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Towards modeling the supply chain's performance evaluation criteria

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Abstract—The problem of supply chain performance is a major factor that companies have to consider for increasing its competitiveness in a market in continuous evolution. In this framework, we suggest in this paper, in first place, to identify the role and the importance of performance criteria in the achievement of the company performance. In second place, we formalize a UML class model to clarify the relationship between the supply chain, its performances criteria and their indicators. Thereafter, we present the study of the various performance criteria's junction using an interaction grid.

Keywords—Supply chain, Performance criteria, Performance indicators, Interaction grid, Relation model.

I. INTRODUCTION

Logistics is the strategic process by which the company organizes and supports its activity. As such, we can determine and manage related flows (financial, material and informative), internal as external, upstream as downstream. Its mission consists in allowing the elaboration of the company offer and realizing the meeting with the market requests while looking for systematically the conditions of optimality in the execution [28].

A supply chain is the system by which companies bring their products and their services up to their customers [26]. It is the awareness of supply chains that brought to the foreground new needs regarding integration of companies and coordination of flows. To satisfy these needs, methodologies and tools must be in position: where hence the birth of the supply chain management [19].

The supply chain management is the systematic and strategic coordination between internal or external functions of one or several companies [23]. Its objective is to improve the competitiveness of firms by minimizing the costs, by insuring a level of service required by the customer, by assigning effectively the activities on the actors of production, distribution, transport and information, by watching that the actors do not develop conflicting local behavior coming to burden the global performance [17].

Companies are often eager to look for a maximum performance level of their supply chains. This performance depends on the structure of the supply chain, as well as several elements appearing in this chain. Besides, it allows the enterprise development and ensures a good brand image as well as a competitive advantage.

The evolution of supply chains and performance characteristics generates a questioning on instrumentation and methods of piloting used until then. The definition and the setting-up of performance indicators raise numerous problems connected in particular to the performance notion evolution. Indeed, in this article, we are going to study the performance notion, performance indicators, performance measurement, and finally criteria to measure this performance, etc.

II. PERFORMANCE CRITERIA OF SUPPLY CHAIN EVALUATION

A. Concepts

1) Performance concept

The notion of performance is extremely relative because an appearing system as having powerful performance in the eyes of someone is not necessarily successful in the eyes of others. Alongside the traditional measure of productivity, other forms of performance have been gradually imposed. Induced by competitiveness, not only mono criterion based, (cost reduction) [13], performance must nowadays to be multi-criteria, taking into account different indicators to ensure the visibility and performance of all processes that interact in a supply chain. Several works on performance study concern the physical flows, financial flows and information flows [14].

Under the term "performance" are three nations that are performance indicator, performance measure and evaluation that we detail thereafter.

2) Performance indicator

The performance indicator can be defined as information that must help an actor, individual or collective, to lead the course of an action towards the achievement of an objective or to enable it to assess an outcome, [22]. We distinguish various types of indicators which can be classified according to the performance nature: external or internal indicator, [5].

In a general way, the indicator has sense only with regard to a piloted action. It is thus closely linked to a precise process of action. It has to correspond to an objective and measures the achievement of this objective (result indicator) or informs
about the good progress of an action to reach this goal (piloting indicator). It is intended for use by specific actors.

3) Performance Measurement

The measure allows informing the performance affected by the system/process [4]. It is returned by the indicator and should reflect the real state, compared with the wished state (objective). The capacity to measure processes performance can be seen as an important prerequisite for the improvement. Companies have increased, during these last years, the possibilities offered by their performance measurement systems.

The performance measure, in a context of supply chain, becomes increasingly important. The theme is widely approached by scientific community who is interested in improving operations processes and increasing productivity [1].

4) Performance assessment

Traditionally, performance assessment refers to management control, that formulates (especially with numbers) goals and then measure the performance realized in attaining these goals [4].

