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Doctoral Thesis

The Contribution of Shared Knowledge and Information Technology to Manufacturing Performance: An Evaluation Model

A sectorial research study among Manufacturing, Quality, and R&D groups in the global economy era of the 21st century.

Doctoral Candidate: Charalampos (Haris) Papoutsakis
Director: Dr. Ramon Salvador Vallés

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by

Charalampos (Haris) Papoutsakis

Dipl. Electrical Engineer, National Technical University of Athens, 1971
Postgrad. Dipl. in Business Administration, Athens Economic University, 1974

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To the 'anonymous' Greek TEI student
for whose sake this Dissertation
has been accomplished.

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“A writer is only as good as his
sources, teachers, and muses.
I have been lucky in all three.”
T.S. Stewart (1998, p.xxi)

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Figures and Tables*

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Abstract

The Doctoral Thesis builds and tests a theoretical model that evaluates the contribution of shared knowledge and information technology to manufacturing performance. This is achieved through a sectorial research study among Manufacturing, Quality and R&D groups in the global economy era of the 21st century.

Theoretically, our research stands upon the 'knowledge-based theory of the firm'. The theory has received influences from earlier research lines. It is considered to originate from the 'epistemology' of the cognitive philosophers and –through contradiction to the 'transaction cost economics' and the traditional product-based or competitive advantage view- it builds heavily upon the 'resource-based theory'. Starting with an analysis of previous empirical studies and by means of a productive synthesis, we develop the Shared Knowledge and Information Technology evaluation model which we later use in order to test the investigation hypotheses. Survey data collected from 51 medium to large size industrial companies with a total of 112 manufacturing groups, representing 5 industrial sectors (alimentation, automotive, chemical and pharmaceutical, electro-mechanical, and textile) were analyzed to test the model.

A methodology, particularly deployed for the Thesis and the proposed evaluation model, was developed. Its key elements are:
(a) Two types of questionnaires, addressing the inter-group relationships and the performance issues respectively, were developed and pilot tested prior to being used as the principal research instruments.
(b) Design of the indicators and measures has been carried out using two types of measures, general and multiplicative, for all the variables. Manufacturing group performance has been conceptualized in two parts: operational and service performance.
(c) Key-informant methodology has been used for selecting our research responders.
(d) Validity threats have been given special attention and three different types of validity criteria are applied.
(e) Path analysis, a regression-based technique that permits testing of causal models, has been used. The investigation hypotheses have been tested and found to be fully or partially supported, by the significance -or insignificance- of the relevant paths.
(f) Finally, four confirmatory tests have been conducted in order to further secure the validity of the hypotheses.

As shared knowledge and information technology (IT) are central points of our investigation, we have focused on the issues of Knowledge Management (KM), and we have purposely directed our research on specific IT Systems for Supporting Collaboration and Knowledge-based Work. Our final target was to connect both shared knowledge and information technology to manufacturing performance, the subject matter of our investigation. Today's global economy era is the environment of our study, so it was under this perspective also that: (a) we have examined the influences of the globalization phenomenon to the

recent information technology developments; (b) we have regarded KM and sharing knowledge in practice as an answer to globalization.

Finally, our conclusions are presented together with a reference to the study's limitations and some recommendations for future research. Based on the literature and the results of our research we are demonstrating that the two main findings of the study –the proved significant contributions of (a) shared knowledge to the manufacturing group performance, and (b) information technology to, mainly, the manufacturing group performance and, secondarily, to sharing knowledge- are useful to researchers and the business community alike. Manufacturing, Quality and R&D groups have the opportunity to increase shared knowledge and, in this manner, to positively affect manufacturing performance by developing mutual trust and influence through repeated periods of positive face-to-face or IT-based communication, social interaction and common goal accomplishment.

Chapter One
Introduction

Chapter 1. INTRODUCTION

"An investment in knowledge
pays the best interest"
Benjamin Franklin

In the last two decades of the 20th century, a group of distinguished scientists[1] (Drucker 1985, 1990, 1991; Sveiby 1992, 1997; Nonaka & Takeuchi 1995; Grant & Baden-Fuller 1995; Grant 1996b, 1997, 2000; von Krogh, Ichijo & Nonaka, 1998, 2000, among others) have supported that evolution is based on the administration of knowledge, in other words, on the expansion or upgrading of human and organizational potential and on the creation of an environment that leads towards innovation, learning, creativity and novelty. It is inarguable that Knowledge Management (KM) is the new paradigm towards the 21st century, however, neither all of the above scientists nor every manager in the industry would give it the same significance. As a result, companies attempting to deploy knowledge management are very often confused by the variety of actions emerging under the KM umbrella.

A second group of distinguished scientists[2] (McFarlan, McKenney & Pyburn, 1983; Davenport & Short, 1990; Henderson & Venkatraman 1993; Venkatraman 1994; Applegate, McFarlan & McKenney 1999; McNurlin and Sprague 2004, among others) are emphasizing the prospect that the emerging Information Technology (IT) may become the driving force behind the required business transformation. In order to take full advantage of the opportunities facilitated by IT, senior managers must integrate the Management of Information Technology into the various business departments.

Many companies have tried, with varied achievement rates, to leverage knowledge assets by centralizing knowledge management functions or by investing heavily in information technology. In parallel, an increasing number of articles and research have proposed and tested models for the management of knowledge, with or without the support of information technologies. A considerably smaller number of such studies, though, have investigated into how companies can leverage knowledge in order to improve performance. Most studies have focused on intellectual capital accounts and knowledge audits (Larsen at al 1999, Liebowitz et al 2000), or on measurement systems based on the Balanced Scorecard (Knight 1999, Lee and Choi 2003). Other researchers -and many practitioners- have expressed their preference in methods that evaluate and measure the impact of knowledge management and information technologies, thus connecting it directly with profitability, efficiency and performance (Cohen 1998, Glazer 1998, Firestone 2001). Some studies are using quantitative measures of knowledge management projects impact, like the return on investment (Anderson 2002). Finally, quite a few empirical studies are investigating into

[1] Listed in chronological order since their first publication on the subject
[2] Ibid.,

the causal relationships of knowledge management and/or information technologies with performance (Nelson and Cooprider 1996, Armistead 1999, Chong et al 2000).

The objectives of this Doctoral Thesis are to investigate:

1. the concept of shared knowledge, among Manufacturing, Quality and R&D groups, as a key contributor to manufacturing group performance, and
2. the role and contribution of information technology (IT) as an enabler and facilitator towards both manufacturing performance and shared knowledge.

During the years marking the end of the industrial revolution, and the increasing importance of the IT, it became common belief that the Manufacturing group ability to effectively work with two diverse but knowledge and technology oriented groups (the R&D group and the Quality group) can be a major factor in both the Manufacturing group and the overall organizational performance.

The Thesis question is based on the following two remarks and one question:

- As the business environment becomes more turbulent, organizational productivity often depends on an in-depth knowledge of technologies, processes, and people who may be available both in and across diverse functional groups. The day-to-day operations of the business can present barriers among the groups, as managers and employees involved often speak different technical and procedural languages, and they do not all share the same functional knowledge and the same perspective of this bidirectional cooperation. The interdependence among functional groups becomes especially critical in complex environments. (Origin: Second group of scientists)
- Mutual knowledge bases among functional groups provide a potential bridge to organizational productivity. This is particularly true in the case of Manufacturing, R&D and Quality groups. (Origin: First group of scientists)
- What is unique about shared knowledge among Manufacturing, R&D and Quality groups?
    - The three groups are constantly involved in a two-way knowledge and technology transfer process.
    - Shared knowledge of these processes supports and enhances the performance of the Manufacturing group.
    - Through this shared knowledge base, barriers to understanding and acceptance among the three groups are removed, and the groups increase their ability to work towards a common goal.

As it is not easy to accurately measure the organization's overall performance, the unit of analysis in this research is the Manufacturing group. These groups are the departments within the organization that are producing its final product. We believe that the degree to which the Manufacturing group shares knowledge with R&D and Quality groups, can impact its ability to perform successfully. The objective of using the Manufacturing group as the unit of analysis is to understand how its perception of shared knowledge contributes to performance.

The sharing of knowledge is a process distinct from managerial communication, which also deserves consideration. Managers should manage not by being isolated behind their desk, but by making best use of informal communication, walking around their departments. Shared knowledge goes beyond the basic information level, and it does so by first building a common language among the groups involved. This common language, expressed in words or symbols that are understood by the three groups, facilitates knowledge transfer. It enables the groups and their managers to develop an appreciation and understanding of each other's environment rather than simply exchanging information and translating technical and procedural terms. Under this perspective, communication is only a means and facilitator to shared knowledge.

Nelson & Cooprider (1996, p. 411) define "Shared Knowledge as an understanding and appreciation among groups and their managers, for the technologies and processes that affect their mutual performance". Appreciation and understanding are the two core elements of shared knowledge. Appreciation among diverse groups must be characterized by sensitivity to the point of reference and interpretation of the other group, in order to overcome the barriers caused by the different environments and languages used. For example, the appreciation that exists between a production and a personnel group is different than the appreciation between personnel and accounting. This is due to the different environments and languages used by personnel and production groups.

A deeper level of knowledge must be shared in order to achieve mutual understanding and this is often characterized as organizational knowledge. Badaracco (1991, p. 81) describes organizational knowledge as embedded knowledge, which is defined as: "knowledge which resides primarily in specialized relationships among individuals and groups and in the particular norms, attitudes, information flows, and ways of making decisions that shape their dealings with each other". A lack of this organizational and cross-functional knowledge may result in loses of Manufacturing group performance.

1.1 Previous Empirical Studies

In today's knowledge economy a continuously increasing number of organizations identify more intangible assets –at the cost of their tangible ones- as strategic assets. Fifty years ago, 'hard' assets such as equipment and tooling represented three-quarters of a company's value. Today, hard assets represent only about half of a company's value. The other half belongs to 'soft' assets such as employees' knowledge that play a hinge role in their effort to achieve and maintain competitive advantage. In doing so, companies put emphasis on their cognitive resources and admit that its viability depends directly on "… the competitive quality of its knowledge-based intellectual capital and assets; and the successful applications of these assets in its operational activities to realize their value to fulfill the enterprise's objectives" (Wiig, 1997a, p. 399). Under this perspective, the challenge for managers is to identify and evaluate intangible assets already existing within the organization and at the same time to come across ways to better manage these assets in order to maximize their value and capitalize on this increased value for the company's benefit.

The gains or benefits of KM comprise 'hard' or financial returns and 'soft' or intangible benefits. The first point that should be made clear is that advanced knowledge management tools must be justified on a different basis compared to technology used to support the firm's operational needs, such as word processing, communications and even document management. Knowledge management technologies, and other advanced systems, are justified if they reduce expense, improve productivity or enhance value.

Linking knowledge management with business performance has never been an easy task. Recently, an increasing number of publications are focused on this point by investigating the different ways that management of intangible assets can assist in improving the overall business performance. The performance of intellectual capital, strengthened by KM, may be considered as analogous to the performance of labor and capital. Like money, intellectual capital can also be invested, with one basic difference; it is intended to bring a return in terms of intellectual property, from which other income streams will then flow. Various researchers are approaching the issue from different perspectives that can be classified into six categories: (a) accounts and/or audit type of studies; (b) studies based on the balanced scorecard; (c) studies that evaluate and measure the impact; (d) quantitative measures studies; and (e) studies of the causal relations between knowledge management and performance, with or without the involvement of information technology. Finally, we have included under (f) the important finding of the American Productivity and Quality Center, regarding time, a significant parameter of every measurement system. In the following paragraphs we are presenting the most dominant of these perspectives and we situate our own proposition into this framework.

a) Accounts and Audits

After studying the intellectual capital accounting statements of five Scandinavian firms Larsen et al (1999) conclude that "… there is no set model for intellectual capital statements, and they do not provide a bottom-line indicator of the value of intellectual capital." According to the authors "… intellectual capital statements are situational (…) they are not concerned merely with metrics (… and they) do not disclose the value of the firm's intellectual resources. Instead, they disclose aspects of the firm's knowledge management activities." (pp. 18-19).

For Liebowitz et al (2000) conducting a knowledge audit is one of the first critical steps in the knowledge management area. In the same manner that a traditional manufacturing company will first inventory its physical assets, an aspiring knowledge organization should inventory its intellectual capital assets. The knowledge audit they propose (based on a case study of a medium size US-based company) is focused on determining what knowledge is needed, what is available and missing, who needs this knowledge and how it will be applied.

b) Balanced Scorecard

Criticizing both the ROI (Return on Investment) and EVA (Economic Value Added) approaches used by several organizations, Knight (1999) proposes a Balanced Performance Measurement System (BPMS) based on the Kaplan and Norton (1992) Balanced Scorecard. He argues that “Leveraging intellectual capital requires a company to become a knowledge-based organization and to revise its performance measures accordingly.” (p. 23). The BPMS is used to measure and leverage the organization’s intellectual capital and its financial performance that involves the level of profitability and growth achieved. Based on the equation: Market Value (MV) = Book Value (BV) + Intellectual Capital (IC), Knight proposes generic performance indicators that can be used by almost any organization, in order to evaluate measurable performance objectives. Unfortunately, the case study presented in support of the method, is based on a hybrid (non-real) company.

Lee and Choi (2003) propose a method to measure organizational performance, based on the balanced scorecard which retains financial performance, and supplements it with measures on the drivers of future potential. The model links seven KM enablers (among them collaboration, trust and IT support which are also used in our model) with Nonaka’s knowledge creation model and organizational creativity, in order to measure their impact on organizational performance. The questionnaire-based survey was conducted among 58 major Korean companies covering manufacturing, service and financial business sectors. The method illustrates cause and effect links among the proposed model components in a way that, if we ignore the use of the balanced scorecard, we could consider it related to the one used in our study.

c) Evaluate and measure the impact

This is an approach that has gained greater support and appreciation within the business world (CEOs and senior executives) rather than the academia. Cohen (1998) reports Gordon Petrash (Global Director of Intellectual Assets and Capital Management at Dow Chemical) making a very strong statement of the feasibility and importance of measuring knowledge: “If you can ‘visualize’ it, you can ‘measure’ it; and if you can measure it, you can ‘manage’ it for continuous improvement.” (p. 32). He also reports Jan Torsilibri (of Booz Allen & Hamilton) saying that “… the value of knowledge cannot be directly measured, but it is possible to measure outcomes: changes in profitability, efficiency, or rate of innovation that follow from knowledge efforts.” (p. 33). And he gives the example of Buckman Laboratories that “… has used the increase in percentage of sales from new products as a measure of innovation and attributes the improvement to the firm’s development of a better knowledge culture and infrastructure“(note 7, p. 39).

Glazer (1998) says that the most meaningful measure of knowledge value is its value to the knower: the meaning he finds in it and the use he makes of it. Under this perspective, and with the presence of the subjective knower, knowledge measurement cannot be both objective and meaningful. Meaningful knowledge measures may be approximate, subjective and shifting.

Firestone (2001) with his Comprehensive Benefit Estimation (CBE) presents the basic concepts, methodology and tools for producing improved KM benefit estimates. CBE is firmly coupled to corporate goals, and distinguishes benefits according to their relative importance. Firestone claims that various degrees of comprehensiveness are appropriate for different corporate situations, while he recognizes that CBE might not be practical in many situations. So, instead of a single methodology he is proposing an 'abstract pattern' of CBE that could easily be tailored in different 'ideal type' situations to achieve a feasible estimation procedure. Three such ideal situations are presented in the paper.

d) Quantitative measures

Return on Investment (ROI), defined as [(Benefits – Cost) / Cost] X 100, is the most popular among the quantitative measures of knowledge management projects' impact. Anderson (2002), in a case study of a large equipment manufacturer that had invested in deploying a company-wide Internet-based knowledge management capability, and using proven measurement methodology (Phillips, 1997), estimates the annualized cost of knowledge management and the financial benefits produced into five areas (personal productivity, the productivity of others, speed of problem resolution, cost savings and quality), and calculates a ROI of 50%.

Kingsley (2002) who studies law firms' profit models, the costs of KM systems and document reuse statistics, develops a framework for measuring the return on investment (ROI) and the cost of information (COI), proposes tools to evaluate alternative knowledge-sharing strategies. He sees ROI as the return (or incremental gain) from a project minus its cost. To our understanding, ROI can only capture part of a KM project's impact, mainly because such projects always have accidental effects that can not be easily captured as financial return.

e) Causal relations

Comparing KM projects to their two prevailing predecessors (total quality management and business process re-engineering) Armistead (1999) notices that authors on KM "… do not use the same hard measures of success consistently" (p. 143). He believes that for a knowledge-based view to be useful, it must help improve some key performance indicators (like quality, flexibility and cost). Referring to manufacturing companies he notes that operational processes, which depend more on knowledge, are expected to perform well against measurements of quality in consistence, while at the same time they improve productivity. He expects the knowledge-based approach will lead the design of products, will help in the planning and control of the achievement of performance and will enable further improvements.

Nelson and Cooprider (1996) are investigating the causal effects of knowledge shared between Information System (IS) groups and their line customers, to the performance of the IS group. They base their empirical study on data collected through interviews and questionnaires addressed to managers of 86 IS groups and their line customers, in the USA. Their shared knowledge model, which does not include information technology among its variables, has been incorporated into the model we propose for our study.

The perspective of Chong et al (2000) is also very close to the one proposed for our research. In their effort to provide a well-defined framework that relates investment in expertise or internal competencies to corporate performance, they first conducted key informant interviews with 20 managers of four companies that belonged to financial services, energy and consultancy sectors and their final survey sample consisted of 25 FTSE 500 organizations from the financial services and technological sectors, in the UK. They propose a “Corporate Health Check Model”, based on the extent to which knowledge investment is aligned with the company’s business priorities. Despite some findings (i.e. few organizations have explicit goals and tangible deliveries for their KM projects, the contribution of KM to meeting business objectives is often not clear, etc), they note that organizations recognize that their performance is no longer determined by the ability to restructure and delayer management structures. They urge companies to use their model to regularly assess themselves against other organizations with recognized good knowledge practices in order to identify performance gaps and areas of improvement. In this way, companies are learning from and act on the knowledge of others.

Although the Lee and Choi (2003) study, presented under (b) above, is characterized as a balanced scorecard-based one, we have noted that at least part of the methodology in use for testing the hypotheses is based on the study of causal effects. Their use of information technology as an enabler, affecting knowledge creation, has been adopted in the model proposed for our study.

f) Time and Other Issues

There are other issues that are related to KM and the measurement of its effect on performance that do not fall under any of the above KM measurement perspectives. For example, Davenport and Prusak (2000) have observed the increased interest in knowledge management among Human Resources managers and they interpret this “… as a sign that organizations are realizing the vital connection between knowledge-oriented behavior and overall employee performance.” (p. xiii).

Time is also a measurement issue: Not only ‘what’ we measure but ‘when’ we expect measurable results must be part of the measurement system. The American Productivity and Quality Center (APQC) during its 2000 consortium implemented a multi-client benchmark among some of the most advanced early knowledge management adopters from both the US and Europe. According to the report that appears in APQC (2001), although they recognize five stages of KM project implementation, only during the more structured ones measurement is considered of importance. During the early implementation stage, measurement rarely takes place, but interviewing key stakeholders –the methodology used in our study- is recommended. As companies move into more advanced stages the need for measurement steadily increases and during the latest stages, when KM becomes a way of doing business, the importance of KM-specific measures diminishes.

APQC recognize that measuring knowledge management is not simple, and is in fact analogous to measuring the contribution of marketing, employee development or any other management or organizational competency. But this does not stop APQC from proposing certain types of measurements appropriate for each stage.

1.2 Synthesis of Previous Studies

Measuring manufacturing performance is a very significant task as it strongly affects the behaviour of managers and employees not only of the manufacturing group, but those of the collaborating groups (in our case the quality and R&D groups). After all, the ultimate test of any business is whether it leads to measurable improvements in performance.

The extended literature analysis presented above, where business performance in general is the focus, yields some observations. First, it points out that the link between knowledge management (KM), information technology (IT), and business performance is not a simple issue. It involves two basically different research areas: The measurement –in terms of both qualitative and quantitative results- of a KM project's impacts and, at the same time, the identification of the cause-effect relationship that exists between KM, IT, and the overall business performance enhancement. Some studies captured KM contribution by measuring outcomes such as knowledge satisfaction, whereas others adopted conventional performance measures (such as ROI and EVA) or more abstract and tailored to the company ones, like CBE. It becomes obvious that, measuring the results that an organization acquires from the implementation of any KM initiative is of great importance.

Second, the role of shared knowledge[3] among a company's departments is not consistent, despite the fact that the knowledge transfer process has been studied extensively. Trust and influence have only been recognized as antecedents of shared knowledge in one study, while in another study, trust and information technology have been considered as knowledge creation enablers among seven others.

Third, an integrative model combining shared knowledge and information technology with performance is still missing. Although some studies investigate the relationship between KM and performance, or IT and

[3] In section 3.2, we shall come back to this issue, demonstrating that lately the concepts of knowledge sharing and knowledge management have almost become synonymous.

performance, they fail to explore the relationships among KM, IT and performance simultaneously. We strongly believe that if managers become conscious of the fact that these relationships have interactive features, they can stand a much better chance of improving their departments' or company's performance.

Another significant outcome from the above literature analysis is the identification of the company's strategy –by the majority of the authors- as the most important factor driving KM initiatives. The way Zack (1999b) puts it "An organization's strategic context helps to identify knowledge management initiatives that support its purpose or mission, strengthen its competitive position, and create shareholder value" (pp. 125-126). And he concludes, by noting that "If knowledge management is to take hold rather than become merely a passing fad, it will have to be solidly linked to the creation of economic value and competitive advantage. This can only be accomplished by grounding knowledge management within the context of business strategy." (p. 142). Thus the relevance of strategy and measurement of the results obtained from KM initiatives are two issues that have to be very closely considered.

1.3 The Proposed Evaluation Model

Aiming to gain insight into the essential factors influencing manufacturing performance, we chose to develop and empirically test a conceptual model containing the minimum selected theoretical constructs. Three have been our major concerns, upon building our research model. First, we did not want to propose a model that delineates all the variables or processes that affect manufacturing performance. Second, we wanted to focus on shared knowledge as the leading expression of knowledge management, among the manufacturing, quality and R&D groups of a firm. Third, information technology, in our model, has been perceived to affect both manufacturing performance and shared knowledge.

Therefore, we have opted for our model to highlight a few key factors that can explain a large proportion of the variation noted in manufacturing performance. We have modified the sharing knowledge model validated and used by Nelson & Cooprider (1996) and we enhanced it with links allowing us to draw conclusions on the role and contribution of information technology as an enabler and facilitator towards both manufacturing performance and shared knowledge. The proposed evaluation model shows cause and effect links between sharing knowledge, its components, information technology and manufacturing performance. In this respect we consider the model more consistent than the intellectual capital or the tangible and intangible approach used in other studies. In this respect we coincide with Chong et al (2000, p.367) who claim that "… analytical techniques to assess returns from intangible investments are in their infancy".

Schematically, our empirical evaluation model illustrates the relationships among the five variables as shown in Figure 1. To a great extent, our hypotheses derive from theoretical statements found in the literature related to knowledge management and information systems and technology. In the following paragraphs, we shall elaborate upon the variables incorporated in our model and, at the same time, we shall present our investigation hypotheses.

Upon defining shared knowledge in our introduction, we have already hypothesized that shared knowledge among manufacturing, R&D and quality groups will have a positive impact on the performance of the manufacturing group. As we do not have *a priori* reasons to expect a different relationship, it is here that we are founding our first hypothesis.

> **Hypothesis 1**: Shared knowledge among Manufacturing, R&D and Quality groups, as perceived by the manufacturing organization, leads to improved manufacturing group performance.

In an effort to make more comprehensible the relationship between shared knowledge and the manufacturing group performance, we shall now define the two components or antecedents of shared knowledge: Trust and Influence.

Trust

The significance of trust has been given considerable attention in the last decade. Trust has even been described as a ‘business imperative’ (Davidow and Malone, 1992; Drucker, 1993 among others). According to Huemer, von Krogh and Roos (1998, p. 123) “Trust is commonly regarded as crucial since its roles or functions for the well being of business relationships are cardinal”. Zucker (1986) defines trust as “a set of expectations shared by all those in an exchange”. In a similar way, Sitkin and Roth (1993) define trust as a set of expectations that tasks will be reliably accomplished. Lee and Choi (2003, p. 190) define trust as “… maintaining reciprocal faith in each other in terms of intention and behaviors”. Under this perspective, we can conclude that when the relationships among the individuals involved in an exchange are high in trust, people are more willing to participate in creative knowledge sharing. According to Bradach and Eccless (1989) trust is an expectation that alleviates the fear that one’s exchange partner will act opportunistically. We can thus gather that high level of trust contributes in maintaining reciprocal faith in each other in terms of intentions and behaviors.

Nelson and Cooprider (1996, p. 413) define mutual trust as*:* “the expectation shared by the [involved] groups that they will meet their commitments to each other.” In this sense, trust may facilitate open, extensive, and influential knowledge sharing. Szulanski (1996) empirically found that the lack of trust among employees is one of the key barriers against knowledge sharing and that the increase in knowledge sharing brought on by mutual trust results in knowledge creation.

In the framework of this research, we can assume that Manufacturing, R&D and Quality groups work better in an atmosphere of mutual trust based on mutual commitment and a stable long-term relationship, which is the foundation for our conceptualization of trust. In this type of cross-functional or interorganizational collaborations, trust is a critical parameter, because withholding information due to lack of trust can be particularly harmful to knowledge sharing.

Although it may also seem reasonable that sharing knowledge might lead to trust, trust –developed through repeated communication- is shown to be different from and a determinant of shared knowledge. The increase in mutual understanding, brought on by mutual trust, results in shared knowledge among the groups. Trust also leads to appreciation through the common belief in the performance of the groups involved. We thus hypothesize that mutual trust is a determinant of shared knowledge and it is here that we advance our second hypothesis.

> **Hypothesis 2**: The perception of increased levels of mutual trust among Manufacturing, R&D and Quality groups leads to increased levels of shared knowledge among these groups.

Influence
As organizational groups engaged in joint work are often dependent upon each other, influence relationships are created. One way influence is developed, is through the law of reciprocity (Cohen and Bradford, 1989). People expect payback for contribution to an exchange. The perception of reciprocal benefits leads to mutual influence and success in future exchanges among the groups. It is not to be overlooked that influence, in a business environment, may also have a negative sense, but for the purpose of this research, we focus on its positive sense. In contrast with trust, influence has not received large attention in the reviewed literature, most probably because it did not affect the relationships of the groups involved in it the way we expect it to do so in our study.

Nelson and Cooprider (1996, p. 414) define mutual influence as: “the ability of groups to affect the key policies and decisions of each other.” Consequently, we expect the following relationship to hold true and it is here that we are basing our third hypothesis.

> **Hypothesis 3**: Increased levels of mutual influence among manufacturing, R&D and Quality groups lead to increased levels of shared knowledge among these groups.

One should not overlook, of course, that once shared knowledge is achieved, it may result in higher levels of mutual influence among groups.

Figure 1 presents the complete Shared Knowledge and Information Technology evaluation model to be used in this research. The central part of the model illustrates the two important aspects of shared knowledge.

- First, mutual trust and influence are presented as antecedents of shared knowledge.
- Second, shared knowledge is presented as a mediating variable between mutual trust and influence, leading to manufacturing group performance.

Therefore, we can hypothesize:

> **Hypothesis 4**: Shared knowledge acts as a mediating variable between mutual trust and influence and manufacturing performance.

As we have no *a priori* reasons to exclude that mutual trust and influence could possibly affect manufacturing performance directly, to a certain extent, we are here introducing our fifth hypothesis.

> **Hypothesis 5**: There is a positive relationship between mutual trust, mutual influence, and manufacturing performance.

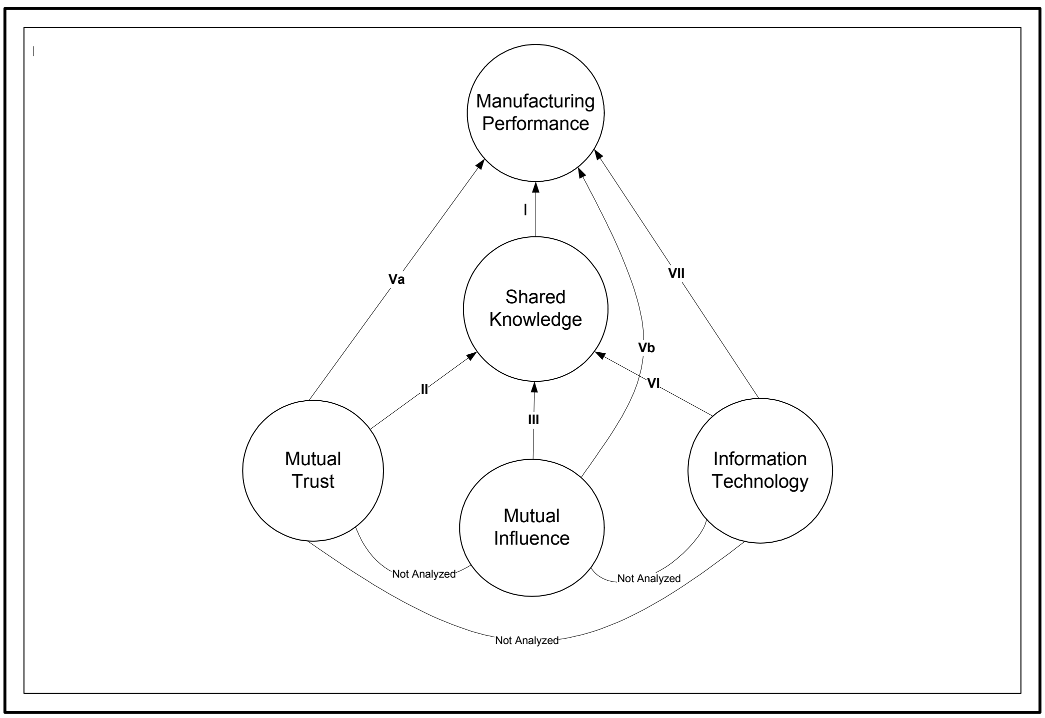


Figure 1. The Shared Knowledge and Information Technology Evaluation Model

Information Technology

Communication, under the perspective of our study, is considered an antecedent of mutual trust and influence. That is, repeated and frequent communications contribute to manufacturing group performance through the development of mutual trust and influence leading to shared knowledge. In the new economy era, information technology (IT) has a very significant role to play in supporting both communication and, in particular, knowledge sharing. IT affects knowledge sharing in a variety of ways:

- IT facilitates rapid collection, storage, and exchange of knowledge in a scale not possible up to recent times, thus fully supporting the knowledge sharing process (Roberts, 2000).
- Specially developed IT integrates fragmented flows of knowledge, eliminating, in this way, barriers to communication among departments (Gold et al, 2001).
- Advanced IT (like electronic white-boarding and videoconferencing) encourages all forms of knowledge sharing and is not limited to the transfer of explicit knowledge only (Riggins and Rhee, 1999).

Thus we can hypothesize:

> **Hypothesis 6**: There is a positive relationship between IT support and the knowledge sharing process.

Manufacturing Performance

For the purpose of our study, organizational stakeholders in every participating company have been questioned to assess the manufacturing group performance, based on broadly accepted output measures (such as market share, profitability, growth rate, innovativeness, successfulness) and, in addition, to compare the manufacturing unit under investigation with other units they have managed. Madnick (1991, p. 30) points out the major ways in which IT support affects manufacturing group performance:

- IT provides opportunities for increased inter- and intra-organizational connectivity and, thus, increases both efficiency and effectiveness,
- new IT architectures offer significant cost/performance and capacity advances, and finally
- with IT support, adaptable organizational structures that lead to significant cost reductions are made possible.

As there are also a significant number of other variables (such as employees' competences and qualification, raw material quality, technology level of the machinery in use, etc) which affect manufacturing group performance and are not included in our model, we can only hypothesize:

> **Hypothesis 7**: There is a positive relationship between IT support and the manufacturing group performance.

The variables incorporated in our model are structured upon a socio-technical perspective that "… adopts an holistic approach which highlights the interweaving of social and technical factors in the way people work" (Pan and Scarbrough 1998, p.57). Based on this view, the two authors describe an organization from both the social and technical perspectives, which are often used in research related either to knowledge management or information systems management. In our study, the organization is considered to be made up of two equally independent but correlative interacting components: mutual trust and influence, as related to the organizational structure and culture as well as to the employees themselves, are considered social variables; on the other hand, IT is considered a technical variable. For purposes of clarity, most studies consider the impact of social and technical variables independently, a precaution we are also adopting for our study.

Based on the Shared Knowledge and Information Technology evaluation model presented in Figure 1 and the above assumptions, we shall investigate the contribution of shared knowledge to manufacturing performance and the supporting role of IT towards both sharing knowledge and manufacturing performance. In the next section, we shall present the methodology of our research.

1.4 Investigation Methodology

The methodology that has been used in order to contrast the investigation hypotheses mentioned above reflects a study method to a specific investigation, which has been specified as the research advanced through the following stages.

State-of-the-Art
The literature research on the various aspects linked with the Thesis has offered us the opportunity of a systematized compilation of the Knowledge Management and Information Technology related methods and tools, available within the academia and the industrial world. In this study, state-of-the-art issues are discussed in four chapters. In chapter 2, we focus on the state-of-the-art issues on Knowledge, Knowledge and/or Intellectual Capital Management, and Information Technology, which are the basic issues of our investigation. In section 3.2 and chapter 4, we investigate into the state-of-the-art on more specific issues (like Sharing Knowledge and Systems for Supporting Collaboration and Knowledge-based Work) and their relation to Performance, the subject matter of our investigation. Finally, in section 5.2 we once again look into the same issues, this time under the globalization perspective.

Theoretical Framework
The theoretical framework upon which our investigation is based has been established early in our study and is presented in chapter 3. We have adopted the Knowledge-based theory of the firm, proposed by Grant (1997) and Sveiby (2001). This theory offers an alternative to the product-based or competitive advantage view, primarily of Porter (1985), building on research developed during the last decade of the 20th century (Prahalad and Hamel, 1990; von Krogh and Roos, 1995; Grant, 1996) towards a resource-based theory.

Design of the Investigation
The various phases of our research, as analytically presented in chapters 6 and 7, are:

- The design of the two questionnaires, which are the principal research instruments. The relationship questionnaire addresses matters concerning characteristics of the relationship among manufacturing, R&D and quality groups. The performance questionnaire tackles matters concerning the manufacturing group performance and has been addressed to "stakeholders" in each company: executives and senior managers supervising the three groups involved. Special effort has been made to customize every questionnaire in order to include the names of the specific groups as used in every company, in an effort to avoid misunderstandings.

- The research has been conducted in two phases. In phase one, measures and collection instruments have been developed. First step was to identify an initial set of measurement items as candidates for later use in the construct scales. Some candidate indicators have derived from published research articles, and some others have been generated from the above mentioned contacts and interviews with executives managing organizational 'partnership-style' relations. A pilot questionnaire was created and tested using a small group of managers from organizations not participating in phase two of the research.

- Design of the indicators and measures has been a task of significant importance. Two types of measures have been used to assess the organizational characteristics of the variables in our evaluation model (Figure 1): general and multiplicative.
  - General, where each informant is asked to assess the overall level of interaction for a specific characteristic of a particular relationship
  - Multiplicative or interaction measure, where each informant is asked to assess separately the role of manufacturing and either R&D or quality group for each characteristic. Using the proposed by Venkatraman (1989) conceptualization of fit as interaction, the measurements have been operationalized as 'manufacturing role X R&D or quality role', by multiplying the two responses together.

  There are a number of advantages to this measurement scheme:
  a) the two types of measures (general and multiplicative) can be thought of as two distinct methods,
  b) it provides a stronger test of the validity of the measurement scheme,
  c) it balances possible threats to validity inherent in either type alone.

  Manufacturing group performance has been conceptualized in two parts: operational and service performance.
  - Operational (or 'inward') performance is operationalized as the quality of the manufacturing group's work product, the ability of the manufacturing group to meet its organizational commitment, and the ability of the manufacturing organization to meet its goals.
  - Service (or 'outward') performance is operationalized as the ability of the manufacturing group to react quickly to R&D and/or quality needs, its responsiveness to the R&D and/or quality group, and the contribution the manufacturing group has made to the R&D and/or quality group's success in meeting its strategic goals.

- The research responders have been chosen based on the key-informant methodology developed by Phillips and Bagozzi (1986) and included –for each company- manufacturing, R&D and quality group managers or their deputies, as well as senior managers. As the measurement of organizational characteristics requires research methods different from those used for measuring the characteristics of individuals, key-informant methodology is a frequently adopted approach.

- Validity threats have been given special consideration, in our study, and the following criteria have been applied:
  - Bagozzi Construct Validity Criteria,
  - Cook and Campbell Construct Validity Criteria, and
  - Huber and Power Key-informant Validity Criteria.

- The field research framework has been established by pre-selecting the companies from which data for the research were collected. Finally 51 medium to large size industrial companies, representing 5 sectors (alimentation, automotive, chemical and pharmaceutical, electro-mechanical, and textile) participated in the research. The size of the company has been used as a criterion, due to the fact that the unit of analysis of the research is the manufacturing group. It was, for this reason, convenient for the selected companies to have multiple manufacturing groups (or departments/divisions/lines as they might be named) who would cooperate with preferably one R&D and one quality group, respectively.
  This prerequisite is not far from the real industrial world situation, as most of the big industrial organizations tend to have various, remote or not, manufacturing facilities and, at the same time, central R&D and quality divisions. This has allowed the research to be addressed to a big number of manufacturing groups, out of which 112 have participated by responding to the relevant questionnaires.

Analysis of the Results

Given this information, a detailed analysis of the obtained results has been conducted and it is presented in chapter 8. The proposed Shared Knowledge and Information Technology evaluation model (Figure 1) has been tested empirically using the following statistical method and program:

- Path analysis, a regression-based technique, proposed by Pedhazur (1982) that permits the testing of causal models using cross-sectional data and normalized path coefficients (*betas*) in order to determine the strength and direction of causal paths or relations.
- MINITAB (version 14), an Excel like and user-friendly program, fully compatible with the Office 2003 tools. It offers full graphic and text capabilities, an ODBC interface for databases handling and a powerful macro language that permits automating and personalizing the tasks.

Hypotheses 1 to 7 have been tested and supported –fully or partially- by the significance of paths I to VII, respectively.

Finally, four confirmatory tests, Cronbach's *alphas*, the Multi-Trait Multi-Method correlation matrix, Linearity and Collinearity tests, and the Analysis of

Variance (ANOVA) have been carried out in order to further secure the validity of the hypotheses.

1.5 Summary

In this chapter, first the Thesis question has been placed: To investigate the concept of shared knowledge, among Manufacturing, R&D and Quality groups, as a key contributor to manufacturing group performance. In addition, the importance of the emerging information technology in the so called society of knowledge and the global economy environment will be investigated in relation to both manufacturing performance and shared knowledge.

Second, we have analyzed a significant number of previous empirical studies and grouped them in six major categories, based on their target and, mainly, the unique approach used for achieving it.

Third, after a synthesis of the above studies, we built the Shared Knowledge and Information Technology evaluation model proposed for use in our study and utilized it for formulating the investigation hypotheses.

Finally, we have deployed a particular methodology for the development of the Thesis. In the next chapter we present state-of-the-art issues and in chapters 3–8 to follow we deploy our methodology as described in the following quick Thesis Overview.

1.6 Thesis Overview

In chapter 2, we start our investigation into the state-of-the-art by focusing on the issues of Knowledge, Knowledge and/or Intellectual Capital Management, and Information Technology, which are considered very essential for our investigation. Later, in section 3.2 and chapter 4 –after having established the theoretical framework- we continue investigating into the state-of-the-art on more specific issues (like Sharing Knowledge and Systems for Supporting Collaboration and Knowledge-based Work) and their relation to Manufacturing Performance –the subject matter of our investigation. Finally, in section 5.2, we are once again focusing onto the same issues, this time under the perspective of global economy.

In section 3.1 the theoretical framework is defined, built upon the ‘knowledge-based theory of the firm’ endorsed primarily by Robert Grant and Karl-Erik Sveiby. The theory has received influences from earlier research lines. It is considered to originate from the ‘epistemology’ of the cognitive philosophers and –through contradiction to the transaction cost economics and the traditional product-based or competitive advantage view- it builds heavily upon the ‘resource-based theory’.

In chapter 5, we are briefly looking into today's global economy era and, under this perspective, we examine the influence that the globalization phenomenon has had into the recent information technology developments. Managing and sharing knowledge in practice is here regarded as an answer to globalization.

In chapter 6 the design of our research and its various phases are presented. First, two types of questionnaires, one dealing with the relationships of the groups involved and a second addressing the performance issue, are presented as the principal research instruments. They were designed carefully and pilot tested prior to application. Second, the design of the indicators and measures is carried out using two types of measures, general and multiplicative, for all the variables. Manufacturing group performance is conceptualized in two parts: operational and service performance. The research responders have been chosen based on the key-informant methodology and include –for each company- manufacturing, R&D and quality group managers or their deputies and senior managers. Validity threats have been given a special attention and three different types of validity criteria are applied.

In chapter 7 the field research framework is presented and the sectorial sample of industrial companies, from which the data for our research were collected, is brought together. Finally 51 medium to large size industrial companies, and a total of 112 manufacturing groups, representing 5 sectors (alimentation, automotive, chemical and pharmaceutical, electro-mechanical, and textile) participated in the research. The size of the company has been used as a criterion, as it was convenient for the selected companies to have multiple manufacturing groups. The 112 who participated in our research have responded to both types of the questionnaires, with the required number of key-informants.

In chapter 8 the analysis of the results is presented. The proposed evaluation model has been tested empirically using path analysis, a regression-based technique that permits the testing of causal models using cross-sectional data and normalized path coefficients (betas) in order to determine the strength and direction of causal paths or relations. The investigation hypotheses have been tested and fully or partially supported, by the significance -or insignificance- of the relevant paths. Finally, four confirmatory tests, Cronbach's *alphas*, the Multi-Trait Multi-Method correlation matrix, Linearity and Collinearity tests, and the Analysis of Variance have been conducted in order to further secure the validity of the hypotheses.

Finally, in chapter 9, our conclusions are presented together with a reference to the study's limitations and some recommendations for future research. Based on the literature and the results of our research we are demonstrating that the two main findings of the study –the proved significant contributions of (a) shared knowledge to the manufacturing group performance, and (b) information technology to, mainly the manufacturing group performance and, secondarily to sharing knowledge- are useful to researchers, as well as the businesses management community. Manufacturing, Quality and R&D groups have the opportunity, to increase shared knowledge and, in this manner, to positively affect manufacturing group performance, by developing mutual trust and influence through repeated periods of positive face-to-face or IT-based communication, social interaction and common goal accomplishment. Information technology definitely acts as an enabler and a facilitator in the entire spectrum of the above transactions.

Chapter Two
State of the Art

Chapter 2. STATE OF THE ART

> "Our knowledge can only be finite,
> while our ignorance
> must necessarily be infinite."
> Karl Popper

Although it is this chapter only entitled 'State of the Art', in this Thesis state-of-the-art issues are discussed in four chapters. We shall first, in this chapter, look into the state-of-the-art issues on Knowledge, Knowledge and/or Intellectual Capital Management, and Information Technology, which are basic issues of our investigation. In section 3.2 and chapter 4, we shall continue investigating into the state-of-the-art on more specific issues (like Sharing Knowledge and Systems for Supporting Collaboration and Knowledge-based Work) and their relation to Performance –the subject matter of our investigation. Finally, in section 5.2 we shall look into the same issues under the globalization perspective.

First question: Why all this recent interest in knowledge? If we judge from the number of conferences as well as articles in both academic and business journals, we shall come to the conclusion that knowing about knowledge has become critical to business success and survival. As Davenport and Prusak (2000) note in the introduction of their book (from where Benjamin Franklin's quote, at the first page of our chapter 1 is also cited) we are faced with a "new emphasis on an age-old subject" (p. xviii). An issue that has been first analyzed by Plato and Aristotle and has continued to concern many philosophers after their time. But, as Davenport and Prusak note, managers have only recently realized the fact that they have relied on knowledge throughout their careers, long before the days of 'core competencies' and the 'knowledge-based theory' of the firm. Managers always valued the experiences and the know-how of their employees, which is exactly what we now label as their knowledge.

If this could be considered a philosophical answer, other distinguished academics (Drucker 1985 and 1988, Porter 1985) have given a more realistic answer to the above question: Because knowledge is generally recognised as the main source of sustainable competitive advantages in society nowadays.

After the two industrial revolutions of the 18th and the 19th centuries, at the closing of the 20th century we are facing a new revolutionary era, product of the expansion of the Information Technology (IT) and Telecommunications. However, both are no more than a means for the transmittance of contents (texts, images, films, songs, etc) and for the efficient management of knowledge, which in the opinion of the scientific community is the main source of sustainable competitive advantages for organizations. On this matter Laurence Prusak, Director of Knowledge Management in IBM states that: "The main source of competitive advantages for the industry resides fundamentally in its knowledge, or, to be more precise, on what it knows, how it uses what it knows and on its capacity to learn new things" (WEB-02). Along these lines and in connection with this prominence of knowledge the actual society also receives the name of Society of Knowledge.

The Society of Knowledge is the society of the future in which innovation, investigation, education and training are the key elements for the growth and the competitiveness of organizations, of regions and countries. As we are heading towards a Knowledge-based economy, structural, political and economical changes affect not only the industrial unit but also the society as a whole.

Innovation and Knowledge share a tight relationship that has already been marked by Drucker (1985). The above mentioned relationship is noticeable in the area of industrial competitiveness as a factor of development and as a fundamental element for the creation of value. In order to appreciate innovation and R&D from a Knowledge Management perspective, we have to understand the flow of knowledge in the industry.

There is a dynamic cycle of Knowledge, [which Nonaka (1991) presents in the form of a spiral] within the industry which reflects the process of generation and its consolidation: create, capture, organize, share… It is a never-ending process, which is continuously being updated, generating new spirals of creation of knowledge.

It should be accentuated that knowledge is an element that becomes stronger with its use, that does not wear out but instead it increases. The generation and distribution of knowledge in the future, in a world in which IT and communication have opened a new path, come to grant special importance to the matter of industrial development.

Concentrating our analysis on the industrial sector we have based it on concepts like globalization, competitiveness and new technologies. Knowledge improves competitiveness, by contributing value to existing products and services, favoring the appearance of products based on knowledge, reducing the cycle of innovation and providing continuous training for employees. Under a similar perspective the European Union, in the European Summit in Lisbon[4] defined the creation of infrastructures of knowledge and the increase and modernization of the educative systems as an urgent challenge and as a strategic objective.

[4] Presidential Conclusions, European Summit of Lisbon, 23-24 March, 2000. SN 100/00

2.1 Knowledge and Knowledge Management

For most of today's researchers 'knowledge' is not a new issue. They have studied it in graduate school under topics like 'intellectual history' or 'sociology of knowledge' but recently it became the new focus of their research. They all agreed that knowledge was centrally important for most organizations. Winter (1994) describes business firms as "organizations that know how to do things" (p. 189). For Winter, a company truly is a collection of people organized to produce something; goods, services or a combination of the two. Their ability to produce depends on what they currently know and on the knowledge that has become embedded in the routines and machinery of production. The material assets of a firm are of limited value unless people know what to do with them. So, if "knowing how to do things" defines what a firm is, then knowledge is the company in a very important sense.

2.1.1 Data, Information and Knowledge

Researchers in the area of knowledge and knowledge management define knowledge, in most cases by building upon previous definitions. Here, we shall present a selection of definitions, starting with one that clarifies the difference among Knowledge, Data and Information as in informal language the three terms are often used indistinguishably and this could lead to a free interpretation of the concept of knowledge.

Davenport and Prusak (2000) early in their book clarify that "Knowledge is neither data nor information, though it is related to both …" and further down they say that "… data, information, and knowledge are not interchangeable concepts." (p. 1). In their clearly written account, they point out that confusion among the three has resulted in many organizations investing large amounts of money in the technology of knowledge management without achieving any useful results. They consider that understanding the difference among the three concepts is crucial: "Organizational success and failure can often depend on knowing which of them you need, which you have, and what you can and can't do with each. Understanding what these three things are, and how you get from one to another is essential to doing knowledge work successfully" (p.1). We are summarizing here below how they distinguish among the three concepts in pages 1-6 of their above mentioned book.

Data is hard, factual information often in numerical form - it can tell you when, and how often something happens, how much it costs and so on but it does not say why it happened. Organizations love accumulating vast quantities of data - the sheer bulk of which serves to confuse and obscure any value.

Information for Davenport and Prusak comes in the form of a message - and it is the receiver rather than the sender of the message who determines that it is information - through some communication channel whether voice, e-mail, letter, etc. It is different from data in that it has meaning or shape. In fact, data can be transformed into information with the addition of meaning. The two authors (in p. 4) list a number of ways for doing it, all beginning with C:

- Contextualized - the purpose of the data is known;
- Categorized - the unit of analysis or key component is known;
- Calculated - perhaps through a statistical or mathematical analysis;
- Corrected - through the removal of errors;
- Condensed - by being summarized or tabulated.

Knowledge transcends both data and information in a number of ways. It is a mixture of experiences, values of information and know-how, which serves as a frame for the creation of new experiences and information. It is fluid although at the same time has a formal structure and can be considered both as a process and a stock. It derives from information -in a similar way information derives from data- via a transformation, which takes place in and within persons. The two authors (in p. 6) list a number of transformation procedures, all starting with C:

- Comparison – with other situations we have known;
- Consequences – for our decisions and actions;
- Connections – how does it relate to others;
- Conversation – what do others think about it.

In a similar way, Zack (1999a) distinguishes knowledge from data and information:
Data represent observations or facts out of context that are, therefore, not directly meaningful.
Information results from placing data within some meaningful context, often in the form of a message.
Knowledge is that which we come to believe and value on the basis of the meaningfully organized accumulation of information (messages) through experience, communication, or inference.
He also states that knowledge may also vary from:

- General which is broad, publicly available and independent of particular events, to
- Specific, which in contrast is context-specific (Both context & contextual categories must be described/defined by the firm).

Nonaka & Takeuchi (1995) and von Krogh, Ichijo & Nonaka (2000) define knowledge as a justified true belief: When somebody creates knowledge, he or she makes sense out of a new situation by holding justified beliefs and committing to them. The emphasis in this definition is on the conscious act of creating meaning.

According to Sveiby (2001) above definition is building on Plato and arguing against the Descartian body and mind split. In previous works, Sveiby (1994, 1997) building upon (Polanyi, 1958) and (Wittgenstein, 1995), defines knowledge as a capacity-to act, which may or may not be conscious. The emphasis of the definition is on the action element: A capacity-to-act can only be shown in action. Each individual has to re-create his or her own capacity to act and reality through experience. Sveiby (2001) offers his own distinction of knowledge, data and information: Knowledge defined as a “capacity-to act” is dynamic, personal and distinctly different from data (discrete, unstructured symbols) and information (a medium for explicit communication).

Cohen (1998) in his report of the U.C. Berkeley Forum on “Knowledge and the Firm” quotes a number of definitions that have been given, by different participants, during the forum:
John Seely Brown (of Xerox) defines knowledge, in a similar to the above way, as “justified or ‘warranted’ beliefs relative to a framework” (p. 28). The framework (or shared context) is created by the shared practice of a community drawn together by work. For Seely Brown, the community of practice is the main source of knowledge creation, and like Nonaka, he sees knowledge creation as a dynamic group process of seeking meaning and testing beliefs.
Rashi Glazer (of the Haas School of Business) defines knowledge as “information given meaning” (p. 33) in a very similar way to that of Davenport and Prusac (2000) quoted above.
David Teece (also from the Haas School of Business) defines knowledge as “information in context” while, as Cohen notes, “participants [of the forum] understand ‘context’ in roughly the same way: as a wider view, a setting, statement, or body of information that explains or gives meaning to words, ideas, or actions” (p. 30).

From what we have seen until now, it is obvious that there is no unanimity in defining knowledge. In order to do that, researchers will first have to search for a common vocabulary to express a common understanding of the basic knowledge concepts. Cohen (1998) reports Paul Duguid (of the U.C. Berkeley School of Education) cautioning that “there is a trap in assuming we will suddenly hit on the one right definition of ‘knowledge’. It is neither possible nor desirable to validate a single set of terms and meanings and banish the rest. (…) Language is both the common ground on which we meet and the medium through which we express the diversity of our ideas” (p. 35).

The difficulty for defining knowledge originates on the very intangible meaning of the term: knowledge, wisdom, intelligence are concepts constantly revised and redefined as part of cognitive psychology and philosophy of science. It might be due to this lack of coincidence that we have such a variety and diffusion to the interpretation of Knowledge Management.

2.1.2 The Nature and Creation of Knowledge

In the relative literature, one can find various classifications for knowledge. It is first Polanyi (1958) who makes the critical distinction between tacit and explicit knowledge, by noting that people can know more than they can tell. The most extensive, is the one proposed by Nonaka & Takeuchi (1995), which as they admit, derives from the above mentioned work of Polanyi. According to this classification:

Tacit knowledge is subjective and experience based knowledge that cannot be expressed in words, sentences, numbers or formulas, often because it is context specific. This also includes cognitive skills such as beliefs, images, intuition and mental models as well as technical skills such as craft and know-how. Tacit knowledge is highly personal and hard to formalize, making it difficult to communicate with others.

Explicit knowledge is objective and rational knowledge that can be expressed in words, sentences, numbers or formulas (context free), and shared in the form of data, specifications, manuals etc. It includes theoretical approaches, problem solving, manuals and databases. It can be readily transmitted between individuals formally and systematically.

This distinction of the types of knowledge uncovers the existence of a more tangible knowledge, the explicit knowledge, consequently more adaptable in appearance and with a clearer relationship or link with the term 'information'. Polanyi (1966) made the confusing assumption that all knowledge has tacit dimensions, but today most scientists and researchers agree that knowledge exists on a spectrum. At one extreme of the spectrum it is almost completely tacit, that is, semiconscious and unconscious knowledge held in peoples' heads and bodies. At the other end of the spectrum, knowledge is almost completely explicit, or codified, structured, and accessible to people other than the individuals originating it. Of course, most knowledge exists in between the two extremes of the spectrum.

According to Nonaka and Konno (1998), explicit is the form of knowledge that has been emphasized in the West world, while many Japanese view knowledge as being primarily tacit. Cohen (1998, p. 24) identifies some more differences between the Western (primarily U.S.) and the Eastern (primarily Japanese) ways of perceiving knowledge issues. Westerns are focused on knowledge re-use, knowledge projects, and knowledge markets; Easterns, on the other side, are interested in knowledge creation, knowledge cultures, and knowledge communities. Westerns aim to managing and measuring knowledge and look for short-term results; Easterns are nurturing knowledge and aim for long-term advantages.

Zack (1994) also states that Knowledge may be of several types, all of which can be made explicit:

- Declarative knowledge, which is about describing something
- Procedural knowledge, which is about how something occurs or is performed, and
- Causal knowledge, which is about why something occurs.

From a more realistic perspective Zack (1999b, p. 133) classifies the knowledge a firm possesses, according to whether it is core, advanced or innovative:

Core knowledge is that minimum scope and level of knowledge required for the company to survive. Companies owning this level of knowledge can not assure long-term competitive viability, but it does represent a basic industry knowledge barrier to entry.

Advanced knowledge is what enables a firm to be competitively viable. Competing organizations may generally have the same level, scope or quality

of knowledge but only when the specific knowledge content varies it enables knowledge differentiation.
Innovative knowledge is that knowledge that enables a firm to lead its industry and to significantly differentiate itself from its competitors. According to Zack, it is innovative knowledge that often enables a firm to change the rules of the game.

Nonaka & Takeuchi (1995) use the distinction between tacit and explicit knowledge in order to explain how an interaction between these two categories of knowledge forms what they call the knowledge creation spiral. Here is how they define the four different modes of knowledge creation:

- Socialization: from tacit knowledge to tacit knowledge.
  It is the process to acquire tacit knowledge through sharing experiences by means of oral expositions, documents, manuals and traditions, which adds new knowledge to the collective base, owned by the organization.

- Externalization: from tacit knowledge to explicit knowledge.
  Is the process of converting tacit knowledge in explicit concepts which presumes that knowledge which is on its own difficult to communicate, becomes tangible by means of metaphors, thus integrating in the culture of the company. It is the essential activity in the creation of knowledge. (i.e. This occurs when someone documents his or her knowledge in an area.)

- Combination: from explicit knowledge to explicit knowledge.
  It is the process of creating explicit knowledge by reuniting explicit knowledge drawn from a certain number of sources, through the exchange of telephone conversations, meetings, mail etc., and which can be categorized, tackled, classified with basic forms of data to produce explicit knowledge. (i.e. Reading a research article demonstrates explicit to explicit knowledge transfer.)

- Internalization: from explicit knowledge to tacit knowledge.
  It is a process by which explicit knowledge is incorporated into tacit knowledge. It analyses the acquired experiences of the new items of knowledge put to practice and is incorporated in the bases of tacit knowledge of the members of the organization in the form of shared mental models or work practices. (i.e. As people consume [read] explicit knowledge, it morphs and merges into their tacit realm of understanding.)

In a more simplified way they say that: explicit knowledge is shared through a combination process and becomes tacit through internalization; tacit knowledge is shared through a socialization process and becomes explicit through externalization.

In a later article, Nonaka and Konno (1998) named this ongoing process of interactions between tacit and explicit knowledge, the SECI model, which serves only as an outline for knowledge creation. In order to answer the fundamental question of how people can be activated to create and share knowledge, they propose the Japanese concept of '*ba*', which roughly translates into English as 'place'. It also means 'field' or a shared place; a physical or mental space, or a combination of both. *Ba*, originally proposed by the Japanese philosopher Kitaro Nishida (1970 and 1990) and further developed by Shimizu (1995), was adapted by Nonaka and Konno for the purpose of elaborating SECI, the knowledge creation model.

Nonaka and Konno (1998, pp. 45-47) describe four types of *ba* that correspond to the four stages of their SECI model as shown in Figure 2.1.

- Originating *ba* is the place where barriers between self and the others are removed and where socialization encourages the sharing of tacit knowledge that generates new ideas. Physical, face-to-face interactions are the key in this process, while connection, commitment, trust and even love and care are the characteristics of originating *ba*.
- Interacting *ba* is the place where tacit knowledge is made explicit. Dialogue is the key for such conversions; therefore individuals here discuss and analyze their ideas, developing a common understanding of terms and concepts.

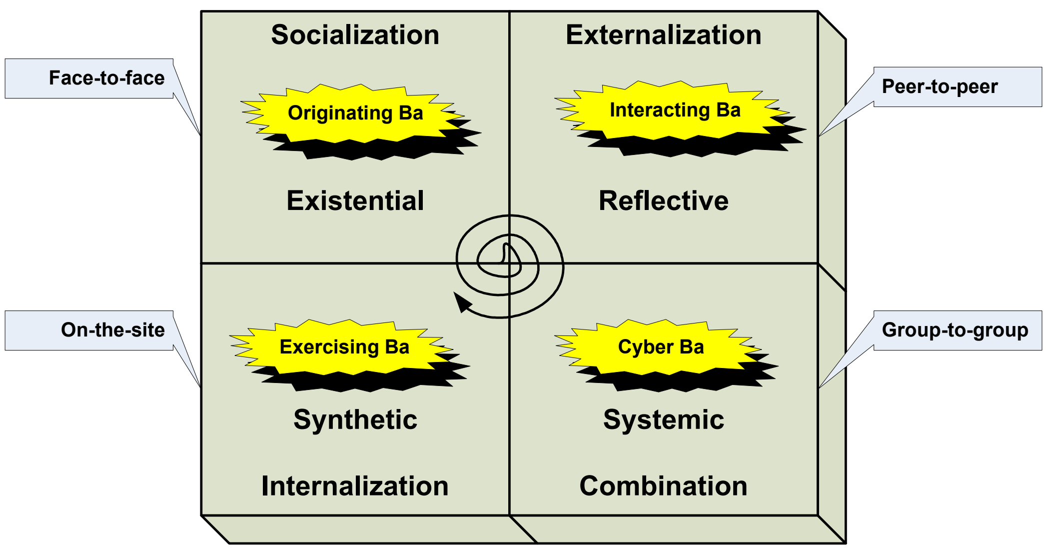


Figure 2.1 The *Ba* platforms in the knowledge spiral process
(Source: Nonaka and Konno (1998), p. 46)

- Cyber *ba* is the place where new explicit knowledge is combined with existing explicit knowledge and is organized, stored and shared through the organization. Cyber ba is the dominion of information technology (groupware, databases and intranets) although meetings and presentations are also important tools.
- Exercising *ba* is where explicit knowledge is converted to tacit knowledge through mentoring and the learning that comes from action.

> This internalized knowledge feeds the next stage of the spiral, contributing to knowledge creation in the area of originating *ba*.

The four types of *ba* correspond to the four stages of the SECI model and offer platforms for specific steps in the knowledge creation process. The knowledge generated within each *ba* is shared and forms the knowledge base of the organization. Tacit and explicit knowledge feed each other in this continual process of knowledge creation, which –according to Nonaka and Konno- is not merely circular but spiraling upward. We shall further build on this concept when referring to the different possible collaboration schemes, in section 4.1.

2.1.3 Knowledge and Intellectual Capital

Organizations today are facing an increasingly elusive challenge; more and more of the value of an organization is becoming intangible. Fifty years ago, 'hard' assets such as equipment and tooling represented three-quarters of a company's value. Today, in the excessively competitive society of our time, hard assets represent only about half of a company's value. The other half belongs to 'soft' assets such as the employees' knowledge. In knowledge-intensive organizations, where their market value is often several times their "book" or accounting value, there is a clear need to incorporate intangible assets in their books. So, 'knowledge capital' should be reflected on the company's balance sheet. Effectively managing an organization now requires effectively managing intangible assets that have their origin in the knowledge of every person whom the company consists of, and that by their very nature, have proven challenging to directly manage. The esoteric and subjective nature of knowledge makes it almost impossible to assign a fixed and permanent value to knowledge.

Stewart (1998) redefined the priorities of businesses around the world, demonstrating that the most important assets companies own today are often not tangible goods (land, factories, equipment, cash), but the intangibles ones: patents and copyrights, the knowledge of workers, and the information about customers and channels and past experience that a company has in its institutional memory. For Stewart, "Intellectual capital is intellectual material – knowledge, information, intellectual property, experience- that can be put to use to create wealth" (p. xi).

It is evident that the knowledge that the company possess will not all be a source of sustainable competitive advantages, but only the part that contributes decisively to the production of economic value. Core competencies, or nuclear competencies, are designated amongst them. Nonetheless, as core or nuclear competencies generate economic value for the company they can be considered, from a financial perspective, as intangible assets, intellectual assets or intellectual capital.

Although definitions and the conceptualizations they are based on are not fully identical, a convergence is noticed in relation to what intellectual capital encompasses. Pioneer researchers and organizations have identified three sub-categories that comprise the conception of intellectual capital. The name each one of them is giving may slightly vary, but all of them have a common sense.

According to Stewart (1998) it is divided into:

- Human Capital
- Structural Capital
- Customer Capital

Above categorization, is "… putting customer capital on the same plane as human and structural capital, on the grounds that customers, like employees, are not the property of the organization" (Stewart 1998, p. 253), and is the one most commonly used.

According to Edvinsson & Malone (1997) it is divided into:

- Human Capital
- Structural Capital

Structural Capital, according to the authors, includes Customer Capital and Organizational Capital, which is further divided into Innovation Capital and Process Capital.

According to Scandia (1996) intellectual capital is structured in a way similar to the one proposed by Edvinsson & Malone and includes, in addition, the company's:

- Intellectual Property
- Intangible Assets

The common points between the two versions are explained by the fact that Leif Edvinsson is Scandia's Intellectual Capital Director.

According to Euroforum (1998) –the most frequently used model by major Spanish companies- it is divided into:

- *Capital Humano*
- *Capital Estructural*
- *Capital Relacional*

The similarities between the Euroforum structure and the one proposed by Stewart (1998) are obvious.

Based on the above basic literature and the work of succeeding researchers on the subject, we are further analyzing here below each one of the above listed components of intellectual capital.

Human capital represents the individual knowledge stock of an organization as represented by its employees. It is the accumulative value invested in employee training, competences and expectations for the future. It is important, because it is a source of innovation and strategic renewal (Bondis 1998, Bondis et al 2002). In a free society organizations cannot own, they can only rent, its human capital (Wiig, 1997a).

Relational (or customer) capital, according to Roos et al (1998) stands for the relationships with internal and external stakeholders. It is the knowledge embedded in organizational relationships with customers, suppliers, stakeholders, strategic alliance partners, etc (Bondis, 1998).

Organizational (or structural) capital is defined as the knowledge that stays within the company at the end of the working day, after the employees have gone for the night. According to Bondis et all (2000) it "… includes all the non-human storehouses of knowledge in organizations which include the databases, organizational charts, process manuals, strategies, routines and anything whose value to the company is higher than its material value" (p. 88). Organizational capital is very often perceived as composed of innovation and process capital.

- Innovation capital refers to the apparent result of innovation in the form of protected commercial rights and trademarks, as well as other intangible resources and values.
- Process capital is the combined value of both value and non-value-creating processes.

The above components of intellectual capital constitute an indication of a company's future and its ability to generate positive financial results. According to Harrison and Sullivan (2000) intellectual capital provides firms with an enormous variety of organizational values like profit generation, strategic positioning (market share, leadership, brand recognition, etc), customer loyalty, cost reductions, improved productivity as well as opportunities for acquisition of innovation from other firms.

Efforts have been made, in the last few years, for the search of methodologies and models that contribute to the improvement of the effective management of this intellectual capital. But the intangible nature of these assets, and the fact that each specific company has its particular combination of key knowledge, have only allowed a relative success.

In Spain some financial institutions like el *Banco BBVA, Banca Catalan*a and *Bankinter* are integrating in their annual reports indicators of Intellectual Capital. Multinational consultants also are pioneering in these fields although most of them centre their efforts in the development of tools for Knowledge Management.

Despite of the evident and increasing importance of the so-called Knowledge Economy, both scientific and professional efforts still remain -according to (WEB-02)- within the mere scope of certain sectors, such as:

- Those realized by consulting companies. Among them, one can mention Ernst & Young, Arthur Andersen, Kaplan and Norton, Technology Broker, Booz & Allen, McKinsey & Company, Centre for High Performance, IBM Consulting Group, KPMG, Peat Marwick, Cap Gemini, etc.
- Those realized by high technology companies whose structure is based on Knowledge. Among them, Hewlett Packard, Dow Chemical, Hughes Space and Communication, Merck, Nova Care, BP Oil, etc.

- Those realized by financial or insurance companies, such as Banca Catalana, Imperial Canadian Bank of Commerce, Banco BBVA, Bankinter, Royal Bank, etc. Among them, the one realized by SKANDIA, under the name Scandia Navigator, has a distinguished character, as its director of Intellectual Capital, Leif Edvinsson, is the co-author, with Michael Malone, of the book "Intellectual Capital: Realizing Your Company's True Value by Finding Its Hidden Brainpower".

Since, generally, the production processes and the use of knowledge are not well coordinated and, on top of that, it is not easy to use this knowledge due to the established culture, some industrial organizations do not apply directly all their potential deriving from knowledge in order to face up to the changes that the market dynamics produce daily. Consequently, it is probable that viable advantages, that have not been considered as important for use, exist, and for this reason a new perspective of the organizational culture, together with Information Technologies, could support the development incorporated into Knowledge Management, thus triggering new competitive prerogatives. We shall further investigate these issues in section 5.2 under the globalization perspective.

2.2 Information Technology (IT)

Let us consider in a nutshell the history of technology. Since the origin of the human species, our distinguishing feature has been our ability to use our intellect to build and use tools to leverage our efforts to gain control within and over our environment. From early hunting tools, through the wheel, the steam engine and electricity, it has always been technology that had proven so successful in solving the technical problems in the work environment.

At the turn of the 20th century, Frederick Taylor revolutionized the workplace with his ideas on work organization, job breakdown and measurement (what we today call Industrial Engineering). It was only during the second half of the previous century that the evolution of computing technologies in business gave real signs of organizational changes. Centralized computer mainframes of the 1960s allowed for massive calculations (the Electronic Data Processing, or EDP of the time) and as the amount of data was increasing, Management Information Systems (MIS), during the 1970s, were put in use in order to convert the data into useful information reports. Soon after the first Information Systems (IS) groups appeared within the organizations. The revolution of the Personal Computer (PC) in the 1980s offered decentralized computing capabilities on the desk of managers, manufacturing automation on the production floor, and distributed information control.

