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An approach to Principal component analysis for the modal choice problem

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***Abstract*— This paper presents the problem of modal choice for freight transport, we observe the growth of road transport in parallel the decline of rail transportation. To determine the reasons and the choice criteria, a questionnaire is elaborated to study companies' perceptions towards land transportation modes. These responses are analyzed by SPSS using the principal component analysis approach to determine the modal choice criteria and obstacles related to road and rail transportation in Tunisia.**

***Keywords*— road transport, rail transport, modal choice, Principal Component Analysis**

I. INTRODUCTION

Freight transport has become an essential activity where the stakes are extremely sensitive and varied. These stakes mainly concern the economic and industrial organization of the country, globalization, the environment, the logistics organization of the companies and they also touch the criteria of the modes of transport and their technical and economic capacities. Major changes have affected land transport, there is a decline in rail traffic to compare the road. The new organization production "just-in-time" has favored the dominance of the road mode, which is able to adapt to the new demands in terms of speed, door-to-door delivery, flexibility, and responsiveness. It should be noted that the growth of road transport causes the decline of rail transport in parallel which loses its market share. It is the consequence of a rigid response to the needs of industrialists, a delivery station to station, in addition, that it is unable to react in case of unexpected demand. It's not competent to manage the fluctuations of demand.

The choice between modes raises a problem that is limited to two principal questions: how to distribute freight traffic between competing modes? What are the modal choice criteria? To answer these questions, we study the existent by using the questionnaire method then the treatment of answers with SPSS and the analysis of the results by the Principal Component Analysis (PCA) method.

II. LITERATURE REVIEW

The behavior of choice means the act of choosing between two or more alternatives, concerning the selection of the mode of transport it's defined by Asensio [1] and Buehler [2].

There are various factors involved in the choice of transport mode among them the time study by Tiwari et al [3]; Tongzon [4], the distance (Tiwari et al [3]), the cost (Lu [5]), environmental issue (Hunecke et al [6]), service quality (Bowersox et al [7]).

Bontekoning et al [8] analyzed the relationship between road congestion and the decision of shippers to use alternative modes. The results of this study showed that most loaders that have favorable conditions for non-road mode use other alternatives.

Tsamboulas and Kapros [9] have shown that when shippers refer to the cost criterion for choosing the mode of transport, they, therefore, prefer combined transport.

Houée et al. [10] presented the modal choice by combining the revealed and declared preferences data. They reached the following conclusions: an increase in cost or road transport time for companies that use their own means of transport led to a remedy on behalf of account of others and rarely to rail transport.

Savy [11], [12] stated that the choice between transport mode depends on such elements, it is necessary to take into account the nature of the products, the size of the lot to be transported and its conditioning, the distance to be covered and the travel time.

III. PRESENTATION OF THE APPROACH PRINCIPAL COMPONENT ANALYSIS: PCA

In order to determine the choice of the companies towards the transport mode, we used the method of Principal Component Analysis PCA.

This method consists in transforming correlated variables into new variables uncorrelated from each other. These new variables are called principal components, or main axes. It

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reduces the number of variables and makes the information less redundant.

The first step is to distribute a questionnaire to 150 companies containing various questions which are interested in transport modes, the types of products transported, the conditions of transport.

The second step has processed the data collected by SPSS software and make the Principal Component Analysis. Finally, we interpret the obtained results.

A. Organizational Chart of the approach PCA

About our methodology for solving the problem, we chose the use of a questionnaire referred to enterprises and then a principal component analysis PCA. This approach identifies the relationship between the variables used in the questionnaire to clarify the situation of transport road and rail in Tunisia. The figure (1) illustrates the process.

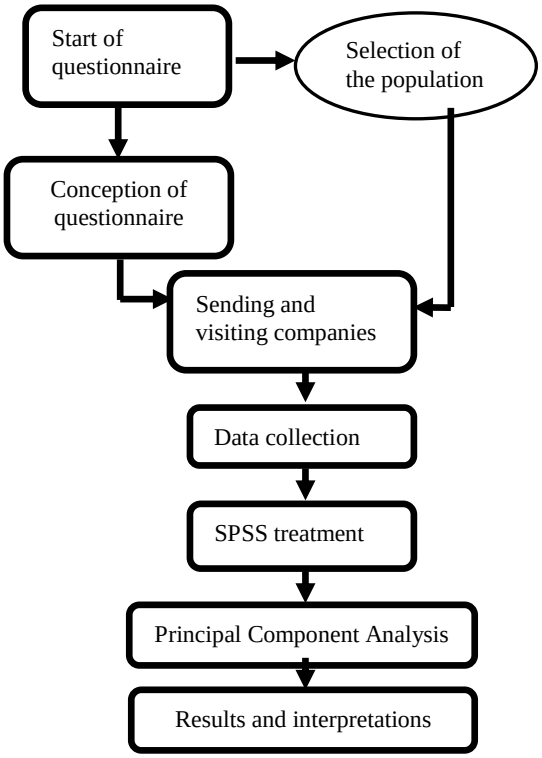

Fig .1 Organizational Chart of the approach PCA

B. Data collection

In order to collect data, we distributed a questionnaire to 150 Companies using land transport for the distribution of their products.

