

Complex systems as key drivers for the emergence of a resource- and capability-based interorganizational network

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Using the complex systems approach to extend the resource- and capability-based theory of the firm and integrate it into the strategic networks perspective, this article introduces the concept of a 'System of Business Enterprises' (SBE). By combining an integrative complex systems framework the two perspectives at hand (strategic resources and strategic networks), I define the SBE as a complex dynamic network of resources and capabilities. Along these lines, the study tries to lay down a first sketch of a theory of firm aggregates, and in particular of the resource- and capability-based interorganizational networks, and fleshes out a few learning points for management practice.

Introduction

Management theorists and practitioners have increased their recognition that firms do not act by themselves, but are deeply embedded in 'networks of external relationships' that influence the exchange of resources and capabilities among them (Granovetter, 1985). Acknowledging the long-term dynamics of "continuous interaction among firms" and that "firms are acting and living together" (Nohria & Eccles, 1992), this article aims to define and introduce the concept of the System of Business Enterprises (SBE), viewed as a resource- and capability-based complex organizational network.

The SBE is defined as a collection of business firms giving shape to a complex and dynamic network of resources and capabilities. The thrust of the argument is that an SBE is a complex dynamic self-organizing network that evolves over time.

The SBE is a conceptual macrocategory or metacategory intended to extend the organizational cognitive scope. I consider the SBE either as:

- the combination of business activities, separated and legally divided into different and entrepreneurially distinct units (strategic agreements, groups of firms, industrial districts); or
- the 'analytic portrait' of large complex firms, apparently compact, but relatively autonomous and interrelated in their component units (national domestic, multinational and transnational firms).

In order to explain how the SBE emerges in pursuing competitive rents, two perspectives, the resource- and capability based theory of the firm and the strategic network approach, provide the eclectic foundation upon which the framework is built. Notably, the two perspectives in hand yield the kernel of a third synergistic perspective: *the network of resources and capabilities*.

With the intention of bringing together and integrating two strategic theoretical approaches, i.e., strategic resources and strategic networks, I embrace a *complex system perspective* (Waldrop, 1992; McKelvey, 1997; Anderson, 1999). This perspective suggests a system concept encompassing complex systems composed of different interconnected levels and qualified by dynamic boundaries. I show below how this perspective proves helpful to integrate resource-based and strategic networks approaches in the theoretical construction of the SBE.

The article is structured as follows. First, I recap complex systems theory, the resource and network approaches, and underline their respective importance in the analysis of the SBE. Second, by integrating, in the light of the complex system theory, resource- and network-based perspectives, I define the SBE as a complex and dynamic network of resources and capabilities. Finally, I gather some relevant learning points for management practice.

Complex systems

Complexity theory is assuming a relevant role in strategic management and organization theory (Cohen, 1999; Axelrod & Cohen, 2000). Notions drawn from complexity theory are frequently invoked when theorizing about the trajectories of firms that will succeed in dynamic and potentially discontinuous environments (Brown & Eisenhart, 1998). Developed primarily in biology and physics (the Santa Fe' and the European perspectives^[1]), and the continental epistemology (Piaget, 1967; Morin, 1977; Bocchi & Ceruti, 1985), its translation into a management framework requires care and attention. However, if carefully mastered and applied, complexity theories have significant potential in management (Anderson, 1999). Among the notions stemming from the growing body of complexity, some seem to be better adapted

to the study of interfirm relationships and aggregates than others. Exceptionally helpful in this context are the basic concepts of complexity itself, 'complexity', 'self-organization' (Kauffman, 1993), 'organizational closedness' (Maturana & Varela, 1973, 1987), 'coevolution' (Lewin & Volberda, 1999), and 'emergence' (Holland, 1998).

