BEHAVIOURAL INSIGHTS INTO SUPPLY CHAIN RISK MANAGEMENT

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Abstract: Literature has focused largely on the field of supply chain risk management. Numerous risks occur within supply chain management. Until lately, behavioural risks (implying large amount of losses) have been neglected and considered not relevant. In this paper we provide an analysis of the importance of including behavioural research in logistics and supply chain risk management, what has been written so far and potential future research directions. Until now, literature on logistics and supply chain management little addressed behavioural dimensions, neglecting the numerous human interactions.

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1. INTRODUCTION

Behavioural risks are a topic of recent interest in the academic field. Different types of risks have been so far, largely debated: quality risks, delay and inventory risk, and even terrorist attack risks. Given the worldwide extension of supply chains, with its main purpose of providing the customer with the lowest cost and highest quality product, it faces a whole range of different risks. Risks come from both internal and external environment, and must be mitigated in the appropriate manner.

Risks have been defined by many authors. In a formal definition by Samir Dani (2009) risks are calculated according to the formula below:

Risk = (The probability of a risk's occurrence) x (the implied consequences, in the case it actually occurs).

Norrman and Jansson (2004) see the risks as:

Risk = p x BI,

Where: p – event's probability

BI – severity or business impact.

At the level of a supply chain, risks can be defined according to the dimensions they incorporate, the sub-chains they include, the level on which they are analyzed, the category in which they find themselves towards the company (internal or external).

The dimensions incorporated by supply chain risks are, according to Spekman and Davis (2004):

- The flows of money and information

- The security of the internal information system of a company
- The company's reputation and CSR
- The relationship between supply chain partners
- The physical movement of goods.

Peck (2005, 2006) approached supply chain risks according to their sources and drivers, and the different level they operate. He proposes four levels of analysis for supply chain risks, covering the component elements and the environment in which they take place:

1. "Value stream/product or process
2. Assets and infrastructure dependencies
3. Organisations and inter-organisational networks
4. Environment."

Christopher and Peck (2003) consider five types of supply chain risks: Process and Control (internal to the firm), Demand and Supply (external to the firm, internal to the supply network), and Environmental (external to the network).

Faisal et al. (2006) suggests that the sources of risk are different variables (environmental, organisational or supply chain related). Predicting those variables is a difficult task, with no certainties, affecting the supply chain – outcome variables.

Zsidisin (2003) gives another definition for supply chain risk – the potential occurrence of an event related to inbound supply, leading to the inability of a company to satisfy customer demand.

If so far many authors have focused on the diverse risks affecting supply chains, Misha Seiter (2008) approaches them in an innovative manner, and states that besides the numerous risks affecting supply chains, a special focus should be targeted towards behavioural risks. The importance and implications of behavioural risks affect supply chains in different contexts, given the losses implied. In his study, Misha Seiter (2008) identified different types of behavioural risks, like opportunistic behaviour and the conflicts between partners. The interactions within a supply chain are the result of a human decision process, which needs to be understood in order to prevent the occurrence of various risks and more so, to be predicted for a more efficient activity. This is why analysing the behaviour of supply chain partners becomes of relevance. Predicting this behaviour could lead to a better management of supply chain risks, and major cost reductions.

The paper has 3 parts. We start our paper with an introduction in which we present the authors, who approach risk in general and supply chain behavioural risk, in particular. We mention the works of Samir Dani, Norrman and Jansson, Speakman and Davis, Peck, Christopher and Peck, Faisal et al. and Zsidisin. We present the work of Misha Seiter (2008) as one of the most important in the field, author who acknowledges the most important supply chain behavioural risk to be opportunistic behaviour and the conflicts between partners, as a starting point of the second part of our paper: the behavioural risks within supply chains. Besides Seiter's (2008) interesting approach to the principal-agent theory at the level of a supply chain, we continue Dornfeld's (2015) assumptions and describe how supply chain human behaviour can be explained throughout the butterfly effect. In the third part, we conceived a model based on Clark Hull's drive reduction theory, one which could help predict the occurrence of opportunistic and the non-compliant behaviour of supply chain partners. Therefore, we introduced a variable in our model through which we aim to discourage non-compliant behaviour, one which could trigger the respect of contracts' provisions. The paper ends with concluding remarks.

2. BEHAVIOURAL RISKS WITHIN SUPPLY CHAINS

Operations management embraces lately, more and more the behavioural perspective, as recent literature proves it. Real human behaviour, beyond the paradigm of normative optimisation, is very important, in operational management, fact proven by behavioural research.

