Ontologies and Information Visualization for Strategic Alliances Monitoring and Benchmarking

Barbara Livieri[1], Mario A. Bochicchio[2] and Antonella Longo[2]
[1]Department of Economic Sciences, University of Salento, Via per Monteroni, Lecce, Italy
[2]Department of Innovation Engineering, University of Salento, Via per Monteroni, Lecce, Italy

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Abstract: Cooperation among firms is universally seen as a catalyst of competitive advantages. However, 50% of alliances fails. This is often due to the lack of tools and methods to quantitatively track the effects of Strategic Alliances (SAs) on firms, to the inherent complexity of a comprehensive analysis of SAa and to the difficulty to link strategic alliances goals with Key Performance Indicators (KPIs). Nonetheless, performance management and performance measurement have a key role in the assessment of the achievement of alliances' goals and of the impact of SAs on firms. In this context, the aim of this paper is to discuss how advanced information processing techniques (e.g. ontologies, taxonomies and information visualization) can be used for SAs monitoring and benchmarking. In particular, we propose an ontology for KPIs, rendered through data visualization tools, and a taxonomy for SAs. This allowed us to develop an interpretative framework able to support both SAs and firm managers to understand how to monitor their alliance and which KPIs to use. Finally, we discuss the pertinence and the coherency of the approach referring to the literature.

1 INTRODUCTION

Cooperation is gaining ever more importance due to globalization, which has forced businesses to rearrange their organizational structures and to focus more on flexible forms of aggregation, such as Strategic Alliances (SAs). Indeed, under certain circumstances, SAs contribute to an increase in performance and to the creation of intangible assets (Das & Teng 2000; Caputo et al. 2013). Through cooperation, the accumulation of knowledge, and the sharing of variously configured resources, SAs can lead to an increase in the economic capital of firms.

However, it is known that globally 50% of strategic alliances fails, often due to the lack of a comprehensive analysis that combine strategic goals and KPIs (Kaplan et al., 2010). In general, *strategic failure is mostly the avoidable result of inadequate governance resulting in inadequate strategy development and implementation* (Hoogervorst 2009). Indeed, in order to engage in SAs firms need to closely monitor each other (Ouchi 1979; Essa et al., 2014).

In this context, firms could benefit from tools and methodologies that allow them to better perform the monitoring in an inter-organizational environment. In other words, firms could find useful to access to more structured and rich information on partners and to compare performances (Parmenter, 2011) in different strategic alliances and firms, in order to understand the drivers of alliances' success and, thus, to enhance their performance.

This analysis is relevant in all the phases of the collaborative firm lifecycle, that is composed by a) the pre-alliance phase, in which firms decide whether to create a partnership (strategy definition) and with whom (partner selection), b) the alliance phase, after the alliance is built and c) the changing/ending phase, in which firms decide to change the structure of the alliance or to stop the collaboration at all.

However, SMEs cannot afford for a customized Performance Measurement Systems, due to a lack of financial and organizational resources. Moreover, they are not always able to understand which KPIs are relevant for them and which to include in their dashboards. When firms use their Information Systems (IS) or analyze their financial statements,

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they have to "manually" choose which KPIs to use, and it is difficult to compare their result with the results of their partners, since they could call the same things with different names and different things with the same name (e.g. ROI can be calculated in several ways).

Therefore, there is the need for a reflective design (Strecker et al., 2011) of the KPIs dashboards and of an analysis of KPIs rationales and linkages, as a part of a more comprehensive taxonomy creation of SAs.

Nonetheless, at the best of our knowledge no tool or service exists to perform this kind of assessment through monitoring and benchmarking.

In this paper, with the general aim of providing an interpretative framework for KPIs and strategic partnership, on which to build such a tool or service, we explore the possibility to use Enterprise Ontologies (EOs) in association with advanced data visualization techniques (e.g., hypertrees and cloud of words) in order to render the complex interplay among the different aspects that affect the success of SAs.

In more detail, we discuss how KPIs hierarchies can be enriched through ontologies and visually rendered through hypertrees. This allows us to give firms a representation of the relationship existing among KPIs, which can be seen as a "picture" of the organizational performance.

Moreover, we propose a taxonomy for alliances and a cloud of words for SAs' goals.

The objective of the proposal is to better understand performance drivers of SAs, facilitating firms in strategic and organizational choices, such as whether cooperate with others, how to structure the alliance (e.g., number of nodes, type of control) and what to monitor. The pertinence of the proposal and its coherence with the existing literature are considered to validate the different aspects.