- **Complexity.** Any adaptive entity contains an adaptive inner environment. Complex systems are *nested* hierarchies that contain other complex systems. These subsystems are therefore subject to evolutionary pressures. The SBE is a complex system of interacting, coadapting firms and the firms in the SBE are complex subsystems embedded within it.
- **Self-organization.** Under the lens of complex systems theory, I define the SBE as a self-designing and self-organizing entity; a dynamic strategic-organizational form that continuously shapes and reshapes itself, its resource and capability dynamics in connection with the external environment. From an evolutionary viewpoint, the SBE is like a ship on the open sea that has to rebuild itself while staying afloat.
- **Organizational closedness.** The SBE is a simultaneously open and closed system. Within the SBE, the concept of openness is combined with (not just juxtaposed to) the concept of 'closedness', although on a different level. The SBE is at the same time organizationally closed and thermodynamically open. SBE openness refers to thermodynamic aspects or to exchanges of the system with its environment, to the ability of the system to extract energetic 'nourishment' from it (e.g., collecting data and information). Closedness relates to the order that defines the organization of the system (i.e., organizational rules of interaction). Organizational closedness is at the basis of what is called the *cognitive dominion* of the SBE. The cognitive dominion of an autonomous system, which is endowed with organizational closure, is the dominion of the interactions that the system can embrace without losing its closedness - without losing its identity. Losing closedness would suddenly mean the disintegration of the system *per se* (Ceruti, 1985: 37).
- **Coevolution.** Firms in the SBE coevolve with one another because changes in the distribution of behaviors among firms change individual fitness functions and such shifts in turn alter behaviors (Anderson, 1999: 223). As a consequence, the SBE as a whole evolves over time through the entry, exit and transformation of firms.
- **Emergence.** Finally, the SBE is a system exhibiting emergent properties - novel organizational traits

which emerge, often unexpectedly, from spontaneous interfirm interactions. SBE transformation, innovation and change can never be fully planned *ex ante* or governed by managerial intervention. They require the capability of flexible adjustments and mastering emergent unexpected behaviors and unintended consequences (Hayek, 1945).

Strategic resources and capabilities

In the strategic resource and capability literature, it is possible to identify two schools of thought: the *resource-based theory* (Wernefelt, 1984; Barney, 1991; Mahoney & Pandian, 1992); and the *dynamic capabilities theory* (Teece, *et al.*, 1997).

Whereas the resource-based theory focuses on the identification of Ricardian rent-generating resources as the genesis of the firm's competitive advantage (Peteraf, 1993), dynamic capabilities theory emphasizes both the creation of the rent-generating firm's competencies and capabilities and its earning of quasi-rents or efficiency-rents as sources of sustainable competitive advantage.

Advantages in this second stream stem from a firm's ability to:

- learn new modalities of managing the aggregates of existing resources, and
- develop new systems of resources, competencies and capabilities.

Thereby among the firm's purposes is for it to reach an acceptable balance between firm's heterogeneous capabilities and environmental uncertainty and instability (Teece, *et al.*, 1997). Examples of such value-creating processes include product development, strategic decision-making, knowledge creation and capabilities transfer (Eisenhardt & Martin, 2000).

As concerns SBE strategic resource research, the major limitation refers to the loci of external resources. Whereas a few strategy scholars (Gulati, 1999; Gnyawali & Madhavan, 2001) have recently turned to consider it as a relevant issue, the existence of resources external to the firm has barely received explicit emphasis. Though some contributions have pointed out the lack of a systematic attention to the environment (McWilliams & Smart, 1995; Foss & Eriksen, 1995), and others have suggested a change in the view of competition *per se*, introducing the concept of industry variety (Miles, *et al.*, 1993), the resource-based focus rests on the individual firm and its internal idiosyncratic resources and capabilities.

For firm capabilities at the firm level, I refer to both Teece, *et al.*'s (1997) and Eisenhardt and Martin's (2000) *dynamic capabilities* approach.

