Track n. 2: DOES IT MATTER? The organizational impact of information systems

Titolo paper: Does ICT really influence coordination mechanisms?

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DOES ICT REALLY INFLUENCE COORDINATION MECHANISMS?

1. Introduction

The extended use of ICT systems exerts an increasingly stronger influence on the best practices and positive government criteria of any enterprise. This phenomenon has generated a growing need for coordination systems capable of managing the complexity caused by it. In literature, the subject of how the activities of complex systems can be coordinated has been considered by several organization theorists (Barnard, 1964; Thompson, 1967; Galbraith, 1977; Williamson, 1975; 1985; Ciborra, 1987; Malone, Crowston, 1994).

Many different definitions of the concept of coordination have been given. Malone and Crowston (Malone, Crowston, 1994) have published a list of definitions that have been proposed for this word. Among these, the most appropriate one for this work is the following: coordination is managing dependencies between activities.

Several scholars have given their contribution in considering the impact of ICT on organizational changes simply caused by a growing use of information systems (Thompson, 1967; Galbraith, 1977; Mintzberg, 1979; Markus, Robey, 1988; Zubov, 1988; Rokart, Short, 1989; Orlikowski, 1992).

As a consequence, it is necessary to control the cost of coordination. In this sense, three different consequences can be considered to reduce these costs: human coordination can be substituted by ICT systems; the increased complexity resulting from the use of ICT systems requires increasingly more coordination; as a consequence of the above two aspects, a huge amount of intensive coordination structures might be needed in order to reduce coordination costs (Malone, Crowston, 1994).

This research focuses on the development of the concept of coordination intended as managing dependencies between activities using ICT systems. In particular, the focus of this work is on the following kinds of activities included in two classes of processes: 1) Decisional processes: support to

decision-making, decisional decentralization and reduced centralization of information power; 2) Collaboration processes: internal communication and knowledge sharing and diffusion. Improving all the activities of these two main processes implies the ability of organizations to create efficient and effective coordination mechanisms, which allow them to reach their objectives and better operate in a competitive context.

The research question of this study aims at verifying if ICT Systems, in this specific case, Business Intelligence Systems (BISs), are actually able to strengthen the existing coordination mechanisms, i.e., make them more efficient and less costly.

This article is organized as follows. Section 2 introduces the coordination concept and the proposed theoretical framework, Section 3 presents the coordination concept in terms of decisional processes and collaboration processes, Section 4 analyzes the coordination and decisional support in recent literature with the emerging role of Business Intelligence Systems. The research question and the research methodology are presented in Section 5, while findings, conclusions and directions for future research are discussed in Section 6.

2. Coordination: a theoretical framework proposal

Coordination can be achieved by different methods, which in turn affect and differently characterize the organizational solutions adopted by the enterprises.

Coordination may play a key role in the harmonization of the various activities set up by a company and the governance of the interdependencies that develop between the various actors, thus contributing to improve the company competitiveness. Therefore, the ability of organizations to create coordination mechanisms able to sustain and increase the efficiency and effectiveness of the relations between the various business units, which interact and cooperate to reach organizational objectives, becomes particularly critical in a competitive context.

Coordination can be examined by means of market, hierarchies or mixed hybrid forms. Following this theoretical approach, the Transaction Costs Theory (Coase, 1937; Williamson, 1979; 1985) deals with the governance of transactions and economic activities in terms of market and in-

ternal organization. In the market, activities are coordinated through the pricing system, while in internal organization this is dismissed and substituted by mechanisms of bureaucratic control. The choice of a particular type of organization is motivated by the search for maximum efficiency.

Several disciplines have contributed over the years to the creation of a coordination theory, by means of computer science and economics and operations research. In this contribution, we will only consider the point of view of the organizational theory. With reference to disciplines like sociology and psychology, several scholars (Galbraith, 1977; Lawrence, Lorsch, 1967; March, Simon, 1958; Simon, 1976; Thompson, 1967) have studied in depth the concept of coordination in terms of how the activities of people can be coordinated in formal organizations (Malone, 1990; Mintzberg 1979; Malone, Crowston, 1994).

When several actors are involved, all the activities to be carried out must be imputed to a different actor. This requires management of the interdependencies between activities. Thompson (Thompson, 1967) has described three types of interdependencies between activities: pooled, sequential and reciprocal. All these types of interdependencies can be conducted by means of different coordination mechanisms, such as mutual adjustment, direct supervision and standardization of processes, outputs and capabilities (Galbraith, 1973; 1977; March, Simon, 1958; Mintzberg, 1979).

