modality did not prejudice the composition of the other groups, both for this case and for the others analyzed subsequently – whose results were very coherent – we preferred to maintain them as active instead of using the alternative suggested by Crivisqui (1993).

and/or branch offices.

In general they were companies that had used only satellite systems or a combination of satellite/radio for between 3 and 4 years (only one of them used the Teletracker system, for less than 1 year) and that obtained positive results on the number of clients, quantity sold and gross profit.

Nevertheless, according to one of them, the results were not better, since the company did not use all the resources the system offered. Another carrier stated that despite having made great expenditures on the system, it only used 50% of its resources, since the full adoption could actually hinder security (the main objective of acquiring the equipment) by, for example, requiring changes to routes not always as safe as those normally used by the company.

Fourth Group

The fourth group is formed by carriers that used only satellite systems (Controlsat, Omnisat), for periods ranging from 8 months to 5 years, despite having indicated in the correspondence analysis the use of systems for periods of only between 4 and 5 years for this group.

There were a considerably larger number of trucks equipped with tracking than for the companies in Group 1, since even companies using the systems for less than 1 year installed them on an average of 20 of their own vehicles. For companies with more than 1 year of use, there were between 41 and 190 trucks so equipped. These elements confirm that the companies initial expectations for the systems were being met. In many cases they had only initially adopted a system under pressure from insurers but had come to believe that the systems could turn into an important differential to consolidate market share by offering better service, a fact confirmed by the increased number of clients after the adoption of tracking by the majority of the carriers.

On the other hand, for those companies where there was only a small increase in the number of clients, there was increased confidence by large clients due to the tracking systems – these clients had become more demanding in choosing carriers offering better quality services.

Another characteristic present in this group was the existence of companies that could not respond to questions related to the impacts on gross profit and extra rate of return on investment, which may have been due to their having used the systems for only brief periods (between 7 and 8 months), or perhaps because the interview subject had not worked very long at the company, and thus in either case not enough time had yet elapsed to properly judge all the changes engendered by the tracking systems.

4.2. Principal Actions Taken by the Companies

Sixteen active variables (characteristics) were analyzed[10] along with 3 supplementary variables (percentage of trucks equipped, time of system use and company annual revenue) to characterize the actions taken by the companies in relation to use of the tracking systems.

The percentage of inertia diminished in regular form after the third factorial axis, indicating it would be reasonable to interpret

[10] The active variables studied were: restructuring of company administration or of the entire company; allocation of extra capital to improve use of the systems; training of employees as operators; hiring of new operators; training of drivers; hiring of new drivers; purchase of new personal computers; replacement of computers; contracting of personnel to carry out maintenance of tracking systems; outsourcing of services for such maintenance; contracting of systems analysts/programmers, use of existing analysts/programmers at the company; outsourcing of analyst/programmer services; internal development of tracking software; development of software through outsourcing. For greater details, see Anefalos (1999).

the first three factorial axes. Furthermore, we also obtained the coordinates and relative contributions of the point profiles and of each factor relative to each of the modalities and to each of the companies, so as to distinguish groups of modalities and of systems based on their greatest relative contributions. Hence, we concluded that three groups could be delineated by means of correspondence analysis, since the second and third factorial planes better related the modalities of the variables and the systems used by the companies[11].

From the coordinates obtained in this analysis and the grouping of the set of tracking systems, we carried out a more refined analysis of the groups through cluster analysis. We initially used the ascending hierarchical classification algorithm (Ward method) to choose the optimal number of classes from the coordinates of the first 3 factorial axes.

In this fashion, we divided the set of individual points into a total of 4 classes[12] by a non-hierarchical method (k-means). The final composition of each class (group) and the modalities that most influenced each class are described in Chart 5. In Annex 3 we present some intermediate results both from correspondence analysis (profile histogram of eigenvalues, graph of the first factorial plane) and cluster analysis (table for obtaining the number of classes by the Ward method) relative to the main actions taken by the companies.

[11] Although in general the first plane better explains the variables and the individuals, in this case it was not a good indicator becuse the first axis related modalities with low frequently. Hence, only the second and third planes permitted identification of possible groups for characterization of the companies.

[12] Since in the correspondence analysis the first factorial plane was not used to assist in identification of possible groups, probably it was not possible to adequately distinguish the groups (only three were obtained). On the other hand, because cluster analysis was used specifically to classify the companies, it is believed this permitted a more precise division of the set of original data into four classes, using more efficient tools for grouping of individuals.

Chart 5. Description of the Groups (Classes) Formed by cluster Analysis.

Groups (classes)	Companies[1]	Most characteristic modalities (variable/participation)
1	L,M,N,O,P,X,Y,	Training of existing employees to work as operators/high; training of drivers/high
2	A,B,C,D,E,F,G, H,I,J,K,Q,R,S, T,V,Z	Training of existing employees to work as operators/low; training of drivers/low
3	W	–
4	U	–

Source: Data from the study.

[1] List of transport firms as to use of tracking systems: A (Combat); B to G (Controlsat); H (Controlsat + Combat); I (Logic); J (Motorola); K (Multisat); L to Z (Omnisat); W (Teletracker); Y (Teletracker + Omnisat + Controlsat).

First Group

The majority of companies in this group had annual revenues in the US$ 9 to 99 million range and carried only non-bulk dry cargoes (except perishables, non-packaged furniture, cigarettes, chemical products and fuels - the latter two requiring special training due to their hazardous nature), and used tracking only for high-value products with consequently greater risks of robbery.

All the carriers used the Omnisat system, with one of them having adopted 3 systems: Controlsat (for 3 years), Omnisat (for 4 years) and Teletracker (for 3 years). Regarding the Omnisat system, for those companies with few of their own vehicles (from 6 to 20), nearly all trucks were tracked, independently of the time of use; companies with large fleets (from 200 to 500 trucks) and that used the system for less than 1 year tracked around 10% to 15% of their total fleets; companies with a large number of trucks and time of use between 1.5 and 4 years tracked from 50% to 90% of their vehicles.

In general there was clear participation of operator/driver training to enable these companies to adapt to the systems, as described in the first group for the second and third factorial planes from correspondence analysis. In this sense, the carriers that used only the Omnisat system (from the firm Autotrac) emphasized their principal strategies for training employees to work as operators: ongoing assistance from the system supplier; training devoted to security with regular recycling; training of employees for 90 days conducted by two instructors from Autotrac; initial training conducted weekly, with oversight from the insurer Pamcary to evaluate the operator performance regarding the functioning of the system and efficiency against robbery.

