Chapter 5
Supply Chain Integration: A Behavioral Study Using NK Simulation

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Abstract This chapter investigates the benefits of supply chain integration (SCI) by including behavioral factors influencing decision-maker behavior. In fact, the majority of the studies on the topic assume that SCI is pursued by a central planner, which is completely rational and adopts an optimizing behavior. Since the central planner is an individual, such assumptions appear to be too simplistic. In particular, I focus the attention on two main behavioral factors: (1) cognitive capacity and (2) resistance to change. Managers in fact differ in terms of ability to solve a problem. This depends on their ability to conceive alternatives solutions to test and on their cognitive limit in comparing alternatives and recognizing the best one. Resistance to change is an attitude of individuals who are averse to risk and prefer not to modify/try new solutions for fear of poor outcomes, fear of the unknown, or/and fear of realization of faults. To pursue the research aim a simulation analysis using NK fitness landscape is carried out, in which a central planner characterized by four increasing levels of cognitive capability and two levels of resistance to change is engaged to manage a supply chain in an integrated manner. Three types of supply chain structures characterized by increasing complexity are considered and their performances measured. Results show that supply chain performance increases as the level of cognitive capacity improves in all the supply chain structures, while resistance to change decreases supply chain performance even if the effect on performance is quite low.

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1 Introduction

Supply Chain Integration (SCI) advocates that the whole supply chain (SC) from the material suppliers to the end customers has to be managed by adopting an integrated approach. Integration allows the interdependencies existing along the SC to be managed in an efficient and effective way. Interdependencies arise because independent actors are engaged in the activities of the same production process and often have conflicting aims. If the SC is managed by local independent efforts, the interdependencies are neglected and the whole system results are inefficient although each part is optimized (Christopher 1992; Simchi-Levy et al. 2000).

There is an ample body of literature on SCI. It recognizes the role of SCI as a source of competitive advantage (Bowersox et al. 1999) and highlights the attendant benefits in terms of enhanced performances such as cost reduction, improved flexibility, and time saving (Frohlich and Westbrook 2001; Vickery et al. 2003).

Usually, integration is pursued by adopting a centralized decision making approach, namely there is a central planner in the supply chain which controls the entire production process and makes optimal decisions for the system as a whole (Giannoccaro and Pontrandolo 2004). This is the case of industrial practices implementing SCI such as Vendor Managed Inventory and Continuous Replenishment.

In the majority of the studies on SCI the central planner is assumed to be completely rational and informed. Human decision makers however behave very differently from this approximation in practice (Simon 1979). Their personal motives and their behavioral attributes profoundly affect their decision-making process (Mantel et al. 2006). Thus, the assumptions above appears to be too simplistic and the need to introduce behavioral factors in the analysis of operating system mandatory.

In particular, our understanding of SCI and its effect on supply chain performance is lacking in this respect. The success of SCI will depend on the accuracy of our understanding and modeling of human behavior (Bendoly et al. 2006).

Thus, the aim of this paper is to fill this gap by studying SCI taking into account human and behavioral aspects of the decision maker. In particular, we will attempt to assess the effect of two behavioral factors concerning the decision maker (i.e., the level of cognitive capacity and the resistance to change) on supply chain performance, when the supply chain is managed in an integrated manner.

Kaufmann's NK simulation (1993) is used as the research methodology. It is particularly appropriate for studying complex adaptive systems such as supply chains (Choi et al. 2001; Surana et al. 2005; Pathak et al. 2007) and suited to the development of simple theories like the one that we propose here (Davis et al. 2007). Simulation in fact permits an in-depth examination of the behavior of complex '*real world*' systems in ways empirical research prohibits, because it can be run many times, allowing the values of the model parameters to be modified in each run and changes to be observed in the outputs (Carley and Grasser 2000; Berends and Romme 1999).

The chapter is organized as follows. First, the theoretical background of the study is presented. Then, the NK model is discussed and the simulation analysis described. Finally, results are illustrated and managerial implications derived.

