

Information Systems and Performance Management for Collaborative Enterprises: a proposal

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Abstract. Much of the research on performance management (PM) for collaborative enterprises (CE) is based on qualitative considerations and does not consider the impact of modern Information Systems both on the collaborative/competitive dimension of firms and on the PM process. The peculiarities of the different types of CEs are not clearly addressed and managed and the performance measurements are often oriented to specific aspects rather than to assess the overall quality of business. Moreover, in several proposals, the skills and the time required to the managers of CEs are far from those available in the largest part of existing SMEs. In this scenario the objective of the paper is to discuss how enterprise modeling techniques can contribute to enhance the governance of collaborative enterprises.

Keywords: Information Systems; Enterprise Modelling; Performance Evaluation; Collaborative Enterprises; Ontologies.

1 Introduction

Strategic alliances, virtual organizations and other forms of Collaborative Enterprises (CE) are gaining ever more importance due to globalization, which has forced businesses to rearrange their organizational structures. In the last twenty years, organizational relationships have moved from intra-organizational to inter-organizational ones and are moving towards trans-organizational relations, with a prediction of a speed for value creation never seen before [1]. Nonetheless, it is known that globally between 50% and 70% of CEs fails [2, 3], often due to the lack of a comprehensive analysis that combine strategic goals and KPIs, whereas performance measurement is a key element in turning goals into reality [4]. In fact, although several authors [5] studied the role of management accounting in inter-organizational environments, to our knowledge no one applied these results in order to quantitatively analyze the performance of CEs, of involved firms and of their linkage [1, 6, 7] for CEs governance purposes. Moreover, in several proposals, the skills required for CEs' managers are far from those available in the largest part of existing SMEs, which are the most numerous actors in CEs. In this context, firms would benefit from methodologies and tools allowing them to better link desired objectives and achieved results in an inter-organizational environment. This requires a more structured and systematic approach to evaluate not only the firms' own

performance but also how it compares with partners and competitors [8], even in different CEs. In practical cases, this kind of interrelated performance evaluation and comparison can't be conceived and realized without a set of suitable IS elements and procedures, which becomes not neutral with respect to the measured performance and to the style of management adopted for modern CEs, as well as a music instrument is not neutral with respect to the played music. In this perspective, Information Systems (IS) have to face the new challenge offered by networked enterprises [9, 10] and IT (Information Technology) concepts become relevant to CEs for doing business: (a) online databases and information modeling assume a key role in managing information and in exchanging it with stakeholders; (b) workflow systems and process modeling become essential to understand how firms and CEs are structured, how they interact with each other's (inter-organizational process modeling), and how they can react to external stimuli; (c) ontologies and Semantic Web techniques become necessary to manage the increasing amount of knowledge and documents (contracts, benchmarks, products, services ...) flowing in CEs; (d) Cloud computing, big data, business analytics, advanced computation and visualization techniques can push CEs to a new levels of understanding about business. In order to start exploring the implications of these assumptions we decided: a) to analyze the existing literature on performance measurement and IS in the perspective of a theoretical foundation for performance monitoring in collaborative enterprises enabled by online IS; b) to elicitate a set of requirements, starting from the gaps in existing literature and from stakeholders' goals; c) to propose an approach that can satisfy these requirements.

The paper is organized as follows: first, a literature review is presented to define a foundation for the explorative research; second, the method is described and a conceptual framework is proposed to organize both the elements coming from the literature and the first evidences coming from the field; third, the main concepts from enterprise modelling and others IS-related research areas are analyzed in relation to performance-monitoring for CEs. Last section is for concluding remarks and recommendation for future research.

2 Literature analysis and theoretical foundation

In this paragraph we will analyze the literature on performance measurement for CEs, in order to understand the domain of application, and on cross-organizational IS to define the research problem. For each topic, we will outline the current state of research and the existing gap and we will analyze the prospective of future research, thus how these topics have to evolve in order to face the new challenges deriving from the changes in society. Finally, we analyze related works on enterprise modeling.