The questionnaire method seems the most sense because the answers must be accurate and clear. This method was chosen because it provides insights into the actual practices of enterprises towards the transportation operation.

In this work, we have taken into account in the choice of companies, those who have the opportunity to use the road mode, rail transport or both modes. The distribution depending on sectors activity, the companies surveyed are subdivided into two sectors of activity as follows: 58% industrials companies and 42% commercials companies.

IV. Results and Discussion

In this section, we present the results obtained by applying the PCA method.

A. Repartition of used modes

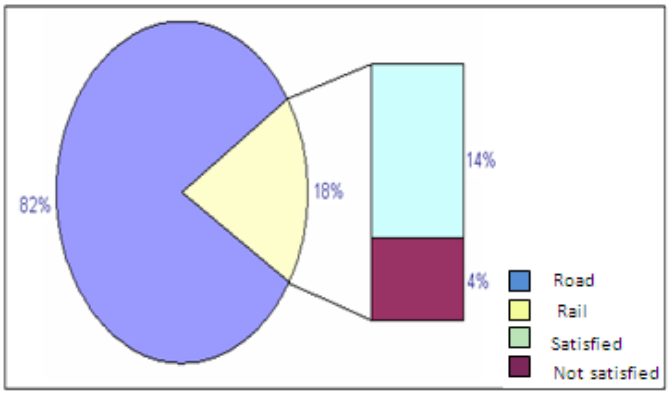

Fig .2 Distribution of the transport mode

The rate 82% of the companies transported these products by the road mode it's due to using their own fleet of vehicles, they are satisfied by only one mode of transportation and ignores the more interesting options that could be offered by others modes. This set of companies exclusively using the road has no idea about the conditions of rail transport. The majority of companies that have access to rail mode is satisfied by the conditions offered by this mode.

B. The modal choice criteria and their importance

The table (I) presented below contains the most interesting modal choice criteria (Cost of transport, quality of services…). We tested the importance of these criteria for the companies surveyed, the result is as follows:

Table I
THE MODAL CHOICE CRITERIA ACCORDING TO THEIR IMPORTANCE

The criteria of choice	Low importance	Normal	Important	Very important
Cost	-	-	12%	88%
Quality of service	-	5%	30%	65%
security	-	4%	48%	48%
Flexibility	2%	24%	48%	26%
Time of transport	-	10%	12%	78%
Nature of goods	9%	11%	50%	30%
Respect of deadlines	-	10%	14%	76%
Respect the environment	16%	74%	10%	-

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Availability	-	-	30%	70%
Better transport conditions	2%	8%	26%	64%

We conclude that companies allowed a great importance to the cost and time of transport, these two criteria are the main determinants of modal choice. Since the cost of transportation is part of the total cost of goods, companies seek to minimize it in order to realize their profit on the one hand and to meet the expectations of their customers in other hands.

C. C*orrelation Matrix*

The correlation matrix is a table of correlations between the sets of variables. As shown in annex (I) the matrix has a number of interesting size coefficients varies between (.024, .797, etc.).

There is a correlation between the cost of transport and the security of the transfer of products, both between the nature of goods and the cost of transport.

D. *EIGENVALUES EI*

The table (II) shows the eigenvalues of the different components.

TABLE III
DISTRIBUTION OF EIGENVALUES AND PERCENTAGES OF VARIANCE ASSOCIATED WITH EACH OF THE PRINCIPAL COMPONENTS

Components	**Initial eigenvalues**		
	Total	**% of variance**	**% Cumulative**
1	3,510	35,098	35, 098
2	1,810	18,104	53,202
3	1,234	12,342	65,543
4	,894	8,941	74,484
5	,720	7,201	81,686
6	,574	5,740	87,426
7	,422	4,221	91,647
8	,375	3,751	95,398
9	,282	2,825	98,223
10	,178	1,777	100,000

The PCA method is to maximize the variance explained by the first component. It can be seen that the eigenvalues of the first component are 3.510 which corresponds to 35.098% of the total variance of 10 components. The second component explains an additional portion of variance, independent of the first, and corresponding to a lower proportion than the previous one. Examination of the table (III) shows that the C2 component explains 1.810 units of variance (out of 10), which corresponds to 18.104% of the total variance. We can, therefore, say that after extracting two main components we reach 53.202% of the total variance. With the third component providing 1,234 we obtained 65,544% of the total variance. Thus, we can be satisfied by 3 components given the purpose of the PCA which allows reducing the data of 10 variables with 3 components which gives 65.544% of the initial variance.