In the mid 1990s, the Internet and related technologies once again gave people, individually and collectively, increasing power to access vast amounts of information in order to accomplish goals. It is worth noticing here that the focus of all these systems was data and information. Thus, it is evident that during the last two decades of the previous century, it was Information Technology (IT) that once again retransformed organizations to an extended degree.

In the modern organization, effective use of technology –and particularly IT- is considered among the key variables that are driving competitiveness. Consider the competitive battles that are fought every day in marketplaces in every region of the world among Ford, GM, and Toyota; IBM, Hewlett-Packard and Dell; Microsoft and Netscape; Exxon, BP and Shell; *Deutche* Bank and Citigroup; and many thousands of other companies, from gigantic multinationals to small businesses. They compete on the value that their products and services offer to customers, including their benefits based on the technical features, and the cost effectiveness that allows them to competitively price these offerings. The efficiency to which technology can be introduced, developed and managed is of major consideration in competitive environments and hence in determining which companies will be the winners and losers in every market.

Porter and Millar (1985, p. 149-150) have since very early warned that "… information technology is more than just computers. Today [1985] information technology must be conceived of broadly to encompass the information that businesses create and use as well as a wide spectrum of increasingly convergent and linked technologies that process the information. In addition to computers, then, data recognition equipment, communications technology, factory automation, and other hardware and services are involved." Despite the fact that they did not foresee, at the time, all 'other hardware and software involved' in today's IT-world, their visualization is remarkable.

Zuboff (1988) identifies another unique and revolutionary aspect of IT. She states that IT does not simply 'automate' information-handling process; it also 'informates', or generates large quantities of information previously unavailable to the organization.

Davenport & Short (1990, p. 11) define Information Technology as "…the capabilities offered by computers, software applications, and telecommunications" and further explain that "Information Technology should be viewed as more than an automating or mechanizing force; it can fundamentally reshape the way business is done" (p. 12) and that "IT can make it possible for employees scattered around the world to work as a team" (p. 19).

L.C. Thurow, in his Foreword to Scott Morton's (Ed., 1991, pp. v-vi) points to the very broad definition of IT, used in the 'Management in the 1990s Research Program of MIT', as: "…including computers of all types, both hardware and software; communication networks from those connecting two personal computers to the largest public and private networks; and the increasingly important integrations of computing and communication technologies, from a system that allows a personal computer to be connected to a mainframe in the office to globe-spanning networks of powerful mainframe computers." In addition, he emphasizes on the IT contribution to the financial world: "Information technologies … are the very means whereby the financial service industry creates markets and distributes its products. Today's world capital markets could not exist without information technologies."

Venkatraman (1994, p. 83) states that "IT is not simply a utility like power or telephone but a fundamental source of business scope reconfiguration to redefine the 'rules of the game'…"

Applegate, McFarlan & McKenney (1999; p. vii) identify Information Technology (IT) as: "…computing, communications, business solutions and services…" and emphasize on the implications of the information explosion, bringing up the example of the rapid expansion of the number of volumes in the Library of Congress. Indeed there was a doubling between 1933 and 1966, a second between 1967 and 1979, and yet another doubling by 1987. And further down (note in p. 3) they explain that "…IT refers to technologies of computers and telecommunications (including data, voice, graphics, and full motion video)."

Information Technology, both in its historical (pre-computer) and modern period, and also for the purpose of our study, has been considered as having four different functions:

- Conversion, storage, processing and communications (Yates & Benjamin 1991) or
- Input-output, storage, processing and transmission (Jonscher, 1988).

We can also opt for, as key characteristics of IT, best suiting to the purpose of our study, the following three, also proposed by Yates & Benjamin (1991):

- Compression of time and distance;
- Expansion and transformation of organizational knowledge;
- Flexibility and adaptability to the needs of virtually any organization.

This view of IT and its applications, both in its past and present forms, provides a useful perspective for thinking about future use of IT. The authors have identified a number of trends that are affecting -and will continue to affect- the development of new IT applications.

Finally Cohen (1998), in his report, gives us the opinion of two executives from the industrial world, as they have been expressed during the U.C. Berkeley Forum. Gordon Petrash and his colleagues at Dow Chemical have seen -during the implementation of a knowledge management project- that "… information technology is not an answer, but a tool that can be effectively used only by people who understand their common purpose" (p. 27). Laurence Prusak, of IBM, in answer to a question about the future role of technology, said that "… cheap wide-band computing will help connect people in the future, but he cautioned against expecting too much from technology" (p. 37). Prusak referred to telephone and the television, as two examples that have recently created 'utopian fantasies' about what technology can do.

From all the above definitions and comments it is clear that IT is not an end in itself. It is a means to the end of business competitiveness and performance.

There are several reasons that have made the mission of successfully managing IT a decisive one for today's organizations:

1. It has recently been considered a strategic asset used to form competitive strategies and modify organizational processes.
2. The applications in which organizations are employing IT have increased in complexity.
3. As the IT capabilities –along with its applications- become more complex, the task of developing strategies and systems to deliver the technology has also become difficult.

Hence, as one of the firm's key resources, IT needs to be planned and exploited within the context of the organization in which it is deployed or being considered.

2.2.1 IT and the Organization

In accordance with the aim of our investigation, we shall now focus on the best ways organizations can use IT in order to support knowledge-based work and, at the same time, positively improve performance. We shall look into IT as one of the key factors in sustaining competitive advantages based on knowledge management. There is no doubt that IT applications (like Lotus Notes and the World Wide Web) have made certain forms of structured knowledge easier to collect, store in repositories and distribute to the desktops of those who need it. Organizations do realize that the role of IT (like the Internet and intranets) in communication and in the way knowledge is actually developed and shared. But we shall always bare in mind the limits, as very cautiously pointed out by Davenport and Prusak (2000, p. xx): "The assumption that technology can replace human knowledge or create its equivalent has proven false time and again".

We will build this section upon the second finding of 'The Management in the 1990s Research Program' of MIT (Scott Morton Ed., 1991, pp. 13-14) stating that: "IT is enabling the integration of business functions at all levels within and between organizations." The continuing expansion of public and private telecommunication networks means that any information, at any time, anywhere and any way corporate managers would like to look at it, could be made available, in most cases, at a reasonable cost. This enormous sped-up in the flow of work is made possible by the electronic network, in a number of ways.

- Within the manufacturing area, at both ends of the value chain. Using Local Area Networks (LANs) many organizations are connecting design, manufacturing, R&D, quality and purchasing, thus creating a real team focusing on one product. Such a team -which is in the center of our investigation-, is expected to accomplish tasks in shorter time, with greater creativity and higher moral than with their previous tools and organizational structures. In principle, with the use of tools like chat, e-mail, e-conference, and groupware there is no part of an organization that is excluded from this team concept. LANs have grown from a rarity in the mid-1980s to the common means of high-speed, intra-office communications among members of work groups who use personal computers.

- As wireless data communication continues to grow in corporations, Wireless Local Area Networks (WLANs) which allow for computers to connect to the Internet without the use of a cable, also grow in usage. The main advantage is that they provide always-on, anywhere communication capabilities to users who are within range of a WLAN node. As McGarvey (2003) notes, there are already 35 million of such installations, with about 15 million of them in corporations which are expected to continue offering WLAN capabilities to their remote or mobile knowledge workers.

- Inter-organizational links (i.e. between the shipping department of a supplier and the buyer's purchasing department) in the form of electronic Just-In-Time (e-JIT) or Electronic Data Interchange (EDI) can be thought of as shifting the boundary of the organization out to include elements of other organizations, thus creating a "virtual" organization. These kinds of networks are constantly replacing either Internal Wide Area Networks (I-WANs, i.e. corporate information networks) or External Wide Area Networks (E-WANs, i.e. public or private telephone networks) providing both voice and data transmission capabilities. A number of WAN technologies, that are totally digital and deal with message switching, are recently replacing the traditional telephone system. It was first ISDN (Integrated Services Networks), then ADSL (Asymmetric Digital Subscriber Line), frame relays and ATM (Asynchronous Transfer Mode), with cable modems coming up fast in some areas.

- Finally, the electronic market is the most highly developed form of electronic integration. While the use of Internet technology for conducting business between corporations has started only since the mid-1990s, the concept has been around[5] since the early 1980s. EDI and the Sabre system, developed jointly by IBM and American Airlines in the early 1960's, are two examples of earlier forms of electronic commerce. Internet has allowed major expansion of the business horizons of small- to medium-sized businesses and other organizations that could not afford extensive private telecommunications networks.

The above three forms of electronic integration have, to varying degrees, the net effect of removing buffers and leveraging expertise both within and across the organization. It should be noted though, that an organization must have the necessary infrastructure of communications software as well as educated and empowered users before any of these forms of integration can be fully exploited.

[5] Nilles (1998, p. 79) claims that "The Internet, a well-kept secret among the military and academic communities for two decades, exploded into public consciousness in 1993… "

We shall now, further define and explain some of the terms already used, building mainly upon Madnick (1991, pp. 34-36); Harrison & Samson (2002, pp. 97-101) and others, wherever specifically cited.

Electronic Mail

In an e-mail application, IT can provide a rapid and convenient means for written communication between two individuals, via multiple electronic intermediaries. The unique advantage of e-mailing is that the recipient does not necessarily have to be in office, or have his PC open, for the communication to be successful. A variation of e-mail is chat-ware, software that allows members of small or even extended groups to intercommunicate synchronously. With various major network service providers –like CompuServe- participating in the software development, chat-ware has recently been made available for corporate Intranets.

Instant Messaging

The advantage of Instant Messaging (IMing) to e-mail is that it provides ultra-fast communication, avoids e-mail gateways, and makes it possible for an instant message just to appear on the recipient's screen. It is no longer a play for teenagers; it has become a key corporate business tool that can bring instant answers to pressing questions. The three major products (AOL's AIM, Yahoo's Messenger and Microsoft's MSN Messenger) are already offered in configurations that give corporations both the immediacy that IMing promises and the control over communications that they desire. With their corporate versions, they provide built-in logging of conversations and a corporate ability to set limits on who has access to the system. The low cost of the corporate version (approximately $30 per seat) is a sign that business use of IMing will soon flourish. As McGarvey (2003) notices the 5,5 million users in 2000 are expected to reach 180 millions in 2004.

Electronic Conferencing

In a combined IT effort to exploit the unique capabilities of both human and computing systems, multiple humans interact using electronic conferencing or brainstorming systems. Here the computing systems help to organize, correlate and structure the information flows, allowing more individuals to participate more effectively than would normally be possible in a non-computer enhanced environment.

Groupware

The concept of groupware was first introduced by Doug Englebart, while at the Stanford Research Institute during the 1960s. Englebart developed Augment, the first integrated knowledge sharing system but for many years groupware used to be synonymous with Lotus Notes. Nowadays, it is seen as a way to encourage the sharing of ideas in a way similar, but simpler, to that of knowledge repositories.

Davenport & Short (1990, p. 19) categorize groupware into "Interpersonal processes [which] involve tasks within and across small work groups, typically within a function or a department." They claim that "IT is increasingly capable of supporting interpersonal processes; hardware and communications companies have developed new networking-oriented products, and software

companies have begun to flesh out the concept of 'groupware' (e.g., local area network-based mail, conferencing, and brainstorming tools)."
According to Johansen, (1991) systems that support groups are important because most people spend 60 to 80 percent of their time working with others. He sees groupware as electronic tools that support teams of collaborators and he believes that they need to be built on platforms already existing within the organization (i.e. e-mail systems, LANs, departmental systems, and public network services, such as the telephone and the Internet).

Electronic Data Interchange Systems
In EDI systems, information flowing between computing systems may take place with minimal, if any, human intervention. EDI systems used between businesses for point-to-point data transactions enabled the automation of several complex and time-consuming functions that were previously handled manually. They have proven beneficial most notably to organizations whose business processes require a large number of daily transactions with customers or suppliers. Apart from the dramatic cost reduction, they may also provide benefits such as: reduced inventory requirements, increased productivity and customer satisfaction, and reduced errors.
Davenport & Short though, (1990, p. 18) warn that: "Buyers and sellers have used EDI largely to speed up routine purchasing transactions, such as invoices or bills of materials. Few companies have attempted to redesign the broader procurement process…"

Internet
We believe that Harrison & Samson (2002, p. 97) are explicitly clear, when they state that: "In recent times, no other technology has had a wider impact on the fundamental way in which firms do business than the Internet. By radically changing the nature and economics of transactions in almost all industries in a manner that provides substantial benefits to both consumers and producers, the Internet has become the most important technology at the beginning of the 21st century in terms of business opportunities, threats and impacts." Since no customized software or hardware is required (other than a PC, always purchased with a built-in modem and browser) the costs of access and implementation are relatively cheap and affordable for almost all businesses.

E-business
As the IT cost continues to drop and thereby reduce transaction costs to the point where the "market" becomes economically effective, electronic markets are increasingly prevalent. The most common form of e-business is:

- Business-to-customer (or B2C), consists of what are essentially electronic shop fronts that allow business to sell goods and services via Internet. It first appeared in the USA, by firms seeking to offer products and services to customers, reaching out to the growing community of Internet users willing to make purchases on line. Some of the more successful sellers of physical goods over the Internet include Amazon.com, Dell Computers, eToys and Wal-Mart.

Realizing the enormous potential of e-business technology to reduce transaction costs and improve service and process efficiencies as well as personnel management, many large organizations are undertaking initiatives to implement other e-business modules, such as:

- Business-to-business (B2B), which requires the complete transformation of processes, organizational structures and management practices in order to capture the benefits of speed, efficiency and geographic independence allowed by the new e-business system. One example is the creation of an electronic platform by automotive manufacturers General Motors and Ford, which enables them to establish an electronic relationship with their suppliers.
- Business-to-employees (B2E) is a personalized information system, sharing resources, application or process e-training, and e-commerce options among the employees of the organization. It has been used mainly by organizations of the financial services sector, like Price Waterhouse Coopers, Ernst & Young, etc.

We believe that it has become obvious from the preceding analysis that not all of the above IT tools contribute equally –and to every particular case- in sustaining competitive advantage. Porter and Millar (1985, pp. 158-159) have very early and clearly indicated five steps that senior executives can follow so that their corporation may benefit from the opportunities that the information revolution has created.

- Assess existing and potential information intensity of the products and processes of its business units. Managers must have a prior good knowledge of the potentially high information [or knowledge] intensity (a) in the value chain or (b) in the product. This may help identify priority business units for investments in certain areas of IT, which –as the two authors warned, back in 1985- involves more than simply computing.
- Determine the role of IT in industry structure and particularly how IT might affect each of Porter's five competitive forces. The authors warn that changes are not only to be expected in each force but also in the industry boundaries, which could lead to a new industry definition.
- Identify and rank the ways in which IT might create competitive advantage. Starting from the point that IT is expected to affect every activity in the value change, the authors urge managers to consider how IT might allow a change in the company's competitive scope (i.e. serve new segments, expand business globally, or even benefit by narrowing its scope), and to take a fresh look at the product, and find out whether the company could embed IT in it.
- Investigate how IT might spawn new businesses. Managers are advised to see IT as an increasingly important avenue for their company's diversification. For example, existing information-processing capacities may be adequate to start a new business, or IT could make it reasonable to produce add-on items for the main product.
- Develop an action plan for taking advantage of IT, as a result of the above four steps. This plan should rank investments in certain hardware, software or new product development activities. The authors note that in order for a company to best capitalize on the IT revolution, senior management in collaboration with the Information

Systems manager should coordinate the architecture and standards of the various IT applications throughout the organization.

In addition they note that good use of IT can help in the strategy implementation process, as well as in measuring their activities more precisely. During the first phase of our study, we encountered a number of companies that have or are taking several of these steps very seriously, in their daily business practice. They also appear to be in line with the spirit of the managerial implications deriving from our study and presented in our closing section 9.3.2.

2.2.2 IT and the Cost-Performance Issue

The value of technology should ultimately be measured in business terms, such as in contribution to revenue, market share, or sales, or in terms of a return to society such as an environmental or ‘quality of life’ benefit. Intermediate measures, such as operational variables of cost, quality, delivery and so on are often useful to consider as being constructs that connect technical performance to business and broader measures of performance. We shall look into this issue from a theoretical point of view here, and we shall come back to the subject, in more detail, as it is in the heart of the Thesis question, in section 4.3.

Venkatraman, in the introduction of his 1994 article, where he presents a framework of IT-enabled business transformation, states: “My aim in this article is to highlight the distinctive role of IT in shaping tomorrow’s business operations … because the emerging business environment calls for a strategy based on three intertwined elements: low cost, high quality, and fast and flexible response to customer needs.” (p. 74). And further down, explains that “…IT’s potential benefits are directly related to the degree of change in organizational routines (strategies, structure, processes, and skills).” (p.85)

Madnick (1991, p. 29) referring to the results of ‘The Management in the 1990s Research Program’ of MIT, states: “In surveying the results that are most strongly influencing the evolution of information technology for the 1990s, a common theme has emerged from our research efforts, research sponsors, and related literature: Advances in information technology provide opportunities for dramatically increased connectivity, enabling new forms of interorganizational relationships and enhanced group productivity.”

Madnick explains this as a result of two forces at work:

- The 1990s business forces
    - Globalization
    - Worldwide competition
    - Productivity requirements
    - Volatile environment
- The 1990s IT opportunities
    - Continued dramatic cost/performance & capacity advances
    - New IT architectures

These business forces can be identified in almost every major industry and, according to Madnick, provide opportunities for:

- Increased connectivity
- Interorganizational business relationships
- Intraorganizational coordination for increased efficiency and effectiveness
- Adaptable organizational structures

In the related literature, one can easily find special cases in which ITs have permitted huge increases in output or decreases in costs, but when it comes to the bottom line there is no clear evidence that these new technologies have raised productivity, or profitability, which are the ultimate determinants of standard business practices.

Building upon research done by Loveman (1991) who observed that “despite years of impressive technological improvements and investment, there is not yet any evidence that information technology is improving productivity or other measures of business performance”, and Strassman (1990) who observed essentially no correlation between levels of investments in information technology and such business performance indices as sales growth, profit per employee, or shareholder value, Venkatraman (1994, p. 74) states that: “The central underlying thesis is that the benefits from IT deployment are marginal if only superimposed on existing organizational conditions (especially strategies, structures, processes, and culture). Thus the benefits accrue in those cases where investments in IT functionality accompany corresponding changes in organizational characteristics.”

In a similar way, again building on the research of Loveman (1988), who approached econometrically the productivity impact of IT in manufacturing firms, and noticed no significant positive impact, and Baily & Chakrabarti (1988), who studied white-collar productivity and IT, as part of a broader study, Davenport & Short (1990, p. 12) state that: “With few exceptions, IT’s role in the redesign of nonmanufacturing work has been disappointing; few firms have achieved major productivity gains. Aggregate productivity figures for the United States have shown no increase since 1973 [To mid-1980s]”.

2.2.3 IT and the Business Process

For the purpose of our investigation, knowledge –and more specifically shared knowledge- has four owners. The manufacturing group, its two line partners (R&D and quality groups), the IT or Information Systems group (which is acting as a mediator) and of course the organization’s general management, or other stakeholders who will contribute to the measurement of the depended variable, manufacturing group performance.

Much of the complexity in achieving high levels of shared knowledge stems from managing the conflict among these groups. The relationships among them vary over time as the organization’s familiarity with different technologies evolves and as the overall company's strategy alters. IT and strategy is a two-way transaction: Suitable IT makes more efficient the implementation of existing company strategy and strategic vision is often necessary to take full advantage of IT.

It appears interesting to look into the slightly different ways that two fundamental researchers (at least for the IT part of our investigation) are addressing this issue. This difference is declared from the very beginning. It actually starts with the titles of the relevant articles.

Davenport & Short, in their 1990 article titled "The New Industrial Engineering: Information Technology and Business Process Redesign" explain the term Business Process Redesign, as "…the analysis and design of work flows and processes within and between organizations. Working together, these tools have the potential to create a new type of industrial engineering, changing the way the discipline is practiced and the skills necessary to practice it." (p. 11)

Further within their article (p. 12-13), they explore the relationship between Information Technology (IT) and Business Process Redesign (BPR). They explain that processes have two important characteristics:

- They have customers –who might be internal or external to the organization- and defined business outcomes.
- They cross organizational boundaries, which means that they normally occur across or between organizational groups and are generally independent of the formal organizational structure.

According to the authors, common examples of processes meeting these criteria include:

- Developing a new product
- Ordering goods from a supplier
- Creating a market plan, etc

Venkatraman, in his 1994 article titled "IT-Enabled Business Transformation: From Automation to Business Scope Redefinition", using a framework that brakes IT-enabled business transformation into five levels, describes each level's characteristics and offers guidelines for deriving maximal benefits. He suggests that each organization first determines the level at which the benefits are in line with the costs or efforts of the needed changes and then proceed to higher levels as the demands of competition and the need to deliver greater value to the customer increases.

Other researchers have a point of view which is much closer to relating Information Technology to strategy. According to Samson (1991) technology strategy refers to the choices that companies make in acquiring, developing, and deploying technology in order to achieve their business goals. It involves the acquisition, management and exploitation of product and process technologies that are consistent and supportive of an organization's business strategy and can ultimately drive its business competitiveness by providing technologically based advantages.

Betz (1993) is also considering the relationship between technology and business strategy. He concludes that in commodity-type businesses where products are undifferentiated, technology should be focused on the cost and quality of production. In a specialty-type business, there is a small but repetitive market and technology should be focused on expanding the market by improving performance while preparing for competition by lowering production costs.

From a different perspective, Zahra et al. (1994) warn organizations whose strategies are built on technological competences alone, that they run the risk of 'technological myopia' and possible overinvestment in these competences.

And we shall close this section with Venkatraman's very short –and indeed very solid- conclusion in his 1994 article (p. 86): "It is clear that IT will have a profound impact on businesses. It is also clear that successful businesses will not treat IT as either the driver or the magic bullet for providing distinctive strategic advantage. Successful companies will be differentiated by their ability to visualize the logic of the new business world (level five of the transformation model) and leverage IT to create an appropriate organizational arrangement –internal and external (levels three and four)- to support the business logic. The transformation trajectory is a moving target, shaped by the fundamental changes in the competitive business world. Management's challenge is to continually adapt the organizational and technological capabilities to be in dynamic alignment with the chosen business vision."

2.3 Summary

In this chapter we presented the state-of-the-art in issues related to knowledge, knowledge management and information technology. First, we distinguished the concepts of data, information and knowledge. Then we explored the nature and creation of knowledge, and its relation with the firm's intellectual capital.

Second, we focused on information technology, as the key enabler to support knowledge-based work, and its relationship with the organization and the business process. Then, we focused on IT and the cost-performance issue which is in the heart of our Thesis question.

In the next chapter we shall establish the theoretical framework of our investigation.

Chapter Three
Theoretical Framework and Managerial Implications

Chapter 3. THEORETICAL FRAMEWORK AND MANAGERIAL IMPLICATIONS

"In classical economics, the sources of wealth
are land, labor, and capital…
Now, another engine of wealth is at work.
It takes many forms: technology, innovation,
science, know-how, creativity, information.
In a world, it is knowledge"
Badaracco (1991, p.1)

3.1 A Retrospective Analysis

As it has already been mentioned it was Plato and Aristotle who first studied the nature of knowledge. Centuries later, in the 1950s, cognitive philosophers –like Polanyi and Wittgenstein, for whom knowledge was explicit, capable of being coded and stored, and easy to transfer- carried on with scientific research in the area of social and psychological sciences, and it is not long ago that business emphasis was given on the topic. In a series of recently published management books (Quinn 1992, Drucker 1993, Nonaka and Takeuchi 1995, Prusak 1997, Davenport and Prusak 1998 & 2000 among them) the implications of knowledge-based work and knowledge-based competitive advantages are outlined and the role of knowledge within the firm is highlighted. What is interesting about these books is the fact that they all integrate theory with practice, in the so called 'knowledge-based view of the firm', and therefore surpass the division between academic research and management practice (Grant, 1997).

On the other hand, amongst academics, the 'knowledge-based view of the firm' has received influences from various research lines. Based upon Polanyi's 'epistemology', the 'resource-based theory' (von Krogh and Roos, Wernerfelt) is acknowledged as the most dominant among them. Other research lines, like 'organizational capabilities and competences' (Prahaland and Hamel), 'innovation and new product development' (Teece, Wheelwright and Clark) and 'organizational learning' (Argyris) have also contributed significantly. As pioneers in the emerging 'knowledge-based view' of the firm, one can easily distinguish the work of Robert Grant, Georg von Krogh, Ikujiro Nonaka, Johan Roos, and Karl-Erik Sveiby listed in alphabetical order and without stating, at this point, their numerous articles.

Based mainly in the work of the above mentioned authors and researchers, we are presenting, in this chapter, the theoretical framework of our investigation. We shall first present the general framework of what is lately referred to as the Knowledge-based Theory of the Firm, and we shall then focus on the most specific issues of Sharing Knowledge, the Information Systems Supporting Knowledge-based Work and the unrevealed link of Knowledge Management and Business Performance.

3.1.1 The Transaction Cost Economics

It is mainly in the management and organizational areas where knowledge research has been focused in businesses. Scientists have long ago investigated knowledge related issues mainly due to their desire to understand why serious cost-performance differences are noticed among firms. It was first Robert H. Coase who with his 1937 article "The Nature of the Firm" revoked the conventional microeconomic view of the theory of the firm (as viewed in orthodox textbook chapters under titles 'Production and Cost', 'Competitive Supply', 'Monopolies', and so forth) with his perspective of 'transaction cost economics' that succeeded in linking organization with cost.

Coase's views were neglected for almost thirty years, and they were only ultimately accepted and finally honoured with the 1991 Nobel Prize in Economic Sciences. Winter (1993, p. 180) compares the orthodox view, according to which "firms were characterized by the technological transformations of which they are capable –formally, by production sets or production functions" to the one proposed by Coase, where firms make the production decisions mainly guided by market forces. As Coase explained in his 1991 Nobel Lecture, his intention –in 1937- was just to argue "… that in a competitive system there would be an optimum of planning since a firm, that little planned society, could only continue to exist if it performed its co-ordination function at a lower cost than would be incurred if it were achieved by means of market transactions and also at a lower cost than this same function could be performed by another firm" (in Williamson and Winter ed, 1993 p. 230).

In the new economy that emerged at the end of the 20th century, even the product-based theory has been altered. The manufacturing and transportation of physical goods from suppliers, via a factory to a buyer gave us the concept of the Value Chain (Porter, 1985). If we see the organization as creating value from transfers and conversions of knowledge together with its customers the Value Chain collapses so the concept should better be seen as a Value Network (Allee, 2000); an interaction between people in different roles and relationships who create both intangible value (knowledge, ideas, feedback, etc) and tangible revenue.

3.1.2 The Resource-based Theory

Coinciding with Coase's Nobel Award, in the last decade of the 20th century the resource-based theory of the firm (Prahalad and Hamel 1990; von Krogh & Roos 1995; Wernerfelt 1984, 1995) received attention as an alternative to Coase's transaction cost economics and the traditional product-based or competitive advantage view (primarily of Porter 1980, 1985). Under the latter perspective, research on sources of sustained competitive advantage for firms has focused on describing a firm's strengths and weaknesses, isolating its opportunities and threats, and analyzing how these are matched to define strategies. Under the resource-based view of the firm, research emphasis has been given to the importance of alternative firm's resources, including intellectual capital, as a source of sustainable competitive advantage.

As the resource-based theory is the one most closely related to the knowledge-based view, we are reviewing the way core competencies or capabilities, the basis of the resourced-based theory, are defined in the relevant literature by authors who have in parallel contributed to the development of the knowledge-based theory.

Polanyi (1958) describes competence as "… the ability of know-how within a certain domain …" Competence is thus not a property but a relation between individual actors and a social system of rules. Polanyi also makes an illustration of incompetence drawing the distinction between two kinds of error, namely scientific guesses that have turned out to be mistaken, and unscientific guesses, which are not only false but also incompetent. An individual is thus not competent per se, rather it is the individual in a role and in a context who is competent or not. In order to change the rules a competent individual needs a social or communicative knowledge in addition to know-how.

Wernerfelt in his 1984 article titled "A Resource-based View of the Firm" recognizes resources and products as the two sides of the same coin, and notices that: "Most products require the services of several resources and most resources can be used in several products" and he proposed that "… by specifying a resource profile for a firm, it is possible to find the optimal product-market activities. In this pioneering article, Wernerfelt develops simple economic tools for analyzing the "…relationship between profitability and resources, as well as ways to manage the firm's resource position over time" (p. 171).

Oddly enough, Wernerfelt's article has also been neglected until 1994, when it won the annual prize for the 'best paper' published in the Strategic Management Journal five or more years prior. On receiving the prize at the 1994 Strategic Management Society meeting, the author used the following metaphor: "[in 1984] I put a stone on the ground and left it. When I looked back, others had put stones on top of it and next to it, building part of a wall." (Wernerfelt 1995, p. 172).

Prahalad and Hamel start their 1990 article with an ascertainment and a prediction: "During the 1980s, top executives were judged on their ability to restructure, declutter, and delayer their corporations. In the 1990s, they will be judged on their ability to identify, cultivate and exploit the core competencies that make growth possible…" (p. 79). They define core competences as the "… collective learning in the organization, especially how to coordinate diverse production skills and integrate multiple streams of technologies" (p. 82) and further down, they emphasize that:

- The force of core competence is felt as decisively in services as in manufacturing.

- Core competence is communication, involvement, and a deep commitment to working across organizational boundaries. It involves many levels of people and all functions.
- Unlike physical assets, competences do not deteriorate as they are applied and shared. They grow.
- Cultivating core competences does not mean outspending rivals on research and development.

It is evident that the implications of the above definition, as well as the emphasis on collaboration across organizational boundaries (i.e. Manufacturing-Quality-R&D) are strongly related to the focus point of our investigation.

Evans et al (1992) in reference to the above definition are suggesting (based on a well documented case study) that "…competencies and capabilities represent two different but complementary dimensions of an emerging paradigm for corporate strategy. Both concepts emphasize 'behavioral' aspects of strategy in contrast to the traditional structural model. But whereas core competences emphasize technological and production expertises at specific points along the value chain, capabilities are more broadly based, encompassing the entire value chain. In this respect, capabilities are visible to the customer in a way that core competencies rarely are." (p. 66). The differentiation they bring up is very well understood from a customer's perspective, so significant in today's business world.

von Krogh & Roos (1995, pp. 56-57) in the introduction to their article on knowledge, competence and strategy, are further "... building on the resource-based perspective, [in order to develop] a better understanding of how competences build firms' competitive advantage. The point of departure is knowledge, implying that the relevant unit of analysis in competence-based prospective is the individual. This is different from the unit of analysis used both within the competitive strategy perspective (the industry) and the resource-based perspective (the firm)." According to the authors "… knowledge is not seen as a resource in a traditional meaning [i.e. financial, physical, organizational, technological, intangible, and human resources]… and differs from these types of resources in many ways;". We consider this perspective as the common link between the recourse- and the knowledge-based theories and we have totally adopted it in the course of our investigation.

3.1.3 The Knowledge-based Theory

It has been widely accepted that traditional human resources management can improve an organization's competitiveness up to the point when it reaches the 'knowledge base' of a business: the skills and expertise of its employees. On the other hand, information and communication technology is another parameter that has greatly increased traditional management capabilities. According to Grant (2000, p. 36) "What distinguishes the present economy from a knowledge perspective is the sheer accumulation of knowledge by society, the rapid pace of innovation and, most important, the advent of digital technologies that have had far-reaching implications for the sources of value in the modern economy". Thus, one can easily assume that modern management of human resources could provide a competitive advantage by adopting a knowledge management perspective assisted by information and communication technologies.

At the turn of the 20th century Grant, in a series of articles, and Sveiby (2001) presented in a very clear way the fundamentals of a knowledge-based theory of the firm. Let us quote Grant summarizing his recent work (Grant 1995, 1996a, 1996b): "Based on certain premises regarding the nature of knowledge and its role within the firm, the [knowledge-based] theory explains the rationale for the firm, the delineation of its boundaries, the nature of organizational capabilities, the distribution of decision-making authority and the determinants of strategic alliances" (Grant, 1997, p. 451). Grant has also gone one step further, by exploring the implications of the new theory for practicing managers, an important issue that we shall further analyze in section 3.2.2.

According to Grant (1997) the knowledge-based view is founded on a set of basic assumptions:

a. Knowledge is a vital source for value to be added to business products and services and a key to gaining strategic competitive advantage.
b. Explicit and tacit knowledge vary on their transferability, which also depends upon the capacity of the recipient to accumulate knowledge.
c. Tacit knowledge rests inside individuals who have a certain learning capacity. The depth of knowledge required for knowledge creation sometimes needs to be sacrificed to the width of knowledge that production applications require.
d. Most knowledge, and especially explicit knowledge, when developed for a certain application ought to be made available to additional applications, for reasons of economy of scale.

For Grant (1997) the role of the firm, as an institution, is to resolve the dilemma presented in (c) above, by allowing individuals to specialize their expertise, and at the same time, to establish the mechanisms required to integrate their different knowledge bases in the transformation of inputs into outputs. As most important among these mechanisms, Grant proposes: 'knowledge transfer' (one person learning what is known by another) and 'direction' (specialists in an area of knowledge issue rules, directives and operating procedures to guide non-specialists). Furthermore, he claims that at more complex levels, integration of knowledge can be achieved without direct transfer taking place. At a basic level it can be achieved by simple 'sequencing' (each specialist's input occurs independently). At a more advanced level, 'organizational routines' are used to coordinate individuals performing their own specialized tasks.

According to Sveiby (2001, p. 345) while competitive-based and product-based strategy formulation generally makes markets and customers the starting point for the study, the resource-based approach tends to place more emphasis on the organization's capabilities or core competences. Thus the knowledge-based strategy formulation should start with the primary intangible resource: the competence of people.

Sveiby (2001, p. 346) believes that people can use their competence to create value in two directions: by transferring and converting knowledge externally or internally to the organization they belong to.

- When the managers of an industrial company direct the efforts of their employees internally, they create tangible goods and intangible structures such as better processes and new designs for products.
- When they direct their attention outwards, in addition to delivery of goods and money they also create intangible structures, such as customer relationships, brand awareness, reputation and new experiences for the customers.

In both these above transactions, shared knowledge among manufacturing, R&D and quality groups becomes a critical factor for the performance of the manufacturing group. Emphasizing on this shared knowledge, Sveiby (2001, p. 346) defines the Individual Competence Family, consisting of the competence of the professional/technical staff, the [manufacturing and quality] experts, the R&D people, the factory workers, sales and marketing – in short all those that have a direct contact with customers and whose work is directly influencing the customers view of the organization. This is exactly the way sharing knowledge is conceptualized for the purposes of our investigation. We shall refer to this issue in more detail, in the section following.

3.2. Sharing Knowledge

At its first stages, knowledge management focused on sharing knowledge related to industrial world applications. The two dominant and mostly cited examples of the 1990s refer to new product design and development, and industrial innovation. The first one, by Nonaka (1991), relates to the development of new product lines (like Matshusita's bread making machine, the Honda City car, and Canon's revolutionary mini-copier) and persuades researchers, product designers, manufacturing and sales personnel to work together across departmental boundaries. With these examples Nonaka has made Matshusita's software developer Ikuko Tanaka and her 'twist dough' identical to his SECI model; Honda's project team leader Hiroo Watanabe and his 'Tall Boy' concept, and Canon's task-force leader Hiroshi Tanaka and his beer can analogy, identical to terms like 'metaphor', 'analogy' or 'model'. The analogy to the knowledge sharing situation that our research is focused on is very strong.

The second example refers to the sharing of what Seely Brown (1991) and the researchers of the Xerox Palo Alto Research Center (PARC) call 'local innovation' in the design of usable technology by sharing the knowledge end-users have of the products under consideration. PARC research is focused on new work practices, in parallel to new products, and recognizes the customer as the research department's ultimate innovation partner. In both these classic examples, the emphasis is on the way large organizations (namely

Matsushita, Honda, Canon and Xerox) used brainstorming methods and software systems for co-designing and cross-leveling the knowledge within the organizations.

Recently, knowledge sharing emphasizes more on indirect interactions between members of different groups in an organization, or members of a community, that are not always working at the same geographic location. Davenport and Probst (2002), in their Siemens Best Practices case book, refer to a number of organizations devoted on their staff sharing 'best practices' using document repositories (such as reports of past successful or failed projects, employee, product and service profiles, known as Yellow Pages) and IT-based tools for inputting and extracting knowledge from the repositories. The range of such knowledge sharing systems includes from simple document management systems that help in the storage, annotation and retrieval of documents (Gibbert et al 2000, Kalpers et al 2002), to Group Support Systems and Expert Systems that help in problem solving and decision making (McNurlin and Sprague 2004). We shall come back on these issues, further down in chapter 4.

Classical knowledge sharing models suggest that the knowledge transfer and/or sharing process involves the conversion of tacit knowledge into explicit and vice versa. At the same time, there are processes that help share tacit and explicit knowledge without conversion; although for Nonaka and Takeuchi (1995) the conversion of knowledge from tacit to explicit and finally tacit is the basis of knowledge creation. The knowledge conversion process involves close interaction between, and complete understanding amongst key employees, the so called knowledge group of an organization. This team includes employees and staff (from manufacturing, quality, R&D, marketing, supplies and sales) and in most cases the end-users of the products or services created by the organization.

3.2.1. Knowledge Sharing Networks

For knowledge to be shared effectively between, within and across organizations and persons, those who possess knowledge should make it available in an accessible place and manner and with a focus on its application. Those who seek knowledge should first be aware of the knowledge locus and, second, be capable of interpreting the knowledge within their own context, prior to applying it.

In recent literature, a number of scientists have successfully addressed the topic of inter-organizational networks. Based mainly in the work of von Krogh et al (1999), Zack (1999a) and Dyer and Nobeoka (2000) we consider Knowledge Sharing Networks (KSN) as those types of networks among individuals, communities, organizations (or even between groups of organizations), which have as main common characteristic the sharing of both tacit and explicit knowledge. Dyer and Nobeoka (2000) consider that a KSN serves as a locus for facilitating knowledge sharing and effective knowledge work, since it makes knowledge permanent, accessible and portable to those who need it, both inside and outside organizations. Zack (1999a) proposes a framework that he calls Knowledge Management Architecture, in order to manage mainly explicit knowledge, based on two KSN elements:

- Repositories of explicit knowledge, and
- Refineries for accumulating, refining, managing and distributing explicit knowledge.

He also recognizes the new organization roles needed in order to execute and manage the refining process, and the importance of IT in supporting the repositories and processes. We shall briefly explain these two KSN elements, building mainly upon Zack (1999a) and Ruggles (1998).

Knowledge Repository

Knowledge repositories capture explicit, codified information wrapped in varying levels of context. They are used to store and make accessible 'what the organization knows'. They include data warehouses, which are useful in knowledge management when the mining and interpretation of their content allows employees to become better informed. More sophisticated repository approaches attempt to enfold more context around information as it is captured.

According to Zack (1999a) the basic structural element of a repository is the Knowledge Unit, a formally defined, atomic package of knowledge content (labeled, indexed, stored, retrieved and manipulated). The repository structure also includes schemes for linking and cross-referencing the different knowledge units. A Knowledge Platform may consist of several repositories, each one with a structure appropriate to a particular type of knowledge or content.

The most common types of knowledge repositories are those accumulating:

a. Structured internal knowledge (or knowledge embodied in documents) like memos, reports, product oriented material, etc
b. Informal internal knowledge, a less structured form of accumulated knowledge, like discussion databases, containing know-how, and usually referred as "best practices' or 'lessons learned'
c. External knowledge, like competitive intelligence knowledge encompassing analyst reports, trade journal articles and external market research on competitors.

Repositories may be linked to form a 'virtual' repository (i.e. product literature, best-sales practices and competitor intelligence might be stored separately, but viewed as though contained in one repository).

Knowledge Refinery

The refinery represents the process for creating and distributing the knowledge contained in a repository. This process includes five stages:

- Acquisition (a firm either creates or acquires knowledge)
- Refinement (value-adding process, i.e. cleansing, labeling, indexing, sorting, abstracting, standardizing, integrating, and recategorizing)
- Storage and Retrieval (bridges upstream repository creation and downstream knowledge distribution)
- Distribution (mechanisms used to make repository content accessible)

- Presentation (the context in which knowledge is used influences its value).

Acquisition, refinement and storage create and update the knowledge platform, whereas retrieval, distribution, and presentation derive various views of that knowledge.

For KSN –and knowledge projects in general- to succeed, organizations must create a set of roles and skills to do the work of capturing, distributing and using knowledge. The majority of researchers (Earl and Scott 1999, Zack 1999a, Davenport and Prusak 2000, among others) coincide with the need of a Chief Knowledge Officer (CKO), responsible for the overall organization's knowledge management. As Davenport and Prusac (2000) mention, many firms in the United States and a few in Europe have already appointed CKOs, although in some of them the title may vary. It may be Chief Learning Officer (CLO), Director of Intellectual Capital, or Director of Knowledge Transfer, just to mention a few. Zack (1999a) gives a more detailed scheme of the organizational roles required, including knowledge creators, finders, collectors, and more, like organizational 'reporters', analysts, classifiers, integrators. Finally, a librarian, or 'Knowledge curator' must manage the repository.

We have already emphasized on the role of IT in section 2.2. The IT infrastructure provides a 'pipeline' for the flow of explicit knowledge through the five stages of the refinery process. Using IT (i.e. the World Wide Web and Groupware) a firm can build a multimedia repository with knowledge units indexed and linked by categories. In this way, the organization's explicit knowledge will be displayed as flexible subsets via dynamically customizable views. Effective use of IT allows knowledge communication via electronically mediated channels. Explicit, factual knowledge may be disseminated by means of an electronic repository. When the exchanged knowledge is less explicit, e-mail or discussion databases are more appropriate and when knowledge is primarily tacit, most interactive modes, such as videoconferencing or face-to-face conversation are the best answers.

3.2.2. Sharing Issues and Managerial Implications

Despite the fact that many companies today consider knowledge as an asset (Drucker 1988, Davenport and Prusak 1998 & 2000), it is treated differently from the traditional assets of land, labor and capital. Knowledge is a resource locked in the human mind, so creating and sharing knowledge are intangible activities that can neither be supervised nor forced out of people. Active cooperation of the individual possessing the knowledge is absolutely necessary for knowledge to be shared. A common language among all the participants –not just English or Spanish, but also 'industrial engineering' or 'field sales'- is a major factor in the success of any knowledge transfer. Individuals who do not share a common language will neither understand nor trust one another. When they are brought together to collaborate, they will spar or simply not connect. Over the same perspective Nonaka and Takeuchi (1995) emphasize on 'redundancy' when people from overlapping areas of expertise are working together, while other researchers simply refer to 'cultural mismatch' as a barrier to knowledge or technology transfers.

We are summarizing here below some reasons that make sharing knowledge a complicated task:

- Knowledge is not simple and should not be simplified to be made to fit into a KSN, because doing so lessens sharing and exchange.
- People do not easily share knowledge, even if its value grows as it is shared.
- Culture often blocks sharing, especially in highly competitive environment. A sharing culture is a prerequisite, for the existing disincentives not to prevent the use of the KSN.
- Technical solutions do not address the sharing issue, or to put it in another way, technology does not change the culture.
- Sharing is not cure-all; neither is good in all cases. Unlimited knowledge sharing does not work, either. Managers (and especially the CKO, wherever exists) must be aware of that and take the necessary measures.
- Even hiring and promotion practices may affect knowledge sharing. If not rewarded, sharing may be seen as an anathema.

Barriers to generating and sharing knowledge do exist even in cases where management has taken all necessary steps to encourage it. Most of those barriers have to do with either the stimulation of divergent thinking among the knowledge workers, or the distribution of that thinking among the collaborating group members. We shall briefly present some of the most typical ones:

- Individuals who possess knowledge –especially tacit one- may be actively discouraged from participating, or even worse, could sensor themselves. In order to avoid this, companies must first reward knowledge sharing, mentoring and assisting others, and second, provide the required time for personal contacts.
- Inequality in status among group members is also a strong inhibitor to sharing knowledge, especially when worsen by differences in accessing information. Technicians often hesitate to propose solutions, not only because engineers have higher status, but because technicians base their recommendations on different knowledge bases.
- Distance –both physical and time- makes sharing of knowledge, and especially its tacit dimension, difficult. Technology may offer a partial solution, despite the fact that much knowledge is generated and transferred through body language, physical skill demonstration, and very often requires the use of three-dimensional prototypes.

To conclude, getting value out of knowledge sharing requires more than technology. Knowledge is inherently hard to control as it is ever expanding and unpredictable. Only when executives view knowledge in this light will they manage it for most effective use. The knowledge-based theory of the firm is obviously the most adequate framework for these objectives to be fulfilled. The fundamental problem in traditional management theory is how to align the objectives of workers with those of managers and the stakeholders. In accordance with the knowledge-based view, "… if knowledge is the preeminent productive resource, and most knowledge is created by and stored within individuals, then employees are the primary stakeholders" (Grant 1997, p. 452). Under this perspective, management's principal challenge is to establish the mechanisms for collaborating individuals and groups to coordinate their activities in order to best integrate their knowledge into productive activity.

Grant (1997) points out a number of implications for management practice, all stemming from the company's decision to follow the knowledge-based theory:

1. Assist firms to understand the challenges inherent in building new capabilities, by uncovering the mechanisms through which knowledge is integrated. One has to recognize that a firm's capabilities reflect long-term evolutionary processes, and management has limited power to create new capabilities.
2. The knowledge-based view allows firms to unravel the process through which capabilities are systematized and internally replicated, building – at the same time- barriers to knowledge replication by potential rivals and imitators.
3. Permits firms to look beyond the conventional transaction cost economics analysis to better understand the optimal boundaries of the firm, by enabling them to transfer knowledge even in cases where it is not embodied within products.
4. The knowledge-based theory helps firms to overcome the deficiencies of hierarchy, proposing an alternative team-based structure where team membership only depends upon the specific –at a point of time-knowledge requirements. Even under such a scheme, hierarchy is necessary in order to link different teams.
5. The knowledge-based view, also in relation to hierarchy, points to the importance of co-locating decision making and knowledge, rejecting 'delegation', the method used by traditional management. Decisions based on tacit knowledge must be made where this type of knowledge is located. Decisions which require explicit knowledge can certainly be centralized.
6. As firms need to diversify their products in order to gain full utilization of their internal knowledge resources, the knowledge-based theory better serves the required inter-firm collaborations that will allow for 'strategic options' on new technologies.

Under this perspective the knowledge-based view is expected to create one of the most profound changes in management thinking since the scientific management revolution of the early 19th century, finally showing the way to a knowledge-based management through the necessary close collaboration between academics and management practitioners.

3.3 Summary

In this chapter the theoretical framework has been defined, built upon the 'knowledge-based theory of the firm' endorsed primarily by Robert Grant and Karl-Erik Sveiby.

First, we presented earlier research lines that have considerably influenced the knowledge-based theory. Originating from the 'epistemology' of the cognitive philosophers and –through contradiction to the transaction cost economics and the traditional product-based or competitive advantage view- we have introduced the basic elements of the theory. We have finally demonstrated that the knowledge-based theory builds heavily upon the 'resource-based theory'.

Second, we concentrated on the concept of sharing knowledge –the core of our investigation- and introduced the basic elements of a Knowledge Sharing Network. Knowledge repositories and refineries were briefly presented and a first effort to formulate concrete managerial implications –as derived from the literature- was attempted. The managerial implications that derive from our study will be presented in our concluding chapter.

In the next chapter, we shall look into the role of information technologies under the knowledge-based theory perspective.

Chapter Four
Knowledge-based Theory and the IT Role

Chapter 4. KNOWLEDGE-BASED THEORY AND THE INFORMATION TECHNOLOGY ROLE

"In the end, the location of the new economy
is not in the technology, be it the microchip
or the global telecommunications network.
It is in the human mind."
Alan Webber (1993, p. 27)

For the purpose of our investigation it is important to examine the channels that permit and facilitate information to flow inside and within the Manufacturing, Quality and R&D groups of an organization. Two are the main types of information-handling activities: The procedure-based ones (related to the procedures that each one of the three groups is involved in) and the knowledge-based information-handling activities. We shall focus our interest on the Information Systems (IS) aiming on supporting knowledge-based activities. IS that support employees of the three groups in performing information-handling activities in order to work together, share expertise and knowledge, and solve problems. As of their nature, these IS must support activities that do not follow the same or similar process every time and that deal with information and knowledge that cannot be easily captured.

There are more than one patterns that allow this flow of information and knowledge in organizations. Cohen (1998), in his well documented Report on the First Annual U.C. Berkeley Forum on Knowledge and the Firm, distinguishes among two different approaches to knowledge transactions in organizations: Internal knowledge markets and internal knowledge communities. It is obvious that the choice of one of the two viewpoints is of significant importance, as it affects action. According to Cohen, the proponents of knowledge markets are mainly talking about knowledge interactions between individuals and may emphasize on incentives as they tend to consider that knowledge is a 'thing' that can be transferred. The devotees of knowledge communities focus on the group and give more attention to encouraging connections between people, which may lead to more exploration of the process of knowing.

Supporters of the two approaches can be found in the scientific literature and they also made themselves obvious in the Berkeley Forum. Prusak (1997 and during the Forum) stated that there are knowledge buyers, sellers and brokers in firms, each of whom expects to gain something in a knowledge transaction. The main price mechanism governing the knowledge market is reciprocity, the expectation that one will get valuable knowledge in return for giving it. Or, to put it in another way, one needs to contribute knowledge to become part of the knowledge networks on which his success depends. Gilmour (2003) goes one step further and proposes that organizations should focus on collaboration management based on a brokering model that forces people to share knowledge when there is something in it for them. Let us consider, for example, two managers (i.e. the Manufacturing and Quality managers of a company) evaluating the same vendor; wouldn't they want to talk to each other and compare their notes and experiences? The brokering model is there to connect people who should be connected. One IT-based solution, proposed by Gilmur (2003), is to continually survey the flood of electronic information that flows through the company in order to find out who is likely to know what. Then, when somebody needs information, those who have it can be asked privately whether they are willing to share.

Supporters of the knowledge community approach, suggest more emphasis on personal connection and commitment to shared success –but also risks and benefits- and less on knowledge transactions, which von Krogh (1998) associates with 'low care' social situations. Collaborators worry about themselves and their partners; buyers and sellers don't. Trust and good will influence action much more powerfully in a community or collaboration world than they do in the relatively impersonal market environment.

The knowledge market approach driven by pure self-interest and that of the knowledge community characterized by sharing, trust and generosity represent the two extremes, with real-life situations somewhere in between. In practice, many individuals care about their colleagues and knowledge markets do depend on trust and reciprocity, as the value of exchanged knowledge cannot be precisely defined and 'payment' for it is usually intangible and delayed. In the same way, knowledge community members are individuals who are better prepared to contribute to the group effort when they expect a share of the benefits of the group success. In their way, they also make a 'market' calculation of what they will get in exchange for the knowledge they offer.

4.1 Supporting Collaboration

In a prophetic article Drucker (1988) stated that organizations are becoming information based, and that in the future they will be organized not like manufacturing organizations, but more like a symphony orchestra, a hospital or a university. Each organization will be composed mainly of specialists who direct their own performance through feedback from others: colleagues, customers and headquarters. Three are the factors driving this move, according to Drucker. One, knowledge workers are becoming the dominant portion of labor, and they resist Taylor's command-and-control form of organization. Two, all companies, even the largest ones, need to find ways to be more innovative and entrepreneurial. Three, information technology is forcing a shift. Once companies use IT to handle information rather than data, their decision processes, management structure and work patterns change.

Based on what we have experienced from our sample companies, work is done mainly in task-focused teams, where specialists from various departments (i.e. manufacturing, quality and R&D) work together as a team for the duration of a project (i.e. the development of a new product) based on a variety of IT tools for their collaboration. Drucker had long ago foreseen that we were at the beginning of the third evolution in the structure of organizations: the organization of knowledge specialists.

Expecting information and knowledge simply to flow through organizations is unrealistic, because people's time and energy are limited and they will choose to do what they believe will give them a worthwhile return on those scarce resources. Robert Johansen, in the web site of the Institute for the Future (IFTF), notes that systems that support groups are important because most people spend 60 to 80 percent of their time working with others. At the same time, from informal polls he has taken, people seem to feel they are most productive when they are working alone, or to put it in another way, they are not happy about how they work with others. These findings reveal a need for systems that support groups.

The tools people need to work with others are different from the ones they need to work alone. So groupware (electronic tools that support teams of collaborators) is different from past software. In many of the companies in our sample groupware represents a fundamental change in the way people think about using computers. Taking full advantage of existing IT platforms (e-mail systems, LANs, departmental systems and public network services such as the telephone or the Internet) groupware is not just another part of corporate information systems. Successful firms have discovered the right mix of people, process, and technology elements in order to use their groupware systems as the backbone of their knowledge sharing infrastructure.

Supporting collaboration has lately been a main effort in organizations as it is commonly accepted that it is conductive to both knowledge generation and sharing. Making available the wealth of knowledge that exists throughout the organization is of real benefit to firms that wish to improve the ability of employees to make decisions. For the past 25 years, Group Decision Support Systems (GDSS) have been used in order to help more than one person work together to reach a decision. McNurlin and Sprague (2004) note that GDSSs traditionally support 'pooled-interdependent' decision making (several people to reach a decision jointly by working together simultaneously and interacting) or 'sequential interdependent' decision making (one person makes a decision –or part of a decision- and passes it on to another person). As it has been increasingly difficult to tell when decision making starts and when supplementary activities (such as data gathering, communicating and interacting) the 'D' has disappeared and we now talk about Group Support Systems (GSS).

The activities of groups can be divided into two generic categories:

a. Communication and interaction, where communication is conceived as transmitting information from one person to another or to several others and interaction means back-and-forth communication over time. (Example: Office systems and in particular e-mail.)
b. Decision making and problem solving, where members of the groups reach a decision or form a consensus. (Example: The evolution of group DSSs from the already existing DSSs.)

Both types of group activities are needed in collaboration and, historically, systems supporting group work have originated from one or the other of these two major functions.

Johansen (1991) and his colleagues of the IFTF are categorizing the work of groups using a variation of the DeSantis and Gallupe (1985) matrix, by having time on one dimension (same time/different time) and place on the other (same place/different place). The time/place framework they propose in their search for ways in which technology can be utilized to support 'anytime, anyplace' collaboration is shown in Figure 4.1. The two options (same or different) of the parameters time and place designate the way the group members are communicating and interacting over time and/or distance. The 'same time/same place' cell, for example, includes electronic meeting support systems. The 'different time/different place' cell incorporates such communication-oriented systems as e-mail, computer conferencing and use of Lotus Notes or more modern software.

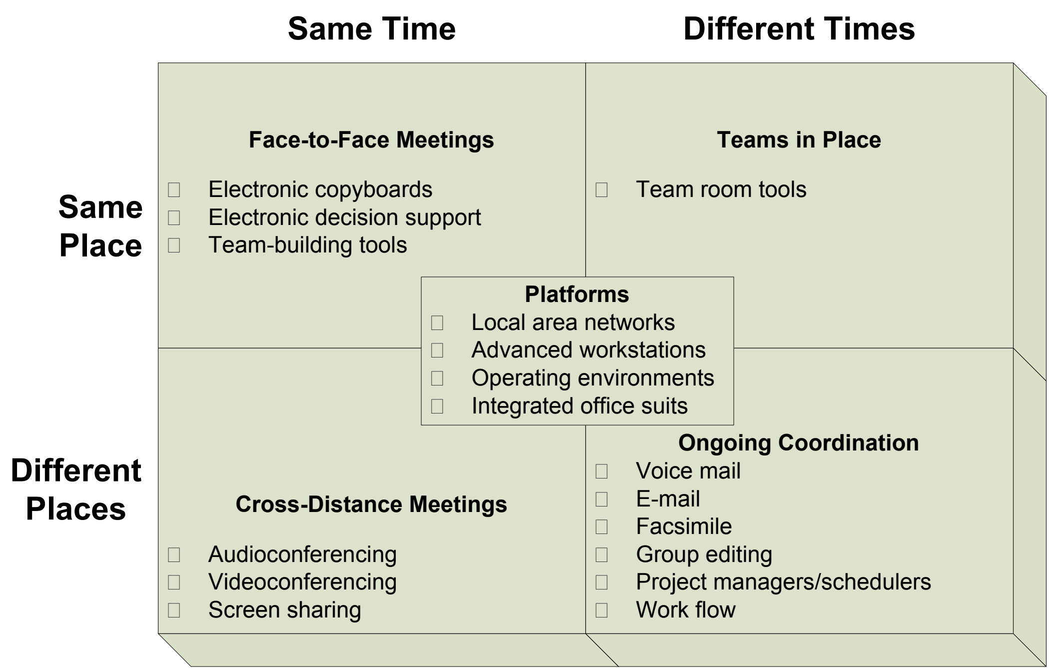


Figure 4.1 Groupware Options
Source: R. Johansen of the Institute for the Future, Menlo Park, CA.

Bearing in mind the three groups (Manufacturing, Quality and R&D) on the collaboration of which our investigation is focused, we shall further comment on some particular situations where the use of IS to support collaboration is of importance. Until recently there has been little integration among the systems in the four cells, even though it is clear to investigators and system developers that supporting collaboration must aim to permit anytime, anyplace group working.

4.1.1 Same Time / Same Place Collaboration

Supporting same time/same place collaboration has generally meant supporting meetings. Team members from the groups involved meet face-to-face in order to develop the basic plan and objectives and finally reach a decision. Meetings are part of the daily schedule of any staff member and McNurlin and Sprague (2004) mention the results of a US study that have found that the average executive in a US company spends more than 800 hours a year in meetings. The number alone represents an approximate 30 percent of total work hours, but in addition, the executives reported that they considered about 240 of those hours to have been wasted in useless meetings.

Let us summarize the main problems with meetings, based mainly upon the comments managers made during our interviews (first phase of our study):

- Often there is no agenda, participants do not study the documentation provided before the meeting and expect to be briefed during the meeting.
- Key people arrive late or do not attend at all, time may be spend on briefing attendees or on routine matters, and due to a poor job of the chairperson a few people –very often the same ones- dominate the discussion and others do not speak up.
- Many meetings are wasteful from a cost standpoint (consider cost per hour in salaries, travel expenses, etc) not to mention the unavailability of the participants at their place of duty.

The goals of systems used for improving meetings are to (a) eliminate some meetings, (b) encourage better planning and better preparation for those meetings that must be held, and (c) improve the effectiveness of meetings that are finally held. The following measures can be taken and it is here that information technology can help.

a) Eliminate some meetings. Use of e-mail or the company intranet can eliminate all meetings that do not call for a group decision or action (i.e. progress report meetings). Electronic and voice mail systems allow meetings to be cancelled at the last moment (when key people can not attend or essential information is not yet available).

b) Better preparation for meetings. Computer conferencing can play a significant role in improving preparation for meetings. A computer conferencing system is actually a form of enhanced e-mail, allowing participants to log on at their convenience, read all entries made by others since they last logged on, and make their contributions. The chairperson can use the system to obtain reactions to the proposed agenda and even for handling routine actions (like approval of previous meeting minutes and voting on routine issues) as well as for providing a written record of pre- and post-meeting communications.

c) Improve the effectiveness of meetings. The major benefit of using meeting support systems is improved meeting efficiency and effectiveness. Meetings are more effective when the ideas generated by the group are more creative and the group commitments materialize more quickly.

Another ‘same time/same place’ situation that can benefit from the use of group support systems is the traditional presentation and discussion sessions usually applied in conferences and in business meetings of a certain importance.

4.1.2 Different Place Collaboration

Collaboration of groups that work in different places and probably at different times is another promising use of information systems, and mainly groupware. In the global economy era multinational companies can use the three main regions of the globe (Asia, Europe and the Americas) to extend their workday to round-the-clock by passing work from groups in one region to the next at the end of each one’s workday.

Imagine the following situation: Two scientists collaborate on writing a report. The one based in Europe, e-mails his thoughts and questions on the topic to his US based colleague at the end of his workday. During his workday –and while his EU partner is sleeping- the US scientist does some thinking and research on the topic, and e-mails his thoughts and findings back to Europe at the end of his day. Now, when the US scientists sleeps, the EU one can work again and this may continue for, let’s say, a week. At the end of the week, they will have accomplished at least two weeks’ worth of work, without either of them having to work long hours. In an extreme case (of a company having a third person involved in the project and working in Asia) the result could have been even three weeks’ worth of work done.

One of the results of using IT to support collaboration is the formation of the so called virtual teams; they exist in a space but not in one place. Some of them never meet face-to-face. They are formed to handle a project and then disband after the project is completed. Virtual teams tend to operate in three cells of the Johansen matrix.

- Same time/same place: The team meets face-to-face probably once, at the beginning, to develop the basic plan and objectives.
- Different time/different place: Team members then communicate by e-mail and do data gathering and analysis separately.
- Same time/different place: If the company possesses strong enough technology, team members may have audio or video conferences to discuss developments and progress towards goals.

It is obvious that there is a spectrum of group working situations and many types of IT-based systems that support collaboration. These systems have been around for at least 30 years, becoming increasingly sophisticated over that time. They permit more discussion, more evenly spread participation, more high-level companywide discussion, and involvement by more people than a traditional planning meeting would allow. Other tools allow real-time collaboration among distributed team members who not only need to hear each other's voices, but also need to simultaneously see their hand-drawn changes to an engineering drawing in real time. Still other collaboration tools help team members located around the globe 'converse', not in real-time but at different times of the day.

In all these, and many other cases, use of IT-based collaboration tools changes the collaboration process, revolutionize who can participate, how they participate and even the kind of work they do. Collaboration is at the heart of business world today. Use of collaboration software can change the structure within one enterprise, working relationships between enterprises, and working relationships between people in different parts of the world.

4.1.3 Collaboration in Manufacturing

It is particularly in manufacturing and product development where cross-functional collaboration turns out to be vital. Wheelwright and Clark (1992) describe in a very clear way the importance of this collaboration: "Outstanding [product] development requires effective action from all of the major functions in the business. From engineering one needs good designs, well-executed tests, and high-quality prototypes; from marketing, thoughtful product positioning, solid customer analysis, and well-thought-out product plans; from manufacturing, capable processes, precise cost estimates, and skilful pilot production and rump-up. … Furthermore, if new products and processes are to be developed rapidly and efficiently, the firm must develop the capability to achieve integration across the functions in a timely and effective way. "(p. 165).

Wheelwright and Clark (1992) classify the patterns of communication between the two extreme situations represented by the second and third column of Table 4.1 in the following page. The communication pattern proposed in the second column is sparse, infrequent, one-way, and takes place late in time. The one represented in the third column is rich, frequent, and reciprocal and takes place early in time.

No doubt that the latter is the preferred mode of communication in the manufacturing and product development environment because collaborating engineers meet face to face with their colleagues early in the design process and share preliminary ideas, draft-drawings and notes.

Cross-institutional collaboration may also be necessary in cases where the manufacturing and product development process imposes collaboration with sources of knowledge external to the organization. It is very often that organizations need to work with Research Institutes or Universities with which they have no formal relationship, and in such a case knowledge has to be shared among the members of the collaborating organizations.

Dimension of Communication	Range of Choice	
Richness of Media	Sparse: documents, computer Networks	Rich: face-to-face, models
Frequency	Low: one-shot, batch	High: piece-by-piece, on-line, Intensive
Directions	One-way: monologue	Two-way: dialogue
Timing	Late: completed work, ends the process	Early: preliminary, begins the process

Table 4.1 Communication between Functional Groups in Manufacturing
Source: Wheelwright and Clark (1992, p. 177)

4.2 Supporting Knowledge Work

Supporting knowledge work, and the information systems used for that, is an issue very closely related to managing knowledge. We have addressed the subject in section 2.2 of this study from a general perspective. Here, we shall do it from a practical point of view, emphasizing on the IT-based tools and techniques that facilitate knowledge work within the company and particularly among the Manufacturing, Quality and R&D groups. That means not only encouraging people to share knowledge personally, but also to put their knowledge in a form that others can easily access it. Because knowledge originates from both inside and outside the company, practical issues on knowledge management deal with customer knowledge and researcher knowledge and how to embed this outside knowledge in a real-time system. Under this umbrella we are examining the intellectual capital issues (i.e. how we value the company's intellectual property) as well as usage and sharing of knowledge. The challenge is to recognize where IT fits in the overall knowledge management and knowledge sharing arena.

4.2.1 Manage or 'Share' Knowledge

Knowledge management has been an enduring subject in the IT field since the mid-1990s. Many attempts have been made to capture knowledge in computer systems, but soon top management realized that their greatest assets (their employees) walk out the door every evening, taking with them another crucial asset, knowledge. Many experts and researchers in the field

(Davenport, Sveiby, and von Krogh, among them) believe that knowledge is not something that can be captured in a machine; it only exists inside a person's head. Information can be captured in computers, knowledge cannot. Some of them feel that the term knowledge management creates the wrong impression, as knowledge cannot be controlled or engineered. It can only be leveraged through processes and culture. The more people are connected, and the more they exchange ideas, the more their knowledge spreads and can thus be leveraged.

The above view has not been generally accepted, yet. Brewer (1995) researched the topic and tried to answer the question: If we cannot disembody knowledge, how do we better manage the knowledge within people to leverage this asset? He notes that as we move from a service economy to a knowledge economy, companies move toward more effective knowledge management by transferring knowledge between the two states it exists. From tacit knowledge (within a person's mind and thus private) to explicit knowledge (articulated, codified and thus public) and vise versa. According to Brewer, knowledge is not a physical asset, and as such it is not effectively described in terms of manufacturing analogies such as storing it in inventories.

The process of transferring tacit knowledge to others is a key part in managing knowledge. Emphasizing on this aspect, some companies have stopped talking about knowledge management and only use the term knowledge sharing. Under this perspective, IT is seen as one enabler, but not the only one. Getting people together face-to-face to explain how they do things, is still very important in knowledge sharing. Talking about what they do and why, barriers fall, knowledge flows, and sharing increases. Unfortunately, free time for sharing knowledge is not yet seen as important by the majority of top and senior management executives.

4.2.2 Design the 'System' in Practice

In the real world, the Information System (IS) needs to be designed to meet the needs of the people who will use it and gain value from it. In our case, it is the Manufacturing, Quality and R&D people.

Recently, in the business oriented literature a variety of approaches and models has appeared urging organizations to systematically implement knowledge management processes. Most approaches propose a taxonomy of the processes to manage knowledge, based either on their descriptive or prescriptive nature. They identify and describe all –or most of- these processes (knowledge generation, codification, storing, mapping, application, sharing and transfer) which are strongly interrelated and very often overlapped. Based on the dynamic nature of knowledge, each of these approaches and models propose a vaguely different way for adding or creating value by more actively leveraging know-how, experience, and judgment resident within and, in many cases, outside of the organization. Some others focus on the evaluation of the company's intellectual capital, and propose a classification of the organizational knowledge, based on the possible resources; stakeholders, structural etc.

As we have the feeling that our investigation might be considered incomplete without a reference to such a practical model, we shall present here the model for managing intellectual capital, proposed by the Giga Information Group (Giga, 1997). The model, as shown in Figure 4.2, is circular and has four stages, each of which is representing what people generally do with knowledge.

People first create or capture knowledge from a source. Then they organize it and store it into categories for easy retrieval. Next, people distribute (push) or access (pull) knowledge, and finally they absorb another's knowledge for their own use or in order to create more new knowledge. This way the cycle begins again.

The four stages create three types of capital: human, structural and customer, into which Giga looks from a different perspective than the one we used upon defining these types of capital, in section 2.1.3 above.

