BRAZILIAN JOURNAL OF

ISSN 1679-8171

Operations & Production Management

Volume 2 | Number 2 | 2005

Published by

ABEPRO

BRAZILIAN JOURNAL OF

ISSN 1679-8171

Operations & Production Management

Volume 2 | Number 2 | 2005

Published by

ABEPRO

ISSN 1679-8171
Brazilian Journal of Operations & Production Management
Volume 2 – Number 2 – 2005

Editorial Introduction

On behalf of the Editorial Board, I am happy to deliver the second issue of volume 2 (2005) of the Brazilian Journal of Operations & Production Management. We appreciate all the people who support and contribute to the editorship. The accomplishment of this issue would not be possible without the work of our editorial review board. As always, we would like to take this opportunity to acknowledge them due to their contribution to the authors and to the journal referral process.

We hope the readers find the articles in this issue a useful source within the scope of production engineering and operations management. Please enjoy them.

In this Issue

The present issue has five competitive and up-to-date papers from some of the top Brazilian researchers. Once again, there is a rich mixture of qualitative and quantitative approaches. The first paper, by Lauro Freitas and Lin Cheng, presents an interesting application of service development to the planning of new prevention service in the Minas Gerais Military Police. The paper is characterised by an action-research intervention. This is followed by the study of Afonso Fleury and Maria Tereza Leme Fleury. It focuses on the global networks of Telecommunications industry in Brazil by empirically examining how competencies are built in six subsidiaries operating in Brazil. A quantitative data analysis is considered in the third article by Antonio Fernando Costa, Maysa de Magalhães and Eugenio Epprecht. They propose the use of the double-sampling procedure with a non-central chi-square statistic to control the process mean and variance. Next, Luiz C.R. Carpinetti, Mateus Cecílio Gerolamo, and Olívia T. Oiko describe an empirical research conducted in a Brazilian division of an international automotive manufacturer of autoparts. The central point of the study is the subject of improvement and change management. In the final article, Anísia Carla de Lima Galvão, Thais Bezerril Brandão de Lima, and Sérgio Marques Júnior report the results of a survey to investigate the perception of marine shrimp producers on the impact of environmental management as a driver for improving competitiveness.

After the changes in the chain of command of ABEPRO (the Brazilian Production Engineering and Operations Management Association), this issue closes with its executive and fiscal board.

The journal expects to count on the research community by considering the journal as the outlet for publication of their research work mostly related but not limited to the research areas defined by ABEPRO[1].

Paulo A. Cauchick Miguel
Editor of BJO&PM

[1] Production Management; Quality Operations; Economic Management; Ergonomics and Work Safety; Product Development; Operational Research; Strategy and Organizations; Technology Management; Information Systems; Environmental Management; Education issues in Operations Management.

Service Development Management: A Study of its Applicability in the Minas Gerais State Military Police

Lauro Soares de Freitas
Faculdade Pitágoras
Belo Horizonte, MG, Brazil
E-mail: laurof@pitagoras.com.br

Lin Chih Cheng
Departamento de Engenharia de Produção
Universidade Federal de Minas Gerais – UFMG, Belo Horizonte, MG, Brazil
E-mail: lincheng@dep.ufmg.br

Abstract
The chaotic situation faced by the public safety system in Brazilian states has forced authorities to replace ineffective reactive police strategies with "community preventive actions" to fight criminality. However, the military police lacks necessary instruments to develop fast new prevention services that have the quality and effectiveness the community desires. This paper describes how the conceptual-theoretical basis of Service Development Management (SDM) was adapted to the planning of new prevention services in the Minas Gerais Military Police (PMMG - *Polícia Militar de Minas Gerais*). The work consisted of two interventions: 1) formulating a management pattern for developing preventive services; 2) creating a management instrument for gathering, evaluating, and selecting service ideas, and internal launching of new services. The methodology of action-research was used as the engaging strategy. The conclusion is that transposing the SDM conceptual-theoretical basis from private companies to the PMMG is possible with minor changes which are mostly related to the nature of the corporation. Nevertheless, it must be said that the similarities between principles and characteristics of preventive policing services and those of private companies have made such transposition easier.

Keywords: service development management, community preventive services

Introduction

This paper describes the application of the conceptual-theoretical basis of Service Development Management (SDM) in the planning of new prevention services in the Minas Gerais Military Police (*PMMG – Polícia Militar de Minas Gerais*). The increasing criminality

rates have been making the Brazilian society more skeptical to the possibility of finding a solution to this social problem. In average, one person is murdered every 13 minutes in Brazil. The rate of violent criminality has grown up more than 300% in the last 4 years in Minas Gerais; and the annual damage caused by the criminality, only in the city of Belo Horizonte, is around R$ 883 million (Rondon, 2003). In this crisis and damage scenario, the evaluation made by the Minas Gerais society about the quality of the services provided by the PMMG shows dissatisfaction – only 43% of the people have a positive perception of the PMMG work, just 37% trust in the services provided, and 57% believe that the PMMG is competent (Beato, 1999).

An analysis of the service portfolio of the PMMG reveals that about 85% of the services provided to the Minas Gerais society are repressive or reactive, in other words, services provided only after the crime has already happened. The number of PMMG's reactive services reveals that, even with the growth of indicators (showed in Table 1) in 2004 compared to 1993, the PMMG has not been successful in reducing the increasing criminality in Minas Gerais.

Table 1 – Indicators of the reactive service of the PMMG in the years of 1993 and 2004.

Service indicators	1993	2004
Distance travelled by all the PMMG's vehicles (in million km/year)	60	132
Number of occurrences attended/year (in million)	0.9	3.0
Number of people arrested/year (in thousands)	112	227

Source: PMMG.

This ineffectiveness and disbelief in the reactive services provided by the PMMG impelled the High Command of the PMMG and the people in charge of the state public security to start a process of inter-institutional and intra-institutional restructuring. Concerning the inter-institutional restructuring, an attempt has been made to promote a greater integration and interaction with other Criminal Justice segments such as Civil Police, Public Ministry and the Judiciary, so as to have a greater information exchange and coordinated and joint actions.

Regarding the intra-institutional change, several works have been implemented, such as: criminality geo-processing, electronic bulletin, improvement of the services provided, among others. In order to provide a better service, which is the focus of our study, the corporation has become more concerned with providing preventive services to fight the micro-criminality – undersized crimes against property, person and public order. In view of this, since 1999, the PMMG has been creating Community Councils for Public Security (CONSEP – *Conselhos Comunitários de Segurança Pública*) as an attempt to implement Community Policing in the state. However, there is a need for enhancing the competence of police units and providing them with resources and instruments for service management, so that they can seek together with the community solutions to the criminality problems and, most of all, develop community preventive services.

A comparative analysis of the "public security services" provided by the Military Police and the "market services" provided by the private companies (e.g.: bankers services, hospital services and so on), reveals similarities and differences between them. Among the similarities, there are the general service characteristics such as: intangibility, inseparability, heterogeneity, and perishability. These similarities become greater when the preventive service, characterized by a greater interaction and integration between the policeman and the community, happens. Among the differences, stand out two: 1) services as citizen's right instead of services by acquisition (purchase); and 2) reactive services, though undesirable, are necessary because of circumstances.

A comparison of the characteristics of these two types of institutions also points out differences and similarities. Contrary to the private companies that aim the profit and have missions determined internally, the Military Police is a public institution without profit aims and has its mission determined by the Federal Constitution. In addition to this, in this security public institution, the work functions are more stratified and visible because of its military hierarchy. In relation to the similarities, as the private companies, the police units also have functional work areas (Human Resources, Logistic, Communication, Planning, and so on) that design and execute the services determined by its mission.

The literature about public security SDM, from the perspective of Operations Management, is very scarce. Although there is literature about models or strategies of policing, it does not focus on how the security services can be developed nor does it indicate which methods or instruments could be used as support. Hence, the present study proposes to investigate how the literature on product management and service development, used by the private companies, can be relevant to the work of a public security institution.

The main body of this article is divided into two sections. The first section presents a literature review of Policing Models and SDM in private companies. The second section describes the application study, the research strategy, the interventions and the outcomes.

Policing Models

There are in the police literature three most known policing models: Traditional Policing, Community Policing, and Problem Solution Oriented Policing. These models have, respectively, an emphasis on: **reactive actions** (wait for the problem to occur and then act), **community preventive actions** (actions are taken before the problem occurs) and **preventive actions oriented by the community problems** (the police preventive action is demanded by the real needs of the community).

The traditional policing model, born in the beginning of the 20th century, is characterized by high specialization, centralization, and distance from the community. It has not been effective in the fight against criminality and in guaranteeing citizens' security (Skolnick and Bayley, 2001; Cerqueira, 2001; Rosenbaum, 2002). Aware of this situation,

the Brazilian Military Polices are gradually incorporating the concepts of another policing philosophy, Community Policing, to tackle micro-criminality.

The Community Policing, born in the 70s', is characterized by the work with the community in a partnership of mutual trust. Some principles that permeate this model are:

- Recognition of the important role the community plays in the conception and production of police services (Skolnick and Bayley, 2001);
- Prioritization of police tactical actions, paying more attention to small crimes (non-emergency services) and disorder (Leigton, 1991);
- Making the frontline policemen known to the community through enhancement of their autonomy in decision-making and action (Mastrofski, 2002; Reiner, 2002); and
- Reciprocal information exchange and effort synergy with non-governmental organizations, churches, schools, associations and others (Skolnick and Bayley, 2001).

The Problem Solution Oriented Policing, mostly implemented with the Community Policing model, is composed of five phases: 1) identification of problem; 2) analysis of fundamental causes; 3) action planning; 4) implementation; and 5) outcome evaluation. The experiences of police agencies in countries like Singapore, United States and Japan reveal that preventive solutions to criminality problems, taken together with the community, have achieved great outcomes in the reduction of criminality (Skolnick and Bayley, 2001).

However, the police literature does not present management processes for development of community preventive services and support instruments to facilitate the police agencies' work. Studies have also demonstrated an increasing desire of incorporating concepts, principles and administrative processes from traditional organizations into police corporations (Cerqueira, 2001; Reiner, 2002).

Service Development Management - SDM

The field of Product Development Management (GDP – *Gestão de Desenvolvimento de Produto*) is extremely wide (Cheng, 2000), and the review carried out in this paper is focused on the area of services, especially on two issues: 1) formal development framing; and 2) initial and final stages of development, i.e., idea generation and introduction into the market, respectively. The reason for this choice was due to the *in loco* study, when a consensus between the researchers and the PMMG work team was reached on priority topics within the general theme of preventive service development.

The formal development process

In order to increase the efficiency and the efficacy of the service development system, some top companies have adopted practices such as:

- Use of formal development processes without skipping stages, and application of techniques and support instruments in these stages (De Brentani, 1995; Griffin, 1997);
- Development of multidisciplinary teams with autonomous (empowered) leaders and the presence of front line people (Edvardsson et al., 1994; Edvardsson 1997; Fitzsimmons and Fitzsimmons, 2000; Goldstein et al., 2002);
- Strong market orientation, trying to incorporate client voice in the planning of new products and services (Cooper and Edgett, 1999; Cooper, 1993); and
- Involvement of all functional areas, suppliers and clients in the development process since the initial stages (Cooper, 1993).

Some of these practices are present in the managing models of service development described in the literature, specially: the Booz-Allen and Hamilton (1982) model; the Stage-Gate by Cooper and Edgett (1999); the Scheuing and Johnson (1989) model; and the Edvardsson et al. (1994) model.

A synthesis of some elements and the main characteristics from each model, together with an analysis of their applicability in the context of preventive security service development are presented in Table 2.

Table 2 reveals that: a) most of these formal service development structures are derived from models initially conceived for products; b) the most common elements among these models are strategic direction, evaluation tests, and training of service providers; and c) some features that could be included in a development management model for the PMMG are having multidisciplinary teams, being orientated toward citizens-customers' needs, having evaluation and decision points throughout the process, and involving front line people in the development process.

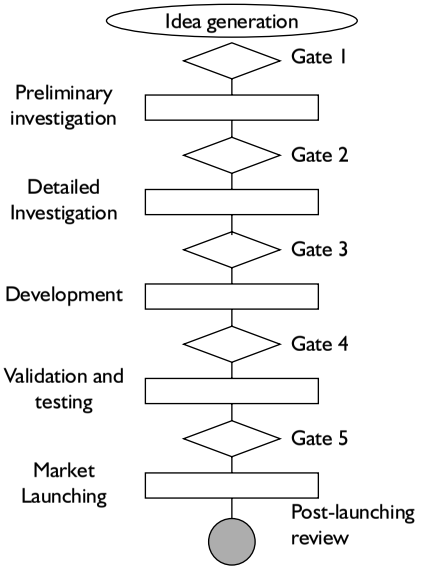
Generation of ideas and introduction into the market

A new idea is the starting point or the raw material for the development of new services. For this reason, many companies consider the establishment of systems for obtaining and evaluating ideas as an important step towards a greater competitiveness (Cooper, 1993). In this system, the customers' suggestions obtained through brainstorming sessions and focus group dynamics, and the utilization of the knowledge from those who are in direct contact with clients, have given good ideas for new services (Urban and Hauser, 1993; Cooper and Edgett, 1999; Fitzsimmons and Fitzsimmons, 2000; Goldstein et al., 2002).

Other internal and external sources for idea generation used by private corporations are: creation of research and development programs, analysis of new technologies, attendance of the personnel from the marketing and R&D areas to congresses, establishment of communication channels inside the organization (chat, intranet, ideas bank), creativity techniques, and analysis of the strategies of competitors' services and business.

Table 2 – A comparative analysis of the four development models in SDM literature.

A comparative analysis of the four development models most referred to in SDM literature						
Authors and year	**General characteristics**	**Model structure**		**Advantages and disadvantages**	**Conclusion**	**Features that may be applied to the potential PMMG model**
Booz Allen and Hamilton (1982)	One of the first methodologies created to plan service development. It was drawn from a product development model.	Strategy definition		Simple and dynamic, this model organizes the process in logical steps.	This model inspired new ones, and maybe for being the first of its kind it is also the least sophisticated.	The strategic orientation as the first step for the units to define the communities where services will be generated at short and medium-term, and the stages of viability analysis and tests.
		Service pre-development				
		Service concept development				
		Service providing process development				
		Viability analysis				
		Implementation				
		Market test				
		Commercialization				
Scheuing and Johnson (1989)	This model was based on empirical experiments. It includes 15 steps organized into 4 stages.	Direction choice	Setting company's goals	This is a more complete and sophisticated model, although not the most suitable for derivate or low-innovation services.	The following stages should be highlighted generation of ideas (in which internal and external sources are valued); and personnel training.	In addition to the goal setting stage, a frontline personnel training might ensure that preventive service quality features are not lost when it is actually provided for the community. Furthermore, preventive service testing and evaluation stages could also be applied.
			Generation of ideas			
			Evaluation and selection of ideas			
			Service concept development			
			Concept testing			
			Business analysis			
			Authorization for project start			
		Service project	Service project and testing			
			Process project and testing			
			Marketing program project and testing			
			Pesonnel training			
		Service testing	Service testing in pilot lot			
			Marketing testing			
		Market launching	Large scale launching			
			Post-launching evaluation			

Cooper and Edgett (1999)	This model is known as Stage-gate systems or Game-plan and has 5 development stages and 5 evaluation points (gates).		The presence of evaluation points allows the abortion of misconceived projects, and ensures the participation and follow-up of senior managers in the course of projects. This model displays little concern with personnel training activity and may be mistaken for a bureaucratic model. In addition, little emphasis is placed on service project and process project activities.	This model has shown quite useful for the banking industry. According to its author, the model was designed to ease and expedite services for the market and should not be regarded as a strict or inflexible system.	The concern with the client's voice, the creation of multifuncional development teams, and the presence of evaluation points to prevent misconceived projects from being implemented, all these suggest that this model has potential great contributions to the service development process at PMMG. Listening to the community voice, involving police officers with different skills, and creating evaluation points for unit commanders and CONSEP would be possible transpositions from this model to the management pattern at PMMG.
Edvardsson, B et al. (1994)	This model was also based on product development models. There are only four stages.	1- Gathering and evaluating ideas, concept development. 2- Project making, customer and competition analysis. 3- Service project and co-service system project. 4- Co-service process project and implementation.	The concern with the service final quality impacts on the 4 stages of a simple model. Front-line personnel participation is limited to the idea and service gathering and evaluation.	The author's focus on quality leads to an emphasis on involving customers and frontline personnel in planning a new service.	It is possible to envisage a great involvement of frontline officers and community members in planning new services at PMMG.

After the generation of a large number of ideas, the literature recommends that a filtering process should be carried out (Cooper, 1993). In this sense, a criterion list is applied to evaluate and select the best ideas that could become new projects. The most used criteria are: the strategic alignment of the idea with the mission and image of the company, its technical and economic viability, compatibility of the idea with the organizational structure, and its innovation degree to the market and the organization.

The stage of introduction to the market, although has a great importance in the product and service development process, has a large study and empirical research gap (Griffin, 1997, 1999; Di Benedetto, 1999). Internal service release is an activity of the release stage that large corporations that own several units may have to face. These corporations may have this additional strategic decision which is to release or not a product or service developed by one unit to other corporation units.

There are several questions about the internal release that still do not have answers in the literature. Among the main questions some call for special attention:

- Is the decision of releasing services internally a decision that precedes, is simultaneous to, or succeeds the external release?;
- Which are the most efficient instruments and communication channels for the organization to make the new services internal release?; and
- How can one assure that the service created in a unit does not loose its concept and its quality characteristics when it comes to be produced by another unit?

Summarizing the review of the SDM literature, it is important to point out that the field of new service development is new and demands more investigation (Menor et al., 2002). What is noticed in the practice is that the demand of the service area is being supplied by the adaptation from the product domain (Easingwood, 1986; Hollins and Hollins, 1991; De Brentani, 1995).

SDM Application in the PMMG Preventive Service Planning

The research strategy used in this study was the action-research. As Rapoport (1970, p. 449) wrote: "Action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by joint collaboration within a mutually acceptable ethical framework". The action-research (AR) process is cyclical and consists of following five steps, according to Susman and Evered (1978): Diagnosis, Action Planning, Action Execution, Evaluation, and Learning Specification.

The activities of this research began in August 2001 and ended in December 2003. Four members from the PMMG (a Colonel, a Major, and two Captains) and two researchers from the *Núcleo de Tecnologia da Qualidade e da Inovação – NTQI, DEP/UFMG*, formed the research team.

In the first step of this research, the diagnosis, an evaluation of the PMMG service portfolio and preventive services development process was carried out. Two semi-structured questionnaires were formulated and applied in 12 of the 25 units of the PMMG in Belo Horizonte. The first questionnaire, filled out by unit commandants, aimed to analyze the portfolio of new service projects in the unit and the practice of community policing. The second questionnaire, filled out by the officer responsible for planning operations of the unit, aimed to understand the process of new preventive service development.

In addition, other research methods were applied, such as, analysis of PMMG management documents, attendance to meetings for planning operations, and direct observation of preventive services. All members of the research team took part in the planning and execution of data collection.

The analysis of the services that the PMMG offers to the Minas Gerais society revealed that:

- The Service Portfolio (Preventive and Reactive) is unbalanced and not aligned with the strategic planning;
- There is a lack of instruments to manage and control the relation between the demand for criminality preventive services and the corporation's preventive services portfolio; and
- An unfamiliarity from the operational units with the preventive service portfolio provided by other corporation units.

The outcome of the analysis of the existing Service Development Process under focus compared to the theoretical basis in SDM and in the policing models is evidenced in Table 3, and is divided into negative and positive aspects. Table 3 reveals several weak points. Among the main ones, we can point out two: the services' unilateral conception without the participation of the front line personnel and the lack of procedures that help community planning new preventive services.

In the second step of AR, the action planning, two lines of action were established from the preceding stage: 1) formulation of a pattern of community preventive services development to be used by the area operational units; and 2) development of an instrument to be used by the general command, allowing it to manage (identify, evaluate and select) prevention services ideas and to facilitate the institutionalization of new preventive services created by operational units.

The research team met together weekly to collect and analyze information, and to make decisions. The role played by the researchers was to prepare and conduct seminars where alternative actions for problem solution were presented. These alternatives for problem solution were supported by academic literature from the fields of Product Development Management, Community Policing and Policing Oriented towards Problem Solution.

Table 3 – An analysis of the PMMG development practice compared to two theoretical basis.

		Theoretical Basis	
		New Service Development Management	**Community Policing and Problem Solution Oriented Policing**
Positive and negative aspects in the practice of preventive service planning in PMMG	**Negative Aspects**	• Individual development work instead of team work; • A single, confused, and not updated pattern for all kinds of services developed by the PMMG; • Front line people are not involved in prevention service planning; • Lack of instruments for efficiency and efficacy evaluation of prevention services; and • Absence of a Development Center or task-force for specific services conception.	• Timid community participation in new service planning; • Unit managers have restrictions to community participation in problem solution; • Lack of procedures that help the Unit Commandants in planning service together with the community; • Unit Commandants unaware of the Community Policing and Policing Directed to Problem Resolution; and • Front line policemen not engaged with the prevention service planning.
	Positive Aspects	• Strong entrepreneurial character of some commandants; and • Autonomy given to units for planning and developing preventive services oriented to their reality.	• Joint planning of the PMMG prevention services together with some associations; and • Good results that some commandants have obtained in their units with the Community Policing.

With regard to the formulation of the pattern, some requisites were pre-established as important: be flexible (non-bureaucratic), be simple and easy to be understood, be faithful to the community policing principles and oriented to problem solution. Based on these, the third step of AR - the action execution, was prepared:

- **1st phase:** seminars on development management patterns and policing models. This stage was called work team training;
- **2nd phase:** analysis of the current way of developing services, establishment of the new pattern and presentation to the Major State Planning Section for approval;
- **3rd phase:** choice of two units for the training of a group of policemen and CONSEP members in using the new pattern; and
- **4th phase:** final considerations about the pattern creation process and presentation of the outcomes to the PMMG General Command.

The created pattern, as shown in Figure 1, presents a combination of elements from the four models reviewed in the SDM literature. The five work stages and the three evaluation and choice making points (P.A.R.E. – *Pontos de Avaliação e Realização de Escolhas*) are derived particularly from the "stage-gate" model by Cooper et al. (1999).

The strategic direction, as an important starting point in the four models presented, was incorporated into the PMMG model. In this first moment, the unit Commandant and the CONSEP director board analyzed the front line policemen availability in the unit to manage preventive services projects and define the communities inside the unit sub-area that have preventive services project priority. For illustration, only the two first stages will be presented.

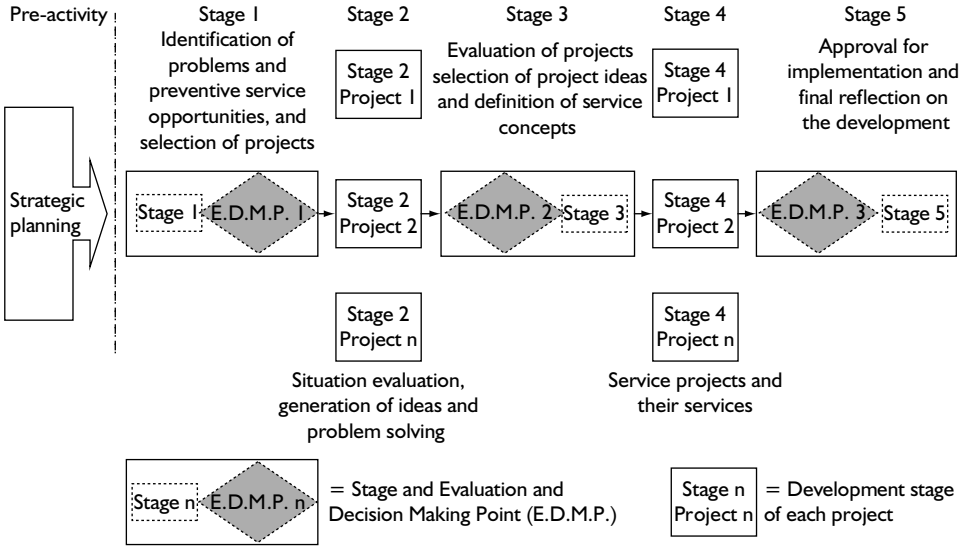


Figure 1 – Management Pattern for Community Preventive Services Development at PMMG.

