Modularity and strategic flexibility: a cognitive and dynamic perspective

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Abstract

The paper addresses the question whether a modular organizational structure breeds mechanisms that promote proactive strategic flexibility. We examine this question from the perspective of the cognitive school of strategic management with the aid of system dynamics modeling and simulation to explore long-term dynamic effects. Both our analysis and our experiments with the model suggest that modular organizations do not necessarily encourage the construction of managers' mental models with a capability to generate more strategic options and, thus, do not increase strategic flexibility.

1. Introduction

Strategic flexibility is defined as the ability to precipitate intentional changes and adapt to environmental changes through continuous rethinking of current strategies, asset deployment and investment strategies (Bahrami, 1992; Evans, 1991; Sanchez, 1995). Consequently, strategic flexibility can be thought as extending along two dimensions: on the one dimension, it concerns the variation and diversity of strategies, while on the other, it refers to the degree at which firms can rapidly shift from one strategy to another (Slack 1983; Nadkarni and Narayanan, 2004). Sanchez and Heene (2004) argue that strategic flexibility is a function of the firm's resources flexibility defined as the number of different uses to which the resources can be applied, the cost and time required to switch the resources to different uses, as well as of the managerial capabilities required to achieve coordination flexibility. The latter refers to the capabilities required in identifying new resources which can be effectively applied in responding to new opportunities and demands, configuring these resources into an effective system, and deploying the new resources to new purposes. In other words, coordination capability, on which indirectly the sustainability of resource flexibility depends on, is contingent to the ability of management to generate strategic options with respect to resource endowments, e.g. to envision and implement the type and range of flexibility of its products and its production system.

It has been argued by many authors (e.g. Worren *et al,* 2002; Sanchez and Heene, 2004) that product and organization modularity is a strategic decision that results in augmenting the strategic flexibility of organizations. According to this stream of logic, modular products lead to modular organizations (Sanchez and Mahoney, 1996) as the various units involved in the design process of products with interchangeable components are loosely coupled, operate autonomously, and can be easily reconfigured. Loosely coupled organizational forms allow organizational components and their corresponding resources to be flexibly recombined into a variety of configurations (Schilling and Steensma, 2001), thus increasing strategic flexibility by managing organizational knowledge in a way that facilitates specific forms of "coordinated self-organizing processes" (Sanchez and Mahoney, 1996).

In other words, in modular organizations, coordination tasks are delegated to individual modules (functions, teams, etc.) and coherence is achieved easily through fully specified interfaces. In addition to the reduction of managerial complexity, this structural, hierarchical function-based decomposition results in the localization of the impacts of environmental disturbances within specific modules, increasing the immunity and adaptability of the overall organization in a turbulent environment (Sanchez and Mahoney, 1996).

A fundamental question that arises from the operational characteristics of a modular organization is whether this organizational form can be self-sustained by promoting internally the attributes of strategic flexibility. That is, whether this organizational structure breeds mechanisms that promote proactively strategic, not only operational, flexibility. In this paper, we examine this question from the perspective of the cognitive school of strategic management, and with the aid of system dynamics modeling and simulation we explore long-term dynamic effects. In the cognitive perspective, based on the assumption that strategies are mental constructs, the specific research question becomes: do modular organizations encourage the construction of managers' mental models with the capability to generate more strategic options and, thus, increase strategic flexibility? Our research aims at contributing to the growing stream of research that examines the role of managers' cognition in the achievement of strategic flexibility (e.g. Combe and Greenley, 2004; Shimizu and Hitt, 2004) by including a system dynamics perspective to challenge the assumption that organizational modularity leads to strategic flexibility.

2. Cognitive schemata and strategic flexibility

The term cognition refers to the way individuals perceive, filter and conceptualize information (Weick, 1990). These perceptions are cognitive schemata that take the form of frames (Goffman, 1974), mental models (Senge 1990), cognitive maps (Axelrod, 1976) (and many other names) that indicate the way individuals associate various concepts and use them as the foundation of decisions and action.

