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INTER-ORGANIZATIONAL PERFORMANCE AND BUSINESS PROCESS MANAGEMENT IN COLLABORATIVE NETWORKS

Abstract*. In the global economy, collaboration is no longer an option but a requirement for the organizations that want to achieve and maintain the competitive advantage on the market. The society based on knowledge and innovation, globalization and increased competition are the stimulating factors for switching from a traditional organization to an extended organization and further to the organization connected into a collaborative network. The organization networks have many advantages but also face challenges and problems mainly linked to the complexity of the collaborative environment. One of the main challenges of the organization networks is raised by the inter-organization processes. The complexity of these collaborative processes makes them difficult to model and represent them in a form that can be understood by electronic computing systems. Collaborative processes performance representation, automation and management require a good understanding of collaboration impact on business processes. This paper identifies the main characteristics of collaborative business processes, classifies them on several criteria, identifies possible approaches for management and implementation and proposes a mathematical model for measuring inter-organizational business process performance.*

Keywords*. Collaborative business processes, organization networks, performance measurement, business process management, service oriented architecture.*

JEL classification: O33, L20, D85

1. Introduction

Collaborative business processes between organizations catch more and more the attention of researchers and practitioners in the current business environment. Through collaborative processes, organizations achieve flexible and dynamical collaborations in order to adapt and remain competitive on the market (Liu et al., 2011). The knowledge society, globalization and competition are stimulating factors for switching form the traditional organization to the extended organization and further to the organization connected to a collaborative network (CNO – Collaborative Network Organization).

Collaborative practices have various shapes, from stable collaborative networks to dynamic networks or occasional collaboration, like collaboratively connected organizations and virtual business ecosystems. CNO is a logical, provisional and dynamic aggregation of heterogeneous and autonomous units (companies, people, government institutions etc.) that have various competencies and efficiently combine and coordinate collective resources for a given time in order to achieve a common goal (Yassa et al., 2012).

The complexity or collaborative business processes prevents their easy modeling, implementation and management. Successfully completing these steps requires good knowledge of the business processes and of the impact collaboration has on them. In order to support the intensification of adherence to collaborative business environments, this paper aims to: identify and describe the main characteristics of the collaborative processes; classify the collaborative business processes on several criteria; identify management and implementation approaches; measure the performance of collaborative business processes. In this paper, by collaborative business processes we will refer to inter-organizational business processes within CNO.

The results are supported by references to current research. The arguments are presented gradually, in a logical manner, starting from the current state of collaborative processes and moving to process analyses (identification of their characteristics) and classification followed by the identification of management and implementation approaches. The final section of this paper is dedicated to the performance of business collaborative processes and proposed performance measurements. In order to better understand and visualize, some elements are presented as graphics and tables. The paper is the result of interdisciplinary research, including elements of economy theory, management and information and communication technology (ICT). The research is based on recent published advances (mainly papers indexed in international databases and recognized publications), reports from practitioners and case studies regarding the creation and development of collaborative networks of organizations.

2. Main characteristics of collaborative processes

The collaborative environment involves changes of the business processes and requires the existence of specific collaboration characteristics. Identification and definition of main collaboration characteristics within a process is one of the main stages of reengineering the business processes. The collaborative processes combine characteristics of business processes and organization collaboration. Some of the main characteristics of collaborative processes are:

a) Several independent identities. Collaborative processes involve several independent entities (organizations, individual, institutions etc.) that bring specific competencies and play specific roles. The independent entities exchange resources and perform activities collaboratively in order to achieve the process goal.

b) Governance among involved parties. The governance establishes the executive responsibility for management and quality of the results produced by the collaborative processes.

c) Several workflow engines. The collaborative process is not performed by a single centralized workflow engine; instead there are several engines that collaborate (Chen and Shu, 2001).

d) Internal security of information. A flexible mechanism of hiding the information is required in order to ensure the security of internal processes. The information provided in an inter-organizational process must not provide unveil the inner workings of any partner (Bouchbout and Alimazighi, 2011). The data in a collaborative process may be private, shared or publically available to all participants, depending on their roles in CNO.