The work is structured as follows. In section 2 we define the background and the main works concerning performance in inter-organizational settings, enterprise modelling and enterprise ontologies. Section 3 discusses the main problems related to performance monitoring and benchmarking for SAs, The proposal is detailed in section 4. Section 5 is for conclusions and future works.

2 BACKGROUND AND RELATED WORKS

At the best of our knowledge there are no tools or conceptual framework offered as a means of manage and analyze strategic partnerships.

Therefore, we will shortly examine several aspects, such as performance measurement and enterprise modelling.

2.1 Performance Measurement in Strategic Partnerships

Several authors (Caglio & Ditillo 2008) have analyzed control mechanism in inter-organizational environments, such as management accounting. In alliances the monitoring can operate on three layers: a) firm; b) effects of the alliance on the firm; c) alliance. For sub-c) researchers and practitioners propose several guidelines, performance management tools (e.g., modified Balanced Scorecard and scorecards) and enforcement methods, such as Open Book Accounting (Agndal and Nilsson, 2008; Caglio and Ditillo 2012b; Caglio and Ditillo, 2012a; Kajüter and Kulmala, 2005; Kulmala, 2002; Mouritsen et al., 2001; Romano and Formentini, 2012). In particular, Open Book Accounting (OBA) allows firms of a SA to share accounting information, which enable an improvement in the decision process (Caglio and Ditillo, 2012a). However, many firms are reluctant to disclose these data, because OBA is sometimes seen as formal control mechanism that damages trust (Windolph and Moeller, 2012).

Moreover, while there is a consolidate literature on sub-a), there are still few works on how to measure the effects of SAs on firms (sub-b)), and even in those there is no focus on quantitative aspects. Nonetheless, performance management and performance measurement have a key role in the assessment of the achievement of alliance goals and of how the strategic partnership is affecting firms.

In this context, a tool that allows the analysis of the effects of SAs on firms without a breakdown of costs and revenues can be helpful to increase the probability of the success of an alliance.

2.2 Enterprise Modelling

The research on enterprise engineering and modelling has three main topics. Some authors focus on the analysis of business processes (Comuzzi et al., 2012; Comuzzi et al., 2013; Pan et al., 2004), others on the information architecture (Kulkarni 2012) of firms and some others on the modellization of strategic an organizational aspects as well (Strecker et al., 2011; Frank, 2012).

A definition of enterprise architecture (EA) has been offered by (Lankhorst, 2013), who states that EA is "a coherent whole of principles, methods and models that are used in the design and realization of an enterprise's organizational structure, business process, information systems and infrastructure".

In this sense, a comprehensive research work in this field has been performed at University of Duisburg-Essen (MEMO: multi-perspective enterprise modelling) (Frank, 2012; Strecker et al., 2011). For the purpose of our research, MEMO and MML (Meta Model Language) are relevant because of their ability to model software engineering, social, managerial and economic aspects of the firm.

2.3 Enterprise Ontologies

Nowadays enterprise are entities far more complex than in the past; therefore it is not easy to manage them. In this frame, there was the need for a "*…a conceptual model […that is…] coherent, comprehensive, consistent and concise…*" (Dietz 2006).

Indeed, enterprise ontologies are developed and used for several reasons linked with enterprise modelling, such as the development of Management Information Systems and strategic decision support systems, Business Process Reengineering and the construction of Virtual Enterprises. However, still few enterprise ontologies have been developed and use in productive settings, due to the complexity and the novelty of the methods (Bertolazzi et al., 2001).

In more detail, there are two enterprise ontologies, which are: a) the Enterprise Ontology developed from the Edinburgh Group (Uschold et al. 1996) and b) the Toronto Virtual Enterprise Project (TOVE) (Fox et al., 1993; Gruninger and Fox, 1994; Fox et al., 1995).

However, there is still a lack of ontologies for SAs, which are entities more complex than individual enterprises, or, more in general, for KPIs and performance measurement.

3 PROBLEM DEFINITION

Control mechanisms such as monitoring and benchmarking are key elements for the management of all kinds of organizations, no matter if the level of analysis is the individual enterprise or a SA. In particular, through the analysis of KPIs and their comparison with a benchmark, it's possible to understand if the organization is performing well, thus if it's achieving its strategic goals.

Therefore, monitoring and benchmarking are essential in order to promptly notice a gap between goals and achieved result and to define which actions to undertake in order to reduce the gap. In order to "track" and store KPIs large enterprises usually benefit from internal control systems (Enterprise Information Systems), whilst SMEs perform, whenever that even happens, a manual analysis of their financial statements and compare their values with those of similar firms, by means of public databases of financial statements.