- The first difference between the complex system framework and the dynamic capability approach is that, whereas dynamic capabilities are concerned with the levels of the firm and the industry (internal and external capabilities), here is the SBE (the complex network of resources and capabilities) which is both the originator and exploiter of its basic strategic capabilities.
- The second difference is that the external congruence with the changing business environment of the dynamic capabilities perspective may not be sufficient: in the SBE approach I match *external* and *internal* congruence in such a way that is later defined as the *SBE coherence*.
- Third, there is a twofold nexus between resource, competence and capability. On the one hand, past accumulated, and *networked* resources and capabilities, are the drivers of present and new capabilities of the SBE. On the other, new capabilities massed together in a superadditive way (Langlois & Robertson, 1995) determine the SBE's overall economic and organizational competence and its potential to develop and evolve.

Table 1 juxtaposes complex systems perspective, strategic resource and capability theory and the strategic networks approach taken in the SBE viewpoint.

Strategic networks

The bridging of organizational and social network studies with strategy research, strategic network perspective originates mainly from network theorists with a background in sociology and organiza-

tion theory. The increasing interest in these particular kinds of aggregate organizational forms is made clear by the following concepts:

1. dynamic networks (Miles & Snow, 1986);
2. constellations of firms (Lorenzoni & Ornati, 1988);
3. network firm (Butera, 1990);
4. the relational view based on firm dyads (Dyer & Singh, 1998);
5. strategic networks (Gulati, *et al.*, 2000).

For they embody the analysis of collections of different firms. All these existing notions are to some extent cognate to the SBE; nevertheless they are not equal. Gulati, *et al.*'s (2000) concept of *strategic networks* is germane to the SBE in that:

- strategic networks are networks where stable interorganizational ties are strategically important to participating firms, and
- there is a link between the network configuration and value creation.

This implies, on the one hand, that the different firms each play a well-defined role sharing common superior objectives, but on the other, that the locus of value creation is the interfirm network rather than the individual firm level. In this perspective, the network structure defines and limits the relationships between the units. The thrust of the argument is that firms enter a network of embedded ties in order to pursue mutual trust and valuable information exchange across organizational boundaries. A network of embedded ties accumulated over time may rest at the basis of rich information and learning networks (Gulati, 1999). However, a strategic network is also different from the

	COMPLEX SYSTEMS	STRATEGIC RESOURCES & CAPABILITIES	STRATEGIC NETWORKS
Unit of Analysis	Complex Systems Discontinuous and Turbulent Environments	Resources Capabilities	Interfirm Relationships External Relations Network Resources
Level of Analysis	Personal Organizational Societal	Firm (Industry)	Firm in Networks (Interfirm Networks)
Objectives	Behavior of Complex Systems Emergent Behavior	Rent-Seeking Behavior (Resource- Based) Rent-Generation Behavior (Dynamic Capabilities)	Interfirm Behavior: Structures, Boundaries Processes
Major Contributions	Prigogine & Stengers 1984 Maturana & Varela 1987 Nicolis & Prigogine 1989 Waldrop 1992 Kauffman 1993	Wernerfelt 1984 Barney 1991 Teece, <i>et al.</i> , 1997 Eisenhardt & Martin 2000	Gulati 1999 Gulati, <i>et al.</i> , 2000 Gnyawali & Madhavan 2001

Table 1 Perspectives on complex systems, strategic resources and strategic networks compared

SBE in that:

1. it is based primarily on structural and control factors, the so-called 'network ties' which assemble and locate the networks;
2. it is related not so much to a complex resource and capability network but, on the contrary, to the 'distinctive capability' of the individual firms in the network;
3. it is rooted in an idiosyncratic concept of 'industry synergy', the symmetry between the characteristics and operations of the strategic network and the features and behavior of the firms within an industry; and finally
4. despite the authors' claims, its focus rests more on the firm level than on the network level and that "a firm's network allows it to access key resources from its environment" (Gulati, *et al.*, 2000: 207).

Network resources

In the strategic network literature a notion that has come to fill the resource-based chasm on the loci of external resources is the concept of *network resources*. Network resources are resources that emerge from firms' participation in interfirm networks.