2 Theoretical Background

2.1 Supply Chain Structures: A Taxonomy

A supply chain is a network of firms collaborating in the development of a product/service for a final customer. Firms in the supply chain perform one or more activities of the entire production process, starting from the raw material supply to the distribution of the end product/service to the final customer. Thus, the supply chain may be described as a set of activities carried out by the firms.

The supply chain structure is concerned with coordinating all these activities. Various taxonomies regarding the supply chain structure have been provided in the literature. For example, Lambert et al. (1998) describe the supply chain structures in terms of primary and supporting members and types of business links. Stock et al. (2000) classify them based on the degree of geographical dispersion of the operations and on how the supply and the distribution channels are governed. Lin and Shaw (1998) define three types of supply chain structures, using the following variables: number of nodes, number of tiers, type of participants, type of operations, primary business objectives, product differentiation, product architecture, assembly stages, main inventory type, and product life cycle. Ernst and Kamrad (2000) develop a framework, based on the levels of modularization and postponement, which identifies four classes of supply chain structures, namely rigid, flexible, postponed, and modularized.

We characterize the supply chain structure focusing on the interdependencies existing among the activities carried out by supply chain firms, being the existence of such interdependencies requiring integration and making complexity the coordination of supply chains (Simchi Levy et al. 2000).

Interdependencies are primarily due to the division of labor along the supply chain. Indeed, each supply chain partner performs just a few activities of the entire value creation process from the supply of raw materials to the delivery of the final products and/or services to the customer. Thus, the outcome of each supply chain firm depends on the other partners.

Interdependencies differ in number and pattern. This mainly depends on the adopted supply chain strategy. For example, high modularization reduces the number of interdependencies among the constituting components and respective producing activities (Ulrich 1995). This strategy results in a particular pattern of interdependencies which occur not between activities referring to the production of distinct components, but only within a given component (Ethiraj and Levintal 2004). Conversely, low modularization is characterized by a large number of interdependencies among their components. In such a case, each component influences all the others and this makes high the degree of interdependencies among supply chain activities.

Based on the above, we conceptualize the supply chain structure as a set of interdependent activities carried out by supply chain firms. We characterize it on the basis of two taxonomic variables: (1) the number of interdependencies and (2) the pattern of interdependencies.

For our research purpose, we define three main ideal supply chain structures characterized by increasing complexity.

The *linear* structure is the simplest. It is characterized by a small number of interdependencies among activities. Such interdependencies occur only between adjacent activities, i.e., those belonging to the upstream and downstream phases of the production process. This structure is exhibited by serial supply chains modeled as a repeated chain of buyer–supplier relationships. It characterizes distribution supply chains and those implementing the JIT strategy.

The *modular* structure describes supply networks adopting a modular production process, i.e, interdependencies occur only within blocks and not between blocks. Such a structure is shown by the modular production networks observed in the electronics industry in many countries (Sturgeon 2002). The modular structure is more complex than the serial one, because of the higher number of interdependencies.

The *complex* structure characterizes supply chains in which all activities are interconnected among each other. Full interdependencies among firms occur in supply chains designing and producing integral products, where all firms at the same time need to be linked in order to design an effective product. This is the most complex structure because it has the highest number of interdependencies.

2.2 Supply Chain Integration

An ample literature has investigated SCI. Integration means that an entire supply chain is designed and managed as a single entity by a central planner, which plans and controls the whole system so as to optimize the global performance. This is a challenging task because it requires strategic alignment among partners, huge information sharing among firms supported by an ICT infrastructure, strategic partnerships and collaboration between buyers and suppliers, and joint forecasting and planning for controlling supply chain relationships (Lee et al.1997; Morash and Clinton 1998; Frohlich and Westbrook 2001; Zhao et al. 2008).