2.1 Background and research problem outline

First, performance management and performance measurement have a key role in the assessment of CEs and of how the CE is affecting firms. However, enforcement methods, such as Open Book Accounting (OBA), which allows firms to share accounting information, are sometimes seen as formal control mechanism that damages trust [11],

and there are still few works on how to measure the effects of CEs on firms [12], and even in those there is no focus on quantitative aspects [1, 6]. Also, there are few works that take into account both CEs and SMEs [13]. Therefore, whilst we are going towards a network-SMEs-driven society, new challenges arise for performance measurement systems, since they have to be developed and used across the traditional organizational boundaries. The question is how to manage both the performance of CEs and of firms for SMEs [1]: it is necessary to modify existing tools for inter-organizational settings, overcoming the clear-cut between external and internal environment. Indeed, whilst it is possible to use the same performance measurement frameworks used for firms, it is still necessary to structurally and operatively change the measurement system [14].

Another relevant aspect concerns cross-organizational Information Systems (IS), which can assure a flow of information among and within organizations [15], thus coordination among partners, which is a key factor in order to achieve goals. However, according to the contingency theory, a change in the organizational structure implies a change in the IS. In this sense, IS usually distinguish and oppose relations within a firm, from those across it, whilst in an inter-organizational setting it is necessary to broaden data sources so to include partners and to consider them as beneficiary of the information [16]. At the Enterprise Systems level, this can be achieved through shared databases, data warehouses, workflow management systems, web services, SOAs or cross-organizational ERP, which are used from several independent firms whom cooperate in an inter-organizational environment (value web) [17]. The use of cross-organizational ERP systems can lead to a lost on flexibility because it implies processes standardization and collaborative relations are not always stable. Anyway, most of the IS adopted are not cross-organizational; thus, “they focus on a single enterprise with some supports towards sharing performance information with external parties” [1]. However, the key element in the future seems to be “cooperation” [10], whilst IS should “enable new forms of participation and collaboration, catalyze further the formation of networked enterprises and business ecosystems [...] ushering in a new generation of enterprise systems” [9]. Therefore, the question is how to design and develop IS for CEs and for networked SMEs, allowing a monitoring at two levels of granularity: the CE level and the firm level, with a guarantee of comparability between KPIs and perspectives of the two levels.

2.2 Related works

Part of the literature on enterprise modeling concerns performance indicators, which are modeled by means of domain-specific modeling languages (DSML) and ontologies. The aim is to offer models able to support the creation and the effective and efficient interpretation of “*performance measurement systems [...] by providing differentiated semantics of dedicated modeling concepts and corresponding descriptive graphical symbols*” [18]. In particular, Popova and Sharpanskykh [4] developed a framework for modeling KPIs and their relations through dedicated first-order sorted predicate logic-based modeling language, while temporal relations are expressed through Temporal Trace Language (TTL). With similar intentions in [19] the Business Intelligence Model

(BIM) is used in order to model the strategy and the related goals, indicators and potential situations (Strengths, Weaknesses, Threats and Opportunities). In [20] techniques and algorithms to define KPIs metrics expression and value are developed. Moreover, In [18] a model for enabling reflective performance measurement, namely MetricM, and a domain-specific modeling language, named MetricML, are offered. Even though these works, and in particular [18], offer a broad analysis of performance indicators and of their relations, DSML and semi-formal frameworks cannot be directly integrated in IS. In this sense, in [21], the authors develop an ontological approach for the definition of Process Performance Indicators (PPIs) through OWL DL. However, only PPIs are taken into account, without perhaps considering the relation between goals and KPIs. A wider range of indicators and the analysis of the related objectives would be indeed useful to assess the overall performance of the firm. An interesting work has been done in [22] where an ontology of KPIs with reasoning functionalities for Virtual Enterprises is presented. The model enables the definition and manipulation of heterogeneous KPIs calculated in partner firms. The main reasoning functionalities are formula manipulation, equivalence checking, consistency checking and extraction of common indicators. Nonetheless, authors put much of their focus on innovation processes and not on the firm as a whole. Also, in their model they don't consider goals. In general, there are still few works that analyze ontologies of KPIs and a lack of works that simultaneously take into account KPIs, goals and CEs, which are entities far more complex than individual enterprises.

