Use of Innovation Radar and Hierarchical Cluster Analysis for the Diagnosis of Organization Climate and Innovation

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Abstract

This paper aims to diagnose the climate for innovation in different economic sectors in the region of Vale do Rio Pardo (Rio Grande do Sul - Brazil) using as basis the Hierarchical Cluster Analysis (HCA) and the Innovation Radar. The present survey covered companies in the Mechanical, Chemical, Petrochemical, Services, Food and Information Technology (IT). According to the HCA, it appears that the sectors studied in this work can be divided into three groups: brown, red and green. The brown group is comprised by the chemical and petrochemical industries, green is formed by the mechanical industries and services and the red group is composed by the food industry and IT. The results obtained by HCA are used to maximize and support the analysis carried out by the Innovation Radar. According to the analysis performed based on the radar, it appears that the red group has a higher amount of climate-friendly innovative features, so this group is considered the most innovative within the scope of this research. The brown group is considered less innovative than the red and the green group has the least amount of climate-friendly innovative features, hence this is the least innovative. The results based on HCA confirm and complement the results of a quantitative acquired under the radar of innovation. Based on this premise, it is concluded that the HCA is a valid tool to help diagnose the climate of innovation.

Keywords: climate of innovation; innovation radar; hierarchical cluster analysis.

1 Introduction

The technological and global society presents us with new challenges filled with socioeconomic needs, emergencies and opportunities. This feature encourages the organization's competitive advantage through the generation of products, processes and services. For this, it is necessary an organizational environment conducive to creating something new. According to Joseph Schumpeter (1961) innovation occurs when a new product is launched in the consumer market or when a new production method is used by a company. The exploitation of these products, services or processes can generate unprecedented competitive advantage to the organization, so the medium and long term, innovation is essential for the sustainability of companies and countries in the future.

Research related to organizational climate had a major development in the U.S. in the mid-60 due to work done by Forehand and Gilmer (1964), Pelz and Andrews, Litwin and Stringer (1966). In Brazil there is a growing research and development work related to the subject in order to diagnose the climate and innovativeness of enterprises. This fact can be verified by the number of papers, dissertations and theses that address this issue, as well as the growing number of Letter Patent granted in recent years. According to Coda (1992), research related to job satisfaction are important mechanisms to verify and innovative organizational climate.

In this context, this paper aims to diagnose the innovative climate in the sector food, mechanical, petrochemical, chemical, services and IT of the Vale do Rio Pardo (RVRP) - RS - Brazil. This process is accomplished by HCA and Radar Innovation. The contents of the article is organized as follows: section 2 discusses the research related to the innovation process in Brazil, section 3 deals with the scales and tools used in this work to diagnose the creative climate, section 4 presents the methodology used to develop the work and section 5 discusses the results and analysis.

2 Innovation in Brazil

The information covered in this section refer to surveys conducted by different agencies and is intended to inform regarding aspects of the innovation process in Brazil.

According to research of The Global Innovation Index Brazil takes up the 47th position in the ranking of innovation among 125 countries surveyed (WIPO, 2011). This degree is calculated based on the analysis of environments conducive to innovation.

The research conducted by WIPO (2011) points out that Brazil has qualified human resources to innovate, however, there are some weaknesses that need to be improved or reconsidered. According to the survey, the country's infrastructure is the most critical aspect to be improved to facilitate favorable conditions for innovation.

According to the survey Current Stage of Innovation Management, conducted by Innoscience Consulting (2011) and the IEL (Regional Center of the Institute Euvaldo Lodi), at the 3rd International Congress of Innovation, it was found that 91% of survey participants consider innovation as a strategic priority and 79% plan to increase investment in innovation during the year 2011.

The increase in capital is due to meet to the company's growth. According to the survey, 64% of respondents are satisfied or very satisfied because of the innovation brought about by financial return, however, it appears that less than one fifth of the participants are very satisfied with the results brought about by innovation.

The research, Technological Innovation Survey, conducted by ABDI (Brazilian Agency for Industrial Development) (2010), found that 70% of large Brazilian companies investing in innovation. This survey is conducted quarterly with industrial companies with 500 or more employees. There are approximately 1,650 companies with this feature in the Brazilian industry and this whole was performed on the sample.