Participation by drivers was also very important for the companies to successfully manage the system, mainly due to: cultural and social change of drivers prior to training; expectations for increased personal safety and encouragement of pride in using a new technology; creation of codes and macros (key words to facilitate sending and receiving messages) in the on-board computer; and periodic recycling (every 6 months).

Besides this, all the carriers used the services of Autotrac (and of the companies of the other 2 systems used) to carry out maintenance of the tracking equipment, and had systems analysts at the company to develop specific software applications. Nevertheless, only one of the companies had developed other software to connect the tracking apparatus to the company other systems.

Second Group

This group contains companies that mainly used satellite systems alone (Combat; Controlsat - 6 out of a total of 8; Combat and

Controlsat; Logiq; Motorola; Omnisat - 7 out of a total of 14), and had varied annual revenue levels. They basically tracked chemical products, medications, processed agricultural products, tires, electronic goods, cosmetics and clothing.

In general there was no company restructuring due to adoption of the system, since they were already highly computerized and tracking was only an additional fleet management and security tool. Besides this, the carriers used the services of the supplier to develop the software acquired (although having their own systems analysts) and to maintain the equipment.

Furthermore, there was little training of operators (from a few hours to 3 or 4 days), since the majority considered that the system was easy to handle and there were good manuals to clarify doubts. One of them did not even have an operator, since it was tracked directly by its insurer. The drivers also underwent quick training, but many companies stated the drivers had experienced problems adapting to the tracking systems, mainly those using on-board computers (with keyboards). One of these disclosed that its drivers still used telephones rather than the on-board equipment to communicate with the company.

Third Group

This group includes only one company, which transported general cargo (with the exception of some perishables). It used the Teletracker system for 100% of its own fleet (total of 16 trucks) for a period of 8 months and stated that it had not trained the operator because this individual already knew how to use the system, also mentioning that attempts to train the drivers had not been very successful. There was little restructuring due to adoption of the system, and the supplier developed the software and maintained the system (although the company had its own systems analysts).

Fourth Group

This group also consists of only one company, which transported only pharmaceutical products and whose entire fleet was tracked by the Omnisat system from Autotrac (the same as described in Group 2 of Item 3). It had annual revenues in the US$ 100-500 million range.

The company allocated a large amount of capital to maximize the effectiveness of the tracking system, mainly to minimize robbery through risk management. The system includes management information systems to evaluate the performance of the equipment and has an integrated routing system (developed by Autotrac in partnership with the company own analysts, for its exclusive use).

Driver training was very important in the process of adaptation. Besides this, the operators also were regularly trained (around 6 hours per week) by technicians from Autotrac and the insurer Pamcary, so that they could be fully autonomous in taking decisions about the carriers internal logistics. To this end, they routinely traveled to check the routes followed by the trucks.

4.3. Principal Benefits Obtained by the Carriers

We used 18 active variables (characteristics)[13], and 3 supplementary variables utilized in the previous analyses to characterize the influence of the main benefits obtained by the carriers from using the tracking systems.

[13]The following active variables were studied: reduction of overall costs; reduction of costs for security; reduction in the number of employees; increased cargo security; contracting of insurance coverage for cargo/truck; improved decisions about route changes for load collection; reduced number of routes; reduced idle time for delivery/collection; availability of real-time vehicle position information; assistance for broken-down vehicles; improved vehicle maintenance; better driver confidence in company; better control of drivers; greater competitive advantages; exploitation of new technologies; and reduction in overtime hours. For more information, see Anefalos (1999).

The percentage of inertia diminished regularly after the fourth factorial axis, indicating that it would be reasonable to interpret the first four factorial axes. Besides this, we also obtained the coordinates and relative contributions of the point profiles and of each factor relative to each of the modalities analyzed and each of the companies, so as to distinguish groups of modalities and of systems based on their greater relative contributions.

Since the first factorial plane better related the modalities from the variables and the systems used by the companies, we concluded that four groups could be delineated by means of correspondence analysis.

Starting from the coordinates obtained in this analysis and based on the grouping of the set of tracking systems, we analyzed the groups with greater precision, initially using the ascending hierarchical classification algorithm (Ward method) to choose the optimal number of classes from the coordinates of the first 4 factorial axes.

Thus, the set of individual points was divided into 4 classes by means of non-hierarchical methods (k-means). The final composition of each class (group) and the modalities that most influenced each class are described in Chart 6. Annex 4 contains some intermediate results both from correspondence analysis (histogram of the profile of eigenvalues; graph of the first factorial plane) and cluster analysis (table to obtain the number of classes by the Ward method) relative to the main benefits obtained by the trucking firms.

Chart 6. Description of the Groups (Classes) Formed by cluster Analysis.

Groups (classes)	Companies[1]	Most characteristic modalities (variable/level of satisfaction)
1	C,F,G,I,J,K,L, M,N,O,P,S,T	Contracting of insurance for truck/cargo/none; reduce fleet idle time/none
2	E,V	Contracting of insurance for truck/cargo/low
3	D,H,R	Improve driver confidence in company/low; better control of drivers/average
4	A,B,Q,U,X,Z, W,Y	Contracting of insurance for truck/cargo/high; real-time position information/high;reduced fleet time/high

Source: Data from the study.

[1] List of transport firms as to use of tracking systems: A (Combat); B to G (Controlsat); H (Controlsat + Combat); I (Logic); J (Motorola); K (Multisat); L to Z (Omnisat); W (Teletracker); Y (Teletracker + Omnisat + Controlsat).

First Group

This group is characterized by companies that used only satellite systems (Controlsat, Logiq or Omnisat), concerned exclusively with risk management. The tracking included high-value cargoes, among them pharmaceutical products, tires, chemical products, processed agricultural products, and electronic equipment.

In general there was a large improvement in client service due to the tracking, mainly due to increased confidence. Nevertheless, some companies did not obtain positive effects, due to the dearth of equipment (with consequent installation on few vehicles), or because they passed on the extra costs to large clients.