The assessment enriches the information given by a simple measure, and delivers an interpretation with regard to a global vision or a reference frame [7]. Thus, contrary to the measure, which retains an important role but sticks to the effects, assessment is more general: we try to go up the causes and also decide on the objectives and their implementation. More precisely, evaluate is to assign a value, good or bad, better or worse, to an entity or to an event. This is not simply measuring the intrinsic value of objects but to establish an order of preference, [15]. In a case or another, the evaluation is based on a model, either emulate the future system or to interpret the real system. This is not simply measuring the intrinsic value of objects but to establish an order of preference [24].

B. Performance Evaluation Criteria

1) Efficiency:

It designates the fact of realizing with minimum possible of committed means. This term is initially used in economy. It should not be confused with the effectiveness that does not specify the used means. So, being efficient, means to be effective by making a good use of resources [21].

2) Reactivity:

In the literature, several definitions of reactivity have been provided by researchers such as: it is the capacity and responsiveness steering to face an unexpected event, both endogenous as a machine failure, and exogenous as a significant change in the order book, [16]. Also, it is the ability of a system to answer, within a given time, to an external request, [6].

We can assess the impacts of management practices on the supply chain reactivity with eight sub-stakes [12]:

- The design reactivity. Assess the practice impact on the period of design and development of products / services.
- The purchases reactivity. Assess the practice impact on the purchase period of raw material / components.
- The supplies reactivity. Assess the practice impact on the procurement time of raw materials / components.
- The sales administration reactivity. Assess the practice impact on the time-to-market products / services.
- The production reactivity. Assess the practice impact on the production time of products / services.
- The distribution reactivity. Assess the practice impact on the distribution period of products / services.
- The flow management returns reactivity. Assess the practice impact on the back flow of time.
- The supply chain overall reactivity. Assess the practice impact on the overall delay in the supply chain.

3) Reliability:

In logistics, reliability translates into the ability to deliver perfect orders in accordance with customer expectations. The logistic reliability recovers the respect notions of the commitments, of means and of result with regard to the specifications and to the predefined objectives. The global language used by the supply chain actors, including international standards of coding and marking products and logistical units and Electronic Data Interchange (EDI) messages are also some means to produce and to exchange reliable, precise and complete information. "Deliver, the first time and in compliance with specifications, the right product to the right place at the right time", also it allows reducing the additional costs associated to the delay and pollution related to repetition of deliveries, [27].

According to Emilie [11], the impacts of management practices can be evaluated on the supply chain reliability through four sub-stakes:

- The service to customers. Assess the practice impact on customer satisfaction in terms of choice of products / services, quality or delay.
- The service to suppliers. Assess the practice impact on supplier performance.
- The stocks reliability. Assess the practice impact on stock-outs.
- The forecasts reliability. Assess the practice impact on the forecasts reliability.

4) Agility:

Agility is primarily flexibility (static and dynamic) [8] and adaptability of processes, organizations and supply chains that are searched to cope and develop in unstable, turbulent, uncertain and risky environments.
The agility of the supply chain is its ability to quickly and effectively manage market fluctuations by adapting the response of the supply chain to demand, it requires the redesign of the traditional organization of the supply chain to meet these criteria.

5) The robustness:

The definition of robustness may vary depending to the scientific field that interested. In Automatic, the robustness is the ability to control the system to ensure compliance with the regulations in spite of the disturbing factors and uncertainties. This concept has since expanded to planning problem [29]. To qualify a plan as robust, if and only if it provides low dispersion characteristics despite the disruptive changes in uncontrollable factors.

Robust optimization is the ability to provide solutions by optimizing a function expressing a level of service or risk to the decision maker; these solutions are progressively less sensitive to the value of data in a set of scenarios allows the control system to identify the piloted system realities [20].

6) Productivity:

Generally, productivity is defined as the ratio between the production of a good or service and all the inputs required to produce it.

It constitutes, in fact, a measure of the effectiveness with which an economy takes advantage of resources that it has to produce goods or provide services. The evaluative character of human resources productivity is evoked because the operations duration can evolve in liaison with the operators learning who repeat the same work, but also with the fatigue or other elements more difficult to model [2].