As complexity and specialization increase, the coordination mechanisms developed within the organizations may prove more efficient than market governance mechanisms. Coordination is managing dependencies between activities.

The focus of this work is on the following kinds of activities included in two classes of processes: 1) Decisional processes: support to decision-making, decisional decentralization reduced centralization of information power; 2) Collaboration processes: internal communication and knowledge sharing and diffusion. Improving all the activities of these two main processes implies the ability of organizations to create efficient and effective coordination mechanisms, which allow them to reach their objectives and better operate in a competitive context.

These assumptions are the basis of the theoretical framework proposed in this paper: efficient and effective coordination mechanisms can be reached by improving the activities defined above. This causes reduced

costs of coordination mechanisms and consequently reduced organizational complexity.

In Figure 1, the proposed theoretical framework is explained.

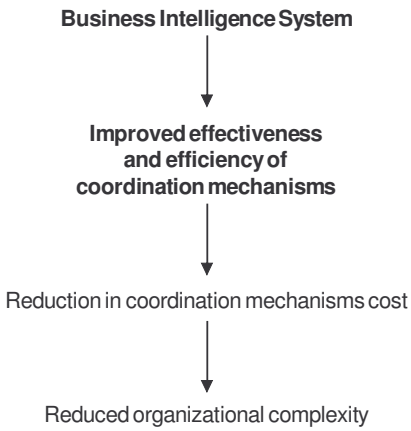

Fig. 1: The proposed theoretical framework

3. The concept of coordination in terms of decisional processes and collaboration processes

The aim of Collaborative Decision-Making is the study of how progress can be made in decisional processes within groups when several decisional alternatives are available. These decisional processes can be structured or unstructured. In this work, the objective is to find new modalities by means of which it is possible to adopt ICT, in this specific case BIS, to obtain formal decisional processes in a context where these decisional processes are not easily structurable.

From the point of view of literature, a leitmotif is that of Computer Supported Cooperative Work and Group Support System (Raghu *et al.*, 2001).

In this session, the first objective is to analyze the literature on the relationship between coordination and decision-making, along with aspects relative to decisional decentralization and reduced centralization of information power. The subject of collaboration processes will then be enlarged.

In the field of coordination and decision-making, studies have concentrated on specific domains such as Computer Supported Cooperative Work (CSCW) and Group Support System.

The concept of CSCW has imposed as a research discipline as ICT became increasingly more relevant (Bowers, Benford, 1991; Goldberg *et al.,* 1992).

In literature, the term "groupware" can be considered a specific type of computer-based system to support collaborative work (Johnson-Lenz, Johnson-Lenz, 1982; Ellis, Gibbs, Rein, 1991, Greenburg, 1991; Grief, 1988). Moreover, this type of computer system is defined as Group Support System.

In a well-known paper published in 1987 and named "A Foundation for the Study of Group Decision Support System", DeSanctis and Gallupe gave a literary contribution to the research in this field. The concept is defined as a combination of "communication, computer and decision technologies to support problem formulation and solution in group meetings" (DeSanctis, Gallupe, 1987).

Comparing the two terms – GSS and GDSS – the former can be considered a more general and comprehensive concept than the latter. GDSS entails the concept of decision room, while GSS can be used at several stages and types of work group. GSS can be considered a particular combination of communication mode, tools and structuring of process by means of a facilitator or procedural instructions (Hiltz et al., 2001).

The study in the field of decisional decentralization and reduced centralization of information power is related to the research on the optimal design of organizations. In this area, an important role is played by the costs of communication and information processing (Markus, Robey, 1988). An important role is played by the technological aspects of this question (Calvo, Wellisz, 1978, Rosen, 1982; Waldam, 1984; Sah, Stiglitz, 1986; Geanakoplos, Milgrom, 1991; Radner, 1993; Bolton, Dewatripont, 1994).

In past literature, an analysis of decentralization had been done comparing unitary U-form versus multidivisional M-form by Chandler (Chandler, 1962) and Williamson (Williamson, 1975). The study of Chandler confirmed that when a U-form grows (enlarges), it risks becoming inefficient due to a loss of control on the part of the top management. In this case, the

solution becomes a more efficient and less centralized M-form organization.

According to Aoki, decentralization should be more prevalent if a quick response to changing technologies and environment is required, even if centralization may have beneficial coordination effects (Aoki, 1986; Zabojnik, 2002).