e) Several decision makers. A collaborative process requires several participants that get involved, discuss, iterate and decide before going to the next activity or stage of the business process (Dam and Fontaine, 2008).

f) Several collaborative activities. A collaborative process involves more than one collaborative activity; together they lead to achieving a coherent collaborative goal (Osorio et al., 2008)

g) Trust between partners. CNO involves the management of trust between partners, to promote trust relations, including the evaluation of trust levels of the members and between members in order to successfully perform the collaborative processes.

h) Collaboration terms. The collaboration agreement within a CNO establishes the terms/conditions for collaboration between participants, as well as the policy for managing this collaboration for the duration of the CNO.

i) Secured communication. Communication in collaborative business processes must be secure by means of special software/hardware/functional configurations.

Starting from the above characteristics and the definition of business process, the collaborative business process must be envisioned as a set of collaborative actions or activities, performed in a certain order to achieve a collaborative object (figure 1). In a collaborative process, the inputs, the outputs and the resources belong to entities involved in collaborative actions.

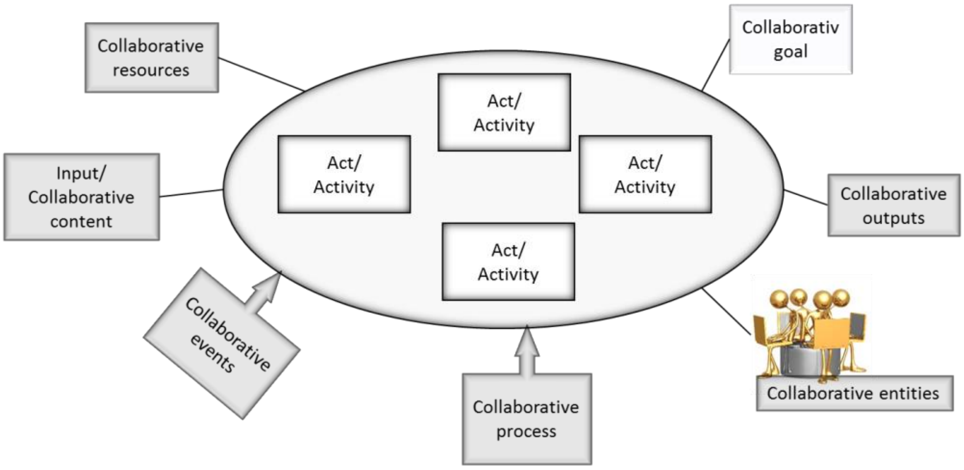

Figure 1. Definition of collaborative process

3. Classification of collaborative processes

In order to model and implement collaborative business processes we have to identify the types of business processes, their specific features and peculiarities and the classification criteria. Collaborative business processes may be classified on several criteria like: the way they implement execution control, creation type, level of access to the process, automation level, structuring level.

a) Regarding the implementation of execution control, collaborative processes can be classified in two categories (Liu et al., 2011): coordination processes and cooperation processes. ❶ The coordination of a business process involves the execution of a business process made up of activities that take place in several organizations, but a single organization controls everything. ❷ Cooperation in a business process means the execution of a business process made up of activities that take place in several organizations, each one controlling only the activities it performs.

Each partner has full autonomy regarding design, implementation, execution and monitoring its internal processes, as long as it fulfills its obligations towards the other partners (Medjahed et al. 2003). Participants act autonomously and must coordinate through inter-actions.

b) Regarding the creation of the collaborative process, they can be classified as (Osorio et al., 2008): planned processes and ad-hoc (or dynamical) processes. ❶ Planned collaborative processes are defined a priori. This class of processes involves execution according to the process definitions, and a timetable of actions with various characteristics and, perhaps, various life cycles (time wise). ❷ Ad-hoc or dynamical processes are executed according to a process definition recorded during the process execution itself.

c) Regarding the level of access to the project, collaborative processes can be classified as private processes, public processes (view) and abstract processes (ATHENA, 2005). ❶ A private business process is described inside the company and cannot be viewed by external partners. ❷ A public business process is a partial image of a private process, with hidden elements and a control flow that can be modified as needed. A public process allows visualization/transmission of a part of the private process that is relevant for interaction with other partners. ❸ Abstract processes are abstract views or public processes that only have input and output operations.

