Impacts of Quality Management Systems Standardization in SMEs: a case study of the Brazilian aeronautics chain

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Abstract: The main focus of this paper is to evaluate the organizational impacts associated to the implementation of quality management system standard called NBR 15100:2004 (a specific standard for quality management systems for the aerospace sector) in the Brazilian aeronautical sector. The research was performed in five SMEs suppliers of Embraer – one of the most important aircraft manufacture in the world. As research instrument, was utilized a questionnaire based on the Nadle, Gestein and Shaw model, evaluating: performance requirements, organizational relationships, human resources, technological structure and organizational structure. In order to identify those impacts, employees that were participating directly in the NBR 15100 implementation were interviewed. The results of research have demonstrated a major impact on performance requirements and organizational relationships.

Keywords: Standardization, NBR 15100, aeronautical sector, quality management systems, SMEs

1. Introduction

In the aerospace productive chain (composed by civil and military aeronautics, and space and defense sectors) the existence of processes and products of complex nature, with recognized economical and strategic importance, has stimulated a cooperation and articulation process that was historical and decisive for its development. The profile of those relationships that promoted the consolidation of those sectors, has suffered important transformations in the 80s, such as: changes in the North American defense politics; technological evolution influenced by products and processes with more complexity; a dynamic industry evolution, characterized by production concentration and outsourcing; and many other factors. In that context, it has been happened a deep reorganization and internationalization in the production, and also a project and strategy redefinition in order to review the marketing positioning of those sectors (AIA, 2004).

In Brazil, the aerospace arrangement has also been going through changes in the political driven and, also, on its organizational structure with the aeronautical production insertion in the international arena. It was accomplished through the Program of Expansion of the Aeronautic Brazilian Industry sponsored by BNDES (National Bank of Social and Economic Development); by the satellites and thrower projects development of the Brazilian Aerospace Program, focusing on the Brazil's participation in the market of experiments and telecommunications (Gonçalvez, Dolinsky and Fazolli 2005); and the priority for the development and acquisition of technologies for civil and military use (dual technologies), established as guideline by Science Technology's System and Innovation of Interest of the National Defense (Brandão, 2005).

Despite those transformations in the political guidelines for the sector, the Brazilian aerospace arrangement, has as its nucleus the city of São José dos Campos, at São Paulo State, where is located the General-Command of Aerospace Technology (CTA) and Embraer (one of the most important aircraft manufactures in the world), faces a series of challenges. Berrnardes (2002) cites some of them: the development of innovative capacity for competitiveness; the

increase the medium level of technological intensity of products and processes developed by the new arrangement; and the development of an articulation pattern and relationship in the chain that promotes a technological learning by the cooperation. They also stand out, the historic structural problems associated to the chain, as the restriction to the access of the critical technologies, the small operational scales and the practical difficulties of technological transfer for the aerospace productive sector.

In that context, the present work has as objective to identify the possibilities and potential impacts that can be related to the diffusion of quality management systems standardization in relation to deal with the challenges of competitiveness previously mentioned. In that sense, it intends to formulate hypotheses in relation to the possibilities of efficiency earnings that can be associated to the effects of those standardizations. The focus are the SMEs (Small and Mediums Enterprises – companies with less than 250 employees), that have implemented a quality management standard of international recognition in order to participate in the aeronautical chain in Brazil.

The present work is organized in five items, besides this introduction. In the item that follows are presented a literature review regarding concept of quality management standardization and its relationship with competitiveness. The general characteristics of the governmental regulation for the quality management system of the aerospace production and the Brazilian context are presented in the third item. In the fourth and fifth items are specified the research methodology used to collect data of the SMEs and, finally, the results are shown. The conclusions and the formulation of the hypotheses for subsequent studies are presented in the last item.

1. Concept of standardization and perspectives of the literature

The literature suggests three types of standards applied to the productive process and/or to the products, as follows: "in fact" standards, consensus standards and public standards. The “in fact” standards are established to attend the market needs, being defined at the level of the contract among the agents, while the public standards or regulations are established for the government authority, and its utilization is mandatory. The consensus standards are defined for a group of interest, being your utilization of voluntary option (and managed by non-governmental organizations).

In the beginning of the century XX the diffusion of the standardization happened in the context of the market developments and it focused mainly the subject of the technical interoperability. Beginning in the 50s, as the product development and complex systems, the standardization had as objective to assure the product requirements established contractually (Standard Engineering SES, 2000). In the 70s, in order to promote the process approach, the standardization started to involve the performance and quality systems, utilizing the principles of the systemic approach and the production Japanese models.