In this area, Malone and Smith (Malone, Smith, 1988) studied different alternative coordination mechanisms, developing a formal model to represent forms of markets, centralized and decentralized, and forms of hierarchies, based on products and functions (Malone, 1987; Smith, Davis, 1981; Malone, Crowston, 1994).

In the second part of this section the concepts of collaboration, internal communication, knowledge sharing and diffusion are analyzed.

Considering the large number of definitions of collaboration, some scholars have underlined the fact that collaboration is a knowledge-based process and therefore collaboration is a process that is led by knowledge, makes use of knowledge and has a knowledge-rich outcome (Simonin, 1997). Therefore, peculiar skills such as acquisition, selection, internalization, generation and externalization of knowledge are essential (Holsapple, Joshi, 2002; Hartono, Holsapple, 2004). The purpose of Computer-based systems is exactly to allow and facilitate these types of activities (Tsui, 2003). BIS technology emphasizes all these aspects.

4. Coordination and Decision Support in recent Literature: the emerging role of Business Intelligence Systems

Over the last three decades, the systems that support decision-making have been discussed extensively in the literature on information systems. These discussions began with a class of systems called Decision Support Systems, and, over the years, research has yielded a common definition of Decision Support System (DSS) and the components that constitute it (Ariav, Ginzberg, 1985; Cats-baril, Huber, 1987; Coyle, 1977; Eom, 1998; Gorry, Scott Morton, 1971; Goslar et al., 1986; Sanders, Courtney, 1985; Sprague, 1980). However, other types of systems that support decision-making processes have also been developed to meet the ever increasing decisional needs (Arnott, 2004; Arnott, Pervan, 2005). Some of these sys-

tems, however, are quite close to the original DSS concept, although they expand it to incorporate a broader set of users and a wider variety of decision-making (Clark et al., 2006).

Business Intelligence Systems are included in DSS (Alavi, Leidner, 2001; Anderson-Lehman et al., 2004; Lee, Choi, 2003; Rouibah, Ould-ali, 2002; Schultze, Leidner, 2002): they provide significant access to data, information or knowledge that can be specific to the needs of individuals or groups and also the ability to "roll up" these elements to support broader organizational decisionmaking needs (Anderson-Lehman et al., 2004; Kanhankalli et al., 2005, Massey et al, 2002).

Clark et al. (Clark, 2007) place Business Intelligence Systems (BIS) within Management Support Systems (MSS), intended as managerial support systems and decision-making activities (Scott Morton, 1984).

MSSs continue to evolve and are fueled by technology improvements coupled with the ever increasing organizational needs for the type of support to decision-making that MSS provide (Clark et al., 2007).

BISs allow users to carry out more sophisticated data analyses thus enhancing their ability to learn and make decisions (Clark et al., 2007).

BISs enable organizations to generate knowledge about their environments through extraction from existing knowledge (Gold et al., 2001). Much of this knowledge is acquired from, and applied through, the knowledge of individual users (Grover, Davenport, 2001). BIS' usability is the quality of the interaction between users and the system (Keen, 1980b). It is largely driven by the ease with which users can dialog (interface) with the system (Houdeshel, Watson, 1987; Kottermann, Remus, 1989). However it also depends on the ability of users to effectively elicit the desired information from the BIS (use of multiple analysis tools) and users' knowledge (Steiger, 1998).

Despite the increased emergence of new technology, there is still a gap between what is available in the marketplace and the ability of organizations to acquire or leverage the technology into an effective system (Malhotra et al., 2002; Zahra, George, 2002).

The aim of a BIS consists of easing the improvement of decision-making for a broader set of users. This improvement is achieved with the ability to increase previously acquired knowledge through the use of the system on the part of users.

Improving the decision-making process implies a decisional decentralization, a reduction in the information centralization, better internal communication and collaboration, and knowledge sharing and diffusion.

Organizations succeed in understanding and using BISs, which are becoming strategically important for enterprises.

However, from an in-depth analysis of organizational implications, a misalignment is being observed between the potential offered by these systems and their actual use, especially in order to set in motion processes of knowledge sharing and diffusion. (Kankanhalli et al., 2005).

This paper focuses on the role played by ICT, in particular Business Intelligent Systems (BISs) in supporting coordination mechanisms as detailed in the proposed theoretical framework (Figure 2).