SCI involve all managerial levels: strategic, tactical, and operational (Stevens 1989) and might be viewed in terms of the functions to integrate, such as marketing, supply, production planning, distribution, and inventory (Ballou et al. 2000). Key business processes that should be linked along the SC include logistics processes (such as demand management, order fulfilment, manufacturing flow management, and procurement) as well as strategic processes (such as customer relationship management, customer service management, new product development, and commercialization (Lambert et al. 1998)).

There are a number of successful SCI practices implemented across a variety of industries. These include the quick response (QR) method, vendor managed inventory (VMI), co-managed inventory (CMI), jointly-managed inventory (JMI), and collaborative planning, forecasting, and replenishment (CPFR).

In the majority of studies on SCI, the central planner is implicitly assumed to be fully rational and adopting an optimizing behavior. The assumption of full rationality implies that the decision maker is able to gather all the information needed, has the cognitive capacity to make the optimal decision by analyzing the collected information, and behaves in the best interest of the system as a whole. However, the central planner is an individual and her/his behavior is much more complex than this approximation.

In the next section we review behavioral studies in the Operations Management field and investigate SCI by relaxing the assumption of full rationality of the decision maker and by introducing human factors describing the decision maker's behavior.

2.3 Behavioral Decision Making in Operations Management

Behavioral Operations Management (BOM) is the discipline that explores the deviations from rationality of the decision makers involved in the management of a system like a process, a project, an organization, or a supply chain (Siemsen 2009). It investigates the impacts of such deviations on performances and analyzes the strategies to improve them (Gino and Pisano 2008; Loch and Wu 2007).

Bendoly et al. (2006) provide a recent review of BOM studies. They identify three modeling assumptions commonly adopted in many different OM contexts and classify studies on the basis of the OM context and the type of assumption examined. Their review highlights the need for further research especially in the supply chain management area.

Mantel et al. (2006) classify BOM studies in three major classes on the basis of the factors influencing human decisions, i.e., personal attributes, risk, and task characteristics. Payne et al. (1993) highlight that motivation, personal relevance, and expertise are critical personal characteristics that can influence the decision-making process. The other most frequently personal attributes of decision makers analyzed in the literature include trustworthiness, cooperativeness, fairness, individualism, mutuality, integrity, ethics, and opportunism (Wathne and Heide 2000; Bendoly et al. 2006; Mantel et al. 2006; Gino and Pisano 2008; Loch and Wu 2007; Hill et al. 2009).

In this study we focus on two factors we believe critical for the management of a SC: (1) the decision maker's cognitive capacity and (2) the decision maker's resistance to change.

As discussed in the previous section, a decision maker pursuing SCI is involved in a coordination problem of managing interdependent activities. The efficiency and efficacy in solving this problem largely depends on the cognitive capacity of the decision maker, which in turn depends on: (1) his/her ability to conceive diverse solutions to be tested and (2) his/her cognitive limit to evaluate the outcomes of the proposed solution and to identify the best one.

Resistance to change is a personal attribute influencing decision maker behavior. It characterizes a decision maker adopting conservative rather than innovative behavior (Kotter 1995). Conservative behavior means that the decision maker will prefer to maintain the common way activities are accomplished, because he/she is averse to risk. Dubrin and Ireland (1993) in fact have highlighted that resistance to change is driven by fear of poor outcomes, fear of the unknown, and fear of realization of faults.

To the best of our knowledge, no study considers the effect of these factors on SCI.

3 Methodology

The NK model was conceived by Kauffman (1993) to study the evolution of biological systems but it has been also successfully adapted to strategic and organization studies (Levinthal 1997; Rivkin and Siggelkow 2003; Rivkin 2000, 2001; Siggelkow and Rivkin 2005).

An NK model consists in a decision problem defined by the number of decisions (N) and the number of interactions among the decisions (K). The decision problem is modeled as a landscape that maps combinations of choices regarding specific decisions (choice configurations) showing their respective payoffs. The solution of the decision problem consists in reaching the highest peak of the landscape, i.e., to identify the specific combinations of choices regarding the given decisions which yield the highest payoff. During the simulation, the system evolves by assuming higher positions on the landscape so as to reach the highest peak. If the highest peak is reached, the system is evolved with success. The more rugged the landscape, the more difficult it is to reach the highest peak and thus to evolve successfully (Kauffman 1993).