A company looking to be more profitable as possible must make most profits possible by trying, for example, to be more productive. The productivity measures the effectiveness of a company. It is information about the speed, the quality of the company organization. We should not confuse the productivity and the production; a company can be more productive while producing less.

7) Profitability:

In literature, the profitability represents the ratio between company income and the sums that it has mobilized for obtaining them. It constitutes an element favored to estimate the company’s performance. The economic analysts distinguish two types of profitability: economic and financial.

According to Giunipero & al [12], it is possible to increase competitive advantage and company profitability by the Supply Chain Management (SCM), by raising the general level of customer satisfaction. Thus, the SCM implementation, by improving the value creation and the customer satisfaction, contributes to strengthen the competitive advantage of the chain and each of its actors and, thereafter, the profitability of the one and others.

The SCM aims to improve simultaneously the profitability (cost reduction) and the performance (customer service) in a strategic context (i.e. create value for the customer and satisfy his expectations by a supply chain integrated management) to obtain a competitive advantage which guarantees, consequently, the profitability.

8) Sustainability:

The pressure on companies to widen its report and responsibility of the economic performance for shareholders to sustainability performance for all the stakeholders has increased [30].

The interaction between sustainability and supply chains is the critical next step from recent examinations of operations and the environment [9] and operations and sustainability [18]. Thus, the focus on environmental management and operations is moved from local optimization of environmental factors to consideration of the entire supply chain during the production, consumption, customer service and disposal of products.

Sustainability is generally defined as the use of resources to meet the needs of the present without jeopardizes in danger the capacity of future generations to answer their own needs [10]. Sustainability strategies of company are thus challenged to recognize at the same time, the market sustainability as well as the social and environmental sustainability [25].

III. PROPOSED MODEL

To facilitate the study of the choice of performance criteria and their indicators on supply chain performance, we propose first to show the relationship between these three concepts through a formalized model by a class diagram UML see Fig.1. Thereafter, we will study the interaction between the various performance criteria to evaluate their complementarities in improving the supply chain performance.

A process is a set of correlated means and/or activities which transform inputs into outputs elements. These means can include staff, installations, equipments, techniques and methods.

We distinguish three types of process such as the processes of support, management and realization. Each of these processes can contain several levels according to a downward vision going of the most generic to the most detailed: process, activity, task and operation.

Every activity is characterized by performance criteria (cf. II-B) to estimate its capability to reach its goals.

Every performance criterion is periodically measured through one or several performance indicators qualitative or quantitative type. However, performance indicator must be measurable, realistic, significant, actionable, time-defined, etc.

Performance indicators are fed by input elements as data from recordings taken over the development activities of the product/service. These indicators are manifested in three main families:

- Economic: reflecting a monetary character (increase in turnover rate, investment rate, etc.)
- Physical: reflecting a quantitative character of physical flows (quantity of delivered products, quantity of stored products, etc.)
To transform the input data of the performance indicator into useful value (result), a formula prove to be necessary. This formula must be reliable, effective and precise in the purpose to facilitate the evolution and the analysis follow-up of this indicator.

During the performance indicator’s follow-up, obtained result will be compared with a target objective. This target is fixed according to the strategic orientations of the company. If the process pilot noticed a gap between indicator result and its target, he has to make decisions to adjust the trajectory of the indicator in question.

Any company must to set goals declined from its policy. However, the achievement of these objectives requires implication of several resources: human, materials, financial and informative.

Objectives are systematically controlled, according to periods declined from their types, namely:

- Strategic objectives: long term,
- Tactical Objectives: medium term,
- Operational Objectives: short term.

If the pilot notices a gap between control result of the objectives and the purposes fixed in the action plan, decisions must be undertaken. That is to adjust this gap or to modify objectives. We distinguish four orientations types of objective:

- Service level: energy management, environmental respect, etc.
- Time: operating times, payback period of investment, etc.
- Cost: quality cost, investment cost, etc.
- Quality: skills quality, the delivered products quality, etc.