However, in traditional control systems built for individual enterprises, there is a clear-cut between external and internal environment. Indeed, whilst for SAs it is possible to use the same performance measurement frameworks used for individual firms, it is still necessary to structurally and operatively change the measurement system (Bititci et al., 2004).

In particular, the same KPI can be calculated or interpreted in several ways, making them not comparable within a SA or among different SAs (P.1). This problem concerns both financial and non-financial KPIs and derives from the need to share a common understanding of the domain (Bertolazzi et al., 2001).

Problem 1. *In order to monitor SAs and to perform benchmarking within and between SAs and firms in SAs, it is necessary to share a common language for KPIs.*

Moreover, benchmarking within a SAs enable the analysis of benefits, of their distribution among partners and of the performance drivers for the SA. Indeed, firms are concerned both with performance drivers and targets; therefore benchmarking is relevant not only for KPIs comparison, but also for the identification of the "collaborative practices" that contribute to the success of a CE (Simatupang & Sridharan 2004).

In this frame it is obviously not enough to compare SAs only for business sector or size, but other factors, such as the SA type and the goals, come into play.

Problem 2. *SAs goals and SA types are relevant in order to perform an effective and accurate benchmarking*.

Furthermore, SAs are heterogeneous clusters of partnerships among enterprises. SAs can be of different types (e.g., horizontal SAs, vertical SAs) and have different goals; therefore, they need for different KPIs (Parung and Bititci, 2006). In other words, firms and SAs have to understand which KPIs are relevant and what a KPIs mean in a given firm, a SA with defined goals.

However, this kind of understanding is not immediate, especially in several SMEs, which lack of the know-how needed to perform this kind of analysis and often choose the more "known" KPI, instead of the more relevant, with possible negative effects on the SA equilibrium.

Therefore, SAs need to understand which KPIs are relevant for them, taken into account their "type" and "goals".

Problem 3. *Build domain-specific KPIs, which means KPIs specific for the SA type and the goals*.

Finally, SAs are a multifaceted phenomena, that is sometimes difficult to analyze and to comprehend. Therefore, the analysis by itself of SAs' goals, SAs type and related KPIs could be misleading for firms and SAs.

Problem 4. *Reduce the complexity of the analysis and of the monitoring of SAs performance.*

4 KPIs ONTOLOGY, SA TAXONOMY AND DATA VISUALIZATION TECNIQUES

In order to address the problems presented in Section 3, we propose the following solution.

For Problem 1, we propose the use of KPIs ontologies (Section 4.1). For Problem 2 we propose the use of SAs taxonomies (Section 4.2). Moreover, for Problem 3, we highlight the importance to consider both a KPIs ontology and a SAs taxonomy (Section 4.2). For Problem 4, we propose the use of data visualization techniques, such as interactive hypertrees, to better understand complex phenomena (Section 4.3).

Finally, in Section 4.4 we analyze the pertinence of our approach with the existing literature.

4.1 Towards a KPIs Ontology

Ontologies can be very effective to represent shared conceptualizations of specific domains (Bertolazzi et al. 2001) and to allow people to reason about sameness and differentness of concepts.

They can be seen as repositories of concepts, intended as complex information structures tightly interconnected with each-other. In knowledge modeling it is customary to see ontologies as a three layer organization of the knowledge in which the lower layer is where information about individual items is stored; the middle layer concerns the conceptual modeling that allows creating ontologies and the upper layer contains the meta-concepts or modeling ideas. The technology used to implement the ontologies is typically that of databases, where the middle level corresponds to the database schema. In this perspective, a KPIs Ontology represents a good solution to the problems P2 and P3 defined in section 3. In particular in the lower layer the KPI ontology should store information on individual KPIs, in the middle layer it should define the concepts on financial and non-financial KPIs while in the third layer it should describe the meta-concepts needed to define the database schema.

In our proposal the concepts of the KPIs Ontology are grouped according to three main conceptual areas (meta-concepts, in the third layer):

- Atomic measures: including all the quantitative information items (e.g. balance sheets' items) coming from firms and SAs;
- Ratios and Indicators: including all the relevant indexes which can be derived from the atomic measures or from other indexes by means of formulas or algorithms;
- Triggers and Conditionals: representing all the actions (e.g. warnings and alerts) and complex expressions that may be tested to see if they are satisfied or not.

For the lower layer (instances) and the middle layer (schema) we propose a hierarchical structure organized as in the following ontology fragment:

[fragment start]

KPI: a measure of the performance of activities, processes, departments, firms, SAs or whatever organizational entity at several level of granularity. Each item should include the description, one or more literature references, their rationales, formulas and "limit values".