- First, firm network resources result from the informational advantages assured by its participation in a firm's network of ties that channels valuable information (Gulati, 1999; McEvily & Zaheer, 1999).
- Second, the network resources a firm can receive from its participation in interfirm networks is akin to the 'social capital' of the individual and is referred to as the "structure of relations between firms and among firms" (Gulati, 1999).
- Third, this results from the firm's unique historical experience and comes about in a unique path-dependent process where both the frequency of past ties and the identities of its partners are critical.

However, by focusing on the firm level and considering the social context in which it is embedded (i.e., the set of interfirm relationships), the network resource literature has not gone much further than coupling a single firm to its external social factors and has thus virtually failed to address unambiguously the level of firm aggregate. Stressing the informational advantage that expands the opportunity set, or space, a firm may perceive for strategic actions, network resources actually underestimate the *social* advantage provided by the complex interfirm endowment of resources and capabilities. Giving emphasis to specific strategic resources stemming from firms 'relational capabilities' (Lorenzoni & Lipparini, 1999), network resource re-

search has overlooked the potential benefits of viewing a 'system of firms' as *itself* a network of resources and capabilities.

The SBE as a complex dynamic network of resources and capabilities

As heretofore mentioned, the SBE is conceptualized as a *network of resources and capabilities*. Two main network levels form this network: the *elementary* level and the *complex* level.

- **Network level 1.** Starting from a sole resource/capability, the first level shapes a simple or elementary network of resources and capabilities. This may include a minimum of two firms (in order to achieve the system configuration) and is capable of generating first level aggregation or agglomeration economies.
- **Network level 2.** The second level masses together and combines all the resources, competencies and capabilities extant in the SBE (and, therefore, all the firms) in a *superadditive* way until a complex and dynamic network of resources and capabilities takes its very shape. This second moment plays a crucial role in the emergence and evolution of the system for it enacts a 'synergistic pool of variety', generating second-level agglomeration economies. Since the firms are pooled together through and within the resource and capability complex network, by 'synergistic pool of variety' I purport a collection of different firms (the pool of variety) that jointly performs superadditively.
- **Two-level agglomeration economies.** Having observed the SBE as a two-level network of resources and capabilities, it is possible to represent the correspondingly two-level agglomeration economies in the SBE. For them fallout from elementary or complex networks of resources and capabilities, *agglomeration* economies can be found on the first and the second level in the SBE. The first level applies to the 'decomposability' of the tasks of entrusting the firms in the system, and in particular to the firm-related economies of production and distribution specialization. Second level refers to both agglomeration economies attainable throughout the flexible division of labor and by gaining access to complex information and the accumulation of learning and knowledge (learning, time and knowledge economies) at the system level.

The SBE as a complex dynamic network

It is time to proceed with the representation of the SBE in terms of a complex system. As previously noted, the SBE is a complex network system formed by interacting and coadapting firms that are complex

subsystems in themselves. As a consequence of the inner complexity and emergence, both the firms in the SBE and the SBE complex strategic behavior cannot be accurately predicted.

Dual dynamics. The SBE presents a specific twofold exogenous *and* endogenous dynamics that has a significant impact on its strategic evolution. Whilst recombining old and new and developing new resources, competencies and capabilities, the complex and dynamic network of resources and capabilities displays some endogenous emergent properties.

The SBE continuously shapes and reshapes itself: in a nutshell, it is 'self organizing' and 'self-designing'. The resource/capability complex network shows neither definite borders nor predefined evolutionary paths: the coevolution of the firms embedded in it (Uzzi, 1997) makes the SBE order change constantly and induces it to display thermodynamic openness and organizational closedness. Nevertheless, for the interaction with the exogenous environmental forces, the SBE also evolves exogenously. Since it coevolves with its general environment, the SBE shows an intense environmental connection with both its own institutional environment (e.g., public institutions, local communities) and the other SBEs. This continuous benchmark consents to determine and measure the SBE economic and social performance and to grasp the advancements made in its evolution and development.