d) Regarding the level of automation, collaborative processes can be classified as automated, partially automated and manual. ❶ Application integration allows for fully automated collaborative business processes. The new technology as well as the existence of service oriented architecture allows tasks to be carried out as services. ❷ Partially automated processes include both automated and manual activities. This requires a user interface that allows capturing the user knowledge in order to control and improve the processes. ❸ Manual processes are performed manually by the participants.

e) Regarding the structuring level, collaborative business processes are classifies as structured, semi-structured and unstructured. ❶ Structured processes are rigorously defined, with complete and final models. ❷ Unstructured processes depend on the events that occur and the content and knowledge involved. Unstructured processes involve activities based on knowledge, where many of the important steps are performed individually or in collaboration, leading processes that rely heavily on knowledge, thus being hard to analyze and structure. ❸ Semi-structured processes include both a structured and an unstructured part, depending on exceptions.

Depending on the type of process and its characteristics, there are various methods for implementation and management. For processes that rely heavily on knowledge only a subset of activities may be automated. Additionally, collaborative processes involve complex interactions between participants and the need to use knowledge leads to a level of complexity that many of the business process management systems (BPM) are unable to provide. Case Management provides many of the BPM benefits, but it is designed mainly for ad-hoc, dynamical, unstructured, non-repeatable, unpredictable processes.

Successful completion of a collaborative business process requires fulfillment of at least the following requirements: strong inter-organizational structure; flexible and adaptive workflows; security, which allows collaboration between organizations; collaboration technologies; interoperability, which allows the use of a set of basic methods, techniques and instruments.

4. Approaches regarding collaborative process implementation and management

Allocation of resources and performance between business partners, establishing responsibilities for the financial and materials exchange relations, as well as data and information exchange through interfaces must planned collaboratively. All these lead to an increased need for a business process management solution. In order to remain competitive in the global business environment, organizations must expand process management from intra-organizational level to inter-organization (Oh et al., 2011).

In collaborative environments existing BPM methods must be adapted to collaboration scenarios requirements. In order to evaluate these management solutions and analyze their feasibility, traditional Monte Carlo simulation methods may be employed. Business process management in collaborative environment involves certain changes due to collaboration characteristics. Successful implementation of inter-organizational processes requires good knowledge of both BPM and collaboration impact.

BPM, according to (Ghalimi and McGoveran, 2004), supports business processes using methods, techniques and software to design, create, control and analyze operational processes involving humans, organizations, applications, documents and other sources of information. Most of the times, BPM presents as an integrated set of instruments that provide a closed system for business optimization.

Collaboration is the natural result of interaction between persons and cognitive actions, and most of the times this happens ad-hoc and dynamically. Unlike BPM, these do not have a fixed value or predetermined return of investment (ROI). Results are not fully predictable, but the improvements often come from increased efficiency. Innovation is the result of efficient collaboration and if events are repeatable, innovation may be transformed into a process (Dam and Fontaine, 2008).

CBPM (Collaborative BPM) extends the scope of traditional BPM through features provided by business process interaction management. This provides an integrated environment for coordination of human activities and collaborative processes. Thus, the new generation of BPM provides the possibility for participants from several organizations to analyze, design, validate, implement, perform, monitor and optimize inter-organizational processes.

The business process is often composed of a process model and workflow model (IONA, 2004) (figure 2). The collaborative business process is composed of processes, web services and internal flows (Oh et al., 2005). The work flows are used to describe the business processes on an abstract level. Each task of a work flow represents a single activity and may be completed by using a single service. Combining a BPM with service oriented architecture (SOA – Service Oriented Architecture) helps create flexible business solutions. Interactions between participants are supported by interaction flows (exchanges of messages and information) (Bouchbout and Alimazighi, 2011).