There was no influence on the contracting of insurance since all the companies already used insurance and adopted tracking at the insistence of the insurers. On the other hand, there was a very significant increase in cargo security because the systems served to discourage hijackers.

The routes remained practically unchanged. In this sense, there was no improvement in choice of routes, truck idle time or delivery time. Regarding the drivers, there was a large increase in their confidence in the company and they were also better monitored by the firms. The companies in this list were characterized in the second and third groups of the fourth plane and in the first group of the fifth and sixth factorial planes from correspondence analysis.

Second Group

This group consists of only two companies, which utilized only satellite systems (Controlsat and Omnisat). Although one of them had used the system for just 7 months and the other for 2.5 years, respectively, both had obtained large improvements in client service, mainly due to the ability for real-time knowledge of the position of the vehicle and driver, providing reduced delays and increased security (one firm stated that experienced bandits avoided robbing tracked cargo). On the other hand, there was little influence of the system on whether to insure the cargo, even though one of the insurers offered a discount for tracked cargo. Fleet idle time was reduced only slightly. No route changes were observed, because they did not use routers[14]. Furthermore, there was a large improvement in availability of real-time information: the firm using Omnisat tracked its vehicles every 5 minutes with a 5% position error; and the other, using the Controlsat system, tracked the fleet every 30 minutes due to the high calling cost (besides encountering difficulties in accessing the system during peak hours - between 5:00 and 6:00 PM - taking up to 40 minutes to get through).

[14] These are technologies that allow planning of pick-up and delivery routes and together with trackers enable real-time monitoring to reduce deviation from what was planned (Parceria, 1997).

Third Group

This group contains companies that used only satellite systems (Controlsat and Omnisat) and also two types of systems (Controlsat and Combat), from 1 to 3 years. They transported only high-value cargoes, among them chemical products (pesticides/herbicides, paints), processed agricultural products, and clothing.

There were large differences in the reduction in insurance costs, because the companies used different strategies for fleet management: regular, substituting escorts with tracking systems, dividing the costs with the insurance company; small, due to the existence of an inefficient structure at the company; and none, because the entire fleet was tracked on the highways and the trucks traveled in convoys (only one tracked out of a total of 8), besides being escorted. Still, all observed an increase in cargo security.

Regarding drivers, there was only a small increase in their confidence in the carriers, because they felt watched and more fearful of robberies, presenting great resistance to using the system. The companies, however, obtained better control of the drivers, to the point of being able to reduce overtime hours for pick-ups within the city of São Paulo. In highway freight distribution (only in relation to satellite systems because their reach includes the entire country), there were time savings, avoiding late deliveries.

The companies practically did not exploit other new technologies associated with tracking, although two of them already used the Internet, management information systems and EDI. This group was also described in the third group of the sixth factorial plane from correspondence analysis.

Fourth Group

The majority of companies in this group used satellite systems (Controlsat and Omnisat). Two of them adopted satellite/radio systems (Combat, Teletracker), and one used three systems (Controlsat, Omnisat and Teletracker). They tracked nearly all their own fleet. In general they carried pharmaceutical products, electronic equipment, cosmetics, footwear, and clothing (only high-value, non-bulk cargo).

There were large improvements in client service, for these began to demand tracking to obtain better cargo security. Some companies implemented customer response service (SAC - Serviço de Atendimento ao Cliente) to allow shippers to know exactly where the truck was and when the load would arrive.

There were significant reductions in security costs, mainly due to less need for escorts and reduced losses, a direct result of increased cargo security.

With tracking, insurance costs fell in relation to those charged before the tracking systems. However, one carrier warned of a contradiction between the logistical and security benefits, because it could not utilize all the logistical advantages without reducing its performance in risk management.

Among the logistics benefits were reduced idle time (conditional on the use of routers along with tracking), fewer route errors by drivers, quicker return (without trailer), and greater overall agility (faster hook-up to full or empty trailers due to real-time position information). Hence, the total pick-up and delivery times were significantly lowered. The main characteristics of this group were delineated in the first group of the first and second factorial planes from correspondence analysis.

5. Final Considerations.

Since this study is based mainly on qualitative data, the use of adequate multivariate techniques (correspondence analysis and cluster analysis) allowed a better understanding of the simultaneous relationships among the variables. The analyses of the three groups of active categorical variables (greatest impacts provided by use of the systems, main actions taken by the companies to adjust to the systems, and greatest benefits so obtained) permitted characterization of the use of satellite tracking in highway freight by means of classification of companies with similar behavior vis-à-vis each of the characteristics studied.

Regarding the financial impacts of the systems on the companies, it must be pointed out that they followed different strategies in adopting this new technology, which affected their level of benefit and performance attained. Mention must also be made that the main concern in acquiring the systems was risk management, due to pressure from insurance companies to combat the high level of hijackings of valuable cargoes. Hence, the firms that managed to incorporate tracking into the routine activities of a large part of their own fleet or aggregate trucks, either opting for more expensive systems (via satellite) or cheaper ones (by radio and satellite), could claim a market advantage over competitors due to positive financial effects. On the other hand, those that had difficulties in introducing the new technology, as a reflection of the low number of trucks equipped, saw practically no positive changes in the factors analyzed.

From analyzing the principal actions taken by the firms, we can observe that training of drivers and operators was the main determinant in dividing the groups. In general, the companies used the technology and services offered by the system suppliers (software, accessories and maintenance). Although some transporters had considered the use of an easy to maintain system, in general the drivers had greater difficulties in adapting to the technology. This was particularly true for those that had to learn to use keyboards (necessary for systems that function only via satellite). In some cases there were even reductions in operational performance, resulting in, for example, hauling cargoes with less security and longer delivery times.

However, since the overarching objective in acquiring satellite tracking systems was risk management, one of the major benefits observed was exactly an increase in security, along with lower security costs due to less need for escorts in one of the groups of companies studied. Besides this, there were improvements in customer service and monitoring of drivers. In characterizing the companies in accordance with the benefits obtained, there were differences from one group to another in relation to the advantages gained both in security and logistics after adoption of tracking. Although a central concern of all companies was cargo security, client service also went up in direct measure with rising opportunities to use the systems acquired. For example, the initiation of special customer response service (SAC) was cited, allied with the availability of more precise logistics information, such as forecast delivery times, route changes and real-time vehicle position.