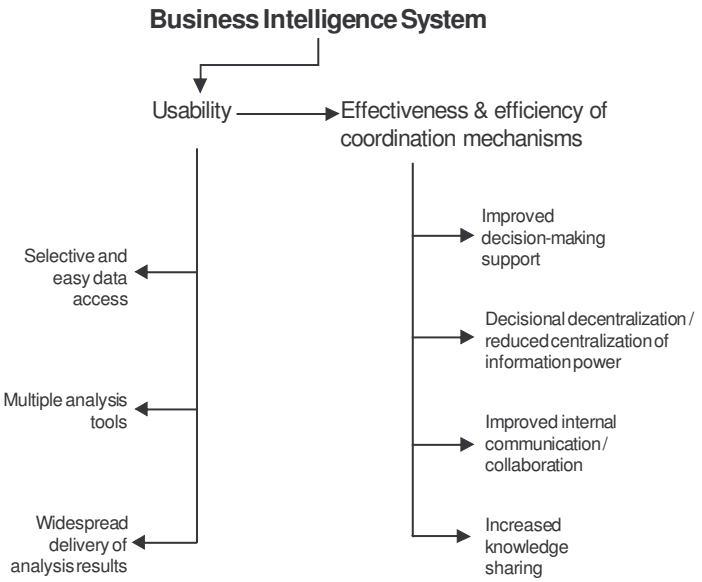

Fig. 2: Business Intelligence Systems and coordination mechanisms.

5. The Research Question and the Research Methodology

The question of this research aims at verifying if such awareness is disappearing and therefore if BI systems are actually able to strengthen the ex-

isting coordination mechanisms, i.e., make them more efficient and less costly, since they reduce company complexity.

The research methodology (Walsham, 1995; Yin, 2003) is a survey (empirical research) carried out on a sample of thirty enterprises located in Northern Italy and characterized by the use of a BI system by a large number of users (from top management to operational levels).

The reference sample of the research includes 180 enterprises selected according to a criterion of heterogeneity in terms of industry and size, in order to highlight any differences and/or organizational dynamics in the use of the BISs in specific industries.

The investigation started in January 2007, when the research object and the subjects to be interviewed were identified. Later on, between early March 2007 and late July 2008, the selected enterprises were contacted.

Out of 180 companies contacted on the phone, 83 have accepted to be interviewed (46% of the sample).

The survey was carried out by means of a phone interview with the IS Manager based on a questionnaire. The first question allowed to identify the companies that had been using a BIS for at least a year. The rest of the analysis was carried out in relation to these companies only, which were 30 (36% of the entire sample).

Despite the small number, these companies are in any case heterogeneous in terms of industry and size, as required for the analysis. As for industry, the sample is made as follows: 8 in Manufacturing, 5 in Services, 4 in Trade and Distribution, 3 in Chemical/Pharmaceutical, 3 in Food, 2 in Textile/Clothing, 2 in Healthcare, 2 in Automobile, and 1 in Public Administration.

The size is expressed by the turnover in the year 2006 (37% over 500 million Euros, 10% in the range of 251-500 million Euros, 23% in the range of 101-250 million Euros, 13% in the range of 51-100 million Euros, 7% in the range of 11-50 million Euros). The questionnaire contained questions relative to the following variables:

- implementation time of the BI system (1 to 3 years, 3 to 5 years, over 5 years),
- technical/application functions given by the usability of the system by the users at all levels of the organization (selective and easy data access, multiple analysis tools, widespread delivery of analysis results),

– factors affecting coordination intended in terms of collaboration, which in turn is a prerequisite for better knowledge sharing: improved support to decision-making, decentralization of decisional power, reduced centralization of information power, improved communication.

Answers to the questions were given using a Likert scale, in which 1 was equivalent to the lowest and 5 to the highest, in order to guarantee homogeneity and easy interpretation and analysis of questionnaires. A univariate analysis of descriptive statistics was carried out. For each variable the following was calculated (Table 1):

– position indexes (mean, mode and median),
– variation indexes (standard deviation and variation coefficients),
– percentiles.

Four macro variables were defined for the variables inherent in the factors affecting coordination.