In his article, David Dornfeld (2015) makes a very interesting analogy between the impact of human behaviour on supply chain management, and the butterfly effect. Starting from the idea that each decision has an influence on other decisions, people and businesses, he states that in a globally interconnected economy there is a complex infrastructure composed of people, locations and goods, also known as a supply chain. In his view, the butterfly effect idea can be transposed to explain supply chain interactions. The butterflies involved are people from various parts of the world, whose behaviour influences other people and businesses in totally different parts of the world. Dornfeld (2015) considers the most important human effect (butterfly) to be the derivation of supply related work, production and handling of components, materials and products, at the level of a supply chain. This work is carried out by human slaves, namely persons not paid or lowly paid, held captive in a modern slavery system, exploiting them for their labour and services.

Therefore, we consider continuing Dornfeld's (2015) idea and expanding his analogy to behavioural risks in supply chains, which could easily be compared explained with the butterfly effect. One human's decision affects another's decisions, in different places of the world, at different levels of a supply chain. If a person exhibits opportunistic behaviour, this behaviour will most certainly affect others, alongside the entire supply chain management.

An actual issue even nowadays is the fact that also in the supply chain field, the majority of assumptions focus on rational behaviours, especially when referring to traditional contracting theories. However, people do not always act rationally, and their behaviour is often biased. People have various drives triggering a number of different behaviours. Simon (1955) states that people have limited cognitive abilities, even though trying to optimise their general performance. They exhibit bounded rationality in decision-making, as their decisions are taken with certain limitations: according to the information they have access to, their minds' cognitive limitations, and the limited time they have at their disposal in order to decide. Moreover, besides bounded rationality there are other limitations in the decision-making process, such as willpower and selflessness.

In line with Simon's assumptions, Mullainathan and Thaler (2000) complete this statement, adding that besides bounded rationality, there are two more bounds of human nature: bounded willpower and bounded selfishness. The failure to include these three traits into an economic model leads to sensible heuristics, and thus, to systematic errors (1979). Judgements (beliefs) and choices are consequences of different deviations from rationality (1982). Examples of cases in which judgement deviates from rationality include optimism, extrapolation, overconfidence, anchoring.

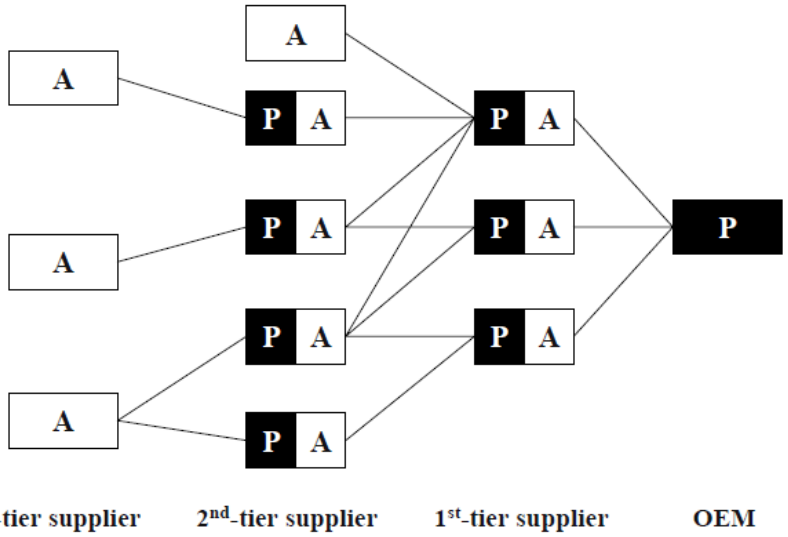
Kahneman and Tversky's (1979) prospect theory is about these deviations from rationality. It is a theory describing the manner in which people make choices in uncertain conditions, involving risk, and knowing the probabilities of outcomes. According to this theory, the decisional process is not dependent on the final outcome, but on the potential value of losses and gains, people assess using certain heuristics. This theory promotes a

model describing real-life choices, which often are not optimal decisions. This theory was created in order to provide a more psychologically accurate description of the decision-making process, by comparing it to the expected utility theory.