In observing the composition of the three groups of variables, it can be noted that despite using different systems (satellite only versus satellite and radio), the companies always remained together in the groupings. Based on this fact, one can state that these companies experienced small financial impacts after implementing the systems, probably due to the low percentage of trucks equipped, which in turn caused little need for adaptation of routines and small benefits both for logistics and security.

Due to the huge repercussion of these tracking systems since their introduction in Brazil in 1994, and given their perspectives for wider applications in the transport sector as well as other areas of the Brazilian economy, there is a great need for further studies to evaluate the evolution of their use and to obtain statistics to properly analyze their impact. Hopefully this work has made a contribution to this effort.

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Annex 1

Questionnaire given to companies using tracking systems

1. Mark with an X the product(s) carried by the company without using a tracking system (second column) and those products (s) carried using a tracking system (third column):

Products carried	Transported W/O tracking		Transported WITH tracking	
Eletronic equipment	[ ]	101	[ ]	141
Pharmaceutical products	[ ]	102	[ ]	142
Cosmetics	[ ]	103	[ ]	143
Eletrical appliences	[ ]	104	[ ]	144
Clothing	[ ]	105	[ ]	145
Money/negotiable instruments	[ ]	106	[ ]	146
Vehicles	[ ]	107	[ ]	147
Cigarettes	[ ]	108	[ ]	148
Bottled liquids (in crates)	[ ]	109	[ ]	149
Steel products	[ ]	110	[ ]	150
Chemical products	[ ]	111	[ ]	151
Unprocessed agricultural products	[ ]	112	[ ]	152
Processed agricultural products	[ ]	113	[ ]	153
Animals	[ ]	114	[ ]	154
Wood	[ ]	115	[ ]	155
Moving and hauling	[ ]	116	[ ]	156
New furniture	[ ]	117	[ ]	157
Fuels and lubricants	[ ]	118	[ ]	158
General cargo	[ ]	119	[ ]	159
Computer equipment	[ ]	120	[ ]	160
Auto parts	[ ]	121	[ ]	161
Tires and rubber	[ ]	122	[ ]	162
Weapons	[ ]	123	[ ]	163
Animal medication	[ ]	124	[ ]	164
Footwear	[ ]	125	[ ]	165
Others	[ ]	140	[ ]	180

2. Mark with an X the region(s) of most frequent deliveries during the year:

Delivery region	Transported W/O tracking		Transported WITH tracking	
Brazil–North	[ ]	201	[ ]	221
Brazil–Northeast	[ ]	202	[ ]	222
Brazil–Midwest	[ ]	203	[ ]	223
Brazil–Southeast	[ ]	204	[ ]	224
Brazil–South	[ ]	205	[ ]	225
Argentina	[ ]	206	[ ]	226
Bolivia	[ ]	207	[ ]	227
Chile	[ ]	208	[ ]	148
Paraguay	[ ]	209	[ ]	230
Uruguay	[ ]	210	[ ]	150
Other countries	[ ]	211	[ ]	231

3. Please assign scores (from 0 to 5) to the items listed below according to their impact on the use of the tracking system(s) in 1997:

Score 0 to 5:	(0)Don't know	(1)Negative	(2)None	(3)Very weak	(4)Neither strong nor weak	(5)Very strong

[ ]	301	Sales
[ ]	302	Number of customers
[ ]	303	Quantities sold
[ ]	304	Final price of the service sold
[ ]	305	Cost of the service sold
[ ]	306	Gross profit
[ ]	307	Selling expenses
[ ]	308	Operating profit
[ ]	309	Rate of return on investment (net profit/average assets)
[ ]	311	Others:__________

4. Please respond to the question related to the system(s) used by the company:

Types of Systems existing in the market	What percentage of your fleet's trucks have a tracking system? own?	total?	For how many years have you used the system(s)?	How satisfied are you with the system(s)? Scores from (0) to (4): (0)Don't use (1)Poor (2)Regular (3)Good (4)Excelent
Braslaser/Motorola (Braslaser)	% 401	% 461	421	[ ] 441
Cargosat (Prosat Comum)	% 402	% 462	422	[ ] 442
Teletracker (Vence Eng.)	% 403	% 463	423	[ ] 443
Logiq (Avibrás Telecom.)	% 404	% 464	424	[ ] 444
Omnisat (Autotrac)	% 405	% 465	425	[ ] 445
Radiototal (Radiotrack)	% 406	% 466	426	[ ] 446
Controlsat (Schahin Cury)	% 407	% 467	427	[ ] 447
Satcom (Geo Ecosat)	% 408	% 468	428	[ ] 448
Sky Mark (Combat)	% 409	% 469	429	[ ] 449
Trucksat (Trucksat Systems)	% 410	% 470	430	[ ] 450
Others:______________	% 411	% 471	431	[ ] 451

5. Please give scores (from 0 to 3) to the main actions listed below, according to their roles in the process of harmonizing the company to the tracking systems:

Score 0 to 3:	(0)none	(1)small	(2)regular	(3)great

[ ]	501	Restructuring of company administration
[ ]	502	Restructuring of all sectors of the company
[ ]	503	Allocate more capital to improve the use of tracking systems
[ ]	504	Training of employees to work with operators/data entry technicians
[ ]	505	Contracting new employees for the IT area (operators/data entry technicians)
[ ]	506	Training of drivers
[ ]	507	Contracting new drivers
[ ]	508	Purchase of new personal computers
[ ]	509	Replacing computer equipment
[ ]	510	Contracting personnel for maintenance of tracking equipment
[ ]	511	Outsourcing of services to maintain tracking equipment
[ ]	512	Contracting systems analysts/programmers
[ ]	513	Using existing systems analysts/programmers at the company
[ ]	514	Outsourcing services of systems analysts/programmers
[ ]	515	Developing specific software/database within the company for tracking
[ ]	516	Developing specific software/database for tracking via oursourcing
[ ]	517	Other relevant factors:___________

6. Please give scores (from 0 to 4) to the level of satisfaction related to the benefits listed below obtained from using tracking systems:

Score 0 to 4:	(0)Don't know	(1)None	(2)Low	(3)Regular	High

[ ]	601	Better customer service
[ ]	602	Cost reductions
[ ]	603	Reduction of costs on security
[ ]	604	Downsizing
[ ]	605	Increased security for cargo hauled
[ ]	606	Contracted insurance for truck/cargo
[ ]	607	Better decisions regarding routes, etc.
[ ]	608	Reduced number of routes
[ ]	609	Reduced fleet idle time
[ ]	610	Reduced time for delivery/collection
[ ]	611	Real-time information on vehicle position
[ ]	612	Assist broken down vehicles
[ ]	613	Improved vehicle maintenance
[ ]	614	Improved driver confidence in the company
[ ]	615	Better control of drivers
[ ]	616	Competitive advantages over other companies
[ ]	617	Exploit new technologies
[ ]	618	Reduced overtime hours
[ ]	619	Other relevant factors:___________

7. Please indicate on the lines below what type(s) of analysis were used to decide on purchasing the tracking systems:

____

____

8. Mark with an X:

If the company is:			Type of fleet used by the company:		
[ ]	801	Head office	[ ]	811	Own
[ ]	802	Branch office	[ ]	812	Of third parties

9. Please indicate the number of branch offices per state that use and that do not use tracking systems:

State	How many branches do not use tracking systems in the state		How many branches use tracking systems in the state	
Acre	[ ]	901	[ ]	931
Alagoas	[ ]	902	[ ]	932
Amapá	[ ]	903	[ ]	933
Bahia	[ ]	904	[ ]	934
Ceará	[ ]	905	[ ]	935
Distrito Federal	[ ]	906	[ ]	936
Espírito Santo	[ ]	907	[ ]	937
Goiás	[ ]	908	[ ]	938
Maranhão	[ ]	909	[ ]	939
Minas Gerais	[ ]	910	[ ]	940
Mato Grosso do Sul	[ ]	911	[ ]	941
Mato Grosso	[ ]	912	[ ]	942
Pará	[ ]	913	[ ]	943
Paraíba	[ ]	914	[ ]	944
Pernambuco	[ ]	915	[ ]	945
Piauí	[ ]	916	[ ]	946
Paraná	[ ]	917	[ ]	947
Rio de Janeiro	[ ]	918	[ ]	948
Rio Grande Norte	[ ]	919	[ ]	949
Rondônia	[ ]	920	[ ]	950
Roraima	[ ]	921	[ ]	951
Rio Grande Sul	[ ]	922	[ ]	952
Santa Catarina	[ ]	923	[ ]	953
Sergipe	[ ]	924	[ ]	954
São Paulo	[ ]	925	[ ]	955
Amazonas	[ ]	926	[ ]	956
Tocantins	[ ]	927	[ ]	957

10. Mark with an X the other types of systems that are connected to the tracking systems used:

[ ]	1001	Internet
[ ]	1002	Intranet
[ ]	1003	Electronic document transfer (EDI)
[ ]	1004	Bar code readers
[ ]	1005	Just in time delivery (JIT)
[ ]	1006	Automatic resources
[ ]	1007	Management information systems
[ ]	1008	Other systems:__________

11. Mark with an X the annual company billing expected for 1997:

[ ]	1101	Above US$ 500 million
[ ]	1102	Between US$ 100-500 million
[ ]	1103	Between US$ 9-99 million
[ ]	1104	Between US$ 1-9 million
[ ]	1105	Less than US$ 1 million (JIT)
[ ]	1106	Do not wish to divulge
[ ]	1107	Other indicator:__________

12. Please, what is the company's average annual cargo transported?

[ ]	1201	Tons/km/year	1205	Tons/year
[ ]	1202	Trips/year	1206	Collections (deliveries)/year
[ ]	1203	Boxes/year	1207	Not divulged
[ ]	1204	Pallets/year	1208	Others:__________

Note: Weights are in metric tons.

13. Please, answer the questions below:

Question	Response	
How many years has the company existed?		1301
Age of interview subject?		1302
Position held at company?		1303
How long in current position (years)?		1304
How long with company (years)?		1305
Level of schooling?		1306

14. Suggestions, criticism or comments:

Annex 2

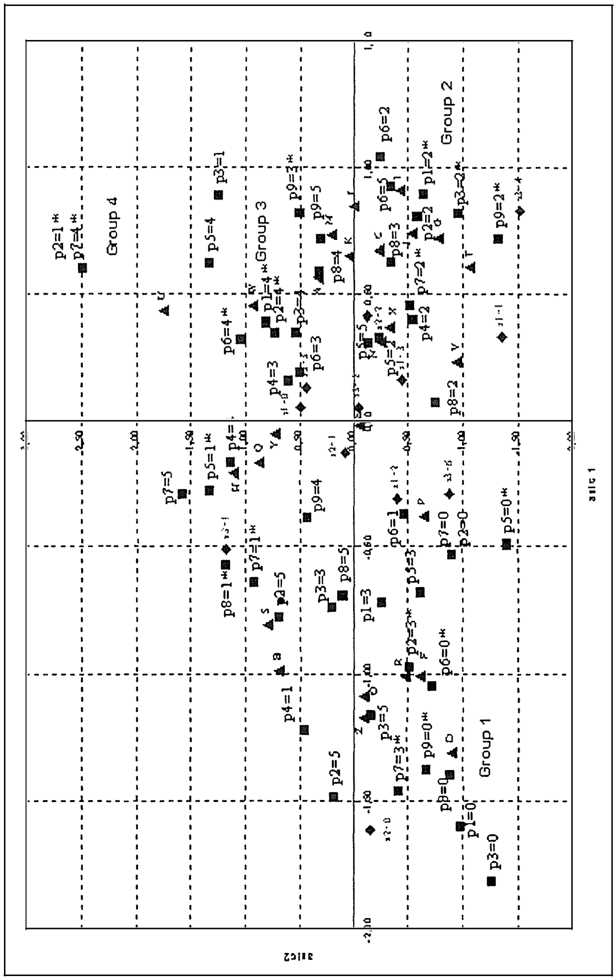
Histogram of the first 25 Eigenvalues[1]