Tab. 1: Univariate analysis of descriptive statistics

	Mean	Median	Mode	Standard deviation	Min.	Max.	Percentiles		
							25	50	75
Years of use of BIS	2,17	2,50	3	0,913	1	3	1,00	2,50	3,00
FR1*	4,593	4,700	4,8	0,9240	2,6	6,0	3,800	4,700	5,050
FR2*	4,140	3,800	3,8	1,2386	1,2	6,0	3,550	3,800	5,000
FR3*	4,387	4,600	5,0	0,8220	2,6	5,8	3,600	4,600	5,000
FR4*	4,367	4,400	4,8	0,8535	2,8	6,0	3,750	4,400	4,800
FR5*	4,133	3,800	4,8	1,0175	2,2	6,0	3,550	3,800	4,800
CR1**	3,3833	3,3333	3,00	0,70187	2,00	5,00	2,9167	3,3333	4,0000
CR 2**	3,6733	3,6000	3,20	0,65768	2,40	5,00	3,2000	3,6000	4,0625
CR 3**	10,9000	11,0000	12,00	3,55596	4,00	19,00	9,0000	11,0000	12,2500
CR 4**	17,4667	18,0000	19,00	3,83031	8,00	24,00	15,000	18,0000	19,2500

** Answers relative to technical/application functions*

***Answers relative to factors affecting coordination (each answer comprises several sub-answers: the value used to calculate the various indexes corresponds to the mean calculated from the values of each sub-answer)*

Furthermore, the same indexes were calculated for the three groups corresponding to the years of implementation (Table 2).

Tab. 2: Univariate analysis of descriptive statistics stratified over the years of implementation of the Business Intelligence System

Years of implementation of the BIS			FR1	FR2	FR3	FR4	FR5	CR 1	CR 2	CR 3	CR 4
1 to 3 years											
	Mean		4,280	3,900	4,060	4,060	3,740	3,266	3,385	10,400	16,500
	Median		4,600	3,800	4,000	4,000	3,700	3,166	3,200	10,500	17,500
	Mode		4,600	3,8(a)	3,4(a)	4,0(a)	3,6(a)	3,00	3,20	9,00	18,00(a)
	Std. Deviation		0,870	0,737	0,542	0,718	0,794	0,466	0,503	2,412	3,503
	Minimum		2,600	2,600	3,400	3,000	2,200	2,670	2,800	6,000	11,000
	Maximum		5,600	4,800	5,000	5,400	4,800	4,330	4,250	15,000	22,000
	Percentiles	25	3,600	3,350	3,550	3,500	3,300	3,000	3,000	9,000	12,750
		50	4,600	3,800	4,000	4,000	3,700	3,166	3,200	10,500	17,500
		75	4,850	4,650	4,600	4,600	4,600	3,416	4,000	12,000	19,000
3 to 5 years											
	Mean		4,360	4,280	3,800	4,400	4,360	2,933	3,520	10,400	18,000
	Median		4,200	3,800	3,600	4,400	4,200	2,666	3,400	12,000	18,000
	Mode		3,8(a)	2,8(a)	4,800	4,800	3,4(a)	2,670	3,200	12,000	17,000
	Std. Deviation		0,517	1,293	0,979	0,424	0,973	0,4346	0,363	2,880	1,000
	Minimum		3,800	2,800	2,600	3,800	3,400	2,670	3,200	6,000	17,000
	Maximum		5,000	6,000	4,800	4,800	5,800	3,670	4,000	13,000	19,000
	Percentiles	25	3,900	3,200	2,900	4,000	3,500	2,666	3,200	7,500	17,000
		50	4,200	3,800	3,600	4,400	4,200	2,666	3,400	12,000	18,000
		75	4,900	5,600	4,800	4,800	5,300	3,333	3,900	12,500	19,000
Over 5 years											
	Mean		4,880	4,253	4,800	4,560	4,320	3,611	3,916	11,400	17,933
	Median		4,800	4,800	5,000	4,800	4,800	4,000	3,800	11,000	19,000
	Mode		6,000	3,8(a)	5,000	4,800	4,800	4,000	3,40(a)	11,000	13,00(a)
	Std. Deviation		1,013	1,512	0,744	1,009	1,140	0,8301	0,751	4,420	4,605
	Minimum		2,600	1,200	3,400	2,800	2,200	2,000	2,400	4,000	8,000
	Maximum		6,000	6,000	5,800	6,000	6,000	5,000	5,000	19,000	24,000

	Percen-tiles	25	4,000	3,600	4,400	3,600	3,600	3,000	3,400	7,000	15,000
		50	4,800	4,800	5,000	4,800	4,800	4,000	3,800	11,000	19,000
		75	6,000	5,600	5,000	5,600	5,000	4,000	4,600	15,000	22,000

(a) Multiple modes exist. The smallest value is shown.