Dell case. We consider the Dell Computer (tightly related) 'direct model' (Dell, 1998) a characteristic SBE. As Dell stitches together a business model with many partners (customers and suppliers) that are treated as intimately as if they are inside the company (Magretta, 1998), Dell system is a complex network of resources and capabilities. Since it is a dynamic complex network system of firms, blurring traditional boundaries in the value chain(s) among suppliers, manufacturers and end users and proposing a model of 'vertical disintegration', Dell has developed its direct system in a way that is practically counterpoised to vertical integration. In addition, Dell's massive investment on the relational side of the exchange, presents the basic traits of complex systems: complexity, self-organization, organizational closedness, coevolution and emergence.

Industrial districts. We take into account Italian industrial district, such as Carpi (knitwear and sweaters), Parma (cured ham, Parmesan cheese), Prato (textiles and clothing), and Valenza Po (gold jewelry) (Brusco, 1982; Pyke, *et al.*, 1990) made of multiple interconnected small and medium firms. They present emergent properties and a high internal self-organizing capability in that they tend to cover all the value net

of production and distribution, and are able to adapt themselves to changing conditions. Nonetheless, they are also dependent on the external environment: both on their own community, institutions and, at times, on the governance of a focal firm.

Coopetition strategy

Another economic organizing principle of an effective SBE, is that of 'coopetition'. The mutual cooperation among the firms embedded in the SBE, which is essential for strategic planning, R&D, production, marketing and distribution of new products or new processes, is matched with the internal interfirm competition. Interfirm reciprocal interdependence, trust and cooperation coupled with the ongoing interfirm competition generate a peculiar system dynamics that takes the shape of *coopetition* (Brandenburger & Nalebuff, 1996; Lado, *et al.*, 1997).

1. By competing and cooperating in a context that is competitive *and* cooperative, coopetition strategy drives out firm coevolution within the SBE.
2. By promoting a balance of cooperation and competition among firms in the SBE, coopetition strategy offsets the overall SBE dynamic development over time.
3. By enhancing social exchanges and knowledge flows among firms and generating organizational innovation, SBE coopetition strategy helps to spawn new and local solutions to problems (i.e., new product/processes/routines).

Table 2 shows an emerging framework that gathers complex systems, economic and social properties and patterns of integration of the SBE considered as a complex resource and capability network.

Social exchanges, knowledge flows, enduring commitments

As previously asserted, the SBE properties of emergence and coevolution - its flexibility and reactivity - lead to the formation of a *complex network* of resources and capabilities. Since the simple interaction and exchange between elementary resources and capabilities is not suitable to shape a complex and dynamic network, to give birth to a complex dynamic network of resources and capabilities, a three-step framework turns up to support us. This framework is made by social exchanges, knowledge flows and enduring commitments intervening at multiple levels in the SBE (individual, firm, interfirm, SBE levels).

- **Social exchanges.** The intense social interaction that is observed among the firms in the SBE and the people (groups, teams and individuals) who are working in these firms, which leads to the forma-

PROPERTIES	PATTERNS OF INTEGRATION
<p>Complex System</p> <ul style="list-style-type: none"> • Complexity • Emergence • Self-Organization • Co-evolution • Organizational Closeness (and Thermodynamic Openness) 	
<p>Economic</p> <ul style="list-style-type: none"> • Super-additivity • Agglomeration Economies • Coopetition Strategy 	
<p>Social</p> <ul style="list-style-type: none"> • Social Exchanges • Knowledge Flows • Enduring Commitments 	

Table 2 Properties and patterns of integration in the SBE observed as a complex resource and capability network

tion of social capital (Nahapiet & Ghoshal, 1997).