The first international quality standard was published in 1987 (and updated in 1994 and 2000) by the International Organization for Standardization (ISO), a non-governmental organization formed by institutions related to the subjects of the Basic Industrial Technology (TIB). Defined in a consensus approach for associated committees, the standard has as basic principles: a) a continuous improvement process; b) preventive actions; c) assure the quality management system for an external auditor (called third part), and also it is responsible for the certification of conformity related to defined requirements. Therefore, it was pursued an

increase in the reliability and reduction in the level of complexity because so many different quality standards to be attended by the organizations in the international businesses.

In 2004, there were in the world about 500 thousand certified companies and the ISO had 154 countries as members, so it has given to the standard a important role in the international economic relationships. Because of that it was considered a competitive requirement for the organizations to access an international market and to be qualified as a world class company (Amato Neto, 2001). Neumauer and Perkins (2004) affirm that standards have been responsible for the convergence of practices and for the mobility of the organizational innovations in the value chains, principally in the international context.

Despite of the great importance for international economic relationships, there is a great debate in the literature regarding results of the standardization for companies, involving a private analytical reference. It is possible to classify those discussions in two groups: the institutional vision, which proposes that standardization does not offer advantages in a long period for companies; and, on the other hands, there is a vision inspired in the theory of transaction costs and in operations area, advocating that standardization provides advantages of efficiency and productivity for the companies.

The institutional vision, elaborated from a systemic perspective argues that standardization has been utilized in reasons of a social pressure to attend product conformity (Guler, Guilen, Macherson, 2004). It can be explained by the coercion processes, of juridical nature; for the tendency to the institutional isoformism; and for the tendency to the adoption of the best practices in uncertainty situations (Dimaggio and Powell, 1983). In these perspectives, the standardization impacts are relevant just in the external point of view, particularly on the level of the customers' satisfaction.

In the vision based on the theory of transaction costs, standardization facilitates the coordination process among the agents and reduces the governance costs (Humphrey and Schimitz, 2000). In other words, it is obtained gain of efficiency from the harmonization of the international standards (Stevenson and Barnes, 2001) that represent chain external elements of governance that were established in a public and private scenario.

The perspective of operations area suggests that the models used to compete in the market, with quality as basic requirement – such as lean production and mass customization – they implicate in structural changes related to an organizational point of view and, based on them, competitive advantages are built. In other words, if we consider the standardization as part of the qualification process to compete based on quality, we have as necessary condition, the definition of a new organizational arrangement, and from them are established the competitive requirements.

2. The standardization in the aerospace chain

In the 90s, the internationalization process of the aerospace production required a model to assure the quality in the development, production, installation and services of the projects. It happened because different structures and regulations, associated to National States, had to implicate in relevant complexities in order to structure the international value chain of the sector. In that context, the representatives of the largest aerospace companies of the United States, Europe and Asia have organized the International Aerospace Quality Group (IAQG)

with the intention of minimizing the complexity of international integration process of aerospace components, sub-systems and systems.

Therefore, in 1999, the IAQG, in partnership with Aerospace Technical Committee of ISO, organized the first international standard for aerospace chain, called SAE AS 9100. They used as reference the requirements for standardization of the suppliers' quality management system that had already implemented the ISO 9000. So, they have established the basic conditions to the alignment required in the chain context to attend demands of the aerospace production, as, for instance, the configuration management and verification test.

In Brazil, the Brazilian Committee of Aeronautics and Space, the Brazilian Association of Technical Standards (ABNT) elaborated, in 2004, a standard technically equivalent to SAE AS 9100, registered as NBR 15100:2004, it was ratified by IAQG and were established the most favorable conditions for the insertion of aerospace production in the international chain, as well as the participation of the national companies in the growth of this market, derived of the increment in the international changes.

The fig. 1 presents a model of the quality management system associated to NBR 15100. Initially the process has begun by the identification of the customer's need and the evaluation of the organizational capacity to achieve those needs, considering the references of product and/or service conformity. In sequence, those needs are translated in technical requirements that assure the effectiveness of the product, observed the regulatory restrictions. Then, the established configuration is documented, as well as the resources used for the production process, operation and maintenance of the product, according to an established a pattern for the standard. The production is accompanied by monitoring devices, to analyze the conformity levels with the product requirements, and to identify opportunities for preventive actions and improvements.