E. THE MATRIX AND DIAGRAM OF THE COMPONENTS AFTER ROTATION

The table (III) presents the results of the matrix after rotation which simplifies the structure of the solution by maximizing the variance of the components.

TABLE III
MATRIX AFTER ROTATION

	Components		
	1	**2**	**3**
Transport availability	,828	,203	-,005
Better transport conditions	,823	,240	,020
Respect the environment	,621	,186	-,369
Respect of deadlines	,129	,186	-,275
Quality of service	,070	,725	,218
Nature of goods	,357	,689	,059
Security	,422	,506	,309
Cost	-,210	,098	,865
Time of transport	,603	-,112	,626
Flexibility	,085	,543	,570

The study of the matrix after rotation shows that the first component is defined by the importance of the availability of transport, better conditions and less important respect for the environment. The second component is defined by the respect of deadlines, quality of service and nature of goods. Concerning the third component, it is defined by the cost of transport, the time and less important the flexibility.

V. OBSTACLES OBTAINED BY USING THE ROAD AND THE RAIL TRANSPORT

In this section, we presented the obtained obstacles by transport mode road and rail according to the opinions of companies.

A. OBTAINED OBSTACLES FOR ROAD TRANSPORT

The main obstacles road transport is presented in the figure (2) in below, we noted:

- P1: road infrastructure problem
- P2: congestion
- P3: insecurity
- P4: loss or destruction of goods
- P5: limited capacity
- P6: others problems

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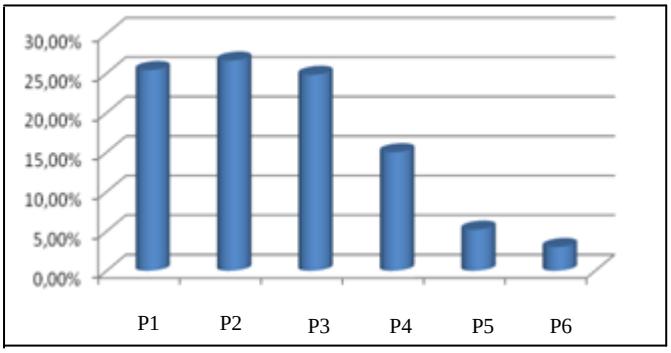

Fig .2 Obtained problems using road transport

The surveyed companies affirm that there are three essentials obstacles: congestion, bad infrastructure and the risk of road accidents. Regarding the capacity of vehicles, it is not an obstacle since the 34% of companies have a cargo that does not exceed 5 tonnes, so they can be transported by road.

B. OBTAINED *OBSTACLES FOR RAIL TRANSPORT*

For companies using rail for the transfer of their products, they encounter difficulties in terms of travel frequency. 26% of companies make more than 10 trips daily to various cities of Tunisia, this relatively large number of travel can be carried out by road transport. The rigidity of the rail is another problem since it transports from gare to gare. The transported products must wait at the terminal until they are loaded into the truck, which causes the increase of transport costs.

Although the wagons used by SNCFT are varied, they remain non-adaptable for all types of products, for example, liquids products. The latter need transmitted in cistern wagons which are generally reserved for the transport of fuels to the detriment of other types of liquids.

VI. CONCLUSIONS

This work presented the modal choice problem. We observe the growth of road transport in parallel with the decline of rail transport. A questionnaire is elaborated to determine companies' perceptions of land transport modes. These responses are treated by SPSS and analyzed by the principal component analysis approach to determinate the modal choice criteria and the related obstacles to road and rail transport in Tunisia. The companies affirm that the rail transport is limited and it's conditioned by the types of products transported, the frequencies of travel and the traveled distances for these reasons they resort to road transport.

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ANNEX 1
CORRELATION MATRIX

		Cost	Quality of service	Time of transport	Security	Flexibility	Nature of products	Respect of deadlines	Respect the environment	Transport availability	Better transport conditions
Corrélation	Cost	1,000	,191	,755	,090	,781	,051	,096	,042	,096	,114
	Quality of service	,191	1,000	,063	,797	,362	,739	,296	,020	,296	,331
	Time of transport	,755	,063	1,000	,357	,295	,224	,024	,162	,344	,580
	Security	,090	,797	,357	1,000	,429	,519	,202	,223	,355	,367
	Flexibility	,781	,362	,295	,429	1,000	,290	,282	,124	,184	,160
	Nature of products	,051	,739	,224	,519	,290	1,000	,721	,290	,302	,458
	Respect of deadlines	,096	,296	,024	,202	,282	,721	1,000	,332	,571	,236
	Respect the environment	,042	,020	,162	,223	,124	,290	,332	1,000	,430	,347
	Transport availability	,096	,296	,344	,355	,184	,302	,571	,430	1,000	,755
	Better transport conditions	,114	,331	,580	,367	,160	,458	,236	,347	,755	1,000

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