The impact of executive cognition in the strategy formulation processes and their outcomes has been a subject of great interest in the strategic management literature. According to upper echelons theory (Hambrick and Mason, 1984), the organization is a reflection of its top managers whose beliefs, in turn, have a decisive impact on the majority of the strategy attributes (innovation, diversification, quality management, risk-taking, etc.) (Adamides and Karacapilidis, 2005). The factors and processes that

shape executives' beliefs include executive demographics, functional position and professional background, peer-assigned roles and performance metrics (Schwarz, 2003), and organizational issues such as size, structure, strategy and (recent) financial success (Barr and Haff, 1997; Schwarz, 2003). While cognitive schemata, such as frames, originate from the cognitive psychology of the individual, management scholars have found it useful to conceptualize them as a property of larger organizational entities such as groups and firms (Reger and Huff, 1993; Prahalad and Bettis, 1986). The strategy development process, i.e. which and how individual mental models converge (or are "accommodated") towards a coherent list of actions, plays a decisive role in the justification of this assumption.

Two key attributes of mental models (in the rest of the paper we use the term "mental model" to include the characteristics of all similar cognitive schemata) are of particular importance to strategic flexibility: *complexity* and *centrality* (Nadkarni and Narayanan, 2004). Complexity is the result of the degree of differentiation (the range of internal and external environmental concepts included in the model) and integration (degree of connectedness among concepts) of the model. Complex strategy-related mental models embrace a wide range of strategic logics and a diverse set of alternative strategic solutions. At the organizational level, they allow firms to notice and response to more stimuli, thus increasing their adaptability (Lyles and Schwenk, 1992). Complex mental models contribute to strategic flexibility by reducing *discounting* (the phenomenon of focusing in specific (more familiar) events ignoring other more important) and *cognitive inertia* (the search for specific events and causes to strengthen the dominant logic(s) of the model). They allow managers to scan the environment and to respond to stimuli coming from it more effectively by considering more options and (eventually) implementing a wider range of them.

Centrality, on the other hand, refers to the focus and hierarchy of mental models. A centralized model is focused around a limited number of core concepts. The continuous long-term involvement with a limited number of concepts breeds centrality of mental models (Carley and Palmquist, 1992) and, as a result, amplifies a limited number (frequently a single) of dominant strategic logics. Centralized mental models lead to cognitive inertia as firms always refer to their past key successes instead of looking how to absorb new knowledge and create novel strategic options (Reger and Palmer, 1997; Adamides *et al*., 2003).

Vickers explained the formation and dynamics of individual and shared/group mental models though the concept of "appreciative systems" (Vickers, 1983). He distinguished human systems from natural and manmade systems by identifying judgment as the additional aspect of the former (Vickers, 1984). Judgment is an inherent attribute of decision making's three principal functions: noticing things about the situation (receiving information), evaluating the information (comparing to a "standard"), and acting on the interpretation (selecting a response). This was termed by Vickers as an appreciative system and the mental activity and social process of attaching meaning to perceived signals as appreciation. The appreciative system determines what facts to select from those related to the situation, the meaning that is given and the means that are used to fill the gap between existing and desired situations. The standards or criteria by which actions to be followed are judged are not given from outside. They are generated by the previous history of the system (past) and its interaction with the environment (culture).

This means that in the strategy formulation context, managers set standards or norms subjectively (rather than objective measurable goals of Simon's rationalistic tradition (Checkland and Holwell, 1998)) and they focus on managing relationships according to standards generated by their own culture, history and power status, and maintained through their self-reference attribute. The discussion and debate which leads to action is one in which those taking part make judgments about both "what is the case" (reality judgments) and about its evaluation as "good" or "bad", "satisfactory" or "unsatisfactory" (appreciative judgments). Under this prism, strategy making can be thought as social action based upon personal and collective *sense making* rather than a one-off task performed on the basis of objective scientific foundations. Consequently, in the long term, strategic processes per se influence executive beliefs and mental models in the same way their outcome is influenced by them (Chattopadhyay *et al*., 1999; Weick, 1995). In knowledge management terms, different perceptions/beliefs are the result of managers' association with different sources of principally tacit, cultural and, to a lesser extent, codified, knowledge.