The information indicated possible to conclude that Brazil has the potential for innovation to be explored, however, the country's infrastructure proves to be the main negative aspect of innovation.

3 Scales and Tools

The tools and scales used to diagnose the organizational climate are considered strategic mechanisms to manage human resources that are part of an organization. These mechanisms make it possible to create conditions to diagnose and manage the quality of work life by identifying the source of the problems related to employees.

The most widely used mechanism for diagnosing the organizational climate is the SOQ (Situational Outlook Questionnaire), proposed in 1999 by Ekvall. This mechanism is the result of more than 50 years of research by Ekvall during the twentieth century and was developed by re-reading of organizational diagnosis model CCQ (Creative Climate Questionnaire), developed in 1983 by Ekvall.

The CCQ consists of 10 factors (challenge and involvement, conflict, debate, dynamism, freedom, idea support, idea time, risk-taking, trust/openness, playfulness and humor) each factor is composed of five questions (Ekvall , 1996). Table 1 concisely presents concepts related to the 10 factors that make up the CCQ.

Table 1: Concepts relating to the factors of the CCQ 10.

Factor	Concept
Challenge and Involvement	Degree to wich people are involved in daily operations, long-term goals and visions.
Conflict	Presense of personal and emotional tensions in the organization.
Debate	The workplace should stimulate discussion of new ideas.
Dynamism	Dedication, willpower, strength of character, are elements that instigate the creation.
Freedom	Grant autonomy and space for the employee to carry out their activities freely.

Idea Support	The ideas and suggestions are received in an attentive and professional way.
Idea Time	Period dedicated to conducting research, setting objectives and goals.
Risk-Taking	Do not be afraid to create, innovate and accept challenges are positive traits in employees.
Trust/Openness	Mutual respect, confidence in the character of co-workers, are essential.
Playfulness/Humor	The workplace should provide an entertaining atmosphere.

Source: Ekvall, 1996.

The SOQ is used by several authors (Lamers, 2007; Cabra, Talbot, Joniak, 2005; Isaksen, 2007; Isaksen, Lauer, Ekvall, 1999; Isaksen, Lauer, 2002; Crespo, Wechsler, 1999; Plebani, 2009), and that each author uses the model CCQ as a reference point for the development of SOQ to meet the needs of the context analysis.

Depending on the context under consideration, the authors create different SOQ comprised of different dimensions that are relevant to the context in which organizational climate analysis is performed. After application of the SOQ to check the organizational climate in the organization, you must perform the analysis of data on this mechanism. The analysis covered in this paper correspond to HCA and Radar Innovation.

According to Scherer, Bignetti and Charlemagne (2009), the radar is an innovative instrument that covers the various dimensions of business, innovation intensity and the degree of dependence. It is constructed from rays that start from a central point, each ray represents one dimension of the business in which business can innovate. The data are represented in this mechanism by the Likert scale.

The Likert scale is a type of psychometric response scale used in questionnaires and was proposed by Rensis Likert in 1932(Bertran, 2004). This scale requires respondents to indicate the degree of agreement or disagreement with statements regarding the attitude being measured. Statements of agreement should be given high or positive values while the unfavorable statements should receive low or negative values.

The method considered in this work to perform the data analysis of the organizational climate is the HCA. The applications of HCA are diverse and include various branches of knowledge such as Psychology, Social Science & Medicine, Geology, Chemistry, Engineering, and others (Mingoti, 2005). In this work, this technique is used for the same purpose for which it was proposed, ie, is used to verify the similarity and differences between the samples that comprise the universe of the study. In the context of this work, the variables are represented by the ten dimensions of the CCQ and the samples are represented by branch of economic sectors in the services, mechanical, chemical, petrochemical, food and IT.

The HCA connects the samples by their associations, producing a dendrogram where similar samples are grouped together. The parameter considered in this process is the measure of distance between samples. In this case, the smaller the distance between samples, the greater the similarity between them and the greater the distance, the greater the difference between the samples (Mingoti, 2005). The next section covers the methodology addressed to develop this work.