- ***Non-financial KPIs***: KPIs that do not take into account accounting information (e.g., KPIs on sustainability or environmental impact).
  - *[…]*
- ***Financial KPIs***: KPIs based on accounting information (e.g., from the Management Accounting System and from financial statements).
  - **Return on Equity (ROE)**: measure of the efficiency of organizations.
    Rationale: how much profit a unit of stock equity generates
    Formula: (Net Result/Equity)*100
    Limit values: OK if > 6%
    Notes: ROE can be calculated also as product of ROS*icp

- **Return on Investment (ROI):** measure of the efficiency of the total investments in the core business made by an organization.
  Rationale: efficiency of an organization, regardless of the funding choices or the tax policies.
  Formula: (EBIT/Core business investments)*100
  Limit value: warning if < 7%; OK if > 15%
- **Return on Sales (ROS): how** much profit has been produce for 100 units of sales.
  Rationale: how much of the revenues is available in order to cover financial costs and taxes.
  Formula: (EBIT/Total revenues)*100
  Limit value: warning if <2%; OK if>13%
- **Increase in Intangible Assets:** measure how many intangible an organization have done in a set time interval.
  Rationale: effort for intangible assets.
  Formula: gross value t_1 – net value t_0
  Limit value: variable by business sector.

[fragment end]

Moreover, particularly relevant is the information (e.g., questions, answers, notes) exchanged by users about the interpretation of KPIs used for alliance monitoring purposes.

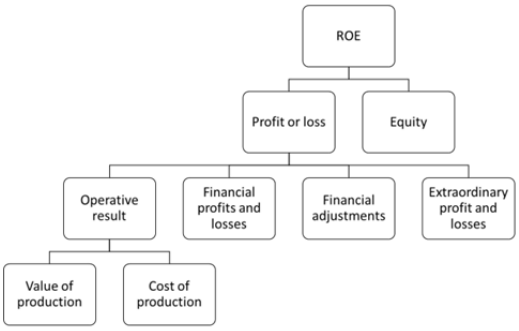

Figure 1: Example of KPI STRUCTURE applied to ROE.

The relations among KPIs are tracked through the analysis of the items (atomic values and/or other indicators) composing the ratio. Referring to the schema shown in Fig. 1, KPIs and their relations are described by means of the recursive relation on the entity named "Item Type". The elements needed for the semantic annotation of KPIs are included as attributes of the class. The recursive relation can be put in its hierarchical form (i.e. as a tree) through a conversion of the relation "Is Composed By" of fig.1 to an associative entity. As an example, Fig. 2 shows the KPI STRUCTURE, which forms an association between the instances of the ITEM TYPE class.

4.2 An SAs Taxonomy Based on Goals Analysis

From the literature analysis we can observe that not all KPIs have the same relevance for all SAs and that the performance monitoring of SAs sharing similar goals is based on the same (or similar) KPIs.

For example, SAs aimed at distribution are often monitored in terms of KPIs such as ROI, ROE and ROS while SAs which aim is to jointly invest in R&D are more focused on KPIs measuring the value of their intangible assets (an increase in ROI, ROE or ROS may occur years later). Moreover, when a given KPI is relevant in more domains, it has different value limits depending on the domain of analysis.

Similar considerations apply to benchmarks.

Consequently, in order to offer a solution for Problem 2 and Problem 3, a taxonomy on SAs based on the analysis of SAs' goals is needed as well.

In our proposal, referring to the database schema, the taxonomy is modeled through the "IS-A" relationships defined on the classes "Strategic Alliance". A further taxonomy on the class "Item Type" has been defined in the same way. These taxonomies take into account the lack of homogeneity of partnerships, which is relevant for the performance analysis. For example, partnerships can be "vertical" alliances or "horizontal" alliances. Then, vertical alliances can be subdivided in supply-chains or in distribution SAs and so on (e.g., basing the subdivision on number of participants, duration of the alliance, inter-firm exchanges).

KPIs can be structured according to their peculiarity in general purpose, domain-specific or SA-specific.

The integration of the previously defined "KPIs ontology" with the above outlined taxonomies offers a guideline for the use of performance dashboards, answering to questions such as "which KPIs should I use in my SA?", "how can I understand if my SA or my firm are achieving the predefined goals?".

Finally, the tracking of KPIs' interests for firms and SAs enable the creation of an interpretative framework for SAs performance. Each firm and each SA can see the best practice in its domain and compare it to them. For example, if a SA in the biotech sector, which aim is to invest in R&D, has an increase of only 2% in intangible assets, when

similar SAs have an increase of 20%, it means that something is not working right.