Naturally, as the above discussion suggests, strategic processes are contingent to organizational forms and to operational structures. Strategic flexibility and managerial mental models are not related only through external environmental attributes, such as industry clockspeed (Nadkarni and Narayanan, 2004), but also through internal (organzational) ones. Narrow strategic processes with limited participation and interaction, which are simplified through well-defined interaction rules/interfaces, lead to managerial mental models of limited complexity, as managers have to focus in a limited number of concepts (a specific technology, a specific product or certain functional elements of a product range) and communicate them through the established interfaces. In a static, or short-term, view this seems logical and is the main advantage of the modular organization. A different, more dynamic, stance, however, suggests that modular organizational architectures enhance the centrality of managers' mental models at the expense of complexity. As a consequence, the ability of managers to envision and create options (i.e. novel systems of activities and resources) is reduced and the firm's strategic flexibility does not increase. On the other hand, strategic development and implementation processes that include managers with wide mental horizons, who can actively contribute to them, do not only result in more diverse and novel strategies, but also themselves widen further the mental models of the participants. Under these assumptions, to explore the dynamics of mental model characteristics with respect to organizational modularity and strategic flexibility, we have built the system dynamics model presented in the following section.

3. The dynamics of cognition in modular and strategically flexible (?) organizations

The system dynamics simulation model developed to explore the dynamics of the role of managerial cognitive models to strategic flexibility in modular and non-modular organizations is shown in figure 1. All variables can refer to both individual managers or organizational entities. The two principal attributes of mental models which are relevant to strategic flexibility, complexity and centrality, are represented as stocks. The flow *build_new_nodes* represents the addition of new nodes/concepts (horizontally, adding breath) in the managerial mental models which result in increasing their complexity (flow in the *COMPLEXITY* stock). The flow

nodes_not_used represents the natural depletion of mental models' complexity as nodes that are not used become obsolete and are rejected because the limited capacity of the human brain replaces them with new ones. As far as *CENTRALITY* is concerned, the flow *strengthen_links* refers to the process of strengthening existing links between existing nodes (or adding depth to a specific node), whereas the opposite is represented by the flow *weaken_links*. The continuous consideration of the same, or similar, concepts strengthens the links of existing nodes while, on the other hand, increased focus to core concepts results in the loosening of some concepts in the periphery which are then gradually driven out of the model. In addition, naturally, as no new events are noticed (or taken into account seriously) to confirm existing links, some facts are gradually disassociated.

The stock *ABILITY_TO_CREATE_OPTIONS* represents the ability of managers to create new options and, consequently, acts as the principal measure of strategic flexibility. In the model, the rate of increase of this stock's level (*increase_in_ability_to_create_options*) depends on the difference between the values of *COMPLEXITY* and *CENTRALITY*. This is a valid assumption as the ability to create options is positively correlated to complexity and negatively to centrality, and the two variables are not mutually exclusive at the short term (single simulation interval). Since both are stock variables, an increase in *CENTRALITY*, for instance, will only have a relative effect on the ability to generate options since the level of *COMPLEXITY* will not be reduced in proportion to the increase in the other variable. It should be noted that at the level of organization *ABILITY_TO_CREATE_OPTIONS* represents organizational ability as a sum of individual abilities.