With the unit strategy defined, a meeting was carried out with each chosen community for identification, evaluation and selection of the problems that have priority in the prevention projects. These activities defined the first Evaluation and Choice Making Point in the project. In this meeting, a group of people was chosen to form the project teams. These activities constituted the 1st stage of the pattern.

In the second stage, the information obtained for the problem causes analysis was structured with the application of quality tools such as: cause-effect diagram, affinity diagram, the five whys, among others. The immediate solutions to the problems and the community preventive services ideas were obtained through brainstorming sessions, and afterwards the team evaluated the technical and economic viability.

With the approval of this first version of the pattern by the PMMG Major State, four police officers from two units of the capital were chosen to put into practice the application of the pattern. These officers have started the implementation of the pattern attached to the communities of the unit's area and all this work has been closely monitored by the research team. This was the third phase of the schedule proposed above.

The initial outcomes of this first version of the pattern demonstrated that there was no internal resistance from the corporation's officers in the execution of activities, and that the Major State and the members of the CONSEP have approved it with few changes. However, it must be said that the implementation of this new pattern cannot happen suddenly. It is a continuous and progressive work that demands new pilot-projects in the units for a better visualization of the implementation difficulties and obstacles.

With regard to the creation of an instrument to gather, evaluate and select new services ideas and the internal release of new preventive services, the work schedule was divided into three phases: 1st phase, organization of seminars about ways of gathering and evaluating ideas, and release of new products and services; 2nd phase, formulation of a filling form for newly created services and ideas, management flowchart, definition of rewards for ideas and services, incorporation of the instrument in a computer system, and final validation tests; and 3rd phase, final considerations about the work carried out by the team and presentation of the outcomes to the PMMG Major State.

The final outcome of this intervention is a system integrated to the intranet and to the PMMG Web site to collect ideas from internal and external sources to the Corporation and to release internally new services. The procedure is simple: firstly, policemen or people from the community fill in a form describing their idea of service (for the new services, the creator unit fills in a more detailed form); secondly, a commission of officers from the Public Security Learning Institute receives and evaluates the ideas and the services based on a criteria list, to select the best ideas that will become new projects and to approve the services that will be incorporated to the corporation's electronic services portfolio; and, thirdly, the units which had their services approved and the people who had their services accepted are rewarded by the Major State. In order to make the new system known and to have an effective participation from all the corporation, a campaign was created with the following slogan: "Ideas against the crime". In addition to this, all the preventive services and operations that already were at the PMMG portfolio (DIAO) were transposed to the new computer system.

Although it has a great potential of success, this system could fail if: 1) the reward incentives are not well applied, which can cause feelings of injustice in the awards; 2) there lacks continuous public campaign to guarantee the generation of new ideas and new services; and 3) there are not investment acquisition and maintenance of computers necessary to the units so as they can have access to the service portfolio through the intranet. It is hoped that, as soon as the ideas and prevention services start to come up in the corporation, the units commandants can implement the services already developed and the IESP researchers can work in the transformation of new ideas into services.

Concluding Remarks

This study aimed to inquire to which extend conceptual-theoretical basis of SDM used in private companies can be adapted and be relevant to the service planning of a public security institution. The conclusion of this study is that the transposition of this conceptual-theoretical basis from the private companies to the PMMG is possible with few adaptations, which are mainly related to the corporation's nature. The adaptations, together with the benefits that may come with the implementation, are listed bellow:

1. Different of private companies, which formulate formal development processes pursuing to increase service quality and reduce costs and development time in order to have competitive advantages over their competitors, the PMMG model was created to facilitate the work between the military police, the community and its partners, to reduce the response time for a service preventive demand claimed by the community, and to raise the chances of service success;
2. The incorporation into this pattern of some successful practices in the products and services development, such as project multidisciplinary teams, participation of front line people and partner, and strong orientation to the market pursuing to incorporate "client voice" in the planning, was made easier because of the similarities between these practices and the principles of community policing and policing oriented to problem solution;
3. The theoretical basis about idea generation was used with a few adaptations, and the recommendations of listening to citizens-customers' suggestions and to those who are in direct contact with them were incorporated to the created system. There were no differences between the criteria chosen for idea selection and new services approval from the ones used by private companies. In the PMMG, these criteria have the aim of avoiding situations where services that are not viable or services that go against the ethical conduct of the police work are incorporated into the portfolio;
4. The service internal release for the corporation is important as a way to reduce the preventive response time to the communities and to reduce costs in the services and solutions development. The internal release was considered by the corporation as a stage that has to succeed the external release. Besides this, it was noticed that the intranet can be an efficient channel to promote the internal release, and all the information about new services have to be obtained so as its concept is not lost in its transposition from one unit to another;
5. One of the starting points for the formulation of the new management pattern for preventive service development of PMMG was the theoretical review. The management models showed to be helpful in revealing various possible structures for new service development. However, there is a lack of specific literature on how to formulate a management model for security service development. A solution to this was obtained through informal interviews with researchers who have experience in this area; and
6. The incorporation of evaluation points in the PMMG management model reflects great similarity to the stage-gate model. During its conception, the development team understood that the evaluation points, i.e. "gates", were necessary to provide, simultaneously, autonomy to the frontline policemen and a possibility of controlling to the unit commandant.

After the approval by the PMMG Major State, the model for new preventive service development was tested for a period of three months in a unit of PMMG in the state capital. During the implementation process, two frontline policemen of that unit were trained and they conceived two new types of community preventive services using the model. Although these two new services have not resulted in a significant reduction of criminality rate in the unit area, they have enhanced the subjective security of the community. This has been shown through the increase in community participation in meetings with the police. In addition, according to the unit commandant, the model made the integrated planning of preventive services easier as it offered a clearer definition of the responsibilities of all parties involved (Municipal Government, Civil Police, Community Association, and PMMG).

These results have motivated the PMMG and the State Secretary of Social Defense to extend the application of the model to all units of the capital city, with the participation of the team that took part in this project. The model is presented in the officer training course of Academy of Military Police at Belo Horizonte, and it has been an object of interest of police from other states.

Acknowledgments

The authors are grateful to the *Polícia Militar de Minas Gerais* for their support in carrying out this joint research work. We are also thankful to Dr. Lin Cheng Wen Tzeng and the two anonymous referees for their valuable comments and suggestions.

References

Beato, C. C. (1999). Ação e Estratégia das Organizações Policiais. *Proceedings of the III Congresso do Projeto Polícia e Sociedade Democrática*. June 1999. Rio de Janeiro: Fundação Ford. pp. 25-38.

Booz-Allen and Hamilton Inc. (1982). *New product Management for 1980´s*. New York: Booz-Allen and Hamilton Inc..

Cheng, L. C. (2000). Caracterização da Gestão de Desenvolvimento do Produto: delineando o seu contorno e dimensões básicas. *Proceedings of the 2nd Congresso Brasileiro de Gestão de Desenvolvimento de Produtos*. 30-31 August 2000. São Carlos: UFScar. pp. 1-9.

Cerqueira, C. M. N. (2001). *Do Patrulhamento ao Policiamento Comunitário*. 2. ed., Rio de Janeiro: Editora Freitas Bastos.

Cooper, R. G. (1993). *Winning at new Products – Accelerating the Process from Idea to Launch*. Reading: Addison-Wesley Publishing.

Cooper, R. G. and Edgett, S. J. (1999). *Product Development for the Service Sector – Lessons from markets leaders*. New York: Perseus Books.

De Brentani, U. (1995). New Industrial Service Development: Scenarios for success and Failure. *Journal of Business Research*, 32(2), pp. 93-103.

Di Benedetto, C. A. (1999). Identifying the key success factors in new product launch. *The Journal of Product Innovation Management*, 16(6), pp. 530-544.

Easingwood, C. J. (1986). New Product Development for Service Companies. *Journal of Product Innovation Management*, 4(3), pp. 264-275.

Edvardsson, B. et al. (1994). *Quality of Service – Making it really work*. Maidenhead: McGraw-Hill, pp. 209-248.

Edvardsson, B. (1997). Quality in new service development: key concepts and a frame of reference. *International Journal of Production Economics*, 52(1-2), pp. 31-46.

Fitzsimmons, J. A. and Fitzsimmons, M. J. (2000). *Administração de Serviços – Operações, estratégia e tecnologia de informação*. 2. ed., Porto Alegre: Editora Bookman.

Goldstein, S. M. et al. (2002). The Service Concept: the missing link in service design research?. *Journal of Operations Management*, 20(2), pp.121-134.

Griffin, A. (1997). PDMA Research on New Product Development Practices: Updating Trends and Benchmarking Best Practices. *Journal of Product Innovation Management*, 14(6), pp. 429-458.

Hollins, G. and Hollins, B. (1991). *Total Design: Managing the Design Process in the Service Sector*. London: Pitman Publishing.

(Leigton), B. (1991). Visions of community policing: Rhetoric and reality in Canada". *Canadian Journal of Criminology*, 33(3), pp. 485-522.

Mastrofski, S. D. (2002). Policiamento comunitário e estrutura da Organização Policial. in: BRODEUR, J. ed. *Como Reconhecer um bom Policiamento: problemas e temas*. São Paulo: Edusp, pp. 197-229.

Menor, L. J. et al. (2002). New Service Development: areas for exploitation and exploration. *Journal of Operations Management*, 20(2), pp. 135-157.

Rapoport, R. (1970). Three dilemmas in Action research, Human Relations, 23(6), pp.499-513.

Reiner, R. (2002). Processo ou produto: Problemas de avaliação do desempenho policial individual. in: Brodeur, J. ed. *Como Reconhecer um bom Policiamento: problemas e temas*. São Paulo: Edusp, pp. 83-102.

Rondon, V. V. (2003). *Custos da criminalidade em Belo Horizonte*. Unpublished Master degree dissertation, Federal University of Minas Gerais.

Rosenbaum, D. P. (2002). A mudança no Papel da Polícia: Avaliando a transição para o Policiamento Comunitário, in: BRODEUR, J. ed. *Como Reconhecer um bom Policiamento: problemas e temas*. São Paulo: Edusp, pp. 27-56.

Scheuing, Z. E. and Johnson, M. E. (1989). A proposed model for new service development. Journal of Services Marketing, 3(2), pp. 25-34.

Skolnick, J. H. and Bayley, D. (2001). A Nova Polícia: Inovações nas polícias de seis cidades norte-americanas. *Coleção Polícia e Sociedade*. São Paulo: Edusp.

Susman, G. I. and Evered, R. D. (1978). An Assessment of Scientific Merits of Action Research. Administrative Science Quarterly, 23(1), pp. 582-601.

Urban, G. L. and Hauser, J. R. (1993). *Design and Marketing of New Products*. Englewood Cliffs: Prentice Hall.

Biography

Lauro Soares de Freitas is the Director of a Production Engineering course at *Faculdade Pitágoras*. He also teaches Operations Management and Policing geared towards problem-solving at the Academy of Military Police of Minas Gerais State. He is an associate researcher at the *Núcleo de Tecnologia da Qualidade e da Inovação – NTQI/UFMG*. He holds a Master degree in Production Engineering from the Federal University of Minas Gerais, Brazil.

Lin Chih Cheng is an Associate Professor at the *Departmento de Engenharia de Produção, Escola de Engenharia da UFMG*. He received his Ph.D. degree in Systems in Management, from the School of Management of Lancaster University in 1990. His teaching and research interests are mainly Quality Function Deployment (QFD) and Product Development Management in large corporations and in emergent technological firms (academic spinoffs).

The Non-Central Chi-Square Chart with Double Sampling

Antonio F. B. Costa
Departamento de Produção, UNESP
Guaratinguetá, SP, Brazil
E-mail: fbranco@feg.unesp.br

Maysa S. de Magalhães
Escola Nacional de Ciências Estatísticas (ENCE),
Instituto Brasileiro de Geografia e Estatística (IBGE), Brazil
E-mail: maysa@ibge.gov.br

Eugenio K. Epprecht
Departamento de Engenharia Industrial, PUC-Rio, RJ, Brazil
E-mail: eke@ind.puc-rio.br

Abstract

In this article, we consider a non-central chi-square chart with double sampling (*DS* χ^2 chart) to control the process mean and variance. As in the case of Shewhart control charts, samples of fixed size are taken from the process at regular time intervals; however, the sampling is performed in two stages. Let *X* be the process quality variable being measured. During the first stage, one item of the sample is inspected; if its *X* value is close to the target value of the process mean, then the sampling is interrupted. Otherwise, the sampling goes on to the second stage, where the remaining items are inspected and a non-central chi-square statistic, say *T*, is computed taking into account all *n* items of the sample, that is, their *X* values. A signal is triggered when the sample point given by the *T* value falls above the upper control limit of the proposed chart. The *DS* χ^2 chart performs better than the joint $\overline{X}$ and *R* charts, except when there is a large change in the process mean. Furthermore, if the *DS* χ^2 chart is used for monitoring diameters, volumes, weights, etc., then the employment of appropriate devices, such as go-no-go gauges can reduce the effort to decide if the sampling should go to the second stage or not.

Keywords: non-central chi-square chart, double sampling, joint $\overline{X}$ and *R* charts

Introduction

The Standard Shewhart control chart has been widely used for process surveillance because of its operational simplicity. However, this operational simplicity, that is, taking

samples of size *n* from the process every *h* hours and searching for an assignable cause only when a point falls outside the control limits, makes the Shewhart chart slow in detecting small to moderate changes in the process parameter being controlled.

Among various statistical devices, specially designed to detect process changes quickly, is the adaptive control chart. A control chart is considered adaptive if at least one of its design parameters (that is, the sample size, the sampling interval, the coefficient of the control limit) varies as a function of the process data. For example, if the sample size is variable, then the position of each sample point on the chart establishes the size of the next sample (see Costa, 1994, or Epprecht and Costa, 2001). When this point falls inside the control limits, but near of one of them, it is reasonable to tighten the control by increasing the size of the next sample. On the other hand, if the sample point falls near the central line, it is reasonable to relax the control by decreasing the size of the next sample. The idea of varying the sample size (VSS) in an adaptive fashion can be applied to all chart's design parameters, including *h*, the sampling interval (see Costa, 1999a, or Epprecht et al., 2003), even though the logistical problem associated with the lack of fixed sampling points makes the use of variable sampling intervals (VSI) awkward. The number of samples in any given time period will be a random variable, and the time points at which the samples are taken will be unpredictable. Reynolds (1996a,b), Costa (1998a), and Lin and Chou (2005) considered a modification of the VSI idea. In this modification, samples are always taken at some fixed, equally-spaced time points, but additional samples are allowed between these time points whenever there is some indication of a process change. The charts using this modification of the VSI idea are called *variable sampling interval with sampling at fixed times* (VSIFT) control charts.

The results from published articles on adaptive control charts (see for example, Reynolds et al., 1988, 1990; Runger and Pignatiello, 1991; Saccucci et al., 1992; Amin and Miller, 1993; Runger and Montgomery, 1993; Prabhu et al., 1993, 1994, 1997; Costa, 1994, 1997, 1999a; Park and Reynolds, 1994, 1999; Das et al., 1997; De Magalhães et al., 2001, 2002) demonstrate that the adoption of adaptive schemes instead of fixed schemes can bring considerable economic benefits once their use leads to a better trade-off between the time to detect a process disturbance and the sampling rate required to control the process.

Double sampling (or two stage sampling) procedures combined with control charts is other alternative that has been used to improve the performance of the traditional Shewhart charts. The control charts where the samplings are performed in two stages (see Croasdale, 1974; Daudin, 1992; Steiner, 1999; Costa, 2000; Costa and Rahim, 2004) are, usually, faster than the standard Shewhart control charts to detect small to moderate shifts in the parameter process being controlled, without increasing the sampling frequency. During the first stage, one or more items of the sample are inspected and, depending on the results, the sampling is either interrupted or it goes on to the second stage, where the remaining sample items are inspected.

In recent years, considerable attention has been devoted to joint charts for monitoring the process mean and variance. For instance, Costa and Rahim (2000); and Rahim and Costa (2000) developed economic models to the joint $\bar{X}$ and *R* charts. Gan (1995) considered the joint *EWMA* charts; Albin et al. (1997) studied an *X* and an *EWMA* chart for individual observations. Chen et al. (2001) combined two *EWMA* charts into one chart and showed that the new *EWMA* chart is effective in detecting both increases and decreases in the process mean and/or variance. In the adaptive case, Costa (1998b, 1999b), and De Magalhães and Moura Neto (2005) studied the joint $\bar{X}$ and *R* charts with variable parameters. Reynolds and Stoumbos (2001) have investigated three joint charts for monitoring the mean and the variance of a normal quality variable using individual observations and variable sampling intervals. From these studies, one can observe that the joint charts are not totally reliable in identifying the nature of the disturbance. For example, if the joint $\bar{X}$ and *R* charts are in use, and the $\bar{X}$ chart signals the presence of an assignable cause, then it should be investigated which process parameter the assignable cause is affecting due to the fact that the *X* chart is not only sensitive to a shift in the process mean but also is sensitive to an increase in the process variance.

We propose in this paper the use of the double-sampling procedure with a non-central chi-square statistic to control the process mean and variance. As in the case with Shewhart charts, samples of fixed size are taken from the process at regular time intervals; however, the sampling is performed in two stages. Let *X* be the process quality variable being measured. During the first stage, one item of the sample is inspected; if its *X* value is close to the target value of the process mean, then the sampling is interrupted. Otherwise, the sampling goes on to the second stage, where the remaining items are inspected and a non-central chi-square statistic, say *T*, is computed taking into account all *m* items of the sample, that is, their *X* values. A signal is triggered when the sample point given by the *T* value falls above the upper control limit of the proposed chart. The performance of the proposed chart (*DS* χ^2 chart) is better than the joint $\bar{X}$ and *R* charts, except when there is a large change in the process mean. Furthermore, if the *DS* χ^2 chart is used for monitoring diameters, volumes, weights, etc., then the employment of appropriate devices, such as go-no-go gauges can reduce the effort to decide if the sampling should go to the second stage or not.

The Properties of the Non-Central Chi-Square Chart with Double Sampling

Throughout this article, it is assumed that the non-central chi-square chart with double sampling (*DS* χ^2 chart) is employed to monitor a process whose quality characteristic of interest (say, *X*) is normally distributed with mean μ and variance σ^2. The process is considered to start with the mean and the variance on target ($\mu = \mu_0$; $\sigma^2 = \sigma_0^2$; in-control state), but at some random time in the future an assignable cause shifts the mean from μ_0 to $\mu_1 = \mu_0 \pm \delta\sigma_0$, $\delta > 0$ and/or increases the variance from σ_0^2 to $\sigma_1^2 = \gamma^2\sigma_0^2$, $\gamma > 1$. The objective of process monitoring is the detection of any assignable cause that shifts μ and/or σ.

When there is a change in σ, it is usually assumed that the primary interest is in detecting increases in σ, because an increase corresponds to deterioration in quality.

The $\overline{X}$ and *R* charts are the traditional control charts used to detect changes in μ and σ, respectively. When two charts are used concurrently, a signal would be given if either chart indicates a possible occurrence of an assignable cause. For different values of δ and γ, Table 1 provides the probabilities $P_{\overline{X}}$, P_R, and $P_{\overline{X}-R}$ for samples of size $n = 5$ and $\alpha = 0.0027$, the risk of a false alarme when the joint $\overline{X}$ and *R* charts are in use. When the joint charts produce a signal, $P_{\overline{X}}$ is the probability that the signal was given only by the $\overline{X}$ chart, P_R is the probability that the signal was given only by the *R* chart, and $P_{\overline{X}-R}$ is the probability that the signal was given by both. From Table 1, one can observe that $P_{\overline{X}-R}$ has always a low value, even when a shift in the mean is accompanied by an increase in the variance ($\delta \neq 0$ and $\gamma > 1$). So, the major contribution of the joint $\overline{X}$ and *R* charts is on the process change detection and not on the identification of the nature of the change, whether the change is on the mean and/or on the variance. In practice, the speed with which the control charts detect process changes seems to be more important than their ability in identifying the nature of the change. Under these circumstances, it is advantageous to consider a single chart based on only one statistic to simultaneously monitor the process mean and variance. Domangue and Patch (1991), Gan (1995), and Chen et al. (2001 and 2004) have already explored the idea of using single charts to control the two parameters of the process.

When the *non-central chi-square* chart with double sampling (*DS* χ^2 chart) is in use, samples of size $m = n_0 + 1$ are randomly chosen at regular time intervals. Let X_{ij}, i = 1,2,3,..., and $j = 1,2,\ldots,m$ be the measurements of the variable *X* arranged in groups of size $m>1$, with *i* indexing the group number. The samplings are performed in two stages. During the first

Table 1 – Values of $P_{\overline{X}}$, P_R, and $P_{\overline{X}-R}$ for the joint $\overline{X}$ and *R* charts ($n = 5$).

δ	γ	$P_{\overline{X}}$	P_R	$P_{\overline{X}-R}$	δ	γ	$P_{\overline{X}}$	P_R	$P_{\overline{X}-R}$
	1.00	.4996	.4997	.0007		1.00	.9883	.0104	.0013
0.0	1.30	.3556	.6356	.0088	1.0	1.30	.8771	.1012	.0218
	1.50	.3095	.6680	.0225		1.50	.7436	.2022	.0541
	2.00	.2413	.6760	.0827		2.00	.4478	.3987	.1535
	1.00	.9104	.0884	.0012		1.00	.9944	.0043	.0013
0.5	1.30	.6473	.3366	.0161	1.25	1.30	.9221	.0550	.0229
	1.50	.5018	.4617	.0365		1.50	.8143	.1264	.0593
	2.00	.3084	.5859	.1057		2.00	.5152	.3081	.1767
	1.00	.9702	.0285	.0013		1.00	.9968	.0019	.0013
0.75	1.30	.7929	.1874	.0197	1.50	1.30	.9463	.0302	.0235
	1.50	.6387	.3148	.0465		1.50	.8596	.0778	.0626
	2.00	.3756	.4956	.1288		2.00	.5730	.2305	.1965

stage, the first item of the *i*-th sample is inspected. If its value, say X_{i1}, is close to the target value μ_0 (that is, $|X_{i1}-\mu_0| < w\sigma_0$, $w > 0$), then the sampling is interrupted. Otherwise, the second stage is initialized. During the second stage, the remaining n_0 items are inspected and the non-central chi-square statistic is computed.

$$T_i = \sum_{j=1}^{m} \left(X_{ij} - \mu_0 + \xi_i \sigma_0 \right)^2, \qquad i = 1, 2, \ldots \tag{1}$$

We define $\xi_i = d$ if $X_{i1} > \mu_0$; otherwise $\xi_i = -d$, where d is a positive constant. Note that T_i is computed taking into account all m items of the sample, that is, their X values, including X_{i1}, the quality characteristic value from the item inspected during the first stage. A signal is given at sample i if $|X_{i1} - \mu_0| > w\sigma_0$ and $T_i > k\sigma^2_0$, where k is the factor used in determining the upper control limit for the non-central chi-square chart. During the in-control period, T_i/σ^2_0 is distributed as a non-central chi-square distribution with m degrees of freedom and a non-centrality parameter $\lambda_0 = nd^2$, i.e. $T_i/\sigma^2_0 \approx \chi^2_n(\lambda_0)$. During the out-of-control period, T_i/σ^2_1 is distributed as a non-central chi-square distribution with m degrees of freedom and a non-centrality parameter λ_1; being $\lambda_1 = m(\delta + d)^2$ if $\xi_i = d$, otherwise $\lambda_1 = m(\delta - d)^2/\gamma^2$. If devices such as go and no-go gauges can be used, then measurements are not required except when the sampling goes to the second stage. The proposed sampling procedure is highly recommended for processes where such devices can be employed. During the in-control period, the rate of inspected items per sampling, $\bar{n}$, is given by:

$$\bar{n} = 1 + n_0[2\Phi(-w)] \tag{2}$$

If the parameters n_0 and w are designed to make $\bar{n}$ equal to n, the size of the samples when the joint $\bar{X}$ and R charts are in use, then the joint charts and the *DS* χ^2 chart will demand the same average number of items (ANI) to be inspected.