The bounds of human nature (bounded rationality, willpower and selflessness) should be the reasons for which supply chains should focus their attention on a so far neglected risk, namely the behaviour of both individuals and organisations. The occurrence of this behavioural risk has the capacity to disrupt supply chains, to deteriorate the quality, to cause insufficient inventory and price enhancements. Misha Seiter (2008) focuses particularly on two behavioural risks, he considers most important: the opportunistic behaviour and communication among partners. In the business world, everyone seeks to obtain a competitive advantage and higher profits. In this quest for profit and competitive advantage they tend to manifest non-compliant behaviour, and perhaps negatively affect the people surrounding them. Therefore, they have the tendency to break the explicit and implicit provisions of business contracts and agreements in their course of actions. Seiter (2008) built a conceptual model, comprising of three stages, which generates independent variables. These variables are either encouraging, either detracting opportunistic behaviour within a supply chain. The hypotheses of this study were tested on a 104 sample scale, comprising 104 German organisations.

Before Seiter, other scholars have done research on the risk of opportunistic behaviour as well: Joshi and Stump (1999), Das and Teng (1999, 2000), Rokkan and Buvik (2003); Jap and Anderson (2003), Hallikas and Virolainen (2004), Wuyts and Geyskens (2005). Starting from these studies, Misha Seiter conducted a study, with interesting results referring to partner selection, the quality of communication and the sharing of cost accounting information, all these having an impact on opportunistic behaviour.

Seiter (2008) built his model starting from the Principal-Agent Theory, which explains eventual opportunistic behaviour among the partners of a supply chain (a principal and an agent), when asymmetric information is involved. Seiter (2008) interprets the supply chain network as a series of principal-agents relationships, where companies having direct connection to the customers are principals (P). There are two level tiers of supplier: the first which are agents of the principals, and the second tier level suppliers. The first level tier suppliers play the role of principals for the second tier level, which become agents themselves for the latter ones. Therefore, the first tier level suppliers have a double role, both principals and agents.



Source: M. Seiter, 2008

Figure 1 - Principals and agents in a supply network

Seiter (2008) started his model from the results he obtained with the help of interviews and saw that there are two types of commonly used instruments in practice:

The ones which aim to gather information on partners (communication and partner selection),

The ones aiming to increase the cost of opportunistic behaviour (inter-organizational cost accounting, inter-organizational planning, sanctions).

Throughout his study, he found that the quality of communications and inter-organizational cost accounting influence opportunistic behaviour within a supply network directly, whereas sanctions and inter-organizational planning have no significant effects.

Lorenz (1991) also addressed the topic of opportunistic behaviour, considering it to consist of the subtle techniques designed to confuse, in an environment lacking trust. Moreover, if everyone respects its commitments, then trust is not an issue. An interesting remark from Lorenz is that one must differentiate between two types of risks: the risks associated with other's behaviour and risk (in the economic sense, in which it has an uncertainty component, it is an exogenous event). In that context, trust is not related to the possible opportunism and/or violation of commitment.

Another author, Williamson (1975) finds opportunism to be linked to the guile breaking of formal contracts, following only ones self-interest, given the incomplete nature of all contracts – one cannot foresee all future conditions (Tirole, 1999). A manner in which this shortcoming may be mended is regulated by the behaviour of partners with one another (availability, flexibility, solidarity), features which can be shown and are not regulated by the formal contract.

Given the impact of behavioural implications on supply chain risk management we are going to focus on the difficult task of predicting risks in supply chains, a hard endeavour considering the complexity of human behaviour and the difficulty to measure effects, and their range of action.

3. A BEHAVIOURAL PREDICTION MODEL OF SUPPLY CHAINS RISKS

In our effort to conceive a model meant to help us predict the risks a supply chain is confronted with we started from Clark Hull's "Drive Reduction Theory". This theory appeared in the 1930s and was influenced by other important authors in the field of behaviourism: Thorndike, Tolman, Pavlov, but also Darwin. In his theory, a general learning theory, Hull tried to explain and predict human behaviour, with the help of a mathematical formula.

Hull's theory focused on overt behaviour, leaving out the cognitive factors, as they could not be scientifically measured (Dewey, 2014). Therefore, Hull used his drive reduction theory to explain behaviour and learning.

In the following part of our paper, we will present the main concepts used by Hull in his drive reduction theory, which we will further use in our model, aimed at predicting risks within a supply chain.