- **Knowledge flows.** The continuous exchange of information and knowledge among the firms in the SBE, which is allowed by the social exchanges at hand and that leads to shared knowledge (Hoopes & Postrel, 1999).
- **Enduring commitments.** The deep-rooted commitment to establish network-system connections, to work together and to perform jointly so that the firms in the SBE interact through passionate social exchange and zealous knowledge flow among themselves.
- **Patterns of integration and firm independence.** Whilst differentiating partially the roles of the firms in the system and integrating innovation processes at multiple levels, such social exchanges, knowledge flows, and enduring commitments follow a complex and dynamic pattern of integration. As firms in the SBE develop special *asymmetrical* routines, resources and capabilities that allow them to perform 'precise' roles in the various processes and to accumulate organizational memory. The partial differentiation of roles induces specific parts of the system to acquire certain levels of virtual independence.
- **Successful team metaphor and collective identity.** The three SBE characteristics (i.e., the configuration of complex network, the differentiation of firms roles and the administration of multiple innovative processes), on the one hand, interconnect to form a 'complex dynamic system' that portrays the SBE via the 'successful teamwork metaphor'. On the other, since it unfolds a *collective identity*, they contribute to shape and mould

an SBE that tends to be strategically coherent as a whole (see Table 2).

Managerial implications

Starting from the complex system integration of strategic resource and network perspectives, this paper proposes a conceptualization of the SBE as a firm aggregate organizing itself as a two-level complex dynamic network of resources and capabilities. Summing up, the paper contributes to the resource-based and network-based literature by:

- pointing out that in today's strategic and managerial approaches the firm aggregate is to be considered an 'appropriate' and promising level of analysis (along with the more familiar firm and industry levels), and
- suggesting that the system of firms is to be regarded as a complex network of resources and capabilities.

As previously noted, this article has drawn extensively on the burgeoning theoretical body labeled 'dynamic complex systems'. It includes the application of a system perspective in the analysis of firm aggregations. The SBE is conceived as a complex system, which is self-organizing, coevolving, organizationally closed and emergent. Since this attempt has tried to find new links between theories and approaches in strategy research, the SBE concept connects a plurality of interpretive levels (complexity science, strategic resources, and strategic networks perspectives) in a sketch of a *multilevel* (individual, firm, interfirm, SBE) and *multidimensional* (economic, social, strategic) framework (Gioia & Pitre, 1990; Weaver & Gioia, 1994).

On the basis of these premises, we may be able to gather some normative implications for managerial practice.

- First, the concept of the SBE indicates the need to consider with much greater attention the ‘networks of external relationships’. While managers are giving additional interest to a number of interfirm strategic arrangements, they ought to focus more on the fact that the different types of arrangements may be connected into a unifying coherent framework, i.e., the SBE framework. Managers will benefit from realizing that firm aggregations are to be interpreted as complex networks of resources and capabilities that they have to protect, nurture and enhance throughout time and space.
- Second, in order to capture and nurture agglomeration economies, managers ought to perceive the imperative to establish a new SBE or to participate in an existing one. This is not simply the participation in a ‘temporary’ business alliance where interfirm commitment is relatively low, unstable and rootless. It requires instead enduring commitments, knowledge flows and social exchanges, i.e., to establish interfirm dynamic capabilities and routines to enhance collective resource and capability endowment on the ground of the ‘successful sportsteam metaphor’.
- Third, contrary to conventional wisdom that high performance teams are merely cooperative, this also simultaneously means to share a strong spirit of cooperation and a high level of healthy internal competition among firms in the SBE. Managers may hence grasp another implication of this work: the importance to encourage firms in the SBE to benchmark against other firms for individual achievements that result in overall team success. By shaping and governing the how, when and what of competition (internal competitive rules), managers (similarly to sports trainers) can harness and direct SBE competitive strategic energy so that to improve the overall team performance. Coopetition strategy may thus be considered an emerging effective practice within an SBE.

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Notes

[1] As regards the Santa Fe' perspective, refer to Gleick (1988), Waldrop (1992), and Kauffman (1993). As concerns the European Perspective, refer to Prigogine and Stengers (1984), Maturana and Varela (1987), and Nicolis and Prigogine (1989).

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