4 Methodology

According to Santos (2004), the methodology used to develop this research is characterized as exploratory and descriptive. The literature aspect of this work resulted in the identification of concepts, methods and scales that refer to organizational climate, as well as some characteristics related to the innovation process. At this stage we built a mechanism to diagnose the creative climate of some companies from RVRP. The methodology described is contemplated in the application form developed to diagnose the creative climate in companies located in RVRP.

5 Methodological Procedures

This section is divided into three stages: the first includes the development of the questionnaire used to diagnose the climate of innovation RVRP companies, as well as the validation of this mechanism. The second stage covers the process of choosing the companies participating in this study and the questionnaire, and the third stage presents and analyzes results.

First stage

From a study of methods used to observe the climate of innovation, we chose to use the SOQ as a basis for constructing the questionnaire discussed in this research. The questionnaire consists of ten dimensions of the CCQ and has 41 questions related to diagnosis creative. Each factor is composed of four questions, unless the dynamic factor which has five. The Likert scale with 5 points was used to quantify each item that can take one of the following states: never, rarely, sometimes, often and always.

The validation of the questionnaire consisted of items with their analysis of the frequencies given the participants' responses. In this analysis with the companies, it was observed that the items were clearly exposed and good understanding, because only items 15, 24 and 25 had low-frequency (94.55%), whereas the desired value is 100%.

Second stage

To identify the companies participating in this research was to determine which cities would have to contemplate. The method discussed uses to make this process as a reference COREDE – Regional Development council of Rio Grande do Sul (2011), which divides the RVRP three micro-regions (southern, central, north). This diagnosis was made by consulting the reports of the IBGE (Brazilian Institute of Geography and Statistics) (2011), for the period of 2009. Based on these criterion, the cities that comprise the scope of the research are: Santa Cruz do Sul (micro center), Rio Pardo (south) and Sobradinho (north).

After, we identify the companies participating in this study. This process was carried out in consultation with the Records of Companies of the Federation of Industries of Rio Grande do Sul (FIERGS, 2009), in order to find companies that are located in at least one of the cities of RVRP. The criteria considered to select the firm based on the number of patents or trademarks for the same. Based on this information, we selected companies with the largest number of patent applications and trademark. The identification of patents and trademarks of a company was based on searches performed on the database of the National Institute of Industrial Property (INPI, Brazil), and on the basis of European Patents.

The companies identified were invited to participate in this project. This process was conducted by telephone contact to schedule a meeting with the leader of the selected firm. At the meeting the objectives of the study were explained and the form for data collection was given to charge. In some situations it was not possible to schedule a meeting with the company, in this case, the form was sent via e-mail.

The questionnaire took place during 2010 and was a process carried out on individual business lines. In this case it was decided that the questionnaire would be applied to the sector responsible for the research and development (R & D). Upon completion of this process, questionnaires were collected in companies, except when this process was conducted via e-mail.

Third stage

The data obtained from the questionnaires were treated in a quantitative manner in order to establish the Middle Ranking (MR) of the data on the questionnaire. In this case, the data presented in Table 2 are for the averages of each economic sector to a certain size. This process was performed in OppenOffice Calc software version 3.3, 2010.

The first analysis performed on the data set presented in Table 2 corresponds to HCA. This analysis was performed on six economic sectors (IT, food, mechanical, chemical, petrochemical and services) and on the 10 factors (challenge and involvement, conflict, debate, dynamism, freedom, idea support, idea time,

risk-taking, trust/openness, playfulness and humor). The statistical treatment of data was performed in Pirouette software version 3.11. To obtain the dendrogram were used euclidean distance and the incremental method of connection.

The second analysis was performed on the model of the Innovation Radar. This analysis was performed for three groups: IT and food, chemical and petrochemical, mechanical and services industries. The range covered in this mechanism represents a 5-point Likert scale. This analysis was carried out in software version 3.3 Calc OppenOffice 2010.

6 Results and Analysis

This section is divided into two stages: the first presents the data regarding the companies that agreed to participate in this research. The second stage presented the results obtained by running the Radar Innovation and HCA.

First stage

This step provides information regarding the number of companies RVRP participants in this study. The methodology used to conduct this process-related information addressed COREDE (2011), IBGE (2011), FIERGS (2009) and information about the database of the National Institute of Industrial Property (INPI Brazil), and based European Patent Office. This information was defined by the set of companies participating in this study. For ethical reasons the names of companies are not addressed in the survey.