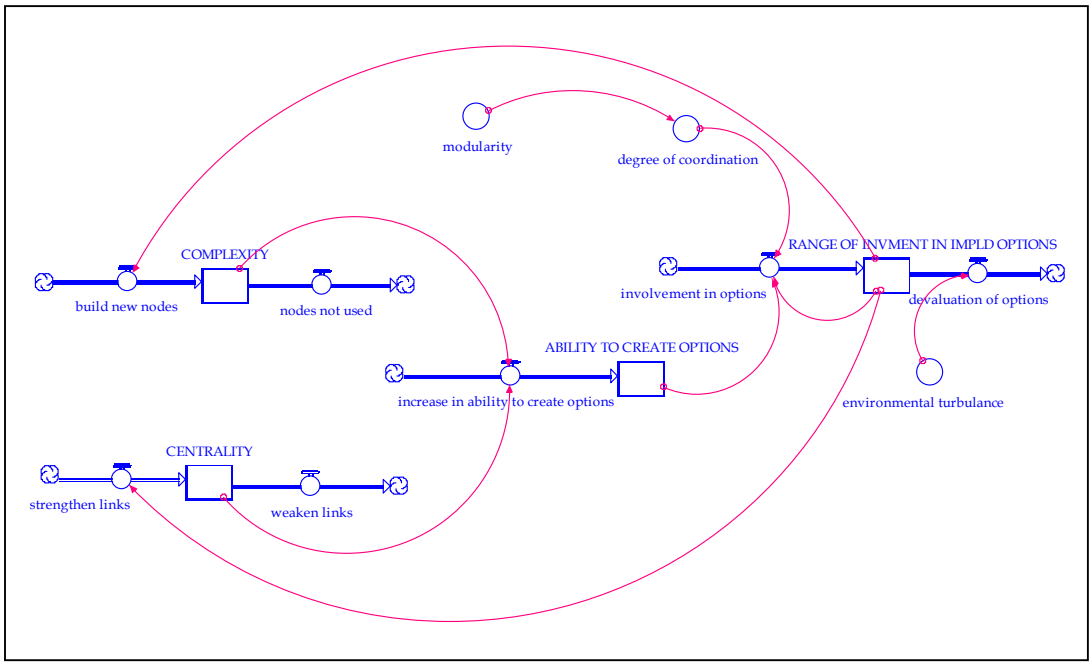

Fig.1. The system dynamics model for exploring the dynamic relation between mental models, organizational modularity and strategic flexibility.

The degree of managers' involvement in strategic option creation and implementation (*involvement_in_options*) depends on three factors: first, on the range of past

involvements (level of stock *RANGE_OF_INVMENT_IN_IMPLD_OPTIONS*), second on the ability to create options, and third, on the degree of coordination that the creation and implementation of the options requires. The latter is a measure of the quantitative and qualitative degree of participation of the individual managers in the strategic processes and it depends on the level of modularity of the organization. As the proponents of the modular organization claim, this form of organizational structure delegates coordination to simply interfacing work tasks and deliverables to the organizational architecture through standardized interfaces. As a result, managers in such organizations are involved only in specific issues and in a limited number of implementations of strategic options and cannot contribute actively to a novel consistent corporate strategy providing their own "helicopter-view" perspective (Friedli *et al*., 2004). Hence, the converter *degree_of_coordination* represents the ability to contribute in the construction of strategic options as systems by integrating knowledge and perspectives (collective sense making), and is inversely proportional to the degree of modularity (*modularity*). This means that, if in two different organizations, the stocks *ABILITY_TO_CREATE_OPTIONS* have the same value but one of them has a modular organization the degree of manager involvement in the creation and implementation of strategic options will be smaller. The rate of devaluation of options (outflow *devaluation_of_options*) as learning cases and, therefore, as factors determining mental model characteristics depends on the degree of environmental turbulence (*environmental_turbulence*). In relatively static environments the experiences gained from the involvement in the majority of the strategic options creation and implementation count more than in turbulent ones. In dynamic settings some of these experiences as learning paradigms, and mental model influencing factors, devaluate very rapidly. Finally, according to the discussion in section 2, the level of the stock *RANGE_OF_INVMENT_IN_IMPLD_OPTIONS* increases the rate of building new nodes (i.e. increases the complexity of mental models), whereas the opposites happens with respect to the centrality attribute. Involvement in the development and implementation of novel strategic options does not strengthen existing links between nodes; it just adds new ones.

Figure 2 shows three traces of the simulation of the model. The simulated variable is the *ABILITY_TO_CREATE_OPTIONS*, an indirect measure of an organization's strategic flexibility. *ABILITY_TO_CREATE_OPTIONS* aggregates the three dimensions of strategic flexibility: market flexibility (ability to assess several markets), resource flexibility (ability to proactively assess resource flexibility) and coordination flexibility (understand market and resource flexibility so that they can be balanced). Trace 1 refers to a modular organization, whereas trace 2 concerns an organization with half the modularity of the first. Trace 3 refers to the second organization operating, however, in more turbulent environment. All three traces indicate that, for the specific set of parameters, the reinforcing loop that extends from *build_new_nodes* to *RANGE_OF_INVMENT_IN_IMPLD_OPTIONS* dominates the balancing one that extends from *strengthen_links* to the stock *RANGE_OF_INVMENT_IN_IMPLD_OPTIONS*.