In the next section we describe the NK model of the supply chain by defining variables and the landscape. Finally, we explore how the evolution on the landscape is influenced by the behavioral factors described.

3.1 The Model of the Supply Chain Structure

Consider a supply chain made up of a number of firms. Each firm performs a number of activities such as production planning, distribution planning, inventory replenishment, etc. Firms make decisions concerning how to accomplish their activities.

As a consequence, the supply chain can be modeled as set of N decisions made by firms on how to perform each activity. The vector $\boldsymbol{d} = (d_1, d_2, \ldots, d_N)$ indicates the combinations of choices regarding activities made by the all firms, i.e., the choice configuration. For the sake of simplicity, we will assume that $N = 12$.

Activities in supply chains are in interaction as described in Sect. 2.1. Thus, interactions occur among decisions. K is the number of interactions among decisions. A decision i is interaction with the decision j when the choice concerning j influences the outcome of i. For example, the inventory replenishment decision of the distributor influences the performance of the retailer's inventory replenishment decision; the decision of the retailer to promote a given product will lead to higher benefits if the producer decides to increase the production of that product.

In the model, each decision makes a contribution C_j to the overall supply chain performance, which depends not only on the choice concerning the single decision, but also on how interdependent decisions (K) are resolved.

The specific pattern of interaction among decisions records which decision affects each one. It corresponds to an$N \times N$ matrix where the "x" in the position (i,j) means that the decision j affects decision i.

Fixing N, K, and the influence matrix, a specific supply chain structure is then defined. Coherently to our discussion in Sect. 2.1, three different supply chain structures are considered, whose influence matrixes are depicted in Fig. 1.

The aim of the supply chain is to identify the choice configuration (d_1, d_2, d_3, $\ldots d_N$) yielding to the highest supply chain performance. The overall performance of each choice configuration is computed as the average of the N contributions C_j:

$$P(d) = \left[\sum_{j=1}^{N} C_j\right] / N.$$

This decision problem is interpreted as a performance landscape, i.e., the map of the effect of all possible configurations on performances. The supply chain is thus engaged in an adaptive trek across the landscape in search of the highest peak (global peak).

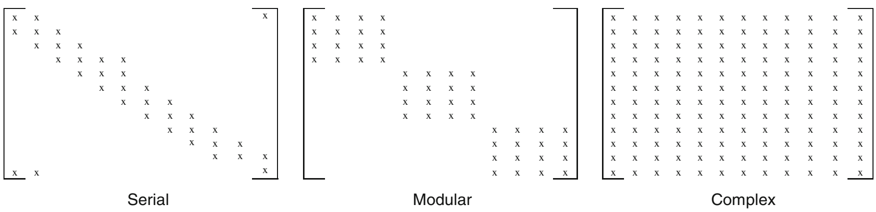

Fig. 1 The influence matrixes of the examined supply chain structures

Pursuing SCI means that a central planner performs just such an adaptive trek across the landscape. He/she is engaged in identifying the choice configuration yielding the highest total payoff $P(\boldsymbol{d})$. The searching procedure is affected by the behavioral factors characterizing the decision maker's behavior, as we will describe in the next sections. First, we will present the procedure to generate a performance landscape.

3.1.1 The Landscape Generation

The landscape is the map plotting the 2^N configurations and their respective payoffs. It is generated by applying the stochastic procedure described below and models the supply chain structure, because it depends on N, K and the influence matrix.

To generate the landscape, first the specific supply chain structure is selected.

Then, the payoff of each configuration is calculated using the formula $P(d) = \left[\sum_{i=1}^{N} C_j\right]/N$, where Cj is the payoff of each single decision d_j.