Agreed to participate in this research four food companies, three mechanic companies, two petrochemical industry, two chemical industry, eight companies in the services and 5 of the IT industry. The companies were grouped by the nature of economic activities they perform. It appears that the whole sample is 24 companies RVRP. The total number of employees who responded to the questionnaire corresponds to 105 people. Of these, 13 are in the food industry, the petrochemical 8, 21 mechanic sector, IT 23, chemistry 21 and 19 people in the sector of services.

Second stage

At this stage results are presented concerning the analysis performed on the data set presented in Table 2. This table presents for each economic sector the RM regarding the dimensions covered in the questionnaire.

The Table 3 presents the highest and lowest average for the ten dimensions. This framework was based on data presented in Table 2. Through analysis of these data, it appears that the services sector had the lowest average for nine of the ten dimensions addressed in this work, while the IT sector had the highest average for nine of the ten dimensions in question.

Table 2: MR 10 for the dimensions for the six economic sectors covered in the survey.

	Food	Mechanical	Petrochemical	Chemical	Services	IT
Challenge	4	3,8	4	3,8	3,4	4
Freedom	4,3	3,6	3,9	3,7	3,2	4,4
Dynamism	3,7	3,2	3,7	3,6	3	4,2
Idea Support	3,8	2,9	3,5	3,3	2,6	3,8
Idea Time	3,9	3,2	3,6	3,8	2,9	4,1
Conflict	4,2	3,9	3,8	4	3,8	4
Debate	4,2	3,2	3,8	3,7	3,1	4,2
Playfulness	3,4	3	3,3	3,6	3,3	3,7
Trust	3,9	3,4	3,5	3,5	3,1	3,9
Risk- Taking	3,8	2,9	3,4	3,2	2,6	3,8

Source: From the authors.

Table 3: Relationship between the highest and lowest averages for each dimension.

Dimension or factor	Sector and the highest average by a factor	Sector and the lower average by a factor
Idea Support	Food and TI = 3.8	Services = 2.6
Conflict	Food = 4.2	Petrochemical and Services = 3.8
Trust	Food and TI = 3.9	Services = 3.1
Risk-Taking	Food and TI = 3.8	Services = 2.6
Debate	Food and TI = 4.2	Services = 3.1
Challenge	Food, IT and Petrochemical = 4	Services = 3.4
Playfulness	IT = 3.7	Mechanical = 3
Dynamism	IT = 4.2	Service = 3
Freedom	IT = 4.4	Services = 3.2
Idea Time	IT = 4.1	Services = 2.9

Source: From the authors.

Upon execution of HCA, we obtained the dendrogram shown in Figure 1. This approaches the level of similarity between the economic sectors according to the chosen variables (10 dimensions covered in the survey), and the scale (0.0 to 1.0) above the dendrogram represents the similarity indices between samples (economic sectors).

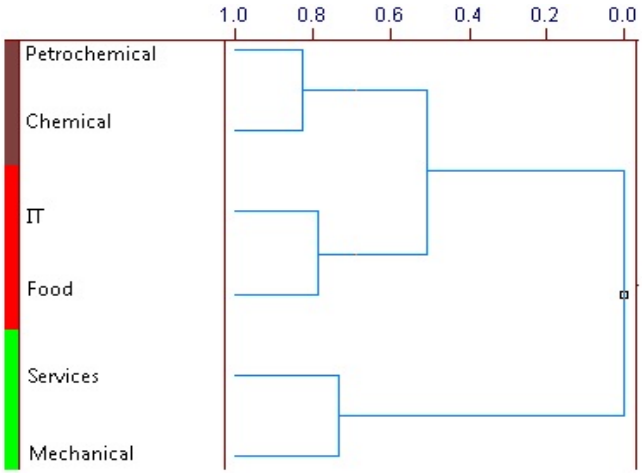

Figure 1: Level of similarity between the economic sectors. Source: From the authors.

This dendrogram shows the formation of three groups when the similarity index is greater than 0.51. In this case, the group is composed of brown petrochemicals and chemicals, the red group is understood by the IT industry and food and the green group is formed by the mechanical and services sectors.