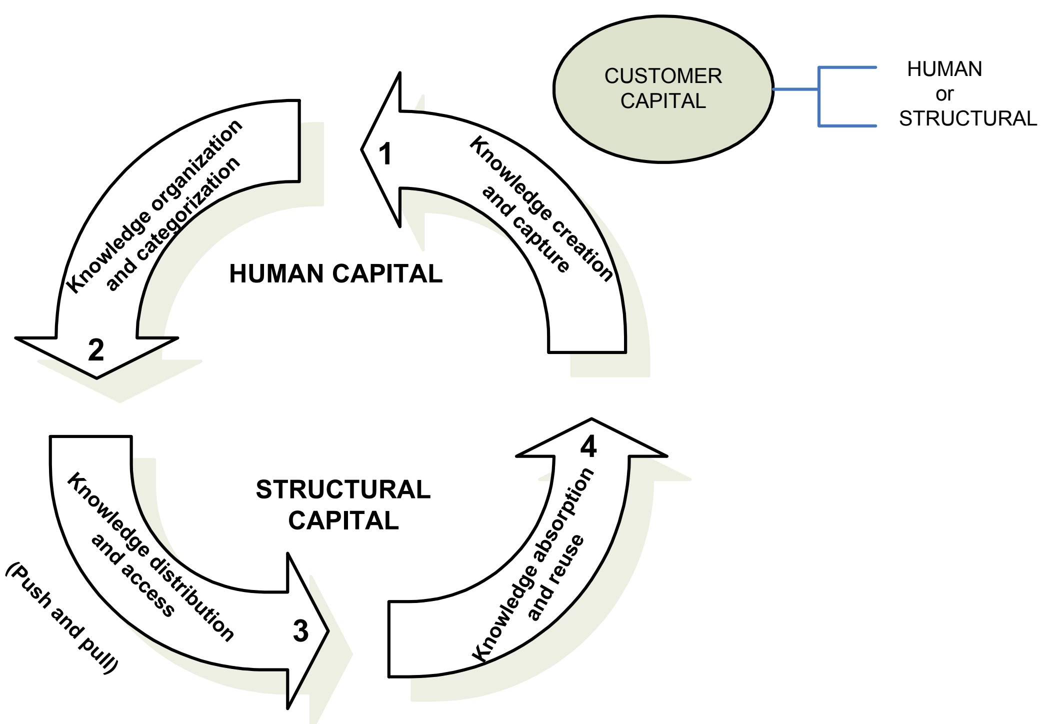


Figure 4.2 The Giga Knowledge Management Model
(Source: "Best Practices in Knowledge Management", Giga Information Group, 1997)

Human capital consists of knowledge, skills and innovativeness of employees as well as company values, culture and philosophy. It is created during stages one and four: knowledge creation and capture, and knowledge absorption and reuse. The emphasis here is on the ‘people’ aspects of knowledge management, as both these two stages focus on getting people together to share knowledge. The company culture and philosophy, together with the adequate human resources strategy have a primer role in attracting people who have more knowledge in their heads to work for the company.

Structural capital consists of the capabilities embedded in hardware, software, databases –that support employees- as well as the company’s patents and trademarks. It is formed during stages two and three: knowledge organization and categorization, and knowledge distribution and access. The emphasis here is on the technology issues supporting knowledge management and sharing, as both these stages focus on moving knowledge from people’s heads into tangible company assets (computers, processes, documents, etc).

Customer capital represents the strength of a company’s franchise with its customers and networks of associates. When customers are familiar with a company’s products or services, ‘familiarity’ customer capital is created. This form of capital –actually the first intangible asset that appeared into the company’s books as ‘goodwill’- can either be human (customer relationships with the company) or structural (products used from the company).

Based on several case studies, Giga discovered that the two human capital stages require different attitudes, compared to the two stages of structural capital. The techniques used to grow human capital do not usually work when the objective is structural capital growth. Companies that focus on human capital use people-centric approaches, while those that focus on structural capital take a typical IS approach and use technology to solve the problem. In the first case, the target is to boost employees’ moral, motivate them and create positive feelings; in the second, emphasis is centred on yellow pages of experts, groupware and knowledge sharing networks. However, as Giga advises, companies wishing to succeed in leveraging intellectual capital in total must follow a mixture of the two approaches that best fits to their strategy.

In Table 4.2, in the next page, are tabulated the key activities in each of the four stages, the form of capital each one supports, the skills required of people, and the IT tools and techniques that an prove valuable for that stage in accordance with the GIGA model.

Stewart (2002) makes the important point that knowledge needs to be managed within the context where value is created. He notes that many official knowledge management efforts have failed just because they did not manage to provide the place where people first look for knowledge. On the other hand, a number of simple, unofficial efforts have succeeded. Stewart gives such an example.

Phase	Emphasis	Skills/People	Tools/Techniques
Creation and Capture Generate new knowledge Make tacit knowledge explicit Hire people with the right knowledge Create culture of sharing Encourage innovation Incentives for sharing	Human capital Customer capital	Knowledge harvesters Knowledge owners Mentoring/coaching Partner with universities Teamwork Business intelligence Top management	Easy-to-use capture tools E-mail Face-to-face meetings Knowledge tree Write-to-think Feedback
Organization and Categorization Package knowledge Add context to information Create categories of knowledge Create knowledge vocabulary Create metadata tags for documents Measure intellectual Capital	Structural capital	Academics Knowledge editors Librarians Knowledge architects Authors Subject matter experts IS	Frameworks Cull knowledge from sources Best practices databases Knowledge bases Knowledge thesaurus Knowledge indexes Measurement tools
Distribution and Access Create links to knowledge Create networks of people Create electronic push and pull distribution mechanisms Knowledge sharing	Structural Capital	Publishers Top management IS	HTML Groupware, Lotus Notes Networks, intranets Navigation aids Search tools
Absorption and Reuse Stimulate interaction among people The learning organization Informal networks	Human capital	Group facilitators Organizational developers Matchmakers Knowledge brokers	Team processes Electronic bulletin boards Communities of practice Yellow pages

Table 4.2 Knowledge Management Stages and IT Tools
Source: "Best Practices in Knowledge Management", Giga Information Group, 1997.

It is about an informal, unofficial Lotus Notes-based e-mail list within the company, providing a place where people (in our case, from Manufacturing, Quality and R&D groups) can collaborate online. Anyone could join the list, which very soon became the premier knowledge-sharing mechanism in the company even though it is difficult to search and generates a lot of messages that fill up e-mail boxes. Four are the main reasons –according to Stewart- for its success:

1. It is demand driven. Some 80 percent of the traffic is members asking each other, "Does anyone know anything about ….?"
2. It roots out tacit knowledge. People contribute what they know, which, in most of the cases, might not be recorded anywhere in the company files.
3. It is right in front of the members in their e-mail boxes every day.
4. It is full of intriguing and strongly held opinions, which the members find most interesting.

It is a generic knowledge management system that fits the exact knowledge-sharing group and works like a 'conversation' rather than a library.

We shall close this section on designing the IS to serve knowledge sharing in practice, with a concluding comment coming directly from the field. Cohen (1998, p. 27), in his report, tells us what Gordon Petrash and his colleagues at Dow Chemical have learned during the implementation of a knowledge management project:

- knowledge management is most effective when it is integrated into people's jobs,
- knowledge value extends beyond dollar value and depends on its context, and
- good knowledge measures integrate quantitative and qualitative elements.

This last comment will be very seriously considered in the following section, where the theoretical basis for relating knowledge management to manufacturing performance will be set.

4.3 KM and Manufacturing Performance

In the course of our investigation we have identified a number of specific KM problems encountered by engineering groups involved in manufacturing and product development. The two areas, have a lot of things in common, but are not the same. As Adler et al (1996) note, "Product development is not manufacturing. It is mainly knowledge work. The tasks are not nearly as repeatable as they are in manufacturing, and standardizing the work would kill creativity." (p.134). Even though we focus on Production, Quality and R&D groups, the role of other groups (i.e. Supplies, Sales and Marketing, Logistics, etc) is of importance.

Some organizations believe that they have internal customers; manufacturing is marketing's customer, for example. By doing so they lose sight of what they are trying to accomplish as an organization. Others are organized around multifunctional processes that are directly focused on serving the end user. They form 'product business teams' that behave completely differently to the way departments behaved in the past over relevant functions. In this way a lot of dumb decisions in manufacturing –made only for the sake of manufacturing- can be avoided. The 'product business teams' are meant to divert the focus from the function to the customer.

There are particular aspects in the manufacturing process that create difficult situations for both the Knowledge Sharing Networks (KSNs), and the knowledge management system in use. We are listing here below some of the most common ones:

- Lack of shared understanding, mainly due to the fact that they do not all use a common language
- Discrepancies among the various versions of information stored in different locations of the KSN
- Extensive use of personal (or group) information stores and the absence of easy-to-use indexing systems
- Over- dependence upon sharing explicit knowledge and information, as the tacit one is more difficult to flow
- Loss of skills developed due to collaboration, as they are not transferable through the KSN
- Over-dependence on the KSN, and thus minimization of face-to-face contacts

In industrial environments where these situations are not overcome, they may result in inefficiencies in the manufacturing process, which may, in their turn, produce a negative influence on the performance of the organization. Thus the effort is to make available infrastructures supporting knowledge management applications and introduce management initiatives promoting knowledge sharing activities throughout the entire manufacturing environment.

Increasing productivity is one of the challenges for KSNs in a manufacturing environment. Product and manufacturing process life cycles are becoming shorter as we move from traditional to more high-technology based engineering. As a consequence, the available time for recovering the expenses related with developing and manufacturing new products, is also compressed. This places a reward on the ability of KSNs to capture knowledge created during the process and re-use it in the next generation of products, thus reducing the development and manufacturing time. This "capture-reuse" cycle is a key enabler for performance improvements. The fact that the challenges associated with capturing and reusing knowledge, are basically knowledge management challenges is underlining KM's key role.

KM responses to this challenge may range from the Knowledge Management Architecture (proposed by Zack, 1999a) to the alternatives of a Knowledge Codification Strategy (a people-to-document approach to codify, store and reuse knowledge) or a Knowledge Personalization Strategy (based on networks of people and dialogue between individuals) proposed by Hansen et al (1999). Companies using codification strategies or approaches rely primarily on repositories of explicit knowledge. Personalization strategies or approaches imply that the primary mode of knowledge transfer is direct interaction among people.

Based on a study of KM practices of companies in several industrial sectors (Consulting Firms, Health Care and High Tech Industry) Hansen et al (1999) note that although in every sector managers had chosen a distinct knowledge management strategy, there is a common pattern among them. “Those that pursued an assemble-to-order product or service strategy emphasized the codification and reuse of knowledge. Those that pursued highly customized service offerings, or a product innovation strategy, invested mainly in person-to-person knowledge sharing.” (p. 112). They also note that many companies that use knowledge effectively have chosen one strategy predominantly and use the second one to support the first, on an 80-20 split: 80% of their knowledge sharing follows the predominant strategy and 20% the supporting one. They advise managers not to straddle as they may find themselves with an unmanageable mix of people and expertise. Grover and Davenport (2001) in a recent article seem to be in complete agreement, when they state: “Both [codification and personalization approaches] are necessary in most organizations, but an increased focus on one approach or the other at any given time within a specific organization may be appropriate” (p. 8). It is noteworthy that they add ‘time’, as a new parameter affecting the company’s decision.

4.4 Summary

In this chapter we focused on the role of IT in connection with the knowledge-based theory. First we presented in an analytical way all the possible collaboration types, in relation to time and place, and we referred to the IT-based Systems for Supporting Collaboration. Emphasis was given to collaboration in a manufacturing environment.

Second, we examined once again –this time from a more practical perspective than in chapter 2- issues related to the company’s intellectual capital and the exploitation and sharing of knowledge, based on IT Systems Supporting Knowledge Work. A practical KM model, namely the Giga model, has been presented as an example.

Third, we focused on problems related to the use of Knowledge Sharing Networks (KSNs) as the KM tool that mostly affects manufacturing performance, the subject matter of our investigation. Codification and personalization strategies, which may –according to the literature- be appropriate in most organizations at a given time, have been presented. In the next chapter we shall look into knowledge management issues under the globalization perspective.

Chapter Five
Knowledge Management and Globalization

Chapter 5. KNOWLEDGE MANAGEMENT & GLOBALIZATION

> "Being an international company –selling globally, having global brands or operations in different countries- isn't enough."
> David Whitwam

David Whitwam, Whirlpool CEO interviewed for Harvard Business Review (March-April 1994 issue, p. 136) accomplished the above quote saying that: "The only way to gain lasting competitive advantage is to leverage your capabilities around the world so that the company as a whole is greater than the sum of its parts."

There is no doubt that the world economy, during the last two decades, has demonstrated unique characteristics such as the critical role of information and communication technologies and the extent of globalization. The new knowledge-based economy, which is inhabited by knowledge-intensive firms employing knowledge workers, has its own economic structures and rules although it does not fundamentally differ from the industrial economy which preceded it. Grant (2000, pp. 29-30) juxtaposes a list of characteristics of the new, knowledge-based, postindustrial economy that –according to his opinion- is closely associated with the increasing interest in knowledge management:

- The principal factor of production in the new global economy is knowledge, as opposed to capital (industrial economy) and land (agrarian economy).
- The primary assets of firms are intangible (like technology, patents and brands) rather than tangibles (land, machines, and financial assets).
- It is digital, fully networked (through Intranets, Extranets and the Internet), and thus virtual. Grant describes the 'virtual' organization as one "… that lacks either formal structure or authority" (2000, p. 29).
- The new economy is fast moving (compressed product life cycles) and still better performing, in developed countries where the demand to appreciate the benefits of the new economy is not stagnant.

The combined effect of these characteristics has resulted to a number of structural changes within the business sector. Dissolving the boundaries between firms and markets, making gradually less clear the distinction between producers and consumers and finally globalization itself are among them. But, as Grant warns, by accumulating every significant change that has occurred in the new economy and accrediting them all to the new knowledge economy we run the risk of failing to analyze contemporary trends. And this analysis is very important if we are to understand the current business environment and plan its traces into the future.

5.1 The Global Economy Era

At the turn of the 20^{th} century multinational corporations and big 'national' companies found themselves competing in a rapidly globalizing economy unified by improved communications and transportation services. This new situation is affecting both companies and consumers and has opened a debate about how far, and to what extend, the world we live in is being reshaped by global forces and processes, what is commonly called 'globalization'. In an effort to conform with this new reality, many national companies follow a transformation path from 'international' to 'multinational' and finally to 'global', as noted by von Krogh et al (1996, p. 204). According to the authors, the international stage is characterized by the development of an autonomous international division, completely independent from the existing domestic business; what characterizes the multinational stage, is the duplication of the firm's value chain across countries with increased local autonomy; finally the global stage is characterized by significant geographic integration of business activities and strategies.

Management and/or sharing of knowledge are processes definitely affected, as a company passes from its international, to multinational and finally to its global phase. Axioms like 'there should be no distinction between domestic and international', or 'each domestic activity exists to serve the greater global interest' very often remain inactive. The complex politics being pursued in recent globalization forums in Washington, Seattle, Genoa, Porto Alegre and elsewhere have created, both in the industrial world and the academia, supporters (the globalists) and enemies, the so called anti-globalists or 'skeptics'. We shall briefly refer to this debate in the next paragraph, as it only marginally affects the focus of our investigation, which is to study the effect of sharing knowledge –locally or globally, when appropriate- within an organization.

5.1.1 The Globalization Concept

The main characteristic of the world industrial economy –as understood up until very recently- was the emphasis on physical centralization of the means of production: factories and industrial workers, since capital never had a 'residence'. This was a direct consequence of the development of various mass production systems that required many workers to attend to machinery that were out of necessity installed in or near residential centers. In most cases these centers were equipped with transportation facilities necessary for the shipment of raw material and the manufactured products. These were dominant requirements from the early days of the industrial revolution –in late 18^{th} century- until the last quarter of the 20^{th} century. They are still principal requirements of large manufacturing organizations, despite the changes noted, mainly due to globalization.

Let us have a closer look to the globalization phenomenon. For Held and McGrew (2002, p. 1) globalization, looked through a broad perspective, simply "denotes the expanding scale, growing magnitude, speeding up and deepening impact of transcontinental flows and patterns of social interaction". Under this perspective we can look at globalization as a revolution in the scale of the industrial organization that links remote communities and allows the flow of power, processes and knowledge across the world's regions and continents.

Although the term globalization only recently gained broad acceptance, the concept is not new. Let us summarize its historical course, building upon Held and McGrew (2002, p. 1-8). It was first mentioned in the work of many 19th and early 20th century intellectuals and sociologists, like Karl Marx and Saint-Simon, who recognized how 'modernity' was integrating the world. The term itself only appeared in the 1960s and early 1970s when the 'golden age' of political and economical interdependence among Western nations demonstrated the insufficiencies of orthodox thinking about politics, economics and culture in local arenas only. The collapse of socialism in the 1990s, which coincided with the information revolution, was the final push that confirmed the belief that the world was fast becoming a shared social and economic space. Although this did not apply for all, it was at least true for the world's most prosperous inhabitants.

Within the academia neither the globalists nor the skeptics have gained the status of pure orthodoxy. Competing theories struggle for dominance. At the same time, existing western political schemes of conservatism, liberalism and socialism do not coincide in their interpretations of the phenomenon. Cases where conservatives and socialists –in one nation- do find a common pro-globalization ground very often have to confront with groups of their colleagues –in another nation- who consider globalization a major threat for their values and traditions. For the skeptics the very concept of globalization is rather unsatisfactory, if not a myth, at the best. For the worse it can be seen to be little more than a synonym to Westernization or Americanization. Globalists, although they do not deny that globalization may well serve the interests of strong western economic and social forces, they see it as a vehicle of deep structural changes in a global scale of modern social organization. They accept that, among others, these changes may be in favor of the growth of multinational enterprises, world financial markets and the diffusion of cultures, but may also affect the global environmental degradation.

5.1.2 The Global Arena

The member countries of the Organization for Economic Cooperation and Development (OECD) are generally considered to constitute the developed world. Although the list includes US, Canada, most of the countries of Western Europe, Australia, and Japan, many still confuse it with the western world, when it comes to globalization issues. When referring to an integrated global economy we bear in mind the increasing organization of the world economic activity within three core regions, each with its own center and periphery. These are Europe, the Americas and Asia-Pacific.

The European region, still counts with the new EU members, eight of which come from the former Eastern Europe and the Soviet Union. Russia is a potential country in the region, mainly due to its well-educated population, something that is valid for most of the former Soviet block countries. With investments and programs supporting infrastructure from both the EU and OECD, many of these countries are soon expected to change region. New countries, mainly from the former Yugoslavia, are going to replace them.

The Americas include the Spanish- and Portuguese-speaking countries of Latin America and the Caribbean. Aided by capital inflows from the OECD countries, this group is beginning to develop the level of infrastructure that will allow it to be considered, soon, an important outsourcing destination.

The Asia-Pacific region includes India, Thailand, South Korea and most of the non-continental pacific countries, like Singapore, Malaysia, Indonesia, the Philippines and Taiwan. It also includes Hong Kong, now being part of the Peoples Republic of China, another future potential outsourcing destination. The region is already considered a major economic force in the globalized world.

Two other regions merit a special consideration, at least from the globalists perspective who see a future for globalization. The first, central and north Asia which includes former Soviet republics like Uzbekistan, Kazakhstan etc, with relatively well-educated populations and a prominent industrial past, as well as the northern territories of China which do not appear to have much in common with its south. The second region includes Africa and the Middle Eastern countries and is characterized by poor economic conditions in much of central and northern Africa, accompanied by political instability. The anticipated countries for outsourcing are Algeria, Egypt, Israel, Nigeria and South Africa.

Searching for higher efficiency, global corporations have outsourced much of the labor of manufacturing to countries where the cost of labor is relatively low, like certain ex-East European countries, Asia, and the Far East. Focused only in Europe’s top 500 companies Berger (2004) reports that 39% of them have already off shored and another 44% have plans to offshore. It is important to notice though that countries preferable for outsourcing combine low labor cost with a sufficient technological background. This has enabled corporations to even move IT functions in countries like India, the Philippines and increasingly to China. Labor cost can be cut to half with a move to Slovakia, for example, or to less than one third, if the company chooses China. A top programmer in India may be paid only a fraction of what his Silicon Valley colleague would earn, but this is only the one aspect of the coin. Corporations have to factor in hidden costs like travel expenses for supervising executives, or the need to provide back-up generators in India, where state provided electricity is distrustful.

The extended outsourcing of manufacturing production by multinationals to the Newly Industrializing Economies (NIE) of Eastern Europe, Asia and Latin America has resulted to a de facto restructuring -that some even call a deindustrialization- of the OECD economies. NIEs have become an increasingly important destination of OECD investment and an increasingly significant source of OECD imports. In the global arena, NIEs now account for an important proportion of global exports, and as they integrate into transnational production networks, they are soon expected to directly compete with the metropolitan economies, which created them.

Under these conditions companies now require quality, value, service, innovation, and speed-to-market for business success. At the same time, customers have an endless choice of new and better product and services offerings from global companies. David Whitwam, Whirlpool CEO in his interview for Harvard Business Review (March-April 1994 issue) explains that in a very vivid way. First (in p. 143) he explains how Whirlpool changed its scope from the ‘refrigerator’ or ‘washing-machine’ businesses into the ‘food-preservation’ and ‘fabric-care’ businesses. He explains that going global has allowed Whirlpool to distance itself from its pure business scope, rethink who its customers were and what their needs were. And second (in p. 145), he gives a real example: the super-efficient, chlorofluorocarbon-free refrigerator. The product was designed under the above ‘food-preservation’ scope, using insulation technology from Whirlpool European business (Philips), compressor technology from their Brazilian affiliates, and manufacturing and design expertise from their US utilities.

The global economy issue, although it appears to have a strong commercial dimension has been the focal point for many academics and researchers. Porter and Millar (1985) are among the first to notice how information technology can increase a company’s ability to compete nationally and globally. Using the newspaper industry as an example they refer to Dow Jones, publisher of the Wall Street Journal, as an example of a newspaper edited centrally but printed in its 17 US plants as well as at local printing facilities in Asia and Europe.

5.1.3 Globalization in Figures

Over the last few decades developing economies’ shares of world exports (outputs) and foreign investment flows (inputs) have increased considerably. Under this perspective, globalization also appears to have an impact into the shares of international commerce. As Davenport and Prusak (2000, p. 13) note, in the 1950s US based companies accounted for 53 percent of the world GDP (Gross Domestic Product), and have dropped to only 18 percent in the global economy era of the year 2000.

Despite the fuss on the globalization effect (positive or negative according to the globalistic or skeptic perspective), the truth is that Multinational Corporations (MNCs) are little more than ‘national corporations with international operations’ Hu (1992). Their home base remains a vital foundation for their continued success and identity.

A close look at the Fortune 500 list of the world's largest companies shows that very few of them are headquartered outside the US, EU (Germany, UK, France and Italy) or Japan, as shown in Table 5.1.

Also from Table 5.1, we can easily gather that EU and Japanese MNCs, summed together, surpass the US ones, and this reveals the myth of globalization acting as a convenient cover for the internationalization of the American businesses. One can easily affirm that the contemporary global economy is structured around the three major centers of economic power: the US, Japan and Europe. This is a clear distinction to the era of the first industrial revolution, during which nation-states and national economies were being forged, or the postwar decades of clear US dominance. In the global era no single centre, not even the US, can dictate the rules of global trade and commerce.

Country (Region)	**No. of MNCs** (in 1999)
United States	179
EU (European Union)	148
Japan	107
Canada	12
South Korea	12
Switzerland	11
China	10
Australia	7
Brazil	3
Other	11
Total	500

Table 5.1 Location of the World's 500 largest MNCs
(Source: Adopted from 'The Fortune Global 500', Fortune, 2 August 1999)

Another myth has to do with the relevant size of national economies and MNCs. M. Wolf in an article published in the Financial Times (on November 7th, 2002) makes an interesting distinction. He claims that comparing the MNCs size of sales, to the national GDP (Gross Domestic Product) is totally misleading. He believes that the true economic power of the MNCs is the 'value added' and he compares that to the national GDP. As Wolf clearly demonstrates no MNC gets into the top forty largest economies in the world. Governments, for the most part, remain the dominant economic players in the global economy. Corporations do not rule the world, as governments -at least the most powerful ones- retain considerable bargaining power, when MNCs require access to vital national economic resources and markets.

With this in mind, we shall present some indicative figures, based mainly on UNCTAD (2001), the annual World Investment Report of the United Nations Conference on Trade and Development. In the year 2000 there were 60.000 MNCs worldwide, with 820.000 foreign subsidiaries selling $ 15,6 trillion of products and services across the globe, and employing twice as many people as in 1990. MNCs are estimated to account for at least 25 per cent of world production and 70 per cent of world trade, while their sales are equivalent to almost 50 per cent of world GDP. During the 1990s the boom in foreign takeovers and mergers affected the size of major MNCs in strategic areas of industrial, finance and telecommunications activity. This has also affected the flow of foreign investments, as in the year 2000 thirty countries accounted for 95 per cent of the investment. The leading triad (US, Europe and Japan) still counts for a 59 per cent, despite the fact that, overall more countries than ever before are recipients.

Among the skeptics, there are fears that globalization increasingly escapes the regulatory reach of national governments while, at the same time, globalists complain that existing multilateral institutions of global economic governance (like IMF, the International Monetary Fund; the World Bank and WTO, the World Trade Organization) have limited authority because nations refuse to cede them substantial power.

5.2 Knowledge Management: An Answer to Globalization

> "Intellectual capital will go where it is wanted,
> and it will stay where it is well treated.
> It cannot be driven; it can only be attracted."
> Walter Wriston (1992)

As we have mentioned in section 2.1.2, knowledge management owes its inspiration to the work of the philosopher Michael Polanyi and the Japanese organization learning 'guru' Ikijuro Nonaka. Both of these theorists argued that knowledge has two forms: explicit and tacit, which have some similarity to Thomas Stewart's hard and soft knowledge assets. Explicit knowledge is the obvious knowledge found in manuals, documentation, files and other accessible sources. Tacit or implicit, knowledge is found in the heads of an organization's employees. It is far more difficult to access and use -for obvious reasons. Typically, an organization does not even know what this knowledge is.

What makes the situation even worse is the impulsive reaction of top managers who fire employees at the first sign of any downturn, and which means that the knowledge is often lost. Davenport and Prusak (2000) give a number of real industrial world examples (from the aerospace industry, Ford, and International Harvester) where during downsizing periods, they had to fire engineers that took valuable knowledge out of the company's door with them, and was so difficult to rehire them, many years later, when similar new business opportunities appeared. And they conclude by noticing that: “Having made costly errors by disregarding the importance of knowledge, many firms are now struggling to gain a better understanding of what they know, what they need to know, and what to do about it” (p. xix).

Very often, in the industrial world, both the size of the products and varying consumer preferences force companies to have regional manufacturing centres. But even though the features, dimensions, and configurations of products like automobiles, home-appliances, and computers vary from market to market, much of the technology and manufacturing processes involved are similar. So, while a global company may need plants in Europe, the United States, Latin America and Asia to manufacture products that meet the special needs of these local markets, it is still possible –and very often desirable- for those plants to share the best available product technologies and manufacturing processes. In order to succeed that, global companies need to create an organization whose employees are skilful at exchanging ideas, processes, and systems across borders, people who are willing to work in teams in order to identify the best global opportunities and to provide solutions to the gravest global problems facing the organization.

Companies that are asking their employees to work together in pursuing global ends across organizational and geographical boundaries, they have to give them a vision of what they are striving to achieve, together with a unifying philosophy to guide their efforts. Many global companies have found out that a sincere, strong and long-term ‘focusing on the customer’ philosophy is the only way to understand and respond to genuine customer needs, and at the same time, this philosophy can lead to breakthrough products and services that earn the desired long-term customer loyalty. Alternative philosophies that simply centred to achieving low cost and high quality products and services have proven inadequate in the global economy era. Based on similar theories, managers of international companies that are not managed as global businesses often incorrectly assume that since consumers differ from country to country, their company cannot operate effectively as a unified entity. As a result, they see the organization as a mosaic of specialized businesses and many of them cannot grasp the idea that their industry could grow into something different over time.

5.2.1 Intellectual Capital and Knowledge Management

It is broadly accepted that the skills and capabilities required to manage the knowledge of a global company are different from those required for a domestic one. Getting an organization –and not just top management- to think globally is not an easy task. Neither can it be accomplished by simply trying to match existing skills with the emerging global management requirements. In some cases education and training programs may provide a remedy, but it is very often that recruiting from the outside is absolutely necessary. For a collection of regional organizations to transform themselves in a sort time to a global enterprise, an injection of new skills or perspectives is required.

Top management can forcibly position the organization at the beginning of the path to globalization by creating the processes and structures to help employees take the first steps. Management has the responsibility to convince employees why transformation is necessary, to get the organization going and keep people aimed at the right direction. For a company to become truly a global enterprise, employees have to change the way they think and act, taking on progressively more responsibility and initiative until the company behaves globally in all of its regions. This is a time consuming process that cannot be accomplished overnight, as most of the global merges usually happen. Merging or acquisition contracts give enterprises ownership of land, buildings and capital while employees have to enter into the work contract of their own free will, motivated by top management. An initiative like globalization does not acquire momentum just because it is enormous. It is the art of knowledge management that has to push hard to overcome the initial inertia, and keep pushing so that friction –in the form of fear, uncertainty, and confusion- does not stop the globalization initiative it its tracks.

We consider it useful to distinguish, at this point, the basic difference between Knowledge Management and Intellectual Capital Management. According to Wiig (1997a, pp. 400-403) there is definitely an overlap between the approaches of both processes. But, undoubtedly, there are orientations that distinguish their focus and approach in a very clear way.

Intellectual Capital Management (ICM) focuses on building and governing intellectual assets from strategic and enterprise governance perspectives with some focus on tactics. Its function is to take overall care of the enterprise's intellectual capital.

Knowledge Management (KM) has tactical and operational perspectives. KM is more detailed and focuses on facilitating and managing knowledge related activities such as creation, capture, transformation and use. Its function is to plan, implement, operate and monitor all the knowledge-related activities and programs required for effective intellectual capital management.

It is clear from the above definitions that Intellectual Capital Management has a strategic approach and its main objective is to manage the entire intellectual capital of the company in a way that it is measurable, using indices easily incorporated in the organization's financial balances and indicating, with the maximum accuracy, the organization's real value.

On the other hand, Knowledge Management has a tactic and operative approach. It is interesting to list, at this point, a number of definitions of Knowledge Management, given by various researchers as quoted in (WEB-01):

- Karl Erik Sveiby: "It is the art of creating value by leveraging the intangible assets. To be able to do that, you have to be able to visualize your organization as consisting of nothing but knowledge and knowledge flows."

- Larry Prusak: “It is the attempt to recognize what is essentially a human asset buried in the minds of individuals, and leverage it into an organizational asset that can be accessed and used by a broader set of individuals on whose decisions the firm depends.”
- Hubert Saint-Onge: “It is creating value based on the intangible assets of the firm through relationships where the creation, exchange and harvesting of knowledge builds the individual and organizational capabilities required to provide superior value for customers.”
- Chris Argyris: “The art of management is managing knowledge. That means we do not manage people per se, but rather the knowledge that they carry. Leadership means creating the conditions that enable people to produce valid knowledge and to do so in ways that encourage personal responsibility.”
- Verna Allee: “Knowledge management means attending to processes for creating, sustaining, applying, sharing, and renewing knowledge to enhance organizational performance and create value.”

Two main Knowledge Management aspects emerge from the comparison of the above definitions: KM is presented as a set of processes, and it s aimed to create value for the organization. Apart from definitions, it is also interesting to look into the different ways that authors describe the processes involved in knowledge management and see how each one of them estimates the created value.

Drucker (1998) contends that knowledge management will have a major impact on the structure of future organizations. He predicts that knowledge-based organizations will have half the number of management layers found in businesses today - and the number of managers will be cut by two thirds. Drucker considers that the organizational structures featured in current textbooks are still those of 1950's manufacturing industries. In the future, businesses will come to resemble organizations that today's managers and students would not pay any attention to: hospitals, universities, and symphony orchestras. In other words, knowledge-based organizations “composed largely of specialists who direct and discipline their own performance through organized feedback from colleagues, customers and headquarters.” (p. 45)

In the 20th century information was collected in order to monitor and control workers. 'Knowledge' was held at the top of the organization where strategies were determined and decisions made. But this Tayloristic view of the organizations ignored the wealth of knowledge held by ordinary workers. In Drucker's view, specialist knowledge workers will resist the primitive 'command and control' model of people management in the same way as professionals such as doctors and university teachers do already.

Drucker recently (2002) reinforced this idea, stating: ”What [in the past] made the traditional workforce productive was the system, whether it was Taylor’s ‘one best way’, Henry Ford’s assembly line, or Deming’s ‘Total Quality Management’. The system embodies the knowledge…. In a knowledge-based organization, however, it is the individual worker’s productivity that makes the entire system successful. In a traditional workforce, the worker serves the system; in a knowledge workforce, the system must serve the worker." And he further emphasizes, claiming that "…today's knowledge workers are not just labor –they are capital. And what differentiates outstanding companies is the productivity of their capital." (p. 76)

Schuppel et al (1998) argue that Knowledge Management has to compromise all activities regarding production, distribution, utilization and multiplication of relevant knowledge. In concrete, knowledge management can be implemented as a process along the following four dimensions:

- First, the process has to focus on the subjects of knowledge by optimizing the ratio of internal and external knowledge elements within the organization.
- Second, the process has to focus on the relevance of knowledge in the actual competitive environment, for building sustainable competitive advantages.
- Third, the process must increase the availability, communication and transfer of knowledge by focusing on both implicit and explicit forms of knowledge.
- Fourth, the richness and availability of knowledge have to be determined.

The authors argue that the goal of systematic knowledge management must be seen in the modelling of a dynamic knowledge spiral that builds on the four process dimensions by using specific, knowledge-oriented instruments.

Stewart (1998) reveals how today's companies are applying the concept of intellectual capital into day-to-day operations to dramatically increase their success in the marketplace. In the second part of his book, he offers a four-step guide to application of knowledge management concepts to modern business, and delivers strategies necessary for organizations to use when investing in intellectual capital and competing with others.

According to his guide, managing intellectual capital entails the following:

1. Identify and evaluate the role of knowledge in your business - as input, process and output. Learn more about your business and its use of knowledge by finding out who gets paid for knowledge, who pays, how much is being paid, and who creates the most value.
2. Match the revenues you've just found with the knowledge assets that produce them. Find out how much value the organization is getting from its expertise, capabilities, brands, intellectual properties, processes and other intellectual capital.
3. Develop a strategy for investing in and exploiting your intellectual assets. To do this, companies will need to determine their value proposition (what they know that they can sell, and how to sell it for a profit), source of control and profit model, as well as current strategies for increasing their knowledge intensity. Looking for ways to leverage or restructure intellectual assets will help.
4. Improve the efficiency of knowledge work and knowledge workers. Remember that knowledge work does not necessarily follow the linear

path that traditional labour follows, and look at ways to increase the productivity of knowledge workers.

Another important issue that derives from the above analysis has to do with the nature of knowledge. Managing knowledge as a static reserve disregards the essential dynamism of the knowledge creation process. And it is here where the role of leadership is vital. Leaders must support and encourage this dynamism and senior management must realize that in order for knowledge to be best managed, it has first to be "nurtured, supported, enhanced, and cared for" as Nonaka and Konno (1998, p. 53) note. Top management may assist in various ways, starting by sending out the message to the entire organization that knowledge management is critical for its success; by providing funding necessary for infrastructure and finally by clarifying the type of knowledge which is most important for the organization.

5.2.2 Knowledge Management in Practice

As we have already mentioned, due to the increasing emphasis on knowledge, it has been considered very often – and especially among middle and senior level managers- identical with 'intellectual capital', mainly in order to distinguish it from other kinds of capital that firms possess. In the industrial world, the term knowledge management is very often used to describe everything from organizational learning efforts to database management tools.

Ruggles (1998) conducted a study among 431 US and European organizations aiming to find out what firms are doing to manage knowledge, what else they think they could be or should be doing and what they feel are the greatest barriers they face in their efforts. What is most interesting in Ruggleses study is the perspective he is using in order to view the role of knowledge in the firm. He applies the traditional process-based view of the firm in order to find out what can be managed about knowledge. During the interviews Ruggles asked executives of participating firms about their organization's performance on eight major categories of the following knowledge focused activities:

- Generating new knowledge (46%)
- Accessing valuable knowledge from outside sources (34%)
- Using accessible knowledge in decision making (30%)
- Embedding knowledge in processes, products, and/or services (29%)
- Representing knowledge in documents, databases, and software (27%)
- Facilitating knowledge growth through culture and incentives (19%)
- Transferring existing knowledge into other parts of the organization (13%)
- Measuring the value of knowledge assets and/or impact of knowledge management (4%)

Numbers in parenthesis indicate the percentage of executives who believe their organization has a good or excellent performance at the knowledge process under question. It is interesting to notice that knowledge processes as common as 'generating new knowledge' or 'embedding knowledge in processes and products' did not receive an above average rating, while on the other hand, the measuring process only rated 4%.

However, a promising finding is that 94 percent of the executives believe that "it would be possible, through more deliberate management, to leverage the knowledge existing in my organization to a higher degree" as quoted by Ruggles (1998, p. 81). Another interesting finding has to do with the 'should-do' efforts proposed by the executives with the higher rating:

- Mapping sources of internal expertise (33%)
- Creating networks of knowledge workers (30%)
- Establishing new knowledge roles (28%)

Although 'should-do' does not necessarily means that it will be done, it is important to notice that all three are related to processes that facilitate knowledge sharing in the firm.

5.3 Summary

In this chapter we have examined the competitive environment as it appears into today's global economy era. First, we analyzed the recently emerged globalization concept and we presented the three most important regions for outsourcing activities. Statistical figures, highlighting the importance of the globalization phenomenon, have been quoted.

Second, we have once again looked into intellectual capital management, versus knowledge management, this time under the globalization perspective. We have also examined the influence that the globalization phenomenon has had into the recent information technology developments. Managing and sharing knowledge in practice has been regarded as an answer to globalization.

In the next chapter, we shall present the design of our research and shall discuss threats to validity.

Chapter Six
Design of the Research and Threats to Validity

Chapter 6. DESIGN OF THE RESEARCH AND THREATS TO VALIDITY

> "What does it mean if a finding is significant or that the ultimate in statistical analytical techniques have been applied, if the data collection instrument generated invalid data at the outset?"
> Jacoby (1978, p. 90)

The objectives of this Doctoral Thesis –as presented in chapter 1- are to investigate:

1. the concept of shared knowledge, among Manufacturing, Quality and R&D groups, as a key contributor to manufacturing group performance, and
2. the role and contribution of information technology (IT) as an enabler and facilitator towards both manufacturing performance and shared knowledge.

The research designed in order to fulfill these objectives has been conducted in two phases. In phase one, measures and collection instruments have been developed, while in phase two the actual field work was conducted.

In phase one, first step was to identify an initial set of measurement items as candidates for later use in the construct scales. Some candidate indicators have derived from published research articles, and some others have been generated through personal contacts and interviews with managers of production, quality and R&D departments and senior executives who experience similar relationships in their everyday business life. Both means of developing indicators (literature and interviews) have their advantages and disadvantages. Drawing on these two sources, offers improved chances to generate indicators of the highest possible validity. With these two inputs in hand we proceeded in a dual parallel approach, building the questionnaire and modifying or enriching the indicators' constructs, until we achieved the final forms used for the research. We have used indicators with proven reliability whenever they were available in literature, but we were also able to ensure that our indicators are meaningful and relevant to the concepts under investigation, through our field interviews.

6.1 The questionnaire

The principal research instruments were two questionnaires. One questionnaire dealt with characteristics of the Manufacturing and Quality or R&D relationship, with emphasis on sharing knowledge, and was completed by managers or senior employees who are actually part of this relationship. The second questionnaire dealt with aspects of manufacturing group performance, and was completed by organizational stakeholders. Both questionnaires were anonymous; a condition that is very common in similar type of research and none of them was simple for a number of reasons, the most important two being:

1. They were aimed to measure a number of variables, as they are presented in our evaluation model (see Figure 1 in section 1.3):
   - three independent ones
     (mutual trust and influence, and information technology)
   - a dependent, and possibly mediating variable (shared knowledge)
   - the basic dependent variable (manufacturing performance).

2. Information had to be collected from four different sources:
   - Production managers or their assistants
   - Quality managers or their assistants
   - R&D managers or their assistants
   - Senior managers or their assistants (plant managers; general directors; technical, quality and/or R&D directors; etc)

Despite these facts, both questionnaires had to be short and avoid all possible misunderstandings, so easy to occur when dealing with this kind of issues. Campbell (1955) emphasizes on the need for the responder (informant) to speak the same language of the researcher (social scientist). With this in mind, special effort has been made in order for the responder to completely understand the questionnaire, bearing in mind that he or she is not a social scientist. In section 3.2.2 we have addressed the common language issue from the general, sharing knowledge perspective. It becomes evident that there are several areas where the issue has been of importance for our study.

Referring to the informant/social scientist common language issue Bagozzi (1980, pp. 118-119), building upon Lachenmmeyer (1971) distinguishes four linguistic problems for any theoretical language:

1. Vagueness: “A term is said to be vague when the range of object predicates forming a term’s referential meaning has not been specified…”
2. Ambiguity: “Any term is ambiguous when more than two but a finite number of object predicates have been specified as equiprobable members of the set comprising its referential meaning.”
3. Opacity: “… refers to the failure of a term’s reference function because there is no referent object of the sort represented by the term’s object predicate.”
4. Contradiction: “… is a special case of ambiguity that occurs when a term has two different, equiprobable object predicates specified as its referential meaning and these object predicates are logically inconsistent.”

Despite the complexity of the problems addressed, special effort has been dedicated in avoiding all four problems upon phrasing and pilot testing the questionnaires used for our research.

6.1.1 Design

Soon in phase one, it became obvious that the relationship questionnaire should have two distinct versions, thus raising the actual questionnaire forms in three:

a) Two symmetrical Relationship Questionnaires were designed to measure the independent and mediating variables. Type A was addressed to Production managers or their assistants and explores the attitude of the Production group towards Quality and/or R&D groups. Type B contained exactly the same questions as Type A, worded in a reverse form, and aiming at portraying the opinion of the Quality and/or R&D groups towards the Production group.
Each of the questionnaires Type A and B included twelve (12) questions aiming to measure:

- dependent or mediating variable Sharing Knowledge (3 questions)
- independent variable Mutual Trust (2 questions)
- independent variable Mutual Influence (4 questions)
- the role and level of contribution of Information Technology (ITsk), both as a tool and/or enabler in supporting sharing knowledge among Manufacturing, Quality and/or R&D groups (2 questions)
- the use of IT infrastructure –under the above described concept (1 question with multiple sub questions).

b) A third, Type C, questionnaire attempting to measure the basic dependent variable –Manufacturing group Performance- was addressed to senior managers or their assistants (plant managers, general directors, technical directors, quality and/or R&D directors, etc).
Questionnaire Type C included nine (9) questions aiming to measure:

- operational manufacturing performance (3 questions)
- service manufacturing performance (3 questions)
- the level of contribution of Information Technology (ITmp) to Manufacturing group performance (2 questions)
- the use of IT infrastructure –under the above described concept (1 question with multiple sub questions).

The intent of our study is to evaluate the relationships among organizational units, rather than individuals, although the questionnaires are completed by the latter. In order to minimize misunderstandings and to facilitate completion, every questionnaire has been customized, in order to reflect the exact names of the participating organizations and functional groups. All three types of questionnaires are exhibited in Appendix 6A, at the end of this chapter, both in English and in Spanish, the latter being the language used, together with a sample of the accompanying introductory letter.

6.1.2 Pilot Testing

As already mentioned, and due to the complexity of the above described three types of questionnaires, pilot questionnaires have been created and tested using a small group of managers from organizations not participating in phase two of the research. Upon configuring the questions, we attempted to word them in as simple terms as possible and to anchor each question to one specific relationship. In addition, each question in the questionnaire was customized to include the exact name of the department, as it is used in the company in question. Since two or three indicators were necessary in order to capture the concept of each one of the variables under investigation, and each indicator generated one or two questions, it was critical to keep the number of indicators as low as possible, maintaining at the same time, the questionnaire length manageable.

The resulting relationship questionnaires (Type A and B) were pilot tested using Production and Quality managers, and the performance questionnaire (Type C) was tested using senior executives from the above small group of companies. Following the completion of each pilot questionnaire, the pilot test informant was debriefed to determine if any questions were confusing for any reason. They were also questioned, whether in his or her opinion, any significant indicators have been left out of the questionnaire.

Based on the results of the pilot test, a number of initially used questions were determined to be poor and were deleted or rephrased. Pilot testing was extremely valuable and contributed a lot to the overall workload of phase two, by minimizing the number of clarification questions addressed to us, and explanations needed during the Field Work.

6.2 Design of the Indicators and Measures

Two types of measures have been used to assess the organizational characteristics of shared knowledge, mutual trust, mutual influence, information technology and manufacturing performance: general and multiplicative.

- General, where each informant is asked to assess the overall level of interaction for a specific characteristic of a particular relationship.
- Multiplicative or interaction measure, where each informant is asked, for example, to assess the role of manufacturing and either R&D or quality group for each characteristic separately. Using the conceptualization of fit as interaction, proposed by Venkatraman (1989), the measurements have been operationalized as “manufacturing role X R&D or quality role”, by multiplying the two responses together.

There are a number of advantages to this measurement scheme, as indicated by Churchill (1979, p. 106) and Campbell and Fiske (1959, p. 81):

a) the two types of measures (general and multiplicative) can be thought of as different methods,
b) it provides a stronger test of the validity of the measurement scheme, and
c) it balances possible threats to validity inherent in either type alone.

The general rules that govern the relationship questionnaires A and B are:

- Informants have been asked to characterize the general working relationship that currently exists between the [Manufacturing] group and the [Quality or R&D] group, or vice versa.
- In every questionnaire, titles in brackets were customized to reflect the exact names of the participating organizations and functional groups, as they are used in every firm.
- The following 7-point Likert scale (1=Extremely Weak, to 7=Extremely Strong) was used to measure the responder's agreement with statements representing the concepts under investigation:

1	2	3	4	5	6	7
Extremely Weak	Weak	Moderately Weak	About Average	Moderately Strong	Strong	Extremely Strong

The common remark that in Likert scales ratings 1 and 7 are not very often used by the responders -as they appear reluctant to express extreme positions- only proved right for the lower rating, in our study. Lee and Choi (2003) in an empirical study using similar type of questionnaires propose the use of a six-point Likert scale, which according to their opinion "… avoids the midpoint [About Average …and] prevents responders from using a neutral default option" (p. 195). In the following sections we shall present, in detail, the indicators designed and used to measure the constructs of every organizational characteristic in focus.

More specifically, each of the five constructs of our evaluation model (manufacturing performance, shared knowledge, mutual trust and influence, and information technology) has at least two indicators in the measurement model.

- One indicator is a general assessment of both sides of the relationship as a whole, as for example in the question:

  The level of trust that exists between the [Manufacturing] group
  and the [Quality or R&D] group is:

  This assessment involves a fairly complex mental summarization and analysis for each response, which can lead to a relative error (Silk and Kalwani, 1982). We attempted to counteract this problem by wording the questions in as simple terms as possible and by anchoring the questions to the specific relationship of interest.

- The second and/or third indicators are multiplicative assessments, so we use as indicator value the product of the responses of a pair of related questions, as for example:

  1. The level of appreciation that the [Quality or R&D] group
     has for the accomplishments of the [Manufacturing] group is:

  2. The level of appreciation that the [Manufacturing] group

has for the accomplishments of the [Quality or R&D] group is:

> For complex assessments, the use of item pairs is preferable over single items for a variety of reasons (Byrne, 1988). Item pair variables are likely to: a) be more reliable, b) contain less unique variance since they are less affected by the idiosyncratic wording of individual items, c) be more normally distributed, and d) yield results having a higher degree of generalizability.

In the sections following we shall analytically present the indicators designed for each of the constructs of our measurement model. For practicality reasons we are using the order they appear in questionnaires A, B and C, instead of the one they appear in our evaluation model.

6.2.1 Shared Knowledge

The three indicators of shared knowledge have been designed to assess the level of understanding or appreciation which the members of the three groups have of each others' work environments. Indicators 1 and 3 assess the level of appreciation that each participant has for what their partners (in the other group) have accomplished, by using general and multiplicative assessments respectively. The second indicator measures the level of understanding which the members of the three groups have of each others' work environments.

Shared Knowledge Indicator 1: (General Assessment)

The level of appreciation that the [Manufacturing] group and the [Quality or R&D] group have for each other's accomplishments is:

Shared Knowledge Indicator 2: (Multiplicative Assessment)

The product of the responses to the following:

1. The level of understanding of the [Quality or R&D] group for the work environment (problems, tasks, roles, etc) of the [Manufacturing] group is:

2. The level of understanding of the [Manufacturing] group for the work environment (problems, tasks, roles, etc) of the [Quality or R&D] group is:

Shared Knowledge Indicator 3: (Multiplicative Assessment)

The product of the responses to the following:

1. The level of appreciation that the [Quality or R&D] group has for the accomplishments of the [Manufacturing] group is:

2. The level of appreciation that the [Manufacturing] group has for the accomplishments of the [Quality or R&D] group is:

Shared Knowledge Construct: The mean of the above indicators.

6.2.2 Mutual Trust

The two indicators of predisposition measure the extent to which the two partner groups trust each other. The first indicator directly assesses the level of trust between the groups, through a general assessment. The second indicator is a multiplicative assessment that evaluates the reputation of each group for meeting its commitments.

Mutual Trust Indicator 1: (General Assessment)

The level of trust that exists between the [Manufacturing] group and the [Quality or R&D] group is:

Mutual Trust Indicator 2: (Multiplicative Assessment)

The product of the responses to the following:

1. The reputation of the [Quality or R&D] group for meeting its commitments to the [Manufacturing] group is:

2. The reputation of the [Manufacturing] group for meeting its commitments to the [Quality or R&D] group is:

Mutual Trust Construct: The mean of the above indicators.

6.2.3 Mutual Influence

The three indicators of mutual influence assess the level of influence and the ability to affect that members of the groups have on each others' key decisions and policies. The first indicator directly assesses the 'level of influence' and the 'ability to affect' between the groups, through a general assessment. The second indicator is a multiplicative assessment that evaluates the 'level of influence' that the members of the groups have on each other's key decisions and policies. The third indicator is a multiplicative assessment that evaluates the 'ability to affect' that the members of the groups have on each other's key decisions and policies

Mutual Influence Indicator 1: (General Assessment)

The average of the responses to the following:

1. In general, the level of influence that members of the [Manufacturing] group and the [Quality or R&D] have on each other's key decisions and policies is:

2. In general, the ability of members of the [Manufacturing] group and the [Quality or R&D] group to affect each other's key decisions and policies is:

Mutual Influence Indicator 2: (Multiplicative Assessment)

The product of the responses to the following:

1. In general, the level of influence that members of the [Quality or R&D] group have on key decisions and policies of the [Manufacturing] group is:

2. In general, the level of influence that members of the [Manufacturing] group have on key decisions and policies of the [Quality or R&D] group is:

Mutual Influence Indicator 3: (Multiplicative Assessment)

The product of the responses to the following:

1. In general, the ability of members of the [Quality or R&D] group to affect key policies and decisions of the [Manufacturing] group is:

2. In general, the ability of members of the [Manufacturing] group to affect key policies and decisions of the [Quality or R&D] group is:

Mutual Influence Construct: The mean of the above indicators.

6.2.4 Information Technology (sk)

By means of the relationship questionnaires (Type A and B) we are measuring the role and level of contribution of IT to support shared knowledge. We thus use the marker (sk) to distinguish from the IT indicators used in the performance questionnaire.

Information Technology (sk) Indicator 1: (Multiplicative Assessment).

The product of the responses to the following:

1. In general, the role and the level of contribution of Information Technology (IT) as a tool and/or enabler, to support shared knowledge between [Manufacturing] group and [Quality or R&D] group is:

2. In general, the role and the level of contribution of Information Technology (IT) as a tool and/or enabler, to support shared knowledge between [Quality or R&D] group and [Manufacturing] group is:

Information Technology (sk) Indicator 2: (Multiplicative Assessment).

The product of the responses to the following:

1. In general, the use of the Information Technology (IT) infrastructure in the [Manufacturing] group is:

2. In general, the use of the Information Technology (IT) infrastructure in the

[Quality or R&D] group is:

Information Technology (sk) Construct: The mean of the above indicators

6.2.5 Information Technology Infrastructure

Finally, the use of certain IT infrastructure by the company, as a whole, is evaluated by the responses to the following multiple question:

Specifically, the use of the following IT infrastructure is:
Intranet [ ] Extranet [ ] Groupware [ ] , Workflow [ ]
Internet [ ] , e-mail [ ] , …………… [ ] , ….………….[ ]
Data warehouse [ ] ,
Other ………… [ ] , ………………….. [ ] …. ……. [ ]

Responses to this question will be analyzed separately in chapter 8 (section 8.3.2 and Appendix 8B), and the useful implication we expect to arise will be presented in chapter 9.

6.2.6 Manufacturing Performance

Manufacturing group performance has been conceptualized in two parts; as operational and service manufacturing performance.

- Operational (or 'inward') performance is operationalized as:
  - the quality of the manufacturing group's work product,
  - the ability of the manufacturing group to meet its organizational commitment, and
  - the ability of the manufacturing organization to meet its goals
- Service (or 'outward') performance is operationalized as:
  - the ability of the manufacturing group to react quickly to R&D and/or quality needs,
  - its responsiveness to the R&D and/or quality group, and
  - the contribution the manufacturing group has made to the R&D and/or quality group's success in meeting its strategic goals.

The general rules that govern the performance questionnaire C are:

- Informants have been asked to compare the [Manufacturing] group to other comparable manufacturing groups they have observed.
- Titles in brackets were customized to reflect the exact names of the participating organizations and functional groups, as they are used in every firm.
- The following 7-point Likert scale (1=Non-Existent, to 7=Extremely Strong) was used to measure responder's agreement with statements representing the concepts under investigation:

1	2	3	4	5	6	7
Non-Existent	Very Weak	Weak	About Average	Strong	Very Strong	Extremely Strong

The indicators used to measure the two constructs of manufacturing performance in our study, are given in detail, here below. As in approximately 95 per cent of the manufacturing units under investigation, the two stakeholders that completed the performance questionnaire have been related, one to Production and the second to Quality or R&D (in most cases Production or Quality Directors) we have used multiplicative assessments of interaction for the questions relating manufacturing performance to collaboration among the groups.

A. Operational Manufacturing Performance

Operational MP Indicator 1: (Multiplicative Assessment)

The product of the two stakeholders' responses (from Manufacturing and Quality or R&D) to the following:

1. In general, the quality of the work produced by the [Manufacturing] group for the [Quality or R&D] group is:

Operational MP Indicator 2: (General Assessment)

The average of the responses to the following:

2. In general, the ability of the [Manufacturing] group to meet its organizational commitments (such as project schedules and budget) is:

Operational MP Indicator 3: (General Assessment)

The average of the responses to the following:

3. In general, the ability of the [Manufacturing] group to meet its goals is:

Operational MP Construct: The mean of the above indicators.

B. Service Manufacturing Performance

Service MP Indicator 1: (Multiplicative Assessment)

The product of the two stakeholders' responses (from Manufacturing and Quality or R&D) to the following:

1. In general, the ability of the [Manufacturing] group to react quickly to the [Quality or R&D] group's changing business needs is:

Service MP Indicator 2: (Multiplicative Assessment)

The product of the two stakeholders' responses (from Manufacturing and Quality or R&D) to the following:

2. In general, the responsiveness of the [Manufacturing] group to the [Quality or R&D] group is:

Service MP Indicator 3: (Multiplicative Assessment)

The product of the two stakeholders' responses (from Manufacturing and Quality or R&D) to the following:

3. In general, the contribution that the [Manufacturing] group has made to the accomplishment of the [Quality or R&D] group's strategic goals is:

Service MP Construct: The mean of the above indicators.

Manufacturing Performance Construct: The mean of Operational MP and Service MP constructs.

6.2.7 Information Technology (mp)

By means of the performance questionnaire (Type C) we are measuring the role and level of contribution of IT in supporting the performance of the manufacturing group. We therefore use the marker (mp) to distinguish from the IT indicators used in the relationship questionnaires (Type A and B).

As, in approximately 95 per cent of the manufacturing units under investigation, the two stakeholders that completed the performance questionnaire were related, one to Production and the second to Quality or R&D (in most cases Production or Quality Directors) we have used multiplicative assessments of interaction for the questions relating manufacturing performance to the collaboration among the groups.

Information Technology (mp) Indicator 1: (Multiplicative Assessment).

The product of the two stakeholders' responses (from Manufacturing and Quality or R&D) to the following:

1. In general, the level of the Information Technology (IT) contribution to the [Manufacturing] group performance is:

Information Technology (mp) Indicator 2: (General Assessment).

The average of the responses to the following:

1. In general, the use of the Information Technology (IT) infrastructure, among the three groups is:

Information Technology (mp) Construct: The mean of the above indicators.

6.2.8 Information Technology Functions

Finally, the use of certain IT functions by the company, as a whole, is evaluated by the responses to the following multiple question:

Specifically, the use of the following IT function is:
- Coordinating business tasks: ☐
  (collecting, facilitating, sharing, etc. information)
- Supporting decision making: ☐
  (reaching the right information at the right time)
- Facilitating member' team to work together: ☐
  (no matter where they are)
- Facilitating access of information in Data Bases: ☐
  (no mater where they are)
- Other ……………………………………….: ☐
- Other ……………………………………….: ☐

Responses to this question will be analyzed separately in chapter 8 (section 8.3.3 and Appendix 8B), and the useful implication we expect to arise will be presented in chapter 9.

6.3 The key-informant methodology

Due to the specific theme of the investigation (the relationship among manufacturing, R&D and quality groups), it was necessary to address the questionnaires to personnel and management of the three groups involved. We tested the proposed evaluation model using a cross-departmental field study of the Manufacturing – Quality and/or R&D relationship dyads in 51 companies. The unit of analysis is the manufacturing group, since the intent of this study is to attempt to explain the relationship of organizational subunits (the three groups) rather than that of individuals.

As already mentioned in section 1.4, the research responders were chosen based on the key-informant methodology developed by Phillips and Bagozzi (1986), and for every company manufacturing, quality and/or R&D group managers or their deputies have been included. In relation to the depended variable, (manufacturing group performance), data has been collected from “stakeholders” in each company: senior managers or their assistants (general directors, plant managers, technical directors, etc). These stakeholders, positioned at the upper levels of the company organization, have also been chosen based on the key-informant methodology, and according to Huber and Power (1985) “… they have important information about organizational events. Their retrospective reports are accounts of facts, beliefs, activities and motives related to prior events." (p. 171).

As the measurement of organizational characteristics requires research methods different from those used for measuring the characteristics of individuals, key-informant methodology is a frequently adopted approach. Campbell (1955) makes the following opening statement: "The anthropological use of the informant is distinguished from the social survey in that the responders are selected not for their representativeness but rather on the bases of informedness and ability to communicate with the social scientist. As such, the method seems to have general social science utility" (p. 339). Phillips and Bagozzi (1986) describe the method as "…a technique of collecting information on a social setting by interviewing a selected number of participants. The informants are chosen not on a random basis but because they posses special qualifications such as particular status, specialized knowledge, or accessibility to the researcher" (p. 313).

Campbell (1955), by whom the use of the informant has been interpreted as a general social science tool, has further added that "… the technique of the informant means that the social scientist obtains information about the group under study through a member who occupies such a role as to be well informed but who at the same time speaks the social scientist's language." Campbell considers the use of informants as an alternative sampling technique "… epitomized by the use of one or a few *special* persons who are extensively interviewed and upon whose responses exceptional reliance is placed and, thus, is to be most clearly distinguished from randomly or representatively sampled interviews" (p. 339).

As Phillips and Bagozzi (1986) have noted, the measurement of group-level properties has often required the use of key-informant method, as a technique for collecting information from a selected number of participants. Initially the use of key informants has been associated with qualitative methodology. In these situations, the key-informant assumes the role of reporting on the behavioral paterns of a group (Manufacturing, Quality and/or R&D) after summarizing either observed or expected organizational relationships.

Recently organizational researchers have used the technique to obtain quantifiable information on organizational structure, technology, environment, internal power distribution and external exchange relationships. Silk and Kalwani (1982), Phillips and Bagozzi (1986), among others, have often used key-informant methodology in conjunction with procedures for collecting survey data to obtain quantifiable measures on organizational characteristics. In these situations, survey responders assuming the role of key-informants provide information at the combined or collective unit of analysis (i.e. group or organizational properties) rather than reporting personal feelings, opinions, and behaviors.

Due to the nature of the method, investigators have expressed concern over the following potential sources of measurement error in key informant reports:

- Reliability of informant reports may be affected by factors such as the types of questions asked and the personal characteristics of informants.
- Informants may often be asked by the researcher to perform complex tasks of social judgment, instead of answering into simple questions.
- Questions which require a person to aggregate over many events, persons, tasks, or organizational subunits may increase measurement error due to fatigue effects etc.
- Collection of data from only a single informant per unit of analysis.

We shall further examine, in section 6.4 following, these sources of measurement error in detail, as they represent real threats to validity. In the cases where these sources of distortion are influencing the informant's judgments about the organizational properties under investigation, there might be a low degree of correspondence between the informant reports and the concepts they intend to refer to. The following measures have been foreseen in our investigation - upon designing the questionnaires in section 6.1.1- in order to minimize all above sources of distortion:

- Questionnaires have been thoroughly checked prior to the investigation's final phase using a pilot questionnaire. This has permitted clarification of all possible points of misunderstanding.
- Questionnaires have been kept simple and in manageable size: Twelve questions for the inter-groups relationships and only nine for the stakeholders.
- Four informants for every unit of analysis have been questioned.
- Questionnaires have been customized. The actual department names of every unit and the related group has been used, in order to avoid misunderstandings.
- Questionnaires have been sent, completed and received in electronic form.

Although the precaution measures, did not make participation in the investigation an easy task, they did minimize to a very large extend the number of cases where responders had to get back to us for clarifications.

6.4 Threats to Validity

Our scientific investigation began with the formation of the concepts comprising our hypotheses and theory. Upon testing the hypotheses (in chapter 8), the concepts of 'validity' or 'invalidity' are used, whenever we refer to the best available approximation of the 'truth' or 'falsity' of propositions, including propositions about cause and effect. As Cook and Campbell (1979) suggest, the modifier 'approximately' should always be used when referring to validity, since we can never know what is true. In this section we shall examine a set of formal criteria –usually termed construct validity- addressing two issues: the measurement scheme in use and its validity as well as threats to validity in key informant analysis.

To test a theory, we need to measure each theoretical construct and analyze the relationships between the measured constructs. This is a process that is completed in two phases:

a) while developing valid measures of the theoretical constructs -as we have done in section 6.2, and
b) while testing the relationships between theoretical constructs, something that we plan to do in chapter 8.

In the literature on industrial group relationships, in particular, and in organizational research, in general, a considerable amount of attention is paid to the statistical analysis of the relationships between measured variables, but the objective of measuring validity is only partially carried out (Bagozzi 1980, Cook and Campbell 1979, Churchill 1979, Huber and Power 1985). This practice assumes that the measures are valid and adequately reflect the theoretical constructs under consideration. But, as Phillips and Bagozzi (1986) note, a possible lack of correspondence between the operational measures and the theoretical concepts they are intended to measure may result in the rejection of a hypothesis as either weak or totally absent.

6.4.1 Bagozzi Construct Validity Criteria

We shall build upon the works previously cited, in order to formally ascertain the issue. Bagozzi (1980) who defines construct validity "… as the degree to which a concept (term, variable, construct) achieves theoretical and empirical meaning within the overall structure of one's theory" (p. 114), is proposing six criteria or 'components of construct validity':

1. Theoretical Meaningfulness of Concepts
2. Observational Meaningfulness of Concepts
3. Internal Consistency of Operationalizations
4. Convergent Validity
5. Discriminant Validity
6. Nomological Validity

We shall further analyze Bagozzi's six criteria while, at the same time, we shall present the facts or parameters upon which the validity of our constructs can be proved. The first two criteria of validity involve semantic issues, not statistical tests and refer to the internal consistency of the language used to represent a construct and the conceptual relationship between a theoretical construct and its operationalization. For Bagozzi (1980) "The theoretical meaningfulness of a concept refers to the nature and internal consistency of the language used to represent the concept" (p. 117). To achieve meaningfulness, theoretical constructs must capture the characteristics and quality of the language used to represent the theoretical concepts. As demonstrated in section 3.1, our theory has derived from earlier research on organizational theory (from the resource-based to the knowledge-based theory), so our constructs are consistent with prior theories.

Bagozzi (1980) states that "… the observational meaningfulness of concepts refers to the relationship between theoretical variables (which are unobservable) and their operationalizations (which, of course, are observable)" (p. 121). To achieve this second criterion, measures must be clear, specific, unambiguous and related to theoretical constructs. Operational indicators, which are observable, can be used as long as one can demonstrate the link to theoretical constructs. In our study, we either used measures that have already been validated in previous studies, or we carried out systematic pilot-testing for the measures of the new constructs introduced by ourselves.

The third criterion is a strictly empirical one designed to determine the degree of internal consistency and single factoredness of one's operationalizations. Internal consistency of operationalizations refers to the degree of homogeneity of indicators asserting to measure the same theoretical construct. Evaluation of internal consistency requires more than one observational indicator or variable for each theoretical construct. The most commonly used summary statistic of internal consistency is the Cronbach's *alpha* coefficient, which is computed across a set of measures of a single theoretical construct. Cronbach's *alphas* vary from zero to one ($0<a<1$) while acceptable limits for the range of reliability scores can vary according to the problems of measurement. For attitudinal measurements, Cronbach's *alphas* above 0,6 are generally considered acceptable. When this minimal level of internal consistency is not achieved, the implication is that these variables could be measuring more than one construct.

Criteria number four and five, are traditional objects of the Multi-Trait Multi-Method Matrix (MTMM) approach. Convergent validity refers to the degree to which two or more measures of the same theoretical construct are in agreement. Discriminant validity refers to the degree to which one theoretical construct differs from another. Campbell and Fiske (1959) proposed a Multi-Trait Multi-Method matrix to assess convergent and discriminant validity of data gathered on multiple traits (theoretical constructs), using maximally dissimilar methods such as self report and unobtrusive observation. To assure that convergent validity and discriminant validity have been achieved in an empirical study, researchers should use more than one theoretical constructs and more than one method. Unfortunately, in many areas of IS and/or organizational relationships research, multiple methods of measuring a theoretical construct are not applied, although most studies do include more than one theoretical construct.

The criterion for convergent validity is that the correlation between measures of the theoretical construct should be different from zero and significantly large to encourage further investigation. The criterion for discriminant validity is that a measure should correlate with all measures of the same theoretical construct more highly than it does with any measure of another theoretical construct.

Bagozzi's final component of construct validity is nomological validity which refers to the degree to which predictions from a formal theoretical network containing the concept under scrutiny are confirmed. Nomological validity can be interpreted as whether one's own theory, once it has been found semantically and empirically valid, is consistent with a wider body of theory and whether it contributes to that theory. Assessment to nomological validity takes place with reference to related research.

While Bagozzi's criteria were originally developed in order to ascertain the correspondence between theoretical constructs and observational constructs, these criteria can and have been used in research design. As Bagozzi (1980) clearly states: "The achievement of construct validity (…) requires satisfaction of all six of the above criteria." (p. 114). That means that after empirical research is undertaken, the internal consistency of operationalizations, convergent validity, discriminant validity, and nomological validity criteria should be ascertained before the relationships among theoretical construct are analyzed on the basis of the empirically measured constructs.

Bagozzi's Six Criteria	**How Addressed in this Study**
Theoretical Meaningfulness of Concepts	Built upon the emerging discipline of the firm's resource- and knowledge-based theory.
Observational Meaningfulness of Concepts	Used previously validated measures, together with new measures that have been pilot tested.
Internal Consistency of Operationalizations	Employed multi-item scales and tested with Cronbach's *alphas*.
Convergent Validity	Employed multi-methods and tested with MTMM (Campbell and Fiske, 1959)
Discriminant Validity	Employed multi-methods and tested with MTMM (Campbell and Fiske, 1959)
Nomological Validity	The results of the study are consistent with a large body of theory and contribute to the reference field.

Table 6.1 Bagozzi's Criteria and How Addressed in this Study.

Table 6.1 summarizes Bagozzi's criteria and briefly indicates how these have been applied in our research.