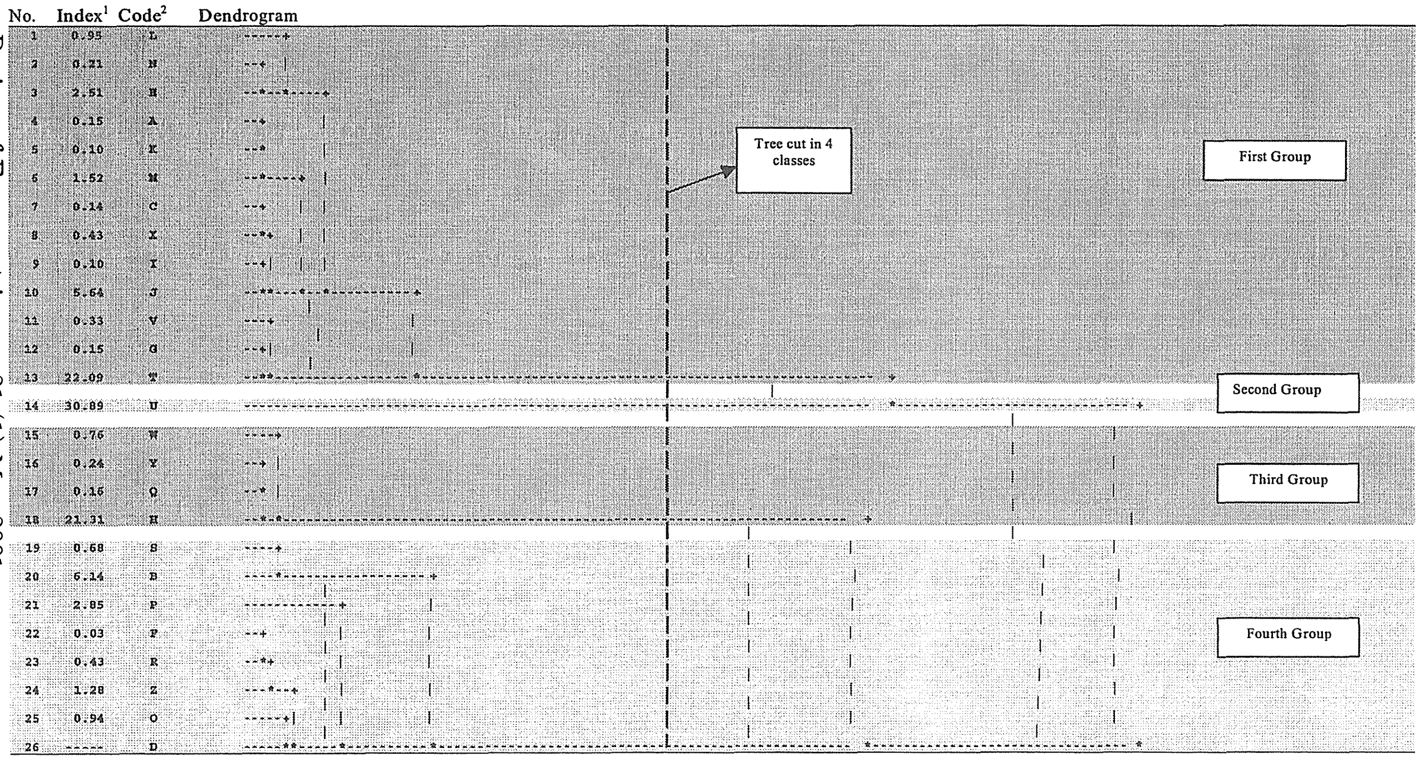
No.	Eigenvalue	Percent (%)	Accumulated percentage	Representation of the relative importance of the percentage of the autovalues
1	0.5212	11.44	11,44	***
2	0.4970	10.91	22,35	***
3	0.4034	8.85	31,21	**
4	0.3493	7.67	38,87	***
5	0.3277	7.19	46.07	***************************************
6	0.2904	6.38	52.44	************************************
7	0.2805	6.16	58.60	*********************************
8	0.2534	5.56	64.16	********************************
9	0.2107	4.62	68.79	****************************
10	0.1999	4.39	73.17	*************************
11	0.1856	4.07	77.25	***********************
12	0.1760	3.86	81.11	**********************
13	0.1441	3.16	84.28	********************
14	0.1242	2.73	87.00	******************
15	0.1238	2.72	89.72	******************
16	0.1930	2.04	91.76	***************
17	0.0782	1.72	93.48	*************
18	0.0699	1.53	95.01	***********
19	0.0657	1.44	96.45	***********
20	0.0579	1.27	97.73	*********
21	0.0382	0.84	98.56	******
22	0.0266	0.58	99.15	*****
23	0.0169	0.37	99.52	***
24	0.0148	0.33	99.84	***
25	0.0071	0.16	100.00	**

[1] Diagonalization trace (4.5556); sum of eigenvalues (4.5556).

Source: Data from the study.

First Factorial Plane





[1] Index as a percentage; sum of the indices: 1.42162 (MIN = 0.03% / MAX = 30.89%)

[2] List of trucking firms as to the use of tracking systems: A (Combat); B to G (Controlsat); H (Controlsat+Combat); I (Logiq); J (Motorola); K (Multisat); L to Z (Omnisat); W (Teletracker); Y (Teletracker+Omnisat+Controlsat).