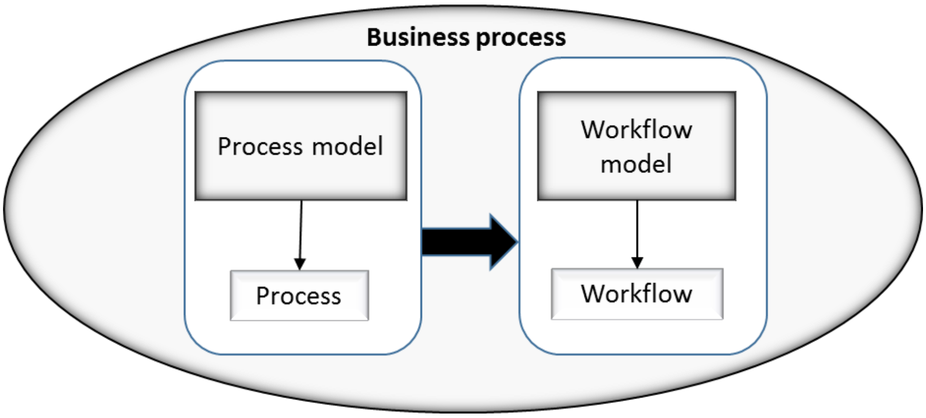

Figure 2. Components of a business process

Modeling business processes at inter-organizational level faces various challenges like: CNO participants employing different languages/approaches for modeling, interoperability, different culture, different views of information (depending on participants' roles), process synchronization, process competition, heterogeneous application environments in the partner organizations.

There are several languages for modeling business processes, like: diagrams, Petri net, IDEF0 (Icam DEFinition for Function Modeling, Icam – Integrated Computer Aided Manufacturing), PCD (Process Chain Diagram) from ARIS, UML activity diagram (UML – Unified Modeling Language) and BPMN (Business Process Model and Notation). The purpose of BPMN is to provide an explicit notation, easy to use and understand by businessmen that create, implement or monitor processes. Thus, BPMN closes the gap between design and implementation of processes (Rjsiri, 2009).

While BPMN is used to model the business process, for its execution BPEL (Business Process Execution Language) may be employed (figure 3 – adapted after Legner et al., 2007 and Hoyer et al., 2007). BPMN may be converted to BPEL and back. Besides the mapping between BPMN and BPEL, the BPEL process must be connected to business services. A business service is a logical representation of a business activity. Service oriented architecture allows the technical implementation of business processes in organizations (Hoyet et al., 2007).

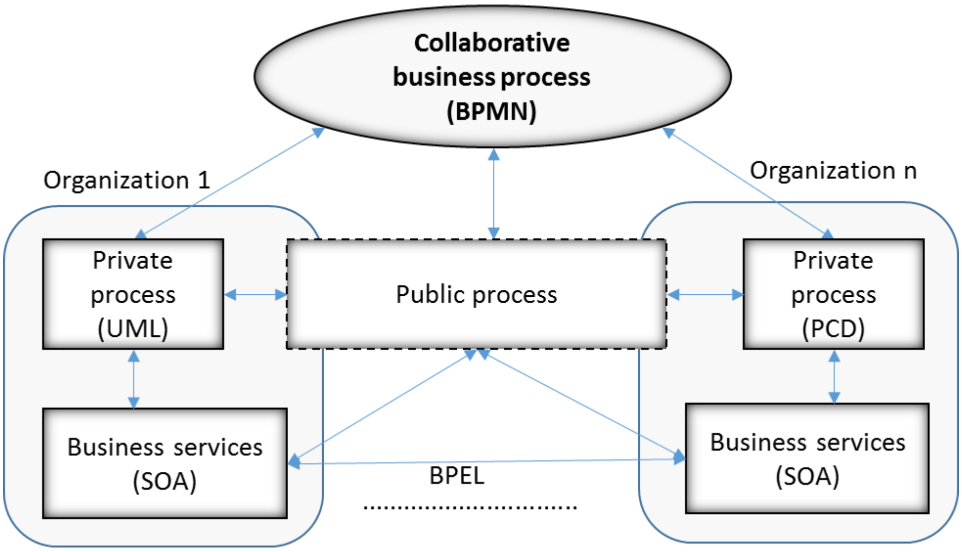

Figure 3. Collaborative business process in SOA

The service oriented architecture model allows the integration of existing processes and new processes. According to (Touzi, 2007), a collaborative process model is BPMN oriented and based on SOA. CBPM along with service oriented architecture allow dynamic interactions between organizations and capitalization of global market opportunities.