Among the characteristics of NBR 15100, stand-out the necessity of continuous improvement of quality management system, through the use of quality policy, quality objectives, audit results, data analysis, corrective and preventive actions and critical analysis of administration system. In that sense, the organization has to show evidences of the commitment with the development and implementation of quality management system as well as with the continuous improvement process, such as: to communicate to the organization the importance in assists the customer's requirements, to attend the governmental regulations, and the assurance of the readiness of resources. In the manufacture of aeronautical products, Embraer Liebherr was the first company to receive the certification in ABNT NBR 15100. In 2005, there were 29 certified companies and registered in IAQG. (Brito, 2005).

It is important to mention that SAE AS 9100 and NBR 15100, are characterized as consensus standards, in other words, both of them are of voluntary utilization, and do not substitute the regulatory requirements required by the Brazilian government in the aerospace production. In Brazil, for instance, they are subject to the Brazilian Regulations of Aerospace Quality (RBQA), whose objective is to assure, through requirements and procedures, that the demands of product contracts and conformities are assisted.

RBQA were elaborated base on NBR ISO 9001:2000, of the requirements and procedures of GGQ - Guaranteed Government of the Quality, certification of quality management system of the supplier and verify the quality in the supplier facilities accomplished by the Institute of

Fomentation and Industrial Coordination (IFI) of the General Command of Aerospace Technology (CTA).

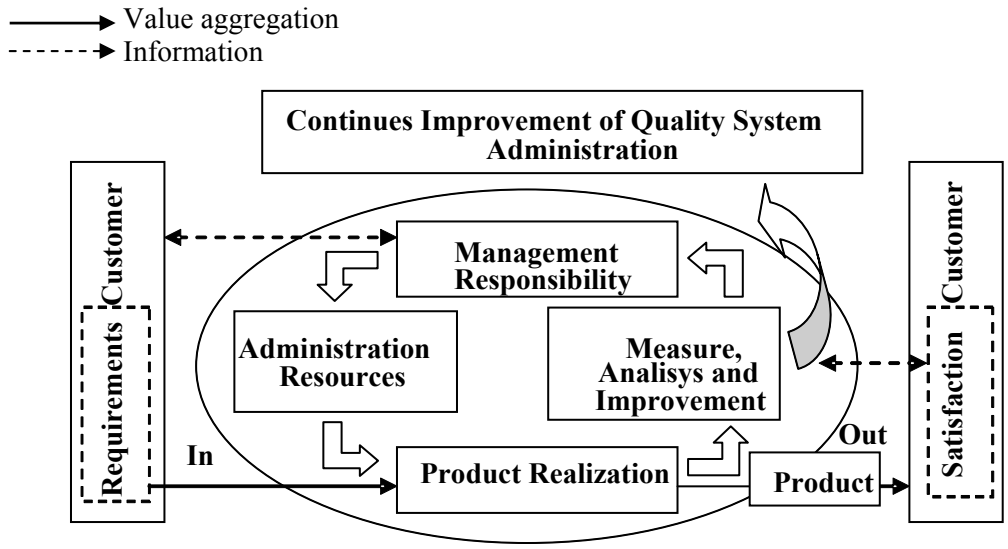

Fig. 1. Model of quality management system based in process (ABNT, 2004)

3. Research Methodology

Considering the objective of formulating hypotheses regarding potential impacts that can be associated to the diffusion of quality management systems standardization in SMEs was used, as research method, the study of multiple cases, with the intention to obtain proposition consistence (Eisenhardt, 1989). In that sense, five Embraer's supplier companies were selected, both of them located in São José of Campos, São Paulo State. All selected companies had already ISO 9001:2000 certification before NBR 15100 implementation. Therefore, it was possible to isolate the specific effects of the standard under investigation when isolating the current implementation impacts of a generic standardization process, like ISO.

As reference to elaborate a research instrument was used the model of Nadle, Gestein and Shaw (1994). The models' variables that can have influence on the research results are classified as external, if the variables can not be controlled directly by the organizations, and as internal one, when the control is possible by the company. There are four internal variables technology, human resources, organizational structure and work organization, and the last one (work organization) is conditioned by the other variables (technology, human resources and organizational structure). So, modifications in the internal variables, that represent the organizational basic elements, can be considered decisive for the changes in the form that the processes (tasks) are accomplished (Pereira and Santos, 2001).