6.4.2 Cook and Campbell Construct Validity Criteria

Cook and Campbell (1979, pp. 37-39) focus on four types of validity threats for, what they call 'quasi-experiments' and is more universally understood as empirical methods:

1. Statistical Conclusion Validity
2. Internal Validity
3. Construct Validity
4. External Validity

Although they consider the four criteria of the same importance, they recognize a "… special stress on internal validity" (p. ix). We shall further analyze Cook and Campbell's four criteria, and at the same time we shall compare them with the ones of Bagozzi. We shall also indicate the facts or parameters which reveal the validity of our constructs.

Statistical conclusion validity refers to conclusions about whether it is reasonable to presume covariation between two variables, given a specific probability level (i.e. 0,05, or 5 per cent) and the obtained variances. As such, statistical conclusion validity appears more closely related to tests of statistical significance than to magnitude estimates. It is not concerned with sources of systematic bias but with sources of random error and with the appropriate use of statistics and statistical tests. The reason why Campbell and Fiske emphasize on statistical significance is because decisions about whether a presumed cause and effect covary, logically precede decisions about how strongly they covary. Threats to statistical conclusion validity are threats to drawing valid conclusions about whether two variables covary. These threats closely correspond to Bagozzi's criterion of internal consistency and add an explicit focus on the assumptions underlying the statistical techniques used. In our study, statistical conclusion validity is addressed by employing multi-item scales tested with Cronbach's *alphas*.

Internal validity is a criterion that does not appear in Bagozzi's framework. It refers to the approximate validity with which we conclude that a relationship between two variables is causal or that the absence of a relationship implies the absence of cause. Internal validity includes the consideration of alternative explanations –other than the theory being tested- which might account for study results such as selection bias, historical reasons, etc. Cook and Campbell (1979. pp. 51-55) list a vast number of threats to internal validity that apply both to randomized and quassi experiments. The ones most suitable to empirical studies, like ours, are: history, which appears when an observed effect might be due to a historical event; instrumentation, a threat that an effect might be due to a change in the measuring instrument (the questionnaire, in our case); selection, a threat that an effect may be due to the differences between the kinds of people in one experimental group as opposed to another. In our study, it is addressed by the variety of industry sectors, companies and units of analysis as well as the range of management levels that our informers are derive from.

Construct validity refers to the possibility that the operations which are meant to represent a particular cause or effect construct can be constructed in terms of more than one construct. It plays an especially crucial role in empirical experiments which only aim to test causal propositions. The criterion of construct validity is well covered by Bagozzi's six criteria and it has already been addressed, as such, in our study.

External validity refers to the approximate validity with which we can conclude that the presumed causal relationship can be generalized to and across different types of organizational settings, persons, and times. It represents the degree of confidence a researcher has in generalizing the specific relationships found in his study sample with the population at large. The issue of external validity is not addressed by Bagozzi. As tests of the extent to which one can generalize across various kinds of settings, persons and times are, in essence, tests of statistical interactions, Cook and Campbell (1979, pp. 73-74) are listing all the threats to external validity in terms of statistical interaction effects. Interaction of selection and treatment –or method- relates to the categories of persons (i.e. social, geographical, or personality groups) on which a cause-effect relationship can be generalized. Interaction of setting and treatment (method) is of particular relevance to our study, as its settings are on such different levels as the organization, the group, and the individual. Finally, interaction of history and treatment (method) relates to the periods in the past and future that a particular causal relationship can be extrapolated. As our study focuses on industrial organizations, the above threats have been addressed by selecting a variety of sectors and implementing easy-to-understand questionnaires in relevantly 'similar' groups. As our sample could not be a random one, the self-selection bias can not be totally dismissed.

Cook and Campbell's Criteria	**How Addressed in this Study**
Statistical Conclusion Validity	Employed multi-item scales and tested with Cronbach's *alphas*.
Internal Validity	Cross-sectional study, variety of industry types (5 sectors, 51 companies, 112 manufacturing units).
Construct Validity	Tested by the six Bagozzi's criteria.
External validity	Variety of organizations and industries; still degree of generalization is low due to self-selection bias. (Use of random sample was impossible.)

Table 6.2 Cook and Campbell's Criteria and How Addressed in this Study

Table 6.2 summarizes Cook and Campbell's criteria and briefly indicates how these have been addressed in our research.

Upon completing the analysis and comparison of the above two sets of criteria, it becomes obvious that there is a significant overlap between them, although they both make unique contributions. Specifically, there are several areas where Cook and Campbell add to Bagozzi's criteria. It seems to be of importance to consider both the Bagozzi and the Cook and Campbell sets of validity criteria upon designing research to test theories. As our investigation is heavily built upon the key-informant methodology, we consider it appropriate to discuss one more set of criteria of significant importance when using key-informant analysis.

6.4.3 Huber and Power Key-informant Validity Criteria

Upon designing a key-informant analysis, one can easily foresee four possible situations, depending on the number of indicators and the number of informants, as shown in the four cells of Figure 6.1.

The use of a single indicator and a single informant (Cell 1) is not very common, as in this case we can neither test internal consistency of observation nor convergent and discriminant validity. Assuming that a single indicator measures the theoretical construct perfectly and without error and, at the same time, that the single informant (for every unit of analysis) shall be unbiased is a very weak assumption.

	Single Indicator	**Multiple Indicator**
Single Informant	**No formal test possible** **Cell 1**	**Reliability** **Cell 2**
Multiple Informants	**Cell 3** **Convergent and discriminant validity**	**Cell 4** **Reliability; Convergent and discriminant validity**

Figure 6.1 Number of informants versus number of indicators in key-informant analysis

When using multiple indicators we can definitely test internal consistency of the operationalizations, but if we insist using one informant per unit of analysis (as in Cell 2) we can still not test convergent and discriminant validity. In addition, Silk and Kalwani (1982) and Phillips and Bagozzi (1986) have noted that there are many other problems in using a single key-informant.

The use of one indicator and multiple key-informants (Cell 3) does not allow researchers to test the internal consistency of the operationalizations, because of the single indicator. In this situation, only Cronbach's *alphas* can be used to test the internal consistency of the responses among key-informants, which might be viewed as one type of internal consistency of the operationalizations.

Multiple indicators and multiple key-informants approach (Cell 4) enable us to assess both the extent to which variation in measurements is due to methodological factors, and to test the internal consistency of the operationalizations. Internal consistency can be tested with Cronbach's *alphas* or the structural equation approach. As we have already noted in section 6.2, in this case, the different informants constitute different 'methods'.

It was for these reasons that we have decided to use multiple indicators and multiple informants for each construct, to fully test the validity of a measurement operationalization. It is considered the most accurate method for studying organizational relationships, and although it is time consuming, the gains in terms of reliability and validity might well offset the costs.

However, there are still a number of threats to validity simply because we are using key-informants. Unlike the respondent method which requires the respondent to report about himself or herself, the collection of data on group properties or relationships from individual key-informants may introduce considerable measurement errors. This occurs because questions which require a person to combine data on many events, persons or tasks may place unrealistic demands on survey responders (Silk and Kalwani, 1982; Philips and Bagozzi, 1986). Huber and Power (1985, pp. 172-174) are identifying the following three criteria, each one corresponding to a threat to validity.

1. Motivator Barrier
2. Perceptual and Cognitive Limitations
3. Lack of Information

We shall further analyze Huber and Power's three criteria and we shall also indicate the facts or parameters which reveal the validity of our constructs.

Motivator Barrier: Huber and Power claim that key-informants may believe that providing certain information could have an undesirable impact on their careers. To a certain extent, this forms a bias in the form of a motivation barrier to their participation and they suggest that investigators should remove as many motivational 'disincentives' to participation as possible. We have taken this very seriously making sure that no self-report was included and we guaranteed strict confidentiality to our informants, who e-mailed their responses directly to our attention.

Perceptual and Cognitive Limitations is, according to Huber and Power the second reason for biased or inaccurate reports. Since key-informants are asked to provide the researcher with group-level properties, this can increase the burdens of their information processing activity. They suggest that investigators should use pre-tested questions that should, at the same time be as specific and simple as possible. In our study the validity of the majority of the questions we used has been previously tested and we pilot tested the ones we invented for this study.

Lack of information is the third source of data inaccuracy, as in many studies researchers do not select those key-informants whose positions give them access to the required information. Often key-informants are chosen because of their proximity to the researcher. In our study, all key-informants were senior members of the groups of which the relationships were to be measured and, thus, they were very well informed about the constructs under investigation.

Huber and Power's Criteria	**How Addressed in this Study**
Motivator Barrier	No self-report included and guaranteed strict confidentiality .
Perceptual and Cognitive Limitations	All questions anchored to group relationships and pilot-tested.
Lack of Information	All key-informants were members of the group under investigation. All stakeholders (for the performance questionnaire) have had relevant experience.

Table 6.3 Huber and Power's Criteria and How Addressed in this Study

Table 6.3 summarizes Huber and Power's criteria and briefly indicates how these have been addressed in our research.

6.5 Summary

In this chapter we have discussed the research design for this study. First, we presented, in an analytical way, all three types of questionnaires used and the way they have been designed and tested.

Second, we revealed systematically the indicators which were developed, through the interviews and from relevant literature areas, for each one of the five variables under investigation.

We then presented the key-informant methodology (Phillips and Bagozzi, 1986), which has guided us to select our responders.

Finally we identified the threats to validity inherent in such studies and discussed how they were addressed in our study. Specifically, we discussed: Bagozzi's (1980) measurement or construct validity criteria; Cook and Campbell's (1979) general criteria for empirical research, and finally Huber and Power's (1985) threats inherent to in key-informant analysis.

The next chapter will discuss the actual field work of this study.

APPENDIX 6A

Questionnaires

ETSEIB
Edif. H (7º piso)
Av. Diagonal 647
08028 Barcelona

Barcelona, December 10th, 2003

Dear Sirs,

At UPC (*Universidad Politécnica de Cataluña*) we are currently working on a study that investigates "The Contribution of Shared Knowledge among Manufacturing, R&D and Quality Groups to the Performance of the Manufacturing Group".

We are contacting you in order to ask you to participate in this study. We have prepared a short questionnaire (12 questions only) for the Managers and/or their deputies of the above mentioned three groups or departments.

We have also prepared a very short questionnaire (9 questions only) for your company's CEO, Managing Director, (President or Vice-President) or other high executive, who –from his position- will be able to judge the overall manufacturing group performance.

Please note, that we shall be glad to share with you the results of the above study, which is expected to be completed in the first half of the year 2005.

Looking forward to hearing from you soon, and thanking you in advance for your cooperation, we remain,

Sincerely yours,

Haris Papoutsakis — Ramon Salvador i Vallés
Assis. Professor (Visiting, TEI of Crete, Greece) — Profesor Titular UPC
e-mail: haris.papout@upc.es Tel. 93 401 6061, FAX 93 401 6054

Relationship Questionnaire A
(Manufacturing)

Please characterize the general **working relationship** that currently exists between the [Manufacturing] group and the [Quality or R&D] group.
Use the following scale to measure constructs:

1	2	3	4	5	6	7
Extremely Weak	Weak	Moderately Weak	About Average	Moderately Strong	Strong	Extremely Strong

1. The level of **appreciation** that the [Manufacturing] group and the [Quality or R&D] group have for each other's accomplishments is: ☐

2. The level of **understanding** of the [Quality or R&D] group for the work environment (problems, tasks, roles, etc) of the [Manufacturing] group is: ☐

3. The level of **appreciation** that the [Quality or R&D] group has for the accomplishments of the [Manufacturing] group is: ☐

4. The level of **trust** that exists between the [Manufacturing] group and the [Quality or R&D] group is: ☐

5. The **reputation** of the [Quality or R&D] group for meeting its commitments to the [Manufacturing] group is: ☐

6. In general, the level of **influence** that members of the [Manufacturing] group and the [Quality or R&D] have on each other's key decisions and policies is: ☐

7. In general the **ability** of members of the [Manufacturing] group and the [Quality or R&D] group **to affect** each other's key decisions and policies is: ☐

8. In general, the level of **influence** that members of the [Quality or R&D] group have on key decisions and policies of the [Manufacturing] group is: ☐

9. In general, the **ability** of members of the [Quality or R&D] group **to affect** key policies and decisions of the [Manufacturing] group is: ☐

10. In general, the role and the level of **contribution** of **Information Technology (IT)** as a tool and/or enabler, to support shared knowledge between [Manufacturing] group and [Quality or R&D] group is: ☐

11. In general, the **use** of the **Information Technology (IT) infrastructure** in the [Manufacturing] group is: ☐

12. Specifically, the **use** of the following **IT infrastructure** is:
Intranet ☐ Extranet ☐ Groupware ☐, Workflow ☐
Internet ☐, e-mail ☐, …………… ☐, ……………. ☐
Data warehouse ☐,
Other ………… ☐, …………………..….. ☐ …. ……. ☐

Relationship Questionnaire B
(Quality or R&D)

Please characterize the general **working relationship** that currently exists between the [Quality or R&D] group and the [Manufacturing] group.
Use the following scale to measure constructs:

1	2	3	4	5	6	7
Extremely Weak	Weak	Moderately Weak	About Average	Moderately Strong	Strong	Extremely Strong

1. The level of **appreciation** that the [Quality or R&D] group and the [Manufacturing] group have for each other's accomplishments is: ☐

2. The level of **understanding** of the [Manufacturing] group for the work environment (problems, tasks, roles, etc) of the [Quality or R&D] group is: ☐

3. The level of **appreciation** that the [Manufacturing] group has for the accomplishments of the [Quality or R&D] group is: ☐

4. The level of **trust** that exists between the [Quality or R&D] group and the [Manufacturing] group is: ☐

5. The **reputation** of the [Manufacturing] group for meeting its commitments to the [Quality or R&D] group is: ☐

6. In general, the level of **influence** that members of the [Quality or R&D] group and the [Manufacturing] have on each other's key decisions and policies is: ☐

7. In general the **ability** of members of the [Quality or R&D] group and the [Manufacturing] group **to affect** each other's key decisions and policies is: ☐

8. In general, the level of **influence** that members of the [Manufacturing] group have on key decisions and policies of the [Quality or R&D] group is: ☐

9. In general, the **ability** of members of the [Manufacturing] group **to affect** key policies and decisions of the [Quality or R&D] group is: ☐

10. In general, the role and the level of **contribution** of **Information Technology (IT)** as a tool and/or enabler, to support shared knowledge between [Quality or R&D] group and [Manufacturing] group is: ☐

11. In general, the **use** of the **Information Technology (IT) infrastructure** in the [Quality or R&D] group is: ☐

12. Specifically, the **use** of the following **IT infrastructure** is:
Intranet ☐ Extranet ☐ Groupware ☐, Workflow ☐
Internet ☐, e-mail ☐, …………… ☐, …………… ☐
Data warehouse ☐,
Other ………… ☐, ………………….. ☐ …. ……. ☐

Performance Questionnaire
(Organizational Stakeholders)

The following questions ask you to compare the [Manufacturing] group to other such Manufacturing groups. In relation to other comparable groups you have observed, how the [Manufacturing] group rates on the following.
Use the following scale to measure constructs:

1	2	3	4	5	6	7
Non-Existent	Very Weak	Weak	About Average	Strong	Very Strong	Extremely Strong

1. In general, the **quality of the work** produced for the [Quality or R&D] group by the [Manufacturing] group is: ☐

2. In general, the **ability** of the [Manufacturing] group **to meet** its organizational commitments (such as project schedules and budget) is: ☐

3. In general, the **ability** of the [Manufacturing] group **to meet** its goals is: ☐

4. In general, the **ability** of the [Manufacturing] group **to react** quickly to the [Quality or R&D] group's changing business needs is: ☐

5. In general, the **responsiveness** of the [Manufacturing] group to the [Quality or R&D] group is: ☐

6. In general, the **contribution** that the [Manufacturing] group has made to the accomplishment of the [Quality or R&D] group's strategic goals is: ☐

7. In general, the level of the **Information Technology (IT) contribution** to the [Manufacturing] group performance is: ☐

8. In general, the use of the **Information Technology (IT) infrastructure**, between the three groups is: ☐

9. Specifically, the **use** of the following **IT function** is:

   - Coordinating business tasks: ☐
   (collecting, facilitating, sharing, etc. information)
   - Supporting decision making: ☐
   (reaching the right information at the right time)
   - Facilitating member' team to work together: ☐
   (no matter where they are)
   - Facilitating access of information in Data Bases: ☐
   (no mater where they are)
   - Other ………………………………………….: ☐
   - Other ………………………………………….: ☐

ETSEIB
Edif. H (7º piso)
Av. Diagonal 647
08028 Barcelona

Barcelona, 10 de Diciembre, 2003

Estimado/a Señor o Señora,

En el Dpto. de Organización de Empresas de la Universidad Politécnica de Cataluña, estamos trabajando en un estudio que corresponde a investigar la ***contribución del conocimiento compartido entre los grupos de Producción, Investigación y Desarrollo, y de Calidad, en la performance de la producción*.**

Les contactamos con la finalidad de solicitarles participar en este estudio, que es de carácter confidencial y anónimo. Hemos preparado un breve cuestionario (sólo 12 preguntas) para los directores y sus adjuntos de los tres grupos o departamentos arriba mencionados. Adjuntamos un ejemplo de los cuestionarios.

Asimismo, hemos preparado otro breve cuestionario (sólo 9 preguntas) para el Director de la fábrica u otro alto ejecutivo, quien –desde esta posición- pueda juzgar la *performance* general del grupo de Producción.

Por favor, tenga presente que estaremos encantados de compartir con ustedes los resultados del mencionado estudio, el cual se espera que esté finalizado durante la primera mitad del año 2005.

Esperando tener pronto noticias suyas, y agradeciendo de antemano su cooperación,

Atentamente,

Haris Papoutsakis — Ramón Salvador i Valles
Ass. Profesor (Visitante, TEI de Creta, Grecia) — Profesor Titular UPC
e-mail: haris.papout@upc.es Tel. 93 401 6061, FAX 93 401 6054

Cuestionario sobre las Relaciones A
(Producción)

Por favor, caracterice las **relaciones de trabajo generales** que actualmente existen entre el grupo de [Producción] y el grupo de [Calidad o R&D].
Utilice la siguiente escala para medir los conceptos:

1	2	3	4	5	6	7
Extremada-mente Débil	Débil	Moderada-mente Débil	Promedio	Moderada-mente Fuerte	Fuerte	Extremada-mente Fuerte

1. El nivel de **apreciación** que tanto el grupo de [Producción] como el grupo de [Calidad o R&D] tienen de los logros del otro es: ☐

2. El nivel de **comprensión** del grupo de [Calidad o R&D] respecto del ambiente laboral (problemas, tareas, roles, etc.) del grupo de [Producción] es: ☐

3. El nivel de **apreciación** que tiene el grupo de [Calidad o R&D] respecto de los logros del grupo de [Producción] es: ☐

4. El nivel de **confianza** existente entre el grupo de [Producción] y el grupo de [Calidad o R&D] es: ☐

5. La **reputación** del grupo de [Calidad o R&D] en el cumplimiento de sus compromisos hacia el grupo de [Producción] es: ☐

6. En general, el nivel de **influencia** que los miembros del grupo de [Producción] y el de [Calidad o R&D] tiene sobre las políticas y decisiones clave del otro es: ☐

7. En general, la **habilidad** de los miembros del grupo de [Producción] y el grupo de [Calidad o R&D] **para afectar** las políticas y decisiones clave del otro es: ☐

8. En general, el nivel de **influencia** que tienen los miembros del grupo de [Calidad o R&D] sobre las políticas y decisiones clave del grupo de [Producción] es: ☐

9. En general, la **habilidad** de los miembros del grupo de [Calidad o R&D] **para afectar** las políticas y decisiones clave del grupo de [Producción] es: ☐

10. En general, el nivel de la **contribución** de las **Tecnologías de la Información (TI)** como herramienta y/o facilitador, para soportar el conocimiento compartido entre el grupo de [Producción] y el grupo de [Calidad o R&D] es: ☐

11. En general, el **uso** de la **infraestructura** de las **TI** en el grupo de [Producción] es: ☐

12. Explícitamente, el **uso** de la **infraestructura** siguiente es:

Intranet ☐ , Extranet ☐ , Groupware ☐ , Workflow ☐
Internet ☐ e-mail ☐ , …………………… ☐ , …………………….. ☐
Data warehousing ☐
Otros ……………….. ☐ ……………………….. ☐ …………………… ☐

Cuestionario sobre las Relaciones B (Calidad o R&D)

Por favor, caracterice las **relaciones de trabajo** generales que actualmente existen entre el grupo de [Calidad o R&D] y el grupo de [Producción].
Utilice la siguiente escala para medir los conceptos:

1	2	3	4	5	6	7
Extremada-mente Débil	Débil	Moderada-mente Débil	Promedio	Moderada-mente Fuerte	Fuerte	Extremada-mente Fuerte

1. El nivel de **apreciación** que tanto el grupo de [Calidad o R&D] como el grupo de [Producción] tienen de los logros del otro es: ☐

2. El nivel de **comprensión** del grupo de [Producción] respecto del ambiente laboral (problemas, tareas, roles, etc.) del grupo de [Calidad o R&D] es: ☐

3. El nivel de **apreciación** que tiene el grupo de [Producción] respecto de los logros del grupo de [Calidad o R&D] es: ☐

4. El nivel de **confianza** existente entre el grupo de [Calidad o R&D] y el grupo de [Producción] es: ☐

5. La **reputación** del grupo de [Producción] en el cumplimiento de sus compromisos hacia el grupo de [Calidad o R&D] es: ☐

6. En general, el nivel de **influencia** que los miembros del grupo de [Calidad o R&D] y el de [Producción] tiene sobre las políticas y decisiones clave del otro es: ☐

7. En general, la **habilidad** de los miembros del grupo de [Calidad o R&D] y el grupo de [Producción] **para afectar** las políticas y decisiones clave del otro es: ☐

8. En general, el nivel de **influencia** que tienen los miembros del grupo de [Producción] sobre las políticas y decisiones calve del grupo de [Calidad o R&D] es: ☐

9. En general, la **habilidad** de los miembros del grupo de [Producción] **para afectar** las políticas y decisiones clave del grupo de [Calidad o R&D] es: ☐

10. En general, el nivel de la **contribución** de las **Tecnologías** de la **Información (TI)** como herramienta y/o facilitador, para soportar el conocimiento compartido entre el grupo de [Calidad o R&D] y el grupo de [Producción] es: ☐

11. En general, el **uso** de la **infraestructura** de las **TI** en el grupo de [Calidad o R&D] es: ☐

12. Explícitamente, el **uso** de la **infraestructura** siguiente es:

Intranet ☐ , Extranet ☐ , Groupware ☐ , Workflow ☐
Internet ☐ e-mail ☐ , …………………… ☐ , …………………….. ☐
Data warehousing ☐
Otra ……………….. ☐ ………..………….. ☐ ……………..……… ☐

Cuestionario sobre el Desempeño (*Performance*)
(*Organizational Stakeholders*)

Las siguientes preguntas le piden **comparar** el grupo de [Producción] respecto de otros grupos de Producción similares. Con relación a otros grupos comparables que usted haya observado, cómo evaluaría al grupo de [Producción] en la siguiente escala:

1	2	3	4	5	6	7
Inexistente	Muy Débil	Débil	Promedio	Fuerte	Muy Fuerte	Extremadamente fuerte

1. En general, la **calidad del trabajo** producido por el grupo de [Producción] para el grupo de [Calidad o R&D] es: ☐

2. En general, la **habilidad** del grupo de [Producción] **para alcanzar** los compromisos organizacionales (tales como la programación de proyectos y presupuestos) es: ☐

3. En general, la **habilidad** del grupo de [Producción] **para alcanzar** sus metas es: ☐

4. En general, la **habilidad** del grupo de [Producción] **para reaccionar** rápidamente frente a las necesidades de cambiar las necesidades de negocio del grupo de [Calidad o R&D] es: ☐

5. En general, la **capacidad de respuesta** o **reacción** del grupo de [Producción] respecto del grupo de [Calidad o R&D] es: ☐

6. En general, la **contribución** que el grupo de [Producción] ha hecho al cumplimento de las metas estratégicas del grupo de [Calidad o R&D] es: ☐

7. En general, el nivel de **contribución** de las **Tecnologías de Información (TI)** al desempeño del grupo de [Producción] es: ☐

8. En general, el **uso** de las **funciones** de las **TI**, entre los tres grupos es: ☐

9. Explícitamente, el **uso** de las siguientes **funciones** de las **TI** es:

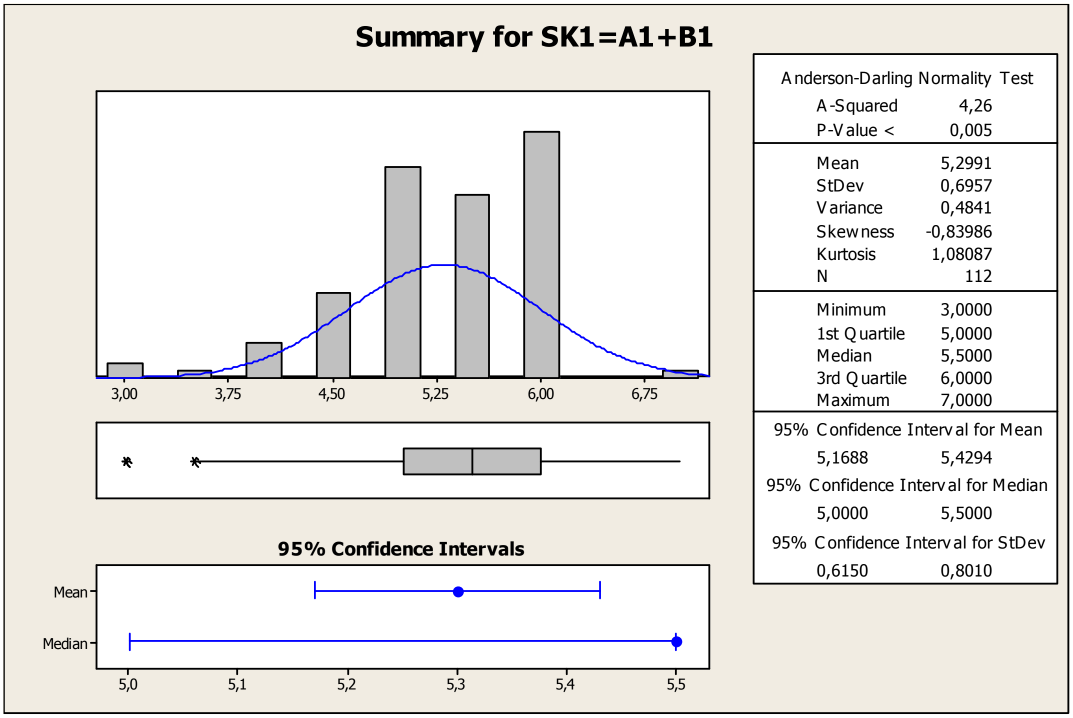
   - **Coordinar las tareas y actividades**: ☐
     (recoger, facilitar, compartir, etc. la información)
   - **Dar soporte a la toma de decisiones**: ☐
     (alcanzando la información correcta en el tiempo apropiado)
   - **Facilitar el trabajo en equipo**: ☐
     (sin importar su ubicación geográfica)
   - **Acceder a la información de las bases de datos**: ☐
     (sin importar su localización)
   - **Otra** ……………………………………….: ☐
   - **Otra** ……………………………………….: ☐

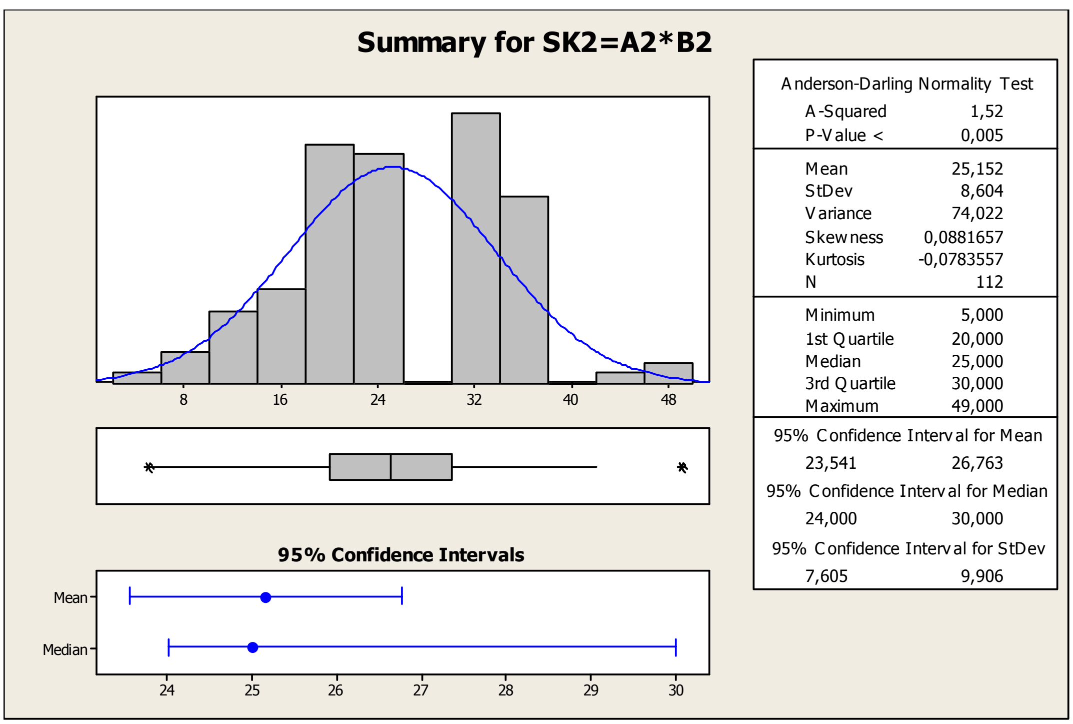
APPENDIX 6B

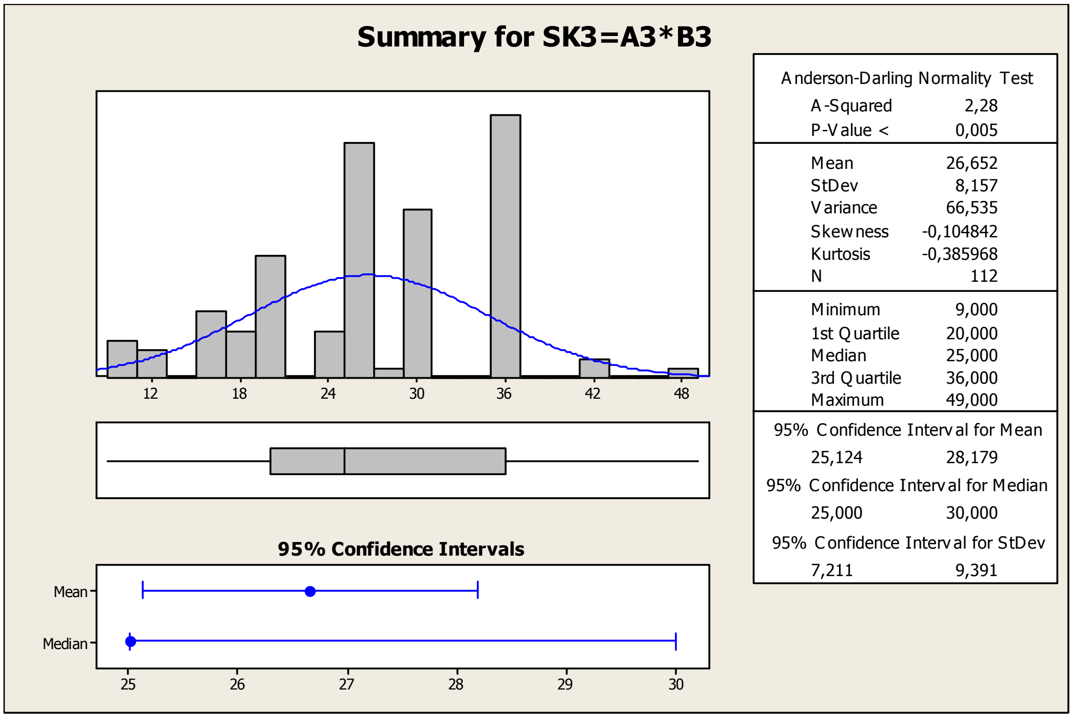
Statistical Analysis Results

Construct Measurements

6B.1 Shared Knowledge



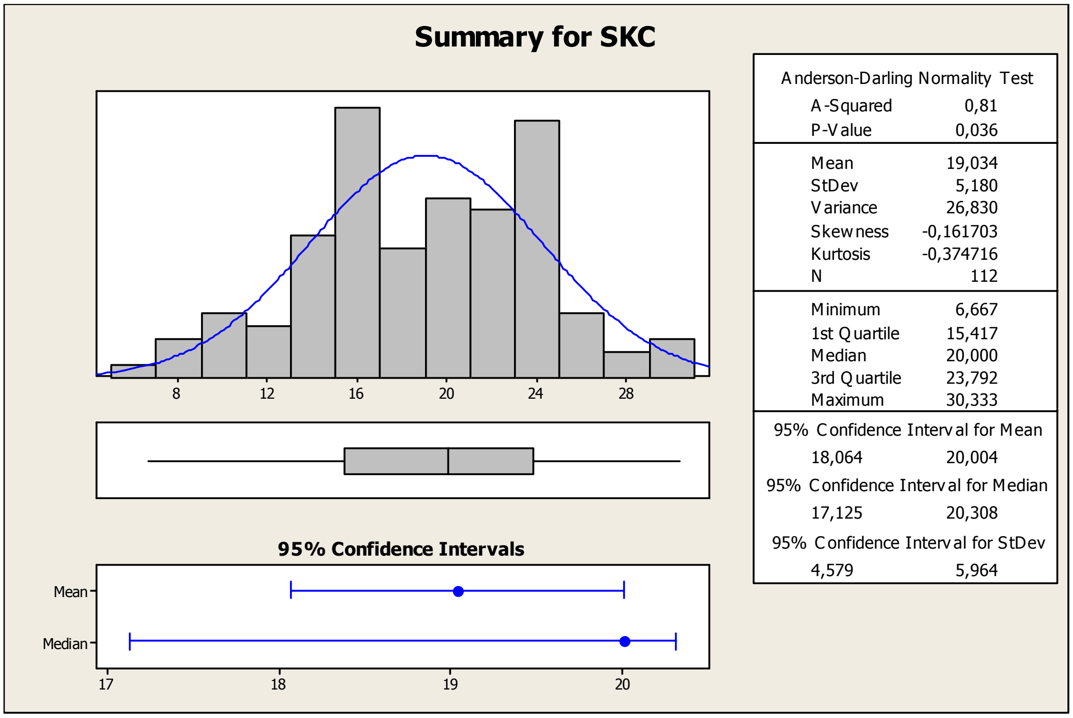




Descriptive Statistics: SK1=A1+B1; SK2=A2*B2; SK3=A3*B3

Variable	N	N*	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median
SK1=A1+B1	112	0	5,2991	0,0657	0,6957	0,4841	3,0000	5,0000	5,5000
SK2=A2*B2	112	0	25,152	0,813	8,604	74,022	5,000	20,000	25,000
SK3=A3*B3	112	0	26,652	0,771	8,157	66,535	9,000	20,000	25,000

Variable	Q3	Maximum	Range
SK1=A1+B1	6,0000	7,0000	4,0000
SK2=A2*B2	30,000	49,000	44,000
SK3=A3*B3	36,000	49,000	40,000



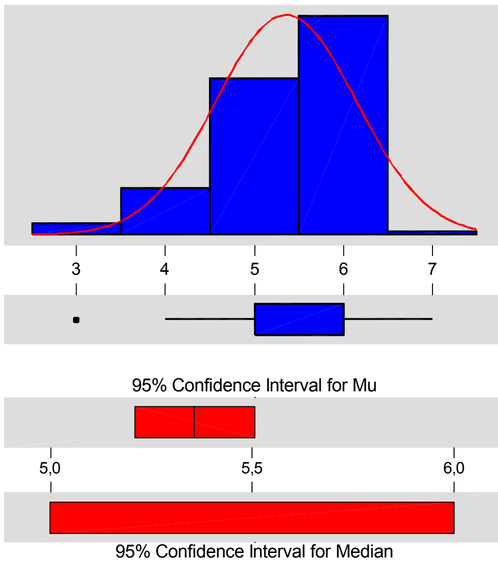
Descriptive Statistics: SKC

Variable	N	N*	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median
SKC	112	0	19,034	0,489	5,180	26,830	6,667	15,417	20,000

Variable	Q3	Maximum	Range
SKC	23,792	30,333	23,667

A1. The level of **appreciation** that the [Manufacturing] group and the [Quality or R&D] group have for each other's accomplishments is: ☐

Descriptive Statistics

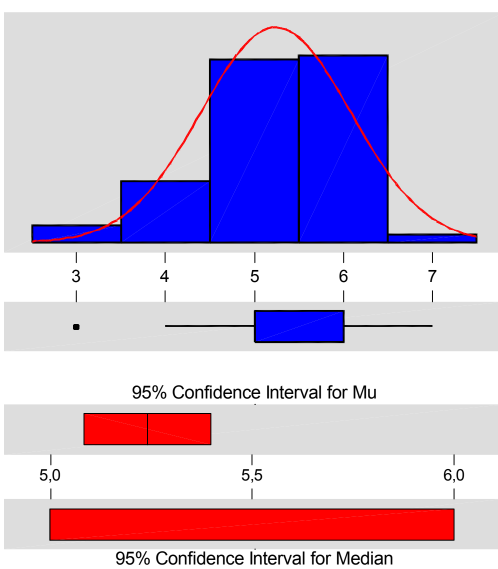


Variable: A1

Anderson-Darling Normality Test	
A-Squared:	10,227
P-Value:	0,000
Mean	5,35714
StDev	0,79250
Variance	0,628057
Skewness	-9,5E-01
Kurtosis	0,553094
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	6,00000
3rd Quartile	6,00000
Maximum	7,00000
95% Confidence Interval for Mu	
5,20875	5,50553
95% Confidence Interval for Sigma	
0,70056	0,91245
95% Confidence Interval for Median	
5,00000	6,00000

B1. The level of **appreciation** that the [Quality or R&D] group and the [Manufacturing] group have for each other's accomplishments is: ☐

Descriptive Statistics

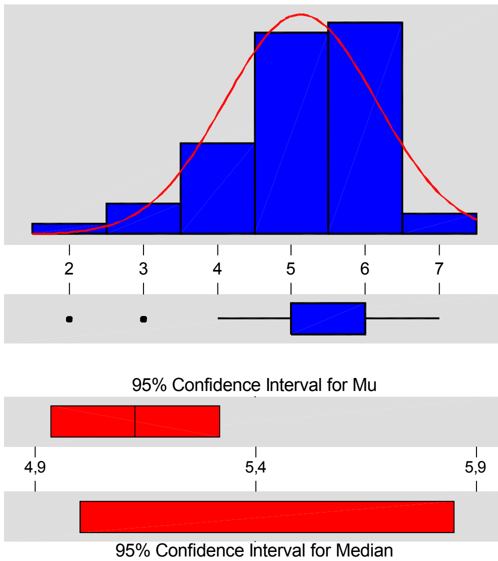


Variable: B1

Anderson-Darling Normality Test	
A-Squared:	7,880
P-Value:	0,000
Mean	5,24107
StDev	0,84091
Variance	0,707127
Skewness	-6,7E-01
Kurtosis	0,169977
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000
95% Confidence Interval for Mu	
5,08362	5,39852
95% Confidence Interval for Sigma	
0,74335	0,96818
95% Confidence Interval for Median	
5,00000	6,00000

A2. The level of **understanding** of the [Quality or R&D] group for the work environment (problems, tasks, roles, etc) of the [Manufacturing] group is:

Descriptive Statistics



Variable: A2

Anderson-Darling Normality Test

A-Squared:	5,935
P-Value:	0,000
Mean	5,12500
StDev	1,02338
Variance	1,04730
Skewness	-7,7E-01
Kurtosis	0,523692
N	112
Minimum	2,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,93338 5,31662

95% Confidence Interval for Sigma

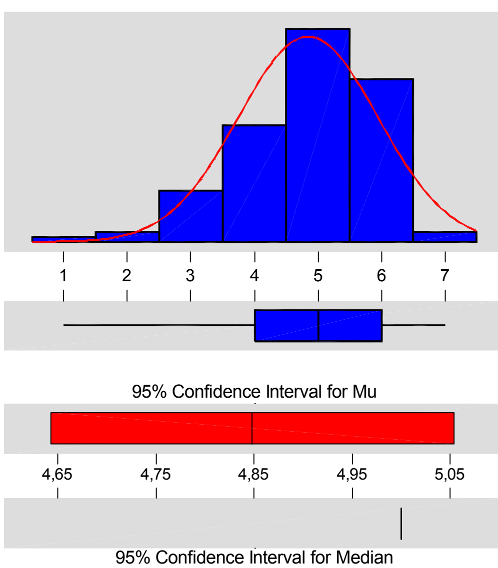
0,90464 1,17826

95% Confidence Interval for Median

5,00000 5,85003

B2. The level of **understanding** of the [Manufacturing] group for the work environment (problems, tasks, roles, etc) of the [Quality or R&D] group is:

Descriptive Statistics



Variable: B2

Anderson-Darling Normality Test

A-Squared:	4,965
P-Value:	0,000
Mean	4,84821
StDev	1,10045
Variance	1,21099
Skewness	-7,7E-01
Kurtosis	0,669901
N	112
Minimum	1,00000
1st Quartile	4,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,64217 5,05426

95% Confidence Interval for Sigma

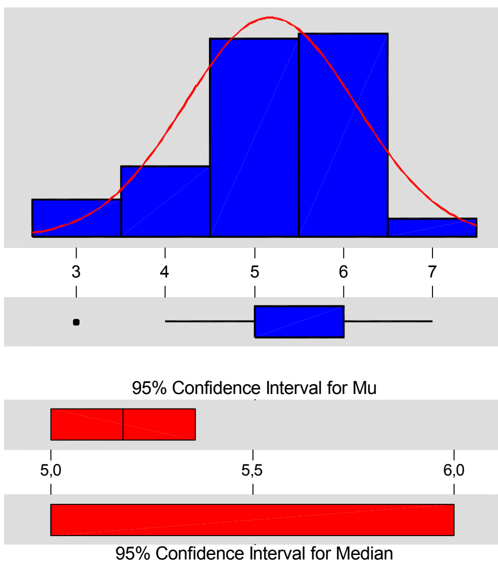
0,97278 1,26700

95% Confidence Interval for Median

5,00000 5,00000

A3. The level of **appreciation** that the [Quality or R&D] group has for the accomplishments of the [Manufacturing] group is: ☐

Descriptive Statistics



Variable: A3

Anderson-Darling Normality Test

A-Squared:	6,507
P-Value:	0,000
Mean	5,17857
StDev	0,96061
Variance	0,922780
Skewness	-6,2E-01
Kurtosis	-3,6E-02
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,99871 5,35844

95% Confidence Interval for Sigma

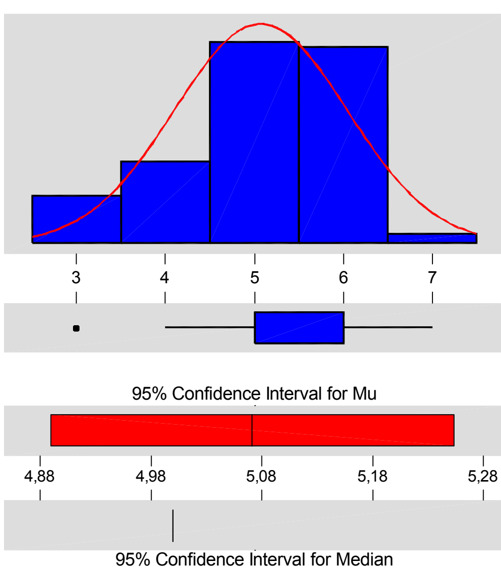
0,84916 1,10600

95% Confidence Interval for Median

5,00000 6,00000

B3. The level of **appreciation** that the [Manufacturing] group has for the accomplishments of the [Quality or R&D] group is: ☐

Descriptive Statistics



Variable: B3

Anderson-Darling Normality Test

A-Squared:	6,617
P-Value:	0,000
Mean	5,07143
StDev	0,97458
Variance	0,949807
Skewness	-6,2E-01
Kurtosis	-2,9E-01
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,88895 5,25391

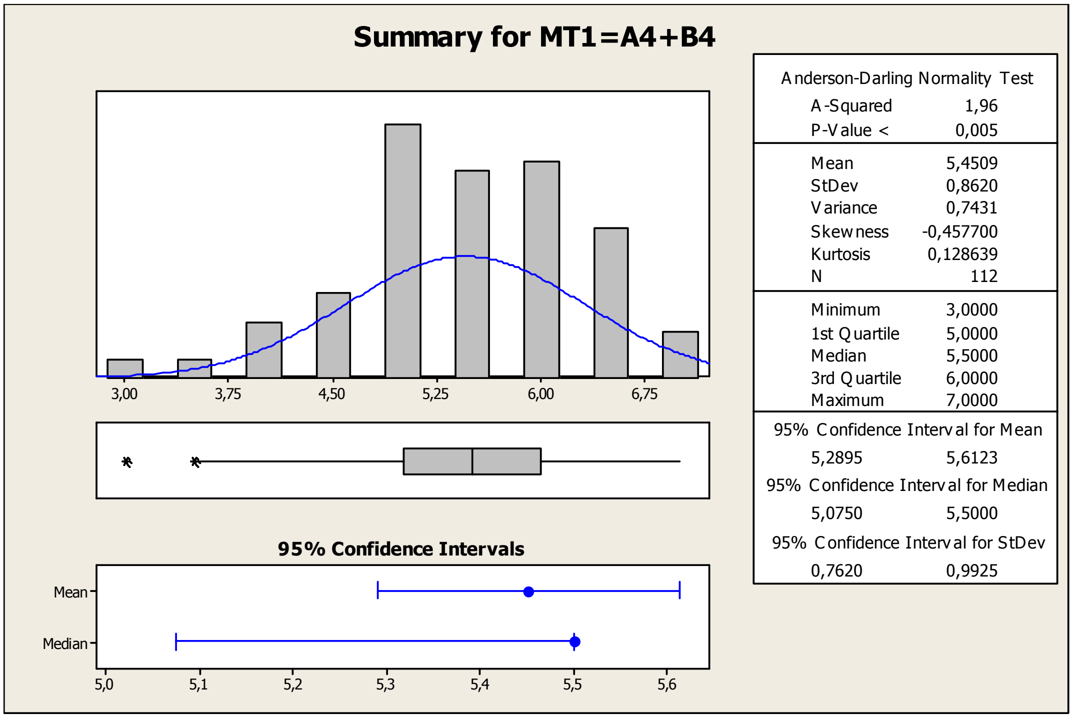
95% Confidence Interval for Sigma

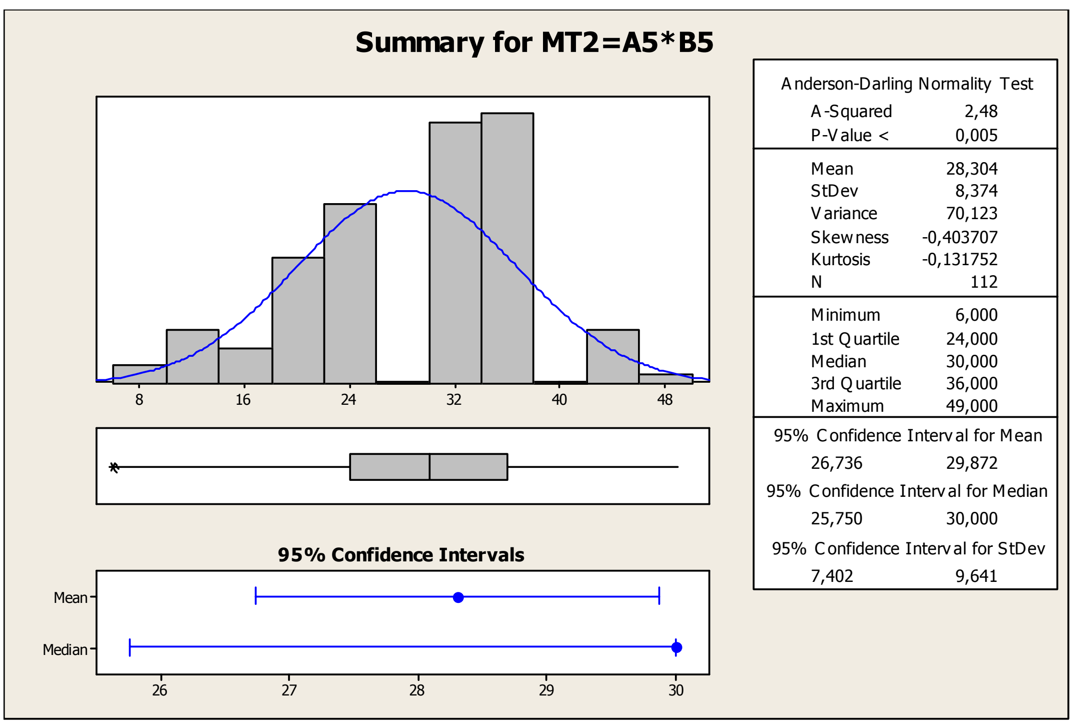
0,86151 1,12208

95% Confidence Interval for Median

5,00000 5,00000

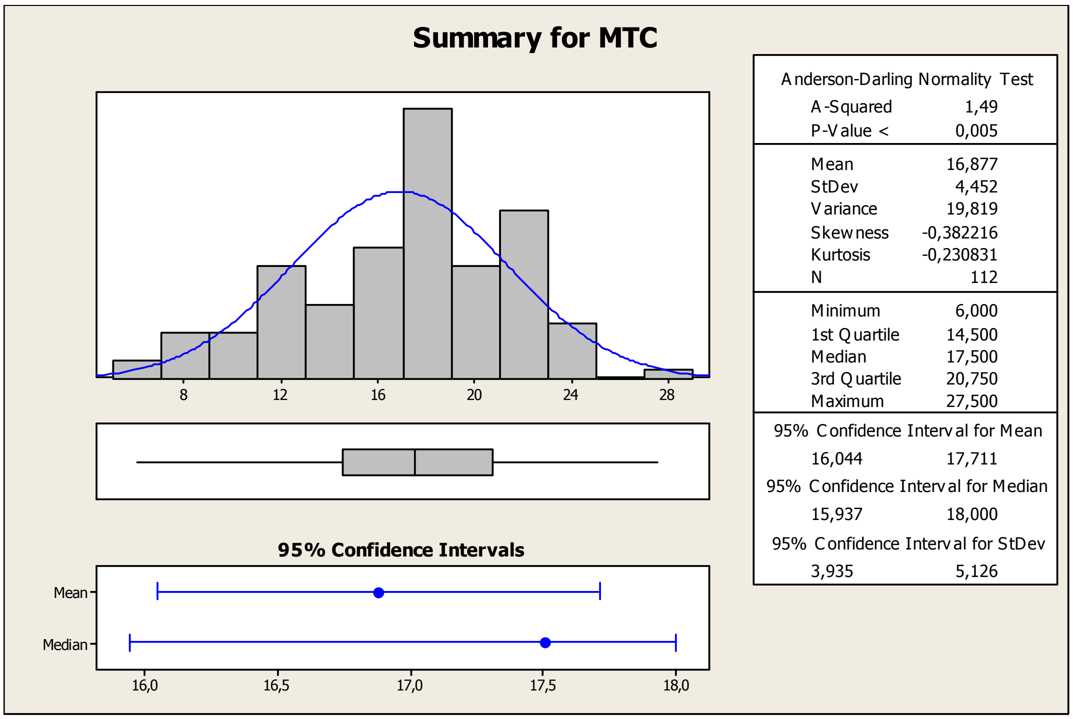
6B.2 Mutual Trust





Descriptive Statistics: MT1=A4+B4; MT2=A5*B5

```
Variable      N  N*    Mean  SE Mean   StDev  Variance  Minimum      Q1
Median
MT1=A4+B4   112   0  5,4509   0,0815  0,8620    0,7431   3,0000  5,0000
5,5000
MT2=A5*B5   112   0  28,304    0,791   8,374    70,123    6,000  24,000
30,000

Variable        Q3  Maximum   Range
MT1=A4+B4   6,0000   7,0000  4,0000
MT2=A5*B5   36,000   49,000  43,000
```

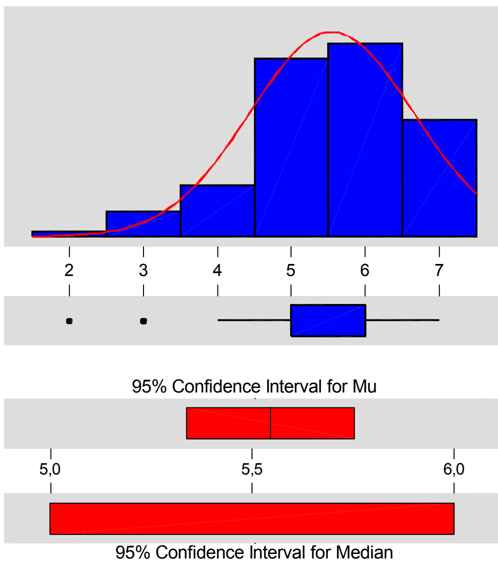


Descriptive Statistics: MTC

```
Variable      N  N*    Mean  SE Mean  StDev  Variance  Minimum      Q1  Median
MTC         112   0  16,877    0,421  4,452    19,819    6,000  14,500  17,500

Variable        Q3  Maximum   Range
MTC         20,750   27,500  21,500
```

A4. The level of **trust** that exists between the [Manufacturing] group and the [Quality or R&D] group is: ☐

Descriptive Statistics



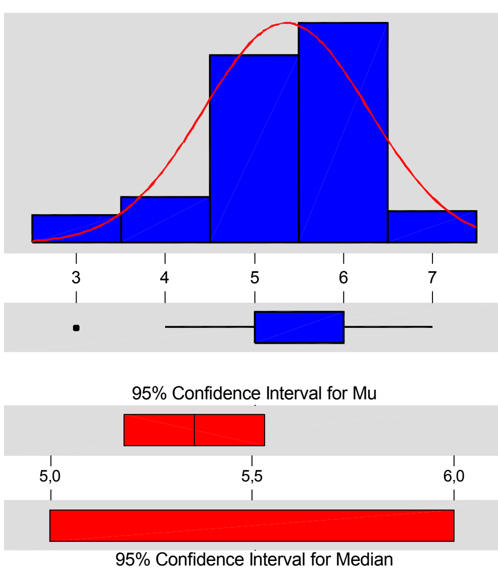
Variable: A4

Anderson-Darling Normality Test

A-Squared:	4,501
P-Value:	0,000
Mean	5,54464
StDev	1,10599
Variance	1,22321
Skewness	-6,4E-01
Kurtosis	0,300402
N	112
Minimum	2,00000
1st Quartile	5,00000
Median	6,00000
3rd Quartile	6,00000
Maximum	7,00000
95% Confidence Interval for Mu	
5,33756	5,75173
95% Confidence Interval for Sigma	
0,97767	1,27338
95% Confidence Interval for Median	
5,00000	6,00000

B4. The level of **trust** that exists between the [Quality or R&D] group and the [Manufacturing] group is: ☐

Descriptive Statistics



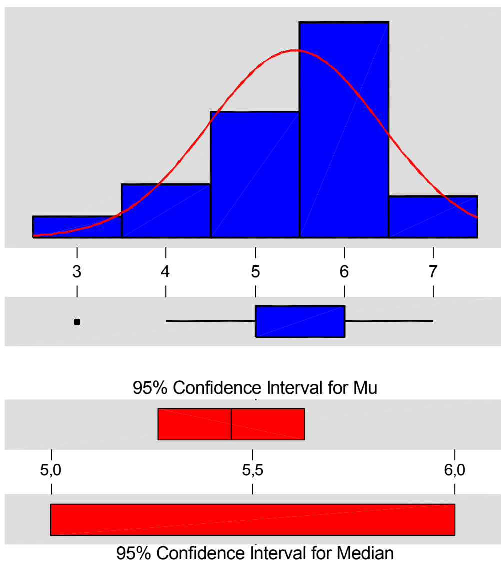
Variable: B4

Anderson-Darling Normality Test

A-Squared:	6,972
P-Value:	0,000
Mean	5,35714
StDev	0,92860
Variance	0,862291
Skewness	-7,1E-01
Kurtosis	0,485433
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000
95% Confidence Interval for Mu	
5,18327	5,53101
95% Confidence Interval for Sigma	
0,82086	1,06914
95% Confidence Interval for Median	
5,00000	6,00000

A5. The **reputation** of the [Quality or R&D] group for meeting its commitments to the [Manufacturing] group is: [ ]

Descriptive Statistics



Variable: A5

Anderson-Darling Normality Test

A-Squared:	6,978
P-Value:	0,000
Mean	5,44643
StDev	0,96646
Variance	0,934041
Skewness	-7,0E-01
Kurtosis	0,192235
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	6,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,26547 5,62739

95% Confidence Interval for Sigma

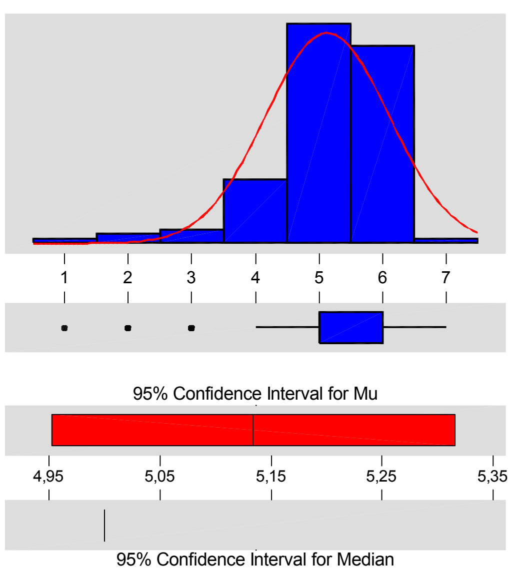
0,85433 1,11273

95% Confidence Interval for Median

5,00000 6,00000

B5. The **reputation** of the [Manufacturing] group for meeting its commitments to the [Quality or R&D] group is: [ ]

Descriptive Statistics



Variable: B5

Anderson-Darling Normality Test

A-Squared:	7,941
P-Value:	0,000
Mean	5,13393
StDev	0,97256
Variance	0,945866
Skewness	-1,47032
Kurtosis	3,36539
N	112
Minimum	1,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,95183 5,31603

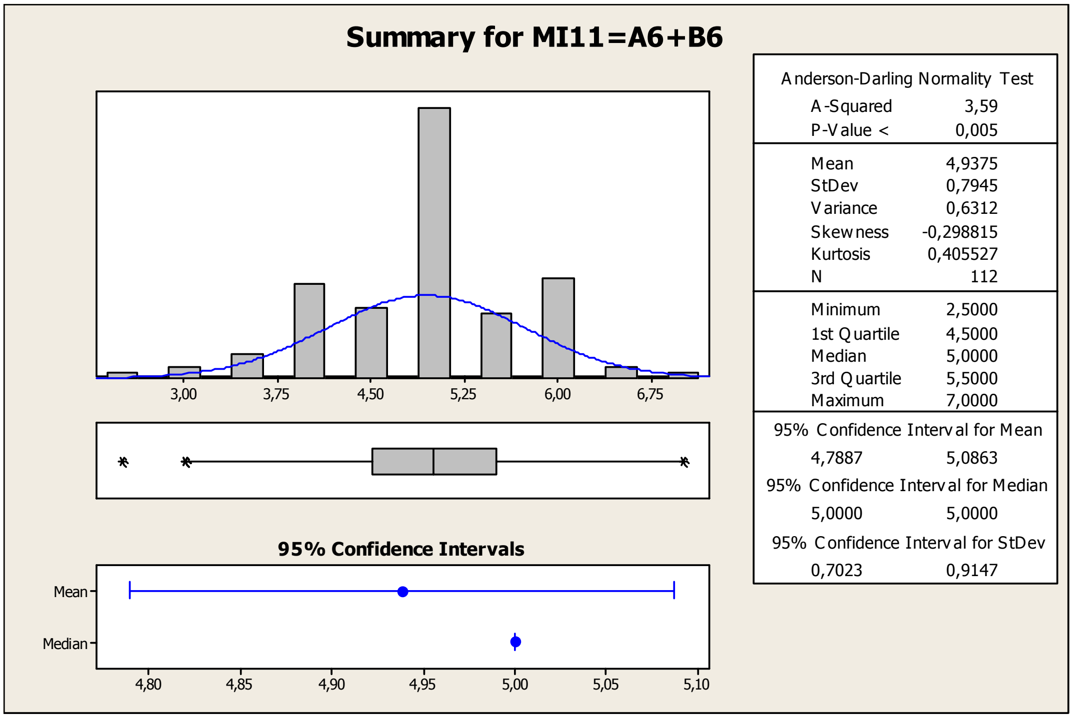
95% Confidence Interval for Sigma

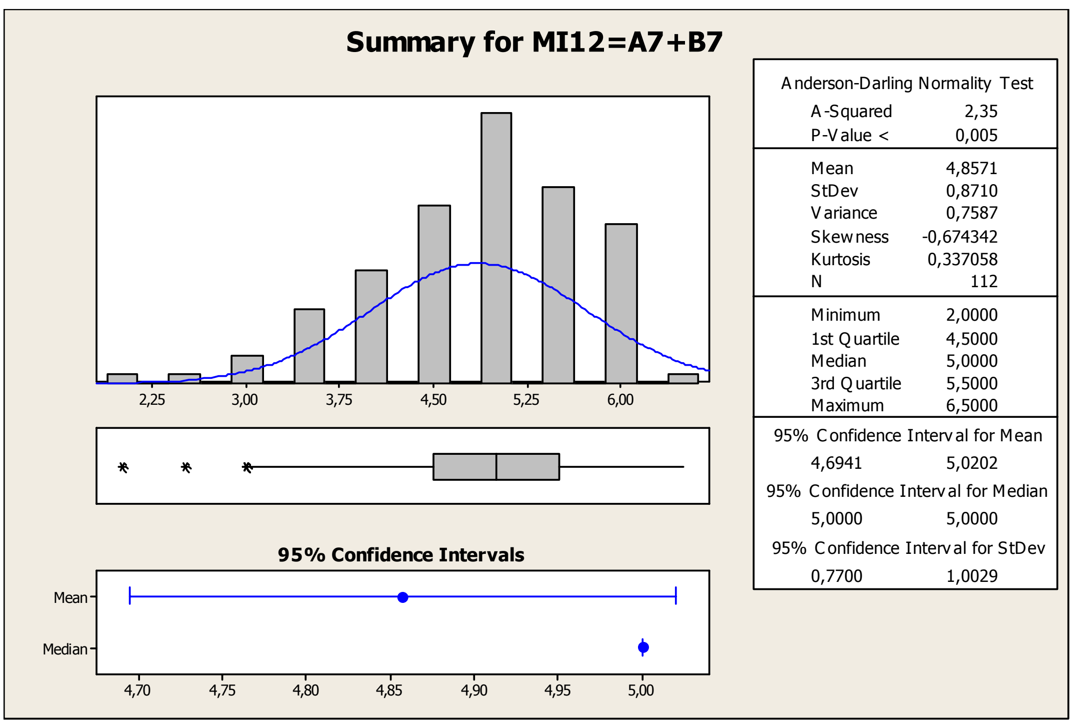
0,85972 1,11975

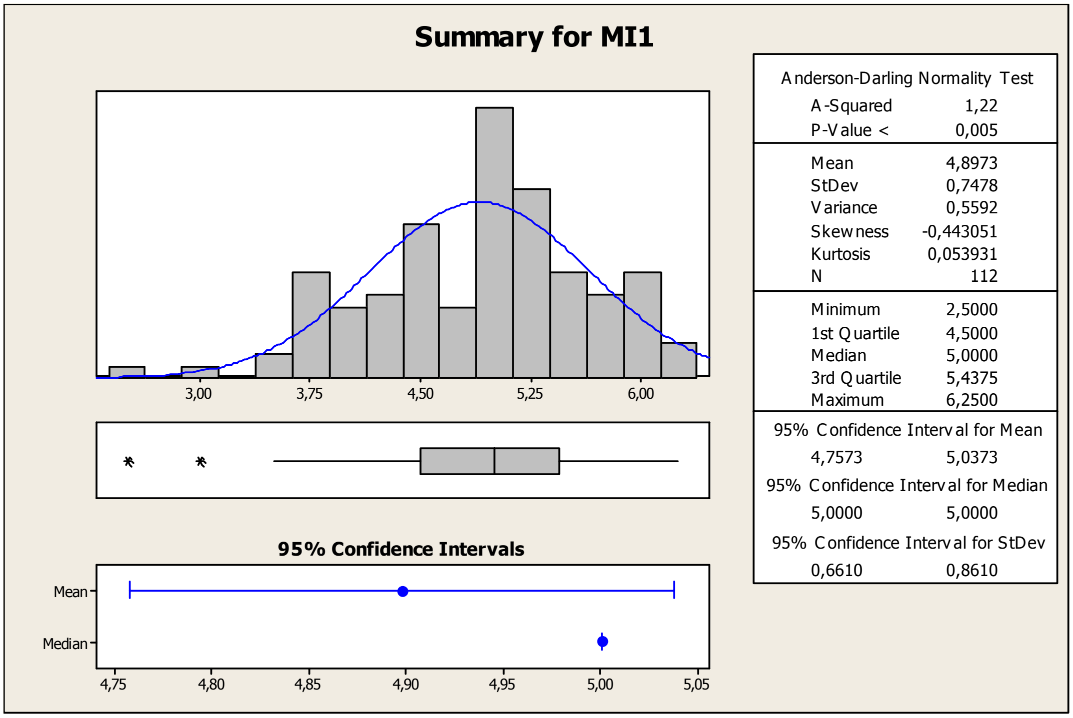
95% Confidence Interval for Median

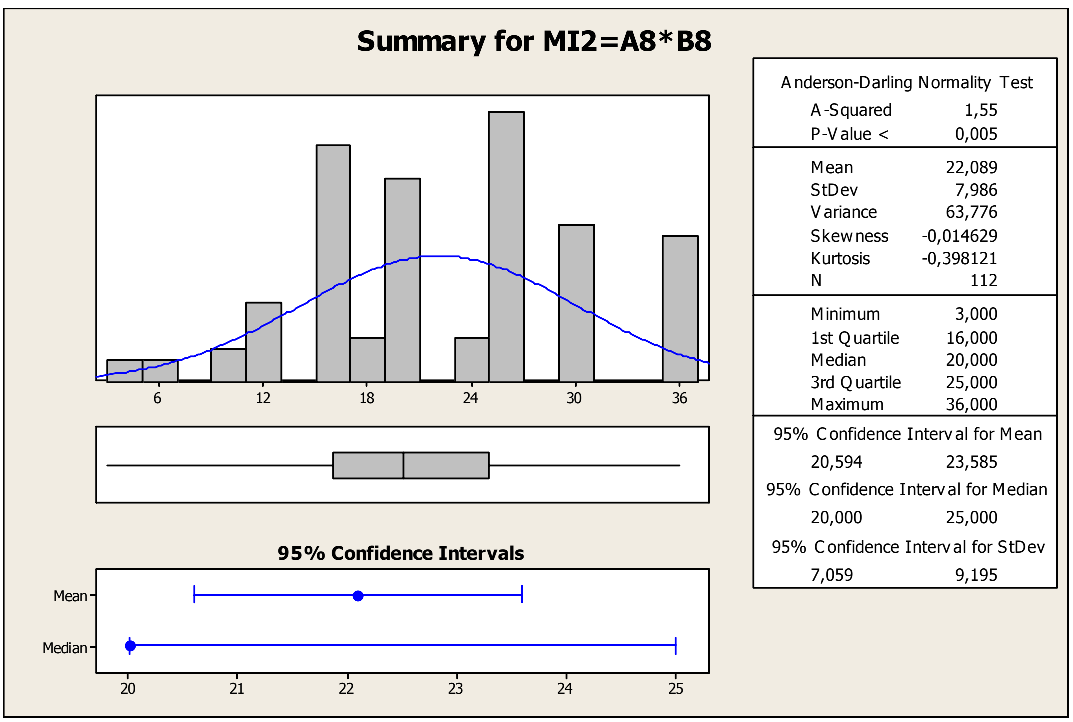
5,00000 5,00000

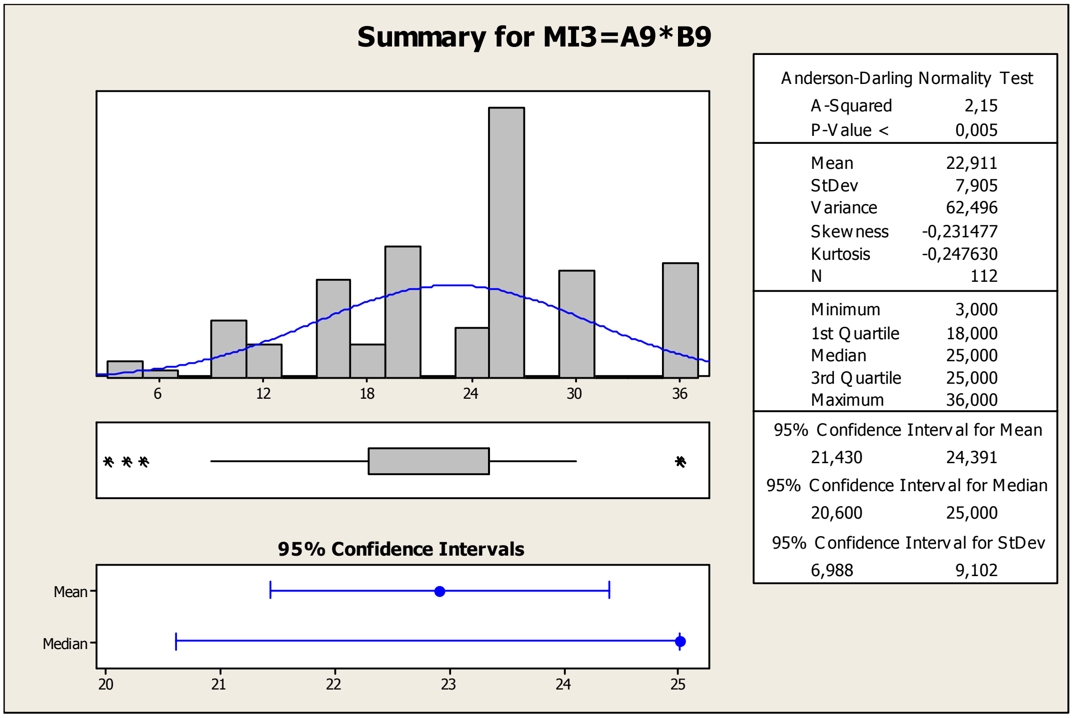
6B.3 Mutual Influence






Summary for MI1
3,00
3,75
4,50
5,25
6,00
95% Confidence Intervals
Mean
Median
4,75
4,80
4,85
4,90
4,95
5,00
5,05
Anderson-Darling Normality Test
A-Squared 1,22
P-Value < 0,005
Mean 4,8973
StDev 0,7478
Variance 0,5592
Skewness -0,443051
Kurtosis 0,053931
N 112
Minimum 2,5000
1st Quartile 4,5000
Median 5,0000
3rd Quartile 5,4375
Maximum 6,2500
95% Confidence Interval for Mean
4,7573 5,0373
95% Confidence Interval for Median
5,0000 5,0000
95% Confidence Interval for StDev
0,6610 0,8610