C_j is drawn at random from a uniform distribution $U(0,1)$. Note that C_j is affected by the choices on the interdependent decisions. Therefore, when $K = 0$, C_j depends only on a single decision, thus C_j assumes the same value in all configurations. When $K = N-1$, as in the complex configuration, C_j depends on how the all other decisions are resolved, thus the C_j differs in all configurations.

This procedure is applied for each supply chain structure, i.e., we generate three types of landscape, i.e., serial, modular, and complex.

3.2 Coding the Behavioral Factors into the Model

3.2.1 Levels of Cognitive Capacity

The decision maker is characterized by one of four increasing levels of cognitive capacity. As described in Sect. 2.3, two factors define the decision maker cognitive capacity: (1) an ability to develop solutions to the problem, (2) a cognitive limit in comparing the alternatives to discover the best one.

Notice that in the model the central planner searches for a new configuration with a higher payoff at each step of the simulation. The level of cognitive capacity affects this search.

In fact, at each step the central planner, coherently with his/her ability to conceive solutions, proposes a number of alternatives that differ from the current configuration. The number of alternatives is modeled by the number of decisions (MD) the decision maker controls, which can be modified at each step. A decision

Table 1 The coding variable of the decision maker cognitive capacity

Decision maker capacities	Coding variables	Options
Ability to conceive alternatives	N. of decisions may differ (MD)	1 versus 3
Cognitive limit to comparison of alternatives	N. of alternatives may be compared (PP)	1 versus All

Table 2 Coding the four levels of the cognitive capacity

Cognitive capacity	Ability	Cognitive limit	MD	PP
Level 1	Low	High	1	1
Level 2	Low	Low	1	12
Level 3	High	High	3	1
Level 4	High	Low	3	298

maker with greater ability can change more decisions at random at the same time, resulting in a greater number of alternatives.

We consider that MD can assume two values: 1 and 3. Only one decision at time is allowed to change when considering a decision maker with low ability; up to 3 decisions change at time for a decision maker with the greatest ability.

Once alternatives are available, the central planner compares the alternative configurations and selects the best one, i.e., the configuration with the highest payoff.

However, due to his/her cognitive limit, the decision maker is able to compare only a subset of alternatives. Such a limit is modeled through the processing power (PP), i.e., the number of total available alternatives that are compared. The higher the PP, the lower the cognitive limit.

Two options for PP are considered: 1 and *all*. PP = 1 means a high cognitive limit, because the decision maker is able to compare only one configuration. Thus, he/she will select one configuration at random among the alternatives. PP = *all* means that all available alternatives are compared and the best one is identified. Thus, the cognitive limit of the decision maker is low.

Table 1 summarizes the code of the two considered factors and the values of the coding variables. All the four possible combinations are considered, resulting in four increasing levels of cognitive capacity.

Table 2 shows for each level of cognitive capacity the values of the coding variables (MD and PP).

3.2.2 Degree of Resistance to Change

Resistance to change is a personal attribute of the decision maker, who prefers to maintain the current way in which the activities are accomplished (status quo configuration), even when alternatives with higher performance for the supply network are available.

We model such an attribute through the probability (p_{RS}) that the decision maker will accept to move in a new configuration with a higher payoff. We consider two options: no (p_{RS} = 1) and high (p_{RS} = 0.3) resistance to change.

The system evolution follows these steps:

1. The central planner conceives MD alternatives;
2. The central planner calculates the payoff of the alternatives;
3. The central planner compares PP alternatives and chooses the alternative with the highest payoff;
4. The central planner adopts the new configuration if this provides a higher payoff, with a probability p_{RC}. Otherwise, status quo is maintained.

4 Simulation Analysis

We designed a plan of experiments consisting of 24 scenarios, resulting from the match between the four levels of the cognitive capacity of the central planner in both cases of high and no resistance to change. In all scenarios N = 12 and each landscape was generated 1200 times to guarantee statistical significance to the results. The simulation period was set to 200 steps.