Through analysis of this dendrogram, it appears that the greatest similarity index focuses on the group brown. For this group, the index presented in the dendrogram is equal to 0.82. Whereas the maximum degree of similarity corresponds to 1, the index recorded for the brown group is the highest among the sectors covered in this research. This means that the chemical and petrochemical sectors are most similar to each other when compared with others. The red group is formed when the similarity index is equal to 0.78 and the green group is made when the similarity index is equal to 0.73. This means that the sectors that comprise a particular group have a higher number of features similar to each other.

When the similarity index is below 0.51 the dendrogram shows the formation of a middle group consisting of red and brown groups. This means that these two groups are more similar to each other when compared with the green group. The dendogram also possible to see when there is the formation of only one group. In this work, this happens when the level of similarity is equal to 0, ie, the group average shows no resemblance to the green group. The results obtained with the application of HCA are used to maximize the analysis carried out by the Innovation Radar. In this context, the radar runs for the three groups identified by the HCA.

According to information presented in Table 3, the food and IT sectors have the highest MR for five of the ten dimensions addressed. Based on this premise and considering the degree of similarity observed for these sectors, innovation radar runs in order to verify the behavior presented by the sectors that comprise the red group.

The Figure 2 presents the results in the form of radar to the five companies in the IT sector and the four food companies. Participated in this process 36 employees for the two sectors. Through observations, it appears that the sectors in question showed similar except for size and relaxation dynamism and playfulness. This fact is ratified by the similarity index seen by the HCA. Through analysis of the radar, it appears that the dimensions of freedom and challenge and involvement had the highest average for the sector food and live on the lowest average factor playfulness. For the IT sector the highest average on the scale lies freedom and less on the relaxation factor playfulness. This finding corroborates the behavior displayed very similar between these two sectors.

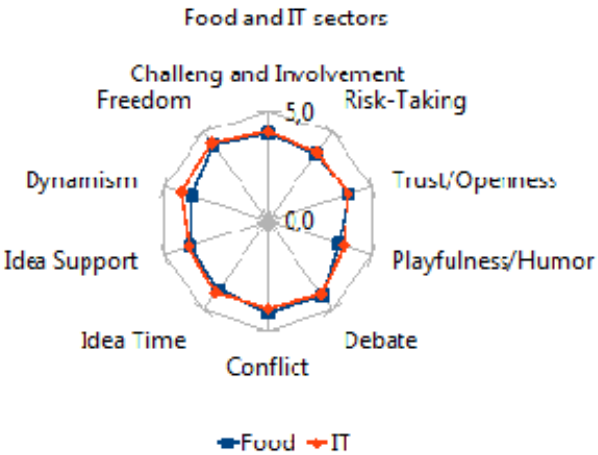

Figure 2: Radar Innovation regarding the food and IT sectors. Source: From the authors.

As observed by the HCA, the largest similarity index focuses on the chemical and petrochemical sectors. Based on this premise, the innovation radar runs in order to verify the behavior presented by the sectors that comprise the group brown. the Figure 3 presents the results in the form of radar to the two companies in the chemical sector and for two of the petrochemical sector.

Participated in this process 29 employees for the two industries. Through observations, it appears that the sectors in question have very similar behavior to each other. This fact is ratified by the similarity index seen by the HCA. Through analysis of the radar, the factor challenge and involvement has the highest average for the petrochemical sector and the dimension playfulness apresents the lowest index. For the chemical industry lies the highest average on the scale conflicts on the factor and the lowest risk-taking.

According to information presented in Table 3, the services sector has the lowest MR for nine of the ten dimensions. Based on this premise and considering the degree of similarity between the mechanical and services sector, the innovation radar runs in order to verify the behavior presented by the sectors that comprise the green group.

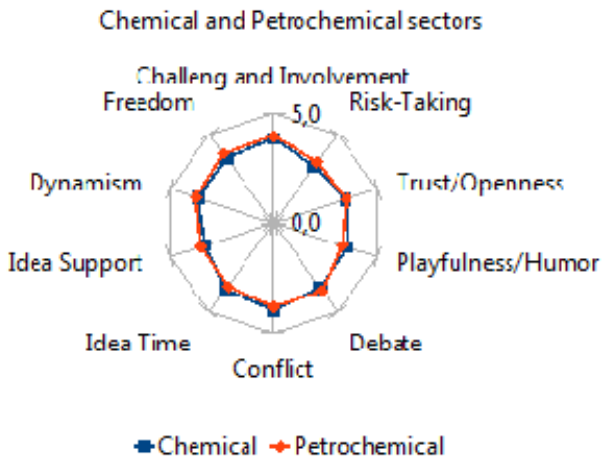

Figure 3: Radar Innovation regarding the chemical and petrochemical sectors. Source: From the authors.