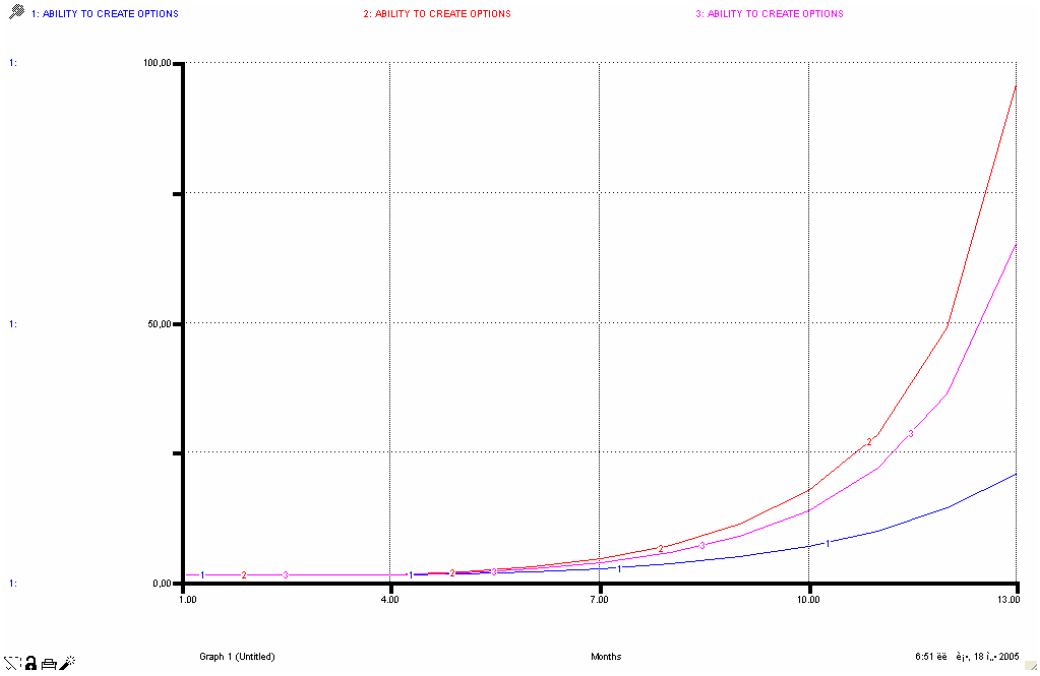

Fig. 2. The effect of modularity (traces 1 and 2) and environmental turbulence (trace 3) on strategic flexibility (ABILITY_TO_CREATE_OPTIONS)

Trace 2 indicates that based on the assumptions made, reducing modularity results in a significant increase in strategic flexibility as mental models become more complex and capable of generating more strategic options. Therefore, organizational architecture, through its associated strategic processes, regulates the mental model complexity loop so that it either dominates, or is dominated by, the option creation processes and consequently strategic flexibility. Fast devaluation of implemented strategic options, however, (turbulent environment – trace 3) results in decreased performance, as far as strategic flexibility is concerned. One implication of this latter observation is that managers in dynamic industries need to be involved in learning-before-doing exercises (such as strategic simulations) to accelerate the adaptation of, as well as widen their mental model structures.

4. Conclusions

In this paper we have addressed the question of whether a modular organizational structure promotes long-term proactive strategic flexibility. We examined this question from the perspective of the cognitive school of strategic management and with the aid of system dynamics modeling and simulation to explore long-term dynamic effects. Both our analysis and our experiments with the model suggest that modular organizations do not necessarily encourage the construction of managers' mental models with capabilities to generate more strategic options and, thus, at least in this respect, they do not promote strategic flexibility at a higher degree compared to more traditional organizational structures with more involving strategic processes.

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