Regarding organizational structure, Nadle, Gestein and Shaw (1994) suggest as basic aspects the communication process, the structure of authority and the work organization. In that sense, were elaborated questions related to the modifications required by NBR 15100, such as: functional responsibility, content and form of the communication process; hierarchical structures and mechanisms of command and control; and, also, in the formalization level and procedure of safety and reliability of the work process.

In relation to the technology variable, those authors selected the instruments, infrastructure and the information process. In that context, the impacts of NBR 15100 were approached in the direct infrastructure, support infrastructure and in the application of machines, equipments and instruments; and also, related to protocol of interaction, software infrastructure and hardware used by the organization.

The impacts of NBR 15100 on the human resources were appraised in relation to the volume of direct and indirect labor allocated in the production process; and also, regarding employee competence profile, represented by changes in the qualifications, knowledge and requested attitudes after the standard implementation.

Following Amato (2001) propositions, regarding a organizational network relationship perspective, were worked out complementary questions about internal and external changes such as: a) the volume and characteristics of the interactions; and b) supply chain fundamental requirements, defined in terms of quality, costs, speed to the answers and flexibility (fig. 2).

So, the research instrument was organized in the form of a semi-structured questionnaire, applied on May of 2006, through interviews performed directly by the researchers in the employees in charge of the operation area at the sample of companies. It was used as research strategy some affirmative phrases and the interviewees evaluated the approval or disapproval degree, according to the Likert scale, in levels that varied from 1 to 5 (I disagree absolutely, I disagree, I do not agree and nor disagree, I agree and I agree absolutely). Follows bellow, in the Fig. 2, the research instrument structure.

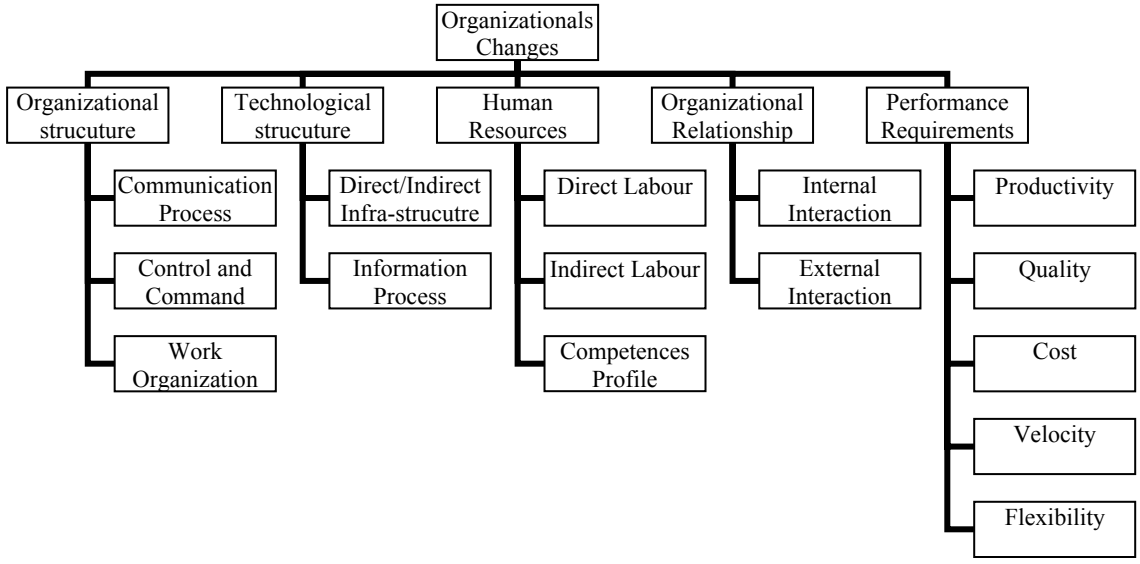

Fig. 2: Variable of the research instrument applied to the companies

4. Description and result analysis

The companies composed at the researched sample in the Brazilian aerospace chain suggest that competitive requirements and organizational relationships were the most important variables observed as consequence of the implementation of the quality management system standardization, with agreement medium values above 4 points (in a scale from 1 to 5). Regarding the nature of the organizational variables, technology and human resources, were obtained medium values below 4 points (fig. 3).