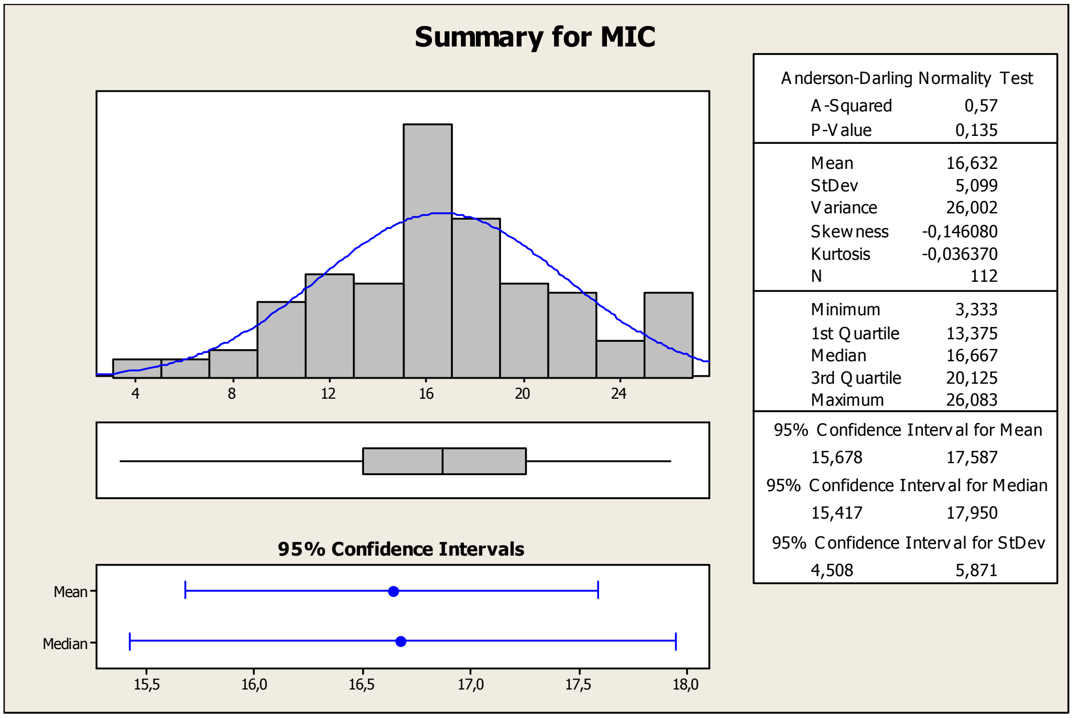

Summary for MI2=A8*B8
6
12
18
24
30
36
95% Confidence Intervals
Mean
Median
20
21
22
23
24
25
Anderson-Darling Normality Test
A-Squared 1,55
P-Value < 0,005
Mean 22,089
StDev 7,986
Variance 63,776
Skewness -0,014629
Kurtosis -0,398121
N 112
Minimum 3,000
1st Quartile 16,000
Median 20,000
3rd Quartile 25,000
Maximum 36,000
95% Confidence Interval for Mean
20,594 23,585
95% Confidence Interval for Median
20,000 25,000
95% Confidence Interval for StDev
7,059 9,195



Descriptive Statistics: MI11=A6+B6; MI12=A7+B7; MI1; MI2=A8*B8; MI3=A9*B9

Variable	N	N*	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median
MI11=A6+B6	112	0	4,9375	0,0751	0,7945	0,6312	2,5000	4,5000	5,0000
MI12=A7+B7	112	0	4,8571	0,0823	0,8710	0,7587	2,0000	4,5000	5,0000
MI1	112	0	4,8973	0,0707	0,7478	0,5592	2,5000	4,5000	5,0000
MI2=A8*B8	112	0	22,089	0,755	7,986	63,776	3,000	16,000	20,000
MI3=A9*B9	112	0	22,911	0,747	7,905	62,496	3,000	18,000	25,000

Variable	Q3	Maximum	Range
MI11=A6+B6	5,5000	7,0000	4,5000
MI12=A7+B7	5,5000	6,5000	4,5000
MI1	5,4375	6,2500	3,7500
MI2=A8*B8	25,000	36,000	33,000
MI3=A9*B9	25,000	36,000	33,000



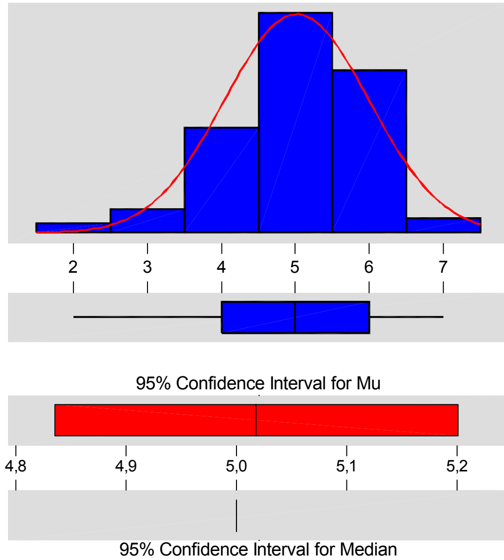
Descriptive Statistics: MIC

Variable	N	N*	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median
MIC	112	0	16,632	0,482	5,099	26,002	3,333	13,375	16,667

Variable	Q3	Maximum	Range
MIC	20,125	26,083	22,750

A6. In general, the level of **influence** that members of the [Manufacturing] group and the [Quality or R&D] have on each other's key decisions and policies is: ☐

Descriptive Statistics



Variable: A6

Anderson-Darling Normality Test

A-Squared:	5,582
P-Value:	0,000
Mean	5,01786
StDev	0,97705
Variance	0,954633
Skewness	-6,3E-01
Kurtosis	0,572943
N	112
Minimum	2,00000
1st Quartile	4,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,83491 5,20080

95% Confidence Interval for Sigma

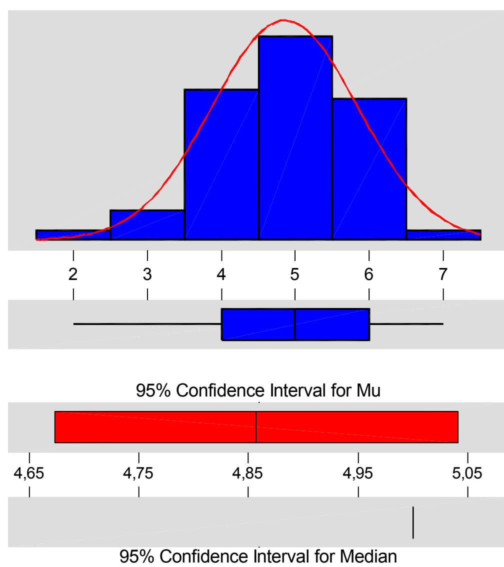
0,86370 1,12493

95% Confidence Interval for Median

5,00000 5,00000

B6. In general, the level of **influence** that members of the [Quality or R&D] group and the [Manufacturing] have on each other's key decisions and policies is: ☐

Descriptive Statistics



Variable: B6

Anderson-Darling Normality Test

A-Squared:	5,071
P-Value:	0,000
Mean	4,85714
StDev	0,98509
Variance	0,970399
Skewness	-4,0E-01
Kurtosis	7,84E-02
N	112
Minimum	2,00000
1st Quartile	4,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,67269 5,04159

95% Confidence Interval for Sigma

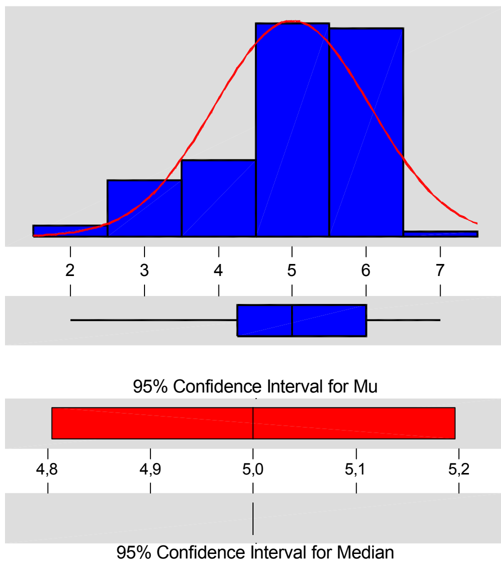
0,87080 1,13418

95% Confidence Interval for Median

5,00000 5,00000

A7. In general the **ability** of members of the [Manufacturing] group and the [Quality or R&D] group **to affect** each other's key decisions and policies is: ☐

Descriptive Statistics

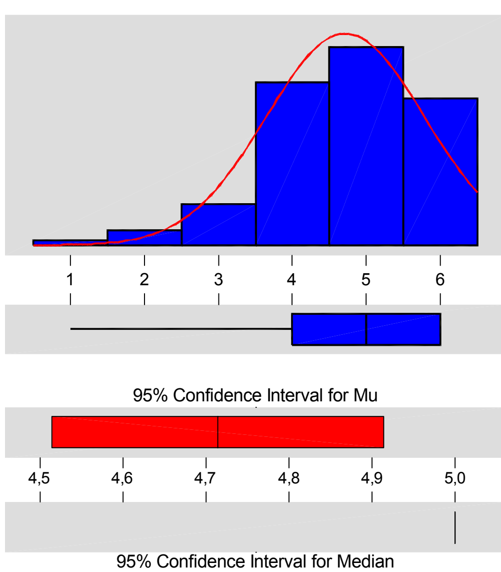


Variable: A7

Anderson-Darling Normality Test	
A-Squared:	6,919
P-Value:	0,000
Mean	5,00000
StDev	1,04838
Variance	1,09910
Skewness	-8,6E-01
Kurtosis	0,144668
N	112
Minimum	2,00000
1st Quartile	4,25000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000
95% Confidence Interval for Mu	
4,80370	5,19630
95% Confidence Interval for Sigma	
0,92675	1,20705
95% Confidence Interval for Median	
5,00000	5,00000

B7. In general the **ability** of members of the [Quality or R&D] group and the [Manufacturing] group **to affect** each other's key decisions and policies is: ☐

Descriptive Statistics

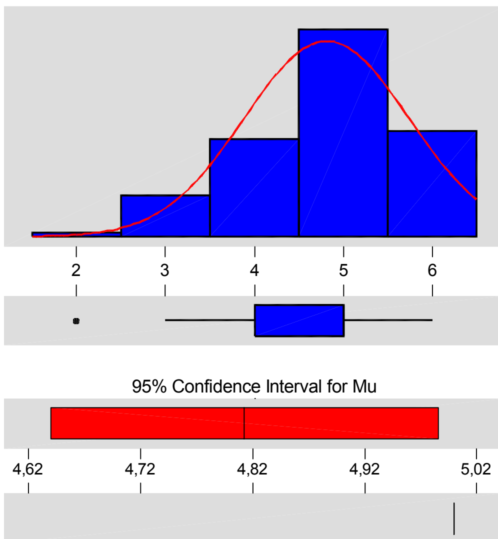


Variable: B7

Anderson-Darling Normality Test	
A-Squared:	4,966
P-Value:	0,000
Mean	4,71429
StDev	1,06904
Variance	1,14286
Skewness	-7,6E-01
Kurtosis	0,630951
N	112
Minimum	1,00000
1st Quartile	4,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	6,00000
95% Confidence Interval for Mu	
4,51412	4,91445
95% Confidence Interval for Sigma	
0,94502	1,23085
95% Confidence Interval for Median	
5,00000	5,00000

A8. In general, the level of **influence** that members of the [Quality or R&D] group have on key decisions and policies of the [Manufacturing] group is: ☐

Descriptive Statistics



Variable: A8

Anderson-Darling Normality Test

A-Squared:	6,349
P-Value:	0,000
Mean	4,81250
StDev	0,92543
Variance	0,856419
Skewness	-5,9E-01
Kurtosis	-6,6E-02
N	112
Minimum	2,00000
1st Quartile	4,00000
Median	5,00000
3rd Quartile	5,00000
Maximum	6,00000

95% Confidence Interval for Mu

4,63922 4,98578

95% Confidence Interval for Sigma

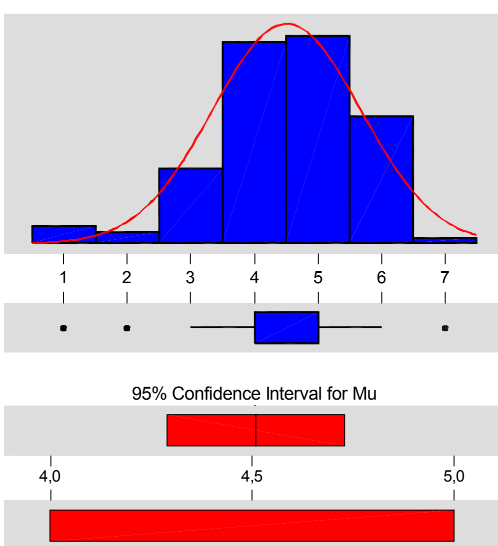
0,81806 1,06549

95% Confidence Interval for Median

5,00000 5,00000

B8. In general, the level of **influence** that members of the [Manufacturing] group have on key decisions and policies of the [Quality or R&D] group is: ☐

Descriptive Statistics



Variable: B8

Anderson-Darling Normality Test

A-Squared:	4,035
P-Value:	0,000
Mean	4,50893
StDev	1,17017
Variance	1,36929
Skewness	-6,7E-01
Kurtosis	0,736950
N	112
Minimum	1,00000
1st Quartile	4,00000
Median	5,00000
3rd Quartile	5,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,28983 4,72803

95% Confidence Interval for Sigma

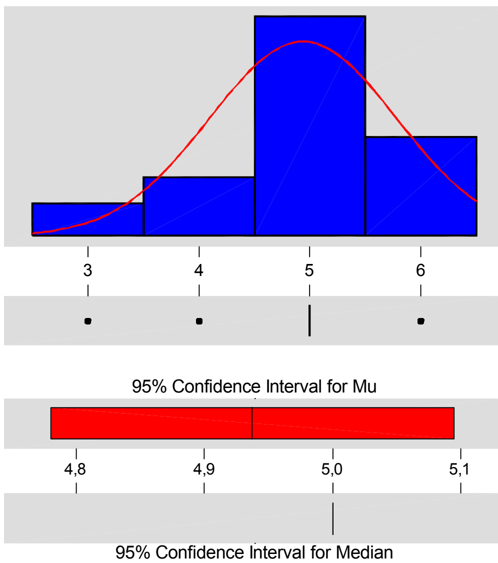
1,03440 1,34727

95% Confidence Interval for Median

4,00000 5,00000

A9. In general, the **ability** of members of the [Quality or R&D] group **to affect** key policies and decisions of the [Manufacturing] group is: ☐

Descriptive Statistics



Variable: A9

Anderson-Darling Normality Test

A-Squared:	8,615
P-Value:	0,000
Mean	4,93750
StDev	0,84129
Variance	0,707770
Skewness	-7,1E-01
Kurtosis	0,212599
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	5,00000
Maximum	6,00000

95% Confidence Interval for Mu

4,77998 5,09502

95% Confidence Interval for Sigma

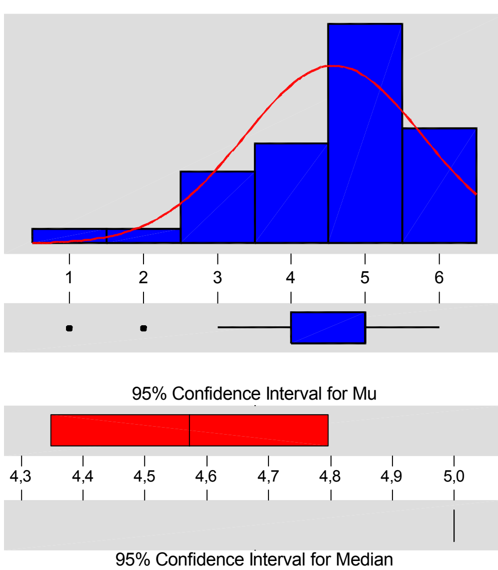
0,74369 0,96862

95% Confidence Interval for Median

5,00000 5,00000

B9. In general, the **ability** of members of the [Manufacturing] group **to affect** key policies and decisions of the [Quality or R&D] group is: ☐

Descriptive Statistics



Variable: B9

Anderson-Darling Normality Test

A-Squared:	5,479
P-Value:	0,000
Mean	4,57143
StDev	1,19845
Variance	1,43629
Skewness	-9,4E-01
Kurtosis	0,671559
N	112
Minimum	1,00000
1st Quartile	4,00000
Median	5,00000
3rd Quartile	5,00000
Maximum	6,00000

95% Confidence Interval for Mu

4,34703 4,79583

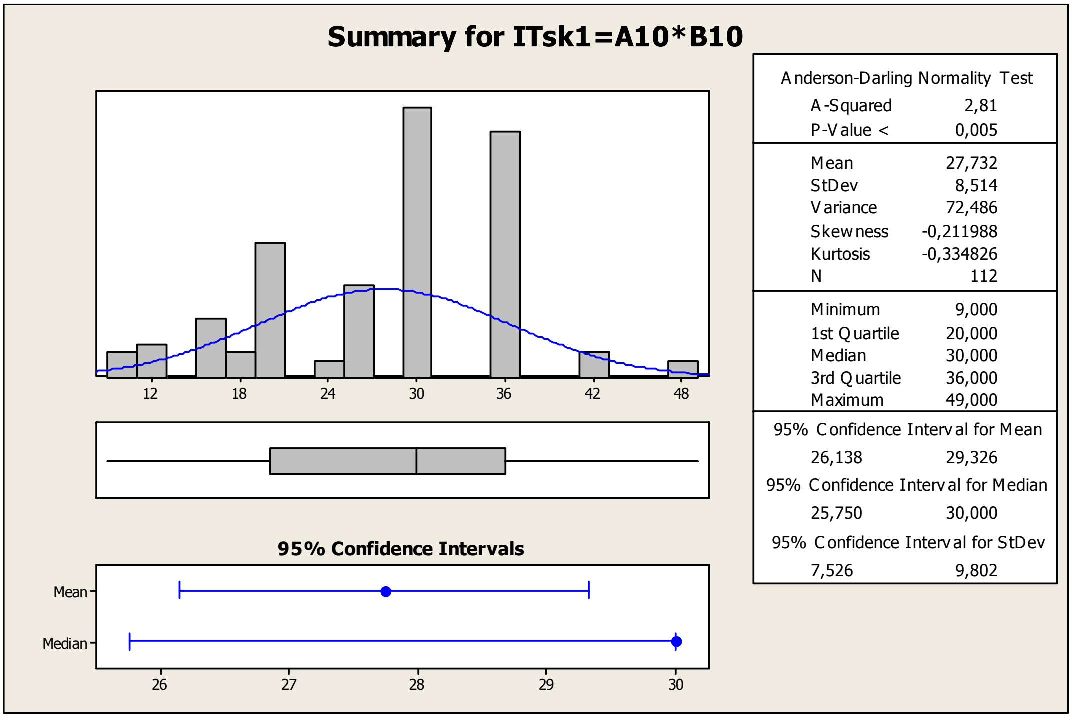
95% Confidence Interval for Sigma

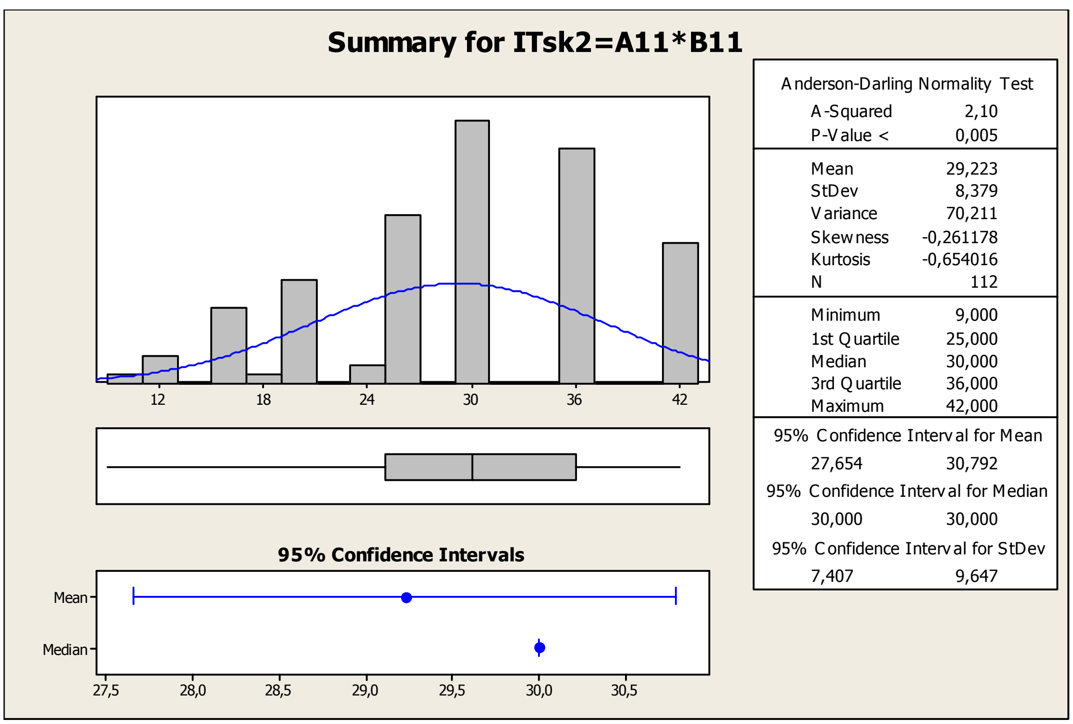
1,05941 1,37984

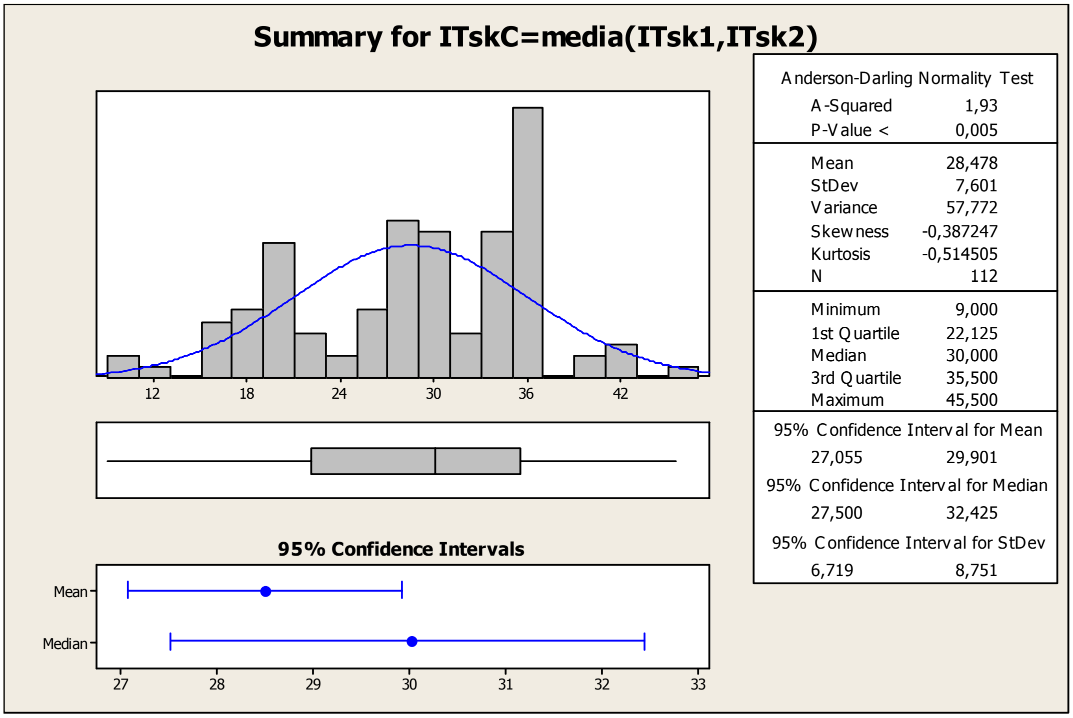
95% Confidence Interval for Median

5,00000 5,00000

6B.4 Information Technology (sk)







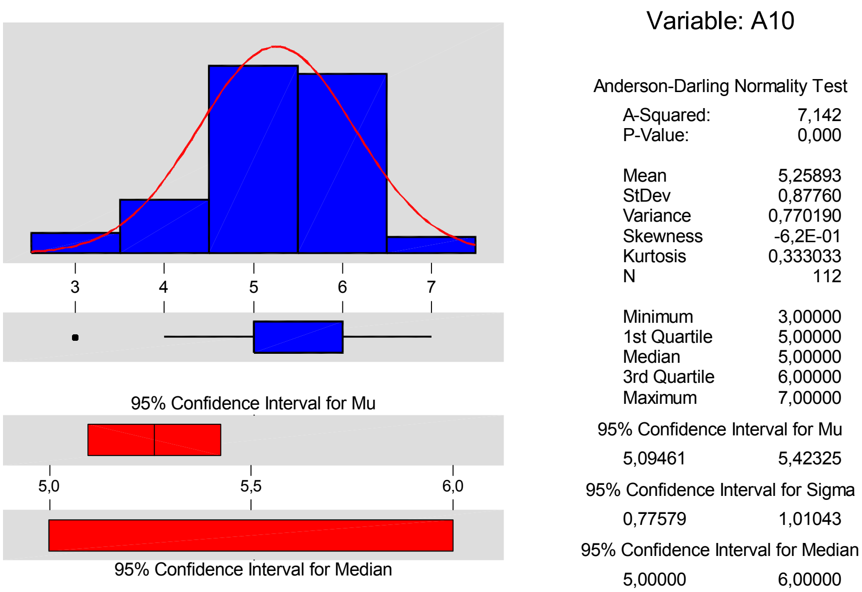
Descriptive Statistics: ITsk1=A10*B10; ITsk2=A11*B11; ITskC=media(ITsk1,ITsk2)

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median
ITsk1=A10*B10	112	0	27,732	0,804	8,514	9,000	20,000	30,000
ITsk2=A11*B11	112	0	29,223	0,792	8,379	9,000	25,000	30,000
ITskC=media(ITsk	112	0	28,478	0,718	7,601	9,000	22,125	30,000

Variable	Q3	Maximum
ITsk1=A10*B10	36,000	49,000
ITsk2=A11*B11	36,000	42,000
ITskC=media(ITsk	35,500	45,500

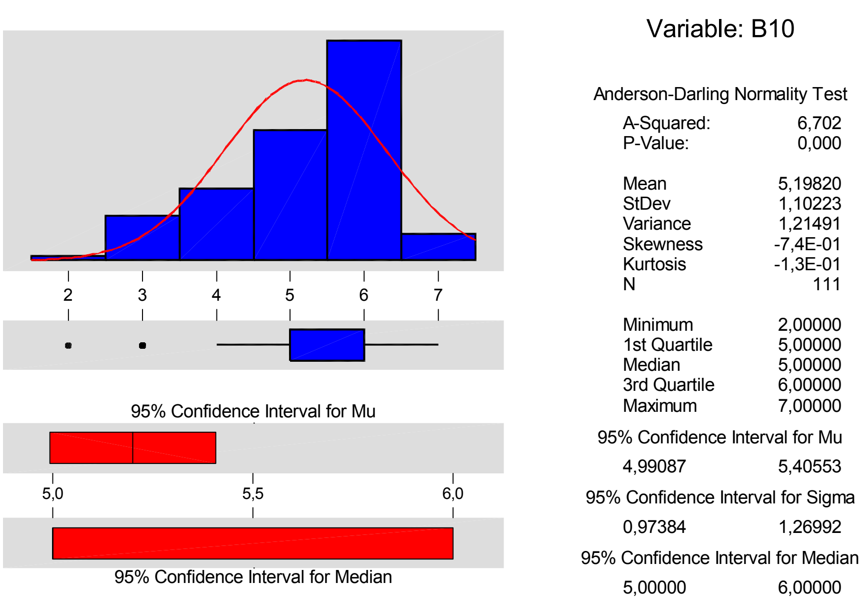
A10. In general, the role and the level of **contribution** of **Information Technology (IT)** as a tool and/or enabler, to support shared knowledge between [Manufacturing] group and [Quality or R&D] group is: ☐

Descriptive Statistics



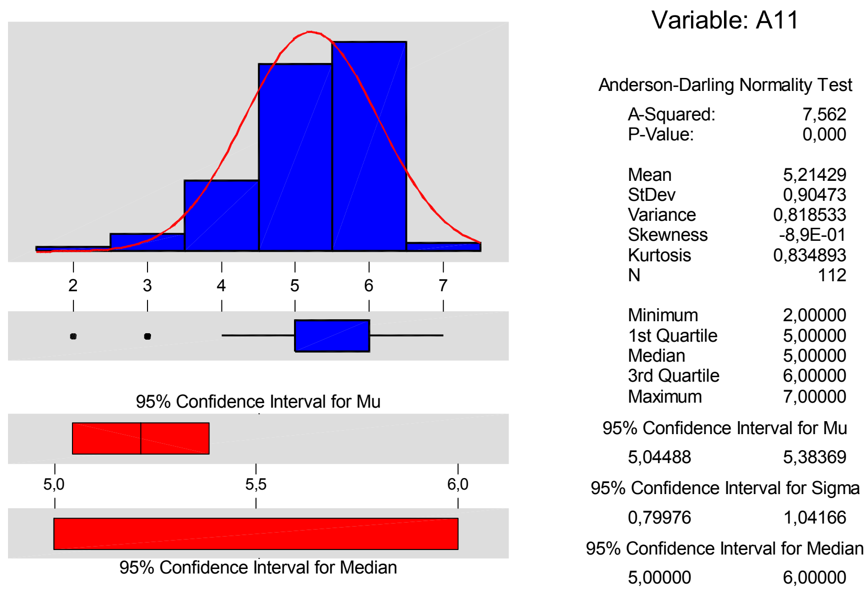
B10. In general, the role and the level of **contribution** of **Information Technology (IT)** as a tool and/or enabler, to support shared knowledge between [Quality or R&D] group and [Manufacturing] group is: ☐

Descriptive Statistics



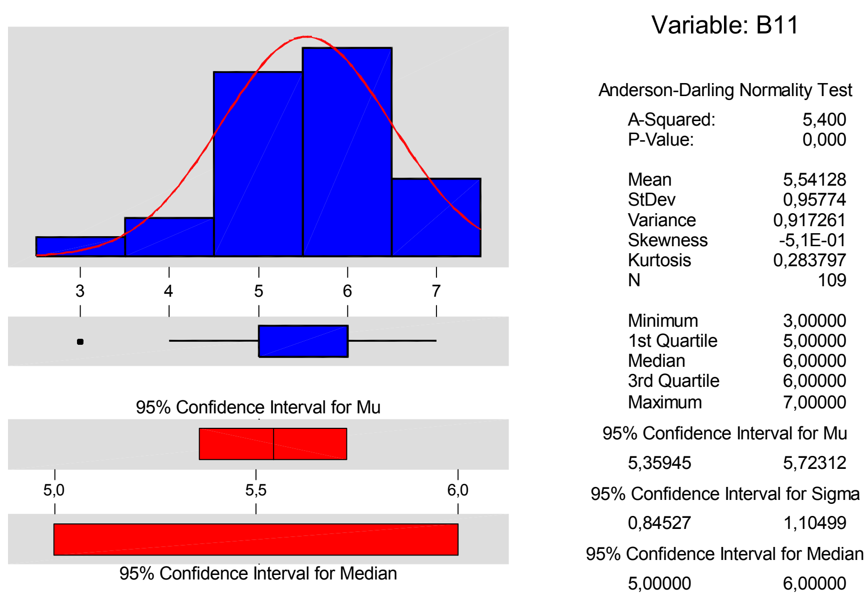
A11. In general, the **use** of the **Information Technology (IT) infrastructure** in the [Manufacturing] group is: ☐

Descriptive Statistics

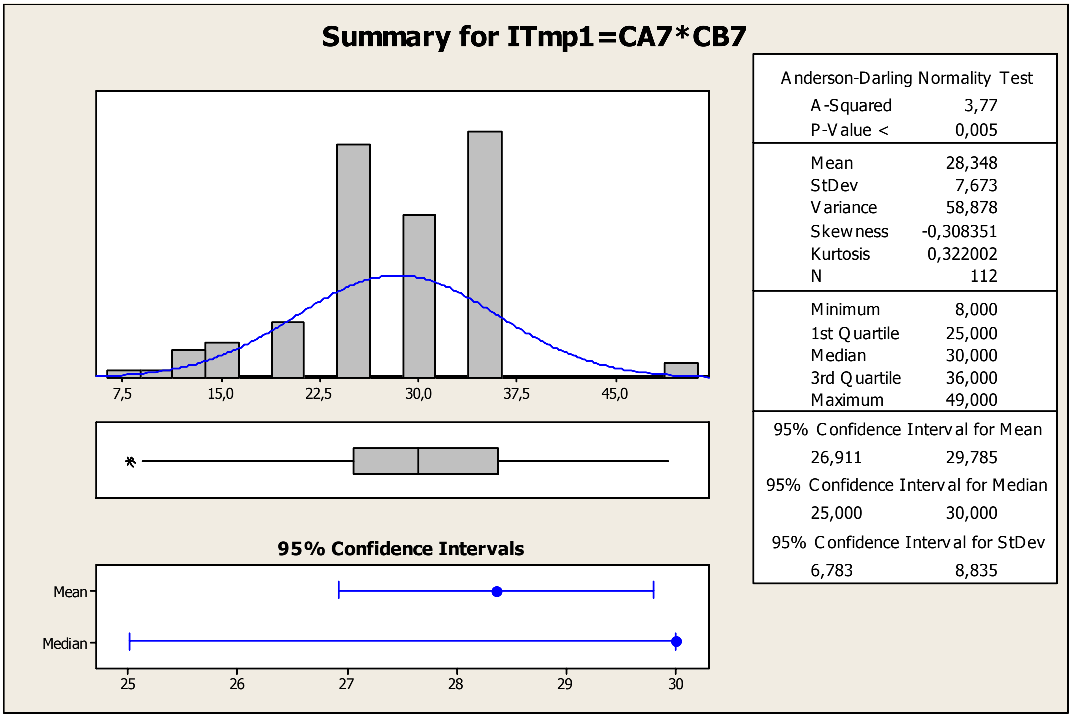


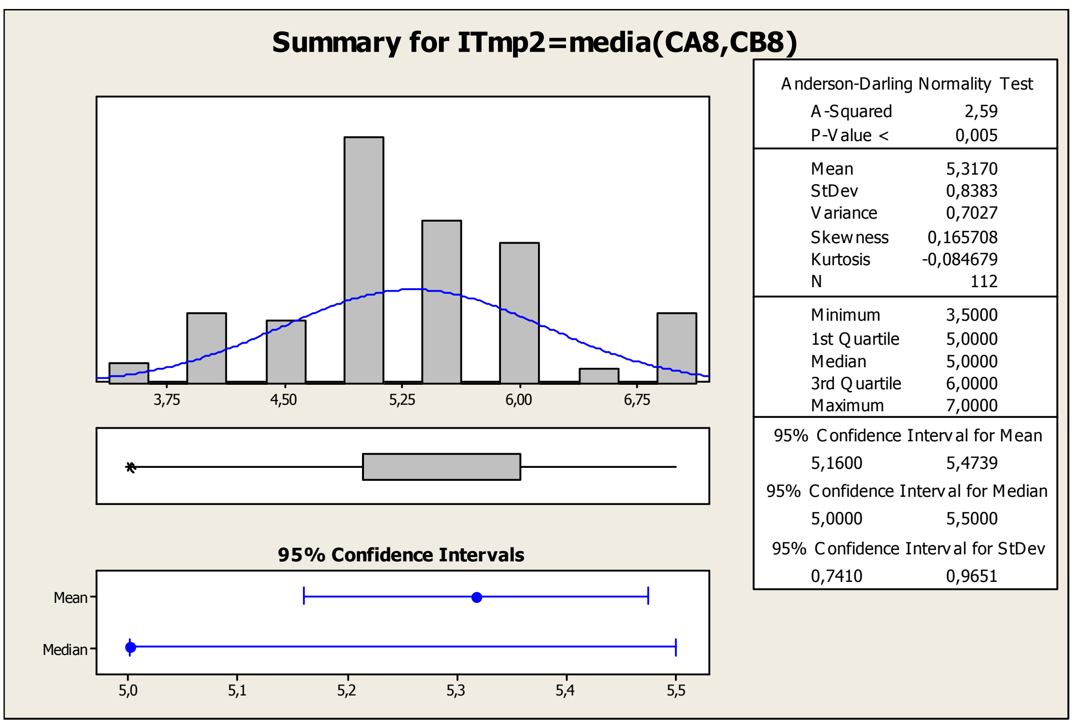
B11. In general, the **use** of the **Information Technology (IT) infrastructure** in the [Quality or R&D] group is: ☐

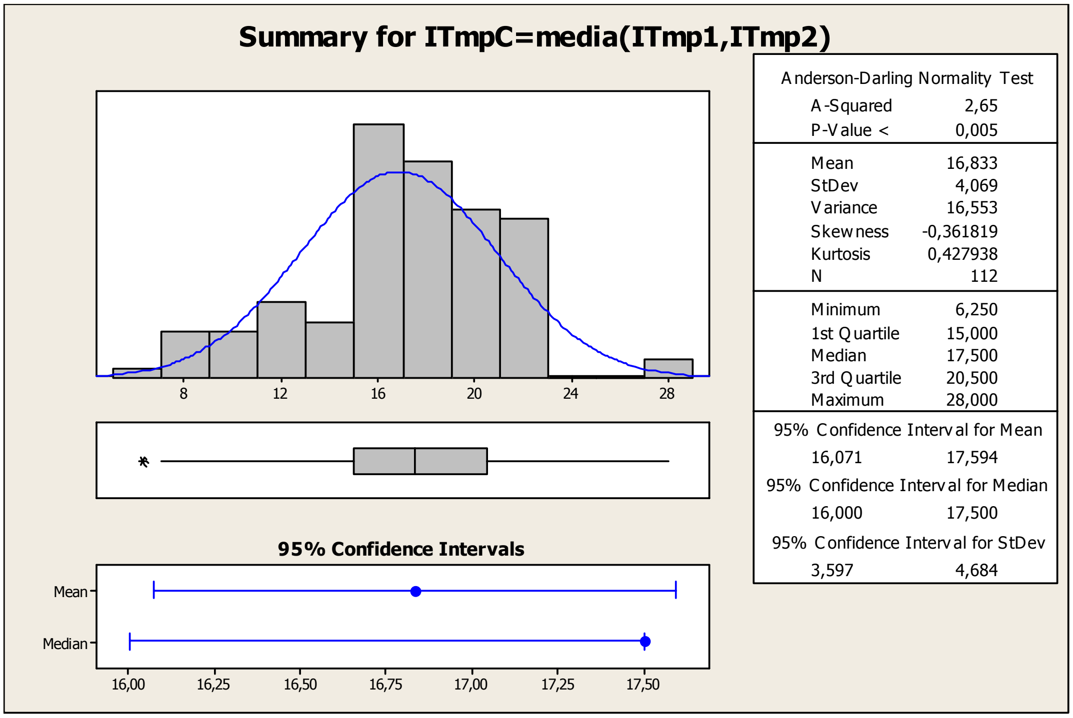
Descriptive Statistics



6B.5 Information Technology (mp)







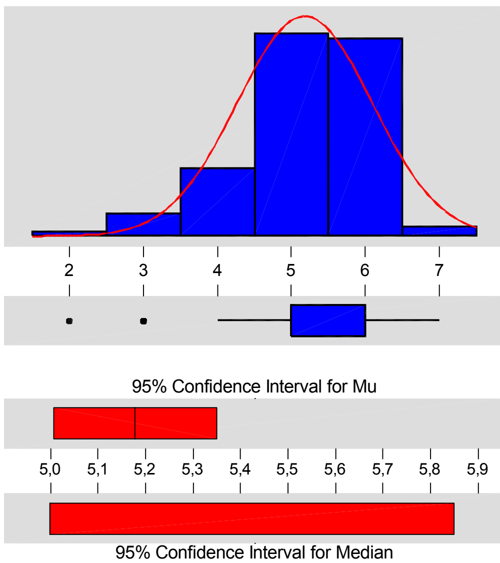
Descriptive Statistics: ITmp1=CA7*CB7; ITmp2=media(CA8,CB8); ITmpC=media(ITmp1, ITmp2)

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median
ITmp1=CA7*CB7	112	0	28,348	0,725	7,673	8,000	25,000	30,000
ITmp2=media(CA8,	112	0	5,3170	0,0792	0,8383	3,5000	5,0000	5,0000
ITmpC=media(ITmp	112	0	16,833	0,384	4,069	6,250	15,000	17,500

Variable	Q3	Maximum
ITmp1=CA7*CB7	36,000	49,000
ITmp2=media(CA8,	6,0000	7,0000
ITmpC=media(ITmp	20,500	28,000

CA/B7. In general, the level of the **Information Technology (IT) contribution** to the [Manufacturing] group performance is:

Descriptive Statistics



Variable: CA7

Anderson-Darling Normality Test

A-Squared:	7,312
P-Value:	0,000
Mean	5,17857
StDev	0,91252
Variance	0,832690
Skewness	-8,7E-01
Kurtosis	0,836032
N	112
Minimum	2,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,00771 5,34943

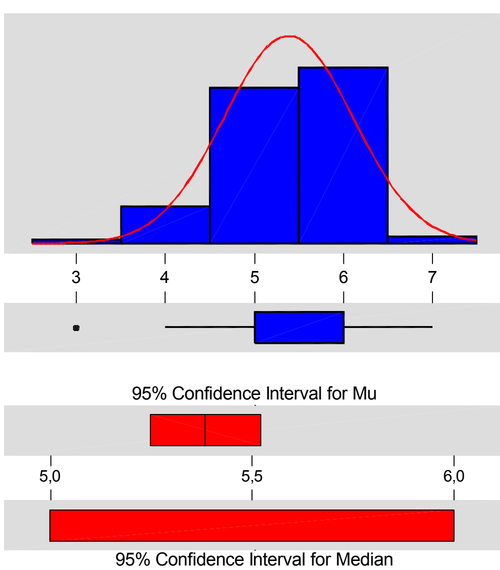
95% Confidence Interval for Sigma

0,80665 1,05063

95% Confidence Interval for Median

5,00000 5,85003

Descriptive Statistics



Variable: CB7

Anderson-Darling Normality Test

A-Squared:	9,922
P-Value:	0,000
Mean	5,38393
StDev	0,72591
Variance	0,526947
Skewness	-5,9E-01
Kurtosis	0,163108
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,24801 5,51985

95% Confidence Interval for Sigma

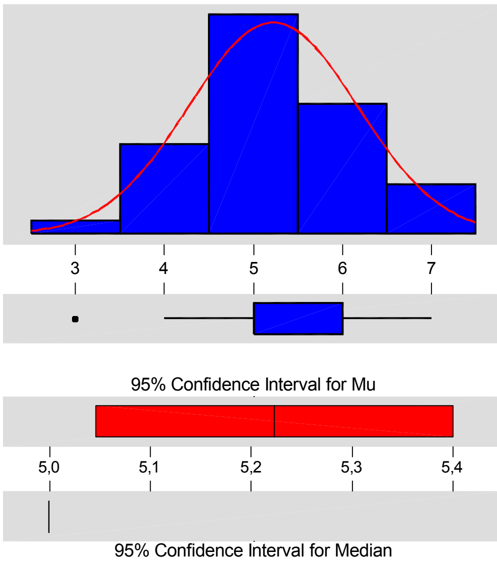
0,64169 0,83578

95% Confidence Interval for Median

5,00000 6,00000

CA/B8. In general, the use of the **Information Technology (IT) infrastructure**, between the three groups is: ☐

Descriptive Statistics



Variable: CA8

Anderson-Darling Normality Test

A-Squared:	5,336
P-Value:	0,000
Mean	5,22321
StDev	0,94640
Variance	0,895672
Skewness	5,60E-02
Kurtosis	-2,6E-01
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,04601	5,40042

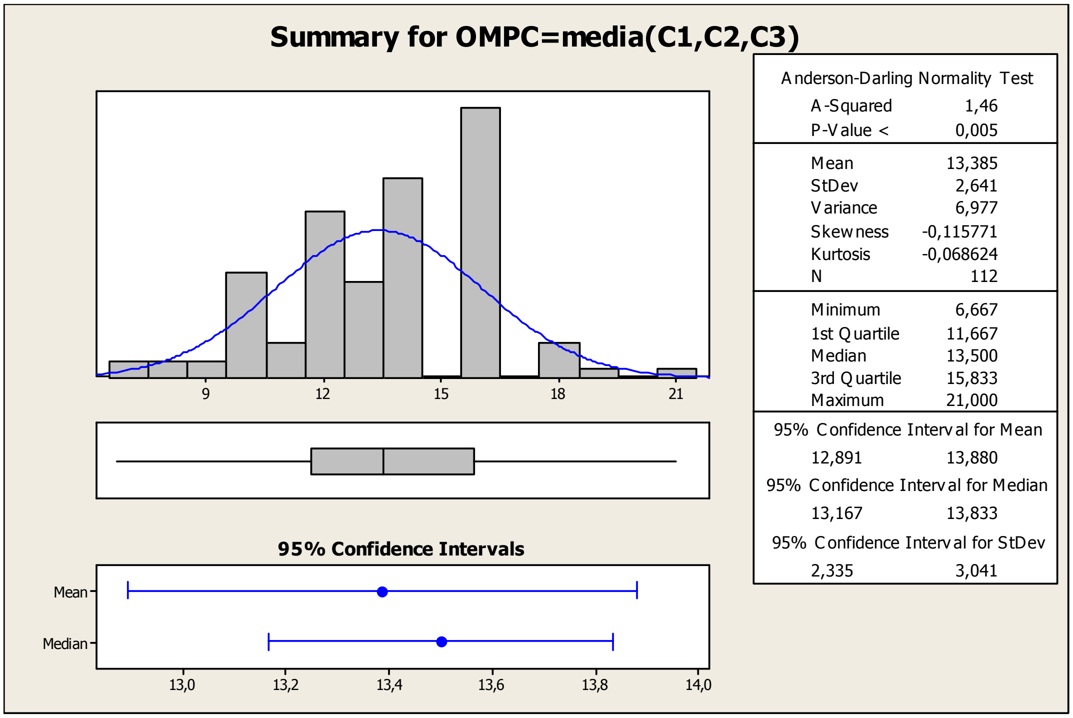
95% Confidence Interval for Sigma

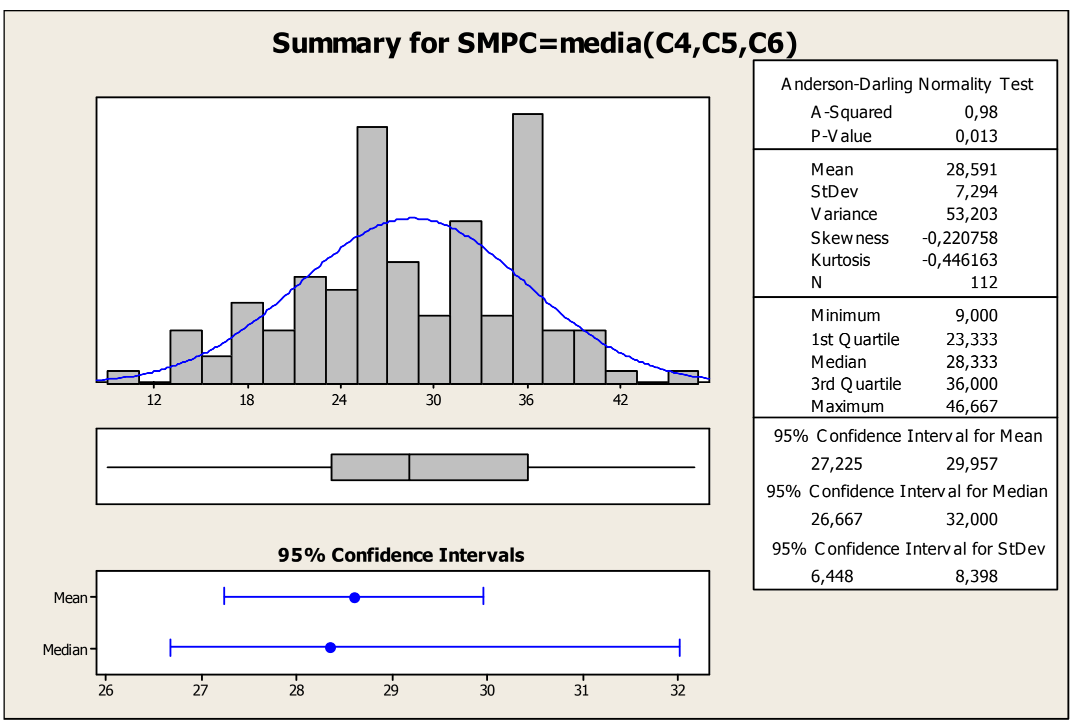
0,83660	1,08964

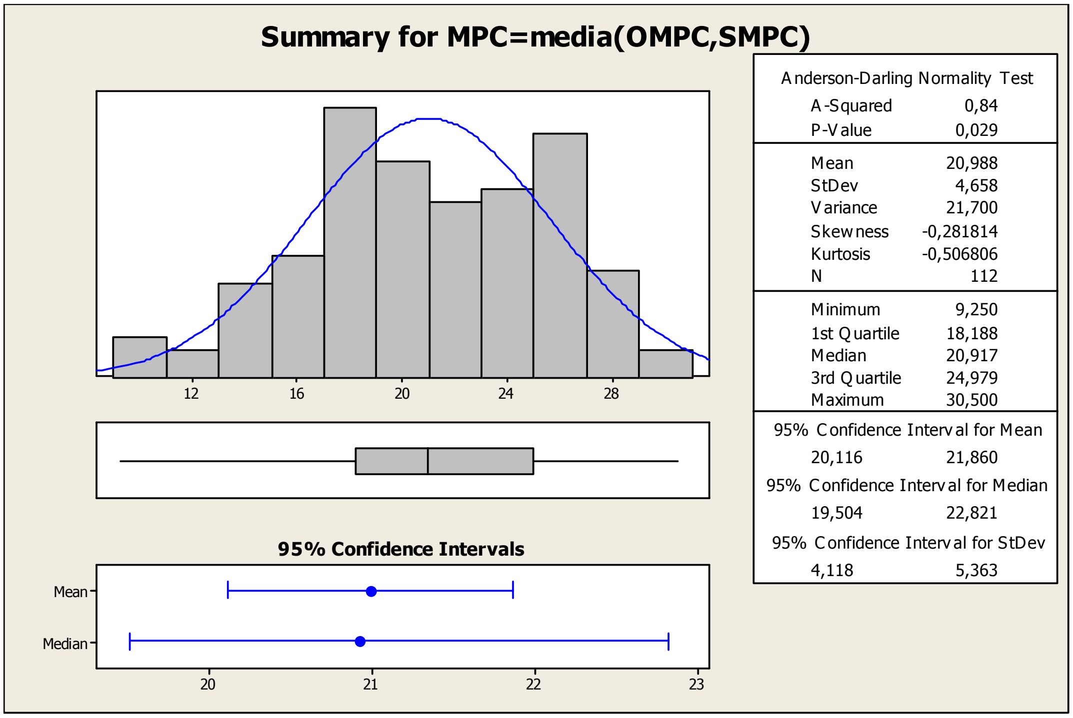
95% Confidence Interval for Median

5,00000	5,00000

6B.6 <u>Manufacturing Performance</u>







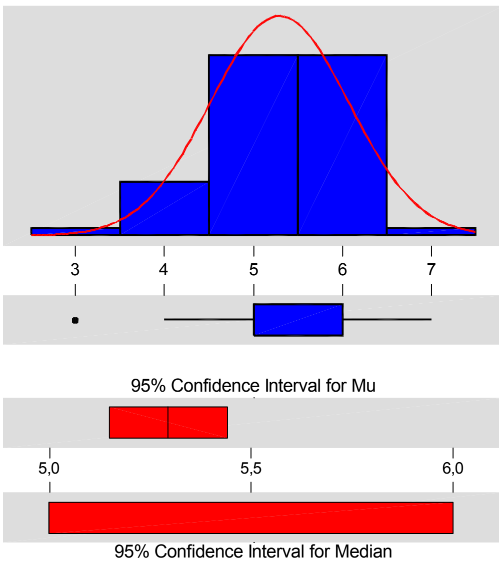
Descriptive Statistics: OMPC=media(C1,C2,C3); SMPC=media(C4,C5,C6) ; MPC=media(OMPC,SMPC)

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median
OMPC=media(C1,C2	112	0	13,385	0,250	2,641	6,667	11,667	13,500
SMPC=media(C4,C5	112	0	28,591	0,689	7,294	9,000	23,333	28,333
MPC=media(OMPC,S	112	0	20,988	0,440	4,658	9,250	18,188	20,917

Variable	Q3	Maximum
OMPC=media(C1,C2	15,833	21,000
SMPC=media(C4,C5	36,000	46,667
MPC=media(OMPC,S	24,979	30,500

CA/B1. In general, the **quality of the work** produced for the [Quality or R&D] group by the [Manufacturing] group is: ☐

Descriptive Statistics



Variable: CA1

Anderson-Darling Normality Test

A-Squared:	8,589
P-Value:	0,000
Mean	5,29464
StDev	0,77852
Variance	0,606097
Skewness	-5,7E-01
Kurtosis	0,118876
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,14887 5,44041

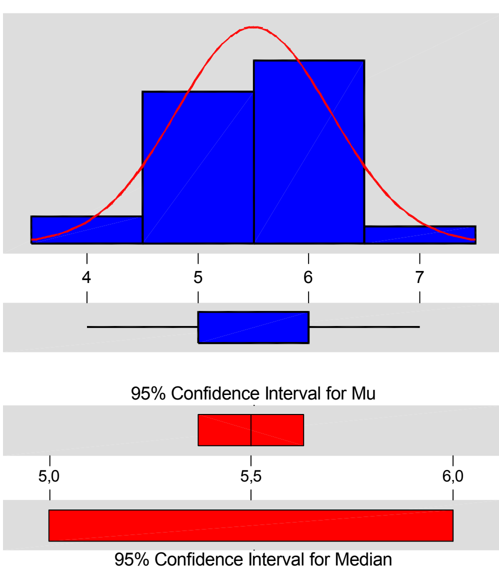
95% Confidence Interval for Sigma

0,68820 0,89635

95% Confidence Interval for Median

5,00000 6,00000

Descriptive Statistics



Variable: CB1

Anderson-Darling Normality Test

A-Squared:	10,004
P-Value:	0,000
Mean	5,50000
StDev	0,69749
Variance	0,486486
Skewness	-2,4E-01
Kurtosis	-1,9E-01
N	112
Minimum	4,00000
1st Quartile	5,00000
Median	6,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,36940 5,63060

95% Confidence Interval for Sigma

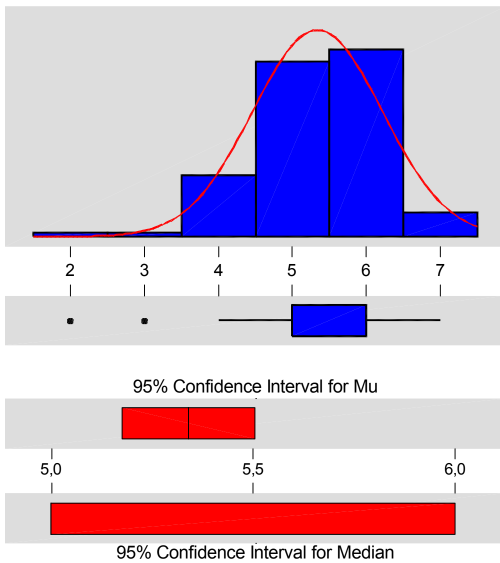
0,61656 0,80305

95% Confidence Interval for Median

5,00000 6,00000

CA/B2. In general, the **ability** of the [Manufacturing] group **to meet** its organizational commitments (such as project schedules and budget) is: ☐

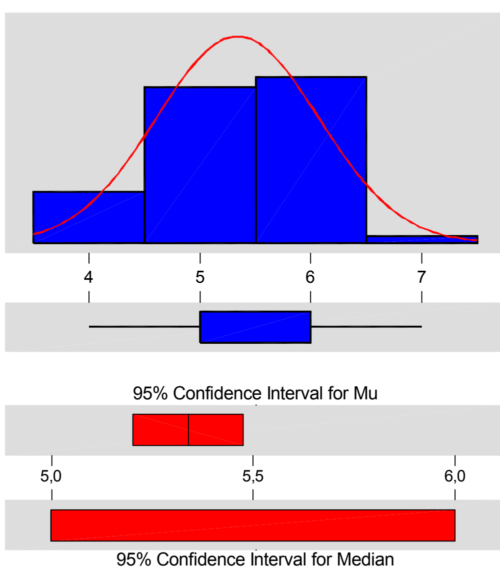
Descriptive Statistics



Variable: CA2

Anderson-Darling Normality Test	
A-Squared:	6,798
P-Value:	0,000
Mean	5,33929
StDev	0,87563
Variance	0,766731
Skewness	-6,4E-01
Kurtosis	1,08281
N	112
Minimum	2,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000
95% Confidence Interval for Mu	
5,17533	5,50324
95% Confidence Interval for Sigma	
0,77404	1,00816
95% Confidence Interval for Median	
5,00000	6,00000

Descriptive Statistics

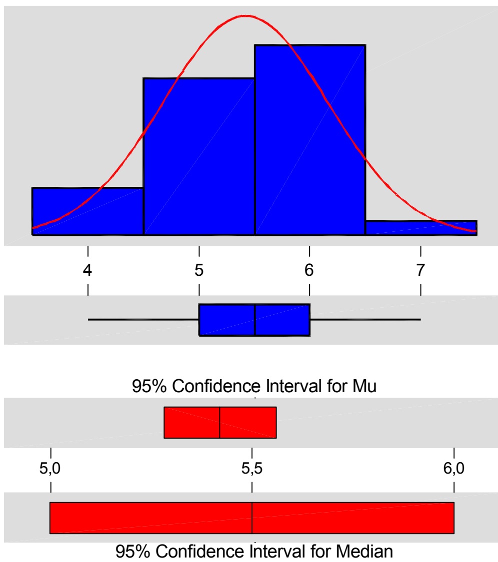


Variable: CB2

Anderson-Darling Normality Test	
A-Squared:	9,505
P-Value:	0,000
Mean	5,33929
StDev	0,72972
Variance	0,532497
Skewness	-3,4E-01
Kurtosis	-6,2E-01
N	112
Minimum	4,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000
95% Confidence Interval for Mu	
5,20265	5,47592
95% Confidence Interval for Sigma	
0,64506	0,84017
95% Confidence Interval for Median	
5,00000	6,00000

CA/B3. In general, the **ability** of the [Manufacturing] group **to meet** its goals is:

Descriptive Statistics



Variable: CA3

Anderson-Darling Normality Test

A-Squared:	9,190
P-Value:	0,000
Mean	5,41964
StDev	0,74300
Variance	0,552043
Skewness	-3,2E-01
Kurtosis	-4,3E-01
N	112
Minimum	4,00000
1st Quartile	5,00000
Median	5,50000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,28052 5,55876

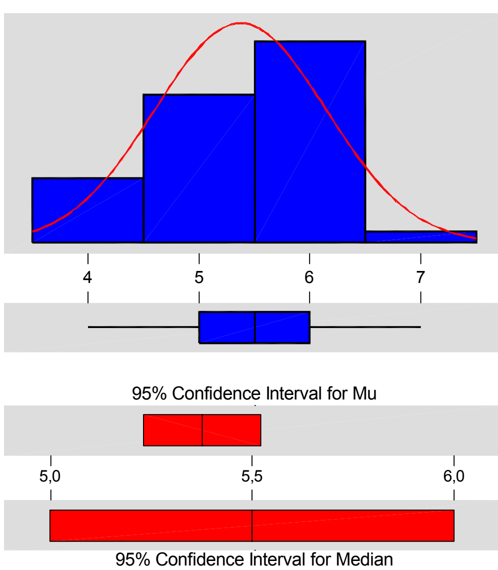
95% Confidence Interval for Sigma

0,65679 0,85545

95% Confidence Interval for Median

5,00000 6,00000

Descriptive Statistics



Variable: CB3

Anderson-Darling Normality Test

A-Squared:	9,368
P-Value:	0,000
Mean	5,37500
StDev	0,77256
Variance	0,596847
Skewness	-4,1E-01
Kurtosis	-6,7E-01
N	112
Minimum	4,00000
1st Quartile	5,00000
Median	5,50000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,23035 5,51965

95% Confidence Interval for Sigma

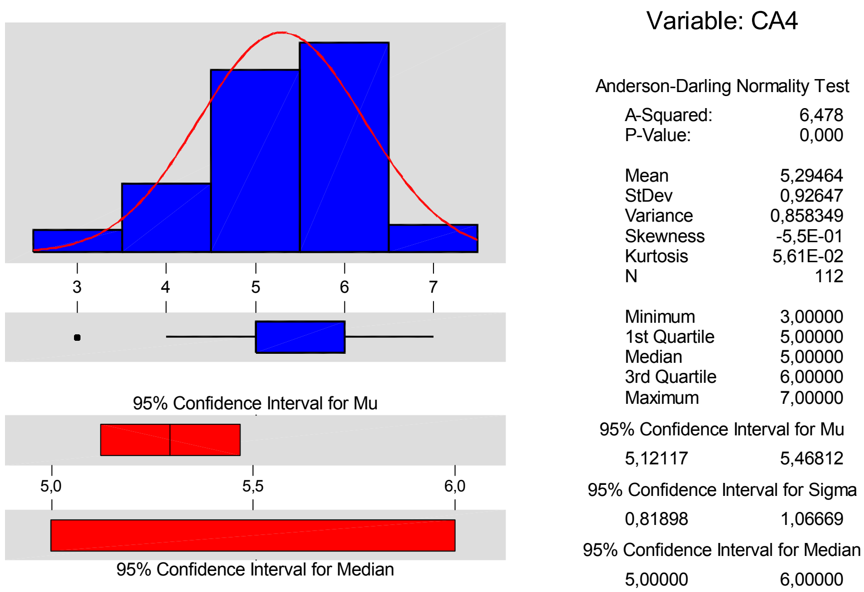
0,68293 0,88949

95% Confidence Interval for Median

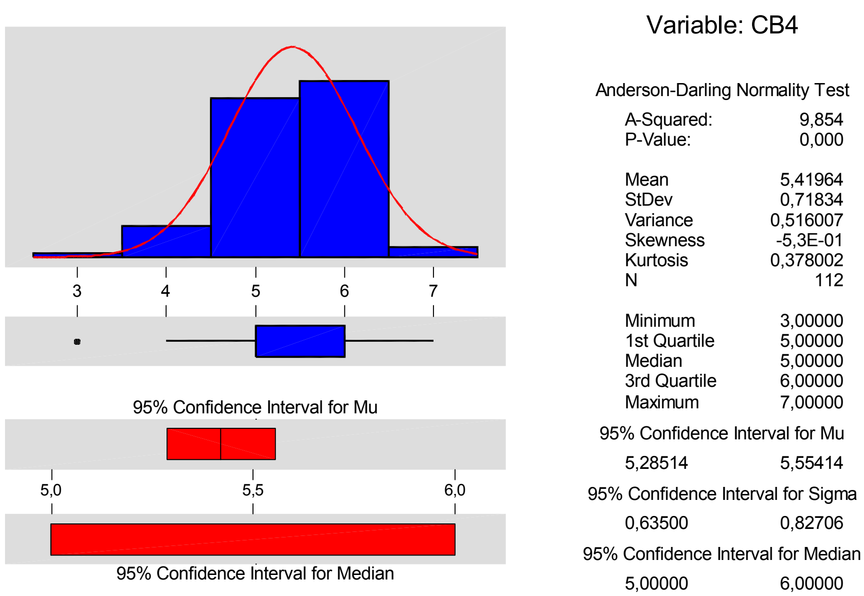
5,00000 6,00000

CA/B4. In general, the **ability** of the [Manufacturing] group **to react** quickly to the [Quality or R&D] group's changing business needs is: ☐

Descriptive Statistics

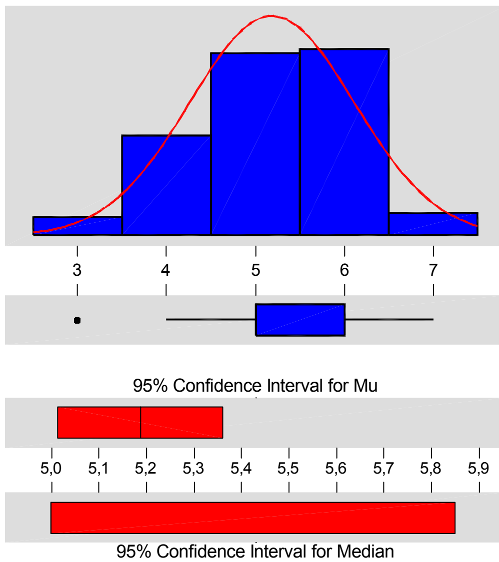


Descriptive Statistics



CA/B5. In general, the **responsiveness** of the [Manufacturing] group to the [Quality or R&D] group is: [ ]