5. Measuring the performance of collaborative processes

CBPM is considered to bring an increased value to organizations. Measuring the performance in a CNO requires instruments and methods that facilitate measuring collaborative the performance of collaborative processes. Performance management systems may help organizations to improve performance, but collaborative networks rely on the individual knowledge of participants (Evans et. al., 2004), which leads to high complexity. Within the network, dynamic performance management allows the creation of an interactive structure that supports consistent and fast performance based decisions. A drawback is the fact that often the time allowed to reconfigure the network is short and not enough for testing and optimization of collaboration between partners (Graser et al., 2005).

Additionally, de decision process becomes complex due to the relatively high number of variables that take part in its modeling. Variables and the unknown factors associated with the decision modeling are emerging results of collaborative processes (Merigo et al., 2013)

About 50% of the inter-organizational performance factors are related to humans, while factors related to processes and technology account for 30% and, respectively, 20% (Zaklad et al., 2004). Considering the high occurrence of the human factor, the literature highlights the fact that network success may be viewed as the satisfaction of stakeholders involved in collaborative processes (Garmann-Johnsen and Eikebrokk, 2014).

The main performance indicators are identified and selected by the network partners before the collaboration is formalized (Parung and Bititci, 2008). The evaluation of inter-organizational processes must consider the type of network (stable or dynamic) and, depending on this, identify the relevant indicators (for short term or long term). Table 1 presents the success factors that characterize inter-organizational processes and may be measured objectively or subjectively (for example scale 1 to 5 – low to high). Organizations must create their own lists of relevant indicators, according to network mission.

Table 1. Aspects of collaborative processes that can be measured

Success factors	Examples	Factor value
Knowledge creation (F_1)	Knowledge is created through interactions between network partners and learning. ICT provides the support for information and idea exchange in collaborative business processes	Y_1
Sharing the knowledge/information (F_2)	The frequency/amount of knowledge/information exchanged between partners. Sharing the knowledge depends on the type of knowledge (tacit, explicit) and the communication environment.	Y_2
Capitalization of knowledge (F_3)	Number of new products, services, patents, business plans or other results produced through transformation/capitalization of ideas/knowledge.	Y_3
Innovation (F_4)	Number of innovative products, models, trends produced through collaboration between network partners.	Y_4
Trust (F_5)	Frequency of meetings where correct/trustworthy data and information is provided by the involved parties.	Y_5
Risk (F_6)	Business risk is shared between network partners, according to collaboration contracts. The risk to lose control over data exchanged through the network is higher (number of attacks against communication systems, frequency of attacks/data loss).	Y_6
Quality of	How well conflicts between partners are	Y_7

Success factors	Examples	Factor value
collaborative process/conflicts (F_7)	solved. Practices and policies for preventing and solving conflicts. Provision of specialized personnel for conflict negotiation and solving. Number of conflicts/complaints the time to solve them.	
Coordination of collaborative activities (F_8)	Number of articles (contract agreements) on which collaborative activity coordination relies on. Number of plans/procedures for proactive problem solving.	Y_8
Communication quality (F_9)	Frequency of problems/misunderstandings due to different culture, insufficient common language skills, different ways of thinking, different value systems.	Y_9
Interoperability (F_{10})	Interoperability can be measured at business level, ICT level, knowledge level (competencies, skills and knowledge) and services (SOA). Measure of ability to exchange data/information/knowledge between network partners.	Y_{10}
Scalability (F_{11})	The possibility to adapt the process to new requirements (for example adaptation to lower/higher number of partners, adaptation of functionalities to other goals).	Y_{11}
Transparency (F_{12})	A poll may be used to evaluate the transparency of decision, performance, data and processes for network partners.	Y_{12}

Collaboration processes lead to increased performance for each partner if the results achieved after joining the network (REC – collaborative exercise results) are higher than results achieved outside the network (REI – Independent exercise results) (Parung and Bititci, 2008). The results achieved by a partner though collaboration also depends on the level of his participation to the organization network.

$$REI = \sum_{i=1}^{n} (\mathrm{W_i} \cdot \mathrm{VI_i} + p_i \cdot \varepsilon_\mathrm{i}) \qquad (1)$$

where:
$\mathrm{W_i}$ – factor *i* weight;
$\mathrm{VI_i}$ – initial value of factor *i*;
p_i – weight of shared resources allocated for collaborative processes (inputs);
ε_i – error in evaluation of factor *i* performance.