The main concept of Hull's theory is drive, in its original meaning of a stimulus, a biological need. In biology, each living organism, who feels a need, will behave predictable, so as to reduce that need and come to the original, optimal biological state. At the level of human behaviour, one could describe the drive as a goal-oriented process, carried out in order to satisfy a need. The original, optimal state of the living organism is restored when the goal is achieved. Therefore, reducing the drive. The concept of drive reduction can be seen as a reinforcer, which strengthened the liaison drive-behaviour (Dewey, 2014). Hull's view on learning was a reduction of a biological drive, reinforced stimulus-response (S-R) learning. Hull's view on the repetitive nature of a living organism's behaviour made his drive-reduction theory, a theory of motivation.

Reinforcement and the relationship stimulus-response (habit strength) are the basic concepts of Hull's theory, as the two concepts are interconnected, the S-R relationship determining the reduction of the drive. In future similar situations the probability of the same response increases. Serial reinforcements strengthen the S-R relationship (the strength of the habit). According to Hull, there are two types of drives, when behaviour is concerned:

Primary drives – the biological needs (the basis level of Maslow's pyramid)

Secondary drives – the learned drives (the ones leading to the reduction of the primary ones). The primary drive characteristics of a neutral stimulus can trigger similar responses to those actually caused by such a primary drive.

In his motivation theory, Hull aimed to explain learning in a scientific manner, using a mathematical formula (valid for living organisms, both human and animal). This formula could explain and predict the likelihood of behaviour. The connection stimulus-response represents learning, and the strength of this connection represents the habit strength. According to Hull:

$$sEr = (sHr \times D \times K \times V) - (sIr + Ir) \pm sOr \quad (1)$$

where:

"sEr – the behaviour that is influenced, in terms of speed and probability, by a certain stimulus (the probability of obtaining a certain reaction)

sHr – represents the number of cycles of forming the behaviour; those cycles improve the relationship between stimulus and reaction

D – (drive) represents the factor that determine a certain action; Hull considered, for example, that hunger determines people to take action to feed themselves

K – represents the result of the taken action (the food procured, in Hull's example); more higher is the result, more satisfied is the person who gets it; in fact, the estimated result of the taken action represents the motivation of a certain behaviour

V – represents the conditions that affects the way the stimulus acts

sIr – represents the number of trainings that have no effect in relation with the objective achievement; those trainings have a negative effect upon forming a certain behaviour

Ir – represents the number of trainings that suppose a lot effort compared with the expected results; those trainings determine a reactive inhibition and influence negatively the expected behaviour

sOr – represents the random or standard error

The theory of drive reduction raised further scientific interest. Kenneth Spence (Hull's student) considered Hull's assumptions that habit factors lead to improvements in performance, was not acceptable, because motivation influences performance. Spence believed that although reinforcement acts as a learning motivator, leading to the enhancement of the response, it actually does not enhance also the learning of the response. Thus, reinforcement has not learning's role in itself. The assumption was later attributed to both Hull and Spence, under the name of the **Hull-Spence hypothesis of conditioning and learning**.

In Spence's view, motivation triggers performance in learned behaviour, and it is not a consequence of habituation. The learned lessons do not determine organisms to always act accordingly. Therefore, learning occurs also latently. Or, as other authors might explain this concept, organisms have bounded rationality. Until a point in his research, Spence conducted all his experiments on animals, and when he tried them on humans, he concluded that they are far too complex. Therefore, his theories do not apply to them, as they lack the impact of cognitive factors.

Although, Hull's theory received criticism, regarding the impossibility to predict complex human behaviour, and was later abandoned, we feel that his formula could be used to predict opportunistic behaviour at the level of a supply chain and could constitute a motivation for the breach of contracts. We consider that starting from Hull's formula we can add variables specific for supply chain management, which could predict opportunistic behaviour, and in the case in which it appears we can add a variable meant to discourage its appearance.

Starting from Hull's model we will further propose a model through which we aim to create a drive to respect the provisions and the obligations of a contract, by partners, within a supply chain. Thus, the proposed model aims to draw reflexes to respect contract provisions, reflexes created in the context of stimuli (incentives) or constraints (sanctions).

In current conditions, of taught competition, companies seek to establish long-term relations with their customers. Presently, companies do not act independently, but within supply chains. At the level of a supply chain there may appear some quantitative, qualitative inconsistencies or delays, regarding material resources or delivered products, inconsistencies due to operational activities of the partner companies, more precisely to the incomplete respect of the contracts' provisions. In this context, the activities' management from within the supply chain becomes essential in order to maintain customers' loyalty despite these inconsistencies. From this perspective we consider it is useful to create a management model at the level of a supply chain, through which the supply chain

inconsistencies can be compensated, inconsistencies which if not compensated would lead to the dissatisfaction of the final customer. This model aims to encourage the emergence of a partner behaviour through which all contracts provisions would be thoughtfully respected.