Let Q be the probability of deciding that the process is out of control:

$$Q = \Pr\left[(|X_{i1} - \mu_0| > w\sigma_0) \cap (T_i > k\sigma_0^2)\right] \tag{3}$$

The effectiveness of a control chart in detecting a process change can be measured by the average run length (*ARL*), which is the expected number of samples drawn until the chart gives a signal. The number of samples drawn until a signal is a geometrically distributed random variable with parameter Q. Usually, the process starts in control and some time in the future an assignable cause shifts the process mean and/or increases the process variance. This assumption was assumed for the developed model. When a process is in control, it is desirable that the average number of samples taken since the beginning of monitoring until a signal (ARL_0) be large; this guarantees few false alarms. The $ARL_0 = \alpha^{-1}$, where α is the type I error probability. The ARL_0 was chosen to be 433.0 (the same value adopted by Costa and Rahim, 2004). When a process is out of control, it is desirable that the average number of samples taken since the occurrence of the assignable cause until a signal (*ARL*) be small, this guarantees fast detection of process changes. The

ARL = $(1 - \beta)^{-1}$, being β the type II error probability. In the Appendix, we show how the Equation (3) can be used to obtain the false alarm risk (α) and the power ($1 - \beta$) of the *DS* χ^2 chart.

Tables 2 and 3 provide the *ARL* for the *DS* χ^2 chart and for the joint $\bar{X}$ and *R* charts. One can see from these tables that, in most of the cases, the *DS* χ^2 chart always detects process changes faster (lower *ARL*) than the joint $\bar{X}$ and *R* charts. The exceptions occur in some cases when there is a large change in the mean (boldfaced values). For given $\bar{n}$, *m* and *d*, the *ARL* for the joint $\bar{X}$ and *R* charts and *DS* χ^2 chart decreases as δ and/or γ increases. One can see from both tables that the *ARL* value always decreases as $\bar{n}$ increases.

Table 2 – Values of the ARL for the joint $\bar{X}$ and *R* charts and for the DS χ^2 chart ($\bar{n} = n = 3$).

			m = 6 *w* = 0.8416			*m* = 9 *w* = 1.15035			*m* = 12 *w* = 1.3352		
	D=		0.5	0.7	0.9	0.5	0.7	0.9	0.5	0.7	0.9
	K=		25.1365	28.9010	33.3133	30.6900	35.4754	41.2003	35.8120	41.5380	48.4800
γ	δ	$\bar{X} - R$*									
	0	433.0	433.0	433.0	433.0	433.0	433.0	433.0	433.0	433.0	433.0
	0.50	102.8	46.40	43.10	40.05	35.30	30.67	28.08	28.77	24.74	22.51
1.0	0.75	37.51	15.23	13.59	12.65	10.61	9.38	8.68	8.72	7.75	7.20
	1.0	15.25	6.04	5.50	5.18	4.38	4.02	3.81	3.88	3.62	3.50
	1.25	7.14	3.04	2.83	2.71	2.43	2.32	2.25	2.38	2.32	2.28
	1.50	3.89	1.89	1.81	1.76	1.71	1.68	1.66	1.80	1.79	1.79
	2.00	1.71	1.20	1.19	1.18	1.25	1.25	1.25	1.34	1.34	1.34
	0	33.46	24.01	26.76	29.35	19.64	22.33	25.04	17.03	19.58	22.23
	0.50	19.53	10.75	10.92	11.11	6.48	8.61	6.77	7.39	7.52	7.66
1.3	0.75	11.98	6.06	5.99	5.97	4.84	4.79	4.78	4.38	4.35	4.34
	1.0	7.30	3.68	3.61	3.57	3.08	3.03	3.01	2.93	2.91	2.90
	1.25	4.63	2.47	2.43	2.40	2.20	2.18	2.17	2.22	2.21	2.21
	1.50	3.12	1.83	1.81	1.79	1.75	1.74	1.74	1.83	1.83	1.84
	2.00	1.75	1.29	1.29	1.28	1.35	1.35	1.35	1.43	1.43	1.44
	0	13.05	8.89	10.02	11.16	7.20	8.21	9.29	6.32	7.20	8.19
	0.50	9.61	5.65	6.22	6.56	4.61	5.13	5.44	4.36	4.65	4.94
1.5	0.75	7.09	4.12	4.25	4.37	3.48	3.60	3.71	3.27	3.39	3.49
	1.0	5.09	2.95	2.99	3.03	2.60	2.65	2.69	2.54	2.60	2.65
	1.25	3.68	2.22	2.24	2.25	2.06	2.08	2.10	2.09	2.12	2.15
	1.50	2.75	1.78	1.78	1.79	1.73	1.74	1.76	1.80	1.82	1.84
	2.00	1.73	1.33	1.33	1.34	1.38	1.39	1.40	1.47	1.47	1.48
	0	3.78	2.72	2.96	3.24	2.42	2.60	2.82	2.33	2.47	2.64
	0.50	3.43	2.46	2.65	2.85	2.23	2.37	2.54	2.20	2.30	2.44
2.0	0.75	3.09	2.22	2.36	2.50	2.06	2.16	2.29	2.06	2.14	2.24
	1.0	2.71	1.98	2.07	2.17	1.89	1.96	2.04	1.92	1.97	2.05
	1.25	2.36	1.77	1.83	1.90	1.73	1.78	1.84	1.78	1.82	1.87
	1.50	2.06	1.59	1.63	1.68	1.60	1.63	1.67	1.67	1.69	1.73
	2.00	1.60	1.35	1.37	1.39	1.41	1.42	1.44	1.48	1.49	1.50

*$\bar{X}$ chart with control limits $\mu_0 \pm 3.250\,\sigma_0/\sqrt{3}$, and R chart with upper control limit 5.009 σ_0.

Table 3 – Values of the ARL for the joint $\overline{X}$ and *R* charts and for the *DS* χ^2 chart ($\overline{n} = n = 5$).

			m = 10 *w* = 0.7665			*m* = 15 *w* = 1.0676			*m* = 20 *w* = 1.2521		
*		D =	0.5	0.7	0.9	0.5	0.7	0.9	0.3	0.5	0.7
		K =	33.3743	38.6042	44.8822	41.9790	48.7906	57.1134	43.9203	50.0360	58.3310
γ	δ	X – *R**									
	0	433.0	433.0	433.0	433.0	433.0	433.0	433.0	433.0	433.0	433.0
	0.50	56.59	28.94	24.74	22.42	20.66	17.38	15.62	22.70	16.82	14.15
1.0	0.75	16.94	8.26	7.21	6.62	6.02	5.31	4.92	6.38	5.26	4.74
	1.0	6.39	3.37	3.07	2.90	2.79	2.62	2.53	3.00	2.78	2.69
	1.25	3.07	1.92	1.82	1.77	1.86	1.82	1.80	2.05	2.03	2.02
	1.50	1.84	1.41	1.38	1.37	1.51	1.51	1.50	1.67	1.67	1.67
	2.00	1.12	1.12	1.12	1.12	**1.21**	**1.21**	**1.21**	**1.29**	**1.29**	**1.29**
	0	26.24	16.53	19.09	21.69	13.13	15.42	17.88	9.66	11.25	13.28
	0.50	13.23	6.81	6.92	7.05	5.50	5.60	5.70	4.89	4.99	5.11
1.3	0.75	7.33	3.85	3.81	3.79	3.31	3.30	3.29	3.20	3.22	3.24
	1.0	4.20	2.46	2.43	2.41	2.31	2.31	2.30	2.37	2.40	2.42
	1.25	2.63	1.80	1.79	1.78	1.83	1.84	1.84	1.95	1.97	2.00
	1.50	1.84	1.47	1.47	1.47	1.57	1.58	1.59	1.70	1.71	1.72
	2.00	1.20	1.20	1.20	**1.21**	**1.30**	**1.30**	**1.31**	**1.38**	**1.38**	**1.38**
	0	9.46	5.85	6.77	7.77	4.77	5.50	6.36	3.85	4.28	4.88
	0.50	6.62	3.87	4.16	4.43	3.34	3.59	3.83	3.00	3.19	3.43
1.5	0.75	4.67	2.80	2.92	3.01	2.56	2.68	2.78	2.48	2.58	2.71
	1.0	3.25	2.11	2.17	2.21	2.07	2.13	2.18	2.11	2.17	2.25
	1.25	2.33	1.70	1.74	1.76	1.76	1.80	1.84	1.86	1.89	1.94
	1.50	1.77	1.46	1.49	1.50	1.57	1.59	1.62	1.68	1.69	1.71
	2.00	1.24	1.23	1.24	1.25	1.33	1.34	1.35	**1.42**	**1.42**	**1.42**
	0	2.64	1.97	2.13	2.33	1.90	2.00	2.14	1.94	1.97	2.03
	0.50	2.41	1.83	1.96	2.11	1.81	1.90	2.01	1.87	1.90	1.95
2.0	0.75	2.17	1.70	1.80	1.92	1.73	1.79	1.88	1.81	1.83	1.87
	1.0	1.92	1.58	1.65	1.73	1.64	1.69	1.76	1.74	1.75	1.78
	1.25	1.69	1.46	1.51	1.58	1.55	1.59	1.64	1.66	1.66	1.68
	1.50	1.50	1.37	1.41	1.45	1.48	1.50	**1.53**	**1.58**	**1.58**	**1.59**
	2.00	1.23	1.25	1.26	**1.28**	**1.35**	**1.36**	**1.37**	**1.43**	**1.43**	**1.44**

* $\overline{X}$ chart with control limits $\mu_0 \pm 3.250\,\sigma_0/\sqrt{5}$, and R chart with upper control limit 5.432 σ_0.

It can be observed from Table 2 that for large disturbances in the mean ($\delta = 2.0$ and in some cases $\delta = 1.5$), the *ARL* value increases as *m* increases. The choice of *d* affects the speed with which the *DS* χ^2 chart signals. In general, larger values of *d* are better for detecting shifts in μ with $\sigma = \sigma_0$, and worse for detecting increases in σ with $\mu = \mu_0$. For example, one can see from Table 3, when $\delta = 0.5$, $\gamma = 1.0$, as *d* increases, the *ARL* value decreases from 28.94 to 24.74 to 22.42, for $m = 10$; from 20.66 to 17.38 to 15.62, for $m = 15$; from 22.70 to 16.82 to 14.15, for $m = 20$. On the other hand, when $\delta = 0$, $\gamma = 1.5$, as *d* increases, the *ARL* value increases from 5.85 to 6.77 to 7.77, for $m = 10$; from 4.77 to 5.50 to 6.36, for $m = 15$; from 3.85 to 4.28 to 4.88, for $m = 20$.

The performance of a control chart can also be measured by the sampling rate. When the joint $\overline{X}$ and *R* charts are in use, the sampling rate is given by *n* (the sample size), and when the *DS* χ^2 chart is in use, the sampling rate is given by $\overline{n}$ (see Equation 2). Like the *ARL*, the sampling rate can be used to compare two charts. To keep the comparison meaningful, the two charts should offer the same protection against false alarms by having the same ARL_0. For specified types of process changes, the control chart with the best performance is the one with the lowest sampling rate and best ability of detection. One can see from Table 4 that the *DS* χ^2 chart is an interesting alternative to the joint $\overline{X}$ and *R* charts, if the aim is the reduction of the sampling rate. For example, one can see from Table 4, when $n = 3.0$, $\delta = 1.0$, and $\gamma = 1.3$, the *DS* χ^2 chart leads to a better trade-off between the time to detect the process change and the sampling rate required to control the process, that is lower *ARL* (5.01 against 7.30), and lower *Sampling Rate* (1.5 against 3.0).

The Design of the Non-Central Chi-Square Chart with Double Sampling

The use of the *DS* χ^2 chart requires the specification of *d*, n_0, $\overline{n}$, and *k*. According to Equation (2), *w* is a function of $\overline{n}$ and n_0. If the practitioners have some idea about the

Table 4 - Values of the ARL for the joint $\overline{X}$ and R charts and for the *DS* χ^2 chart ($n \neq \overline{n}$).

γ	δ	$\overline{X} - R$ $n = 3.0$	*DS* χ^2 chart $\overline{n} = 1.5$; $m = 7$; $d = 0.25$ $w = 1.7317$; $k = 21.8140$	$\overline{X} - R$ $n = 5.0$	*DS* χ^2 chart $\overline{n} = 3.0$; $m = 11$; $d = 0.30$ $w = 1.2816$; $k = 30.0043$
1.0	0	433.0	433.0	433.0	433.0
	0.50	102.8	67.58	56.59	39.12
	0.75	37.51	22.43	16.94	11.31
	1.0	15.25	9.12	6.39	4.56
	1.25	7.14	4.62	3.07	2.53
	1.50	3.88	2.87	1.84	1.80
1.3	0	33.46	23.90	26.24	15.59
	0.50	19.53	12.85	13.23	7.64
	0.75	11.98	7.85	7.33	4.60
	1.0	7.30	5.01	4.20	3.02
	1.25	4.63	3.45	2.63	2.22
	1.50	3.12	2.57	1.84	1.80
1.5	0	13.05	9.41	9.46	5.85
	0.50	9.61	6.86	6.62	4.23
	0.75	7.09	5.15	4.67	3.22
	1.0	5.09	3.86	3.25	2.51
	1.25	3.68	2.99	2.33	2.05
2.0	0	3.78	3.28	2.64	2.25
	0.50	3.43	3.04	2.41	2.12
	0.75	3.09	2.79	2.17	1.99
	1.0	2.71	2.54	1.92	1.86
	1.25	2.36	2.29	1.69	1.69
	1.50	2.06	2.06	1.50	1.51

disturbances the process is subject to, then they can use Tables 5 and 6 for selecting the design parameters. These tables provide the values of d, n_0, and k that minimize the average number of samples required to signal δ standard deviation shifts in the process mean accompanied by $100(\gamma^2 - 1)\%$ of process variance increase under the constraints that $\alpha \approx 0.0023$, $\bar{n} = 3$, $3 < n_0 \leq 15$, and $d \leq 1$ (Table 5), or $\bar{n} = 5$, $5 < n_0 \leq 20$, and $d \leq 1$ (Table 6). For example, Table 6 shows that shifts in the process mean equal to half standard deviation ($\delta = 0.5$), accompanied by 56.25% process variance increase ($\gamma = 1.25$) are detected faster when $d = 0.6$, $n_0 = 20$, and $k = 55.6274$.

Comparing Charts

It seems reasonable to compare the *DS* χ^2 chart and the two-stage sampling (*TSS*) $\bar{X}$ and *R* charts in terms of the speed with which they detect process disturbances. When the *TSS* $\bar{X}$ and *R* charts are in use, samples of size $m = n_0 + 1$ are taken from the process at regular

Table 5 – The ARL and the optimum design parameters for the *DS* χ^2 charts, $\bar{n} = n = 3$.

				$\delta = 0$			$\delta = 0.5$			$\delta = 1.0$		
				γ			γ			γ		
n_0	*w*	*d*	*k*	1.00	1.25	1.50	1.00	1.25	1.50	1.00	1.25	1.50
15		0	27.580	433	**16.8**	**4.83**	66.2	8.99	3.88	6.01	3.47	2.62
15		1	50.649	433	29.6	7.78	**18.2**	7.91	4.79	3.52	3.07	2.77
15	1.501	0.6	36.628	433	22.8	6.05	22.1	**7.83**	4.26	3.70	3.09	2.66
15		0.1	27.855	433	17.0	4.87	48.8	8.42	**3.84**	5.02	3.28	2.56
13	1.423	1	45.936	433	31.1	8.18	19.6	8.25	4.89	**3.43**	2.99	2.70
10	1.282	1	38.667	433	34.01	9.03	23.2	9.15	5.20	3.47	**2.97**	2.66
10		0.3	23.424	433	22.2	5.85	39.1	9.28	4.23	4.56	3.19	**2.51**
Standard $\bar{X}$ and *R* charts				433	45.40	13.10	103.00	23.80	9.61	15.30	8.08	5.09

Boldfaced ARL is the minimum one for the specified δ and γ (for which the minimization was performed).

Table 6 – The ARL and the optimum design parameters for the *DS* χ^2 charts, $\bar{n} = n = 5$.

				$\delta = 0$			$\delta = 0.5$			$\delta = 1.0$		
				γ			γ			γ		
n_0	*w*	*d*	*k*	1.00	1.25	1.50	1.00	1.25	1.50	1.00	1.25	1.50
20		0	40.8006	433	**12.1**	**3.57**	52.6	6.43	2.94	4.23	2.65	2.14
20		1	76.8562	433	23.5	5.90	**11.9**	5.73	3.74	2.67	2.49	2.36
20	1.282	0.6	55.6274	433	17.3	4.49	14.8	**5.68**	3.30	2.76	2.50	2.23
20		0.1	41.5770	433	12.3	3.59	37.0	6.02	**2.92**	3.56	2.54	2.12
15	1.111	1	64.3750	433	26.5	6.62	14.3	6.27	3.88	**2.50**	**2.34**	2.21
15		0.2	36.4343	433	14.9	3.94	32.9	6.51	3.02	3.39	2.46	**2.02**
Standard $\bar{X}$ and *R* charts				433†	36.7	9.50	56.6	16.2	6.62	6.39	4.48	3.25

Boldfaced ARL is the minimum one for the specified δ and γ (for which the minimization was performed).

time intervals. The sampling is performed in two stages. During the first stage, the first item of the sample is inspected. If its *X* value is close to the target value ($|X - \mu_0| < w\sigma_0$, $w > 0$), then the sampling is interrupted. Otherwise, the sampling goes on to the second stage, where the remaining n_0 items are inspected and the $\overline{X}$ and *R* values are computed. The signal is given by an $\overline{X}$ value beyond the control limits ($\mu_0 \pm k_{\overline{X}}\sigma_0/\sqrt{n_0}$) and/or by an *R* value above the upper control limit, $k_R(n_0)\sigma_0$. The sample values can be computed taking into account all *m* values (*DS* procedure), or only the remaining n_0 values (*TSS* procedure). The *DS* charts are more effective in detecting process disturbances. This result is intuitive, once the *DS* scheme makes better use of the sample information. Table 7 provides the *ARL* for the *DS* χ^2 chart and for the *TSS* $\overline{X}$ and *R* charts. One can see from this table that the *chi-square* chart competes with the joint charts. Thus, a single chart can be used for monitoring both the process mean and variance.

Very recently, Reynolds and Stoumbos (2004) investigated the use of two *EWMA* charts or two CUSUM charts for monitoring the mean and the variance. In their study, the $EWMA_X$ chart for detecting changes in μ is based on the control statistic

$$E_k^X = (1 - \lambda)E_{k-1}^X + \lambda\overline{X}_k,\ k = 1, 2,..., \tag{4}$$

where: λ is a tuning parameter satisfying $0 < \lambda \leq 1$ and the starting value is usually taken to be $E_0^X = \mu_0$. A signal is given at sample *k* if E_k^X falls outside the control limits

$$\mu_0 \pm h_{EX}\sqrt{\lambda/(n(2 - \lambda))}\,\sigma_0 \tag{5}$$

where: $\sqrt{\lambda/(n(2 - \lambda))}\,\sigma_0$ is the asymptotic in-control standard deviation of E_k^X. The $EWMA_{X^2}$ chart for detecting changes in σ is based on the control statistic

$$E_k^{X^2} = (1 - \lambda)\max\left\{E_{k-1}^{X^2}, \sigma_0^2\right\} + \lambda\sum_{i=1}^{n}\frac{(X_{ki} - \mu_0)^2}{n},\ k = 1, 2,..., \tag{6}$$

where: $E_0^{X^2} = \sigma_0^2$. A signal is given at sample *k* if $E_0^{X^2}$ falls above the control limit

$$\sigma_0^2 + h_{EX^2}\sqrt{2\lambda/(n(2 - \lambda))}\,\sigma_0^2 \tag{7}$$

Table 7 – Values of the *ARL* for the *TSS* $\overline{X}$ and *R* Charts and for the *DS* χ^2 chart ($\overline{n} = n = 5$; $n_0 = 14$; $w = 1.068$).

	TSS $\overline{X}$ *and R charts** $k_{\overline{X}} = 2.873$; $k_R(n_0) = 5.725$							*DS* χ^2 chart $k = 42.6115$; $d = 0.7$					
	δ							δ					
γ	0.00	0.50	0.75	1.00	1.25	1.50	γ	0.00	0.50	0.75	1.00	1.25	1.50
1.0	433.0	18.01	5.13	2.51	1.78	1.49	1.0	433.0	17.38	5.17	2.62	1.82	1.51
1.3	19.29	7.50	3.88	2.42	1.82	1.55	1.3	15.42	5.60	3.30	2.31	1.84	1.58
1.5	6.57	4.33	3.02	2.22	1.79	1.56	1.5	5.50	3.59	2.68	2.13	1.80	1.59
2.0	2.13	1.99	1.85	1.71	1.59	1.49	2.0	2.00	1.90	1.79	1.69	1.59	1.50

**ARL* values tabulated in Costa and Rahim (2004).

The CUSUM$_X$ chart for detecting changes in μ is based on two separate one-side CUSUM statistics. The upper CUSUM statistic for detecting increases in μ is

$$C_k^{X+} = \max\left\{0, C_{k-1}^{X+}\right\} + \left(\overline{X}_k - \mu_0 - \zeta_\mu \sigma_0/2\right), k = 1, 2, \ldots, \quad (8)$$

and the lower CUSUM statistic for detecting decreases in μ is:

$$C_k^{X-} = \min\left\{0, C_{k-1}^{X-}\right\} + \left(\overline{X}_k - \mu_0 + \zeta_\mu \sigma_0/2\right), k = 1, 2, \ldots, \quad (9)$$

The initial values for the statistics are $C_0^{X+} = C_0^{X-} = 0$. The chart parameter ζ_μ is defined as $\zeta_\mu = |\mu_1 - \mu_2|/\sigma$, where μ_1 is an out-of-control value of μ that should be detected quickly.

The chart signals if:

$$C_k^{X+} > h_{CX}\sigma_0/\sqrt{n} \text{ or } C_k^{X-} < -h_{CX}\sigma_0/\sqrt{n} \quad (10)$$

The CUSUM$_{X^2}$ chart for detecting changes in σ is based on the control statistic:

$$C_k^{X^2} = \max\left\{0, C_{k-1}^{X^2}\right\} + \left(\sum \frac{\left(X_{ki} - \mu_0\right)^2}{n} - \frac{21n\zeta_\sigma}{1 - \zeta_\sigma^{-2}}\sigma_0^2\right), \qquad k = 1, 2, \ldots, \quad (11)$$

where $C^{X^2}_0 = 0$ and the upper control limit is

$$h_{CX^2}\sigma_0^2/n \quad (12)$$

The chart parameter ζ_σ is defined as $\zeta_\sigma = \sigma_1/\sigma_0$, where σ_1 ($\sigma_1 > \sigma_0$) is a value of σ that should be detected quickly.

Comparing the *EWMA* and the CUSUM chart combinations with the corresponding *DS Chi-square* chart in Table 8 shows that the *EWMA* and the CUSUM chart combinations are better for small shifts in μ, but the *DS* χ^2 chart is equivalent or slightly better for changes in σ ranging from $\gamma = 1.25$ to $\gamma = 3.00$.

Illustrative Example

The joint $\overline{X}$ and *R* charts have been used to monitor the diameter of shafts. As the specifications of the diameters (0.7500 ± 0.0030 inches) are very tight, a minor shift in the process mean accompanied by increases in the variance leads to the manufacturing of a large number of shafts with diameters beyond the specifications. Past data show that the standard deviation (σ) of the diameters, originally stable at $\sigma_0 = 0.0012$ inches, increases when the process mean goes off-target. The parameters of the joint charts are $n = 3$, $k_{\overline{X}} = 3.250$ and $k_R(n) = 5.009$. The *Double Sampling Non-Central Chi-Square* Chart was designed to replace the joint charts. At the first stage, one item of the sample is inspected. If its X value belongs to the interval $\mu_0 \pm w\sigma_0$ ($w = 1.3352$), then the sampling is interrupted. Otherwise, at the second stage, the remaining sample items are inspected, $T = \sum\left(X_j - \mu_0 + \xi\sigma_0\right)^2$ is computed and its value is plotted on the *Non-Central Chi-Square Chart* with $k = 41.5380$ ($m = 12$; $d = 0.7$).

Table 8 – *ARL* for the EWMA and CUSUM chart combinations and for the *DS* χ^2 chart.