Descriptive Statistics



Variable: CA5

Anderson-Darling Normality Test

A-Squared:	5,937
P-Value:	0,000
Mean	5,18750
StDev	0,92543
Variance	0,856419
Skewness	-3,1E-01
Kurtosis	-4,0E-01
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,01422 5,36078

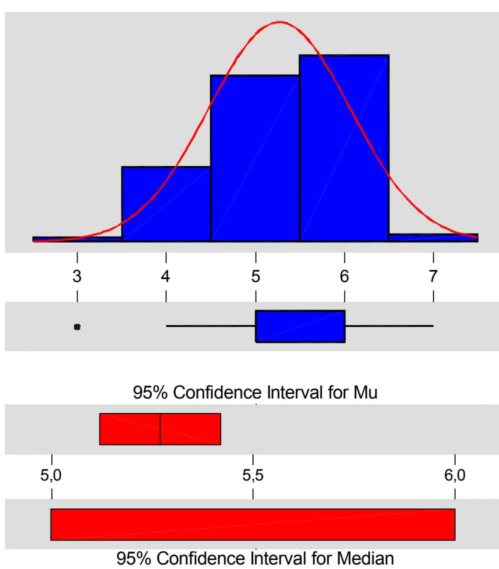
95% Confidence Interval for Sigma

0,81806 1,06549

95% Confidence Interval for Median

5,00000 5,85003

Descriptive Statistics



Variable: CB5

Anderson-Darling Normality Test

A-Squared:	8,353
P-Value:	0,000
Mean	5,27027
StDev	0,79711
Variance	0,635381
Skewness	-4,2E-01
Kurtosis	-5,3E-01
N	111
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,12033 5,42021

95% Confidence Interval for Sigma

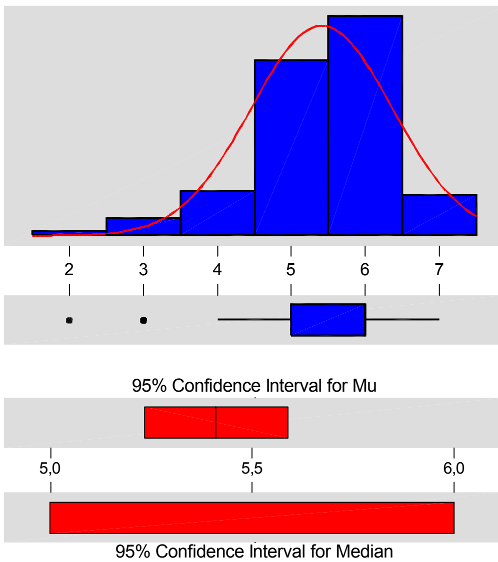
0,70426 0,91838

95% Confidence Interval for Median

5,00000 6,00000

CA/B6. In general, the **contribution** that the [Manufacturing] group has made to the accomplishment of the [Quality or R&D] group's strategic goals is: ☐

Descriptive Statistics



Variable: CA6

Anderson-Darling Normality Test

A-Squared:	6,646
P-Value:	0,000
Mean	5,41071
StDev	0,95440
Variance	0,910875
Skewness	-8,5E-01
Kurtosis	1,20906
N	112
Minimum	2,00000
1st Quartile	5,00000
Median	6,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,23201 5,58942

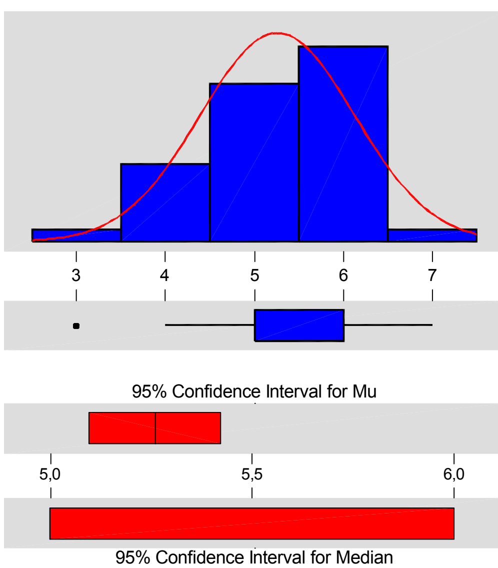
95% Confidence Interval for Sigma

0,84367 1,09885

95% Confidence Interval for Median

5,00000 6,00000

Descriptive Statistics



Variable: CB6

Anderson-Darling Normality Test

A-Squared:	7,594
P-Value:	0,000
Mean	5,25893
StDev	0,86728
Variance	0,752172
Skewness	-5,3E-01
Kurtosis	-2,6E-01
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,09654 5,42132

95% Confidence Interval for Sigma

0,76666 0,99854

95% Confidence Interval for Median

5,00000 6,00000

6B.7.1 Relationship Questionnaire A:

Descriptive Statistics: A1; A2; A3; A4; A5; A6

Variable	N	Mean	Median	TrMean	StDev	SE Mean
A1	112	5,3571	6,0000	5,4200	0,7925	0,0749
A2	112	5,1250	5,0000	5,1800	1,0234	0,0967
A3	112	5,1786	5,0000	5,2200	0,9606	0,0908
A4	112	5,545	6,000	5,620	1,106	0,105
A5	112	5,4464	6,0000	5,4900	0,9665	0,0913
A6	112	5,0179	5,0000	5,0700	0,9771	0,0923

Variable	Minimum	Maximum	Q1	Q3
A1	3,0000	7,0000	5,0000	6,0000
A2	2,0000	7,0000	5,0000	6,0000
A3	3,0000	7,0000	5,0000	6,0000
A4	2,000	7,000	5,000	6,000
A5	3,0000	7,0000	5,0000	6,0000
A6	2,0000	7,0000	4,0000	6,0000

Descriptive Statistics: A7; A8; A9; A10; A11; A12Intranet; A12Extranet; A12Groupware; A12Workflow; A12Internet; A12e-mail; A12Data warehousing; A12SAP(Other);

Variable	N	N*	Mean	Median	TrMean	StDev
A7	112	0	5,0000	5,0000	5,0700	1,0484
A8	112	0	4,8125	5,0000	4,8600	0,9254
A9	112	0	4,9375	5,0000	4,9900	0,8413
A10	112	0	5,2589	5,0000	5,3000	0,8776
A11	112	0	5,2143	5,0000	5,2800	0,9047
A12Intra	107	5	5,009	5,000	5,072	1,217
A12Extra	53	55	3,717	5,000	3,723	1,984
A12Group	36	67	4,389	5,500	4,500	2,060
A12Workf	31	79	3,645	4,000	3,667	1,836
A12Inter	83	27	4,072	5,000	4,133	1,666
A12email	105	7	6,010	6,000	6,105	1,033
A12SAP	2	95	6,0000	6,0000	6,0000	0,0000
A12Data	48	61	5,104	6,000	5,205	1,356
A12Other	10	100	5,000	5,500	5,125	1,491

Variable	SE Mean	Minimum	Maximum	Q1	Q3
A7	0,0991	2,0000	7,0000	4,2500	6,0000
A8	0,0874	2,0000	6,0000	4,0000	5,0000
A9	0,0795	3,0000	6,0000	5,0000	5,0000
A10	0,0829	3,0000	7,0000	5,0000	6,0000
A11	0,0855	2,0000	7,0000	5,0000	6,0000
A12Intra	0,118	1,000	7,000	4,000	6,000
A12Extra	0,273	1,000	7,000	1,500	5,000
A12Group	0,343	1,000	6,000	2,250	6,000
A12Workf	0,330	1,000	6,000	2,000	5,000
A12Inter	0,183	1,000	6,000	3,000	5,000
A12email	0,101	2,000	7,000	6,000	7,000
A12SAP	0,0000	6,0000	6,0000	*	*
A12Data	0,196	1,000	7,000	4,250	6,000
A12Other	0,471	2,000	7,000	4,000	6,000

6B.7.2 Relationship Questionnaire B:

Descriptive Statistics: B1; B2; B3; B4; B5; B6; B7; B8

Variable	N	Mean	Median	TrMean	StDev	SE Mean
B1	112	5,2411	5,0000	5,2900	0,8409	0,0795
B2	112	4,848	5,000	4,910	1,100	0,104
B3	112	5,0714	5,0000	5,1200	0,9746	0,0921
B4	112	5,3571	5,0000	5,4000	0,9286	0,0877
B5	112	5,1339	5,0000	5,2400	0,9726	0,0919
B6	112	4,8571	5,0000	4,9000	0,9851	0,0931
B7	112	4,714	5,000	4,790	1,069	0,101
B8	112	4,509	5,000	4,580	1,170	0,111

Variable	Minimum	Maximum	Q1	Q3
B1	3,0000	7,0000	5,0000	6,0000
B2	1,000	7,000	4,000	6,000
B3	3,0000	7,0000	5,0000	6,0000
B4	3,0000	7,0000	5,0000	6,0000
B5	1,0000	7,0000	5,0000	6,0000
B6	2,0000	7,0000	4,0000	6,0000
B7	1,000	6,000	4,000	6,000
B8	1,000	7,000	4,000	5,000

Descriptive Statistics: B9; B10; B11; B12Intranet; B12Extranet; B12Groupware; B12Workflow;B12Internet;B12email;B12SAP;B12Data warehouse;B12Other

Variable	N	N*	Mean	Median	TrMean	StDev
B9	112	0	4,571	5,000	4,670	1,198
B10	111	1	5,198	5,000	5,232	1,102
B11	109	3	5,5413	6,0000	5,5859	0,9577
B12Intra	106	6	5,311	6,000	5,406	1,237
B12Extra	60	48	3,900	4,000	3,889	1,801
B12Group	39	64	4,897	6,000	5,000	2,280
B12Workf	28	75	4,000	4,500	4,000	2,293
B12Inter	90	20	4,678	5,000	4,725	1,364
B12email	104	8	6,0577	6,0000	6,1277	0,8683
B12SAP	3	108	6,333	6,000	6,333	0,577
B12Data	39	66	5,231	6,000	5,343	1,459
B12Other	8	92	6,000	6,000	6,000	0,756

Variable	SE Mean	Minimum	Maximum	Q1	Q3
B9	0,113	1,000	6,000	4,000	5,000
B10	0,105	2,000	7,000	5,000	6,000
B11	0,0917	3,0000	7,0000	5,0000	6,0000
B12Intra	0,120	1,000	7,000	5,000	6,000
B12Extra	0,233	1,000	7,000	3,000	5,000
B12Group	0,365	1,000	7,000	3,000	7,000
B12Workf	0,433	1,000	7,000	1,000	6,000
B12Inter	0,144	1,000	7,000	4,000	6,000
B12email	0,0851	3,0000	7,0000	6,0000	7,0000
B12SAP	0,333	6,000	7,000	6,000	7,000
B12Data	0,234	1,000	7,000	5,000	6,000
B12Other	0,267	5,000	7,000	5,250	6,750

6B.7.3A <u>Performance Questionnaire CA:</u>

Descriptive Statistics: CA1; CA2; CA3; CA4; CA5; CA6; CA7; CA8

Variable	N	Mean	Median	TrMean	StDev	SE Mean
CA1	112	5,2946	5,0000	5,3300	0,7785	0,0736
CA2	112	5,3393	5,0000	5,3500	0,8756	0,0827
CA3	112	5,4196	5,5000	5,4300	0,7430	0,0702
CA4	112	5,2946	5,0000	5,3200	0,9265	0,0875
CA5	112	5,1875	5,0000	5,2000	0,9254	0,0874
CA6	112	5,4107	6,0000	5,4600	0,9544	0,0902
CA7	112	5,1786	5,0000	5,2500	0,9125	0,0862
CA8	112	5,2232	5,0000	5,2200	0,9464	0,0894

Variable	Minimum	Maximum	Q1	Q3
CA1	3,0000	7,0000	5,0000	6,0000
CA2	2,0000	7,0000	5,0000	6,0000
CA3	4,0000	7,0000	5,0000	6,0000
CA4	3,0000	7,0000	5,0000	6,0000
CA5	3,0000	7,0000	5,0000	6,0000
CA6	2,0000	7,0000	5,0000	6,0000
CA7	2,0000	7,0000	5,0000	6,0000
CA8	3,0000	7,0000	5,0000	6,0000

Descriptive Statistics: CA91; CA92; CA93; CA94; CA95; Other

Variable	N	N*	Mean	Median	TrMean	StDev
CA91	112	0	5,3304	5,0000	5,3400	0,9528
CA92	110	0	4,9545	5,0000	5,0102	0,8922
CA93	110	0	5,1909	5,0000	5,2143	1,0360
CA94	109	1	5,3119	5,0000	5,3434	0,8574
CA95 OTR	8	92	6,125	6,000	6,125	0,835

Variable	SE Mean	Minimum	Maximum	Q1	Q3
CA91	0,0900	3,0000	7,0000	5,0000	6,0000
CA92	0,0851	3,0000	6,0000	4,0000	6,0000
CA93	0,0988	3,0000	7,0000	5,0000	6,0000
CA94	0,0821	3,0000	7,0000	5,0000	6,0000
CA95 Other	0,295	5,000	7,000	5,250	7,000

6B.7.3B Performance Questionnaire CB:

Descriptive Statistics: CB1; CB2; CB3; CB4; CB5; CB6; CB7; CB8

Variable	N	N*	Mean	Median	TrMean	StDev
CB1	112	0	5,5000	6,0000	5,5100	0,6975
CB2	112	0	5,3393	5,0000	5,3600	0,7297
CB3	112	0	5,3750	5,5000	5,3900	0,7726
CB4	112	0	5,4196	5,0000	5,4500	0,7183
CB5	111	1	5,2703	5,0000	5,2929	0,7971
CB6	112	0	5,2589	5,0000	5,2900	0,8673
CB7	112	0	5,3839	5,0000	5,4200	0,7259
CB8	112	0	5,4107	5,0000	5,4100	0,8756

Variable	SE Mean	Minimum	Maximum	Q1	Q3
CB1	0,0659	4,0000	7,0000	5,0000	6,0000
CB2	0,0690	4,0000	7,0000	5,0000	6,0000
CB3	0,0730	4,0000	7,0000	5,0000	6,0000
CB4	0,0679	3,0000	7,0000	5,0000	6,0000
CB5	0,0757	3,0000	7,0000	5,0000	6,0000
CB6	0,0820	3,0000	7,0000	5,0000	6,0000
CB7	0,0686	3,0000	7,0000	5,0000	6,0000
CB8	0,0827	3,0000	7,0000	5,0000	6,0000

Descriptive Statistics: CB91; CB92; CB93; CB94; CB95 Other

Variable	N	N*	Mean	Median	TrMean	StDev
CB91	112	0	5,4911	6,0000	5,4900	0,8489
CB92	110	0	4,8818	5,0000	4,9286	0,8751
CB93	110	0	5,2818	5,0000	5,2959	0,9874
CB94	110	0	5,5091	6,0000	5,5510	0,7751
CB95 Other	8	92	6,250	6,000	6,250	0,707

Variable	SE Mean	Minimum	Maximum	Q1	Q3
CB91	0,0802	4,0000	7,0000	5,0000	6,0000
CB92	0,0834	3,0000	6,0000	4,0000	6,0000
CB93	0,0941	3,0000	7,0000	5,0000	6,0000
CB94	0,0739	3,0000	7,0000	5,0000	6,0000
CB95 Other	0,250	5,000	7,000	6,000	7,000

Chapter Seven
The Field Research

Chapter 7. THE FIELD RESEARCH

7.1 Selection of the sample

This section describes the design of a field study to test the contribution of both shared knowledge (among Manufacturing, Quality and/or R&D groups) and information technology to the performance of the manufacturing group, as well as the data collection process, or the questionnaire administration. As explained in section 6.1, our principal instruments were three types of questionnaires administered to approximately 700 individuals both inside and outside the three groups whose organizational relationships are under investigation.

In an ideal situation, investigation samples are selected randomly. This is done, among other reasons, for the external validity criteria to be *a priori* fulfilled. The maxim applies to the selection of companies, manufacturing units, their quality and R&D associates, and, to certain extend, even to the selection of individuals who answer the questionnaires.

In the case of our study, the actual field work was organized at the *Departamento de Organización de Empresas* (DOE) of the *Escuela Technica Superior de Engenyería Industrial de Barcelona* (ETSEIB), at the *Universidad Polytécnica de Catalunya* (UPC) and lasted for three months, between December 2003 and February 2004. Main sources for selecting the candidate companies were:

a) A small group of companies (*Amigos de la UPC*) that maintain close relationship with the faculty and the Polytechnic.
b) A second, bigger group of companies that collaborate, or have recently collaborated with UPC's *Centro de Transferencia de la Technología*.
c) España 30.000, an industry guide edited by *Formento de la Producción S.L*. (Barcelona, September 1995).

The research was initially directed to industries in Catalonia, mainly due to the required personal contacts. Finally, companies from all over Spain have participated, due to the fact that a big number of Catalonian companies have affiliates or belong to groups of companies with affiliates in other regions of the country. A few groups (Quality and/or R&D) were based out of Spain, due to the fact that the company was a multinational one.

Pilot testing interviews were contacted among companies from the above mentioned group of the *Amigos de la UPC*. The *España 30.000* guide, despite the fact that it was not very recent, gave us an excellent idea about the size of every sector and indicated the top ten or twenty companies in each of the selected sectors. Most of these top companies have been contacted for participation in our study.

While it would have been ideal from the point of view of generalizability to choose companies, groups and individuals (the key-informants) randomly, it was not possible in practice for the following reasons. First, not all of the

España 30.000 guide companies have Quality and R&D groups. Second, we needed a major commitment from the group managers and the company senior managers (the stakeholders) to complete our questionnaire. We estimated that it would take at least half an hour for each informant to carefully fill in the questionnaire. If we also consider the fact that only the companies whose all informants (i.e. the two or three group managers and their deputies, plus the two stakeholders) have completed the required questionnaires were finally included in the sample, it becomes evident why in our field sample, all companies agreeing to participate were included. For this reason, there is a possible selection bias that can not be completely dismissed. As we could not have control over who should participate in the study, bias due to selection of the individual key-informants has been dismissed to a great extent.

Table 7.1 shows the industrial sectors represented, the number of companies contacted (82) and those who finally participated (51) with the identified (165) and participating (112) manufacturing units for each one of them. Our final sample size, of 112 manufacturing units, is considered sufficient in order to perform path analysis (Pedhazur 1982). It is well worth mentioning here the opinion expressed by Cook and Campbell (1979) on the participation percentages for similar type of studies. The authors believe that the "… refusal rate in getting the cooperation of industrial organizations, school systems, and the like must be nearer 75% than 25%, especially if we include those that were never contacted because it was considered certain they would refuse" (p. 74). So we have good reasons to consider the participation rates achieved in our study (62% at company level and 68% at the unit of analysis level) as satisfactory.

Sector	**Companies**		**Manufacturing Units**	
	Contacted	**Participated**	**Identified**	**Participated**
Alimentation	26	14	47	31
Automotive	8	6	25	15
Chemical & Pharmaceutical	7	5	22	19
Electro-Mechanical	25	18	54	35
Textile	16	8	17	12
Total	82	51 (62%)	165	112 (68%)

Table 7.1 Study Participants by Sector, Company and Unit of Analysis

The sectors have been selected aiming to cover a broad array of industries. Our selection process focused on maintaining internal validity, since the broad range of organization and industry types made it unlikely for unmonitored explanations to cause effects in all of our target organizations. However, the generalizability of the results across all firms (in Spain or even Catalonia alone) is necessarily limited, as selection and volunteer bias, regarding which companies or manufacturing units participated, was unavoidable. It is also true that the services industry is not represented. This was done on purpose as, early in our study we considered it very possible that varied interpretation of a number of concepts might appear.

7.2 Questionnaire Administration

The distribution of an approximate number of 700 questionnaires was not an easy task, especially when one takes into consideration the effort needed to establish the initial contact with every candidate company. For this reason it was essential to secure a liaison person in every organization. In most cases it was the secretary to the company or plant director. In the fewer cases of the *Amigos de la UPC* or the *Centro de Transferencia de la Technologìa* this role was assumed by the company's contact person with UPC.

The process that we have followed for the questionnaire administration was:

a) To establish the contact and nominate the liaison person.
b) Each liaison first informed us about the groups and their exact names. In most cases he or she also provided us with the e-mail address of the responders; the Manufacturing, Quality and/or R&D group managers and their deputies, plus two senior managers.
c) Soon after the 'personalized' questionnaires were distributed, by e-mail, to the appropriate individuals.
d) Serious follow-up (via e-mail or telephone) was necessary and it was done either via the liaison or directly by us, as the percentage of informants who responded in due time was very small. In most cases completed questionnaires were only received after a second or third contact.

While this manner of distribution left open the possibility of a certain selection bias, it was felt that it would: a) make the administration of the approximate 700 questionnaires a more manageable procedure, and b) encourage respondent participation by showing internal company support for the study. In addition, the liaison was able to do direct follow-up, encouraging a higher level of participation.

For simple statistical reasons we want to mention here that out of the 51 companies participating, all used e-mail for the questionnaire, except for: One company that insisted on having personal interviews, so that the responders could clarify on the spot their queries; two companies that forwarded the completed questionnaires by post, and three that faxed them to us.

7.3 Summary

This chapter has discussed issues related to the actual field work of our study. First, we presented the methodology followed for the formation of our sample, the industrial sectors it includes, and the way participating companies were selected. The detailed structure of our sample was given in Table 7.1.

Second, we discussed issues related to the actual administration of the approximately 700 questionnaires among the participating companies.

In the next chapter we shall present the analysis of our results.

Chapter Eight
Analysis of the Results

Chapter 8. ANALYSIS OF THE RESULTS

"In explanatory research, data analysis
is designed to shed light on theory."
Pedhazur (1982, p. 11)

The complexity of accomplishing the pursuit expressed by Pedhazur in the above quote depends, among other factors, on the selection of analytic techniques adequate for the theoretical framework. As already mentioned in section 1.4, the data collected through the questionnaires have been analyzed using MINITAB 14, as a tool for statistical analysis and path analysis, as a method for studying patterns of causation within the set of independent, mediating and dependent variables used in our evaluation model.

Despite the fact that in recent years, social and behavioral scientists have been showing a steadily growing interest in studying patterns of causation among variables, the concept of causation has generated a great deal of controversy among both philosophers and scientists. Nonetheless, causal thinking plays a very important role in scientific research. Even in the works of those scientists who strongly deny the use of the term causation, it is very common to encounter the use of terms that indicate or imply causal thinking. Thus, we can conclude that scientists –in general- seem to have a need to resort to causal frameworks, even though on philosophical grounds they may have reservations about the concept of causation.

In the following sections we shall first briefly present path analysis –with both its approaches and limitations- and we shall then proceed to the test of the thesis hypotheses and a series of confirmatory tests in order to further secure their validity.

8.1 The Path Analysis Approach

Path analysis was developed by Sewall Wright (1934) as a method for studying the direct and indirect effects of variables hypothesized as causes of other variables treated as effects. Pedhazur (1982), building upon Wright, further explains that "…path analysis is not a method for discovering causes, but a method applied to causal models formulated by the researcher on the basis of knowledge and theoretical considerations." (p. 580)

Path diagrams, although not essential for numerical analysis, are useful tools for displaying graphically the pattern of causal relations among the set of variables under consideration. We shall refer to Figure 1 (the proposed in section 1.3 evaluation model, repeated here below in Figure 8.1 as a casual model) in order to further clarify the relationship among the particular variables of our research:

- Variable 1: Mutual Trust (MT)
- Variable 2: Mutual Influence (MI)
- Variable 3: Shared Knowledge (SK)
- Variable 4: Manufacturing Performance (MP)
- Variable 5: Information Technology (IT)

In the causal model a first distinction is made between exogenous and endogenous variables. An exogenous variable is a variable whose variability is assumed to be determined by causes outside the causal model. An endogenous variable, on the other hand, is one whose variation is explained by exogenous or endogenous variables within the system.

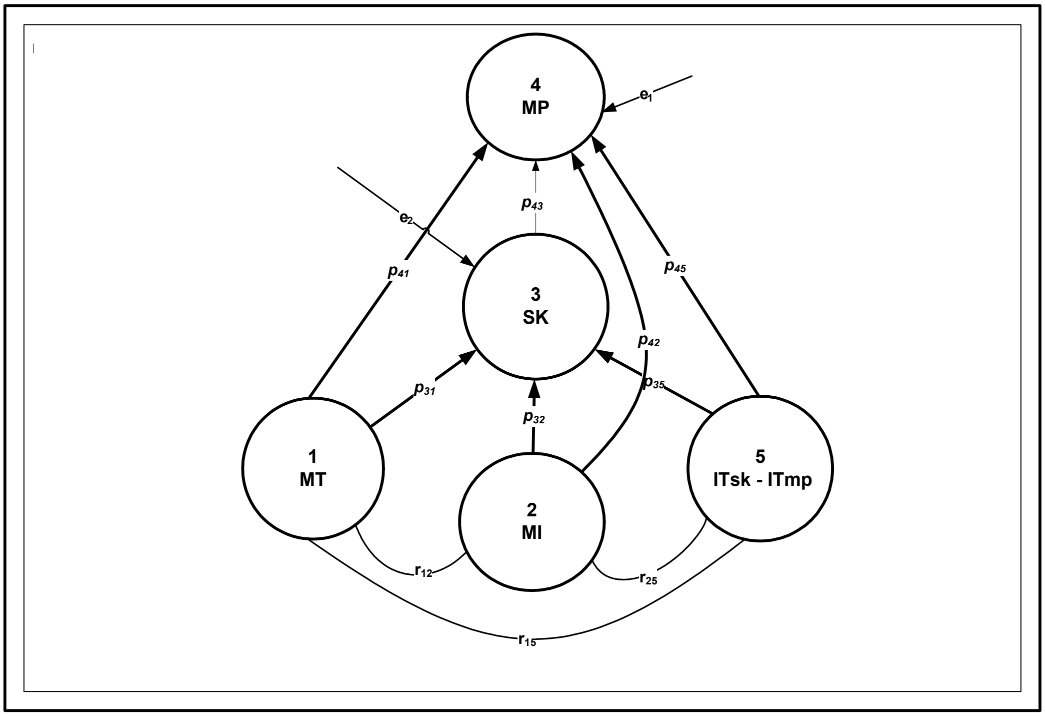


Figure 8.1 The Proposed Causal Model

Variables 1, 2 and 5 in Figure 8.1 (the independent variables MT, MI and IT) are exogenous and their correlations are depicted by curved lines without arrowheads at their ends. This indicates that –in our research- we do not conceive of one variable being the cause of the other. Consequently, the relations between the three independent variables (in this case r_{12}, r_{25} and r_{15}) remain unanalyzed within the system.

Variables 3 and 4 in Figure 8.1 (the dependent and possibly mediating variable SK and the dependent variable MP) are endogenous. Paths, in the form of unidirectional arrows, are drawn from the variables taken as causes (independent) to the variables taken as effects (dependent). The three paths leading from variables 1, 2 and 5 to variable 3 indicate that variable 3 is dependent on variables 1, 2 and 5.

The causal flow in the above model is unidirectional. This means that at a given point in time a variable cannot be both a cause and an effect of another variable. For this reason, our model is called a recursive one.

An endogenous variable treated as dependent in one set of variables may also be considered as an independent variable in relation to other variables. For example, variable 3 is taken as dependent on variables 1, 2 and 5, and –at the same time- as one of the independent variables in relation to variable 4. Thus, we have adopted the term ‘mediating’ variable for SK.

Since it is almost never possible to account for the total variance of a variable, residual variables are introduced to indicate the effect of variables not included in the model. In Figure 8.1, e1 and e2 are residual variables.

The direct impact of a variable hypothesized as a cause on a variable taken as an effect, is indicated by a path coefficient. Wright (1934) defines a path coefficient as: “The fraction of the standard deviation of the dependent variable (with the appropriate sign) for which the designated factor [here, the independent or mediating variable] is directly responsible…” (p. 162)

The symbol for a path coefficient is a *p* with two subscripts, the first indicating the effect (the dependent variable), and the second the cause (the independent variable). So, p_{32} in Figure 8.1 indicates the direct effect of variable 2 on variable 3. Under certain conditions –which are all valid for Figure 1 and are presented in the following paragraph- path coefficients of Figure 8.1 take the form of ordinary least squares solutions for the β’s, the so called normalized path coefficients. We have based this section of our statistical analysis on the systematic calculation of path coefficients as presented in Pedhazur (1982, p. 583-605).

8.2 Limitations

In its generic form the analysis of the data is designed to shed light on the question of whether or not the causal model is consistent with the data. If the model under consideration is inconsistent with the data, doubt is cast about the theory that has generated it. Consistency of the model with the data, however, does not constitute proof of the theory; at best it only provides support to it. Following Popper’s (1959) basic argument that all one can achieve through investigation is the falsification of theory, we would have to conclude that the theory has survived the test, in that it has not been disconfirmed.

In relation to path analysis, the need for caution is even more necessary and it is expressed –in an emphatic way however- in the often repeated warning: “Correlation is no proof of causation”. Under this perspective, nor does any other index prove causation, regardless of whether the index has derived from data collected in experimental or non-experimental investigation. Covariations or correlations among variables may be suggestive of causal linkages.

For the casual model under consideration, the following assumptions, given by Pedhazur (1982, p. 580) are essential:

- The relations among the variables in the model are linear, additive and causal.
- Each residual is not correlated with the variables that precede it in the model. This implies that:
    a) the residuals are not correlated among themselves
    b) all relevant variables are included in the model
    c) each endogenous variable is perceived as linear combination of exogenous and/or endogenous variables in the model plus a residual
    d) exogenous variables are treated as ‘given’ and when are correlated among themselves, these correlations are also treated as ‘given’ and remain unanalyzed.
- There is a one-way causal flow in the system.
- The variables are measured on an interval scale.
- The variables are measured without error.

And Pedhazur concludes that “…given the above assumptions, the method of path analysis reduces to the solution of one or more multiple linear regression analyses.”

It is under these assumptions that we have concluded to the use of Figure 8.1, as the research model for our investigation. With one exception: Not all variables affecting Manufacturing Performance are included in the model. Essential variables like skills and qualification of workers, technological level of the machinery in use, and quality of the raw material –just to mention some very basic ones- have not been taken into consideration simply because they do not relate to the focus of our investigation, which is the contribution of shared knowledge to manufacturing performance. This means that the result of the regression of Manufacturing Performance versus Shared Knowledge could only be considered as a partial causal effect.

It is important though to bear in mind that path analysis is a method, and as such its valid application is subject to the competency of the researcher using it and the soundness of the theory that is being tested. Finally, it is the explanatory scheme of the researcher that determines the type of analysis to be applied to data, and not the other way around.

8.3 Testing the Thesis Hypotheses

Based upon the analysis presented in section 8.1 above, we have chosen path analysis, the regression-based technique that allows testing of causal models using cross-sectional data, as the principal analytical technique in our study. In order to assess the validity of our evaluation model (as has been presented in Figures 1 and 8.1) we have empirically tested it, using path analysis.

8.3.1 Testing Hypotheses 1-7

As our hypotheses have been planted long ago in section 1.3 we consider it appropriate to, once again, repeat them here:

> **Hypothesis 1**: Shared knowledge among Manufacturing, R&D and Quality groups, as perceived by the manufacturing organization, leads to improved manufacturing group performance.
>
> **Hypothesis 2**: The perception of increased levels of mutual trust among Manufacturing, R&D and Quality groups leads to increased levels of shared knowledge among these groups.
>
> **Hypothesis 3**: Increased levels of mutual influence among Manufacturing, R&D and Quality groups lead to increased levels of shared knowledge among these groups.
>
> **Hypothesis 4**: Shared knowledge acts as a mediating variable between mutual trust and influence and manufacturing performance.
>
> **Hypothesis 5**: There is a positive relationship between mutual trust, mutual influence, and manufacturing performance.
>
> **Hypothesis 6**: There is a positive relationship between IT support and the knowledge sharing process.
>
> **Hypothesis 7**: There is a positive relationship between IT support and the manufacturing group performance.

Multiple Regression analysis has been used to test our hypotheses. Two multiple regressions were run for each of the two dependent variables, manufacturing performance and shared knowledge. Testing the hypotheses requires testing the significance of paths I, II, III, Va, Vb, VI and VII as presented in Figure 8.1. The results of this analysis are schematically shown in Figure 8.2 and in the generic regression equations, here below.

a) For manufacturing performance:

$$MPC = \alpha + \beta_1 \, SKC + \beta_2 \, MTC + \beta_3 \, MIC + \beta_4 \, ITmpC + e \qquad (8.1)$$

b) For shared knowledge:

$$SKC = \alpha + \beta_1 \, MTC + \beta_2 \, MIC + \beta_3 \, ITskC + e \qquad (8.2)$$

The third letter C, added to the two-letter acronym used for each one of the variables, indicates that we are referring to its Construct, as defined in section

6.2. As at least two indicators have been used to assess every variable in the research model, the construct is the mean of these indicators. In the acronym of information technology, the indicators mp and sk are used to distinguish: (a) ITskC, the IT construct measured through the relationship questionnaires A and B, in reference to shared knowledge, and (b) ITmpC, the IT construct measured through the performance questionnaire C, in reference to manufacturing performance. As these two types of questionnaires have been filled in by different key-informants we have not used a possible IT Construct (ITC) produced as a mean of ITskC and ITmpC.

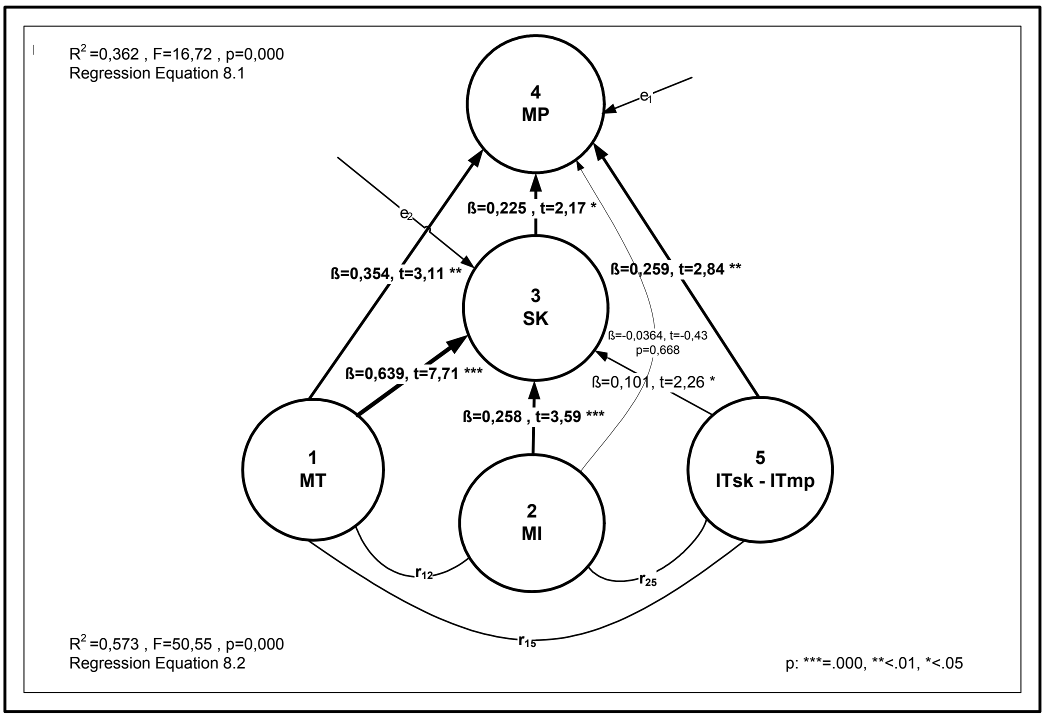


Figure 8.2 Regressions in the Evaluation Model

Regressions in the research model have been conducted in hierarchical order. First, we examined the relationship between manufacturing performance and each one of the variables affecting it; i.e. shared knowledge, mutual trust and influence, and information technology as described in the regression equation 8.1. Here are the results:

$$MPC = 6,98 + 0,354\ MTC – 0,0364\ MIC + 0,225\ SKC + 0,259\ ITmpC + e_1$$

In this first regression mutual trust, information technologies and shared knowledge are found to affect manufacturing performance significantly. Mutual influence appeared not to significantly affect manufacturing performance (β=-0,0364, t=-0,43, p=0,668). The overall regression model for investigating the relationship between manufacturing performance and shared knowledge, mutual trust and information technology, is significant (F=16,40, p=0,000). R^2=0,362 suggests that only 36,2 percent of the variance is explained by these four variables. This is something we expected, as we have already noted (in section 1.3, upon founding hypothesis 7, and earlier in section 8.2) that there are significant factors affecting manufacturing performance which are not included in our model. The aim of our study was to investigate the contribution of shared knowledge and information technology into manufacturing performance.

Finally, we examined the relationship among shared knowledge, mutual trust and influence, and information technology, as described by the regression equation 8.2, and here are the results:

$$SKC = 1,08 + 0,639\ MTC + 0,258\ MIC + 0,101\ ITskC + e_2$$

In this second regression, mutual trust and mutual influence are found to affect shared knowledge noticeably. The resulted β=0,101 (t=2,26, p<0,05) for information technology (ITskC) indicates that IT does not affect shared knowledge in the same significant way that it affects manufacturing performance (β=0,259, t=2,84, p<0,01, from the regression equation 8.1).

This result is explained by the fact that information technologies mainly affect transfer and sharing of explicit knowledge, while in the environment of our study (shared knowledge among manufacturing, quality and R&D groups), tacit knowledge plays a dominant role. The result is also in accordance with findings of other studies. Lee and Choi (2003) have found that IT support is significantly related only with knowledge combination (explicit to explicit knowledge transactions) while they have noticed no significant relation with none of the other three knowledge creation processes (socialization, externalization and internalization).

The overall regression model for investigating the relationship among shared knowledge, mutual trust and influence, and information technology is significant (F=50,55 , p=0,000). R^2=0,573 suggests that 57,3 percent of the variance is explained by these three variables. The detailed statistical results, for both these regressions, are presented in Appendix 8A, at the end of this chapter.

To summarize with our regression results:

- As demonstrated in Figure 8.2 all the *betas* resulted from the regressions performed are large and statistically significant, except for two; thus they are fully supporting four of the seven hypotheses under test by the proposed model. The other three hypotheses are partially supported.
- Each of the hypotheses 1, 2, 3 and 7 are directly supported by the significance of paths I, II, III and VII respectively. This means that:
    - Shared knowledge among Manufacturing, R&D and Quality groups, as perceived by the manufacturing organization, leads to improved manufacturing group performance.
    - The perception of increased levels of mutual trust among Manufacturing, R&D and Quality groups leads to increased levels of shared knowledge among these groups.

- Increased levels of mutual influence among Manufacturing, R&D and Quality groups lead to increased levels of shared knowledge among these groups.
- There is a positive relationship between IT support and the manufacturing group performance.

➢ The statistically insignificant *beta* (β=-0,0364) refers to:
- path Vb, and indicates that mutual influence does not directly affect manufacturing performance, thus hypothesis 5 is partially supported, and

➢ The low *beta* (*β*=0,101) refers to:
- path VI, and indicates that information technology, does not affect shared knowledge in the same significant way that it affects manufacturing performance. Thus hypothesis 6 is supported with varied strength in its two parts.

➢ In addition, the significance of path Va indicates that hypothesis 4 is only partially supported, as:
- shared knowledge acts as a mediating variable only for mutual influence, since mutual trust appears to also significantly affect manufacturing performance in a direct way.

There is one important note to be made at this point. In our investigation, the constructs of shared knowledge, mutual trust, mutual influence, and information technology (ITsk) were all measured on a single instrument; the symmetrical relationship questionnaires A and B. On the other hand, the constructs of manufacturing performance and information technology (ITmp) were measured on a separate instrument, the performance questionnaire C. This fact may have contributed to the lower t value (t = 2,17) between shared knowledge and performance, as noted in Figure 8.2.

This is acceptable and understood as the two separate instruments were filled out by different key-informants at different levels within the organization. It is anticipated that Manufacturing, Quality and/or R&D group managers on one hand, and senior managers on the other, might have different background conditions, when asked to judge the same concept. Pedhazur (1982, p. 34) attributes these differences to the personal characteristics of key-informers, like cognitive styles, self-concept, ego strength and attitudes.

We shall come back into further analyzing the results of our study, in chapter 9, under the perspective of implications to researchers and managers, as they arise from the above results.

8.3.2 Use of IT Infrastructure

Last question in the relationship questionnaires A and B is questioning the use of certain IT infrastructure as tools and enablers for sharing knowledge, among Manufacturing, Quality and/or R&D groups. We repeat the question:

Specifically, the use of the following IT infrastructure is:
Intranet ☐ Extranet ☐ Groupware ☐ , Workflow ☐

Internet ☐ , e-mail ☐ , ………….. ☐ , …..………..☐
Data warehouse ☐ ,
Other ………… ☐ , ………………….. ☐ …. ……. ☐

For simplicity purposes we have grouped ratings of the 7-points Likert scale into three categories, and it is in this way that we have presented the results, in a pie-chart form, in Appendix 8B:

- Extremely Strong, Strong or Moderately Strong: Strong
- About Average: Average
- Extremely Weak, Weak or Moderately Weak: Weak

We are assuming that infrastructures not rated at all in the questionnaires, are not used by the company for purposes of sharing knowledge, although we understand that there might be some few cases where this was unintentionally disregarded.

We are listing here bellow the most striking findings regarding the use of IT infrastructure by the managers, or their deputies, of the three collaborating groups (Manufacturing, Quality and R&D):

- E-mail has been reported as used by 86,6 percent of the participating companies.
- 71 percent of the participating companies use Intranets.
- Internet has been reported as used by 42,85 percent of the participating companies.
- 30 percent of the participating companies use Data Warehouse software.
- Extranets have been reported as used by 23,65 percent of the participating companies.
- 20,95 percent of the participating companies use Groupware software.
- Workflow software has been reported as used by 11,6 percent of the participating companies.
- Finally, SAP has been reported, under Other, as used by only 2,25 percent of the participating companies.

Percentages refer to the average of 'strong' answers (Likert ratings 5, 6 or 7) between informers of questionnaires A and B. We shall come back to this issue in chapter 9, where we shall comment on these findings from the perspective of the managerial implications that they have for the company.

8.3.3 Use of IT Functions

Last question in the manufacturing performance questionnaire C is questioning the use of certain IT functions by the company as a whole. We repeat the question:

Specifically, the use of the following IT function is:
- Coordinating business tasks: ☐
  (collecting, facilitating, sharing, etc. information)
- Supporting making decisions: ☐
  (reaching the right information at the right time)

- Facilitating team members to work together: ☐
  (no matter where they are)
- Facilitating access of information in Data Bases: ☐
  (no mater where they are)
- Other ……………………………………….: ☐
- Other ……………………………………….: ☐

For simplicity purposes we have grouped ratings of the 7-points Likert scale into three categories, and we have presented the results, in a pie-chart form, in Appendix 8B:

- Extremely Strong, Very Strong or Strong: Strong
- About Average: Average
- Non-Existent, Very Weak or Weak: Weak

We are listing here bellow the most striking findings:

- Facilitating access of information in Data Bases has been reported as an IT function used by 84,4 percent of the participating companies.
- 82,6 percent of the participating companies use IT to coordinate business tasks.
- Facilitating team members to work together has been reported as an IT function used by 76,4 percent of the participating companies.
- 69,2 percent of the participating companies use IT to support decisions making.

Percentages refer to the average of 'strong' answers (Likert ratings 5, 6 or 7) between informers of questionnaire C. We shall come back to this issue in chapter 9, where we shall comment on these findings from the perspective of the managerial implications that they have for the company.

8.4 Confirmatory Tests

Four confirmatory tests of the research model, as presented in Figure 8.1, were performed. First the Cronbach's *alphas* were calculated for each of the constructs measured. Second, the MTMM (Multi-Trait Multi-Method) correlation matrix for all construct indicators was checked for convergent and discriminant validity. Third, linearity and collinearity has been tested by examining the scatter plots of the individual variables and the plots of residuals against the explanatory variables as well. Finally, analysis of variance was applied on each variable in order to test the homogeneity of variance among the key-informants. In the following paragraphs, a brief description of the above testing methods and the obtained results are given.

Cronbach's *alphas*

Cronbach's *alphas* are utilized to examine the reliability of the instruments used. Nunnally (1978) suggests the adoption of a higher cutoff value of 0,7 (instead of the generally accepted 0,6) in cases where these instruments have been adopted previously, as in our case. As appears in Appendix 8C -and rounded in four digit decimals here below- all the Cronbach's *alphas* calculated for each of the eight constructs measured, are above the acceptable range for empirical studies of this type, as they range from 0,7819 to 0,9994:

Shared Knowledge (SKC) = 0,9981
Mutual Trust (MTC) = 0,9989
Mutual Influence (MTC) = 0,9979
Information Technology (ITskC) = 0,7819
Information Technology (ITmpC) = 0,9991
Manufacturing Performance (MPC) = 0,9987
Operational Manufacturing Performance (OMPC) = 0,9994
Service Manufacturing Performance (SMPC) = 0,8138

We therefore conclude that the measures are reliable.

MTMM Correlation Matrix

In order to assess convergent and discriminant validity, the MTMM (Multi-Trait Multi-Method) correlation matrix for all twelve indicators –as shown in Appendix 8C- has been used. The matrix shows all correlations within constructs (i.e. MT1 to MT2, MI1 to MI2 and MI3, etc, that appear in bold type) to be higher than any correlations across constructs. According to Campbell and Fiske (1959) this fact is implying convergent and discriminant validity of the constructs under consideration.

Linearity and Collinearity

Linearity and collinearity tests are essential for the assumptions of regression analysis to be met. Because the scatter plots of individual variables, as presented in Appendix 8A, do not indicate any nonlinear relationships, the linearity is guaranteed. In Appendix 8C we present the plots of residuals against the explanatory variables. As they show no model inadequacies, we assume that no variable violates the constant variance.

According to Hogg and Ledolter (1992, p. 386) "Multicollinearity … occurs when explanatory variables convey very similar information, and when there is a 'near' linear dependence among the variables …" Collinearity among the variables involved in the two regression equations 8.1 and 8.2 has been tested by the Variance Inflation Factor (VIF). VIFs "… measure how much the variances of the estimated regression coefficients are inflated as compared to when the predictor variables are not linearly related" (Neter et al 1996, p. 386). When VIF=1,0 there is no linear relation among variables. VIF>1,0 indicates an inflated variance of *betas*, as a result of the intercorrelations among the variables. Neter et al (1996) consider the largest VIF-value among all variables as an indicator of the severity of multicollinearity, while VIF>5-10 indicate that the regression coefficients have been poorly estimated. In our study, VIFs (as appear in the regression results, in Appendix 8A) are:

- VIF = 1,1 – 2,3 (Regression Eq. 8.1)
- VIF = 1,1 – 1,3 (Regression Eq. 8.2)

Thus, we can assume that there is no severe multicollinearity problem.

Analysis of Variance (ANOVA)

The analysis of variance is a frequently used method of analysis on data from designed experiments. In the past, ANOVA and Multiple Regression (MR) have been treated as two distinct analytic approaches, but lately ANOVA has been treated as a special case of MR (Pedhazur, 1982; Draper and Smith, 1980). We are citing here below the opinion and some comments of the above authors that have guided us in utilizing ANOVA as one of the confirmatory tests used in our study.

Draper and Smith (1980) note that "… any 'fixed effect' analysis of variance situation can be handled by a general regression routine, if the model is correctly identified and if precautions are taken to achieve independent normal equations" (p. 423) and they add that "… ANOVA models generally … are overparameterized, that is, they contain more parameters than are needed to represent the effects desired" (p. 424).

Pedhazur (1982) notes that "MR is applicable to designs in which the variables are continuous, categorical, or combinations of both …" and that "conventionally, designs with categorical independent variables have been analyzed by ANOVA" (pp. 6-7). According to Pedhazur, "The most important reason for preferring MR to ANOVA is that it is a more comprehensive and general approach on the conceptual as well as the analytic level" (p. 328).

The results of the ANOVA confirmatory tests are given in the statistics of the two Regression Equations, in Appendix 8A, at the end of this chapter. In the Analysis of Variance, or ANOVA, Table the sum-of-squares decomposition is displayed. The first column identifies the sources of variation, the second and third columns the corresponding degrees of freedom and the sums of squares; the fourth column gives the mean squares, and the last two columns contain the F- and P-ratios.

The following conclusions derive from the two ANOVA Tables:

a) The corresponding r's (or R-S_q) are re-calculated:

$$r = \frac{SSR}{SSTO} = \frac{926{,}38}{2.408{,}69} = 0{,}3846 \qquad \text{(Regression Eq. 8.1)}$$

$$r = \frac{SSR}{SSTO} = \frac{1.739{,}43}{2.978{,}17} = 0{,}58406 \qquad \text{(Regression Eq. 8.2)}$$

and found in accordance with the r's calculated by MR.

b) The overall regression models are significant because both F-ratios are larger than the corresponding critical F-values:

F=16,72 >> F(0.01; 4, 107) = 3,50 (Regression Eq. 8.1)

F=50,55 >> F(0,01; 3, 108) = 3,96 (Regression Eq. 8.2)
So we have confirmed, via an alternative method, the results obtained through Multiple Regression.

8.5 Summary

In this chapter the analysis of the results has been presented. First, we have briefly presented path analysis, a regression-based technique that permits the testing of causal models using cross-sectional data and normalized path coefficients (*betas*) in order to determine the strength and direction of causal paths or relations. The strong points and the limitations of the method have been highlighted.

Second, the proposed research model has been tested empirically using path and multiple regression analyses. The investigation hypotheses have been tested and fully or partially supported, by the significance -or insignificance- of the relevant paths. Results have been summarized from a statistical point of view.

Third, the use of IT infrastructure, for purposes of sharing knowledge, and the use of certain IT functions have both been analyzed, again from a statistical point of view.

Finally, four confirmatory tests, Cronbach's *alphas*, the Multi-Trait Multi-Method correlation matrix, Linearity and Collinearity tests, and the Analysis of Variance (ANOVA) have been carried out in order to further secure the validity of the hypotheses.

In the next chapter, the final conclusions and recommendations of our study will be presented.

APPENDIX 8A

Statistical Analysis Results

Regressions on the Evaluation Model

8A.1 First Regression: MPC vs (MTC, MIC, SKC, ITmpC)

General Note: Symbols used in our study and in the MINITAB extracts, included in the Appendixes, correlate as following:
β = Coef, t = T, p = P, r = R-Sq, R^2 = R-Sq(adj), and **F = F**.
ANOVA Table symbols:
DF=Degrees of Freedom, SS=Sums of Squares, MS=Mean Squares (SSR = SS Residual, SSTO = SS Total)

The regression equation is

```
MPC=media(OMPC,SMPC) = 6,98 + 0,354 MTC=media(MT1,MT2)
                       - 0,0364 MIC=media(MI1,MI2,MI3)
                       + 0,225 SKC=media(SK1,SK2,SK3)
                       + 0,259 ITmpC=media(ITmp1,ITmp2)
```

Predictor	Coef	SE Coef	T	P	VIF
Constant	6,981	1,873	3,73	0,000	
MTC=media(MT1,MT2)	0,3535	0,1136	3,11	0,002	2,1
MIC=media(MI1,MI2,MI3)	**-0,03643**	**0,08470**	**-0,43**	**0,668**	**1,5**
SKC=media(SK1,SK2,SK3)	0,2248	0,1034	2,17	0,032	2,3
ITmpC=media(ITmp1,ITmp2)	0,25948	0,09151	2,84	0,005	1,1

S = 3,72201   R-Sq = 38,5%   R-Sq(adj) = 36,2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	4	926,38	231,60	16,72	0,000
Residual Error	107	1482,31	13,85		
Total	111	2408,69			

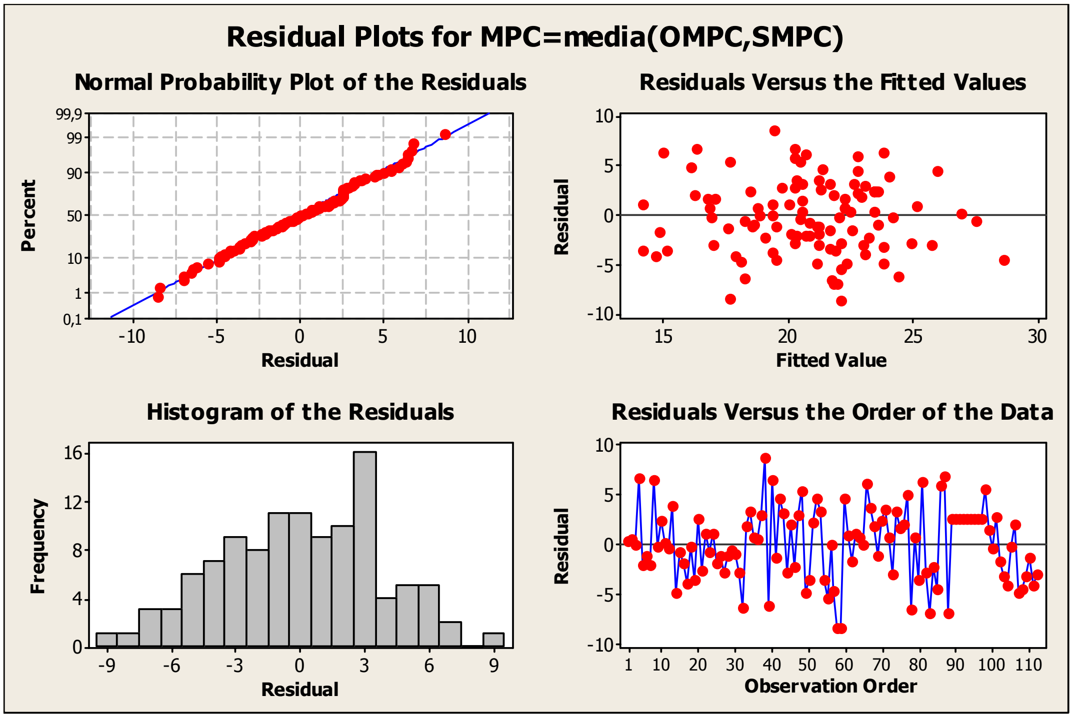
Source	DF	Seq SS
MTC=media(MT1,MT2)	1	730,61
MIC=media(MI1,MI2,MI3)	1	12,91
SKC=media(SK1,SK2,SK3)	1	71,49
ITmpC=media(ITmp1,ITmp2)	1	111,38

Unusual Observations

Obs	MTC=media(MT1,MT2)	MPC=media(OMPC,SMPC)	Fit	SE Fit	Residual
38	15,3	28,083	19,417	0,619	8,666
58	8,0	9,250	17,651	1,010	-8,401
59	18,0	13,583	22,143	0,849	-8,559
107	20,8	18,917	23,830	1,523	-4,913

Obs	St Resid
38	2,36R
58	-2,35R
59	-2,36R
107	-1,45 X

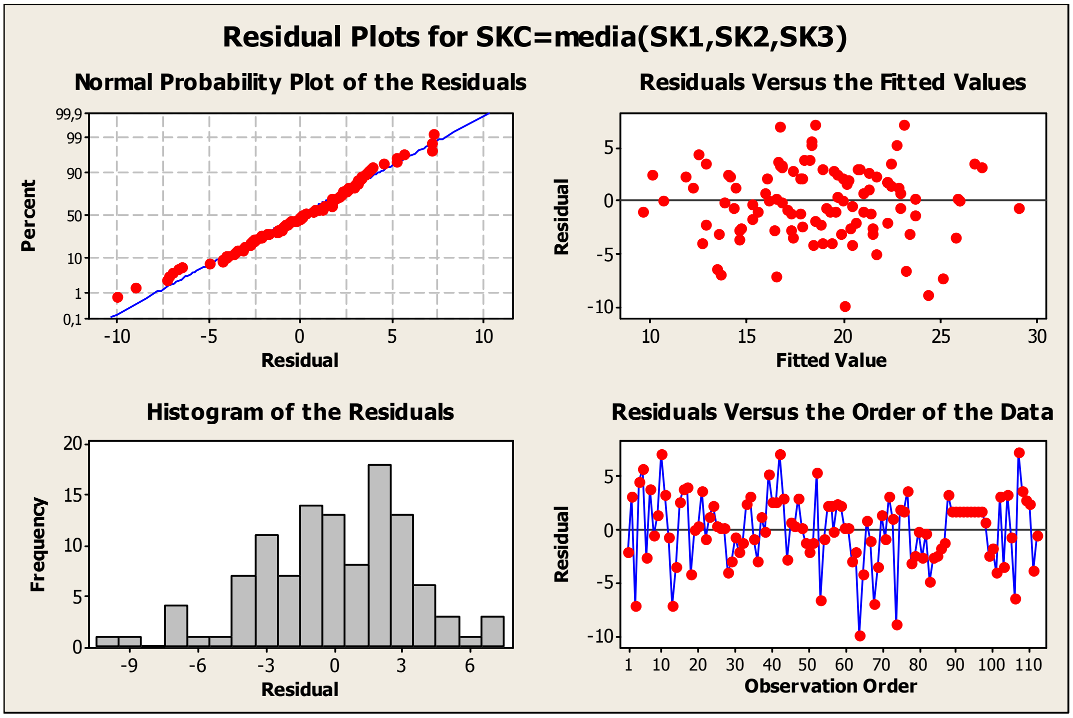
R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.


Residual Plots for MPC=media(OMPC,SMPC)
Normal Probability Plot of the Residuals
Percent
99,9
99
90
50
10
1
0,1
-10
-5
0
5
10
Residual
Residuals Versus the Fitted Values
Residual
10
5
0
-5
-10
15
20
25
30
Fitted Value
Histogram of the Residuals
Frequency
16
12
8
4
0
-9
-6
-3
0
3
6
9
Residual
Residuals Versus the Order of the Data
Residual
1
10
20
30
40
50
60
70
80
90
100
110
Observation Order

8A.2 <u>Second Regression</u>: SKC vs (MTC, MIC, ITskC)

<u>General Note</u>: Symbols used in our study and in the MINITAB extracts, included in the Appendixes, correlate as following:
β = Coef, t = T, p = P, r = R-Sq, R^2 = R-Sq(adj), and **F = F**.
ANOVA Table symbols:
DF=Degrees of Freedom, SS=Sums of Squares, MS=Mean Squares (SSR = SS Residual, SSTO = SS Total)

```
The regression equation is
SKC=media(SK1,SK2,SK3) = 1,08 + 0,639 MTC=media(MT1,MT2)
                         + 0,258 MIC=media(MI1,MI2,MI3)
                         + 0,101 ITskC=media(ITsk1,ITsk2)

Predictor                   Coef  SE Coef     T      P  VIF
Constant                   1,078    1,594  0,68  0,500
MTC=media(MT1,MT2)       0,63865  0,08285  7,71  0,000  1,3
MIC=media(MI1,MI2,MI3)   0,25800  0,07177  3,59  0,000  1,3
ITskC=media(ITsk1,ITsk2) 0,10137  0,04486  2,26  0,026  1,1

S = 3,38672   R-Sq = 58,4%   R-Sq(adj) = 57,3%


Analysis of Variance

Source           DF       SS      MS      F      P
Regression        3  1739,43  579,81  50,55  0,000
Residual Error  108  1238,74   11,47
Total           111  2978,17

Source                    DF   Seq SS
MTC=media(MT1,MT2)         1  1496,66
MIC=media(MI1,MI2,MI3)     1   184,22
ITskC=media(ITsk1,ITsk2)   1    58,56

Unusual Observations

Obs  MTC=media(MT1,MT2)  SKC=media(SK1,SK2,SK3)     Fit  SE Fit  Residual
  3                17,5                   9,333  16,556   0,763    -7,222
 10                21,5                  30,333  23,139   1,005     7,195
 13                23,8                  17,833  25,144   0,603    -7,311
 42                15,0                  23,833  16,661   0,578     7,172
 48                15,5                  16,167  16,116   1,227     0,051
 58                 8,0                  14,167  11,786   1,121     2,380
 64                17,3                  10,000  20,044   0,461   -10,044
 68                10,5                   6,667  13,650   0,561    -6,984
 74                21,5                  15,333  24,367   0,585    -9,034
107                20,8                  25,833  18,535   1,201     7,299

Obs  St Resid
  3    -2,19R
 10     2,22R
 13    -2,19R
 42     2,15R
 48     0,02 X
 58     0,74 X
 64    -2,99R
 68    -2,09R
 74    -2,71R
107     2,30RX

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large influence.
```


Residual Plots for SKC=media(SK1,SK2,SK3)
Normal Probability Plot of the Residuals
Percent
Residual
Residuals Versus the Fitted Values
Residual
Fitted Value
Histogram of the Residuals
Frequency
Residual
Residuals Versus the Order of the Data
Residual
Observation Order

APPENDIX 8B

Statistical Analysis Results

IT Infrastructure and Functions

8B. 1 Information Technology Infrastructure

(Question Nr. 12, Relationship Questionnaires A and B)

A/B12. Specifically, the **use** of the following **IT infrastructure** is:

Intranet [ ] Extranet [ ] Groupware [ ] , Workflow [ ]

Internet [ ] , e-mail [ ] , …………… [ ] , ….………… [ ]

Data warehouse [ ] ,

Other ………… [ ] , …………………..….. [ ] …. ……. [ ]

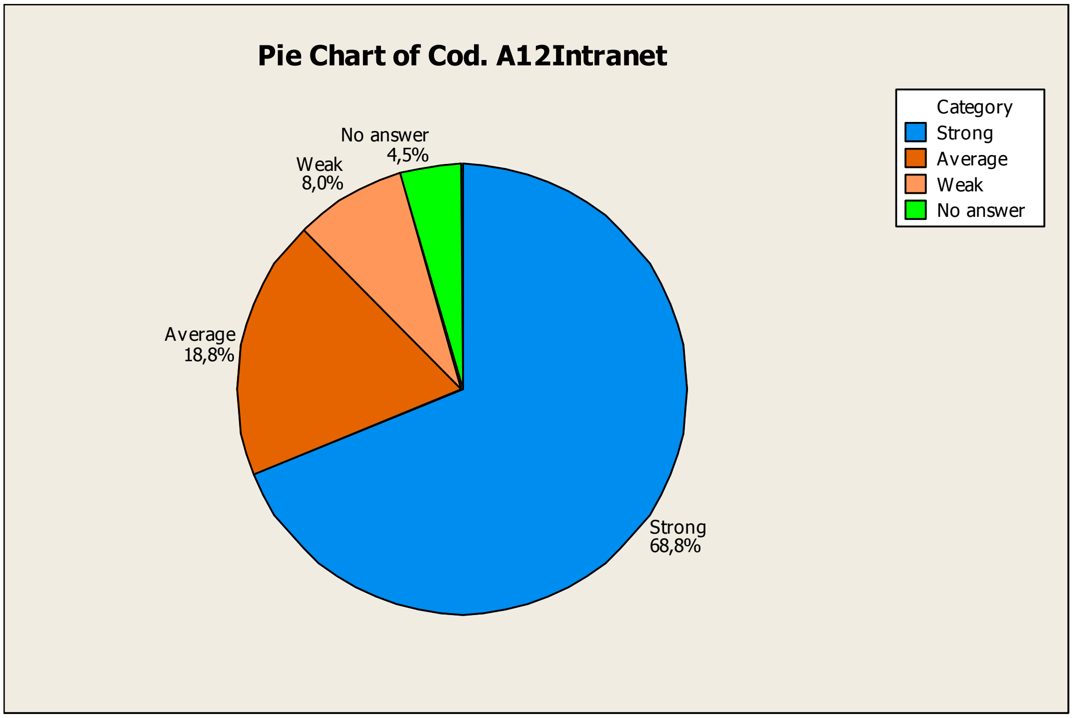
General note:

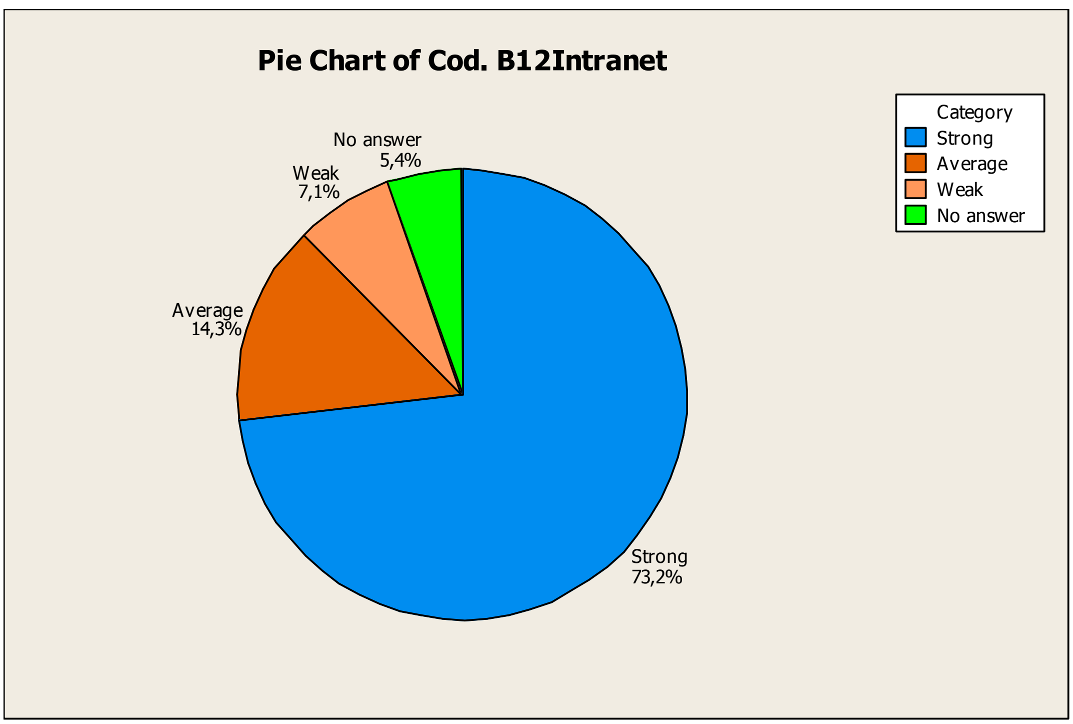
For simplicity purposes we have grouped ratings of the 7-points Likert scale into three categories, and it is in this way that results are presented in the following pie-charts:

- Extremely Strong, Strong or Moderately Strong: **Strong**
- About Average: **Average**
- Extremely Weak, Weak or Moderately Weak: **Weak**

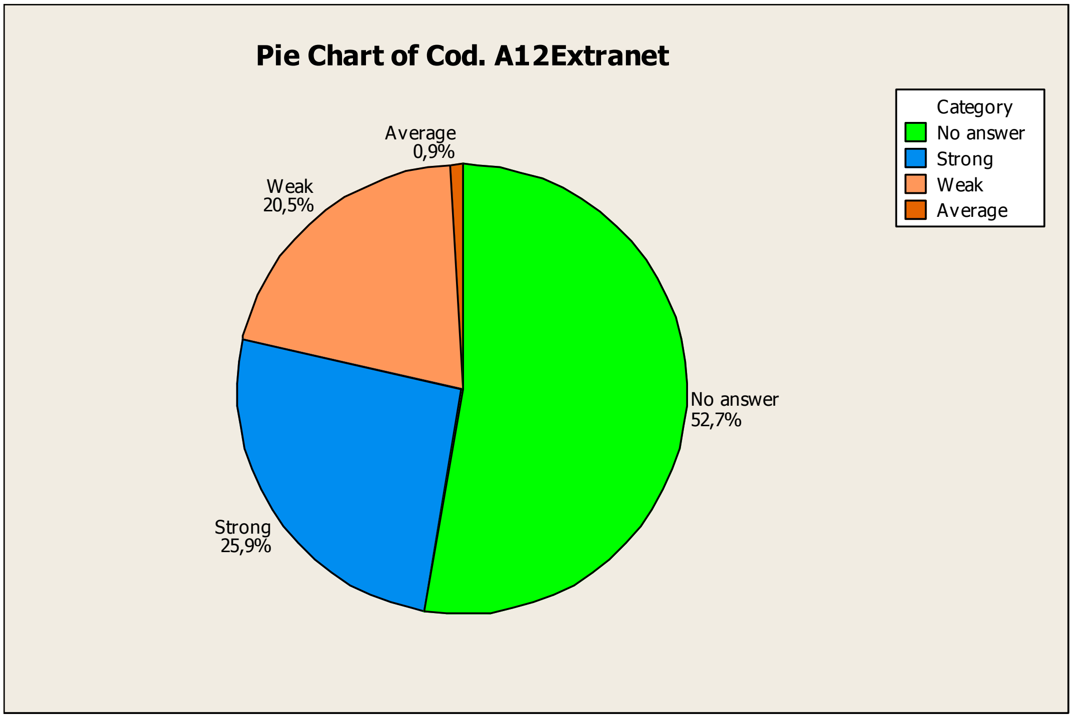
In every page, we present the results regarding a certain IT Infrastructure, as obtained from Questionnaires A and B.