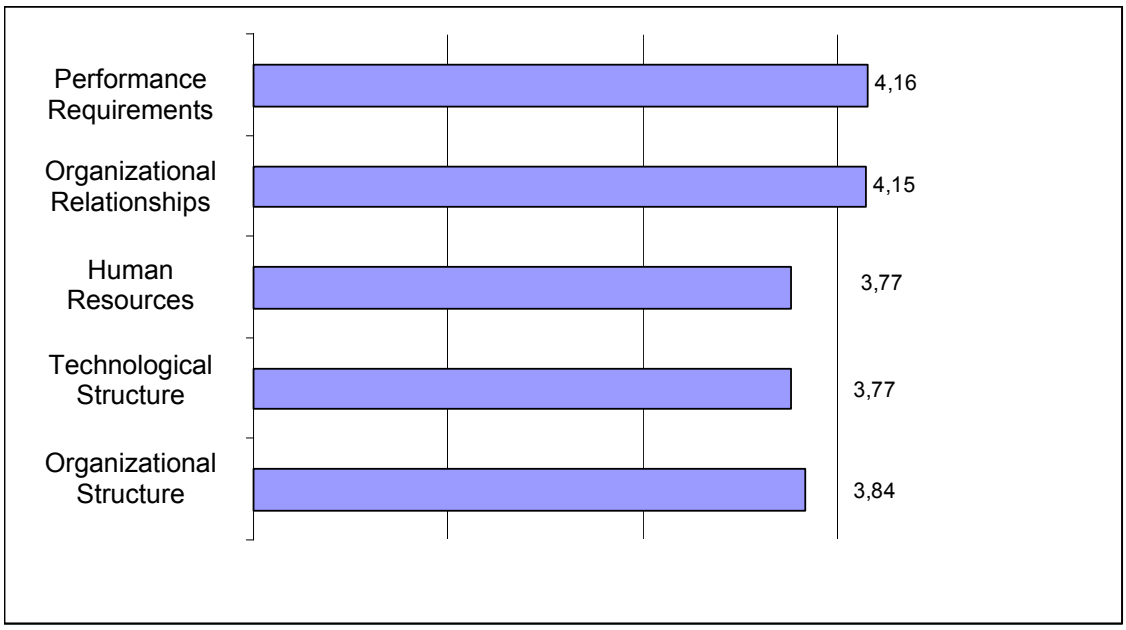

Fig. 3: Impact of variables related to NBR 15100 implementation (scale from 1 to 5)

In relation to the performance requirements, the most important elements identified in the research were the items speed and quality, each one with 4,4 points, on average, and the third in importance was flexibility with 4,2 points. Those results seem to be coherent with the processes of procedure formalization related to the quality process standardization and the trade-offs among the objectives of production performance. In other words, the improvement in the quality requirement was accompanied by changes in the general conditions of flexibility and speed. Finally, there was a small impact in the productivity associated to the organizational modification because quality management standardization, with medium value of agreement in 3,8 points. The companies researched also associated relevant variations in the production costs as consequences of the implementation of NBR 15.100 (average of 4,0).

The variable organizational relationships had impacts in the external interactions. Variation in volume and in characteristics registered an agreement average of 4,2. A similar score was observed in the internal interactions, the change in characteristics of relationship (average of 4,2) was more pronounced than the increase of those interactions (average of 4,0). Therefore, those results seem to be coherent with the proposition regarding changes in the relationships among the companies in order to have an alignment of performance requirements in the supply chain.

The variable organizational structure had the tasks with the highest score observed during the research. Changes in the tasks, particularly in relation to the procedures associated to safety and reliability, suffered a great impact because introduction of procedures related to the quality standardization processes (average of 4,6) due to the reorganization nature. However, the effect on the tasks volume and, also, in the level of work process formalization, it seems it was much less pronounced (average of 3,8).

Regarding organizational structure, in the authority system, was observed an impact on the employee responsibility attributions (average 4,0). But, however, less evident changes were

identified in the command and control routines at the researched companies (average of 3,4). In relation to the communication system, they were pointed changes in the content and form of the communication processes (average of 4,2). It is related to the nature of changes introduced in the quality management system.

Concerning organizational resources, the impacts were punctual. In human resources were detected impact on attitudes (average of 4,2) and volume of indirect labor employed (average of 4,2). It seems to have relation with the quality culture and the administrative procedures to attend the process standardization. In technological resources the direct infrastructure for production (average of 4,2) and administrative software (average of 4,0) suggests that investments are being done to accomplish the standardization implementation.

Attention should be done for the medium deviation obtained from the five researched companies of the Brazilian aeronautical sector. Among all collected variables, organizational structure has presented the largest deviation (average of 0,72 point). Regarding major subgroup "tasks" had the most significant result scoring 0,76 point. In the variable "technological structures", the subgroup "machines, equipments, instruments and infrastructure" also presented a quite expressive medium deviation (0,84 point).