$\bar{n} = n = 4$		EWMA$_X$ and EWMA$_{X^2}$ $\lambda = 0.1000$ $h_{EX}=2.940$ $h_{EX^2}=3.412$	CUSUM$_X$ and CUSUM$_{X^2}$ $\zeta_\mu = 0.8$ $\zeta_\sigma = 1.35$ $h_{CX} = 6.772$ $h_{CX^2} = 19.143$	*DS* χ^2 chart $n_0 = 16$ $d = 0.40$ $w = 1.3180$ $k = 41.0710$
δ	γ			
0	1.00	370.4	370.4	370.4
0.25	1.00	33.1	33.1	107.4
0.50	1.00	10.6	10.4	21.4
1.00	1.00	4.3	4.2	3.2
1.50	1.00	2.6	2.6	1.7
2.00	1.00	1.7	1.8	1.3
3.00	1.00	1.1	1.1	1.1
0	1.25	16.1	16.2	16.2
0	1.50	5.9	5.9	4.5
0	2.00	2.6	2.6	2.1
0	2.50	1.8	1.8	1.7
0	3.00	1.4	1.4	1.4

From Table 2, one can see that the *DS* χ^2 chart detects process disturbances faster than the joint $\bar{X}$ and *R* charts. For instance, to detect mean shifts of half standard deviation ($\delta = 0.5$) accompanied by 69% of process variance increase ($\gamma = 1.3$), the *DS* χ^2 chart, with $n_0 = 11$ and $d = 0.7$, requires, on average, 7.52 samples (*ARL* = 7.52), against 19.53 samples (the *ARL* value for the joint $\bar{X}$ and *R* charts with $n = 3$, $k_{\bar{X}} = 3.250$ and $k_R(n) = 5.009$).

During the in-control period, approximately 82% of the two stage procedure does not go to the second stage (that is, $Pr[\,|Z| < w = 1.335\,|\,Z \approx N(0,1)] \approx 0.82$); consequently, most of the time the user will not have to measure the diameter of any shaft. As the process is very stable (remains in control most of the time) the occurrence of $\bar{X}$ or *R* values outside the control limits is rare. The activity of measuring three shafts at each hour plus computation of $\bar{X}$ and *R* values may be considered tedious. The *DS* procedure provides some relief once the average length of the interval between no-interrupted samplings (when measurements are effectively required) is longer than 5 hours and half (1/0.18 sampling intervals of one hour). Hence, most of the time, measurements will be performed once or twice per day (considering 8 hours of labor). One can raise the question that it is more monotonous to deal with the non-central chi-square statistic than with $\bar{X}$ and *R* statistics, however, with a programmable calculator, the required number of keystrokes to obtain the *T* values or the $\bar{X}$ values is just the same. In summary, the *DS* χ^2 chart is not only more sensitive than the joint $\bar{X}$ and *R* charts, but operationally simpler as well.

Conclusions

In this paper we have shown that it is possible to design one chart, which can monitor both the process mean and variance. The *DS* χ^2 control chart is of particular interest when the quality characteristic can be evaluated either by attribute or variable. As it is much easier to deal with attributes than with variables the proposed chart is a valuable tool. A classical example consists in monitoring the diameter of shafts. During the first stage of the sampling, a gauge is used to decide if the whole sample must be inspected by variable (for instance, using a micrometer) or if the sampling must be interrupted. This two-stage procedure has two advantages. The first advantage is the reduced number of times the user will need to perform measurements, and the second is the gain in speed with which process disturbances will be detected. The *DS* χ^2 chart was conceived to be a practical tool for surveillance of processes subject to small to moderate disturbances. Moreover, when the process is stable, and the joint $\overline{X}$ and *R* charts are in use, the monitoring becomes monotonous because an $\overline{X}$ or a *R* values rarely falls outside the control limits. The natural consequence is that the user pays less and less attention to the steps required to obtain the $\overline{X}$ and *R* value. But in some cases, this lack of attention can result in serious mistakes. When the *DS* χ^2 chart is in use, most of the samplings are interrupted, consequently, most of the time the user will be working with attributes. Our experience shows that the inspection of one item by attribute is much less monotonous than measuring three, four or five items at each sampling.

Acknowledgment

The financial support of this joint work was provided in part by CNPq (the Brazilian Council for Scientific and Technologic Development). Its assistance is gratefully acknowledged.

References

Albin, S. L., Kang, L. and Sheha, G. (1997). An *X* and EWMA Chart for Individual Observations. Journal of Quality Technology, v. 29, p. 41-48.

Amin, R. W. and Miller, R. W.(1993). A Robustness Study of $\overline{X}$ Charts with Variable Sampling Intervals. Journal of Quality Technology, v. 25, p. 36-44.

Chen, G., Cheng, S. W. and Xie, H. (2001). Monitoring Process Mean and Variability with One EWMA Chart. Journal of Quality Technology, v.33, p. 223-233.

Chen, G., Cheng, S. W. and Xie, H. (2004). A New EWMA Control Chart for Monitoring Both Location and Dispersion. Quality Technology & Quantitative Management, v. 1, n. 2, p. 217-231.

Costa, A. F. B. (1994). $\overline{X}$ Charts with Variable Sample Size. Journal of Quality Technology, v. 26, n. 3, p.155-163.

Costa, A. F. B. (1997). $\overline{X}$ Charts with Variable Sample Size and Sampling Intervals. Journal of Quality Technology, v. 29, p.197-204.

Costa, A. F. B. (1998a). VSSI $\overline{X}$ Charts with Sampling at Fixed Times. Communications in Statistics – Theory and Methods, v. 27, n. 11, p. 2853-2869.

Costa, A. F. B. (1998b). Joint $\overline{X}$ and *R* charts with Variable Parameters. IIE-Transactions, v. 30, n. 11, p.505-514.

Costa, A. F. B. (1999a). $\overline{X}$ Charts with Variable Parameters. Journal of Quality Technology, v. 31, n. 4, p. 408-416.

Costa, A. F. B. (1999b). Joint $\overline{X}$ and *R* charts with Variable Sample Sizes and Sampling Intervals. Journal of Quality Technology, v. 31, n. 4, p. 387-397.

Costa, A. F. B. (1999b). $\overline{X}$ Charts with Supplementary Samples to Control the Mean and Variance. International Journal of Production Research, v. 38, n. 16, p. 3801-3809.

Costa, A. F. B. and Rahim, M. A.(1999b). Economic Design of $\overline{X}$ and R Charts Under Weibull Shock Models. Quality and Reliability Engineering International, v. 16, p.143-156, X.

Costa, A. F. B., Rahim, M. A. (2004). Joint $\overline{X}$ and R Charts with Two Stage Samplings. Quality and Reliability Engineering-International, v. 20, n. 7, p. 699-708.

Croasdale, R. (1974). Control Charts for a Double-Sampling Scheme Based on Average Production Run Length. International Journal of Production Research, v.12, p.585-592.

Das, T. K., Jain, V. and Gosavi, A. (1997). Economic Design of Dual-Sampling Interval Policies for $\overline{X}$ Charts With and Without Run Rules, v. 29, p. 497-506.

Daudin, J. J. (1992). Double Sampling $\overline{X}$ Charts. Journal of Quality Technology, v. 24, p. 78-87.

De Magalhães, M. S., Epprecht, E. K. and Costa, A. F. B. (2001). Economic Design of a Vp $\overline{X}$ Chart. International Journal of Production Economics, v. 74, p.191-200.

De Magalhães, M. S., Costa, A. F. B. and Epprecht, E. K. (2002). Constrained Optimization Model for the Design of an Adaptive $\overline{X}$ Chart. International Journal of Production Research, v.40, p. 3199-3218.

De Magalhães, M. S. and Moura Neto, F. D. (2005). Joint Economic Model for Totally Adaptive $\overline{X}$ and *R* Charts. European Journal of Operation Research, v. 161, p.148-161, .

Domangue, R. and Patch, S. C. (1991). Some Omnibus Exponentially Weighted Moving Average Statistical Process Monitoring Schemes. Technometrics, v. 33, n. 3, p. 299-313.

Epprecht, E. K. and Costa, A. F. B. (2001). Adaptive Sample Size Control Charts for Attributes. Quality Engineering, v. 13, n. 3, p. 465-473.

Epprecht, E. K., Costa, A. F. B. and Mendes F. C. T. (2003). Adaptive Control Charts for Attributes. IIE Transactions, v. 35, n. 6, p. 567-582.

Gan, F. F. (1995). Joint Monitoring of Process Mean and Variance Using Exponentially Weighted Moving Average Control Charts. Technometrics, v. 37, n. 4, p. 446-453.

Lin, Y. C. and Chou, C. Y. (2005). Adaptive $\overline{X}$ Control Charts with Sampling at Fixed Times. Quality and Reliability Engineering International (in press).

Park, C. and Reynolds, M. R., Jr. (1994). Economic Design of a Variable Sample Size $\overline{X}$-Chart. Communications in Statistics-Simulation and Computation, v. 23, p.467-483.

Park, C. and Reynolds, M. R., Jr. (1999). Economic Design of a Variable Sampling Rate $\overline{X}$-Chart. Journal of Qual+ity Technology, v.31, p.427-443.

Prabhu, S. S., Montgomery, D. C. and Runger, G. C. (1994). A Combined Adaptive Sample Size and Sampling Interval $\overline{X}$ Control Scheme. Journal of Quality Technology, v.26, p.164-176.

Prabhu, S. S., Montgomery, D. C. and Runger, G. C. (1997). Economic-Statistical Design of an Adaptive $\overline{X}$ Chart. International Journal of Production Economics, v. 49, p.1-15.

Prabhu, S. S., Runger, G. C. and Keats, J. B. (1993). An Adaptive Sample Size $\overline{X}$ Chart. International Journal of Production Research, v. 31, p. 2895-2909.

Rahim, M. A., Costa, A. F. B. (2000). Joint Economic Design of $\overline{X}$ and R Charts Under Weibull Shock Models. International Journal of Production Research, v. 28, p. 2871-2889.

Reynolds, M. R. (1996a). Variable-Sample-Interval Control Charts with Sampling at Fixed Times. IIE Transactions, v. 28, p. 497-510.

Reynolds, M. R., Jr. (1996b). Shewhart and Ewma Variable Sampling Interval Control Charts with Sampling at Fixed Times. Journal of Quality Technology, v. 28, p.199-212.

Reynolds, M. R., Jr., Amin, R. W. and Arnold, J. C. (1990). Cusum Charts with Variable Sampling Intervals. Technometrics, v. 32, p.371-384.

Reynolds, M. R, Jr., Amin, R. W., Arnold, J. C. and Nachlas, J. A. (1988). $\overline{X}$ Charts with Variable Sampling Intervals. Technometrics, v. 30, p.181-192.

Reynolds, M. R., Jr. and Stoumbos, Z. G. (2001). Monitoring the Process Mean and Variance Using Individual Observations and Variable Sampling Intervals. Journal of Quality Technology, v. 33, p.181-205.

Reynolds, M. R., Jr. and Stoumbos, Z. G. (2004). Control Charts and the Efficient Allocation of Sampling Resources. Technometrics, v. 46, n. 2, p.200-214.

Runger, G. C. and Montgomery, D. C.(1993). Adaptive Sampling Enhancements for Shewhart Control Charts. IIE Transactions, v. 25, p.41-51.

Runger, G. C. and Pignatiello, J. J, Jr. (1991). Adaptive Sampling for Process Control. Journal of Quality Technology, v. 23, p.135-155.

Saccucci, M. S., Amin, R. W. and Lucas, J. M. (1992). Exponentially Weighted Moving Average Control schemes with variable sampling intervals. Communication in Statistics – Simulation and Computation,v.21, p. 627-657.

Steiner, S. H. (1999). Confirmation Sample Control Charts. International Journal of Production Research, v. 37, p.737-748.

Biography

Antonio F. B. Costa is a Professor in the Department of Production at UNESP- São Paulo State University, Brazil. He was a postdoctoral fellow in the Center for Quality and Productivity Improvement at University of Wisconsin, Madison, USA. His current interest is in statistical quality control. He has published papers in the Brazilian Journal of Operations & Production Management, Journal of Quality Technology, Communications in Statistics, IIE Transactions, International Journal of Production Research, International Journal of Production Economics, Quality and Reliability Engineering International, Quality Technology and Quantitative Management, Journal of Applied Statistics, European Journal of Operation Research, Quality Engineering, Journal of Quality in Maintenance Engineering and (in Portuguese) in *Gestão & Produção* and *Pesquisa Operacional*. He received a Best Paper Award from IIE Transactions. He is a Certified Quality Engineer by the American Society for Quality. He is a member of the *Associação Brasileira de Engenharia de Produção (*ABEPRO*)* and of the *Sociedade Brasileira de Pesquisa Operacional* (SBPO).

Maysa S. De Magalhães is an Associate Professor in the Escola Nacional de Ciências Estatísticas at Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro, Brazil. She received a PhD degree from Pontifícia Universidade Católica do Rio de Janeiro. Her current interests are in statistical quality control and times series. She has published papers in the Brazilian Journal of Operations & Production Management, International Journal of Production Economics, European Journal of Operational Research, International Journal of Production Research, Quality and Reliability Engineering International, and (in Portuguese) in *Gestão & Produção*. She is a member of the *Sociedade Brasileira de Pesquisa Operacional (*SBPO*)*.

Eugenio Kahn Epprecht is an Associate Professor in the Department of Industrial Engineering at the Pontifícia Universidade Católica (PUC), Rio de Janeiro, Brazil. He received his Engineering and MSc degrees from PUC, Rio de Janeiro, and his Ph.D. from the *Facultés Universitaires Notre-Dame de la Paix*, Belgium. His chief research interests are statistical quality control and industrial applications of statistics and operations research. He has published papers in the Brazilian Journal of Operations & Production Management, IIE Transactions, International Journal of Production Research, International Journal of Production Economics, Quality Engineering, and (in Portuguese) in *Gestão & Produção*, *Pesquisa Operacional* and *Pesquisa Naval*. He is a member of the American Society for Quality (ASQ), of the *Associação Brasileira de Engenharia de Produção (ABEPRO)* and of the *Sociedade Brasileira de Pesquisa Operacional (*SBPO*)*.

Appendix: Computation of the Risk α and the Power of the Control Chart 1-β.

The statistic *T* is given by:

$$T = \sum_{j=1}^{m}\left(X_j - \mu_0 + \xi\sigma_0\right)^2 \qquad i = 1, 2, \ldots$$

$$= \sum_{j=2}^{m}\left(X_j - \mu_0 + \xi\sigma_0\right)^2 + \left(X_1 - \mu_0 + \xi\sigma_0\right)^2$$

$$= \sum_{j=2}^{m}\left(X_j - \overline{X}\right)^2 + n_0\left(\overline{X} - \mu_0 + \xi\sigma\right)^2 + \left(X_1 - \mu_0 + \xi\sigma_0\right)^2$$

$$= \sum_{j=2}^{m}\left(X_j - \overline{X}\right)^2 + n_0\left(\overline{X} - \mu_0 - \delta\sigma_0 + \delta\sigma_0 + \xi\sigma_0\right)^2 + \left(X_1 - \mu_0 - \delta\sigma_0 + \delta\sigma_0 + \xi\sigma_0\right)^2$$

where: $\overline{X} = \sum_{j=2}^{m} X_j$. Dividing *T* by σ^2_1:

$$T/\sigma_1^2 = \sum_{j=2}^{m}\left(\frac{X_j - \overline{X}}{\sigma_1}\right)^2 + \left(Z + \sqrt{n_0}\,\frac{\delta + \xi}{\gamma}\right)^2 + \left(Z_1 + \frac{\delta + \xi}{\gamma}\right)^2 \qquad (A_1)$$

where: $Z = \sqrt{n_0}\,\dfrac{\overline{X} - \mu_0 - \delta\sigma_0}{\gamma\sigma_0} \sim N(0,1)$ and $Z_1 = \dfrac{X_1 - \mu_0 - \delta\sigma_0}{\gamma\sigma_0} \sim N(0,1)$. Therefore, during the out-of-control period, the first term on the right side of Equation (A_1) follows a chi-square distribution with *m*-2 degrees of freedom; the second term follows a non-central chi-square distribution with 1 degree of freedom and non-centrality parameter $\lambda = n_0[(\delta + \xi)/\gamma]^2$. Consequently, the sum of these first and second terms follows a chi-square distribution with n_0 degrees of freedom and non-centrality parameter $\lambda = n_0[(\delta + \xi)/\gamma]^2$. To obtain α and 1-β, we consider the Equation (3)

$$Q = \Pr\left[\left(\left|X_1 - \mu_0\right| > w\sigma_0\right) \cap \left(T > k\sigma_0^2\right)\right] = \Pr\left[\left(\left|Z_1 + \frac{\delta}{\gamma}\right| > \frac{w}{\gamma}\right) \cap \left(\frac{T}{\sigma_1^2} > \frac{k}{\gamma^2}\right)\right]$$

$$= \Pr\left[\frac{T}{\sigma_1^2} > \frac{k}{\gamma^2}\;\middle|\; \left|Z_1 + \frac{\delta}{\gamma}\right| > \frac{w}{\gamma}\right] \Pr\left[\left|Z_1 + \frac{\delta}{\gamma}\right| > \frac{w}{\gamma}\right] =$$

Then, using Equation A_1, we have:

$$Q = \int_{-\infty}^{(-w-\delta)/\gamma} \Pr\left\{\chi^2_{n_0,\, n_0[(\delta - d)/\gamma]^2} > \left[\frac{k}{\gamma^2} - (z + \frac{\delta - d}{\gamma})^2\right]\right\} \frac{e^{-0.5z^2}}{\sqrt{2\pi}}\,dz + \qquad (A_2)$$

$$\int_{(w-\delta)/\gamma}^{\infty} \Pr\left\{\chi^2_{n_0,\, n_0[(\delta + d)/\gamma]^2} > \left[\frac{k}{\gamma^2} - (z + \frac{\delta + d}{\gamma})^2\right]\right\} \frac{e^{-0.5z^2}}{\sqrt{2\pi}}\,dz$$

The Equation A_2 gives 1-β. Making $\delta = 0$ and $\gamma = 1$, the Equation A_2 gives the false alarm risk α and then, it can be used to determine the parameter *k*.

Volume 2, Number 2, 2005, pp. 39-57

The Formation of Organisational Competences in the International Telecommunications Production Network

Afonso C. Fleury
Departamento de Engenharia de Produção, Escola Politécnica, USP, SP, Brazil
E-mail: acfleury@usp.br

Maria Tereza Leme Fleury
Faculdade de Economia, Administração e Contabilidade, USP, SP, Brazil
E-mail: mtfleury@usp.br

Abstract

Competence building and management has been an issue frequently addressed in the literature, but it seldom has been referred to enterprises acting as part of production networks. The literature is still scarcer when the networks are international and include organisational units located in countries classified as "emerging economies". The main purpose of this study is to develop an analytical framework for the understanding of the configuration of organisational competences in the distinct participants of international production networks: multinationals and their subsidiaries organising local production networks. Different types of subsidiaries create local relationships whenever they act as part of a supply network to serve the local markets (interfirm relationship). At the same time, every subsidiary keeps an internal relationship with its parent company and respective headquarters (intrafirm). This article focuses on the global networks of Telecommunications industry and more specifically in Brazil. The networks are essentially constituted by Telecom Operators and Specialised Equipment Suppliers. The field research was done in a sample of six subsidiaries operating in Brazil. In every firm we studied the way in which competences were built. An analytical framework was built to analyse the subsidiary-headquarters relationships, the role played by the subsidiary in the local supply networks and the specific features of the distinct types of subsidiaries. The outcomes show that, in the Brazilian context, where the lack of regulatory constraints allows that multinational corporations (MNCs) operate under a high level of autonomy, the structure of the local supply chain tends to reflect the structure of the chain at global level. In that case, the way in which the global leader, the MNC that exerts the governance of the chain, considers competence formation at the headquarters and at the subsidiary level, as well as the competences that exist ingrained in firms and institutions at local level, are the main determinants of the overall configuration of competences.

Keywords: telecommunications, competence management, strategic management

Introduction

International production networks encompass multinational corporations (MNCs), their subsidiaries located in different countries and local firms as well. One specific subsidiary responds to headquarters and interacts with sister subsidiaries, connects locally with subsidiaries of other international companies and relate to national companies, aiming to compete in markets usually characterised by idiosyncratic features (Prahalad and Lieberthal, 1998).

The aim of this paper is to develop an analytical framework for the study of international production networks in regards to the way in which participant firms manage their organisational competences.

The subject that will be addressed in this paper concerns the configuration of competences in the network. The research question is: how to understand the formation of competences in firms organised as networks, operating and providing services and products for markets in emerging economies?

The empirical evidence comes from an investigation carried out in the Telecommunications industry, a "fast clockspeed industry" (Fine, 1998), meaning that the rate of evolution of products, processes and organisation is very high. This creates a particularly interesting field for investigation when the subject is related to the evolution of strategies and competences.

The paper is structured as follows. In the next sections we present the theoretical foundations of the analytical model that was developed, and how it was made operational. Then, we detail the research questions and present our methodological choices. The following sections discuss the evolution of the Telecommunications industry, both worldwide and in Brazil. The outcomes of the field research reveal interesting insights about organisational competences at the firm level as well as at the value chain level. In the final section we outline our conclusions.

About Organisational Competences

The term core competence became influential after the classic paper "The core competence of the organisation" by Prahalad and Hamel (1990). According to the authors, "[organisational] core competences are built on intangible assets [competences and resources] that cannot be easily imitated by competitors, are the source of the company's ability to deliver unique value to its customers, and allow the company to be flexible in terms of markets and products". Core competences are not necessarily related to technologies *strictu sensu*: they can be the outcome of excellence in different business functions. Notwithstanding, to be a core competence in the long run, a company has to manage a systematic process of organisational learning and innovation, which basically relies on human resources development and education.

Mills et al. (2002) clarified the difference between resources and competences. "A resource is something that the organisation owns or has access to even if that access is temporary.... A competence is an ability to do something.... A competence draws on a set of building 'blocks' called resources" (Mills et al., 2002, p. 9-14).

Although there were some attempts to categorise competences (Mills et al., 2002, Zarifian, 1999), we relied on the classic book "Industrial Organisation", by Joan Woodward in 1965, to create a typology. Woodward (1965) built her analytical framework under the premise that every firm has three core functions: Operations (Manufacturing), Product Development (R&D, Engineering) and Marketing (Sales). We assumed that the core competence of the firm is located at the core function of the firm and, in general, they might be considered interchangeable. Those functions would be complemented and supported by other functions specialised in Finance, Information Systems and Human Resources Management, among others.

After Woodward (1965), other authors, such as Slack et al. (2001), adopted the same pattern. Chin and Pun *apud* Pun (2004, p.908) assume that the determinants of strategy formulation are Marketing Strengths, Technology Strengths and Operational Strengths coordinated by Corporate Strengths.

However, Woodward (1965) also observed that depending on the type of product/market that the firm operated, one of the three core functions would be more relevant in strategic terms and more powerful since it would assume a coordinating role with respect to the other two functions. Engineering type of firms would have R&D as coordinating function; in Mass Product firms, Manufacturing would play the key role and, Marketing would be the key function in Continuous Process firms.

In other words, there must be an alignment between the core function or competence and the competitive strategy of the firm. It is in that core function or core competence that the firm has to excel to be competitive. The remaining two basic functions or competences should always be considered in their supportive role, leveraging the competitive strengths of the enterprise by creating the synergies that reinforce the core competence (Fleury and Fleury, 2003).

In synthesis, we are considering that any firm might be analysed as having three organisational competences (Marketing, R&D and Operations), from which one is core due to the fact that it is more relevant for the achievement of the strategic objectives of the firm.

The Configuration of International Production Networks

Since the times when the Japanese companies challenged the existing paradigms of management, there has been a radical change in the way firms organise themselves and interact with other firms. "Firms are moving towards establishing closer relationships with customers, suppliers and even their competitors to tap into new sources of knowledge and

competence sets. They are finding that they are no longer the dominant repository of vital knowledge and competences that are critical to promoting and sustaining innovation." (Lei, 2003, p.695).

In principle, two basic types of interorganisational networks exist: supply networks and business alliances. "Business alliances are partnerships in which two or more corporations invest resources while retaining individual strategic autonomy" (Dussauge et al., 2001). Thus, alliances involve negotiations between partners of similar sizes and/or strengths in specific products or markets. There is a large spectrum of types of alliances, ranging from technology transfer agreements to joint ventures (Narula and Sadowski, 2002, p.601).

This implies that in business alliances, since the partners possess similar bargaining power, the relationship is symmetric: firms keep their strategic autonomy and combine complimentary competences and/or resources.