In each scenario we measured the supply chain performance, computed as the system performance $P(\boldsymbol{d})$ at the end of the simulation, as a portion of the maximum payoff achievable on the landscape. A performance equal to 1 means that the supply chain reached the highest peak on the landscape. Lower values mean that the supply chain during the evolution was trapped in a suboptimal configuration, reaching a payoff lower than the optimum. Results are averaged over the 1200 landscapes.

Table 3 Simulation results

	Serial		Modular		Complex	
	No RC	High RC	No RC	High RC	No RC	High RC
Mean of the performance						
Level 1	0.9451	0.9383	0.9186	0.9132	0.8320	0.8295
Level 2	0.9546	0.9546	0.9377	0.9353	0.8459	0.8457
Level 3	0.9656	0.9304	0.9564	0.9167	0.8782	0.8511
Level 4	0.9898	0.9799	0.9895	0.9784	0.9271	0.9072
Standard deviation						
Level 1	0.0514	0.0544	0.0615	0.0617	0.0600	0.0636
Level 2	0.0479	0.0483	0.0562	0.0570	0.0555	0.0562
Level 3	0.0406	0.0540	0.0421	0.0602	0.0503	0.0571
Level 4	0.0225	0.0311	0.0227	0.0333	0.0402	0.0459

Difference statistically significant with $p<0.00001$

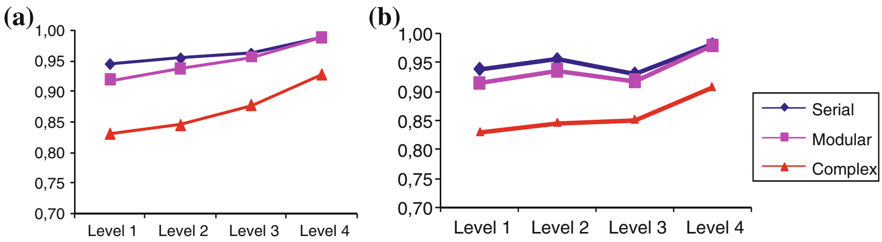

Fig. 2 Performance trends for increasing levels of cognitive capacity

5 Results

The results, reported in Table 3, show that the cognitive capacity of the decision maker and his/her resistance to change affect supply chain performance when supply chain in managed in an integrated manner. Note that there is no scenario where SCI reaches the optimal performance and this is due to the behavioural factors. First, we will discuss the effect of the decision maker's cognitive capacity and then the influence of resistance to change (RC).

Considering a central planner with no resistance to change, increasing the decision maker's cognitive capacity improves supply chain performance (Fig. 2a). In fact, moving from level 1 to level 4, the performance rises in all the three supply chain structures.

Notice that as the complexity of the SC structure increases, i.e., moving from serial to modular to complex, the performance decreases, regardless of the cognitive capacity level. This trend is expected, because it is known that as K increases, the performance of the system decreases, because the landscape becomes more rugged and multipeaked and consequently the adaptation becomes more complex (Kauffman 1993). This result confirms the validity of the proposed model.

We further quantified the effects of the cognitive capacity level by comparing the results achieved in level 4 against those in level 1. In the case of a serial supply chain, the difference in performance between level 4 and level 1 is about 4.5 %, while in that of a modular supply chain, the difference in performance rises to 7.1 %. The highest difference is achieved in a complex supply chain (about 9.5 %).Thus, the more complex the supply chain structure, the more important the cognitive capacity of the decision maker becomes in terms of the impact on performance.

Results for high resistance to change follow a similar trend. As the cognitive capacity level rises (i.e., moving from level 1 to level 4), performance tends to improve, except for level 3 in the case of serial and modular structures. In such structures, a central planner with a high ability to conceive alternatives but a low cognitive limit (i.e., limited ability to compare a number of alternatives) decreases performance. In particular, performances are very close to those achieved in level 1, i.e., when the central planner has a limited ability to develop alternatives.