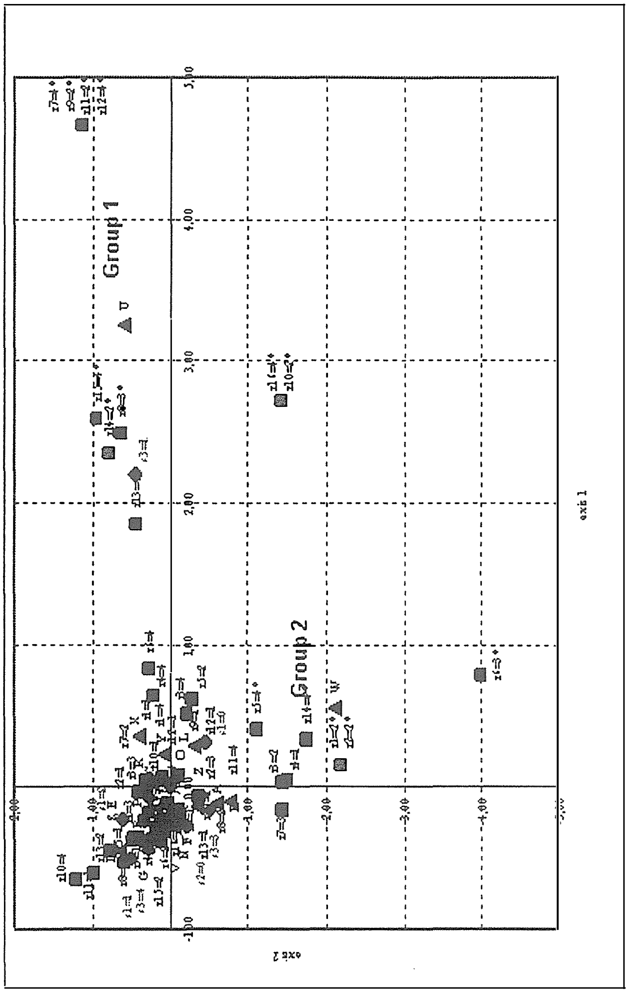
Annex 3

Histogram

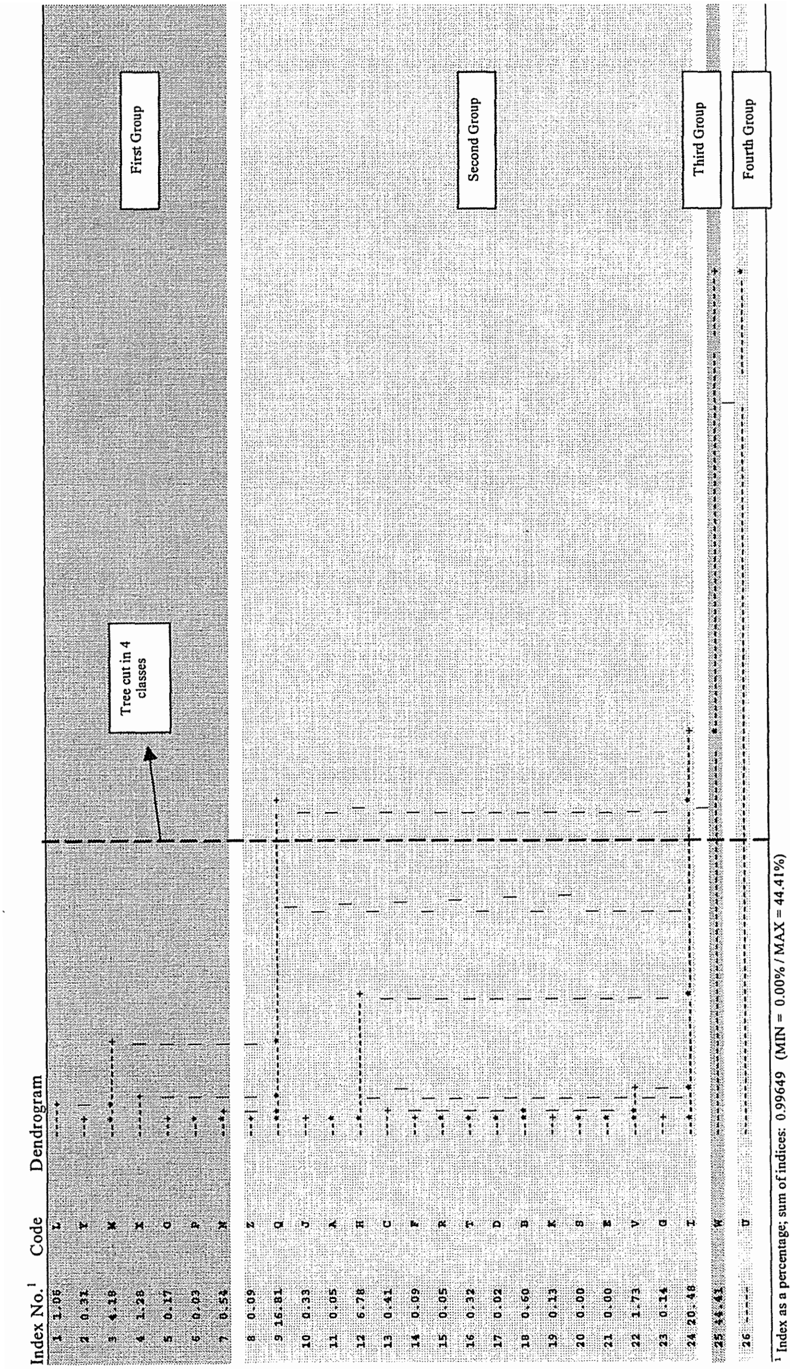
No.	Eigenvalue	Percent (%)	Accumulated percentage	Representation of the relative importance of the percentage of the eigenvalues
1	0.4837	23.45	23,45	***
2	0.2812	13.64	37,09	*************************************
3	0.2316	11.23	48,31	********************************
4	0.1952	9.46	57,78	*******************************
5	0.1613	7.82	65.60	***************************
6	0.1260	6.11	71.71	*********************
7	0.1102	5.34	77.05	*******************
8	0.0846	4.10	81.15	**************
9	0.0684	3.32	84.47	*************
10	0.0544	2.64	87.11	**********
11	0.0490	2.37	89.48	*********
12	0.0480	2.32	91.81	********
13	0.0368	1.79	93.59	*******
14	0.0307	1.49	95.08	******
15	0.0218	1.05	96.13	****
16	0.0202	0.98	97.11	****
17	0.0192	0.93	98.05	****
18	0.0171	0.83	98.88	***
19	0.0096	0.46	99.34	**
20	0.0073	0.35	99.69	**
21	0.0047	0.23	99.92	*
22	0.0017	0.08	100.00	*
23	0.0000	0.00	100.00	*
24	0.0000	0.00	100.00	*
25	0.0000	0.00	100.00	*

Diagonalization trace (2.0625); sum of eigenvalues (2.0625).

Source: Data from the study.