Other types of network are vertical. Different frameworks were developed to capture their functioning: supply chains (Slack et al., 1999), supply networks (Harland et al., 2001), global commodity chains (Gereffi, 1994), global value chains (Gereffi et al., 2004) and global production networks (Ernst and Kim, 2001). For the purposes of this study we will adopt the definition made by Harland et al. (2001) for supply networks: "Supply networks encompass the mess and complexity of networks involving lateral links, reverse loops, and two-way exchanges, and include a broad, strategic view of resource acquisition, development, management, and transformation. The supply network concept appears to be more complex than the supply chain concept".

In vertical networks, power relationships are asymmetric: even if strategies are aligned, one of the participants exerts governance over the rest of the participants of the network. Competences and resources might be complimentary but they do not have the same relevance for the overall functioning of the network: the competence dominated by the leading firm is strategically more relevant for the competitiveness of the whole set of firms. Harland et al. (2001) accept the distinction between parity-based and centralised networks and assume that "this seems to have a clear relevance for the way focal companies can manage their supply networks depending on their relative power". In their model Harland et al. make the concept of power operational utilising a variable named influence.

Lei (2003) makes this point very clearly when defining "innovation nets as a group of firms that compete and cooperate to develop leading-edge technologies and products that form the basis for new sources of value creation, both within and across industries.... Firms within the innovation net are likely to focus on those distinctive activities that will give them the highest potential for significant influence and bargaining power within the net" (p. 696).

The issue of power in the study of international interorganisational networks is central in studies published by Gereffi (1994) and Gereffi et al. (2004) about the formation of global

commodity chains. In his studies of the footwear and clothing industries, he showed how command is exercised by the large global retailers and marketers.

How do companies approach the process of competence building when they are involved in different types of supply networks? In their classic article on core competences, Prahalad and Hamel (1990) had already paid attention to the potential and eventual handicaps associated to outsourcing: "Few companies are likely to build world leadership in more than five or six fundamental competences. This tends to prompt the search for licensing deals and alliances through which the company may acquire, at low cost, the missing pieces. Outsourcing can provide a shortcut to a more competitive product, but it typically contributes little to people embodied skills that are needed to sustain product leadership" (Prahalad and Hamel, 1990, p.8).

Bogner et al. (1999, p. 284) bring another important characteristic of the relationship among firms in supply chains: "The final product or service for which the firm collects its above-average returns may be an intermediate or an end product in the larger value chain of the economy. When the firm's end product is sold to another firm as an intermediate product in the larger value chain of the economy, the competence trait should be retained when the final product is sold".

Therefore, it seems plausible to admit that the relative position and the bargaining power of a given firm within the network is a function of its competences and resources. The relative position that a given firm occupies or can aspire – parity or asymmetrical, leader or follower, vertical or horizontal – would be a function of the relative importance of its organisational competences for the performance of the whole network.

Aiming to advance in the study of the above mentioned issues, we will firstly develop a framework to support the analytical tasks related to the research work.

The Framework

The point that we want to understand is how competences and strategies are built and evolve in firms which are part of international interorganisational networks. Figure 1, below, portrays one archetypical network, operating in an emerging economy.

Subsidiaries are primarily linked to their headquarters located in a developed country. Second, the behaviour of subsidiaries is influenced by their participation as a member of a local production network. Third, each subsidiary has a specific pattern of interaction with the local markets, that can be more or less regulated by the local Government and local suppliers. The framework also considers that the performance of every subsidiary is dependent upon three core functions or competences: Operations, Product Development and Marketing.

The research question is:

- How to understand the configuration of organisational competences in firms that constitute an international intercompany network?

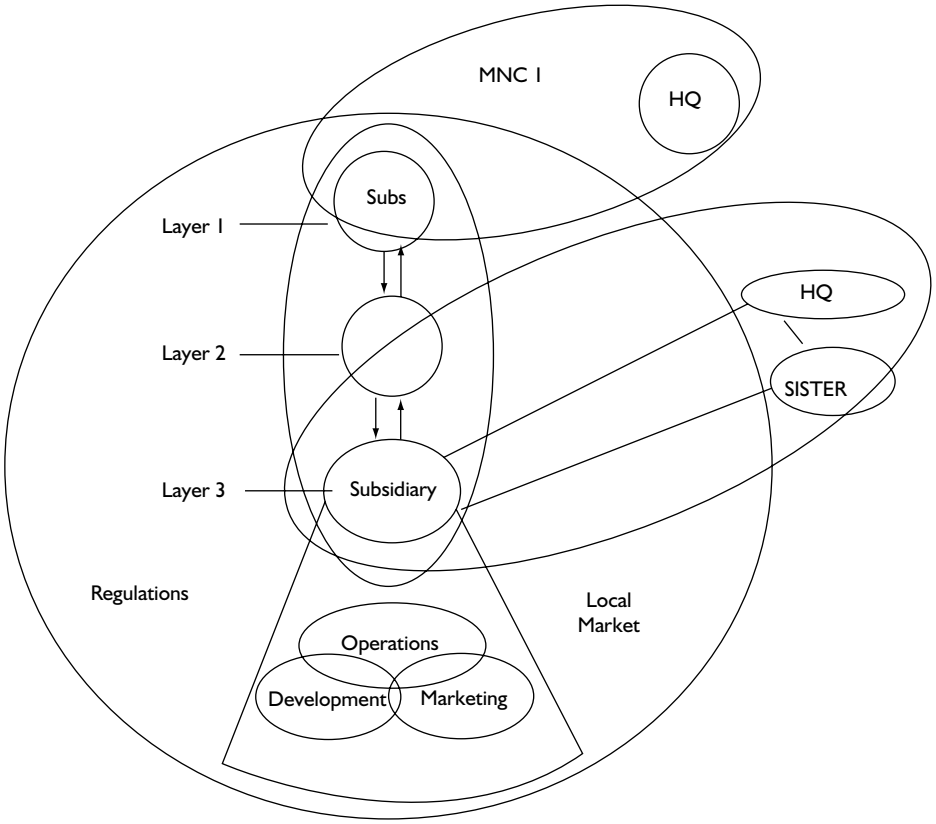


Figure 1 – Schematic representation of an international network as seen from host country HQ stands for Headquarters; Subs for subsidiary.

The more specific questions are:

- How are competences distributed and strategies coordinated in the local chains? Why? and
- How are competences managed from the subsidiary-headquarters perspective?

The field for the empirical research was the Telecommunications industry. The research activities comprised initially an extensive analysis of the literature aiming at a comprehensive view of the evolution of the Telecommunications industry worldwide in what concerns competence formation. This provided the basic framework for a case study research of the international interorganisational network constituted by the subsidiaries of Telecoms multinationals located in Brazil and the supply chains that were structured by them.

In choosing the cases to be studied, we opted for firms that operate in the Mobile Telecommunications sector. It is a more interesting field for research due to the rapid and

profound changes that are observed and usually termed "co-evolution". In other words, it is not evident for the producers which products and/or services could be developed and made available to the different profiles of consumers and at what price. At the same time, consumers have difficulties in understanding their own needs and assessing the value of the products that are being offered. As a result, both parties learn and evolve while participating in the transactions that are characteristic of those markets.

Three subsidiaries of Specialised Equipment Suppliers (one European, one Japanese and one American) and three Telecom Operators (two European subsidiaries and a Brazilian enterprise) were studied. Seeking a better understanding of the market and technological issues, two large users of Telecommunications services (a bank and a newspaper producer, both Brazilian) and the Centre for Research and Technology in Telecommunications (CPqD), who played a key role when the telecommunications system was still under the governmental jurisdiction, were also interviewed. All in all, a total of eighteen persons were interviewed and in one of the Telecom Operators we had the opportunity of running a workshop for the discussion of the outcomes of the research.

The first step in the study of every one of those firms was the search of secondary type of information, in the specialised media and in companies' reports. Then, in each of those companies, we interviewed two or three persons from the directive board who were responsible for the enterprise strategy and planning and human resources management. The interview script focused on the following aspects: competitive strategy, critical organisational functions, relationships in the supply network, both upstream and downstream, service and product development, operations management and human resources management. In every firm we searched for the characterisation of the competitive strategy, the role of the three basic functions (Operations, Product Development and Sales & Marketing) and the efforts and investments in organisational competence building.

We consider that the method was a composition of Case Studies and Grounded Theory because, in the very beginning, we had not any theory on which to rely to construct the research instrument. Actually, what we had were separated and independent bodies of theory. Thus, the first case that was analysed was almost a participative type of research in which the researchers were seeking a pattern for the construction of their conceptual framework.

Glaser and Strauss (1967) affirm that the Grounded Theory approach "has much in common with the case study [approach]... its most distinctive characteristic being that, in order to find out what views are underlying the similarities and differences, the researcher is constantly comparing the various items he/she is observing in reality, both with each other and with theoretical starting points".

According to Verschuren and Doorewaard (1999) the Grounded Theory approach has three main characteristics. The first one would be "an inquisitive attitude" from the researcher, meaning that a theory or theoretical concept materialises slowly but surely

in the course of the research project. Although the researcher does not start with a detailed theory that is subsequently tested, the he or she must attend to the criteria of reliability, validity and imitability by following some specific procedures and techniques. That is why, after the initial case study, the choices of cases and the structure of the questionnaire evolved gradually, as the understanding of the variables and their relationships became more and more evident. Even the decision to study two cases of users of Telecommunications services was done with the aim of clarifying specific aspects of the phenomena.

The second feature of Grounded Theory is "a process of continuous comparison: the researcher is incessantly engaged in a process of comparing findings with previously found phenomena or interpretations, or with the ideas and notions others before him have published on the subject" (*ibid*, p. 172). From the different ways the authors mention as appropriate for comparisons, we utilised: secondary empirical comparison, primary and secondary theoretical comparison during the field work, and deductive comparison for the elaboration of the conclusive framework.

Finally, the third characteristic of the method is a careful and consistent use of specific procedures and techniques. The first one: "sensitising concepts and open coding", and the second: "Axial coding" corresponds to the choice of basic concepts and organisation of the analytical framework, formerly presented. The third, "Selective coding" would be related to the reduction of "the multitude of phenomena described and the formulated concepts and key words into a concise description of the theory that is to be developed" (*ibid*, p.175). This was done during and after the field research.

The Telecommunication Industry

Studies on the Telecommunications industry are relatively recent in the academic literature. Although specialised equipment suppliers, such as Ericsson, Siemens and AT&T among others, have often been used as case studies in the Innovation and Technology Management literature, major players in the field, as the Telecom Operators, were seldom considered relevant cases. That may be due, in part, to the fact that in most countries, Telecommunications used to be a public service, and as such, those companies were evaluated mainly according to social, more than economic, technological or efficiency-related indicators.

That picture had a dramatic shift after the privatisation process that took place in several countries. On the supply side, the now privately-owned enterprises became responsible for the design and delivery of services in a competitive environment characterised by low entry barriers (Fransman, 2002), which has demanded from them the implementation of sound competitive strategies. At the same time, competition is regulated by national and local governments, to guarantee the availability and quality of the services provided to the general public. Under those circumstances, firm's performance became intrinsically

dependent of the service they offered in relation to the amount that customers were willing to pay.

In addition, the privatisation processes led to increasing internationalization of the industry. While Specialised Equipment Suppliers were already large multinational corporations adopting multidomestic strategies (Porter, 1986), Telecom Operators, as incumbents, were strictly national or sub-national companies. After privatisation, most of them became multinational corporations.

In each country, the role and importance of foreign enterprises was the outcome of the criteria chosen for the privatisation process. In Brazil (differently from what happened in many advanced countries), Federal and State governments opted for a complete withdrawal from their positions as the major controllers in the industry. As a result, telecommunications services are currently under the control of subsidiaries of large European or North American Telecom Operators.

Evolution of Organisational Competences in the Telecom Industry (TI)

For Fransman (2002, p.4), "a key part of the "engine" driving change in the Telecom industry is the technological regime that exists in this industry. The technological regime is defined by the conditions under which technological knowledge is created – which determine the rate of technical change and the kinds of technologies that are created – and the opportunities and the constraints that exist in the use of that knowledge. The technological regime, in turn, defines the learning regime that determines the kinds of learning paths and patterns in which the firms and other organisations involved in the industry will engage" (p.7). Based on that concept, the author conceptualizes the Old Telecom Industry (to the mid 1980s) and the new Telecoms Industry.

In the Old Telecom Industry, "the engine of innovation was located in the central research laboratories of monopoly telecom operators, such as AT&T's Bell Labs, British Telecom's Martlesham Labs, France Telecoms's NET Labs or NTT's Electrical Engineering Labs. Typically, after the central research laboratory did the initial research and developed and tested the initial prototypes, the task for further development was handed on to specialist equipment suppliers (SES)" (*ibid*, 10).

By the end of the 1980s, "for different political-economic reasons, Japan, the UK and the US decided to end the monopolies of their monopoly Telecom Operators. The result was the birth of the original new entrants. [DDI, Japan Telecom and Teleway in Japan, Mercury in UK, Baby Bells, MCI and Sprint, in US].... Although liberalising regulatory regimes provided a necessary condition for [the new entrants] rapid and successful entry, they were not sufficient. Equally important were low technological barriers created by the existence of specialist Telecom equipment suppliers. These specialist technology suppliers provided the black-boxed technologies needed to construct and run their own networks....

From the point of view of the specialist technology suppliers, liberalization created new markets for their accumulating knowledge and competences" (*ibid*, p. 14).

Therefore, the SES were facing new times where manufacturing according to the specifications defined by the Telecom Operators was not the only critical success factor: the supply of technology and turnkey projects became another important source of revenues.

The period 1990-1995 witnessed an interesting transition. Although the new entrants were not competent concerning both technology and manufacturing, some of them had a large experience in terms of servicing large household markets. That is the case of Vivendi, in France, that was part of the group Generale des Eaux, responsible for water distribution and sewage, Energis, in UK, the Telecom subsidiary of the English electricity company, and thus, a subsidiary of Scottish power, among others.

The increasing competition in the marketplace justifies another inflection in the trajectory of the Telecommunications industry. "By the end of 1995, the now incumbent Telecom Operators (like British Telecom, France Telecom and Spanish Telefonica) made the decision to leave more and more of the R&D related to the network and its elements to the specialist technology suppliers" (*ibid*, p. 16). With this decision, they were able to concentrate on the development of competences related to better servicing the markets: "Like AT&T, BT also accepted that its main competence lay in operating and developing telecom networks from elements developed by separate specialist suppliers and providing the services that customers wanted over these networks" (Fransman, 2002, p.86).

That implied that a new pattern of technological development, in the strict sense of R&D activities, in the New Telecom Industry would be essentially in the hands of the Specialist Equipment Suppliers and would evolve according to their competitive strategies.

More recently, that pattern is being redefined one more time. Due to changes upstream and downstream, SESs are now considering their strategy as being "Integrated Solution Providers" (Davies et al., 2001). This has two major implications. With the emergence of Manufacturing Contractors (Sturgeon, 1997), the routine associated to Manufacturing and Operations as well as customer care services are now outsourced to newly created global companies such as Celestica, Solectron and others. At the same time, the scope of R&D activity is being redefined in the sense that an SES becomes also a purchaser and assembler of technologies developed by specialist firms. While product and service innovation emerge from the dynamics between Operations and Marketing, the role of R&D is to develop the knowledge and assemble the technologies to make the service available.

In Table 1, below, we synthesise the evolutionary pattern of competence formation in the different layers of the Telecommunications supply network.

Table 1 – The transition in the hierarchy of organisational competences in the TI.

Enterprise	Competences			
	Up to 1990s	1990 - 1995	1995 - 2000	after 2000
Telecom operators	1) R&D and Operations 2) Services	1) Operations and Services 2) R & D	1) Services 2) Operations	1) Services 2) Some Operations
Specialised equipment suppliers	1) Manufacturing	1) Manufacturing 2) Development	1) R & D 2) Manufacturing	1) Integrated solutions (R&D plus Services) 2) Some Manufacturing
Supplier				Manufacturing

Evolution of Telecom Industry in Brazil

Up to a certain degree, the evolution of the Brazilian Telecommunications industry keeps a strong similarity with the evolution of the international industry, especially in the pre-privatisation period.

Following the global trend, in the early 1990s, Brazil decided to develop a new model based on deregulation and privatisation. But, contrary to what happened in the advanced most countries, the privatisation process in Brazil, as in other South America countries, would allow the buyout, both of the local state companies and mobile telephone concession, without restrictions to the participation of foreign capital. Federal and State governments opted for a complete withdrawal from their positions as the major controllers in the industry. As a result, the large local Telecom enterprises became of an European or North American origin.

The enterprises who took charge of the telecommunications services were recently privatised Telecom Operators of advanced countries or the so called new entrants (as the case of MCI in the USA). The movement of those Telecom Operators was followed by new Specialist Equipment Suppliers such as Motorola, Lucent, Nortel, Bell Canada, who joined NEC, Ericsson and Alcatel (ex-Thomson) who have been in Brazil for a longer time.

The field research to be described in the next section aimed at the characterisation of the competitive strategies and at the identification of the priorities in terms of competence building in those subsidiaries, as an indication of the pattern that the TNCs have been choosing in building their international networks.

Telecom Operators

The first point to be highlighted is that both Telecom Operators and Specialised Equipment Suppliers are segmenting the market according to three client/service types, their characteristics being similar to those proposed by Silvestro (1999): Mass Services, Service Shop and Professional Services. This is a key aspect for the analysis of the data gathered in the field research because the way in which the firms and the interorganisational networks are being organised keeps a straight relationship with this segmentation.

For the Telecom Operators, the first segment concerns individual customers that demand voice transmission only: it is the Mass Services segment where customers are counted in millions. The second segment encompasses individual clients who, besides voice transmission, demand other types of services like short messages, photo transmitting, broadband, etc. It is the Service Shop business: even though the number of customers cannot be considered small, it is possible to identify a certain number of groups with similar features and preferences to whom the development of products and services is directed. The third is the institutional and corporate market, where large clients, individually treated, are serviced according to their specific demands. This constitutes the Professional Services market for the Telecom Operators.

Therefore, at a first glance, it becomes necessary to look at Telecom Operators as having three distinct business units that share the same physical infrastructure.

In the case of Mass Services, the Telecom Operators act essentially as large scale producers of standard services, operating standard equipment, constrained by the rules issued by the local regulatory agency. The goals of that business unit are the increase in scale and the minimisation of costs, thus optimising the margin per client. As Mobile Telecommunications Operators, the basic technology for services operations is bought from specialised suppliers as well as the software. In their relationship with suppliers in general, Telecom Operators are tough negotiators: they rely to a great extent in their bargaining power and adopt impersonal methods, e-commerce being one of the most promising, to reduce the price of inputs. The cost of the service depends on the efficient use of the infrastructure, interconnectivity costs included. The latter is an issue of primary importance for the financial performance of Telecom Operators since the markets are always becoming broader.

The role of Marketing is fundamental for the increase in scale, following the classic Four Ps: price, promotions, point of sale and publicity. Interestingly, the efforts for capturing new clients are seldom being followed by efforts to retain them, as recommended by the literature. It seems that, as the local market is still growing, concern with retention and loyalty of customers has not a high priority. Front line tasks (call centres) are repetitive and prone to technological substitution. Quality is monitored through aggregated indicators embedded in the software.

Therefore, in this specific market, strategic orientation and competence development were found relatively similar at the three enterprises studied. Operational Excellence is supported by Operations as core competence to deliver the service according to predefined quality standards and as cheap as possible. The competence in Marketing is also critical to create the demand for the large infrastructure that is in place. Relationships are also critical in the negotiations with other operators to ensure connectivity. The less critical function is R&D because the service has universal features and technological decisions are essentially related to the purchasing of equipment.

In the case of differentiated services – the Service Shop -, the goal of the Telecom Operators is to conquer and retain special clients, through the continuous launching and upgrading of services and products. This is expected to increase loyalty and enhance the use of the infrastructure, thus creating new sources of revenues. In Brazil, the introduction of those new services/products is related to the local adaptation of a product/service already in use elsewhere. For example, the pre-paid mobile phone was used in Europe for the tourist market. In Brazil, it was launched for the low income market with a tremendous success. The youngsters and the SOHO (Small Office, Home Office) are also niche markets for the Telecom enterprises. Evidently, there is a lot of trial-and-error due to the difficulties for a thorough understanding of the demands of the local markets, the specific features of the distinct niches, and so the risk for new launchings is not negligible. Under these circumstances, Marketing assumes a critical role related to the identification of clients' profiles, thus guiding the investment decisions.

The relationship with suppliers is cooperative since the introduction of new services is likely to require new equipment or new software. There are cases where the service was firstly identified and developed by some Specialised Equipment Supplier who, in cases like that, are able to negotiate the distribution of margins with the Telecom Operators.

As Service Shops, Telecom Operators create call centres where front line tasks require a more skilled staff, able to assist preferential customers in their specific inquiries. Price policies are more a function of the purchasing power of defined market segments and niches then to the mark-up derived from the total costs incurred. Market segmentation and the possibility of charging different prices are the drivers for the creation of "packages of services".

From the three Telecom Operators studied, one was considered a real innovator, at least in local terms, more than 20% of its total revenues accruing from this type of service. This was the foreign Telecom Operator that operated in the most sophisticated region in terms of educational level and purchasing power. The second foreign Telecom Operator has a national scope and was considered a follower, while the third, the Brazilian Telecom Operator, for having less financial and technological resources, was a distant third.

Corporate service is considered the most incipient but, at the same time, the most promising market segment. For this type of clients the aim is the development of specific solutions and systems according to their specifications. As these, in general, become large and complex projects, involving different types of enterprises – Telecom Operators, Equipment Suppliers, Consulting Firms, Financial Institutions - there is a dispute among them to become the prime contractor. Therefore, this type of service requires a completely distinct set of competences for the Telecom Operators: those are associated to Project Management and Institutional Relationships. In the companies that were studied, specific structures were created for that market. In this case, the competences required from the front line workers are related a profound understanding of the clients' businesses and the

potential applications of Telecommunications. At the time we were doing the interviews there was an explicit policy for the Telecom enterprises to hire executives originated from the business areas in which their main clients operated.

Therefore, the Brazilian Telecom Operators exploit distinct market segments, utilising different strategies supported by specific configurations of competences. Operations is the core competence for the basic services' segment where the Operational Excellence strategy is followed. In the corporate market, the relationship with the client drives the other functions; the strategy is Customer Driven; Marketing is core. And in the Service Shop market a composition between Operational Excellence and Customer Driven is observed: Operations and Marketing must act in a very integrated way to conquer and retain distinct groups of clients.

Specialist Equipment Suppliers

From the three Specialised Equipment Suppliers of our sample, two were already operating in the country during the pre-privatisation period. Even though they relied to a great extent on technological knowledge developed at the headquarters, they were obliged to manufacture products according to the standards and specifications established by Telebras and the CPqD. The third company settled in the country in the first half of the 1990's. This plant was already designed and operated to produce global products, designed elsewhere, exporting world-wide, competing with the sister subsidiaries in terms of price, quality and delivery.

Those three subsidiaries started a transition period just after the privatisation process ended. Two were the main drivers for that transition. First, the high demand for new equipment and infrastructure in general because Telecom Operators had to achieve the contractual targets within a tight timeframe. Second, the restrictions imposed by Telebras associated to the use of locally defined norms and standards came to a halt. Under those circumstances, the long-established Specialised Equipment Suppliers discontinued their local R&D activities. As the new clientele demanded large turnkey projects, the SESs concentrated in the design of networks, utilising global products developed at the headquarters, the delivery and assembling of equipment and, mainly, the development of software to customise the equipment to operate according to local characteristics and regulations.

A second inflection occurred more recently, when the Telecom Operators achieved their targets and drastically reduced their investments in infrastructure. As previously mentioned, their challenges are now associated to operating efficiently and creating new services. This being the case, the SES had to change again. They now characterise their role in terms of the development of solutions and systems to improve the operations of their local clients, the Telecom Operators, often using a partnership with other local suppliers. In the words of Davies et al. (1999) they are becoming Integrated Solution Providers. For example, the

development of software (e.g. billing systems) and systems for the optimisation of network utilisation are in the project portfolio of those companies. A more radical example concerns one of the SES that is currently responding for the operation of a plant that it has designed and built in the South of the country, commissioned by the respective Telecom Operator whom, in doing so, is able to concentrate its competences on services.

The tendency to prioritise servicing is growing fast. One of the SESs is heavily investing in an internal program entitled "Competence Shift", aiming to create a new corporate culture: engineers should "shift from a product mindset to a service mindset". The above mentioned firm opted for an internal development program which included a set of actions in areas such as training, remuneration system and performance evaluation.