Evaluation of collaborative processes performance involves a mathematic model as well as the definition of a specific collaborative metric. Thus, considering table 1, we may view $\mathrm{Y_i}$ as the value achieved through collaboration for factor *i*. In the context of the mathematical model, the success factors $\mathrm{Y_i}$ from table 1 are in fact outputs, directs results of the collaborative activity (collaboration outputs). Because the control and evaluation are the main functions of management activity, the contribution of each participant to the collaborative process constitutes inputs (collaboration inputs) in the mathematical model. Assuming that the resources made available for the collaborative processes by each participant are IT infrastructure, organizational culture, marketing policies, human capital and finances, the inputs used to model the collaborative processes are presented in figure 4.

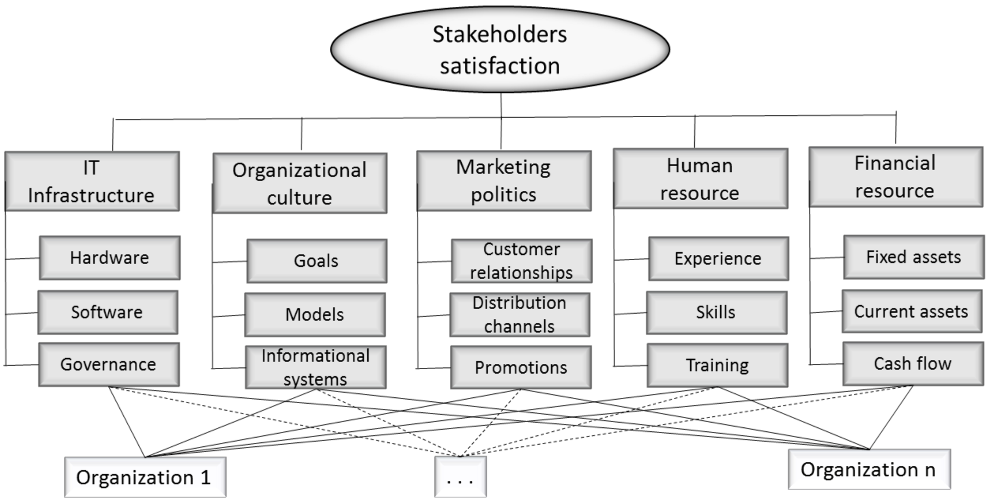

Figure 4. Hierarchical structure of inputs in collaborative processes

Starting from the proportional distribution of collaborative processes outputs compiled by (Zaklad et al., 2004) and performing a reverse translation towards the inputs in figure 4, the proportion of participants' contributions to the collaborative processes looks as in table 2.

Table 2. Collaborative processes participation shares

Main resource	Input component	Input	Share (%)	According to Zaklad et al., 2004
Human factor	Human capital	I_1	35	50
	Organizational culture	I_2	15	
Economic processes	Marketing	I_3	10	30
	Finance	I_4	20	
Technology	IT infrastructure	I_5	20	20
TOTAL			**100**	**100**

In this context, defining the collaborative metrics for evaluation of collaborative processes according to the proposed mathematical model requires a bi-univocal correspondence between success factors F_i with inputs I_i, according to table 3. The correspondence is suggested also by the cybernetic character of the system represented by collaborative processes. In other words, on the level of that cybernetic system we must identify at least one feedback loop (positive or negative, but more likely negative) that closes the input-output relation. With this hypothesis (according to Ginevičius et al., 2012), ε_i – error in evaluation of factor *i* performance, related to the principal of external complementarity as a law of economic cybernetic systems, may constitute the measure of collaborative processes interaction with the external environment.