First Factorial Plane


Index No.[1]
Code
Dendrogram
First Group
Second Group
Third Group
Fourth Group
Tree cut in 4 classes
1 1.06 L
2 0.31 Y
3 4.18 M
4 1.28 X
5 0.17 O
6 0.03 P
7 0.54 N
8 0.09 Z
9 16.81 Q
10 0.33 J
11 0.05 A
12 6.78 H
13 0.41 C
14 0.09 F
15 0.05 R
16 0.32 T
17 0.02 D
18 0.60 B
19 0.13 K
20 0.00 S
21 0.00 E
22 1.73 V
23 0.14 G
24 20.48 I
25 44.41 W
26 ---- U
[1] Index as a percentage; sum of indices: 0.99649 (MIN = 0.00% / MAX = 44.41%)

Annex 4

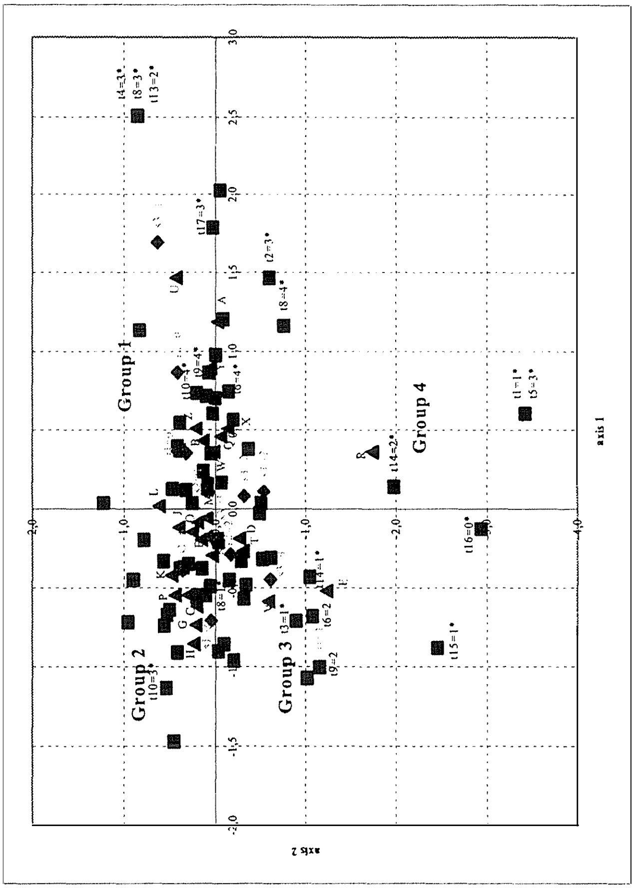
Histogram

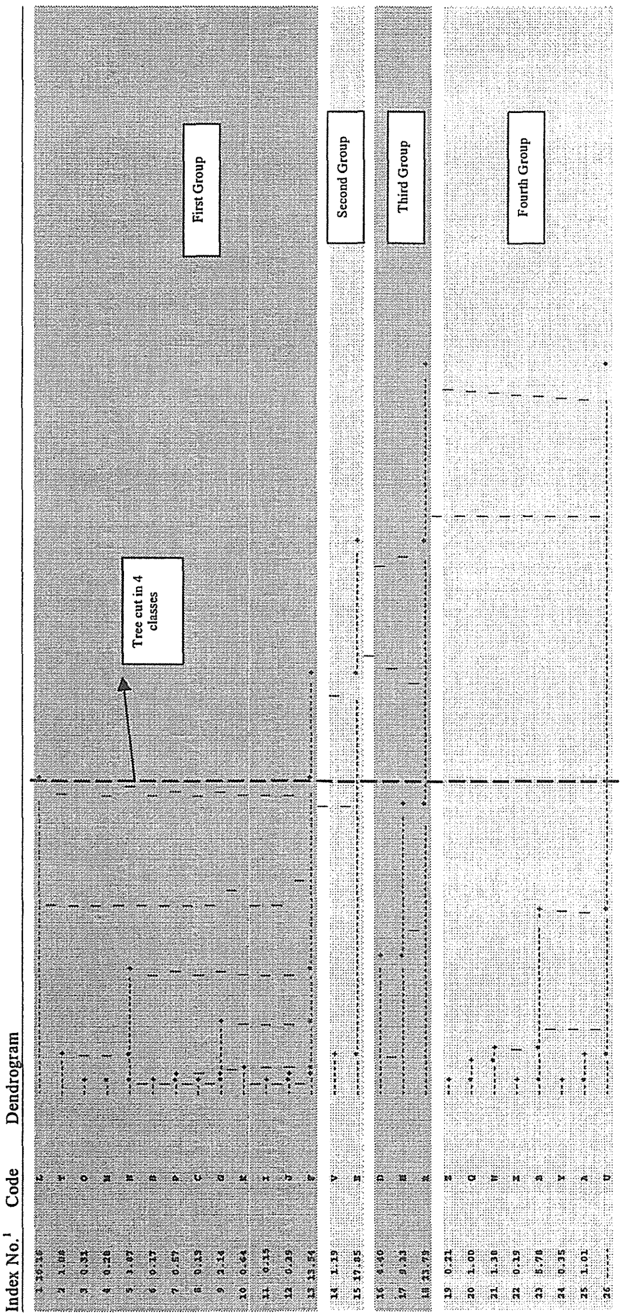
No.	Eigenvalue	Percent (%)	Accumulated percentage	Representation of the relative importance of the percentage of the eigenvalues
1	0.3423	11.62	11,62	***
2	0.2560	8.69	20,32	***
3	0.2483	8.43	28,75	***
4	0.2078	7.06	35,81	**
5	0.1976	6.71	42.52	**
6	0.1862	6.32	48.85	***************************************
7	0.1786	6.07	54.91	************************************
8	0.1525	5.18	60.09	**********************************
9	0.1347	4.57	64.67	******************************
10	0.1234	4.19	68.86	***************************
11	0.1130	3.84	72.70	*************************
12	0.1066	3.62	76.31	***********************
13	0.1061	3.60	79.92	***********************
14	0.0938	3.19	83.10	*********************
15	0.0799	2.71	85.82	*******************
16	0.0760	2.58	88.40	******************
17	0.0633	2.15	90.55	*****************
18	0.0609	2.07	92.61	***************
19	0.0444	1.51	94.12	***************
20	0.0381	1.29	95.42	***********
21	0.0338	1.15	96.57	*********
22	0.0303	1.03	97.60	********
23	0.0285	0.97	98.56	********
24	0.0257	0.87	99.44	*******
25	0.0165	0.56	100.00	****

Diagonalization trace (2.9444); sum of eigenvalues (2.9444).

Source: Data from the study.

First Factorial Plane





[1] Index as a percentage; sum of the indices: 1.05448 (MIN = 0.15% / MAX = 23.79%)

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