In that context, Manufacturing/Operations was repositioned. Following international trends, when the Manufacturing Contractors – Flextronics, Solectron and Celestica - started operations in Brazil, the local SESs, one by one, outsourced their routine manufacturing, logistics and after sales operations, thus becoming more oriented towards the clients.

The organisational competences most valued by the three companies include: i) identification of market needs, in terms of the Telecom Operators and also the end users; ii) identification and assembling of technologies, developed at the headquarters or elsewhere, to create and deliver the best solution – the LEGO analogy was often mentioned; and iii) organisational networking, through strategic alliances and supply chain management.

Therefore, the relative importance of servicing the client is becoming stronger. This indicates a new balance between R&D/Product Development and Marketing and the reinforcement of the Customer Driven strategy.

The Configuration of Competences in the Telecom Networks

The description of the evolutionary configuration of the Telecom industry in Brazil, in the former section, provided a picture of the dynamic relationships among Telecom Operators, Specialised Equipment Suppliers and, more recently, Manufacturing Contractors in terms of strategic positioning, competence formation and change, involving learning and unlearning. Issues of strategic alignment and complementary competences were observed. Patterns of co-opetition also became evident, since the same pair of firms, say a Telecom Operator and a Specialised Equipment Supplier, might keep distinct forms of relationship, depending on the type of market/product that is being served. The relationship is either arm's length or cooperative or still partnering in the Mass, Service Shop or Corporate segments respectively.

The subsidiary-headquarters relationship presents another pattern. Overall, the competences that are localised are those more directly related to the service that has to be provided locally. Table 2 synthesises the roles played by subsidiaries and headquarters in the three layers of the supply network.

Table 2 – Distribution of competences among subsidiaries and headquarters.

	Headquarters	Subsidiary
Telecom operators	Global strategies regarding investments and partnerships Development of new types of services	Definition of local competitive positioning according to local characteristics (segmentation, products, competitors, regulatory constraints) Efficiency
Specialised equipment suppliers	Global strategies R&D targeting radical innovations and global platforms	Provision of integrated solutions for local clients including customisation of global platforms Pro-activism in the sense of interacting with end markets to identify new products and services Local supply chain management and partnering
Manufacturing contractors	Partnering with global firms Procurement in global scale R&D focusing production processes	Creation and management of capacity to supply routine type of products and services to local clients

The main point to be emphasised, concerns the notion of service as the key driver for the organisation of the Telecommunications industry in Brazil. The overall picture shows Telecom Operators servicing final customers, Specialised Equipment Suppliers providing integrated solutions for the Telecom Operators, but also looking for the final market, and Manufacturing Contractors servicing Specialised Equipment Suppliers. In the words of Lei (2003, p. 703) this reflects "the essential driver for firms as they seek to capture and dominate a larger share of the innovation net's overall value proposition". This involves a permanent concern with the identification, development, implementation and delivery of a service to a client.

Discussion and Conclusions

In search for generalisation, the first point to be highlighted concerns the limitations of the outcomes of the field research, namely that we are looking into the network through the lens of subsidiaries located in a country classified as an emerging economy. Second, that for being a fast clock speed industry, the configurations that were found might be distinct from the ones currently predominant in other types of industry. Therefore, any generalisation will have to take those factors into account.

Our initial inference is that, overall, the structure of the local supply network will tend to replicate the structure of the network at global level, the most salient feature being that the governance pattern at global level will also be the main determinant of the configuration of competences at local level. This means that the other participants of the local network will have to develop the competences that will be requested by the leader

which, in its position, will be the only one able to decide what competences it will locate at the respective subsidiary and to what degree.

We are not assuming that it is the headquarters of the leading enterprise that will decide the whole issue; on the contrary, depending on the competences consolidated at the subsidiary level, the latter should have a strong voice to discuss with the headquarters about the overall configuration of competences. But, in the end, the decisions that will affect the overall structure of the local supply network are in the realm of the leading enterprise.

So, even when there are other subsidiaries as members of the network, their decisions on which competences to develop locally will be subordinated to the configuration of competences of the leading enterprise; they will have to develop a certain degree of flexibility. In this case, it is expected that the subsidiary will have a more dependent relationship to its headquarters and sister subsidiaries in terms of competences and resources.

The local enterprises will have to play the game according to the same rules: the configuration of competences that they will have to develop will be those required by the other members of the network.

The contextual conditions: the local regulatory environment and intrinsic market characteristics, as well as the specific features of the industry that was object of the study created constraints for the generalisation of the outcomes.

Further research should be concerned with analysing industries characterised by distinct features operating in contexts where the regulatory apparatus and the characteristics of the local markets, both in terms of local enterprises as well as the consumers' behaviour.

References

Bogner, W., Thomas, H. and McGee, J. (1999). Competence and competitive advantage: towards a dynamic model. British Journal of Management, Vol. 10, pp. 275-290.

Davies, A.; Tang, P.; Brady, T., Hobday, M.; Rush, H.; Gann, D. (2001). Integrated Solutions: the new economy between manufacturing and services. Brighton, CENTRIM, University of Brighton, mimeo.

Dussauge, P., Garrette, B. and Mitchell, W. (2001). The market share impact of inter-partner learning in alliances: evidence from the global auto industry. Conference Cooperative strategies and alliances, IMD, Lausanne, Switzerland, June 23-25, 2001.

Ernst, D.; Kim, L. (2002). Global production networks, knowledge diffusion and local capability formation. Research Policy, Vol. 31, pp. 1417-1429.

Fine, C. (1998). Clockspeed. Cambridge MIT Press, Cambridge.

Fleury, A.; Fleury, M.T. (2003). The evolution of strategies and organizational competences in the Telecommunications industry. International Journal of Information Technology and Decision Making, Vol. 2, Dec. 2003.

Fransman, M. (2002). Telecoms in the Internet age. Oxford University Press, London.

Fruin, M. (1992) The Japanese enterprise system: competitive strategies and cooperative structures. Oxford University Press, Oxford.

Glaser,G; Strauss, A. (1967). "The Discovery of Grounded Theory: strategies for qualitative research". Aldine de Gruyter Publishers

Gereffi, G. (1994). Capitalism, development and global commodity chains. Capitalism and development. L. Sklair (ed). London, Routledge.

Gereffi, G., Humphrey, J. et al. (2004). The governance of Global Value Chains. Review of International Political Economy.

Harland, C. M.; Lamming, R. C.; Zheng, J.; Johnsen, T. E. (2001). A taxonomy of supply networks. The Journal of Supply Chain Management, Fall 2001, pp. 21-27.

Lei, D. (2003). "Competition, cooperation and learning: the new dynamics of strategy and organisation design for the innovation net." International Journal of Technology Management, Vol. 26, No. 7, pp. 694-716.

Mills, J.; Platts, K.; Bourne, M.; Huw, R. (2002). Competing through competences. Cambridge University Press, Cambridge.

Narula, R. and B. Sadowski (2002). Technological catch-up and strategic technology partnering in developing countries. International Journal of Technology Management Vol. 23, No. 6, pp. 599-617.

Porter, M. (1986). Competition in global industries: a conceptual framework. Competition in Global Industries, Boston, Harvard Business School Press.

Prahalad, C.K. and Hamel, G. (1990). The core competence of the corporation. Harvard Business Review, Vol. 68, No. 3, pp. 79-91.

Prahalad, C. K. and Lieberthal, K. (1998). The end of corporate imperialism. Harvard Business Review, July-August, 1998.

Pun, K. F. (2004). A conceptual synergy model of strategy formulation for manufacturing. International Journal of Operations and Production Management, Vol. 24, No. 9, pp. 903-928.

Silvestro, R. (1999). Positioning services along the volume-variety diagonal: the contingencies of service design, control and improvement. International Journal of Operations and Production Management, Vol. 19, No. 4, pp. 399-420.

Slack, N., Chambers, S., and Johnston, R. (2001). Operations Management. Pearson Education Limited (3rd edition),

Sturgeon, T. (1997). Turn-key production networks: a new American model of industrial organization?. University of California at Berkeley, Berkeley Roundtable on International Economy (BRIE) Working Paper # 92A.

Verschuren, P. and Doorewaard, H. (1999). Designing a Research Project. Publisher LEMMA – Utrecht,

Woodward, J. (1965). Industrial Organisation: theory and practice. London, Tavistock Publications.

Zarifian, P. (1999) Objectif competénce. Paris, Liaisons.

Biography

Afonso Fleury is a Professor in the area of Work, Technology and Organisation at the University of São Paulo and head of the Production Engineering Department. He is currently engaged in research about International Manufacturing and Operations and works on a project about the internationalisation of late-movers: firms from Brazil, China, Mexico and other emerging economies. He has published several books and articles on work organization, global operations and technological and industrial policy. His publications include: 'Competitive strategies and core competences: perspectives for the internationalisation of industry in Brazil', Integrated Manufacturing Systems, Vol. 14, No. 1. 2003.

Maria Tereza Leme Fleury is a Professor in the area of Human Resources Management at the University of São Paulo. She is currently the Dean of the School of Economics, Business Administration and Accountancy. She has published several books and papers on strategy and competence management, human resources management, management of organisational culture and labour relations. Her publications include: 'Aligning strategy and competences in the Telecommunications industry', International Journal of Human Resources Management (forthcoming).

Volume 2, Number 2, 2005, pp. 59-74

An Investigation of Improvement and Change Management Practices in a Brazilian Based Company

Luiz C. R. Carpinetti
Departamento de Engenharia de Produção,
Escola de Engenharia de São Carlos, USP, São Carlos, SP, Brazil
E-mail: carpinet@sc.usp.br

Mateus Cecílio Gerolamo
Departamento de Engenharia de Produção,
Escola de Engenharia de São Carlos, USP, São Carlos, SP, Brazil
E-mail: gerolamo@sc.usp.br

Olívia T. Oiko
Departamento de Engenharia de Produção,
Escola de Engenharia de São Carlos, USP, São Carlos, SP, Brazil
E-mail: olivia@sc.usp.br

Abstract
This paper reports the results of a case study research carried out in a Brazilian division of a multinational manufacturer of automobile components with the main objective of investigating improvement and change management practices. The theoretical framework for the research is based on the theories on improvement and change management programs, methods and capability development. After an overview of the theories, programs and approaches for improvement and change, the research method and questions of research are formalized so as to guide the case study. The case study itself is presented and discussed. Results of the study indicate that although several elements of improvement and change capabilities are present, functionally oriented organizational structure and a lack of formalized cross improvement and change business process undermine the potential for management performance improvements.

Keywords: continuous improvement, change management, innovation, total quality management

Introduction

In the past decades, several innovation and improvement programs have gained widespread acceptance as approaches to boost competitiveness. These are the case of Total

Quality Management (Goetsch and Davis, 1995) and, more recently, Six Sigma Programs (Pfeifer, Reissiger and Canales, 2004). Apart from this quality related programs, other programs such as Business Process Reengineering, Just in Time and Lean Production have also been adopted with the same broad objectives of improving customer satisfaction and production and operations performance (Ahmed and Montagno, 1996).

Adoption of these programs by companies in different industries has been generating a generally very positive outcome, although it is widely recognized that it is very difficult to sustain process improvement programs. Despite unexpected negative effects that may be generated by the improvement process dynamics such as low morale and collapse of commitment to continuous improvement (Keating et al, 1999), according to Bessant and Francis (1999) companies have to evolve through a process of continuous improvement capability acquisition to what they call a learning factory. In general the literature on improvement and change management emphasizes the importance of development of organizational values, capabilities and methods for systematic deployment and review of progress, based on strategic orientation of improvement and change actions (e.g. Carpinetti et al, 2000).

However since the ways in which companies can apply these concepts and the outcomes generated by such practices may vary considerably, investigating best cases can contribute to gain new insights on the matter. In view of that, this paper reports an investigation on improvement and change management practices carried out in a division of a multinational manufacturer of automobile components based in Sao Paulo State, Brazil and considered a best case in quality management and improvement. Before presenting and discussing the case study, a brief review is made on the subject of improvement and change management so as to place the research work in context. The research methodology is also presented, outlining research questions and procedures. Finally the case study itself is presented and discussed so as to conclude and suggest further research work.

Improvement and Change Methods

Total Quality Management (TQM) is certainly the most popular of the improvement and change management philosophies in both academic and practitioner communities. Having its roots in the work of writers such as Deming (1986) and Juran (Juran and Gryna, 1993), it has gained worldwide attention after being further developed and successfully applied by the Japanese industry and scientific communities (Ishikawa, 1990). In essence, TQM is concerned with quality improvement on a company-wide basis. It is a comprehensive approach to improving competitiveness through continuous improvement of customer satisfaction and operations performance. Continuous improvement is a very central idea for the TQM philosophy, which is well characterized by the PDCA cycle: a systematic and iterative process of incremental improvement forming a virtuous cycle (Kume, 1995). Therefore TQM strongly rely on total commitment of senior management as well as all

members of the organization with the principle of continuous improvement of products and processes as well as developing human resources capabilities to successfully apply total quality methods and tools in the effort of quality improvement (Kume, 1995).

Very much related with the TQM principle of continuous improvement is Six Sigma program. Initially developed by Motorola as part of its TQM implementation process, Six Sigma has gained considerable attention in the past few years, with many companies adopting it world wide (Henderson and Evans, 2000) and therefore has brought about a revival of quality programs. Six Sigma is based on the concept of bringing process output into statistical control aiming at reducing dispersion and the probability of out of tolerance results and therefore improving product quality and reducing the cost of non-quality (Lientz, 2000). The program ideal is reducing variation of process output so that tolerance interval equates to $\pm$ 6 σ (process standard deviation) which means that the chance of defective results is reduced to 3.4 ppm even in case the process is off mid-tolerance interval by as much as 1.5 σ. Its approach for improvement consists of training special champions, black-belts and green belts, who have to lead or initiate actions following a five steps improvement cycle (DMAIC: define, measure, analyze, improve and control) that resembles very much a PDCA cycle. Apart from the primary benefits, six sigma programs have reinforced the culture of quality management and continuous improvement, which are the main general benefits of six sigma.

Apart from these quality related movements, other management practices and tools have been proposed and applied over the past decades with the generic objective of improving organizational performance. In the late 1980 s and early 1990 s, Business Process Reengineering emerged as a new approach to improvement and change. BPR also aims at satisfying customer expectations and improving organizational performance, however its approach to improvements is more radical. In the words of Hammer and Champy (1991) "Reengineering is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements...". It is intended to revolutionize all the components which make up an organization by focusing on reengineering the business processes, which are defined as a structured set of activities designed to produce a specified output to a particular customer or market. Despite its top-down approach to change, a common criticism is that it generally fails to link and align BPR efforts with business strategy. Also, differently of TQM, it is argued that BPR falls short of methodologies and tools available to facilitate the outcomes required from its activities.

Just in Time (JIT) also stands as another very important philosophy of improvement that emerged in the 1980's. Although originally developed in the west, like TQM, the Japanese academic and industrial communities have further developed it. JIT aims to develop an encompassing philosophy which includes several concepts and practices such as (Currie, 1999): production management methods and techniques; total quality assurance; total preventive maintenance; customer supplier relationships; technology

innovation strategies; flexible working practices and; machine performance. However, JIT implementations tend to have a very narrow focus, concentrating on techniques for production and inventory control and missing the opportunity of integrating effort and benefiting from different programs such as total quality management. Other improvement management concepts and practices that emerged in the past decades are the Lean Production, Activity Based Cost (Cooper and Kaplan, 1991), Theory of Constraints (Dettmer, 1997), and Balanced Scorecard (Kaplan and Norton, 1992), among others.

Even though managers have such an arsenal of theories for improvement, it is certainly not easy to develop capabilities to put them in practice into a general improvement and change process. Most of the time, implementation of these management approaches tend to focus too much on implementing particular techniques. Even worse, it is not uncommon to see implementation of one of these programs be made disregarding the need of integration and even competing for attention in the management consulting business. To overcome these, companies need not only to get expertise on the different tools for improvement, but most important, they need to build capability to systematically deploy, implement and review improvement and change. The following section presents a brief review on methods for improvement and change implementation and assessment of progress.

Methods for Improvement and Change

Several authors have proposed methods for implement and review improvement and change actions, generally based either on the TQM or BPR philosophies of management. This is the case of the Japanese management by policies approach (Collins and Huge, 1993). Very much based on the TQM philosophy of management, it also applies the PDCA cycle, in this case with a much longer cycle, to establish strategic business policies, deploy and implement them through organizational levels, and to periodically review progress. Also based on the continuous improvement principle is the five steps method proposed by Harrington (1991) which consist of: organizing for improvement; understand the process; streamlining; measurement & control and; continuous improvement. This method is supposed to be applied by a team over 90 days period. It is more like a method for guiding consulting people in developing projects and it is unlike to create continuous improvement capabilities.

Based on the BPR approach for improvement and change is the method proposed by Kotter (1995), which suggests 8 phases for transformation projects: establishing a sense of urgency; forming a powerful guiding coalition; creating a vision; communicating the vision; empowering the others to act on the vision; planning for and creating short-term wins; consolidating improvements and producing still more change and; institutionalizing new approaches. Rentes, Van Aken & Butler also presents a method for transformation process management consisting of 7 phases: understanding the need for change; creating infra-structure for change; analysing current situation; setting direction for change;

defining improvement initiatives; deploying and implementing initiatives; reviewing progress and results.

Also a great contribution to the theory of improvement and change in the 1990's is the conceptual models and methods for developing performance measurement systems. The most widely recognized performance measurement framework is the Balanced Scorecard (Kaplan and Norton, 1992), which proposes four interconnected perspectives of performance measurement in which measures of internal business process performance and learning & growth are derived from shareholder and customer views of performance. It is fundamentally based on recommendations such as deriving measures from strategic positioning and planning, and balancing financial and non-financial measures derived from different perspectives of measurement and aimed at managing the process of performance improvement.

Neely and Adams (2000) also proposes a method, named the performance prism, based on interconnected perspectives of measurement, which they illustrate by the facets of a prism. They argue that identifying stakeholders' satisfaction will lead to strategic direction, which in turn will lead to development of solutions that satisfy stakeholders. Delivering satisfaction will depend upon capabilities, which in turn will depend on stakeholders' contributions. Fundamental recommendations implicit in the performance prism framework are: deriving measures from stakeholders' expectations and strategic directions; focus on critical business processes and capabilities and; identify stakeholders' contribution required to generate satisfaction and business excellence.

Generally, all the methods briefly presented above emphasize important principles of management as well the need of systematically performing improvement and change initiatives. However, implementation of any of those methods would be very difficult without an underlying organizational capability to manage improvement and change, as discussed next.

Improvement and Change Capability Models

The business excellence model of the Malcom Baldrige National Quality Award (Black and Porter, 1996) award is frequently cited in the literature as presenting the fundamental elements of management to enable a company to achieve excellence in performance. The basic criteria are: leadership; strategic planning; focus on customer and market; information and analysis; human resources management; business results. The same is true for the business excellence model of the European Foundation for Quality (Neely, 1998) which present similar criteria but divided into two main groups: enablers and results. The enablers are: leadership; human resources management; resources and; policies and strategies. The results are: customer satisfaction; impact on society, business results. These models, although originally conceived to evaluate the candidates for the prizes

are commonly used as a reference for assessment of a company capability for performance management.

Bessant and Caffyn (1996) present a model describing what they call the behaviours that need to be acquired and embedded in the organization in order to enable an evolution of continuous improvement capabilities. The model defines five levels of evolution, from level 0, characterized as no- CI activities, up to level 5, categorized as the learning organization in which there is ability to deploy competence, everyone in the company is actively involved in incremental and radical innovation and sharing of learning. The intermediate level 3, strategic CI, is characterized as having formal deployment of broader strategic goals to operational level activities; improvement driven by monitoring and measurement; training in basic CI tools; use of formal problem solving process and; participation and recognition. Thus, the model presented by the authors attempt to characterize how an organization evolves from operational to organization wide strategic management of improvement and change. This is exactly the question the case research reported in this paper aims to explore, as discussed next.

Research Method, Framework and Questions

The research reported in this paper was based on case study. Case study has been largely used in the field of operations management (Voss, Tsikriktsis and Frohlich, 2002) and is recognized as being particularly good for examining the how and why research questions in theory building and testing (Yin, 1994).

Based on the literature review, it can be said that improvement and change is most dependent on (Figure 1):

a) Organizational values to support the program (e.g. Juran and Gryna, 1993; Kume, 1995);
b) Organizational and individual capabilities on such programs (e.g. Bessant and Francis, 1999);
c) Strategic orientation (Goetsch and Davis, 1995; Carpinetti et al, 2000);
d) Systematic deploying and review of actions (Harrington, 1991); and
e) Measurement system (Kaplan e Norton, 1992).

Moreover, deployment and review of improvement and change actions (central box in Figure 1) should be part of a company wide PDCA cycle. A formal process of planning and prioritization of improvement and change actions, as portrayed in Figure 2, is proposed as a conceptual framework for improvement and change management. This model is based on the PDCA cycle and contemplates the elements of improvement and change identified in the literature and indicated in Figure 1: strategic direction, performance management, continuous improvement culture and improvement programs.

Therefore, the main objective of the field research carried out and described in the following section is to investigate whether a company that is known to have developed

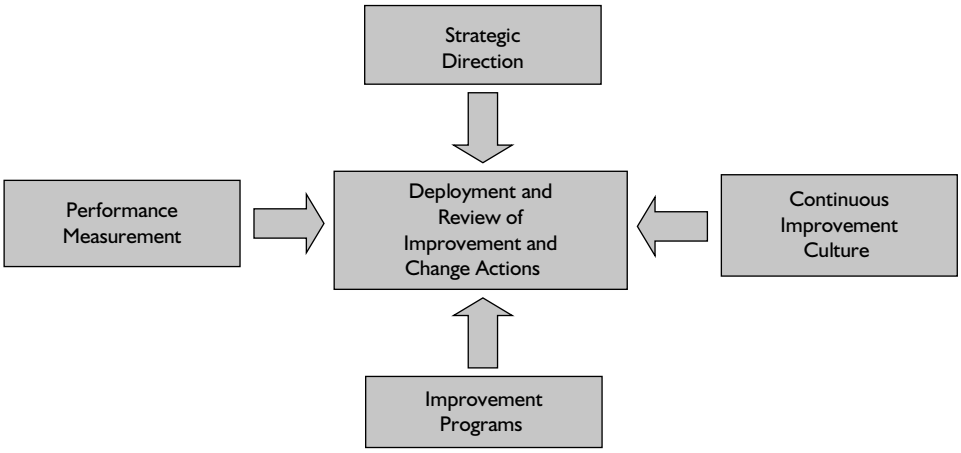


Figure 1 – Elements of improvement and change management in the case study.

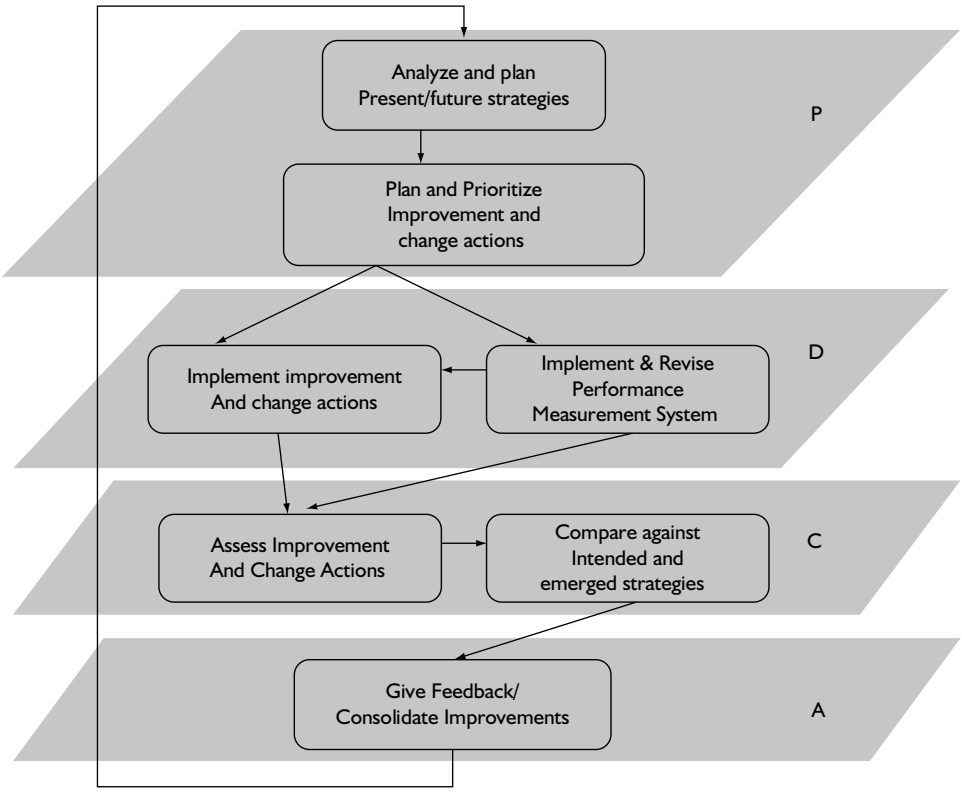


Figure 2 – Systematic activities for managing improvement and change.

capabilities for continuous improvement puts in practice these elements of improvement and change (described in Figure 1) and how it does that so as to integrate efforts into an organization wide improvement and change process (described in Figure 2) that enables systematic deployment and review of progress, based on strategic orientation of improvement and change actions that have been brought about by human resource capabilities.