Table 3. Association between success factors and inputs

F	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}
I	I_1	I_1	I_2	I_3	I_2	I_1	I_4	I_1	I_3	I_5	I_4	I_2

If the initial value of factor *i* is in fact input I_i then equation (1) becomes:

$$REI = \sum_{i=1}^{n}(W_i \cdot VI_i + p_i \cdot \varepsilon_i) = \sum_{i=1}^{n}(W_i \cdot I_i + p_i \cdot \varepsilon_i)$$

Considering the total influence of the external environment introduced in the error of evaluation of factor *i* performance (ε_i) as $C = \sum_{i=1}^{n} p_i \cdot \varepsilon_i$ and the weights associated to the inputs in table 2, we have:

$$REI = \sum_{i=1}^{n}(W_i \cdot I_i) + C$$

where:

$$C = \frac{7}{20}\varepsilon_1 + \frac{3}{20}\varepsilon_2 + \frac{2}{20}\varepsilon_3 + \frac{4}{20}\varepsilon_4 + \frac{4}{20}\varepsilon_5 = \frac{1}{20}(7\varepsilon_1 + 3\varepsilon_2 + 2\varepsilon_3 + 4\varepsilon_4 + 4\varepsilon_5)$$

In these conditions, the result defined for the collaboration (REC) will be (table 1):

$$REC = \sum_{i=1}^{n} W_i \cdot Y_i$$

Analyzing the bi-univocal relations presented in table 3, we will have:

$$\sum_{i=1}^{n} Y_i = \frac{1}{3}I_1 + \frac{1}{4}I_2 + \frac{1}{6}I_3 + \frac{1}{6}I_4 + \frac{1}{12}I_5$$

Considering the evaluation of collaborative processes through the zero sum games approach:

$$REI = REC \Leftrightarrow$$

$$\sum_{i=1}^{n}(W_i \cdot I_i) + C = \sum_{i=1}^{n} W_i \cdot Y_i$$

Applying the fundamental management principle of profit maximization, the mathematical model for evaluation of collaborative processes becomes:

$$REC \geq REI \Leftrightarrow$$

$$\sum_{i=1}^{n} W_i \cdot Y_i \geq \sum_{i=1}^{n}(W_i \cdot I_i) + C$$

$$\sum_{i=1}^{n} W_i \cdot I_i \leq \sum_{i=1}^{n} W_i \cdot Y_i - \sum_{i=1}^{n} p_i \cdot \varepsilon_i$$

In conclusion, the success of collaborative processes depends on the ability of decision factors to establish the importance/weights (W_i) associated to success factors (table 1) so they satisfy the proposed mathematical model (QED).

CONCLUSIONS

Currently more and more organizations adopt collaboration networks for their business strategy, which leads to emergence of inter-organizational collaborative processes. Collaboration involves analyses on organization level, changes internal business plans and finding the most suitable approaches for implementation and management. Collaborative business processes involve complex analyses, which account for many factors. The analysis conducted in this paper is a starting point for further analyses regarding knowledge management and adopting collaborative decisions.

The evaluation of distance (dissimilarity) of the resources involved in collaborative processes can be achieved, for example, in terms of Manhattan distance (also known as the rectangular or city-block distance). This involves operations to normalize the data and transfer them into mathematical models to define specific metrics (distance-norms) based on distance. Mathematical apparatus provides the researchers with classical resources like the Euclidean distance, Hamming distance, Minkowski distance or Mahalanobis dimensionless distance (1936) - recommended for the evaluation of data profiles generated by knowledge curves. Finally, analysis of inter-organizational performance and management of business processes within collaborative networks must use clustering for classifying data into significant information entities / structures (with their own semantics and content).

The scientific approach, as future directions should be focused on specific components of the five resources available to each participant collaborative processes. They are expressed in terms of IT infrastructure, organizational culture, marketing policies, human capital and finance. Also for modeling multi-criteria decision-making processes can use the software implementation of the method Promethee performed by PROMETHEE-GAIA software. Method invoked (the predecessor of the method ELECTRE) was designed/conceived by Jean-Pierre Brans in 1982.

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