This means that, for each domain or SA type, it is helpful to collect information on which KPIs are most used, thus allowing the creation of a set of usage-driven guidelines for the use of KPIs.

4.3 Information Visualization Techniques for KPIs

Advanced visualization techniques are proven to be very useful to help understanding complex phenomena, and Strategic Alliances are an example of "systems of systems" (Jamshidi, 2011) which can benefit from the application of these techniques.

The previously defined KPIs Ontology, for example, can be visually rendered (Katifori et al., 2007) to better understand the KPIs dependency from the "atomic measures", as defined in section 4.1, and/or from other KPIs.

The extensive adoption of information visualization techniques is also fostered from the increased computational and graphic capabilities of personal computers and "smart" devices, such as smartphones and tables, which have made people more receptive to high quality graphical explanations.

For these reasons, our proposal includes the visual rendering of both the KPIs ontology and the alliances goals. In particular, we propose to represent the KPIs ontology as an interactive hypertree, allowing to simultaneously understand which balance sheet items affect a given KPIs, what relation exists among them and which other KPIs are linked.

As example, in Fig. 2 is shown the interactive hypertree of ROE. The hypertree can be browsed by selecting which node of the structure is the focus of the analysis.

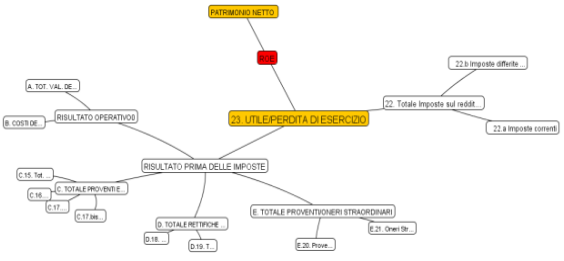

Figure 2: Visual representation of the hypertree for ROE.

Finally, for the analysis of goals we propose to adopt information visualization techniques based on content analysis and text mining methods.

Figure 3: Word cloud for SA agreements' goals.

To exemplify the concept, in Fig. 3 it is shown a word cloud for the alliance goals coming from the documents (e.g. strategic agreements) used to formalize the SA. From this kind of analysis it is possible to extract the relevant objectives of the collaboration, such as offering new services, developing continuing education courses or improving marketing strategy.

4.4 Pertinence of the Approach

The proposed approach is based on the availability, in the public domain, of performance-related information (e.g. financial statements) for both firms and SAs. While this information is already available for firms, no rules and standards have been defined for SAs. On the other hand, strategic alliances, virtual organizations and other aggregative forms are ever more important in the global economy. That's why several countries are working on the above mentioned rules and standards for SAs, like in the case of the "Small Business Act" defined by European Union to promote the aggregation of Small and Medium Enterprises.

In this scenario, at the current state of research it is not possible to evaluate our proposal on the field, due to the lack of performance-related public information on SAs (but in Italy, for example, they will be available by the end of the first semester of 2014). Furthermore, in accordance with (Strecker et al., 2011), we assume that prospective users at present are not yet able to evaluate the effectiveness and applicability of the tools and methods, because they are validated on conceptual models rather than on an adequate sample of actual data.

For these reasons the proposal has been validated against the literature (Strecker et al., 2011), i.e. at the best of our knowledge it has been built to be coherent with existing literature and practice. Indeed, taxonomies and ontologies are widely

adopted to provide users with semantic elements, and this is useful to understand strategic alliances. Moreover, hypertrees have been successfully exploited by several authors (Müller n.d.; Katifori et al. 2007) to explore complex data-sets, to comprehend the relationship existing in complex phenomena and to find clusters, outliers and other relevant patterns such as those outlined in our paper.

Finally, clouds of words have been used in a wide diversity of applications, ranging from the analytical to the emotional, and can be used for an immediate visualization or most used words (static word clouds) or for the illustration of the content evolution in a stream of documents (Cui et al. 2010).

5 CONCLUSIONS AND FUTURE WORKS

In this paper we present the main lines of a work aimed at developing an interpretative framework to understand how to use KPIs' for monitoring and benchmarking of Strategic Alliances. In particular, we propose an ontology, two taxonomies and two information visualization objects to help answering question such as "which KPIs should I use in my SA?", "how can I understand if my SA or my firm are achieving the predefined goals?".

The proposal will be used to design and implement an online database for strategic partnerships governance and analysis and to test it on the field. This online database can be useful to SMEs that lack of the economical and managerial resources required to enforce such a complex performance measurement system.

Future works will include an improvement of the content analysis, the linkage between goals and KPIs and the analysis of SAs financial statements.

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