The Figure 4 presents the results in the form of radar to the eight companies of services and the three of mechanical industry. Participated in this process 40 employees for the two sectors. Through observations, it appears that the sectors in question have similar behavior to each other. Through analysis of the radar, the factor conflict presents the highest average for the two sectors in question and the dimensions risk-taking and idea suport to have the lowest rate the two sectors. This finding corroborates the behavior displayed very similar between these two sectors. This fact is ratified by the similarity index seen by the HCA.

Based on the analysis performed by the Innovation Radar, we can see that the red group has a higher amount of climate-friendly innovative features, in this context, this group is considered the most innovative within the scope of this research. The brown group is considered less innovative than the first, and the green group has the least amount of climate-friendly innovative features, consequently, this group is the least innovative.

The results obtained with the HCA confirm and complement the results of a quantitative acquired under the radar of innovation. The radar makes it possible to ascertain whether the samples exhibit behavior similar to the dimensions, while HCA enables to see the index of similarity between samples. Based on this premise, it is concluded that the HCA is a valid tool to help diagnose the climate of innovation.

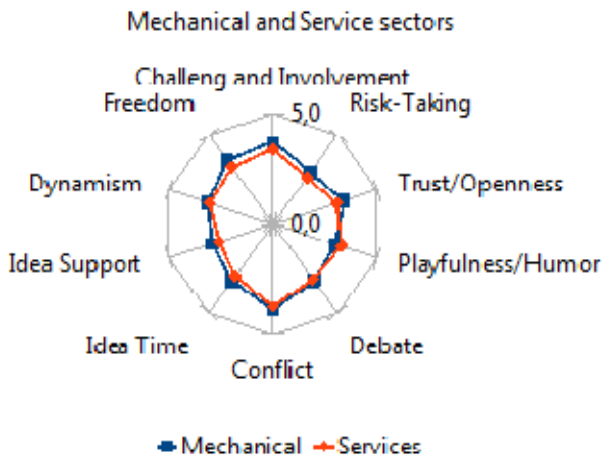

Figure 4: Radar Innovation regarding the mechanical and service sectors. Source: From the authors.

7 Conclusion

This study addressed two different techniques to diagnose the climate of innovation in different economic sectors RVRP understood by businesses - RS. The sectors covered in this research are related to the Food industry, IT, Chemical, Petrochemical, Mechanical and Services. By HCA economic sectors were divided into three groups when the similarity index is greater than 0.51. In this case, the group is composed of brown petrochemicals and chemicals, the red group is understood by the IT industry and Food and the group green is formed by Mechanical and Services sectors.

The brown group is formed when the similarity index is equal to 0.82. The red group is formed when the index is equal to 0.78 and the green group is made when the similarity index is equal to 0.73. When this index is less than 0.51 there is the formation of a group average, which is composed of red and brown groups. This means that these two groups are more similar to each other when compared with the green group. The HCA also possible to see when there is the formation of only one group. In this work, this happens when the level of similarity is equal to 0, ie, the group average shows no resemblance to the green group.

Based on the Innovation Radar notes that the red group has a higher amount of climate-friendly innovative features, in this context, this group is considered the most innovative within the scope of this research. The brown group is considered less innovative than the red and the green group is considered the least innovative. The results based on HCA confirm and complement the results of a quantitative acquired under the radar of innovation. Based on this premise, it is concluded that the HCA is a valid tool to help diagnose the climate of innovation.

From these results it is possible to define actions and training programs specific to each organization studied, starting from the needs of each organization and seeking the full development of innovation in these organizations. The use of HCA also proved efficient to differentiate economic segments in the study area which may contribute to understanding the behavior of certain sectors regarding the use of innovation and its advancement.

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