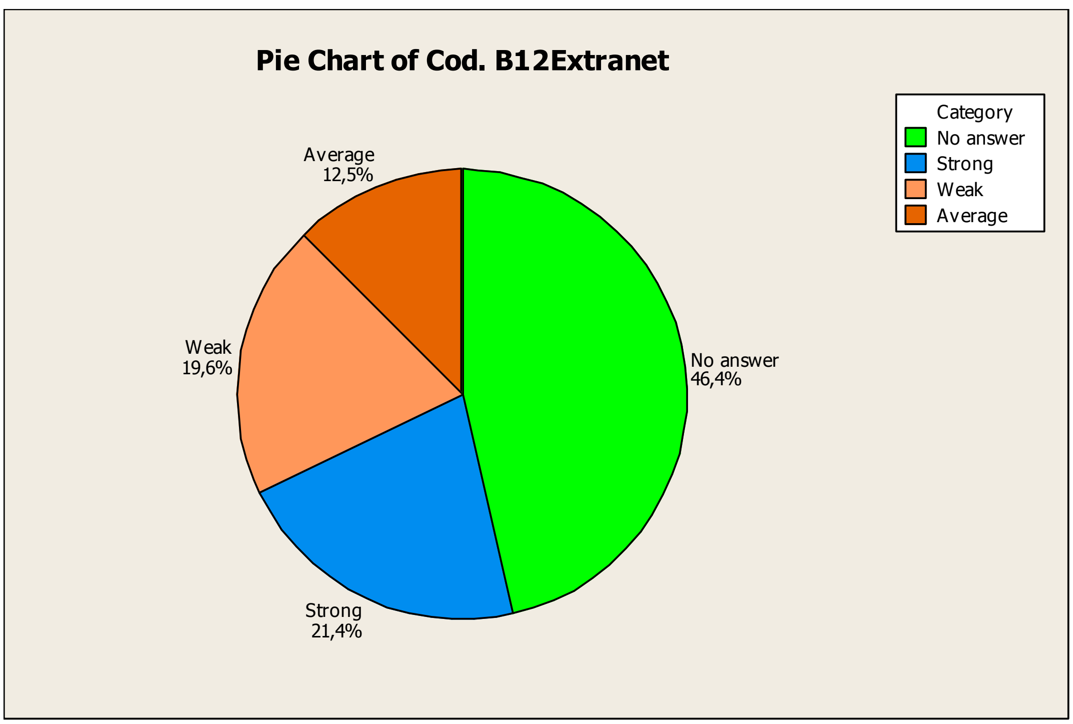
Intranet:


Pie Chart of Cod. A12Intranet
Category
Strong
Average
Weak
No answer
No answer 4,5%
Weak 8,0%
Average 18,8%
Strong 68,8%

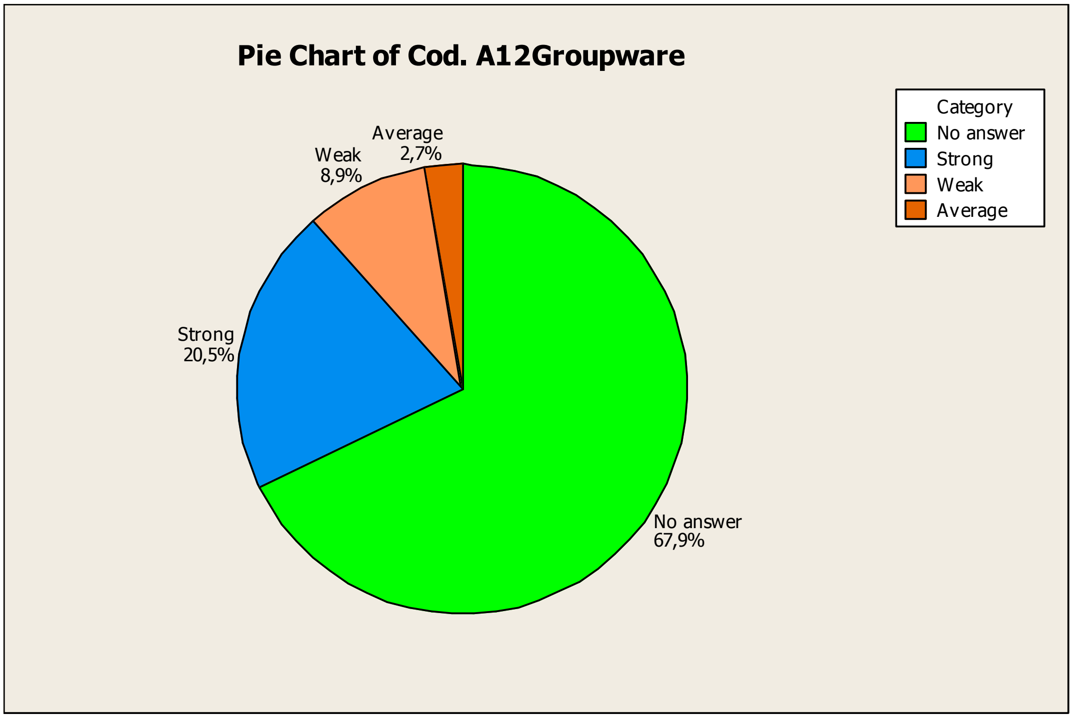

Pie Chart of Cod. B12Intranet
Category
Strong
Average
Weak
No answer
No answer 5,4%
Weak 7,1%
Average 14,3%
Strong 73,2%

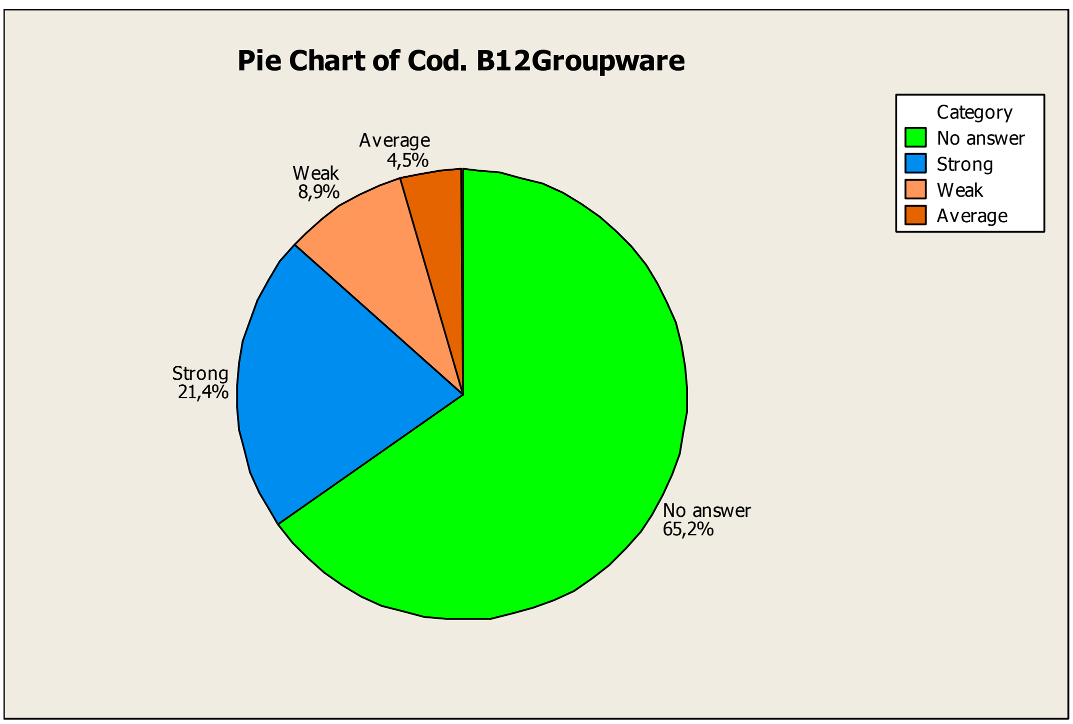
Extranet:


Pie Chart of Cod. A12Extranet
Category
No answer
Strong
Weak
Average
Average 0,9%
Weak 20,5%
No answer 52,7%
Strong 25,9%

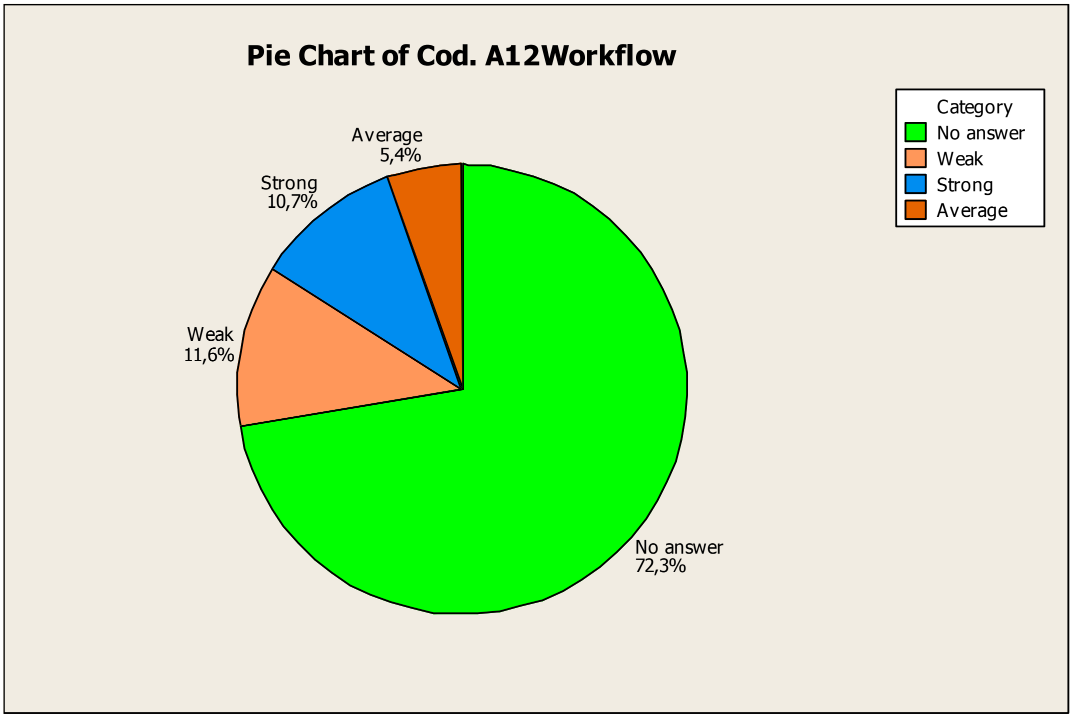

Pie Chart of Cod. B12Extranet
Category
No answer
Strong
Weak
Average
Average 12,5%
Weak 19,6%
No answer 46,4%
Strong 21,4%

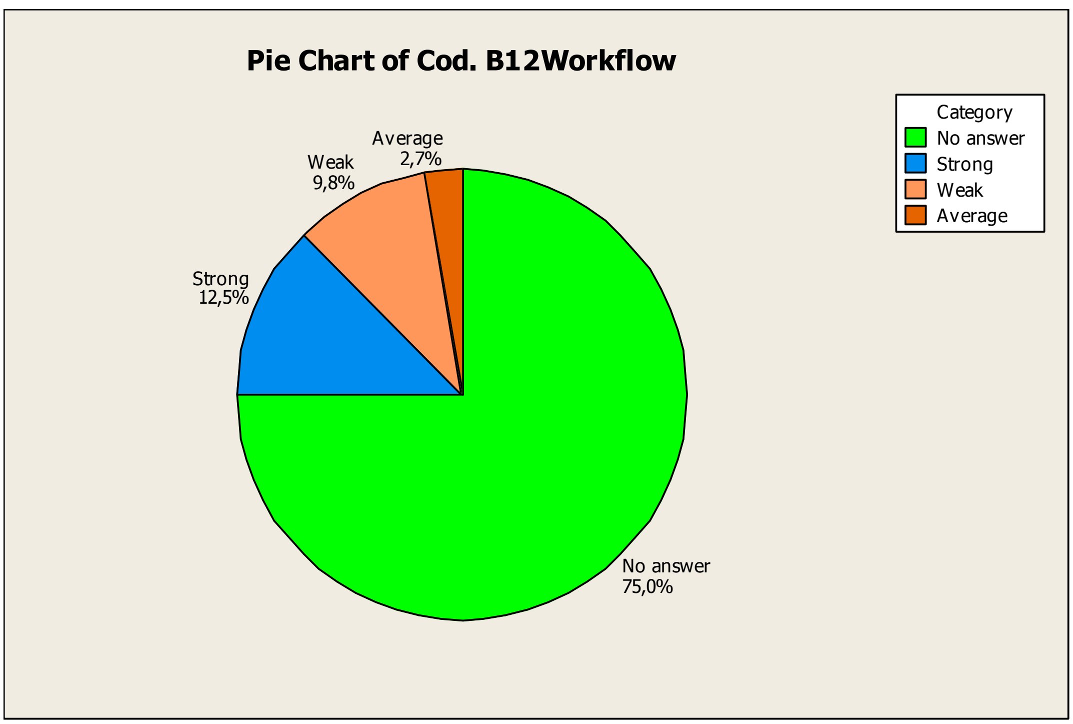
Groupware:


Pie Chart of Cod. A12Groupware
Category
No answer
Strong
Weak
Average
Average
2,7%
Weak
8,9%
Strong
20,5%
No answer
67,9%

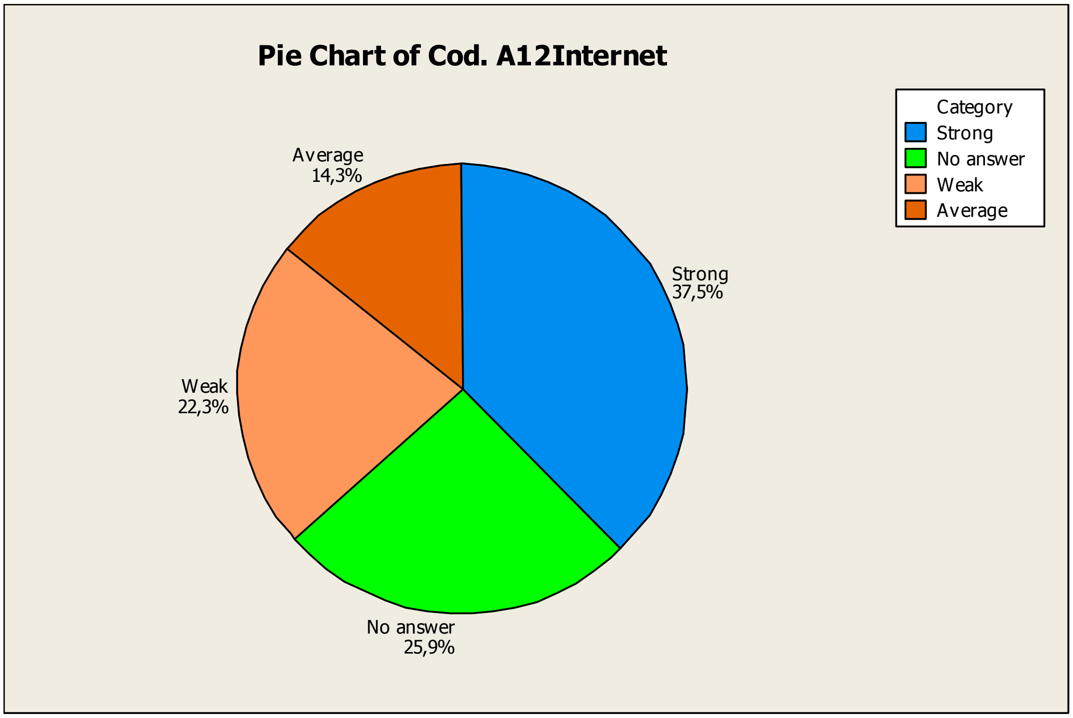

Pie Chart of Cod. B12Groupware
Category
No answer
Strong
Weak
Average
Average
4,5%
Weak
8,9%
Strong
21,4%
No answer
65,2%

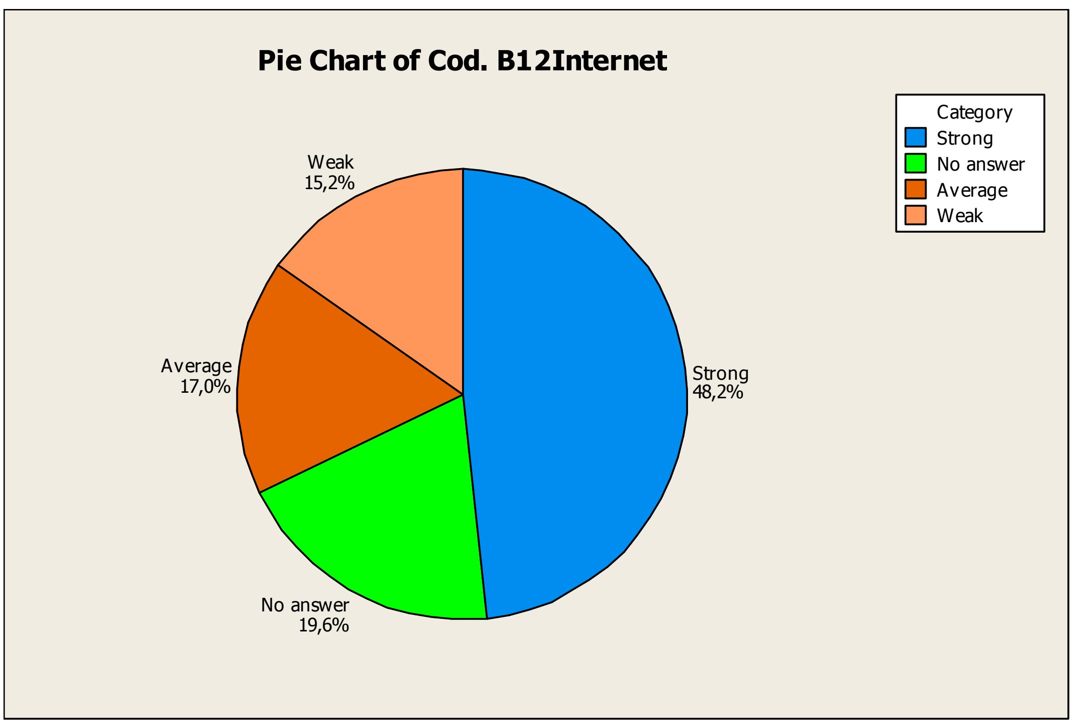
Workflow:


Pie Chart of Cod. A12Workflow
Category
No answer
Weak
Strong
Average
Average 5,4%
Strong 10,7%
Weak 11,6%
No answer 72,3%

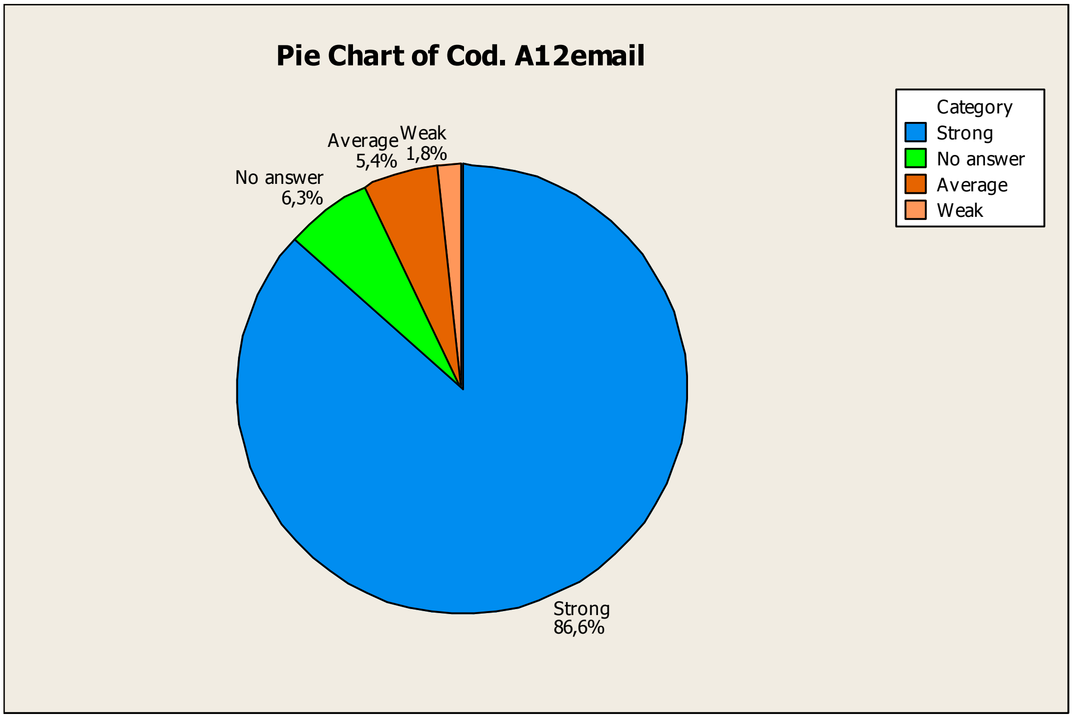

Pie Chart of Cod. B12Workflow
Category
No answer
Strong
Weak
Average
Average 2,7%
Weak 9,8%
Strong 12,5%
No answer 75,0%

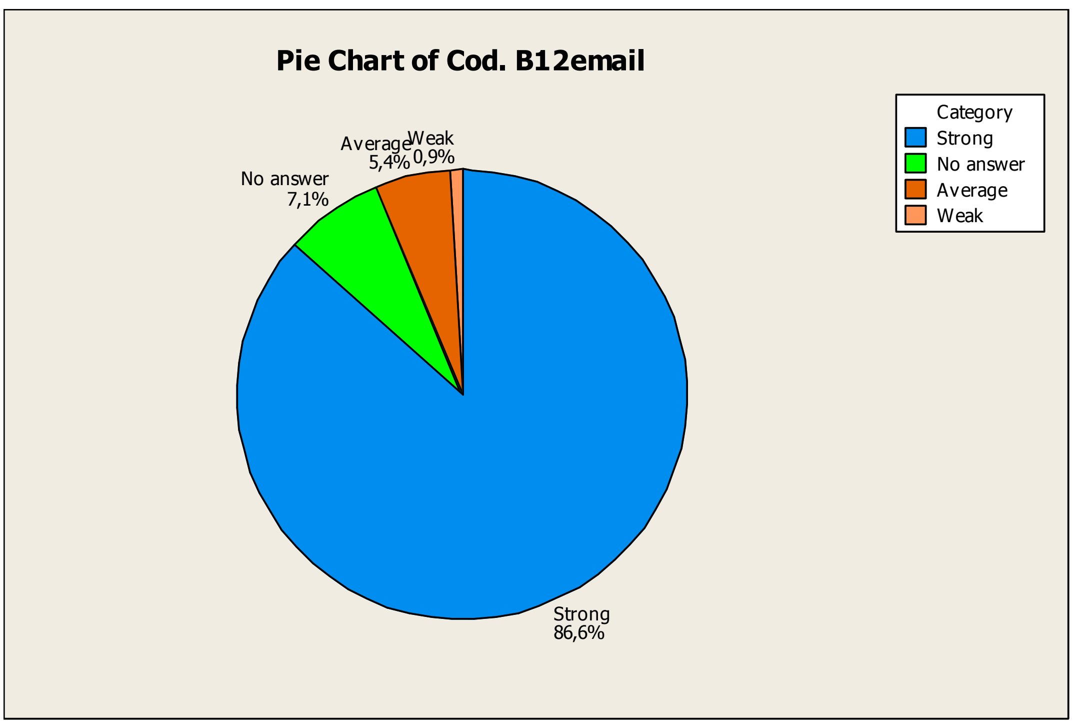
Internet:


Pie Chart of Cod. A12Internet
Category
Strong
No answer
Weak
Average
Average
14,3%
Strong
37,5%
Weak
22,3%
No answer
25,9%

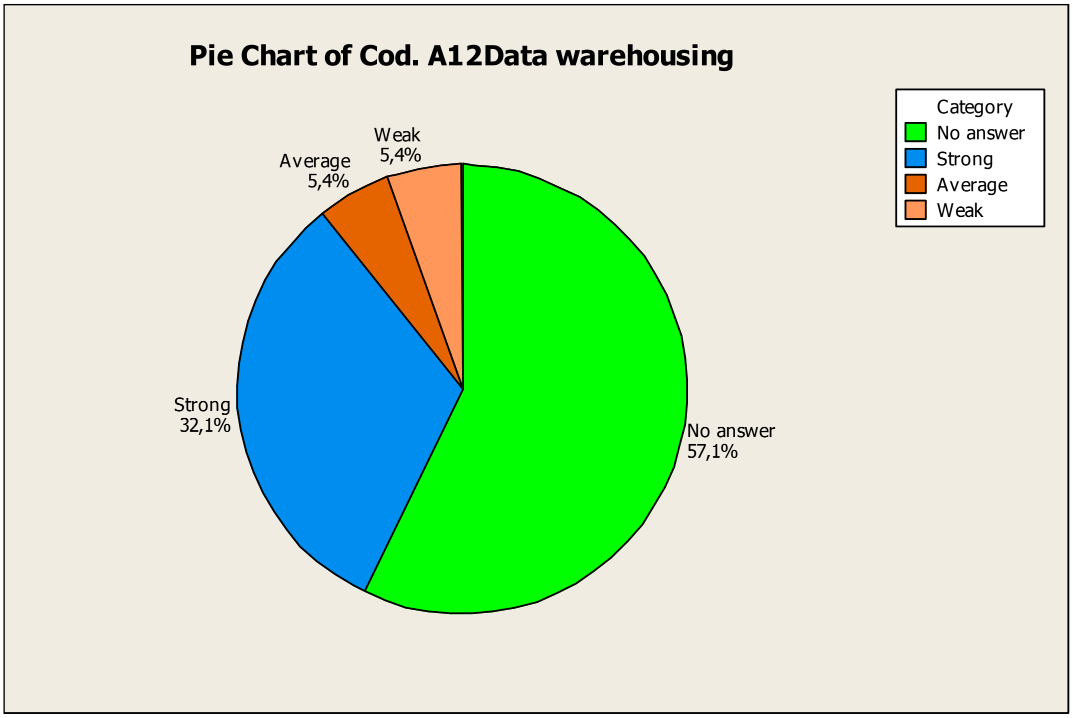

Pie Chart of Cod. B12Internet
Category
Strong
No answer
Average
Weak
Weak
15,2%
Strong
48,2%
Average
17,0%
No answer
19,6%

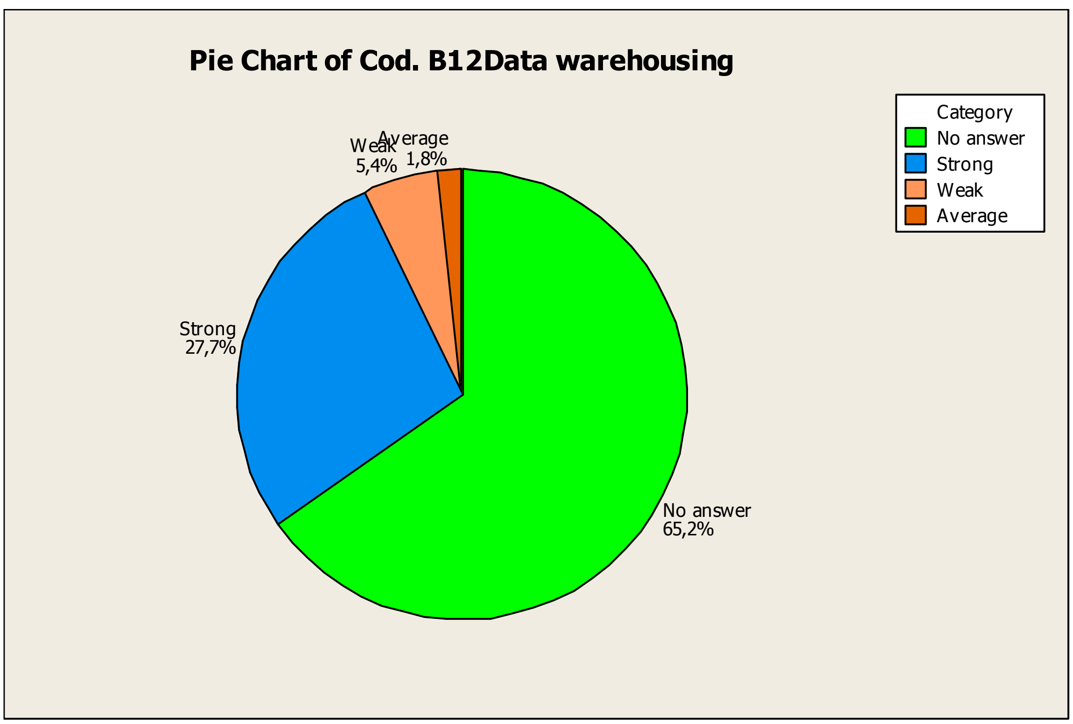
e-mail:


Pie Chart of Cod. A12email
Category
Strong
No answer
Average
Weak
Average 5,4%
Weak 1,8%
No answer 6,3%
Strong 86,6%

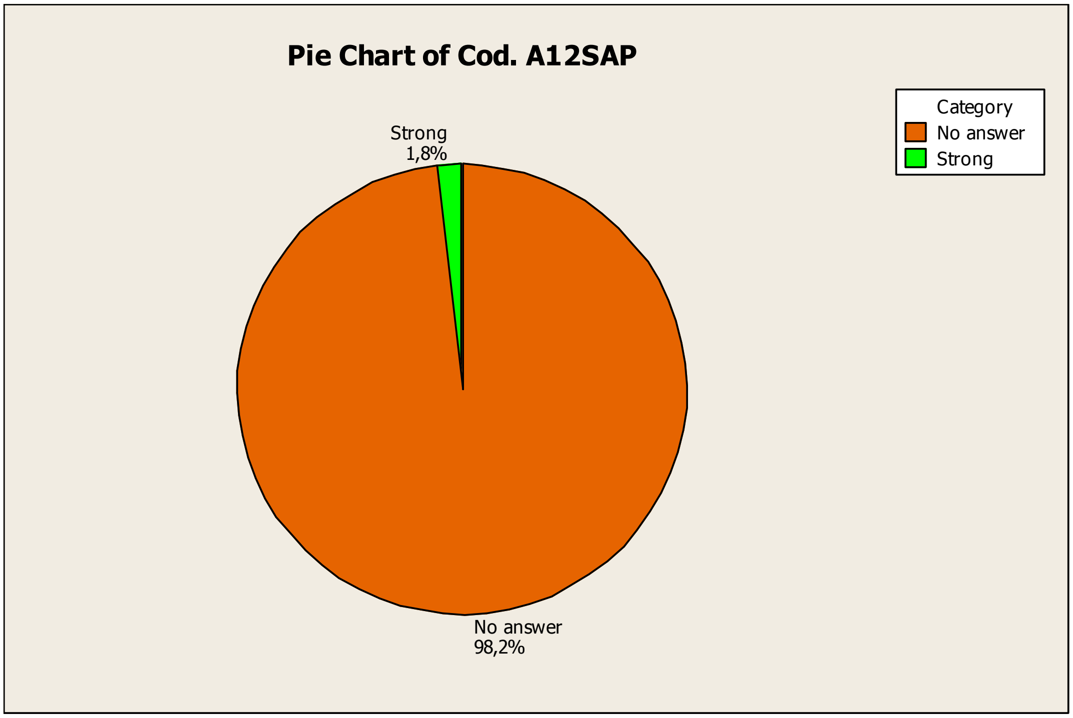

Pie Chart of Cod. B12email
Category
Strong
No answer
Average
Weak
Average 5,4%
Weak 0,9%
No answer 7,1%
Strong 86,6%

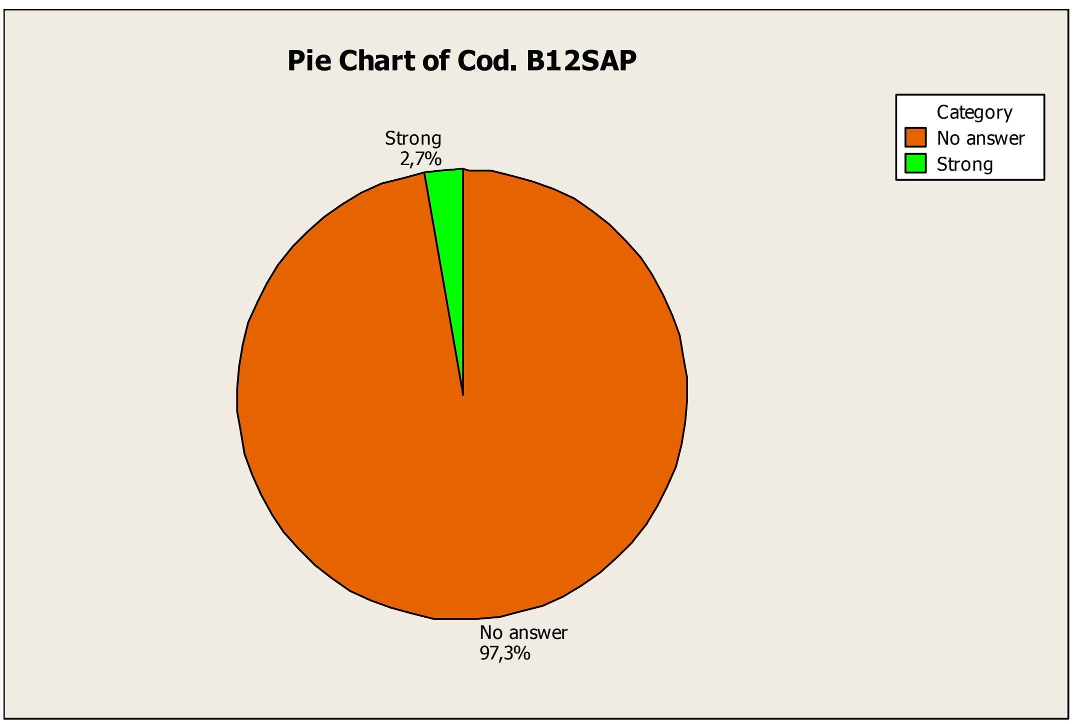
Data warehousing:



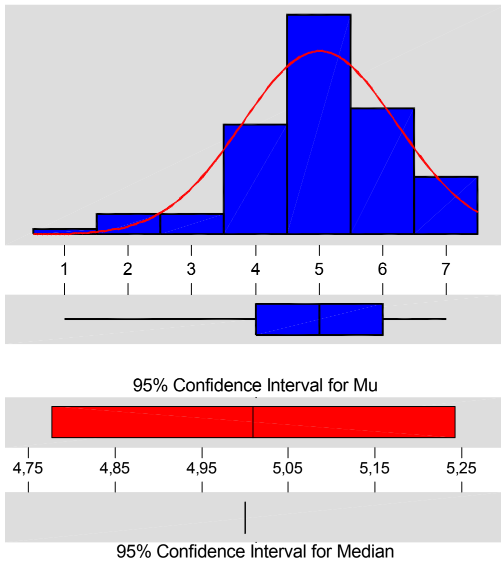


SAP:


Pie Chart of Cod. A12SAP
Category
No answer
Strong
Strong
1,8%
No answer
98,2%


Pie Chart of Cod. B12SAP
Category
No answer
Strong
Strong
2,7%
No answer
97,3%

Descriptive Statistics



Variable: A12Intranet

Anderson-Darling Normality Test

A-Squared:	3,849
P-Value:	0,000
Mean	5,00935
StDev	1,21698
Variance	1,48104
Skewness	-6,3E-01
Kurtosis	0,869732
N	107
Minimum	1,00000
1st Quartile	4,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,77609	5,24260

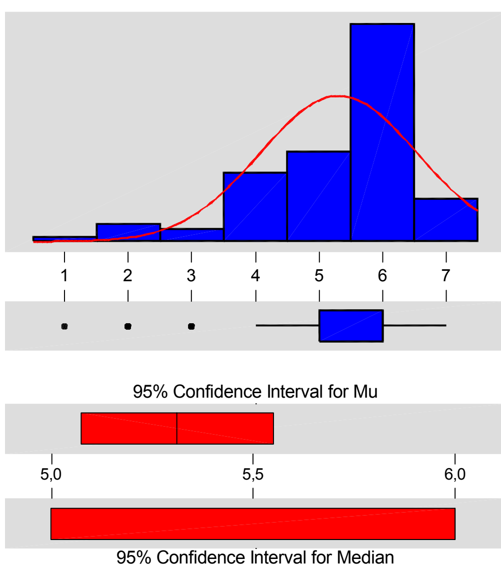
95% Confidence Interval for Sigma

1,07290	1,40612

95% Confidence Interval for Median

5,00000	5,00000

Descriptive Statistics



Variable: B12Intranet

Anderson-Darling Normality Test

A-Squared:	6,996
P-Value:	0,000
Mean	5,31132
StDev	1,23723
Variance	1,53073
Skewness	-1,20096
Kurtosis	1,44113
N	106
Minimum	1,00000
1st Quartile	5,00000
Median	6,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,07305	5,54960

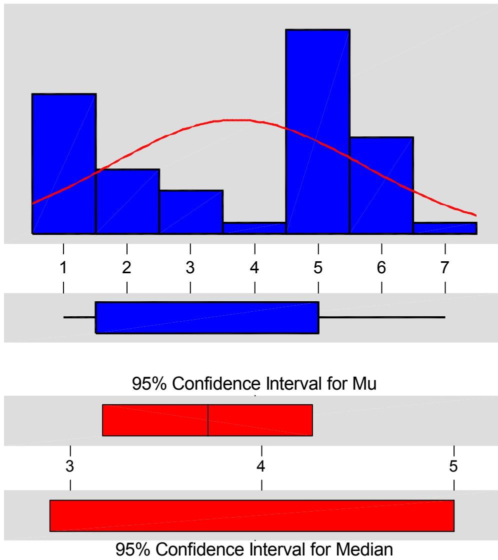
95% Confidence Interval for Sigma

1,09013	1,43057

95% Confidence Interval for Median

5,00000	6,00000

Descriptive Statistics



Variable: A12Extranet

Anderson-Darling Normality Test

A-Squared:	3,737
P-Value:	0,000
Mean	3,71698
StDev	1,98434
Variance	3,93759
Skewness	-2,8E-01
Kurtosis	-1,54717
N	53
Minimum	1,00000
1st Quartile	1,50000
Median	5,00000
3rd Quartile	5,00000
Maximum	7,00000

95% Confidence Interval for Mu

3,17003 4,26393

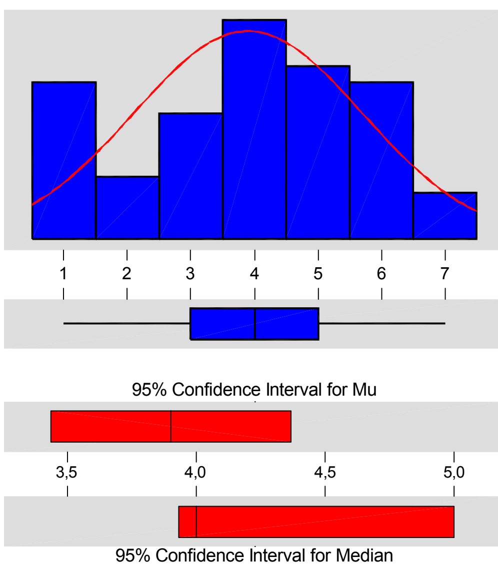
95% Confidence Interval for Sigma

1,66556 2,45517

95% Confidence Interval for Median

2,89810 5,00000

Descriptive Statistics



Variable: B12Extranet

Anderson-Darling Normality Test

A-Squared:	1,490
P-Value:	0,001
Mean	3,90000
StDev	1,80113
Variance	3,24407
Skewness	-2,4E-01
Kurtosis	-9,3E-01
N	60
Minimum	1,00000
1st Quartile	3,00000
Median	4,00000
3rd Quartile	5,00000
Maximum	7,00000

95% Confidence Interval for Mu

3,43472 4,36528

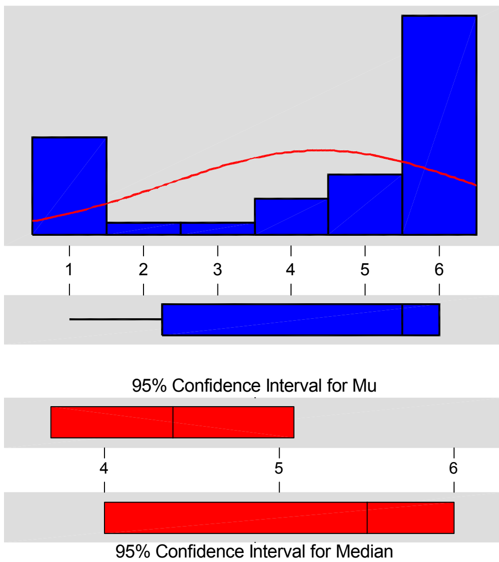
95% Confidence Interval for Sigma

1,52670 2,19677

95% Confidence Interval for Median

3,93066 5,00000

Descriptive Statistics



Variable: A12Groupware

Anderson-Darling Normality Test

A-Squared:	4,196
P-Value:	0,000
Mean	4,38889
StDev	2,06020
Variance	4,24444
Skewness	-8,7E-01
Kurtosis	-9,9E-01
N	36
Minimum	1,00000
1st Quartile	2,25000
Median	5,50000
3rd Quartile	6,00000
Maximum	6,00000

95% Confidence Interval for Mu

3,69182 5,08596

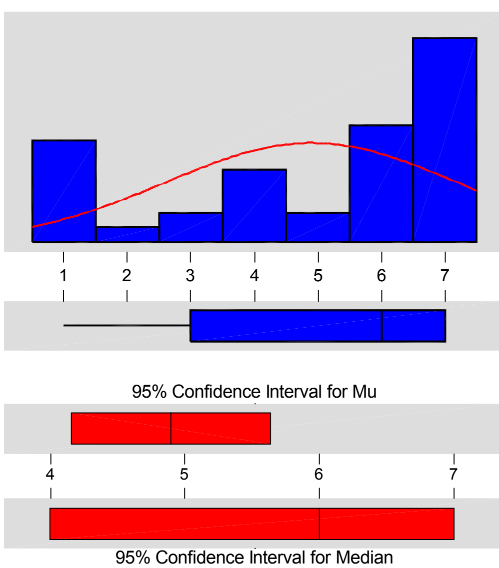
95% Confidence Interval for Sigma

1,67099 2,68741

95% Confidence Interval for Median

4,00000 6,00000

Descriptive Statistics



Variable: B12Groupware

Anderson-Darling Normality Test

A-Squared:	2,788
P-Value:	0,000
Mean	4,89744
StDev	2,28029
Variance	5,19973
Skewness	-7,4E-01
Kurtosis	-9,7E-01
N	39
Minimum	1,00000
1st Quartile	3,00000
Median	6,00000
3rd Quartile	7,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,15825 5,63662

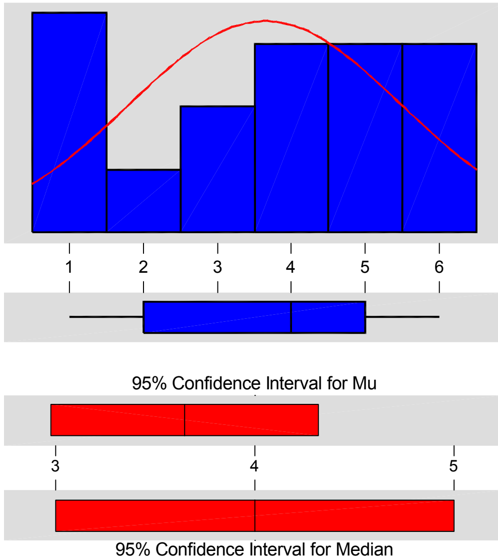
95% Confidence Interval for Sigma

1,86356 2,93879

95% Confidence Interval for Median

4,00000 7,00000

Descriptive Statistics



Variable: A12Workflow

Anderson-Darling Normality Test

A-Squared:	1,178
P-Value:	0,004
Mean	3,64516
StDev	1,83573
Variance	3,36989
Skewness	-2,6E-01
Kurtosis	-1,30678
N	31
Minimum	1,00000
1st Quartile	2,00000
Median	4,00000
3rd Quartile	5,00000
Maximum	6,00000

95% Confidence Interval for Mu

2,97181 4,31851

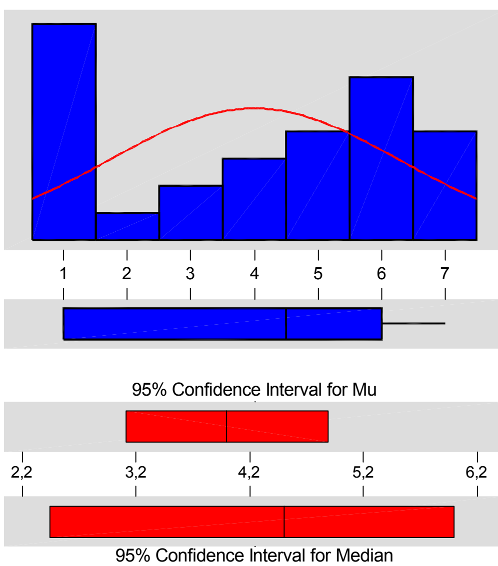
95% Confidence Interval for Sigma

1,46695 2,45377

95% Confidence Interval for Median

3,00000 5,00000

Descriptive Statistics



Variable: B12Workflow

Anderson-Darling Normality Test

A-Squared:	1,403
P-Value:	0,001
Mean	4,00000
StDev	2,29331
Variance	5,25926
Skewness	-2,2E-01
Kurtosis	-1,54132
N	28
Minimum	1,00000
1st Quartile	1,00000
Median	4,50000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

3,11075 4,88925

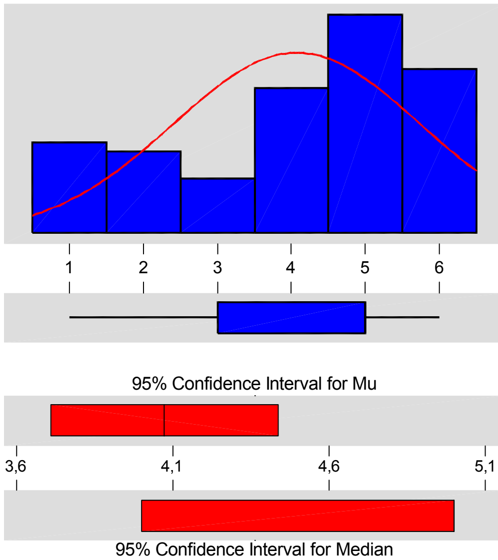
95% Confidence Interval for Sigma

1,81313 3,12150

95% Confidence Interval for Median

2,44829 6,00000

Descriptive Statistics



Variable: A12Internet

Anderson-Darling Normality Test

A-Squared:	3,763
P-Value:	0,000
Mean	4,07229
StDev	1,66589
Variance	2,77520
Skewness	-6,2E-01
Kurtosis	-8,5E-01
N	83
Minimum	1,00000
1st Quartile	3,00000
Median	5,00000
3rd Quartile	5,00000
Maximum	6,00000

95% Confidence Interval for Mu

3,70853 4,43605

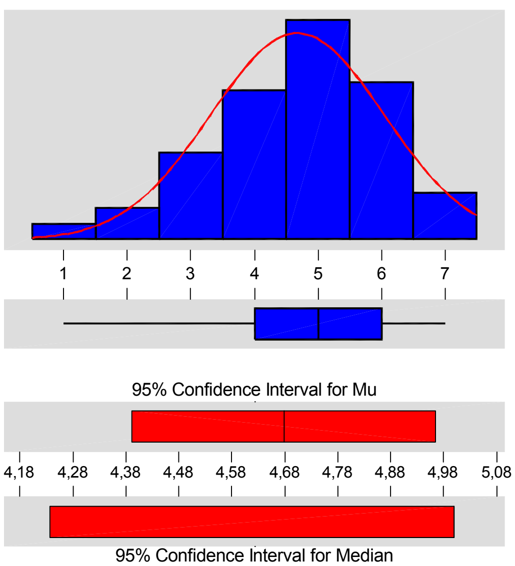
95% Confidence Interval for Sigma

1,44533 1,96653

95% Confidence Interval for Median

4,00000 5,00000

Descriptive Statistics



Variable: B12Internet

Anderson-Darling Normality Test

A-Squared:	2,413
P-Value:	0,000
Mean	4,67778
StDev	1,36429
Variance	1,86130
Skewness	-5,1E-01
Kurtosis	1,40E-02
N	90
Minimum	1,00000
1st Quartile	4,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,39203 4,96352

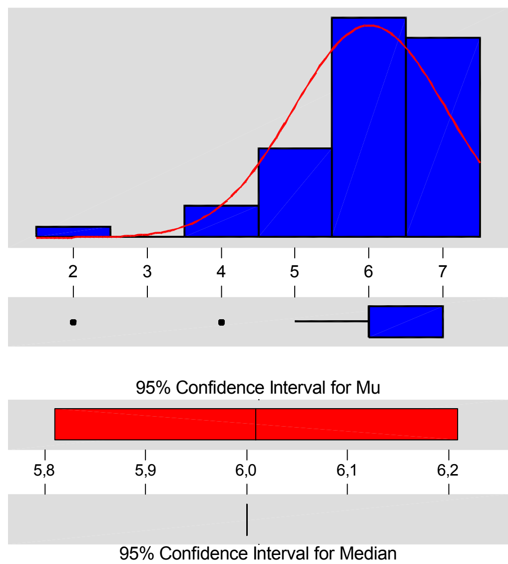
95% Confidence Interval for Sigma

1,18995 1,59896

95% Confidence Interval for Median

4,23726 5,00000

Descriptive Statistics



Variable: A12email

Anderson-Darling Normality Test

A-Squared:	6,681
P-Value:	0,000
Mean	6,00952
StDev	1,03306
Variance	1,06722
Skewness	-1,40627
Kurtosis	2,89454
N	105
Minimum	2,00000
1st Quartile	6,00000
Median	6,00000
3rd Quartile	7,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,80960 6,20945

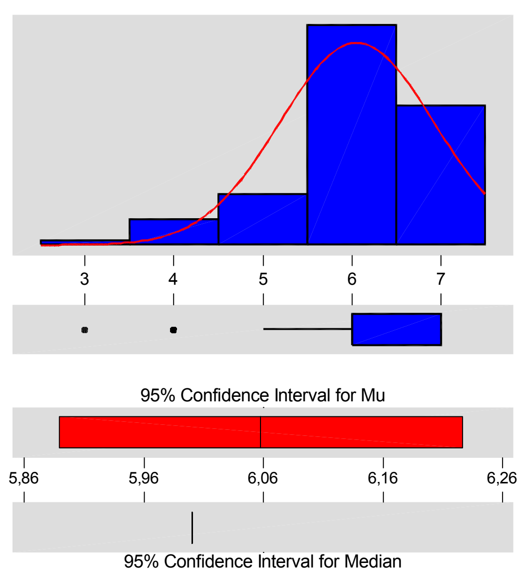
95% Confidence Interval for Sigma

0,90973 1,19539

95% Confidence Interval for Median

6,00000 6,00000

Descriptive Statistics



Variable: B12email

Anderson-Darling Normality Test

A-Squared:	7,893
P-Value:	0,000
Mean	6,05769
StDev	0,86829
Variance	0,753921
Skewness	-1,02013
Kurtosis	1,18380
N	104
Minimum	3,00000
1st Quartile	6,00000
Median	6,00000
3rd Quartile	7,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,88883 6,22655

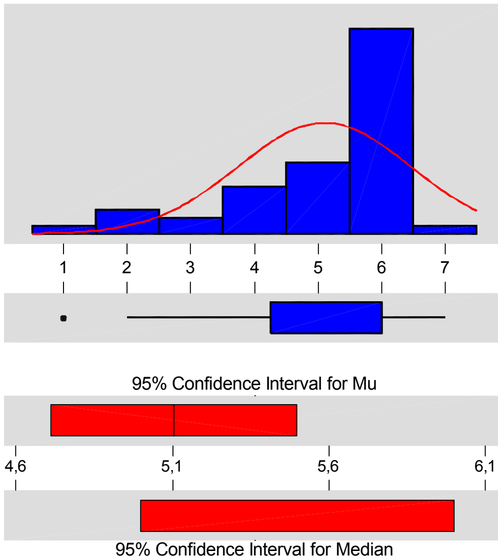
95% Confidence Interval for Sigma

0,76418 1,00549

95% Confidence Interval for Median

6,00000 6,00000

Descriptive Statistics



Variable: A12Data ware

Anderson-Darling Normality Test

A-Squared:	4,770
P-Value:	0,000
Mean	5,10417
StDev	1,35646
Variance	1,83998
Skewness	-1,42397
Kurtosis	1,36907
N	48
Minimum	1,00000
1st Quartile	4,25000
Median	6,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,71029 5,49804

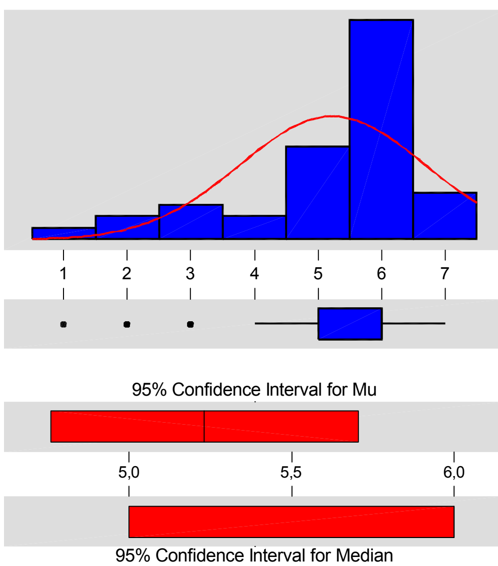
95% Confidence Interval for Sigma

1,12921 1,69907

95% Confidence Interval for Median

5,00000 6,00000

Descriptive Statistics



Variable: B12Data ware

Anderson-Darling Normality Test

A-Squared:	3,197
P-Value:	0,000
Mean	5,23077
StDev	1,45930
Variance	2,12955
Skewness	-1,33443
Kurtosis	1,25379
N	39
Minimum	1,00000
1st Quartile	5,00000
Median	6,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,75772 5,70382

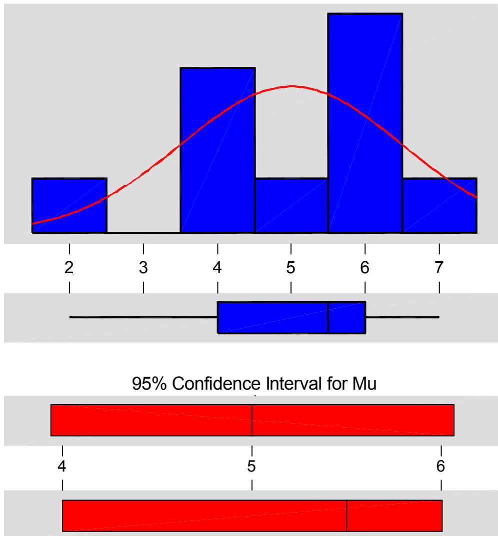
95% Confidence Interval for Sigma

1,19261 1,88071

95% Confidence Interval for Median

5,00000 6,00000

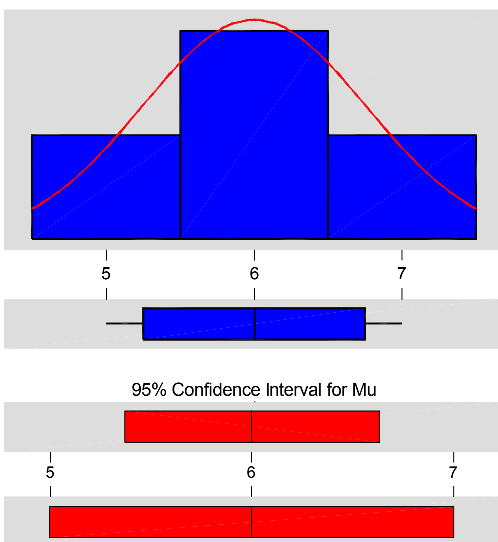
Descriptive Statistics



Variable: A12Otros

Anderson-Darling Normality Test	
A-Squared:	0,540
P-Value:	0,122
Mean	5,00000
StDev	1,49071
Variance	2,22222
Skewness	-7,5E-01
Kurtosis	0,257143
N	10
Minimum	2,00000
1st Quartile	4,00000
Median	5,50000
3rd Quartile	6,00000
Maximum	7,00000
95% Confidence Interval for Mu	
3,93361	6,06639
95% Confidence Interval for Sigma	
1,02536	2,72146
95% Confidence Interval for Median	
4,00000	6,00000

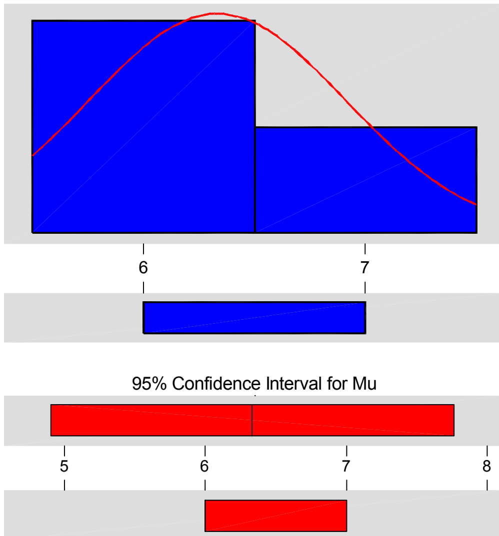
Descriptive Statistics



Variable: B12Otros

Anderson-Darling Normality Test	
A-Squared:	0,604
P-Value:	0,075
Mean	6,00000
StDev	0,75593
Variance	0,571429
Skewness	0
Kurtosis	-0,7
N	8
Minimum	5,00000
1st Quartile	5,25000
Median	6,00000
3rd Quartile	6,75000
Maximum	7,00000
95% Confidence Interval for Mu	
5,36803	6,63197
95% Confidence Interval for Sigma	
0,49980	1,53852
95% Confidence Interval for Median	
5,00000	7,00000

Descriptive Statistics



Variable: B12SAP

Anderson-Darling Normality Test

A-Squared:	0,488
P-Value:	0,057
Mean	6,33333
StDev	0,57735
Variance	0,333333
Skewness	1,73205
Kurtosis	
N	3
Minimum	6,00000
1st Quartile	6,00000
Median	6,00000
3rd Quartile	7,00000
Maximum	7,00000

95% Confidence Interval for Mu

4,89912 7,76755

95% Confidence Interval for Sigma

0,30060 3,62849

95% Confidence Interval for Median

6,00000 7,00000

Note: SAP has only appeared as an IT Infrastructure in use, among managers of Quality or R&D group (Relationship Questionnaire B).

8B.2 Information Technology Function

(Question Nr. 9, Performance Questionnaire C)

C9. Specifically, the **use** of the following **IT function** is:

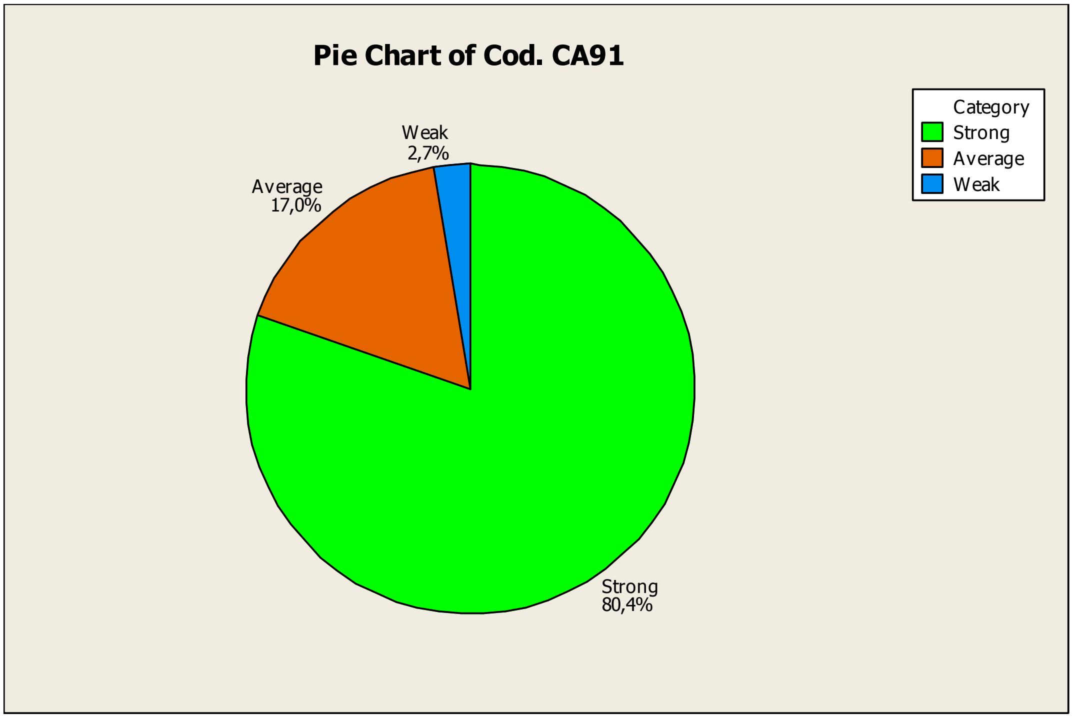
- **Coordinating business tasks:** ☐
  (collecting, facilitating, sharing, etc. information)
- **Supporting decision making:** ☐
  (reaching the right information at the right time)
- **Facilitating member' team to work together:** ☐
  (no matter where they are)
- **Facilitating access of information in Data Bases:** ☐
  (no mater where they are)
- **Other …………………………………………:** ☐
- **Other …………………………………………:** ☐

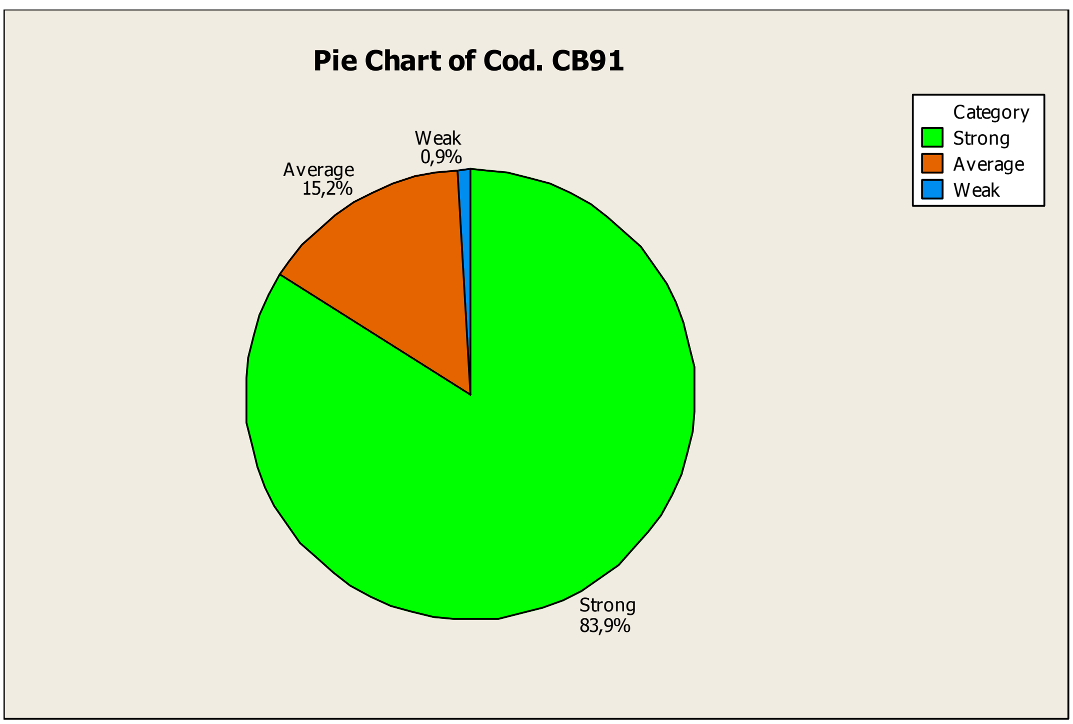
General note:
For simplicity purposes we have grouped ratings of the 7-points Likert scale into three categories, and it is in this way that results are presented in the following pie-charts:

- Extremely Strong, Very Strong or Strong: **Strong**
- About Average: **Average**
- Non-Existent, Very Weak or Weak: **Weak**

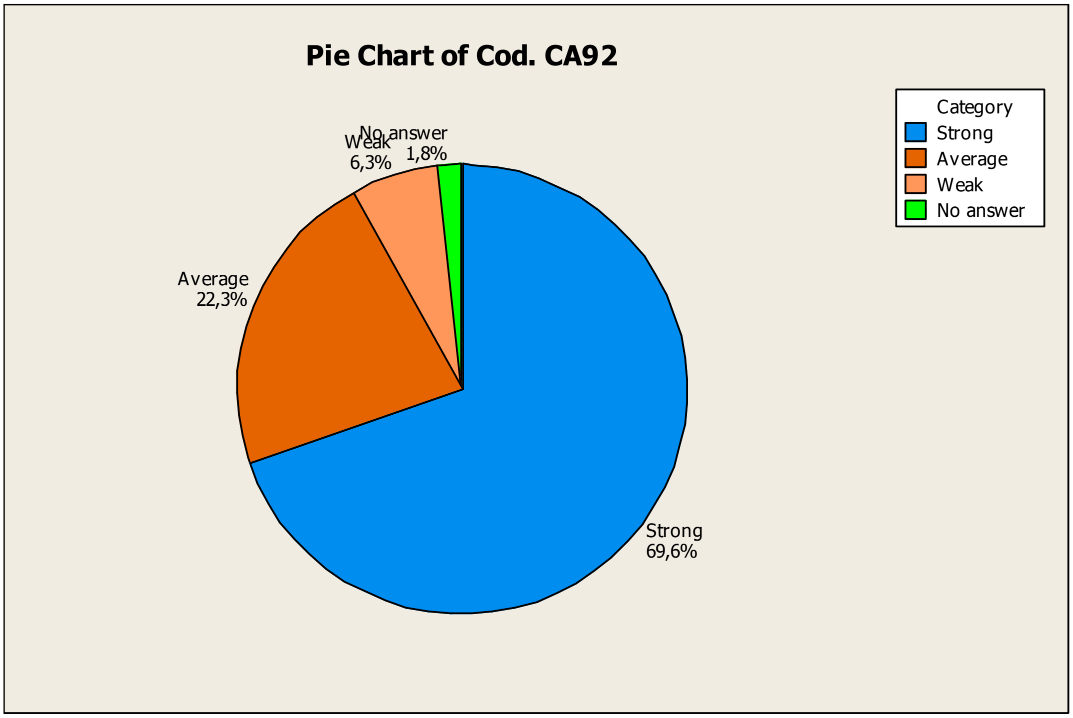
In every page, we present the results regarding a certain IT Function, as obtained from Questionnaire C. We have split, as CA9, answers received from senior managers related to Production, and as CB9 answers received from senior managers related to Quality or R&D.