3 Method

As recommended by [9], the development of IS can't follow anymore a technology-driven approach, but has to follow a technology-enabled enterprise-driven approach. Therefore, in order to develop our approach for the design of IS elements for CEs, we used KAOS [23], a goal-oriented approach coming from requirements engineering. In particular, in order to elicitate requirements, we took into account both stakeholders goals and gaps in existing literature (Section2). After analyzing about 200 peer-reviewed research papers on CEs and after interviewing about 20 people directly involved in CE management, we identified seven main stakeholders interested in CEs and in measuring their performance: firms' and CEs' managers, researchers interested in CEs, network associations, policy makers, banks and consultants. For all of them we defined a complete set of goals and constraints ordered by priority, taking into account:

- their role along the CE's lifecycle, since not all stakeholders have a specific interest in all phases. E.g., while firms have an active role in all phases, CEs' managers are interested only in operational and conclusion phase. Therefore, we distinguished goals in a 'pre-alliance', 'operational life' and 'conclusion of CEs life' ones.
- information granularity since each stakeholder needs for information at different levels of granularity, where the 'elementary information' relevant to the stakeholders is about the performance indicators of each firm. E.g., firms' managers need detailed information on their firm and partners and competitors, CEs' manager details on the

CE and more synthetic information on firms, policy makers synthetic information on the whole system of CEs.

Other dimensions of analysis can be added, but an important point is that all stakeholders characterized by similar values of dimensions can be associated to a similar set of goals, requirements and constraints. As exemplification, a set of goals should include:

- G.1 in the pre-alliance phase, each firm is interested in evaluating the suitability of collaboration for the achievement of specific objectives (e.g., growth in R&D);
- G.2 in the alliance-operative phase, each CE manager is interested in analyzing their own KPIs and of other CE' related data;
- G.3 in all phases, CEs' managers are interested in benchmarking, performed by comparing their KPIs with those of CEs with homogeneous characteristics;
- G.4 in all phases, firms want to control what to show (nothing, just minimal data, financial ratios, etc.) to others users (CEs' partners, external observers, etc.).

From these goals and literature, we defined the following requirements for an IS designed for collaborative SMEs:

- **Requirement 1.** *Define a shared language for KPIs.* Indeed, KPIs can be calculated or interpreted in several ways, making them not comparable within or among CEs.
- **Requirement 2.** *Have a comprehensive analysis of the phenomenon, taking into account CEs type, lifecycle, organizational structures, roles and goals.* CEs are heterogeneous clusters of partnerships among enterprises (FInES 2012): therefore, for benchmarking purposes, it is obviously not enough to compare CEs only taking into account the business sector or the size, since other factors come into play.
- **Requirement 3.** *Build domain-specific KPIs, i.e., specific for the CE type, maturity and goals.* Different CEs need for different KPIs [25]; therefore firms and CEs have to understand which KPIs are relevant and what a KPIs mean in a given firm or a CE with defined goals. This kind of understanding is not immediate, especially in several SMEs, which lack of the know-how needed to perform this kind of analysis.
- **Requirement 4.** *Provide graphical representations, in order to reduce the complexity of the analysis and of the monitoring of CEs performance.* CEs are a multifaceted phenomenon, difficult to analyze and to comprehend in abstract ways. The mere analysis of CEs' goals, type and related KPIs could be misleading for managers.
- **Requirement 5.** *Assist in the contract drawing and enactment;*
- **Requirement 6.** *Guarantee privacy.*

4 Conceptual framework

A CE can be seen as a system [25] composed by three layers: the alliance layer, the firm layer and the relation (among firms and between each firm and the CE) layer. For each layer we can create an information repository: the upper layer (alliance layer) is for information on the CE coming from several data sources (financial statements, web sites and so on). This information regards e.g., objectives, activities, results achieved, and the program. The lower layer (firm), is for information on firms participating in CEs, coming from several data sources (financial statements, web sites and so on). This

information concerns objectives, activities, business sector, characteristics, organizational structure and performance. Finally, the middle layer (relation/formal or informal agreement) is for information on contracts, governance and duration of the collaborative enterprise. The analysis of repositories enable the creation of a database for CEs and firms, with a list of collaborations and objectives. This can facilitate the search for partners (firms or CEs), thus supporting and simplifying the partner selection process. The repository of the relation layer also allows for the storage of contracts, whereas available. In this frame, ontologies have a double role. First, we can provide a semantic representation of the information on the repositories, with a classification of CEs along three dimensions, namely CE type, maturity and objectives. Crossing the three dimensions of analysis enables the construction, by means of reasoning functionalities, of reflective [18] domain-specific KPIs, i.e., KPIs specific for the type of alliance, the maturity and the objectives. For example, some of the domain specific KPIs for a supply chain with an informal-technical based connection at the early stages of the CE and with the goal of cost reduction are the following:

- Overall production costs variation between t_0 (before-CE) and t_1 (after-CE), since the comparison between two periods of time is an effective indicator [14];
- Overall transportation costs variation between t_0 and t_1 ;

Moreover, ontologies can be applied on the contract and organizational repository in order to provide domain-specific contracts and organizational structures templates, such as those provided by the Legal-IST project (www.legal-ist.org), for firms that decide to formalize the collaboration. This approach enables the representation of the linkage between alliances' and firms' goals and KPIs and makes possible to track which KPIs are used from firms with specific goals, of a specific type and with a certain maturity, so that this information are stored and used to suggest to not expert users which KPIs to choose. In short, this approach can facilitate firms also in the choice of which KPIs to include in the dashboard, thus which KPIs are relevant for their goals, CE type and maturity. Indeed, through data visualization tools and KPIs ontologies it is possible to develop an interpretative framework able to understand KPIs and to offer information on relevant variables, depending on the typology of partnership. This is particularly useful for SMEs, who lack of the skills to develop performance measurement systems.

These features can be offered through a collaborative, cloud-based Information System. As stated in [1], IS are essential for the development and use of Performance Measurement Systems. Moreover, the IS has to operate in an inter-organizational setting, thus it has to be Internet-based in order to be easily accessible by all firms. Also, when SMEs come into play, it is important to use Clouds to permit a suitable scalability and low costs: with a unified system the costs for the development and maintenance of the IS are shared costs, thus firms and CEs can use IS with little investments. Furthermore, the IS system should allow firms and CEs monitoring, through the creation of personalized dashboards, elaborated through reasoning features and queries on the ontology, KPIs evaluation and information sharing. Monitoring techniques should be integrated with benchmarking features as well, through which it's possible to compare firms or CEs with similar ones, without the necessity to provide analytic data on costs and revenues and, thus, overcoming one of the main limits of management accounting

solutions such as open book accounting (OBA). Finally, in the collaborative IS firms should be able to share information, in order to better collaborate with partners and to have more detailed benchmarks, with different level of privacy. This means that each firm can be a grey box, a white box or a black box for each other firm. In more detail, it is a) a white box if choose to be completely transparent for other firms, e.g., disclosing its processes and organizational structures, b) a black box if the firm choose to disclose to other firms only external parameters (e.g., financial statements, information on web sites); c) a gray box if the firm choose to disclose only partial information.

The proposed approach can overcome the clear cut between external and internal environment since such a service, partially based on ontologies which enable a shared knowledge of the domain, should allow the creation of aggregated performance, without the need to disclose the atomic values. Also, the use of benchmarking techniques can overcome the issue of implementing highly-complex performance measurement systems, which are too expensive in terms of financial and organizational resources.

5 Discussion and conclusions

In this paper, through the analysis of existing literature, we discussed how the research on Information Systems (IS) can contribute to reshape the PM process to better integrate it in the management cycle. In this perspective, Information Systems (IS) have to face the new challenge offered by a networked society. Starting from the literature analysis we elicitate a set of requirement and propose an approach for the development of a comprehensive service, based on enterprise modelling techniques, for CEs governance and analysis, through the creation of a collaborative IS and of repositories, and the use of ontologies. With respects to related works on DSML for performance measurement, we use ontologies, which can be easily integrated in IS or online services; on the other hand, the ontologies proposed in literature don't consider jointly the inter-organizational settings and the linkage between KPIs and goals. In particular, in the present work, we developed a reference framework useful for understanding KPIs in relation to CEs goals, types and maturity signaling promptly anomalies and offering information on relevant variables, depending on the typology of CEs. The application of this approach is particularly useful when SMEs comes into play, since they often lack of the financial and managerial resources required to enforce a complex and heterogeneous performance measurement system. Future research should move towards the development of cloud based IS designed for collaboration among SMEs.

6 References

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