Case Study Presentation

The case was developed in a plant of the South America division of multinational automotive company. The company as whole has 205 plants worldwide, and its range of automotive components include braking systems, engine components, steering wheel systems and suspensions, seat-belts and inflatable restraints. The South America division has 9 plants located in southwest region of Brazil, employs around 4000 people and its annual sales for the year 2001 was of US$ 307 million. Its main clients are the automobile and off-road vehicle makers such as Chrysler, Fiat, Ford, General Motors, Honda, Mercedes-Benz, Peugeot, Renault, Scania, Toyota, Volkswagen, Volvo, Agrale, Caterpillar.

The plant where the case study was developed, located in Sao Paulo State, is responsible for manufacturing braking systems. Before being incorporated by the multinational automotive company in the end of 1990's, this plant used be part of a Brazilian manufacturing company of braking systems with a long tradition in quality management, with many awards being received from its clients for quality assurance of its products. The plant has ISO and QS 9001 quality certification and by the time the study was developed, it was implementing the ISO-TS quality system.

The case study was developed through interviews, observation and analysis of documents. In total, there were 12 visits to the plant, including 40 hours of interviews with 5 employees and observation of working practices. The interviews were semi-structured, where some questions were made to guide the interviewee to the interests of research, that are:

- What are the improvement and change capabilities developed by the company and how that happens?
- What is the systematic for deploying improvement and change and review progress?
- What is the organizational structure that supports improvement and change?

The following section reports the findings of the case study.

Improvement and Change Programs

The company has several programs in place to develop capabilities in improvement and change. These are the case of the Shop-floor Continuous Improvement Program, Six Sigma and Lean Production programs (the company proprietary names of the programs are omitted).

The Shop-floor Continuous Improvement program started in 1991, before acquisition of the plant by the multinational corporation and its enormous success justified its continuation. It is a program that promotes a bottom-up commitment with continuous improvement through financial rewarding of any employee or team of employees that is able to succeed in idealizing and implementing a project that results in any sort of improvement. The program is coordinated by the human resources management area, which provides training and criteria for evaluating the improvement projects. The projects are conducted by the shop-floor workers, who have time available for meetings and material resources for implementing improvement ideas. The shop-floor managers evaluate the projects and attribute grades according to criteria defined by the program coordination. Although there is freedom to implement any good idea, the program coordination sets direction by defining yearly the main goals for the program and by better grading those projects that meet the goals defined for the program. Weekly, there is a session for presentation of the projects of the week and awarding of the best projects. Even projects that do not classify for prizes, accumulate marks that in the end contributes towards a better evaluation of the workers involved in the projects and to some sort of financial reward. Over more than a decade, this program has created commitment to the principles of continuous improvement and self-control. It is worth to note that this plant is the only one that maintains such a program in the entire organization and it is a benchmark case.

Another improvement program in practice is the lean production program. This program was launched by the company worldwide in 2000. It is a program that aims to get improvements in four dimensions: quality to customers; delivery performance; safety of workers; and cost. This program has a worldwide coordination, under the responsibility of a director of operations excellence who delegates to specially trained employees the responsibility for implementing the program. Mainly based on the principles and techniques of Lean Production, the program was conceived as a road map towards excellence in operations with several phases and gateways. In each phase, several practices based on concepts and techniques of lean production are expected to be implemented through a series of workshops involving technical staff and shop-floor workers and consisting of training, problem definition related to the daily work of the employees involved in the workshop and implementation of improvement actions devised during the workshop. The progress of the program is evaluated against a reference performance map, which evaluates the stage along the roadmap and the level of excellence in the practices expected to be implemented. Plants or units that acquire performance excellence in any of the practices become a benchmark case to the rest of the organization and are expected to share their experience with other plants.

Still another improvement program developed in the plant is Six Sigma. The program started in 2001 also launched world-wide by the organization, which created a Six-Sigma Director responsible for coordinating the process of implementation of Six Sigma world-

wide. It follows the general guidelines proposed by the creators of Six Sigma: the main objective is to reduce the cost of non-quality so as to get better results on customer satisfaction, profit and cash flow. The program is formatted in the same way as seen elsewhere: use of the DMAIC method and training of employees, the black and green belts, who become responsible for disseminating, leading and carrying on Six Sigma projects. Apart from these especially trained employees the program is coordinated by a steering committee, responsible for giving directions and support to the program initiatives in the plants. In the division level, there is a leader black belt, responsible for coordinating the initiatives in the plants, closing the bridge among black belts and steering committee and preparing reports to the steering committee.

Besides these programs, the company has a very mature quality assurance system, with ISO, QS 9001 and TS certificates.

Systematic for Deployment and Review of Progress

The systematic for management of improvement and change in practice is illustrated in Figure 3. At the corporate level, senior executives define company vision and mission that serve as the basis for deployment of annual objectives, goals and budgets, which are

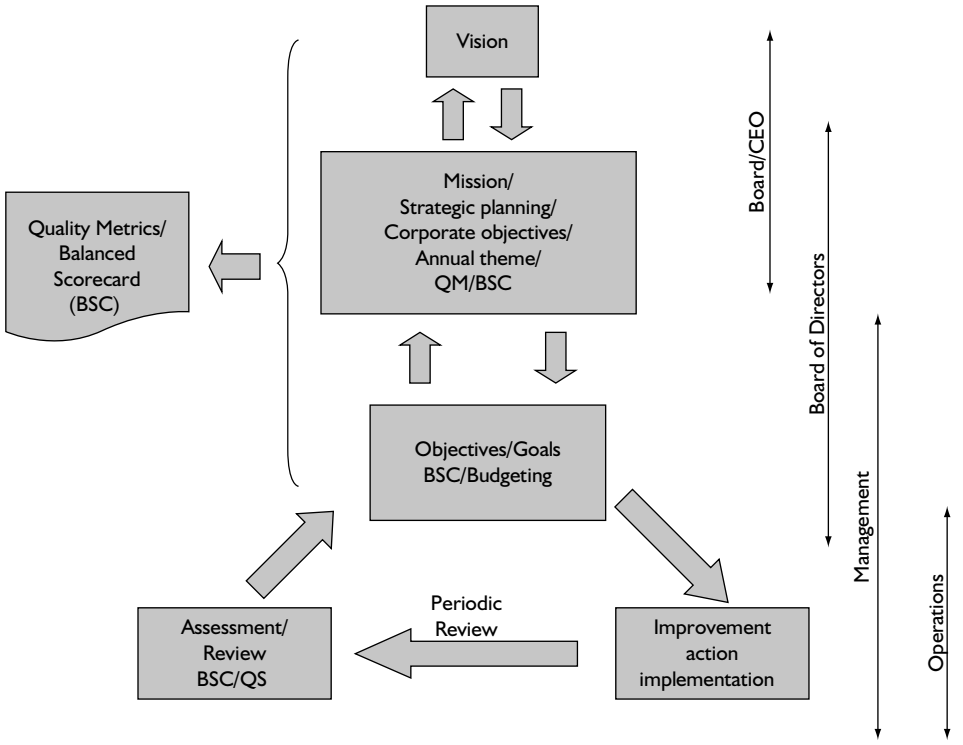


Figure 3 – Systematic for deployment and review of progress.

carried out by division and plant managers, discussed and finally agreed at the corporate level. Also agreed are targets and budget for improvement programs. These objectives and goals are also the base for deploying metrics and targets for them. The company adopts the concept of the Balanced Scorecard for defining its metrics, which are implemented and managed through a performance measurement system database.

At the plant level, the performance of operations is reviewed in monthly meetings involving plant mangers and middle managers responsible for different functional areas. In these meetings, performances on the different dimensions defined by the measurement system metrics are reviewed against target. In case of performance shortfall, managers are expected to present what has been done in the past month and a plan of action for improvement of performance to be reviewed in the following month.

The improvement program leaders do not have direct participation in this process of review of progress although they provide support in planning and implementing improvement actions.

Organizational Structure for Improvement and Change

The plant is organized in the following functional areas: manufacturing; customer support; purchasing; information system; customer development; quality and manufacturing engineering; human resources; controller and legal affairs. The human resources and quality & manufacturing engineering functions coordinate the shop-floor continuous improvement program and the quality assurance system respectively. The Six Sigma and Lean Production programs report directly to their respective organizational structure outside the plant at the corporate level despite the fact that the staff involved with these two programs belong to the quality & manufacturing engineering function and therefore also report to its manager.

The responsibility for management of improvement programs is focused on key individuals, who are responsible for coordinating and leading the programs at the plant level. On the other hand, the responsibility for continuous improvement actions related to plant performance is dispersed among the functional managers. At the shop-floor, the employees work in teams for routine problem solving or improvement actions devised by the programs such as lean production workshops or six sigma projects.

Analysis of Case Study Results

Analysis of results regarding improvement and change management capabilities has shown that the plant has managed to build a very strong culture of commitment to continuous improvement amongst its employee, mostly through its CI programs and training. Such commitment has created a foundation for the company to formally develop several improvement programs that are very well defined, structured and coordinated.

The programs all-together encompass quality related issues as well as improvement and change on other dimensions of performance of operations such as delivery performance as is the case of the lean production program. However, implementation of the improvement programs presents some problems as follows:

- The programs are under the responsibility of different senior managers, which may lead to a lack of integration among program objectives and actions at the plant level; and
- Annual planning of actions of the programs (for budgeting and future assessment) is made by the staff responsible for coordinating and leading the programs without participation of plant and functional managers, which may lead to a situation in which actions planned are not responding to priority improvement needs of the different functional areas.

There could also be seen evidences to suggest that the company systematically deploys improvement and change actions from strategic positioning and reviews progress as follows:

- Strategic orientation for improvement and change actions is ensured through deployment of corporate objectives and targets involving senior and middle management;
- Performance is assessed by a well structured performance measurement system that deploys objectives and targets into metrics and targets for the metrics of the plant performance measurement system; and
- Review of performance is made through a formal management cycle in which managers are expected to present past, present and future improvement actions in case of performance shortfalls.

Regarding implementation of systematic deployment and review of progress, some problems could also be seen as follows:

- There is not a periodic (e.g. annual) process of planning and prioritization of improvement and change actions involving functional managers and integrated with improvement programs to help managers to achieve their targets on defined objectives. The definition of actions is made on a non-systematic basis and not necessarily involving the improvement program leaders; and
- The program leaders are not co-responsible for achieving the targets of the metrics of the functional areas which leads to a certain lack of focus of the programs on the most important performance shortfalls faced by the functional areas.

Regarding organizational structure for improvement and change, it could be seen that:

- The company has a very well defined organizational structure for the improvement programs in place, with staff particularly assigned for the programs and reporting to

senior managers also particularly assigned for managing program implementation and results; and

- Functional managers are responsible for continuous improvement actions related to plant performance.

Additionally, during the interviews with the staff involved with improvement and change, there were some problems pointed out which we believe are related to the organizational structure as follows:

- There is no mechanism in the organizational structure to ensure that employees responsible for coordinating and leading the programs at the plant level also give account to the plant manager on the contribution of the programs in helping the functional middle managers to tackle the problems that are causing performance shortfalls and impede the plant to achieve its targets on strategic objectives; and
- Due to the fact that the program leaders belong to a particular functional area and also reports to its manager, it happens some times that actions developed by the programs tend to concentrate on the same functional area the leaders belong to.

When compared to the CI capability model proposed by Bessant and Caffyn (1996) the case study can be categorized in the intermediate level 3, strategic CI, which means the company has: formal deployment of broader strategic goals to operational level activities; improvement driven by monitoring and measurement; training in basic CI tools; use of formal problem solving process and; participation and recognition.

Conclusions

Analysis of the results of the case study has revealed that the company has a considerable level of maturity in managing improvement and change. It could be seen that the elements of improvement and change as identified in the literature were present in the case study. Most important, analysis of the difficulties in the process of managing improvement and change identified in the study could help to draw some recommendations so as to address the main research question to be answered by this case study, that is how a company puts in practice these elements and evolves an organization wide improvement and change process. The recommendations are as follows:

a) A formal process of planning and prioritization of improvement and change actions with full participation of the functional managers as well as program leaders. Focus on the business process of the value chain. Instead, deployment of actions focused on the functional areas;

b) An organizational structure that overlaps responsibilities for improvement and change among program leaders and functional managers so as to make both of them fully committed with program success as well as achievement of performance excellence on strategic objectives and targets; and

c) A process of improvement formally designed, with description of activities, input and output data and responsible for leading the activities as illustrated in Figure 3.

Finally, although we believe there is not a unique configuration of an improvement and change management process, the points discussed here may help a company to lay down a foundation on which it can built its improvement and change management process and capabilities.

Acknowledgments

The authors acknowledge FAPESP (São Paulo State Science Foundation) and CNPq (National Council for Research and Development) for supporting this research work and to the company that allowed and fully supported the development of the study.

References

Ahmed, N. U.; Montagno, R. V., (1996) "Operations strategy and organisational performance: an empirical study", International Journal of Operations & Production Management, Vol 16, No 5, pp. 41-53.

Bessant, J.; Caffyn, S. (1996) "Learn to manage innovation, Technology Analysis and Strategic Management", Vol. 8, No. 1, pp. 59-70.

Bessant J.; Francis, D. (1999) "Developing Strategic Continuous Improvement Capability", International Journal Operations and Production Management, Vol. 19, No. 11, pp. 1106-1119.

Black, S. A.; Porter, L. J. (1996) "Identification of the critical factors of TQM", Decision Science, Vol. 27, No. 1, pp. 1-21.

Carpinetti, L. C. R.; Gerólamo, M. C.; Dorta, M. (2000) "A Conceptual Framework for Deployment of Strategy Related Continuous Improvements", The TQM Magazine - The International Review of Organizational Improvement, Vol. 12, No. 5, pp. 340-349.

Collins, B.; Huge, E. (1993) Management by Policy: How Companies Focus Their Total Quality Efforts to Achieve Competitive Advantage, ASQC Quality Press, Milwaukee.

Cooper R.; Kaplan R. (1991) "Profit Priorities from ABC", Harvard Business Review, May-June, pp. 130-35.

Currie, W. (1999) "Revisiting management innovation and change programmes: strategic vision or tunnel vision?", Omega, Vol. 27, pp. 647-660.

Davenport, H. (1993) Process Innovation: Reengineering work through information technology, Harvard Business Press, Boston.

Deming, W. E. (1986) Out of the Crisis, MIT Press, Cambridge.

Dettmer, H. W. (1997) Goldratt's theory of constraints: a systems approach to continuous improvement, ASQC Quality Press, Milwaukee.

Goetsch, D. L.; Davis, S. (1995) Implementing Total Quality, Prentice Hall Inc., Columbus.

Hammer, M.; Champy, J. (1991) Reengineering the corporation, McGraw-Hill, Inc, New York.

Harrington, H. J. (1991) Business Process Improvement: The Breakthrough Strategy for Total Quality, Productivity, and Competitiveness, MacGraw-Hill, New York.

Henderson, K. and Evans, J. (2000) "Successful implementation of six sigma: benchmarking general electric company", Benchmarking: an International Journal, Vol. 7, No. 4, pp. 260-281.

Ishikawa, K. (1990) Introduction to quality control, 3A Corporation, Tokyo.

Juran, J.M.; Gryna, F. (1993) Quality analysis and planning, MacGraw Hill, New York.

Kaplan, R.; Norton, D. P. (1992) "The balanced scorecard – measures that drive performance", Harvard Business Review, Vol. 70, No. 1, pp. 71-79.

Keating, K. E. et al. (1999) "Overcoming the improvement paradox", European Management Journal, Vol. 17, No. 2, pp. 120-134.

Kotter, J. P. (1995) "Leading change, why transformation efforts fail", Harvard Business Review, March-April, pp. 59-67.

Kume, H. (1995) Management by Quality, 3A Corporation, Tokyo.

Lientz, B. P. (2000) Achieve lasting process improvement: reach six sigma goals without the pain, Academic Press, New York.

Neely, A. (1998) Measuring business performance, The Economist books, London.

Neely, A.; Adams, C. (2000) "Perspectives on Performance: The Performance Prism", in M. Bourne (Ed.) Handbook of Performance Measurement, Gee Publishing, London.

Pfeifer, T.; Reissiger, W.; Canales, C. (2004) "Integrating six sigma with quality management systems". The TQM Magazine, Vol. 16, No. 4, pp. 241-249.

Rentes, A.F.; Van Aken, E.M.; Butler, M.R. (1999) An organizational assessment method for transformation efforts, Portland International Conference on Management of Engineering Technology Annals - PICMET'99, Portland, Oregon.

Voss, C.; Tsikriktsis, N.; Frohlich, M. (2002) "Case research in operations management", International Journal of Operations and Production Management, Vol. 22, No. 2, pp. 195-219.

Yin, R.C. (1994) Case study research: design and methods. California: Thousand Oaks.

Biography

Luiz C. R. Carpinetti is an Associate Professor at the School of Engineering of São Carlos, University of São Paulo, Brazil. He holds a PhD in Engineering by the University of Warwick (UK) and a MSc in Metrology and Quality Assurance by the Cranfield Institute of Technology (UK). His present teaching and research interests are on the subjects of

Quality Management and improvement and change management, including performance measurement, system dynamics and other tools and methodologies.

Mateus Cecílio Gerolamo is graduated in Production Engineering with a Master of Science degree from School of Engineering of São Carlos, University of São Paulo, Brazil, where he is presently applying for a PhD degree. His PhD project focus on improvement and change management approaches for SMEs based on cooperation management in clusters of firms. His interests on research are on the subjects of Quality Management and Improvement and Change Management.

Olívia Toshie Oiko is graduated in Production Engineering by School of Engineering of São Carlos, University of São Paulo, Brazil, where she is presently applying for a Master degree. Her Master project focus on the development of a benchmarking database for SME´s. Her interests on research are on the subjects of Quality Management and Improvement and Change Management.

Volume 2, Number 2, 2005, pp. 75-86

Environmental Management and Competitiveness: A Survey on Environmental Awareness in Shrimp Producers in the State of Rio Grande do Norte in Brazil

Anísia Karla de Lima Galvão
Universidade Federal do Rio Grande do Norte, RN, Brazil
E-mail: aklg2@yahoo.com.br

Thaís Bezerril Brandão de Lima
Universidade Federal do Rio Grande do Norte, RN, Brazil
E-mail: thaisbezerril@hotmail.com

Sérgio Marques Júnior
Universidade Federal do Rio Grande do Norte, RN, Brazil
E-mail: sergio@ct.ufrn.br

Abstract

The objective of the work was to investigate the perception of marine shrimp producers on the impacts of environmental management as a driver for improving competitiveness. The proposed methodology was the application of a questionnaire, using 24 variables linked to environmental awareness compounded by questions grouped into four scales: environmental attitudes, environmental behaviors, environmental regulations and farming profile. The questionnaire was applied for producers of three sites located in the northeast of Brazil. To analyze the results, it was used descriptive analysis and the analysis of association among variables, using Pearson chi-square statistic test. Results show that 41% of the shrimp producers believe to face aggressive competitiveness in the market, and that the activity generates few environmental impacts. It was verified the existence of dependence among the perception of the producers on the impact of environmental procedures as a driver for implementing competitive advantage to their business and opinion on the competition in the shrimp market, importance of environmental actions of the company in the decision of consumer purchase, and use of some ecological procedure at the farming.

Keywords: environmental management, competitiveness, environmental awareness

Introduction

Worldwide aquaculture has been increasing rapidly in the last decade, approximately at an average rate of more than 10% per year, mainly due to the combined effects of increasing world population, and the increasing demand for aquaculture products in developed countries (Biao et al., 2004). Undoubtedly, shrimp aquaculture is generating significant benefits in socioeconomic terms. Its high profitability and generation of foreign exchange have provided major driving forces in the global expansion of the industry (Primavera, 1997; Páez-Osuna, 2001). In Brazil, the production in 2003 reached 90,000 ton and the productivity was considered the biggest of the world, around 6.5 ton per hectare. The northeast of the country answered per 100% of exportations and 96% of the national production. Rio Grande do Norte state is the biggest national producer, with around 45% of all shrimp produced in the country (Rocha, 2004).

However, this significant growth has generated many concerns about aquaculture sustainability and competitiveness (Queiroz et al., 2003). Due to poor planning and management and a lack of appropriate regulations, numerous examples of decline in production and environmental impacts have occurred around the world (Páez-Osuna, 2001). Adverse environmental impacts related to shrimp aquaculture have been widely reported in the literature (e.g. Flaherty and Karnjanakesorn, 1995; Primavera, 1997, 1998; Páez-Osuna et al., 1998; Páez-Osuna, 2001). The most serious concerns expressed by both environmental activists and scientists are related to the destruction of mangrove, wetlands, and other sensitive aquatic habitat, conversion of agricultural land to ponds, water pollution resulting from pond effluents, excessive use of drugs, antibiotics, and other chemicals for aquatic animal disease control, inefficient utilization of fish meal and other natural resources, salinization of land and water by effluents, seepage, sediment from brackish water ponds, excessive use of ground water and other freshwater supplies for filling ponds, spread of aquatic animal diseases from culture of organisms to native populations, negative effects on biodiversity caused by escape of non-native species introduced for aquaculture, destruction of birds and other predators, entrainment of aquatic organisms in pumps, conflicts with other resource users and disruption of nearby communities (Boyd, 2003). Water pollution by pond effluents is probably the most common complaint, and this concern has attracted the official attention in most nations (Tookwinas, 1996; Boyd and Gautier, 2000; Boyd and Trucker, 2000, Boyd, 2003).

The environmental dilemma perceived from the environmental impacts generated by the productive activities has modified the competitiveness of goods and services. Environmental deterioration has increased the consumer awareness on the environmental problems, forcing organizations for developing strategies of environmental policy, linked to the development of environmental programs for the whole organization (Min and Galle, 1997). Corporations in North America, Europe and Japan, and in the majority of the industrialized nations, are hugging the environmental protection as part of its international

competitive strategies, defined from the pressure of governments, customers, suppliers and competitors (Berry and Rondinelli, 1998).

As the environmental quality can be considered as one of the basic components of the competitiveness in the international market of commodities, the aquaculture industry has been induced to create procedures that aim to minimize the generation of environmental impacts at the farming level. Some companies of shrimp aquaculture have already implemented environmental management systems (EMS) based on ISO 14000 standards, a step to reach sustainable development in the activity.

Based on this context, the main objective of this work was to investigate the perception of shrimp producers about the impacts in the competitiveness of the company when adopting environmental procedures. As a basic premise for the implementation of environmental programs in any organization, it is necessary to define efficient procedures to influence the environmental awareness of all stakeholders of the process, aiming to create an efficient environment to the appropriation of environmental content in the decision-making of any organization.

Environmental Management, Market Segmentation and Competitiveness

Environmental practices have become frequent in several business strategies, as related to process management or the final result in the form of a new product or service. However, there is not consensus on the effect of adopting environmental management as an efficient driver to generate competitive advantage for the organizations. Reinhardt (1998) states that the debate on business and environment is still a polarized subject. If superior environmental performance can creates more profitability for the organization, becoming the core principle of the business, on the other hand, the focus in the environmental affairs can lead to the loss of competitiveness because of the lose of the focus in the vision of the shareholders.