IV. GRID INTERACTION BETWEEN PERFORMANCE CRITERIA

In the literature, the majority of the authors often use the criteria of effectiveness, efficiency, reactivity and flexibility to estimate the supply chain performance. In addition to these four basic criteria, we noticed the emergence of sustainability criteria on most recent publications of science community. Besides, we noticed that in certain researches, authors introduce other performance criteria in a specific activity context in the supply chain such as criteria of:

- Robustness: Robust planning [31]
- Agility: Management of skills and Collaboration [32]
- Profitability: value creation and customer satisfaction [15]
- Productivity: resource optimization [15]
- Reliability: upstream and downstream delivery [3].

Our vision consists in widening the application of these last criteria on all activities of the supply chain and in integrating them with the basic criteria. Nevertheless, we consider that the effectiveness criterion is integrated into the efficiency criterion and that the flexibility is a part of characteristics of the agility criterion.

We conclude that the supply chain performance depends on the following criteria of performance: efficiency, reactivity, reliability, agility, productivity, robustness, profitability and durability. In this context, we suggest studying the interaction of these performance criteria by an interaction grid, table 1.

The binary interaction of criteria in the grid is based on their respective objectives. The result will be a common objective of both criteria. Example for performance criteria, robustness and agility: The robustness objective is the capacity to providing solutions by optimizing a function expressing a level of service or risk for the decision-maker. However, agility objective is the flexibility and the adaptability of the supply chain processes in unstable, turbulent, uncertain and risky environments. So, according to these two different objectives, we propose that the interaction between robustness and agility is to be able to provide solutions face various hazards.
<table>
<thead>
<tr>
<th>Efficiency</th>
<th>Reactivity</th>
<th>Reliability</th>
<th>Agility</th>
<th>Productivity</th>
<th>Robustness</th>
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<td>Respond quickly to external stresses with a minimum of resources</td>
<td>React quickly and in line with customer expectations</td>
<td>Be able to satisfy the requirements of stakeholders</td>
<td>Increase productivity</td>
<td>Find solutions to minimize resource</td>
<td>Minimize the resources and increase profits</td>
<td>Apply the SD principles by minimizing the resources</td>
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<td>React quickly in an adaptable environment</td>
<td>Be flexible to customer requirements</td>
<td>Quickly produce without compromising product quality</td>
<td>Finding solutions to respond quickly to external stresses</td>
<td>React quickly to external stresses with a maximum of profit</td>
<td>Respond quickly to SD requirements</td>
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<td>Be able to satisfy the requirements of stakeholders</td>
<td>Provide solutions to improve the quality of service required</td>
<td>Provide solutions to face various hazards</td>
<td>Satisfy the requirements of shareholders</td>
<td>Meet the requirements of stakeholders</td>
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<td>Being able to provide resources at a profit</td>
<td>Being able to provide solutions at a profit</td>
<td>Optimize the production function on all the shutters</td>
<td>Using the SD principles at the highest profit</td>
<td>Optimize productivity according to profits</td>
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<td>Optimize resources and productivity according to profits</td>
<td>Optimize productivity according to profits</td>
<td>Use profitable resources</td>
<td>Optimize productivity under the SD tab</td>
<td>Provide solutions to successful integration of SD principles</td>
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<td>Apply the SD principles in a profitable way</td>
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SD: Sustainable Development
V. CONCLUSION

The supply chain performance is often measured by using the process approach without giving a high value to certain performance criteria that can influence this measure. In this context, we proposed a Meta model in UML to formalize the relationship between fundamental elements of the chain: mainly the processes, the activities, performance criteria and performance indicators, while identifying the approach to be followed to measure and estimate the performance of this chain. In addition, we proposed a grid of binary interaction between different types of criteria, to identify the complementarily between them latter and consequently intensify the supply chain performance. In future researches, and through the model and the interaction grid, we plan to find way to identify the solutions and the actions to undertaken to improve the binary relation between the criteria and afterward the improvement of the global performance. For further research, an extension to other criteria is presently investigated to reach completeness. Furthermore a study of criteria's selection process to help companies to choose efficient criteria according to their size, type of activity, etc. is in progress.

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