Finally, according to the data collected from the sample of researched companies it is possible to emphasize that the previous companies' structuring level seems to be relate to operational scales, as mentioned by the interviewees during the research. In this context, the medium deviations obtained from the impacts of NBR 15100's implementation should have the same increase as the difference among companies' operational scales.

VARIABLES OF ANALYZE	Medium	Medium Deviation
Organizational Structure	3,84	0,72
Communication	**3,85**	**0,68**
Responsibilites to elaborate the information	3,60	0,73
Information content	4,20	0,53
Form that occurred the diffusion of information	3,40	0,93
Assertives	4,20	0,53
Authorities	**3,60**	**0,73**
Hierarchical estructure	3,40	0,93
Responsibilities	4,00	0,33
Structures and forms of command and control	3,40	0,93
Tasks	**4,07**	**0,76**
Amount tasks	3,80	0,93
Degree of procedure formalization	3,80	0,93
Procedures of safety and reliability	4,60	0,40
Technological Structure	3,77	0,66
Machines, equipments, instruments and infra-structure	**3,87**	**0,84**
Direct infra-structure	4,20	0,80
Support infra-structure	3,80	0,80
Machines, equipments and instruments	3,60	0,93
Process of information	**3,67**	**0,47**
Protocols of communication interaction	3,20	0,53
Infra-structure of hardware	3,80	0,53
Infra-structure of software	4,00	0,33

Tab. 1: Variable of analyze – organizational structure and technological structure

VARIABLES OF ANALYZE	Medium	Medium Deviation
Human Resources	3,77	0,58
Amounts	**3,60**	**0,63**
Volume of direct labour	3,20	0,87
Volume of indirect labour	4,00	0,40
Competences	**3,93**	**0,53**
Profile of requirements qualification	3,80	0,53
Profile of knowledge requested	3,80	0,27
Profile of attitudes requested	4,20	0,80
Organizatinal Relationships	4,15	0,65
Internal Interactions	**4,10**	**0,77**
Volume of interactions between suppliers and internals clients	4,00	1,00
Characteristics of interactions between suppliers and internal clients	4,20	0,53
External Interactions	**4,20**	**0,53**
Volume of interactions between suppliers	4,20	0,53
Characteristics of interactions between suppliers	4,20	0,53
Performance Requirements	4,16	0,59
Productivity	3,80	0,53
Quality	4,40	0,60
Costs	4,00	0,67
Velocity	4,40	0,60
Flexibility	4,20	0,53

Tab. 2: Variable of analyze – human resources, organizational relationships and performance requirements

5. Conclusions and final considerations

The present case study performed in five suppliers of Embraer – one of the most important aircraft manufacture in the world, suggests that the development of specific processes related to the quality management standardization, as the case of NBR 15.100, can bring relevant implications in relation to the performance objectives and the organizational relationship natures, as suggests the basic propositions advocated by the operations area. However, the organizational transformations related directly to the development of those process control seem to be quite specific, concentrating above all on the aspects directly related to the subject of the quality management systems, as area of work procedures and structure of responsibility.

Destaca-se também a perspectiva para competitividade, em um contexto de difusão do processo de normalização, haja vista o desenvolvimento das interações organizacionais, aspecto particularmente importante para as situações em que capacitação tecnológica configura-se em um aspecto crítico, como no caso brasileiro.

Nevertheless, the impacts of the standard diffusion seem relevant for the general conditions of competitiveness. It has observed that those processes were accompanied of investment in the production area and in technology information. It is important to stands out the perspective for competitiveness, in a context of standardization diffusion process, have been seen a development of organizational interactions. It is an aspect particularly important for the situations in that technological capacity is a critical aspect, as in the Brazilian case.

Finally, the medium deviations and the considerations accomplished by the companies suggest that the impacts related to the adoption of standardization processes vary with the scale of the operations, being more important for companies than they operate in smaller scales, where the specialization of the operations tends to be smaller. In that context, we suggested, as subsequent researches, the specification of the impacts diffusion of the quality

normalization processes as form of evaluation impacts about the competitiveness that can be related to the diffusion of those processes.

Finally, the medium deviations and the considerations mentioned by the companies suggest that impacts related to implementation of quality management standards vary according to operations scale, but it is more important for the companies operating in a smaller scale, where the companies' specialization level tends to be smaller. In this context, we suggest, as future research, identify the impacts of quality management standardization diffusion as a way to evaluate the impacts in the competitiveness related to those process.

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