In these terms, the principal question to be placed is in which conditions the use of environmental procedures can increase organizational performance and, consequently, increase organization profitability. Eventually, under certain conditions, the definition of an established competitiveness standard in the market is derived from the aggregate value that the environmental procedure generates to the product or service, focusing the managerial decision of adopting environmental practices in the vision and expectations of the final consumer. According to Gil et al. (2000), the concern of consumers with relation to the environmental damages and the health, has led to a significant increase in the demand for the organic food production. In a study carried through two regions of Spain, the authors had identified the existence of market segmentation with relation to the organic products, when considering the life style of the consumers as a decision variable. Results of the work indicate that consumers worried about a healthful diet and

environmental degradation, are those that probably will consume organic products, even when paying a higher price for the product.

Barrett et al. (2002) state the increasing demand for organic foods in the United Kingdom. The authors identify an increasing market of organic products in EU, where producer countries such as Brazil, Mexico and Sri Lanka are distinguished as main involved countries in the global market of organic products commercialization. According to the authors, the global market of organic products is around US$ 11 billion, equivalent to 2% of the total food market. Barrett et al. (2002) also state that, although increasing, the demand for organic foods in the Europe surpasses its capacity of production, requiring importation; it is estimated that the imported value of organic foods is close to US$ 500 million.

The market segmentation related to organic products generate the need to create production strategies based in the knowledge of the consuming market profile, in terms of the factors affecting purchase decision. Torjusen et al. (2001), in study carried through the region of Hamar (south of the Norway), identified that consumers that buy organic foods are worried about questions related to the ethics, environmental problems and health. The increase in organic food purchase among consumers who already buy organic products, through the improvement in the availability of market preferences, can represent a bigger potential for the increase of the market segmentation.

As a driver element of the product quality and, consequently, competitiveness, the use of environmental management practices in aquaculture sometimes may creates conflicts among fisherman, aquafarmers and environmentalist. Barg and Wijkström (1994) states that, in essence, reasons for conflicts include the decline in quality and quantity of food fish consumption, resulting in reduced consumer confidence and decreasing fish marketability. According to the authors, patterns of social disruption due environmental degradation and resource depletion may decrease employment opportunities with shifts toward unskilled and seasonal labour.

However, a further difficulty in developing resource management and instigating environmental strategies to strengthen competitiveness is that there are no clear development of environmental awareness among aquafarmers and fishering managers. In fact, the productive process involved has been traditionally linked to reactive positions, related to the fulfillment of a stringent environmental legislation, apart from the benefits of the environmental management to the enterprise competitiveness. This premise creates the necessity of studying the mechanisms of improving environmental awareness in shrimp producers, main object in this work.

Research Methodology

A descriptive survey was used to study environmental awareness among shrimp producers. According to Forza (2002) descriptive survey research is aimed at understanding

the relevance of a certain phenomenon and describing the distribution of the phenomenon in a population. Forza (2002) also states that the primary aim of descriptive survey research is not theory development, even though through the facts described it can provide useful hints both for theory building and for theory refinement.

The interviewed population was composed by shrimp producers from Canguaretama, Goianinha and Tibau do Sul, sites located in the state of Rio Grande do Norte, Brazil, registered in local environmental agency. This area was chosen because of the significant concentration of farms in Curimataú, Cunhaú river estuary (Canguaretama) and in Guaraíra, Papeba and Papari estuaries (Goianinha and Tibau do Sul). Because of the shrimp farming, the swamp area covered with mangroves has suffered diverse interferences from the environmental point of view (Wainberg, 1999).

The used survey instrument was a questionnaire structured from variables related to environmental awareness, with 24 questions subdivided in alternatives of fixed answers, using a Likert scale. The questions had been grouped in four groups of variables: environmental attitudes, environmental behaviors, environmental regulations and farming profile, based on Polonsky and Mintu-Wimsatt (1995). The set of variables is presented in Table 1.

The variable COMD (opinion of shrimp producers on the importance of environmental practices as drivers of competitive advantage in the market) was considered the dependent variable used to the analysis model.

The statistical techniques for analysis of data were the descriptive analysis and the analysis of interdependence among variables, using Pearson chi-square statistic test. The main objective in using the descriptive analysis of the absolute values was to present the perception of shrimp producers about the relationship between environmental management and the enterprise competitiveness, some attributes and its dimensions. With regard to the analysis of interdependence of variables, it was used Pearson chi-square statistic test to verify the degree of association between variables and, thus, to define which variables can intervene with the environmental awareness of the shrimp producers about the environmental impacts generated in the activity. To this work, it was adopted as significant for differences comparison among averages, values of probability p lesser or equal to 0.05 ($p \leq 0.05$), i.e. the differences among averages were considered when the value of probability p of the variance analysis was lesser or equal to 0.05.

Findings are presented and discussed at the following section.

Findings

The research was carried through using personal interview as a technique of data collection from August to October, 2003. The interviews were carried through in all the studied shrimp farming. The total population of individuals registered in local environmental agency was composed of 77 shrimp producers, from which 41 answered to

Table 1 – Set of Variables used in survey.

Variable	Variable Description	Group of Variable
COMP	Opinion of shrimp producers on the competition in the shrimp market	Environmental Attitudes
PRIC	Opinion of shrimp producers on the importance of the product price to the consumers decision when purchasing	
QUAL	Opinion of shrimp producers on the importance of the product quality to the consumers decision when purchasing	
SOCA	Opinion of shrimp producers on the importance of social actions to the company for the consumers decision when purchasing	
ENVA	Opinion of shrimp producers on the importance of environmental actions used in the farm for the consumers decision when purchasing	
IMAG	Opinion of shrimp producers on the importance of corporate image to the consumers decision when purchasing	
PROM	Opinion of shrimp producers on the importance of sale promotions to the consumers decision when purchasing	
FACI	Opinion of shrimp producers on the importance of sale facility to the consumers decision when purchasing	
COMD	Opinion of shrimp producers on the importance of environmental practices as drivers of competitive advantage in the market	
EFFI	Opinion of shrimp producers on effectiveness of environmental advertising to shrimp market	
BUYD	Opinion of shrimp producers on when environmental concerns will be important to consumers decision when purchasing	
IMPL	Opinion of shrimp producers on the degree of environmental impact generated in the shrimp production	
EFLU	Frequency of effluent treatment in farm	Environmental Behaviors
FERT	Frequency of chemical fertilizers uses in the water	
ANTI	Frequency of antibiotics uses in the water	
STRA	Frequency of environmental training of employees in the farm	
PROC	Use of procedure in the process of shrimp production considered by producer as environmental correct	
SWAT	Use of procedure to save water in the shrimp production	
SENE	Use of procedure to save energy in the shrimp production	
ATRE	Producer participation in any training about environmental practices	
ETRE	Existence of some program of environmental training to employees in farm	
LKNO	Level of knowledge about environmental legislation related to shrimp production	Environmental Regulations
PROS	Size of the farm	Farming Profile
STOD	Density of shrimp stock used in the production process	

questionnaire, representing a rate of 53%. The questionnaire used as a survey instrument was pre-tested, being applied for 10 shrimp producers with similar characteristics to the population in study. The intention was to verify possible ambiguities of reply, answers that had eventually not been foreseen, a possible occurrence of lack in variability of answers in any question and the time of questionnaire application. Difficulties or ambiguities in the formulated questions were identified from each interview.

Table 2 presents the analysis of association using the chi-square test, between the variable related to the opinion of shrimp producers on the importance of environmental practices as drivers of competitive advantage in the market (dependent variable COMD) and environmental attitudes variables.

Using the value of probability p lesser or equal to 0.05 as criteria for differentiation of averages variable, it is verified through the results presented in Table 2, that there is association between COMD (opinion of shrimp producers on the importance of environmental practices as drivers of competitive advantage in the market) and COMP (opinion of shrimp producers on the competition in the shrimp market). It was observed through expected and observed frequencies tables that the observed frequency of shrimp producers that consider aggressive the competition in the market and that evaluate the environmental concern as a very important driver to competition, is bigger than the expected frequency. Probably, the perception of the existence of high competitiveness in the activity is a factor that intervenes with the opinion of shrimp producers on the use of environmental actions as competitive advantage to the business.

The same inference can be used when it is observed that there is association between dependent variable COMD and ENVA (opinion of shrimp producers on the importance of environmental actions used in the farm for the consumer's decision when purchasing). It was noticed that the observed frequency of shrimp producers that evaluate as very important the environmental concern and consider that environmental actions used in farm are very important factors in the decision of consumer purchase, is bigger than the expected frequency (through expected and observed frequencies tables).

However, it is interesting to verify that there is no association between the dependent variable COMD and EFFI (opinion of shrimp producers on effectiveness of environmental advertising to shrimp market) since the value of probability p corresponds to 0.132. Probably, the perception of the shrimp producers on the use of environmental marketing strategies is not associated with the perception of a possible increase in competitiveness.

Table 2 – Analysis of association between variable COMD and environmental attitudes variables.

Variables	Pearson chi-square	df	n	p-level
COMP	4.48959	1	41	0.034104
PRIC	0.50971	1	41	0.475265
QUAL	0.06646	1	41	0.796551
SOCA	1.49721	1	41	0.221104
ENVA	6.93041	1	41	0.008476
IMAG	1.07287	1	41	0.300301
PROM	1.07287	1	41	0.300301
FACI	0.42302	1	41	0.837046
EFFI	2.25900	1	41	0.132843
BUYD	3.34864	1	41	0.067263
IMPL	2.91371	1	36	0.087833

The descriptive analysis shows that only 48.8% of the interviewed believe that an environmental advertisement certainly would attract more customers, showing that the majority of the interviewed does not believe in the effectiveness of environmental marketing for increase of the competitiveness of the product. Such fact also can be perceived when it is not observed the existence of dependence between dependent variable COMD and IMAG (opinion of shrimp producers on the importance of corporate image to the consumer's decision when purchasing).

Table 3 presents the analysis of interdependence between dependent variable COMD (opinion of shrimp producers on the importance of environmental practices as drivers of competitive advantage in the market) and the variable of the environmental behavior, environmental regulations and farming profile groups.

Through the results presented in Table 3, it is observed the association between dependent variable COMD and PROC (use of procedure in the process of shrimp production considered by producer as environmental correct). Through expected and observed frequencies tables, it was verified that the observed frequency of shrimp producers that consider very important the environmental concern as a competitive driver and use any ecological procedure is bigger than the expected frequency.

However, there is no statistical dependence between COMD and EFLU (frequency of effluent treatment in farm), FERT (frequency of chemical fertilizers uses in the water) and ANTI (frequency of antibiotics uses in the water). Probably, the use of what shrimp producers judge as being an environmental procedure, is not directly linked with action that aim to minimize the main environmental impacts of the activity, i.e. use of chemical fertilizers and antibiotics in water and the lack of effluent treatment. This fact can be considered a critical factor, in terms of environmental management in the activity, especially when descriptive analysis points that only 14% of the interviewed group consider that the shrimp production generates high environmental impact. In terms of environmental

Table 3 – Analysis of interdependence between dependent variable COMD and the variable of the environmental behavior, environmental regulations and farming profile groups.

Variables	Pearson chi-square	df	n	p-level
EFFT	0.37852	1	34	0.538395
FERT	2.47514	1	34	0.115662
ANTF	1.52702	1	35	0.216563
STRA	0.39656	1	34	0.528872
PROC	8.46410	1	41	0.003623
SWAT	0.02087	1	41	0.885131
SENE	0.36044	1	41	0.548264
ATRE	0.72989	1	41	0.392921
ETRE	0.02861	1	41	0.865664
LKNO	0.59134	1	41	0.441901
PROS	0.22285	1	39	0.636873
STOD	0.13928	1	39	0.708993

regulation, it was verified that 73.1% of the interviewed possess little or no knowledge about environmental legislation pertinent to shrimp production.

It was not observed dependence relation between COMD and variable of the farming profile group, i.e. PROS (size of the farm) and STOD (density of shrimp stock used in the production process). In a probabilistic view, the perception of the shrimp producers on the environmental practices as a factor of competitiveness is not influenced by the size of the farm or density of stock of produced shrimp.

Results Implications

Considering the premise that environmental practices in shrimp production can be regarded as a significant element of competitive differential, it can be observed that the relationship between the perception on the competitiveness in industry and the perception of the benefits in creating a green policy. This can be explained by the relationship between dependent variable COMD (opinion of shrimp producers on the importance of environmental practices as drivers of competitive advantage in the market), COMP (opinion of shrimp producers on the competition in the shrimp market) and ENVA (opinion of shrimp producers on the importance of environmental actions used in the farm for the consumer's decision when purchasing), both variables related directly with environmental concerns and competitiveness. Based on this perspective, it is necessary to create a more efficient mechanism of communication on the relationship between environmental management, market segmentation and competitiveness, aiming to improve awareness in shrimp producers. It was verified through the descriptive analysis that 41.4% of the interviewed believe to face aggressive competition in the market, against 58.5% that believe to face pacific competition. In a universe business-oriented, with high competitiveness, probably it was not established, in the surveyed sample, a clear vision of the competitive level that we can find in the shrimp market. In this situation, it seems to be difficult the incorporation of environmental strategies as a competitive business strategy.

Conversely, managerial risks can discourage the adoption of green policy by shrimp producers. It was verified that it exists significant deficiencies in terms of knowledge about environmental procedures, for example, such as the lack of knowledge on the environmental impacts generated by the shrimp production. This can mean the lack of concern or knowledge about the environmental thematic as well as the importance of the environment management or natural resource depletion in a context of business. Another observed significant fact was the lack of knowledge of the interviewed group about environmental legislation. Actually, it can be observed that the concern of environmental legislation are linked exclusively to enforcement, situation that enables to sprout environmental practices in farms, i.e. a reactive attitude not a proactive one. Due the fact that legislation has become more complex, it is also posed that the need to create efficient mechanisms of educational training on environmental aspects and impacts and

communication channels focusing environmental legislation, both pertinent to shrimp production.

Conclusions

Through the results, it can be observed that the environmental perception of the shrimp producers is essentially related to its perception of the competitiveness in the shrimp market. The interviewed shrimp producers that perceive the existence of competitiveness in the market perceive the importance to use environmental practices as a competitive strategy. Similarly, shrimp producers aunts value to environmental practices when they perceive how much the consuming market values environmental practices in the shrimp productive process.

The results pointed in this work, related to the lack of producers perception about the implications of the environmental dimension in the set of the activities of an organization (in competitive terms) reflect, on a point of view of strategic management, the necessity of adopting efficient mechanisms of environmental training, mainly information on environmental practices and competitive aspects of the activity.

It is important to emphasize that in many places of shrimp production, environmental management practices already can be seen as a prescribe requisite in the effective environmental legislation, indispensable for production licensing. In a near future, the lack of adoption of environmental procedures in business might mean the loss of important market segments, mainly abroad. It is evident the sprouting of market segments composed by green consumers, worried in purchasing environmentally benign products. The question that arises is how to reach such markets. We understand that any solution encompass the improvement of environmental awareness among producers, focusing in the relationship existent between environment, business and competitiveness.

References

Barg, U. and Wijkström, U.N. (1994) Environmental management options for coastal fisheries and aquaculture: Role of local authorities, Marine Policy, Vol 18, No.2, pp. 127-137.

Barrett, H.R.; Browne, A.W.; Harris, P.J.C. and Cadoret, K. (2002) Organic certification and UK market: organic imports from developing countries, Food Policy, Vol 27, No. 4, pp. 301-318.

Berry, M.A. and Rondinelli, D.A. (1998) Proative corporate environmental management: A new industrial revolution", Academy of Management Executive, Vol 12, No. 2, pp. 38-50.

Biao, X., Zhuhong, D. and Xiaorong, W. (2004) Impact of the intensive shrimp farming on the water quality of the adjacent coastal creeks from Eastern China, Marine Pollution Bulletin, Vol 48, No.5-6, pp. 543–553.

Boyd, C.E. (2003) Guidelines for aquaculture effluent management at the farm-level, Aquaculture, Vol 226, No.1, pp. 101-112.

Boyd, C.E. and Gautier, D. (2000) Effluent composition an water quality standards, Global Aquaculture Advogate, Vol. 3, No. 5, pp. 61-66.

Boyd, C.E. and Tucker, C.S. (2000) Rule-making for aquaculture effluents in the US, Global Aquaculture Advocate, Vol. 3, No. 6, pp. 81-82.

Flaherty, M. and Karnjanakesorn, C. (1995) Marine shrimp aquaculture and natural resource degradation in Thailand, Environmental Management, Vol.19, No. 1, pp. 27-37.

Forza, C. (2002) Survey research in operations management: a process-based perspective, International Journal of Operations & Production Management, Vol. 22, No.2, pp.152-194.

Gil, J.M.; Gracia, A. and Sánchez, M. (2000) Market segmentation and willingness to pay for organic products in Spain, International Food and Agribusiness Management Review, Vol. 3, No. 2, pp. 207-226.

Min, H. and Galle, W.P. (1997) Green Purchasing Strategies: Trends and Implications, International Journal of Purchasing and Materials Management, Vol. 33, No. 3, pp. 10-17.

Páez-Osuna, F. (2001) The environmental impact of shrimp aquaculture: a global perspective, Environmental Pollution, Vol. 112, No. 2, pp. 229-231.

Páez-Osuna, F., Guerrero-Galvãn, S.R., Ruiz-Fernãndez, A.C. (1998) The environmental impact of shrimp aquaculture and the coastal pollution in Mexico, Marine Pollution Bulletin, Vol. 36, No. 1, pp. 65-75.

Polonsky, M.J. and Mintu-Wimsatt, A.T. (1995) Environmental Marketing: Strategies, Practice, Theory and Research. Haworth Press, Inc. New York.

Primavera, J.H. (1997) Socio-economic impacts of shrimp culture, Aquaculture Research, Vol. 28, No. 10, pp. 815-827.

Queiroz, J.F, Rodrigues, G.S., Campanhola, C. (2003) APOIA – New Rural: A Practical Methodology for Environmental Assessment of Aquacultural Systems, Proceedings of the World Aquaculture Conference, Vol. 2, Salvador, Brazil.

Reinhardt, F.L. (1998) Environmental Product Differentiation: Implications for Corporate Strategy, California Management Review, Vol. 40, No. 4, pp. 43-73.

Rocha, I.P. Brasil quer exportar 30 variedades a partir do camarão. Available in: http://www.tribuna.inf.br/2003/janeiro/17-18/notícia.asp?noticia=economia04. Access: 4 March, 2004.

Tookwinas, S. (1996) Environmental impact assessment for intensive marine shrimp farming in Thailand, Thai Fisheries Gazette, Vol. 46, pp. 119-133.

Torjusen H.; Lieblein, G.; Wandel, M.; Francis, C. A. (2001) Food system orientation and quality perception among consumers and producer of organic food in Hedmark County, Norway, Food Quality and Preference, Vol. 12, No. 3, pp. 207-216.

Wainberg, A. A. (1999), Estudo sobre a Evolução da Ocupação das Margens da Lagoa de Guaraíra nas Décadas de 70 a 90 por Florestas de Mangues e Viveiros da Carcinicultura. Master Dissertation. Aquatic Biology Department of Federal University of Rio Grande do Norte, Natal, Brazil. (In Portuguese).

Biography

Anísia Karla de Lima Galvão is graduated in Animal husbandry from Federal University of Rio Grande do Norte (UFRN), where she was awarded as the best student of the group of Animal husbandry. She holds a Master of Science in Production Engineering at Industrial Engineering Graduate Program at UFRN. Currently, she was selected for a doctorate course in the graduate program in tropical agronomy of the Federal University of Amazonas.

Thaís Bezerril Brandão de Lima is graduated in Animal husbandry, receiving his degree from the Federal University of Rio Grande do Norte (UFRN) in 2004. She is currently a Master of Science researcher at the Industrial Engineering Graduate Program at UFRN.

Sérgio Marques Júnior is an agronomist, working at the Federal University of Rio Grande do Norte. He has involved in research in the Production Engineering Program, where he is a assistant professor on Environmental Strategy and Environmental Management System. His areas of research are related to the environmental theme, developing studies on environmental strategy, environmental management and industrial ecology.

Call for Papers

EUROMA 2006
18-21 June, 2006
Glasgow, Scotland, UK
Abstract submission: 9 January, 2006
Notification to the authors: 20 February, 2006
Full paper submission: 10 April, 2006
http://www.euroma2006.com

The Third International Conference on Production Research – Chapter America's 2006 (ICPR-AMERICAS'2006)
30 July – 2 August, 2006
Curitiba, Brazil
Abstract submission: 7 January, 2006
Full paper submission deadline: 24 February, 2006
http://www.produtronica.pucpr.br/icpr-am06

ABEPRO Executive and Fiscal Board

Manuscript Guidelines

General Instructions
Three copies of the manuscript and a labelled disk should be submitted. Please use Times New Roman font 12 points, justified. The article should be prepared using a A4 paper size (ISO 210 x 297 mm) in double line spacing with wide margins. Papers should not be numbered. Articles should be between 4,000 and 8,000 words in length. Papers exceeding this limit will not be considered for reviewing. The following sequence is suggested for the paper structure: title of the paper; abstract; keywords; introduction; main text and subject; conclusions; acknowledgements (when applicable); and references.

Title
A title not too long should be provided. The title should precisely represents the subject of the paper in times New Roman font 14 points, all caps and centred.

Authors Affiliation and Biography
All authors should be shown and author's details must be printed on a separate sheet and the author should not be identified anywhere else in the article.
A brief autobiographical note (about 100 words) should be supplied including full name, affiliation, e-mail address and full international contact details.

Abstract and Keywords
Authors must supply an abstract of 100-200 words. Up to six keywords should be included which encapsulate the principal subjects covered by the article.

Introduction
The introduction should contain information intended for all readers of the journal, not just specialists in its area. It should describe the problem statement, its relevance, significant results and conclusions from prior work and objectives of the present work.

Methodology
Where there is a methodology, it should be clearly described under a separate heading.

Headings
Headings must be short, clearly defined and not numbered. Sections headings should be typed bold-face, all in capital letters, flush with left-hand margin. Leave one line before and after headings. Subheadings should be typed bold-faced, flush with left-hand margin and only the first letter should be capital. Notes or Endnotes should be used only if absolutely necessary and must be identified in the text by consecutive numbers, enclosed in square brackets and listed at the end of the article.

Main Text and Subject
Please use Times New Roman font 12 points, justified. Paragraphs should not have any space indention.

Figures and Tables
Figures and tables must be included in the main text and must be individually numbered and captioned with a brief title They should be provided both electronically and as good quality originals and must be black and white with minimum shading and numbered consecutively using Arabic numerals. Captions should be put below figures and above tables. Leave one line before (tables) or after (figures).

Equations
Equations should be typed flush with the left-hand margin and numbered consecutively with number in brackets on the right. Leave one line above and before equations.

References
References to other publications should be complete and in Harvard style. They should contain full bibliographical details and journal titles should not be abbreviated. For multiple citations in the same year use a, b, c immediately following the year of publication. References should be shown within the text by giving the author's last name followed by a comma and year of publication all in round brackets, e.g. (Fox, 1994). At the end of the article should be a reference list in alphabetical order as follows:
(a) for books
surname and initials of author(s) and year of publication by brackets, title, publisher, place of publication, e.g. Suh, N.P. (2001) Axiomatic Design – Advances and Applications. New York: Oxford University Press.
(b) for chapter in edited book
surname and initials of author(s) and year by brackets, title, editor's surname, initials, title, publisher, place, pages, e.g. Bessley, M. and Wilson, P. (1984) Public policy and small firms in Britain, in: Levicki, C. (Ed.), Small Business Theory and Policy. London: Croom Helm, pp. 111-26.
(c) for articles
surname and initials of author(s) year by brackets title, journal, volume, number, pages, e.g. Coughlan, P. and Coghlan, D. (2002) Action Research for Operations Management. International Journal of Operations and Production Management, Vol. 22, No. 2, pp. 220-240.
If there are three or more authors, the expression 'et al.' can be used.
Electronic sources should include the URL of the

electronic site at which they may be found, as follows: Neuman, B.C. (1995) Security, payment, and privacy for network commerce. IEEE Journal on Selected Areas in Communications, Vol. 13, No. 8, pp. 1523-31. Available: http://www.research.att.com/jsac. Access: 27th March, 2005.

Papers submitted to the journal should be sent to:

Prof. Paulo A. Cauchick Miguel
UNIMEP – Campus Santa Barbara
Rodovia SP 306, km 1
13450-000 Santa Barbara d'Oeste - SP, Brazil
Further Information: pamiguel@unimep.br

Published by:

Associação Brasileira de Engenharia de Produção

Support:

Fundação Vanzolini