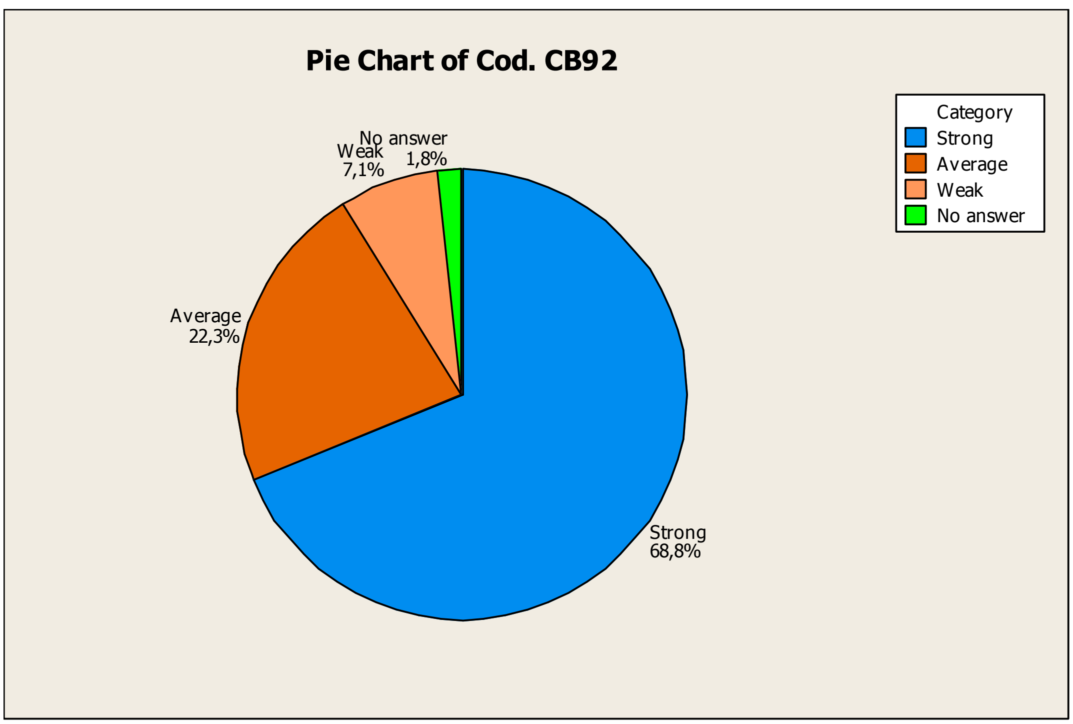
Coordinating business tasks:



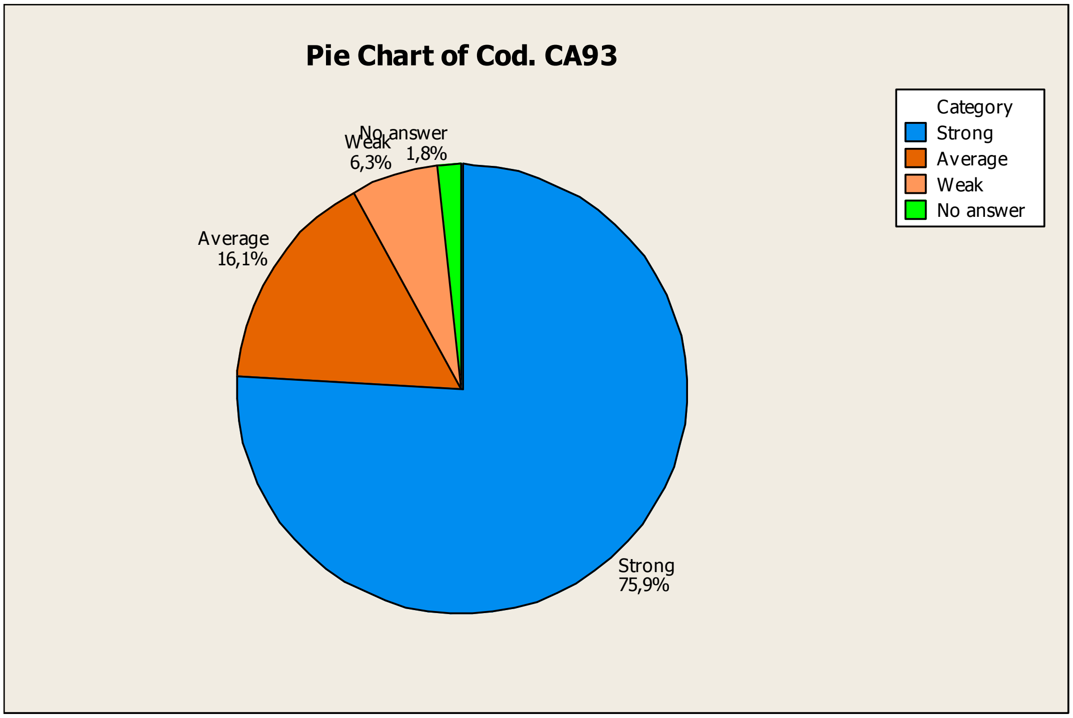


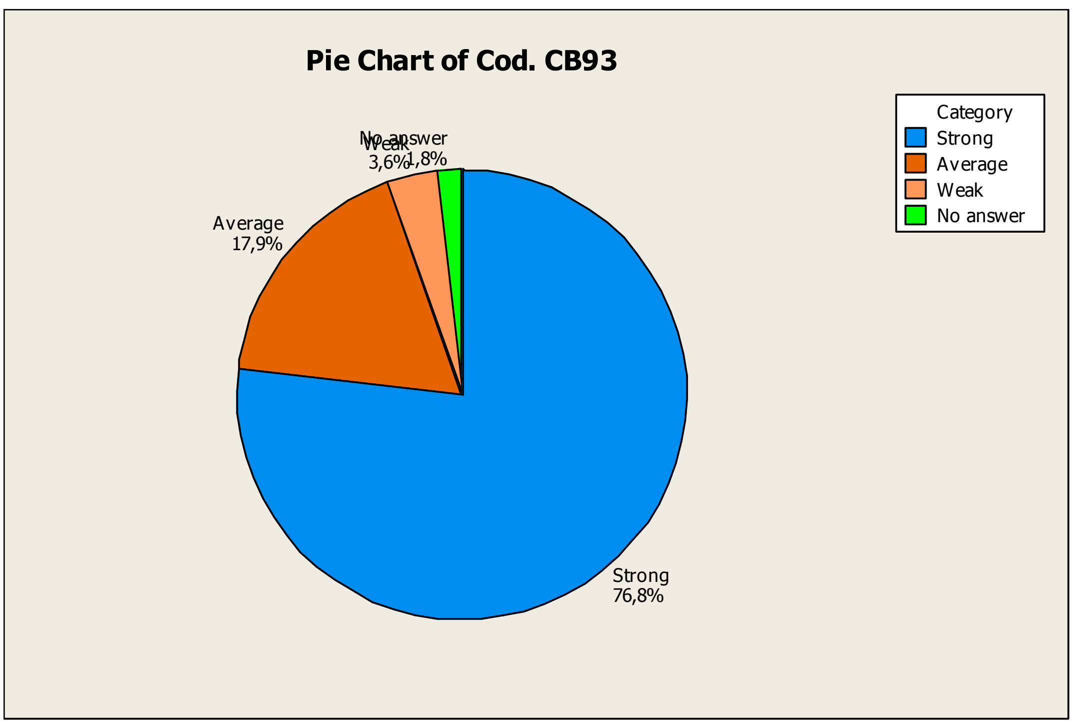
Supporting decision making:



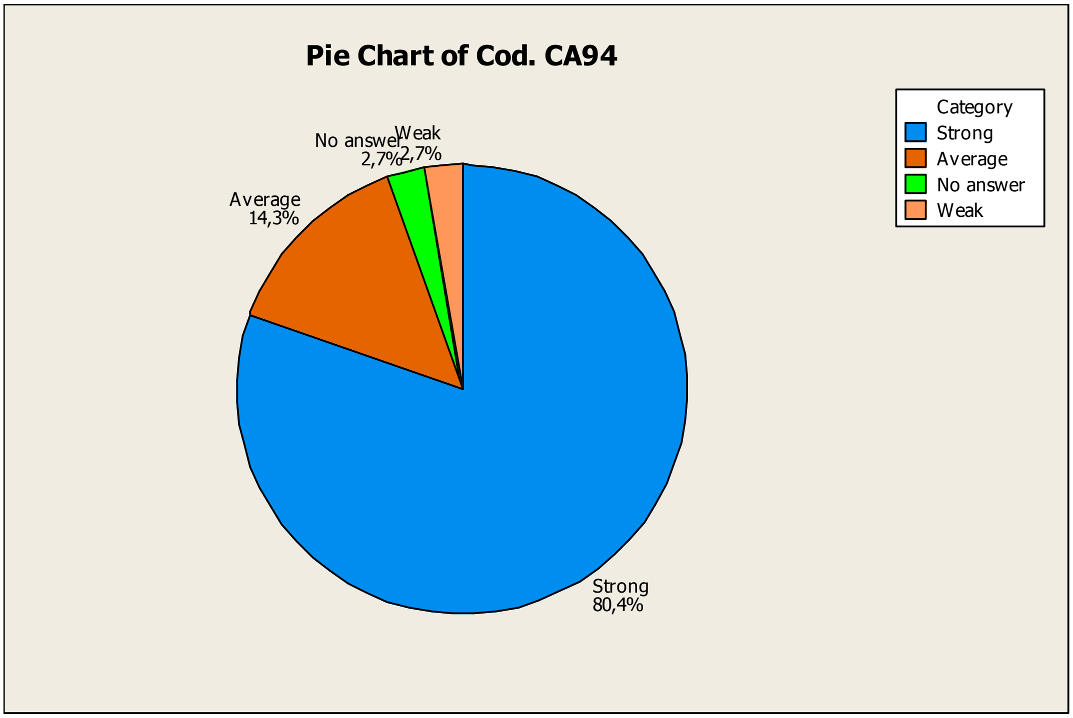


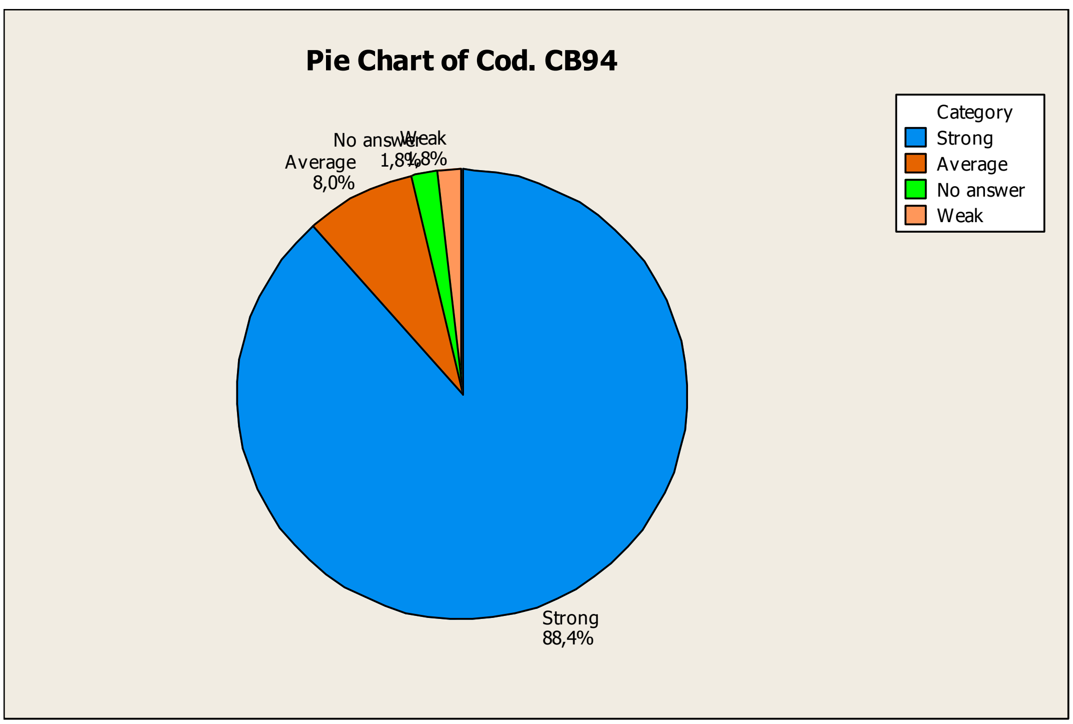
Facilitating member' team to work together:





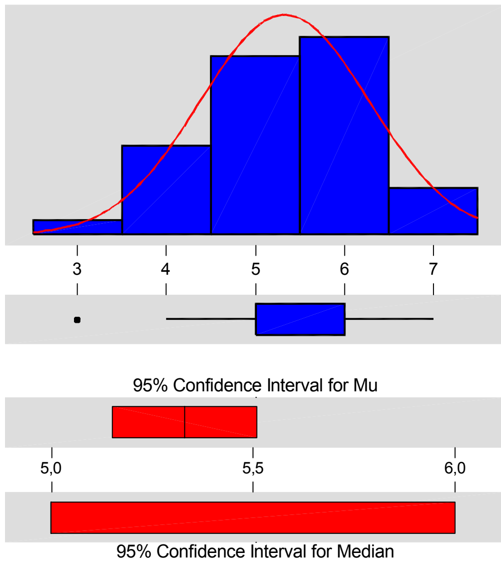
Facilitating access of information in Data Bases:





Coordinating business tasks:

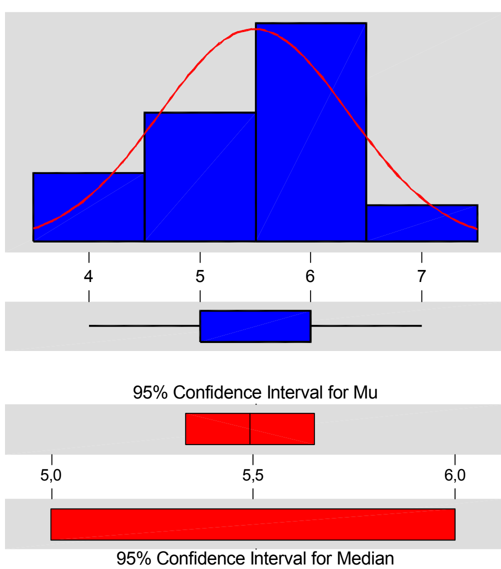
Descriptive Statistics



Variable: CA91

Anderson-Darling Normality Test	
A-Squared:	5,353
P-Value:	0,000
Mean	5,33036
StDev	0,95284
Variance	0,907899
Skewness	-2,6E-01
Kurtosis	-3,8E-01
N	112
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000
95% Confidence Interval for Mu	
5,15195	5,50877
95% Confidence Interval for Sigma	
0,84229	1,09705
95% Confidence Interval for Median	
5,00000	6,00000

Descriptive Statistics

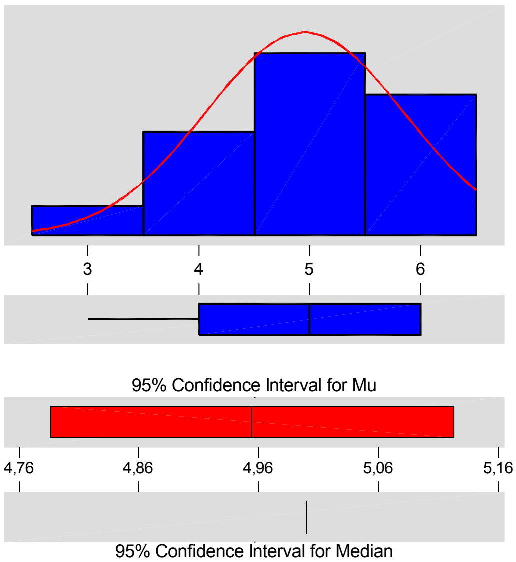


Variable: CB91

Anderson-Darling Normality Test	
A-Squared:	7,865
P-Value:	0,000
Mean	5,49107
StDev	0,84891
Variance	0,720640
Skewness	-3,3E-01
Kurtosis	-5,9E-01
N	112
Minimum	4,00000
1st Quartile	5,00000
Median	6,00000
3rd Quartile	6,00000
Maximum	7,00000
95% Confidence Interval for Mu	
5,33212	5,65002
95% Confidence Interval for Sigma	
0,75042	0,97739
95% Confidence Interval for Median	
5,00000	6,00000

Supporting decision making:

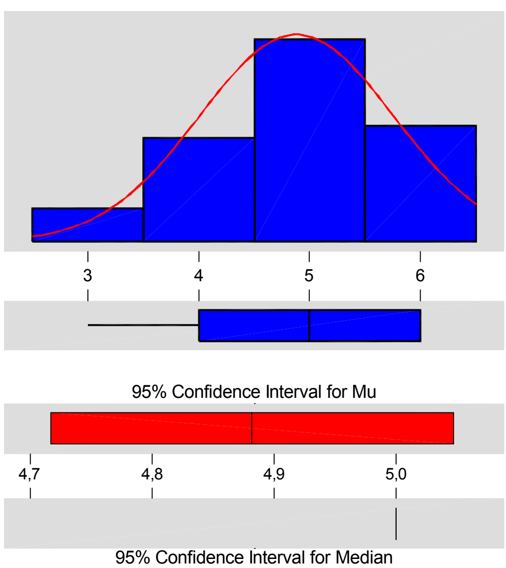
Descriptive Statistics



Variable: CA92

Anderson-Darling Normality Test	
A-Squared:	6,436
P-Value:	0,000
Mean	4,95455
StDev	0,89223
Variance	0,796080
Skewness	-4,6E-01
Kurtosis	-5,8E-01
N	110
Minimum	3,00000
1st Quartile	4,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	6,00000
95% Confidence Interval for Mu	
4,78594	5,12315
95% Confidence Interval for Sigma	
0,78789	1,02869
95% Confidence Interval for Median	
5,00000	5,00000

Descriptive Statistics

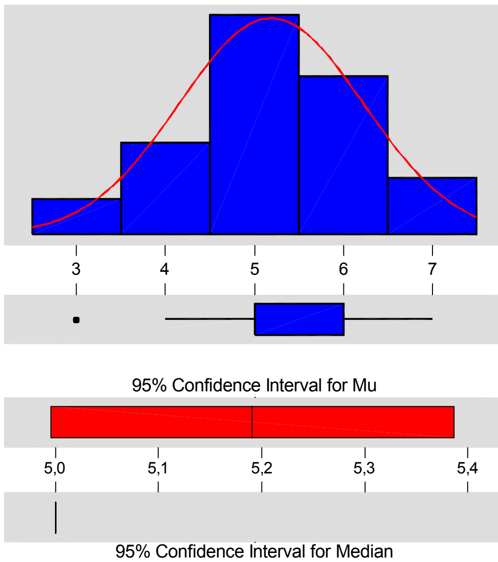


Variable: CB92

Anderson-Darling Normality Test	
A-Squared:	6,429
P-Value:	0,000
Mean	4,88182
StDev	0,87506
Variance	0,765721
Skewness	-4,4E-01
Kurtosis	-4,5E-01
N	110
Minimum	3,00000
1st Quartile	4,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	6,00000
95% Confidence Interval for Mu	
4,71646	5,04718
95% Confidence Interval for Sigma	
0,77272	1,00889
95% Confidence Interval for Median	
5,00000	5,00000

Facilitating member' team to work together:

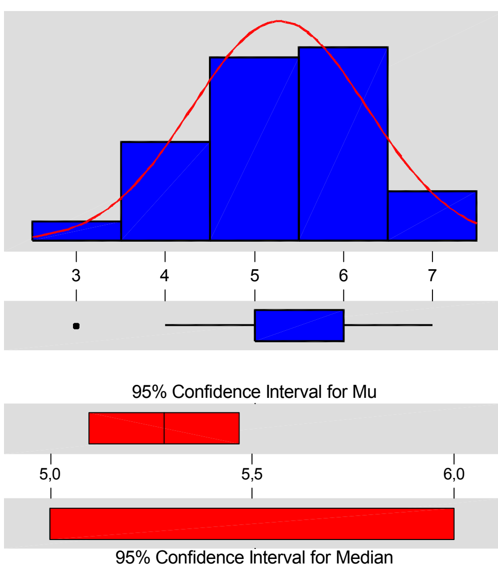
Descriptive Statistics



Variable: CA93

Anderson-Darling Normality Test	
A-Squared:	4,344
P-Value:	0,000
Mean	5,19091
StDev	1,03601
Variance	1,07331
Skewness	-1,9E-01
Kurtosis	-3,2E-01
N	110
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000
95% Confidence Interval for Mu	
4,99513	5,38669
95% Confidence Interval for Sigma	
0,91484	1,19446
95% Confidence Interval for Median	
5,00000	5,00000

Descriptive Statistics

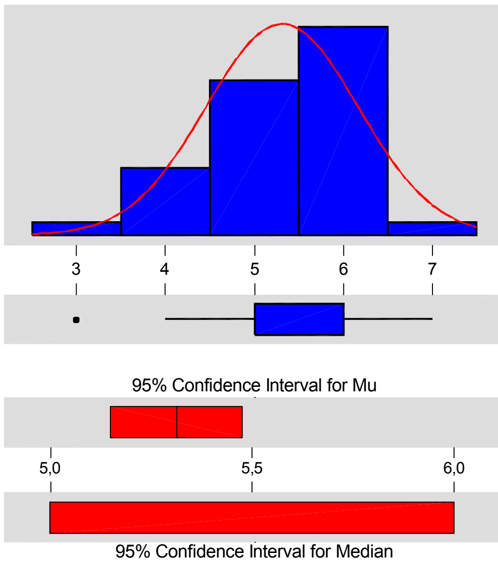


Variable: CB93

Anderson-Darling Normality Test	
A-Squared:	4,859
P-Value:	0,000
Mean	5,28182
StDev	0,98737
Variance	0,974896
Skewness	-2,5E-01
Kurtosis	-4,3E-01
N	110
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000
95% Confidence Interval for Mu	
5,09523	5,46840
95% Confidence Interval for Sigma	
0,87189	1,13838
95% Confidence Interval for Median	
5,00000	6,00000

Facilitating access of information in Data Bases:

Descriptive Statistics



Variable: CA94

Anderson-Darling Normality Test

A-Squared:	7,980
P-Value:	0,000
Mean	5,31193
StDev	0,85740
Variance	0,735134
Skewness	-6,5E-01
Kurtosis	-2,4E-02
N	109
Minimum	3,00000
1st Quartile	5,00000
Median	5,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,14914 5,47471

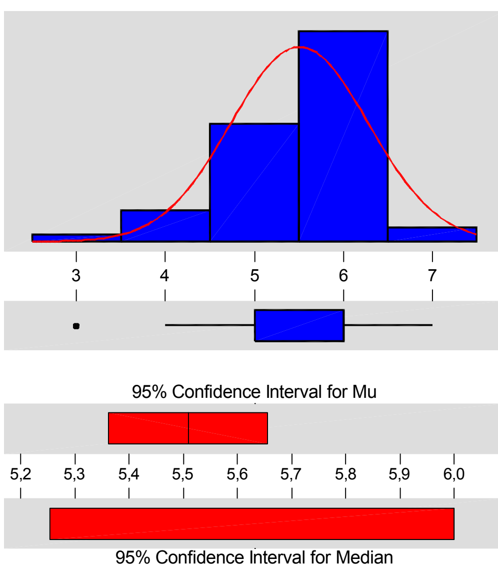
95% Confidence Interval for Sigma

0,75672 0,98923

95% Confidence Interval for Median

5,00000 6,00000

Descriptive Statistics



Variable: CB94

Anderson-Darling Normality Test

A-Squared:	10,571
P-Value:	0,000
Mean	5,50909
StDev	0,77513
Variance	0,600834
Skewness	-9,3E-01
Kurtosis	0,984601
N	110
Minimum	3,00000
1st Quartile	5,00000
Median	6,00000
3rd Quartile	6,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,36261 5,65557

95% Confidence Interval for Sigma

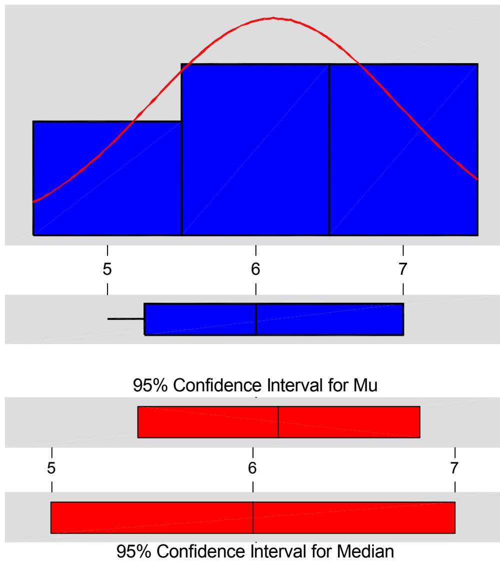
0,68448 0,89368

95% Confidence Interval for Median

5,25472 6,00000

Other:

Descriptive Statistics



Variable: CA95 OTROS

Anderson-Darling Normality Test

A-Squared:	0,580
P-Value:	0,088
Mean	6,12500
StDev	0,83452
Variance	0,696429
Skewness	-2,8E-01
Kurtosis	-1,39172
N	8
Minimum	5,00000
1st Quartile	5,25000
Median	6,00000
3rd Quartile	7,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,42732	6,82268

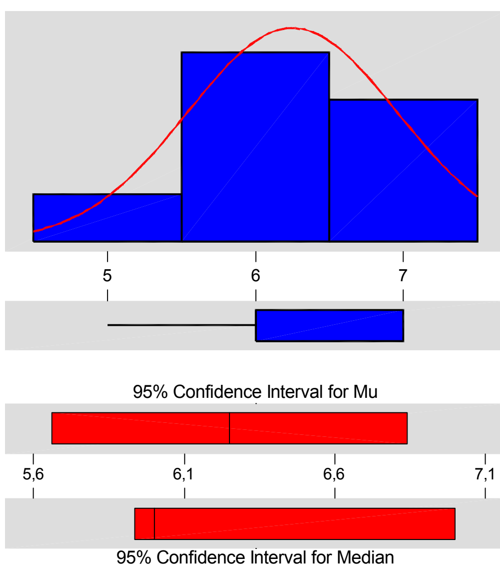
95% Confidence Interval for Sigma

0,55177	1,69848

95% Confidence Interval for Median

5,00000	7,00000

Descriptive Statistics



Variable: CB95 OTROS

Anderson-Darling Normality Test

A-Squared:	0,713
P-Value:	0,037
Mean	6,25000
StDev	0,70711
Variance	0,5
Skewness	-4,0E-01
Kurtosis	-2,3E-01
N	8
Minimum	5,00000
1st Quartile	6,00000
Median	6,00000
3rd Quartile	7,00000
Maximum	7,00000

95% Confidence Interval for Mu

5,65884	6,84116

95% Confidence Interval for Sigma

0,46752	1,43915

95% Confidence Interval for Median

5,93564	7,00000

APPENDIX 8C

Statistical Analysis Results

Confirmatory Tests

8C.1 Cronbach's *alphas*

Have been calculated, for all variables involved, according to the formula:

$$\alpha \equiv \frac{n}{n-1}\left[1-\frac{\sum \sigma^2_{\chi_i}}{\sigma^2_x}\right]$$

Where for the variable: $\chi_1,\ldots,\chi_i,\ldots,\chi_n$

$\sigma^2_{\chi_i}$ = variance of χ_i and σ^2_x = variance of $x=\sum \chi_i$

Shared Knowledge (SKC) = 0,9980971
Mutual Trust (MTC) = 0,99893219
Mutual Influence (MTC) = 0,99789307
Information Technology (ITskC) = 0,78191053
Information Technology (ITmpC) = 0,0,99919877
Manufacturing Performance (MPC) = 0,99870396
Operational Manufacturing Performance (OMPC) = 0,99935936
Service Manufacturing Performance (SMPC) = 0,81379442

8C. 2 MTMM Correlation Matrix

Correlations: MT1; MT2; MI1; MI2; MI3; SK1; SK2; SK3; OMPC; SMPC; ITskC; ITmpC

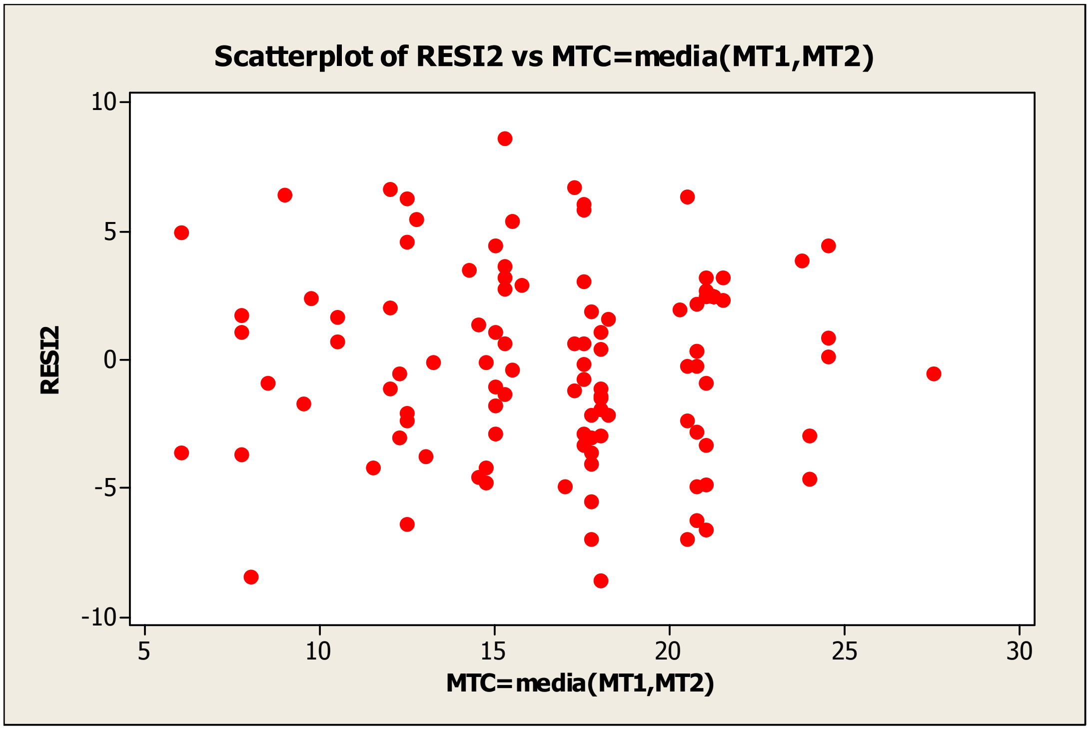
	MT1	MT2	MI1	MI2
MT2=A5*B5	**0,682**			
MI1=media(MI	0,574	0,478		
MI2=A8*B8	0,260	0,327	**0,691**	
MI3=A9*B9	0,371	0,493	**0,737**	**0,714**
SK1=media(A1	0,581	0,612	0,583	0,400
SK2=A2*B2	0,608	0,569	0,485	0,375
SK3=A3*B3	0,612	0,650	0,603	0,373
OMPC=media(C	0,524	0,486	0,515	0,301
SMPC=media(C	0,457	0,506	0,477	0,163
ITskC=media(	0,279	0,287	0,338	0,156
ITmpC=media(	0,057	0,247	0,262	0,319

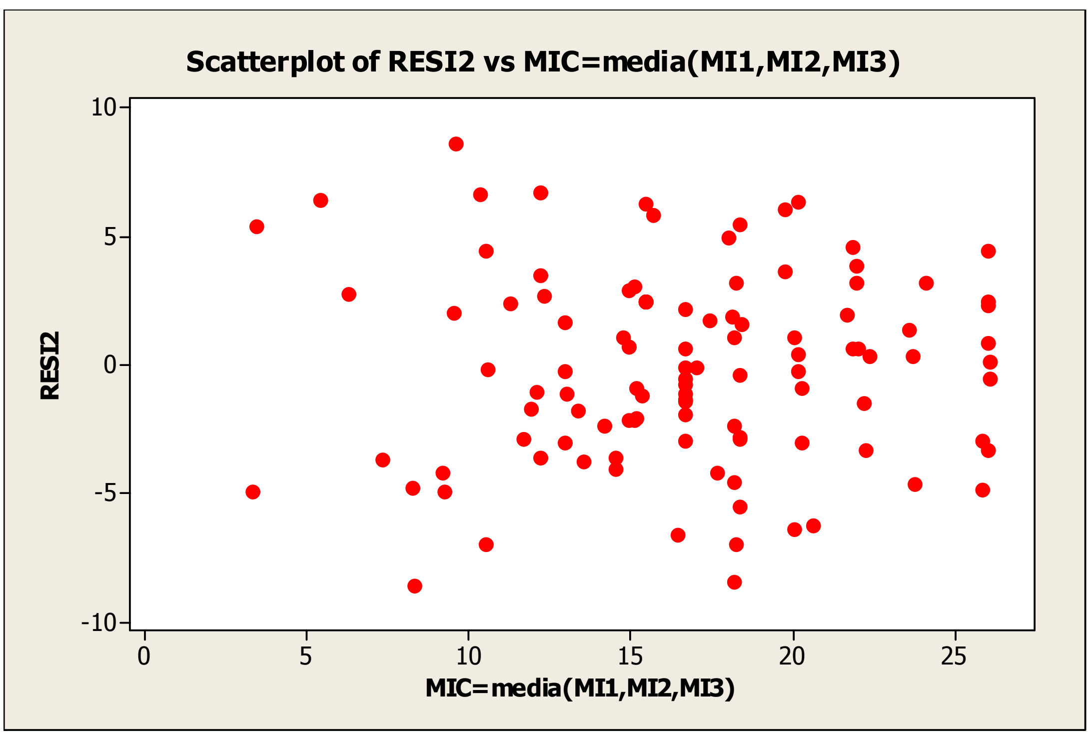
	MI3	SK1	SK2	SK3
SK1=media(A1	0,464			
SK2=A2*B2	0,449	**0,597**		
SK3=A3*B3	0,574	**0,767**	**0,603**	
OMPC=media(C	0,390	0,448	0,448	0,532
SMPC=media(C	0,303	0,395	0,351	0,490
ITskC=media(	0,335	0,348	0,273	0,407
ITmpC=media(	0,217	0,208	0,197	0,233

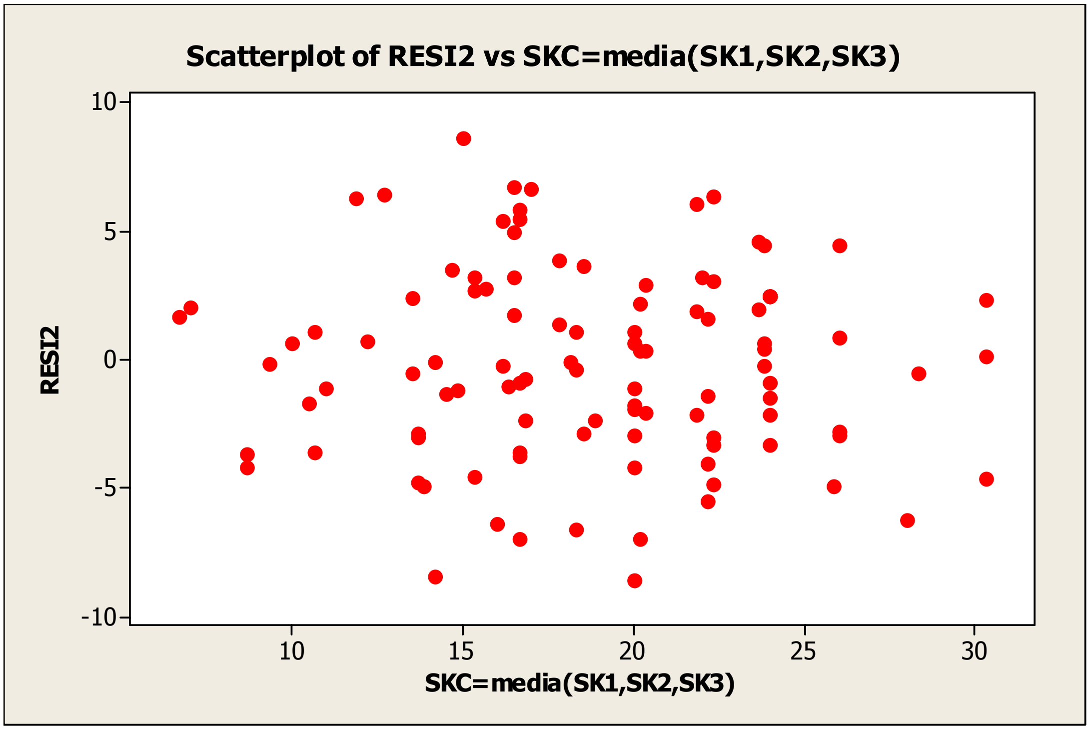
	OMPC	SMPC	ITskC
SMPC=media(C	**0,691**		
ITskC=media(	0,390	0,281	
ITmpC=media(	0,471	0,284	**0,460**

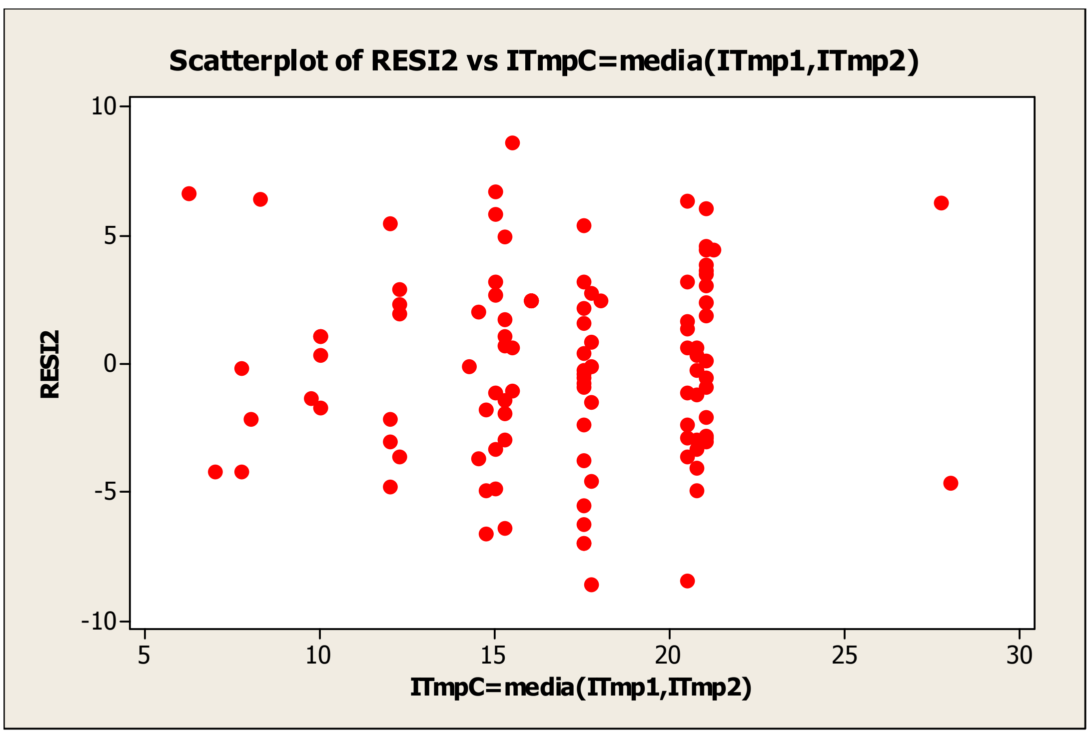
8C.3 Collinearity Tests: (Residuals vs Variables Plots)

First Regression: MPC vs (MTC, MIC, SKC, ITmpC)

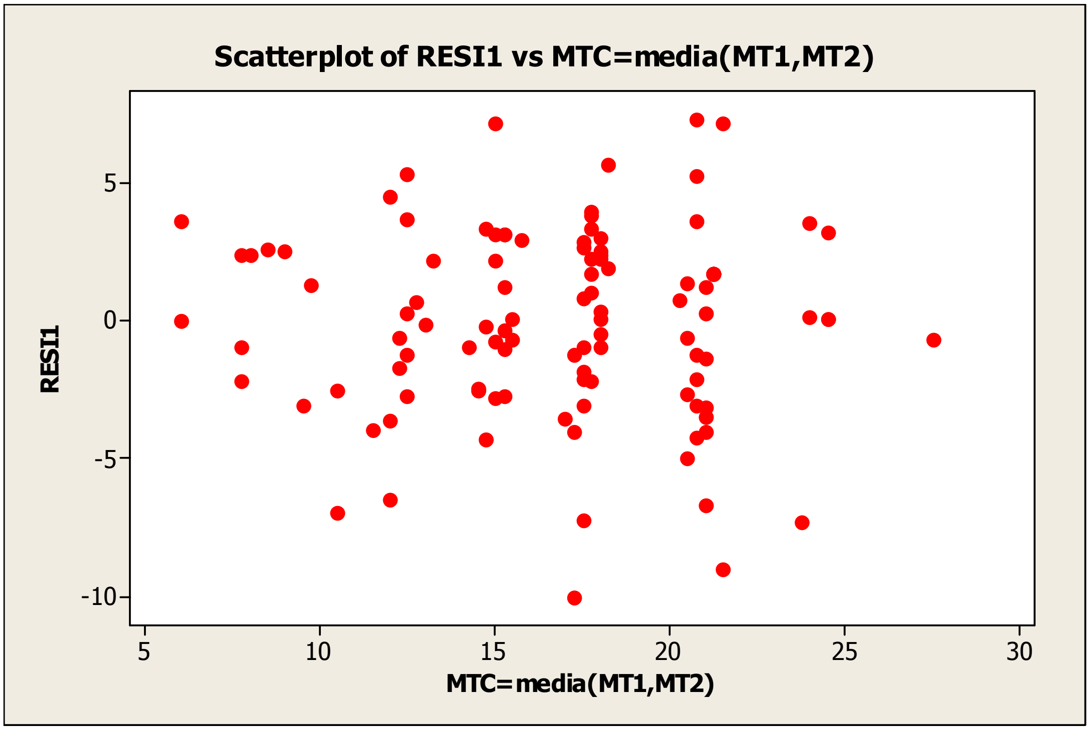


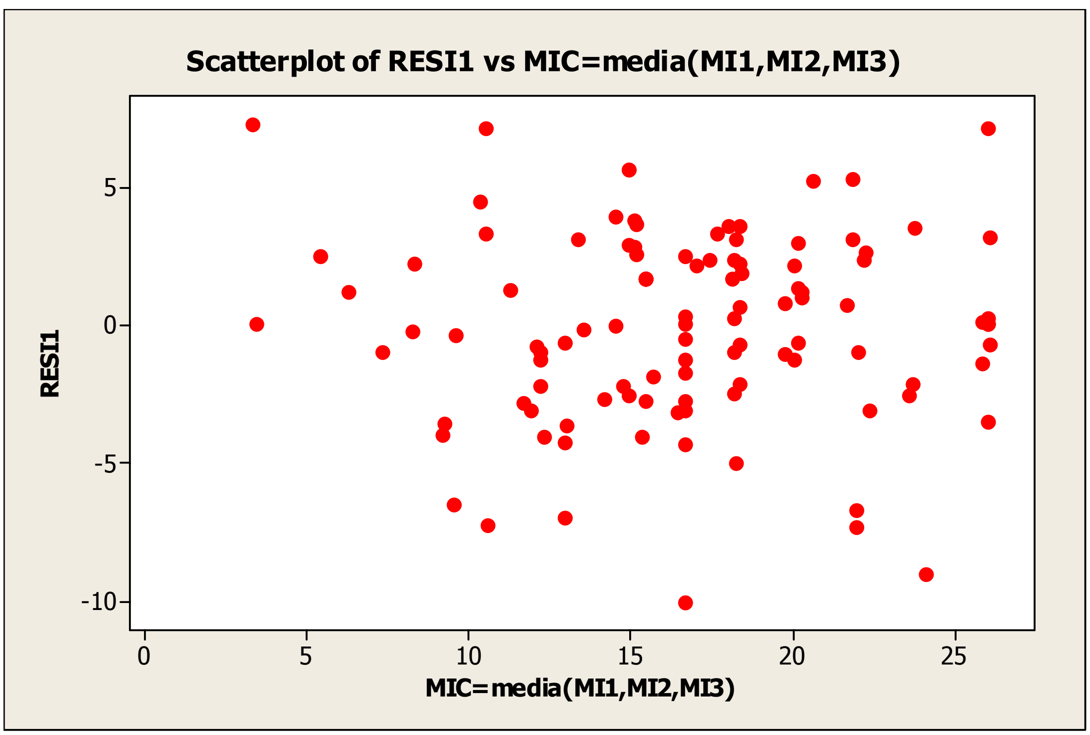


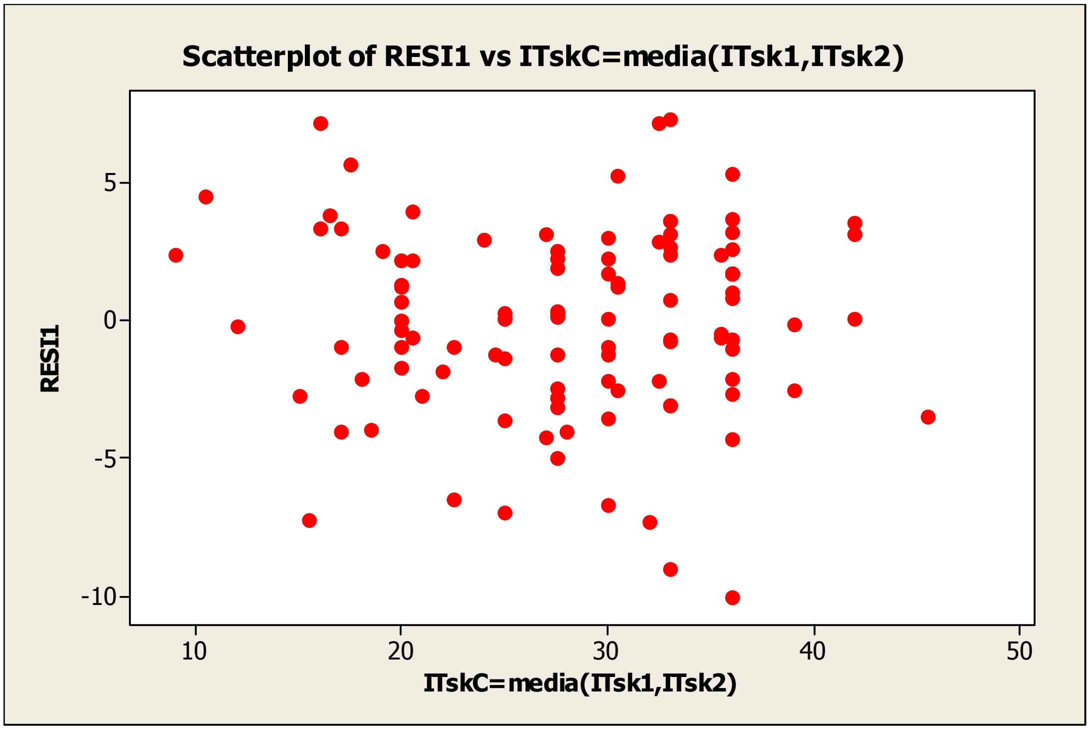

Scatterplot of RESI2 vs SKC=media(SK1,SK2,SK3)
RESI2
10
5
0
-5
-10
10
15
20
25
30
SKC=media(SK1,SK2,SK3)


Scatterplot of RESI2 vs ITmpC=media(ITmp1,ITmp2)
RESI2
10
5
0
-5
-10
5
10
15
20
25
30
ITmpC=media(ITmp1,ITmp2)

<u>Second Regression</u>: SKC vs (MTC, MIC, ITskC)






Scatterplot of RESI1 vs ITskC=media(ITsk1,ITsk2)
RESI1
5
0
-5
-10
10
20
30
40
50
ITskC=media(ITsk1,ITsk2)

Chapter Nine
Conclusions and Recommendations

Chapter 9. CONCLUSIONS AND RECOMMENDATIONS

"The essence of knowledge is, having it, to apply it;
not having it, to admit your ignorance."
Confucius

In chapter 1, upon positioning the Thesis question, and further down, upon building up our evaluation model, we outlined three questions that have guided this research:

1. What are the major components or antecedents of shared knowledge?
2. What is the nature of the relationships among shared knowledge, its components and the manufacturing group performance?
3. What is the role of information technology support towards (a) sharing knowledge and (b) the manufacturing performance?

During the course of our study we were able to satisfactorily answer each of these questions. For the first one, we conceptualized –building upon relevant literature- the two antecedents of sharing knowledge: mutual trust and mutual influence. Perhaps more significantly, we demonstrated the ability to evaluate these constructs in a reliable and valid way.

In order to answer questions two and three we conducted an empirical study and used path analysis on the data collected by means of three questionnaires on a sample of 112 manufacturing units. For the second question the results of this analysis show that:

a. There is a positive relationship between shared knowledge and manufacturing performance (i.e. increasing levels of shared knowledge among manufacturing, quality and R&D groups, leads to increased manufacturing group performance).
b. Shared knowledge mediates the relationship between manufacturing performance and mutual influence, while mutual trust affects manufacturing performance mainly through shared knowledge but also in a direct way.

Finally, for the third question our empirical test has demonstrated that:

c. Information technology significantly affects manufacturing performance, and has a less significant effect on shared knowledge, as it mainly influences explicit to explicit knowledge transactions.

In general, we can state that the results adequately fulfill the aim of our study which was to investigate the contribution of shared knowledge and information technology to manufacturing performance.

9.1 Limitations of the Study

Although the study examines a large sample of 112 Manufacturing units and their relationships with the relevant Quality and R&D groups, in a range of 51 firms, representing 5 sectors of very broad span, issues of concern remain, as:

- The development of mutual trust and influence leading to shared knowledge and the influence of information technology are all ongoing phenomena. In our study, these constructs were measured at a static point in time rather than as they developed.
- The study was conducted in Spain. A future multinational study of shared knowledge among diverse organizational groups could probably further support our findings.

We shall come back to these two limitations, using them as a starting point for anchoring our indications for future research.

9.2 Implications for Researchers and Managers

The evaluation model of the contribution of shared knowledge and information technology to manufacturing group performance appears to have implications for both researchers and managers. The findings of this study indicate that Manufacturing, Quality and R&D groups have the opportunity to develop mutual trust and influence through repeated periods of positive face-to-face or IT-based communication, social interaction and common goal accomplishment. Such behavioral features result to increased shared knowledge regarding the groups' common problems, procedures and technologies. They may also make good use of all the information and communication technologies that the company makes available to them in order to facilitate knowledge sharing and to eventually increase manufacturing performance.

In the following sections we shall further analyze these two different, but fully complementary, implications.

9.2.1 Implications for Researchers

During the course of our study, two have been the main sources for the implications for researchers we are presenting in this section. First, from our analysis of the previous empirical studies (section 1.1) we have concluded that efforts should be focused on deciding on the most appropriate method in order to measure the results. It is also important to identify the meaningful measures in relation to both knowledge sharing activities and the information and communication technologies in use. Questions to be answered include, but are not limited to:

- What should be measured?
- What can be measured?
- What are the key performance indicators to be connected with:

- knowledge sharing activities,
- information and communication technologies,

in relation to the researchers effort to capture their contribution to performance? (i.e. growth in sales or market share, profitability, innovativeness, successfulness, etc).

Answering these and similar type of questions may play a very significant role in shaping the future knowledge sharing technologies.

Second, the limitations of our study, listed in section 9.1 above, are leading to two future research indications:

- As mutual trust and influence –within shared knowledge- vary over time, one could possibly investigate the relationship of those ongoing changes to manufacturing group performance, maintaining the same company sample. It would also be interesting to possibly relate the changes noted over time, with actual changes in both the social (mutual trust and influence) and the technical (information technology) subsystems within the organization.
- A multinational study of shared knowledge among varied organizational groups could further support the findings of a national study, like ours.

The directions are given despite the fact that we are fully aware of the difficulties that these two additional parameters of time and multi-nationality are inducing to the future researcher.

Finally we are giving one more generic indication for a future investigation. The shared knowledge and information technology model proposed in our study could be used as a theoretical lens to examine similar organizational relationships (i.e. Manufacturing and Supplies or Marketing groups), or further IT and knowledge-based organizational relationships, in totally different environments.

9.2.2 Managerial Implications

The evaluation model used in our study was tailored to best evaluate the contribution of (a) shared knowledge among Manufacturing, Quality and/or R&D groups, and (b) information technology to the performance of the manufacturing group. As the two partners of the manufacturing group in the relationship under investigation, are heavily related to innovative activities (mainly the R&D group) and competitiveness (primarily the Quality group), these two concepts have also been in the center of our study. The results of our investigation, combined with the historic remark following, will steer us in formulating some guidelines for managers.

In the old times, capital was considered as the company’s most critical resource, and management was concerned with the return of investment in equipment and plants. In the recent past, the mix of business resources (land, capital, and labor) have drastically changed in terms of the relative importance they bear in attaining sustainable competitive advantage. As the 20th century drew to a close, companies guided by a new logic of value tended to consider knowledge as a sort of capital and innovation as a complex process depending on the development of knowledge and the innovative efforts of its employees. Academics and economists have argued that factors like globalization, increasingly strong competition and the growing complexity of new products are the main contributors towards the new reallocation.

Managers, under this new shift, should become aware that the great challenge is settled on investment in knowledge processes -indispensable for a constant flow of innovation- and knowledge workers. They should recognize knowledge and knowledge workers as the company's intellectual capital and a key factor to its sustainable development. In order for the company's intellectual capital not to be under-managed, management putting to practice the main findings of our study should make sure that their subordinates:

- include in their objectives the task to share knowledge and available information with colleagues in collaborating groups;
- are entirely aware of the information technology resources available (special groupware software and equipment).

In doing so their companies will take maximum advantage of the positive contribution that shared knowledge and information technology have to the performance of the manufacturing group. One particular result of our study (only 20,95 percent of the managers and creative workers among the participating companies use groupware software) is a strong indication that there is room for improvement in this field. Combined with other positive findings about information and communication technologies supporting knowledge-sharing (like the e-mail with 86,6%, the Intranets with 71% and the Internet with 42,85%, that all appear to be amply used), indicate that the infrastructures do exist for further improvements.

Management should not underestimate the unique characteristic of knowledge being one of the few assets that grows almost exponentially when shared. As employees from one group share knowledge with colleagues in the collaborating group, the interactive potential of their knowledge grows at an exponential, creating exponential value-added growth. Getting professionals from various groups to share and thus leverage their knowledge capabilities across the boarders of their groups, is one of the most demanding management tasks. In the recent past, companies have tried to force knowledge sharing by putting research and quality labs next to manufacturing and they motivated team work. The findings of our study show that, today, collaborating groups consider IT supported 'networking' techniques to be more useful as knowledge sharing devises.

Building upon both literature findings, as presented in section 4.1, and the results of our study regarding the use of IT functions by 76,4% of the participating companies in facilitating team members to work together, we can conclude that: Management should facilitate the use of IT among the groups in order to improve meeting efficiency and effectiveness. As we have shown in section 4.1.1, use of e-mail or the company intranet can eliminate face-to-face meetings, significantly. Computer conferencing can play an important role in meeting preparations, whenever a meeting is indeed required.

Managers should also be aware that sharing knowledge in a meaningful manner requires a well balanced merge of technology with the company's culture, in a way that creates an environment supporting collaboration. Trust has been identified, through our study, as one of the company's core values. Management has to create a climate of trust in the organization, for knowledge sharing to become reality. In such an environment people from different groups (Manufacturing, Quality and R&D) feel comfortable to seek for others with the 'missing peace of knowledge' to share. As shown by our study, trust is a necessary condition for, and can lead to cooperative behavior among individuals and groups, especially where tacit knowledge has to be shared. It is only in such an environment that the IT made available (groupware software, knowledge repositories or knowledge sharing networks, expert systems) may lead to the production of innovative products.

Despite the high percentages (69,2% to 84,4%) reported in our study for the use of IT functions, managers should not moderate their efforts to ensure that shared knowledge and information technology are best exploited for the four functions they are primarily designed to assist. This will be achieved by:

- Coordinating business tasks and facilitating team work. Thus, most of the factors that unfavorably affect operating efficiency among the three groups may be eliminated. Sharing knowledge is a sort of response to changes in both the external environment and internal situations, while information technologies do improve the horizontal, inter-group flow of information, necessary to improve the collaborative relationship.
- Supporting decision making processes. In their effort to make better decisions, knowledge workers have the option to search for accurate information usually possessed by their collaborators in another group. Implementing decision systems –based on IT and KM- will allow employees to capitalize on opportunities and to defend the group against threats already recognized in one of the collaborating groups.
- Facilitating access to information in Data Bases, collaborating knowledge workers improve their intellectual skills and may use the accumulated experience to increase manufacturing performance

Two issues that have not been addressed by our study, appear to be of particular importance in the relevant literature. First, education and training have definitely a positive role to play. Second, there are factors like the 'resistance to change' and 'barriers to communication' that may possibly affect in a negative way both shared knowledge and manufacturing group performance. The role of middle level and senior management in reinforcing positive and eliminating negative aspects is, once again, essential. More specifically, as the ability of knowledge workers to cooperate and make good use of available information technology is highly related to their educational background, management in competitive environments has a new task: to make sure that the work force –and especially knowledge workers- have the best possible education and training at any time. There is definitely a cost involved here, but considering the constructive effects on motivation, an important parameter in knowledge-based environments, the overall balance appears positive. Well designed training courses, building heavily on information technology, contribute to reawaken previously acquired knowledge and provide an answer to the company's need for skilled knowledge workers geared up to collaborate for the development of innovative solutions.

Finally, senior management has also a very important role to play. Senior executives have the difficult task to manage the middle-level managers in an effort to minimize the negative effects due to:

- Resistance to change: Up until very recently, Manufacturing, Quality and R&D managers have been traditionally perceived as gatekeepers of the group's information and knowledge. Under the new perspective they are now concentrating on helping 'their people' share their knowledge with their collaborators 'outside' the group.
- Barriers to communication can be structural ones due to the hierarchical organization into groups, departments, divisions, etc, spread over different companies operating in different countries, as well as language and cultural barriers. It is senior management responsibility to dismantle all of the above barriers, artificially created by human intervention.

Factors that help eliminate such negative effects may include joint training on interdependent tasks, joint planning sessions and formation of cross-functional teams. In addition, strategic rotation –the temporary movement of managers from one group to another- can lead to mutual trust and influence, the true antidote to both resistance to change and barriers to communication.

We have included this section with guidelines to managers deriving from the extensive review of the relevant literature and the results of our investigation, with the target to contribute to a better understanding of the consequences of a new management orientation capable of leveraging shared knowledge and information technology advantages to the benefit of the manufacturing performance. We strongly believe that it is the task of management to improve the channels for knowledge to be shared among Manufacturing, Quality and R&D groups, by selecting the information technologies that best fit the innovative efforts and competitive strategy of their organization. It is imperative for both senior and middle-level management to succeed in this task, so that the company benefits to the utmost from all the investment in information technology for sharing knowledge.

9.3 Collateral Results Achieved

In addition to the results already mentioned, the following collateral results have been achieved, at a departmental and personal level during the course of the Doctoral Thesis:

- We have contributed with new dynamics of Knowledge Management to the development of the investigation line of Information Systems (code num. 5311990200) of the *Departamento de Organización de Empresas* of the UPC.
- We have completed the scientific, investigatory and educational assignment of the Doctorate candidate.

In this second direction, and in collaboration –in most cases- with the Director of the Thesis four papers have been presented in two national and two international conferences:

a) A paper has been presented in the 8th Congress of AIM (Association of Information and Management) in Grenoble, France, May 22-23, 2003.

b) A first working paper has been presented at the *1a Jornada de SOCOTE (Soporte del Conocimiento con la Tecnología)*, an inter-university research project, in Valencia, June 13th, 2003.

c) A paper has been presented at the 3rd NHIE 2003 Conference (New Horizons in Industry and Education) in Santorini, Greece, August 28-29, 2003 and has been published in its proceedings.

d) A second working paper (Research in Progress) has been presented in the *2o Congreso de SOCOTE (Soporte del Conocimiento con la Tecnología)*, in Santander, May 21-22, 2004.

The abstracts of these papers are presented in Appendix 9, at the end of this chapter.

9.4 Summary

In this chapter the conclusions of our investigation have been presented together with some recommendations for future research. First, we have analyzed the limitations of our study.

Second, we have presented the implications of our study for researchers and, starting with the study's limitations, we have given three directions for future research. We have also presented a number of essential implications for management deriving directly from the results of our study.

Finally, we have referred to the four papers that have been presented in two national and two international conferences, during the course of the Doctoral Thesis.

APENDIX 9

Abstracts of Presented Papers

How companies plan in practice their information systems on a strategic level: an exploratory survey

Piercarlo MAGGIOLINI
Professor
Politecnico di Milano
Piazza L. da Vinci 32. I - 20133 Milano
Tél. +39 031 332 75 11 **piercarlo.maggiolini@polimi.it**

Haris PAPOUTSAKIS
Associate Professor
Technological Educational Institute of Crete
P. O. Box 140, GR – 711 10 Heraklion
Tél. +30 81 379 327
harispap1948@yahoo.com

Ramon SALVADOR VALLÈS
Professor Titular
Universitat Politècnica de Catalunya
Av. Diagonal 647. E - 08028 Barcelona
Tél. +34 93 401 60 61
rsalvadorvalles@yahoo.com

Abstract

The strategic planning of information technologies and information systems (SISP) has become a key factor in the management of companies in many industries. Companies need to improve the profitability of investments in information technologies and information systems (IT/IS), as well as guarantee integration and coherence among the portfolio of applications and strategic targets of the company.
In this paper we present the preliminary findings of our research into SISP carried out within 25 companies. This research has enabled us to observe that the SISP approaches taken are mainly those of alignment of IT/IS with respect to the objectives of the companies. Most of the methodologies used for these approaches have been adapted from existing standard methodologies. Those responsible for the planning affirm that the methodologies used are especially useful in satisfying the information needs of the companies and in optimizing the resources in IT/IS.
We were also able to ascertain that the participation of the IS manager in the business strategic planning and the participation of senior and functional managers in the SISP process have had a positive effect on the level of planning implementation, and in the level of satisfaction of the users.

Key-words: Information Systems, Information Technology, Strategic Information Systems Planning

Full paper available on the AIM site http://www.aim2003iut2.upmf’grenoble.fr/

Towards a Taxonomy of Knowledge, Intellectual Capital and their Management based on Information Technology

Haris Papoutsakis[1], Ramon Salvador Vallès[2]
[1]Assistant Professor, TEI of Crete, P.O. Box 140, GR-71110, Heraklion, Crete, Greece, harispap1948@yahoo.com
[2]Profesor Titular, Universitat Politècnica de Cataluña, Av. Diagonal 647, E-08028 Barcelona, rsalvadorvalles@yahoo.com

ABSTRACT

This paper presents the results of research on the basic concept and proper definition of what constitutes Knowledge and Intellectual Capital Management. It further focuses on the use of IT in these processes within the firm.
Establishing clear and precise definitions of the concepts used in research work is of obvious importance. This is especially true in this particular case because of the novelty of the discipline under investigation.
Knowledge Management and Intellectual Capital Management together with the integration of IT systems with the firm's business processes have spurred renewed interest in a field that, for many, is destined to play a key role in the way companies compete with each other.

Key-words: Knowledge, Intellectual Capital, Information Technology.

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SAP at INTRACOM: A Strategic IT Adoption and a Knowledge Management Project Based on the Company's Intellectual Capital

Haris Papoutsakis
Electrical Engineering Department
Technological Educational Institute of Crete
Heraklion, Crete, Gr-71500 GREECE
harispap1948@yahoo.com

Ramon Salvador Vallès
Departamento de Organización de Empresas
Universidad Politécnica de Catalunya
Av. Diagonal 647, E-08028 Barcelona, SPAIN
rsalvadorvalles@yahoo.com

Abstract: INTRACOM is the largest Telecommunication and Information Systems manufacturer in Greece, with a strong international presence. The company has three manufacturing facilities in Paiania, Attica, Greece, interconnected with seven warehouses. In 1997, initially aiming at improving its incoming components warehouse, INTRACOM began installing an Enterprise Resource Planning system (ERP, a carousel based system) in its warehouse, and soon after (by the end of 1998) its own Informatics Division developed ESTIA, an Oracle based Warehouse Management System, which has ever since been considered a strong intellectual asset for the company. Early in 2001 INTRACOM's management decided to install a customized version of SAP, based on the SAP Version 4.6 and, at the same time, incorporate all the essential futures of ESTIA. The project was successfully implemented in January 2002.
The paper discusses the various implementation phases, implications, strategic benefits and drawbacks of integrating SAP from INTRACOM's prospective. Special emphasis is given at the two parallel Knowledge Management projects, designed and implemented by both SAP specialists and INTRACOM's staff (the so called Key-Users) in order to manage the new knowledge acquired and train a total number of 700 INTRACOM's employees (the End-Users). It also highlights future development opportunities, as additional modules (subsystems) are being integrated into the system, as well as the company's envisions regarding its warehouse management.

Keywords: Information Technology (IT), Store's Automation, Strategic Management, Intellectual Capital, Knowledge Management.

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The Contribution of Shared Knowledge between Manufacturing, R&D and Quality Groups to the Performance of the Manufacturing Group.

Haris Papoutsakis, harispap1948@yahoo.com, TEI of Crete, Greece

Abstract
The article is a report of the research in progress for a Doctoral Thesis under a similar title, which investigates the concept of Shared Knowledge, between Manufacturing, R&D and Quality groups, as a key contributor to the manufacturing group performance with the support of the emerging Information Technologies. In addition the Global Economy environment and its influence upon the so called Society of Knowledge are key parameters in this study. In its five main sections, after defining the problem and setting up the theoretical framework, the expected results are highlighted and the investigation hypotheses and methodology are presented.

First, the Investigation Problem is defined: To investigate the concept of Shared Knowledge, between Manufacturing, R&D and Quality groups, as a key contributor to manufacturing group performance. The increasing importance of the emerging Information Technology (IT) in the so called Society of Knowledge and the Global Economy environment, are key parameters in this study. Second, the theoretical framework is set and the ambiguous relationship between Information Technology and Performance is analyzed. Third, the results that are expected by the end of the investigation are presented and a first evaluation of their worth, both in the Investigation as well as in the Business Management areas, is provided. Fourth, the Investigation Hypotheses are presented in concurrence with the adopted model of Shared Knowledge and its antecedents –Trust and Influence. This model is the basis upon which the Hypotheses are contrasted. Fifth, the Investigation Methodology is described. The Research Framework, the Measurement Phases, the tools to be used and the methods anticipated for the Data Analysis are exposed. Finally, due to the fact that the investigation is still under progress, some preliminary conclusions are drawn and some suggestions for future research are pointed out.

Keywords: Shared Knowledge, Information Technology, Manufacturing group Performance.

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(WEB-02) www.terra.es/personal17/jm_viedma/ekmedefiniciones.htm
(Profesor José M. Viedma of UPC, who is proposing a number of Web sites, Publications, Associations, etc, related to KM)

http://knowinc.com/knowledgeshop/sitemap.htm = Knowledge shop. A virtual store that offers products related to Knowledge Management and Intellectual Capital.

http://www.brint.com = It is an organization dedicated to the competitive development of companies. It contains a series of resources regarding the administration of companies where the ones committed to Knowledge Management and Organizational Learning can seek consultation.

http://eknowledgecenter.com = Centre dedicated to Knowledge Management. It contains a certification program, a research centre for Knowledge Management, links, international conferences, etc.

http://www.knowledgemedia.org/ = Swiss centre dedicated to the investigation of the area of Knowledge Management.

http://www.knowledgebusiness.com =Bookstore for Knowledge Management that offers links, publications and an interesting research tool search.

http://www.webcom.com/quantera/welcome.html = It offers a series of resources related to Knowledge Management and Intellectual Capital.
http://knowinc.com = It offers tools and methodologies for the management of intangible assets.

http://gutenberg.com/millennium/knwsite.html = It contains a series of references regarding Intellectual Capital and Knowledge Management

http://www.knowledge.org.uk = It is dedicated to Knowledge Management. It contains articles and information on the “gurus”, associations, links etc.

http://www.eu-know.net = It is a virtual networking on intangible assets founded by the commission of the EU and developed by investigators of 9 different European countries.

Journals and Publications

Journal of Knowledge Management: http://www.emerald-library.com
Scientific magazine with top publications on Knowledge Management.

Journal of Systematic Knowledge: http://www.free-press.com
Online scientific magazine with publications on Knowledge Management.

Associations & Institutions

American Productivity & Quality Center: http://www.apqe.org/
Innovation Research Center-McMaster: http://irc.business.mcmaster.ca/
Society of Management Accountants of Canada: http://www.cma-canada.org

OECD: http://www.oecd.org

Research centre, of the scientific Park of Madrid, on the Society of the Knowledge (CIC) that has as a task the development of the area of Knowledge Management: http://wwwforodelconocimiento.com/

Dintel Foundation. A lobby for Information Technologies and communications: http://www.fundación-dintel.org

Cluster of Knowledge: http://www.clusterconocimiento.com
ICTNET: http://www.ictnet.es

And the web: gestiondelcapitalintelectual.com that has been selected as a novelty by the *Instituto Catalán de la Tecnología.*