Two non-parametric tests were then elaborated, namely, the Kruskal-Wallis test and the median test, in which the implementation time of the BI system was considered as a grouping variable, in order to identify the statistical significance of the potential relations between the BI system and the analyzed variables relative to both usability and coordination.

6. Findings and conclusions

The answers to the questions on technical/application functions given by the usability of the system by the users at all levels were overall unanimous (variation coefficients are minimal values) and in the high range (weighted average higher than 4, from 4.140 to 4.593).

Considering the implementation time of the system, the values slightly increase as the number of years increases. Overall it is fair to say that the technological potential of the BI system has been recognized by the respondents. The answers to the questions relative to the factors affecting coordination show average values (weighted average) varying around 3 and variation coefficients of about 0.3. These answers are not as unanimous as those regarding technological/application functions. However also in this case the trend improves as the implementation time of the system increases.

According to the respondents, therefore, the system generates a few positive effects on coordination, although with less relevance with respect to the technological potential. It should be noted that based on the Kruskal-Wallis and median tests, statistically relevant relations that can provide a valid answer to the research question have been found only for a few analyzed variables. Kruskal-Wallis test: 3 variables, one for the relation between technical/application functions and usability and two macro variables relative to the factors affecting coordination, show a statistically significant value (lower than 0.05), while other 3 variables are only marginally significant (higher than 0.05, but lower than 0.1; table 3).

Tab. 3: Kruskal-Wallis test

	Chi-Square	Df	Asymp. Sig.
FR1	3.608	2	0.165
FR2	1.756	2	0.416
FR3	8.375	2	0.015
FR4	2.332	2	0.312
FR5	2.357	2	0.308
CR1	4.651	2	0.098
CR2	4.750	2	0.093
CR3	.632	2	0.729
CR4	1.138	2	0.566

Median test: 1 variable (relation between technical/application functions and usability) shows a statistically significant value (lower than 0.05), while only one macro variable is marginally significant (higher than 0.05, but lower than 0.1; Table 4).

Tab. 4: Median test

	N	Median	Chi-Square	Df	Asymp. Sig.
FR1	30	4.700	3,467(a)	2	0.177
FR2	30	3.800	,536(b)	2	0.765
FR3	30	4.600	9,777(b)	2	0.008
FR4	30	4.400	2,277(b)	2	0.320
FR5	30	3.800	1,741(b)	2	0.419
CR1	30	3.3333	5,000(c)	2	0.082
CR2	30	3.6000	2,277(b)	2	0.320
CR3	30	2.7500	1,357(d)	2	0.507
CR4	30	3.6000	1,357(d)	2	0.507

(a) 2 cells (33,3%) have expected frequencies of less than 5. Minimum expected cell frequency is 2.5.

(b) 3 cells (50,0%) have expected frequencies of less than 5.Minimum expected cell frequency is 2.3.

(c) 3 cells (50,0%) have expected frequencies of less than 5. Minimum expected cell frequency is 2.0.

(d) 3 cells (50,0%) have expected frequencies of less than 5. Minimum expected cell frequency is 2.2.

Both tests confirm the same results. A relation has been found between the BI system and:

- the technical/application aspects relating only to a quick data availability,
- the effects on decisional decentralization, improved support to decision-making and improved internal communication.

The results of the research show how these are mainly considered as technological tools, with little relevance being attributed to their potential in terms of facilitators of coordination mechanisms between actors.

The peculiarities of the system, such as usability at all company levels, have been recognized as factors enabling data access and analysis, especially in terms of speed.

Expressing a positive opinion on strictly technological aspects does not imply however the expression of a positive evaluation regarding more effective and efficient coordination mechanisms.

The use of the system generates effects on organizational coordination mechanisms, such as greater decisional decentralization and improved support to decision-making and internal communication. However, these influences are not particularly significant.

The system does not contribute to enhance knowledge sharing and diffusion, despite early expectations.

It has been observed therefore that the system users fail to take advantage of the opportunities offered by the technology in terms of a better collaboration through knowledge sharing, motivated by the results of the data processing carried out using the Kruskal-Wallis and median tests.

However we are aware of the limited extent of the empirical research carried out.

It is necessary to expand the sample of the companies and to add other variables that are more related to the soft components of the organizations, since the role of users is always decisive for the purpose of a successful implementation of an ICT-based system.

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