Table 4 Performance difference between No and High resistance to change

	Serial	Modular	Complex
Mean			
Level 1	0.0068[a]	0.0054[a]	0.0026[b]
Level 2	0.0000[b]	0.0024[b]	0.0004[b]
Level 3	0.0352	0.0394	0.0269
Level 4	0.0099	0.0111	0.0200
Standard deviation			
Level 1	0.0669	0.0752	0.0778
Level 2	0.0638	0.0722	0.0720
Level 3	0.0631	0.0653	0.0651
Level 4	0.0202	0.0344	0.0539

Difference statistically significant with $p<0.00001$. [a] Significant with $p<0.01$. [b] Statistically not significant

Moreover, for simple supply chain structures, where the landscape is not rugged ($K = 2$ and $K = 3$), improving the ability of the decision maker to develop alternatives is not beneficial. Indeed, there is a high probability that developing many alternatives to compare (i.e. 298), results in a move away from the global peak, since the decision maker then chooses one of many different alternatives at random.

On the contrary, high complexity resulting in a multipeak landscape requires that many different alternatives be tried even when the cognitive limit is high, because in such a case the possibility of exploring the landscape (search capability) improves the chances of discovering configurations with a higher performance.

Based on the above, we can affirm that noncomplex supply chain structures, such as serial and modular ones, may improve performance while pursuing integration only by increasing the cognitive limit of the central planner.

Finally, to quantify the effect of the cognitive capacity level, we compared the results achieved at level 1 with those of level 4. The performance difference increased as the supply chain complexity grew. So we confirm that, even when the central planner is resistant to change, it is more important to have a central planner with a high level of cognitive capacity as the complexity of the supply chain structure increases.

We will now discuss the effect of resistance to change of the decision maker on performance. In Table 4, the performance difference between results in cases of no and of high resistance to change is computed for each supply chain structure and for each cognitive capacity level. It can be seen that resistance to change decreases supply chain performance because all differences are positive. This is an expected result because the central planner, even when a configuration with a better performance exists, prefers to maintain the status quo due to his/her risk aversion. Notice that performance differences are however quite low: the highest are achieved in the case of cognitive capacity level 3, whereas the lowest are associated with level 2.

6 Conclusions

This chapter has investigated the benefits of SCI by including behavioral factors influencing decision maker behavior. In fact, the majority of the studies on the topic assume that SCI is pursued by a central planner, which is completely rational and adopts an optimizing behavior. Since the central planner is an individual, such assumptions appear to be too simplistic. In particular, the personal characteristics and motives of the decision maker are important factors to be considered in the analysis because they affect his/her decision-making behavior.

We have focused the attention on two main behavioral factors: (1) cognitive capacity and (2) resistance to change. Managers in fact differ in terms of ability to solve a problem. This depends on their ability to conceive alternatives solutions to test and on their cognitive limit in comparing alternatives and recognizing the best one. Resistance to change is an attitude of individuals who are averse to risk and prefer to not modify/try new solutions for fear of poor outcomes, fear of the unknown, or/and fear of realization of faults.

To pursue our research aim, we developed a simulation analysis in which a central planner characterized by four increasing levels of cognitive capability and two levels of resistance to change is engaged to manage a supply chain in an integrated manner. Three types of supply chain structures characterized by increasing complexity were also considered. Finally supply chain performances were measured and the results compared.

Our simulation analysis has allowed us to show that supply chain performance varies with the cognitive capacity level of the decision maker and his/her resistance to change. In particular, supply chain performance increases as the level of cognitive capacity improves in all the supply chain structures. Moreover, our results have shown that the cognitive capacity of the decision maker becomes more important, in terms of its impact on performance, as the complexity of the supply chain increases. A further result of the study has been that resistance to change decreases supply chain performance even if the effect on performance is quite low.

Thus, further research will be devoted to identify appropriate strategies able to improve supply chain performances mainly in case of low levels of cognitive capacity of the decision maker.

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