The proposed model seeks to recompensate customers for any given inconsistencies during delivery, may it be quantitative, qualitative or temporal.

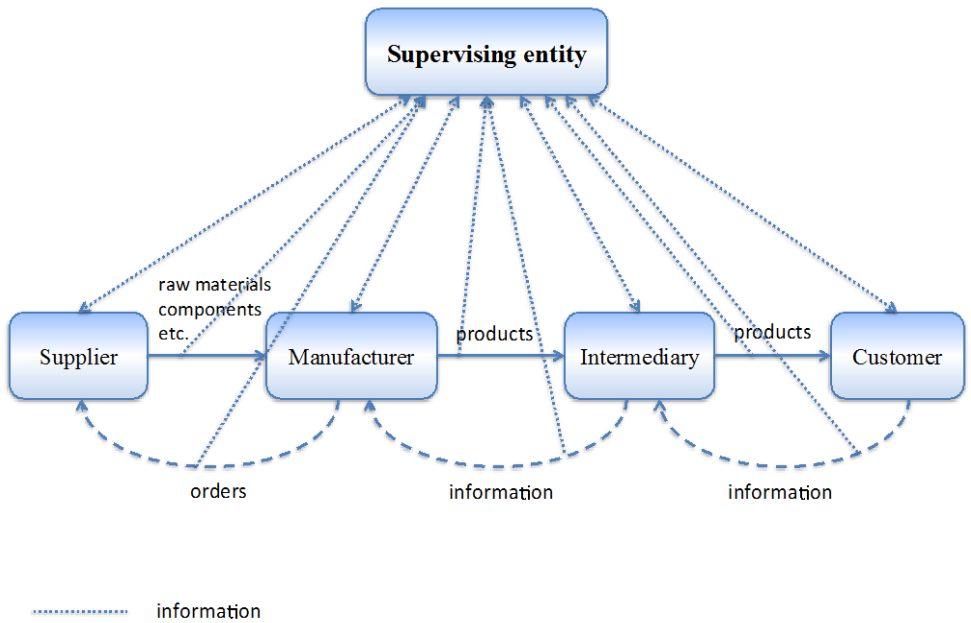
According to our model (inspired by the Bizoi-Sipos Model), we consider useful to create an institution at the level of a supply chain to supervise all supply chain activities and to collect the necessary funding to recompensate dissatisfied customers. Among the employees of this institution, there will be also employees from the supply chain partner companies. Besides these experts, a highly specialised manager will be needed, to coordinate all activities at the level of an entire supply chain.

The proposed model aims two main aspects:

Organising an institution meant to supervise the supply chain activities (Figure 2);

Creating a fund at the level of the supervising institution to compensate customers for the delays and /or temporal or qualitative (Figure 3).

The supervising institution constituted at the level of a supply chain has the role to observe if all material fluxes are consistent with the order which were received (informational flux) in terms of quality, quantity and time.



Source: Bîzoi, C.G., Şipoş, G.L., 2014

Figure 2 – Supply chain management and the supervising institution

The final customer will be dissatisfied if the ordered products do not arrive neither in time nor in the requested quantity. He is not interested that this is due to his final distributor, producer or supplier. In this situation, there is the possibility that this customer prefers the products competition has to offer, which will negatively affect all partners within a supply chain. To avoid such a situation to occur and to retain customers, one must recompensate the latter. Thus, a customer will receive part of his money back, in

accordance with the number of delay days, and also the percent of missing or qualitative inconsistent merchandise. This amount of money will be paid by a constitutedsupply chain level fund (actually, at the level of the supervising institution). We propose the two sources for this fund to be constitute from:

A regular source (NM), constituted from the money paid regularly by the supply chain partners; therefore, each partner will pay to the fund a percent from his value of sales (for exemple, 0,1%);

An exceptional source (EM), constituted from the penalties paid by responsible partners for a delay in delivery or for quantitative or qualitative inconsistencies; the amount of the penalty depends on the number of delay days (percent / day * value of sales), of the percentage of missing quantity or the percentage of qualitatively inconsistent products.

$$TM=NM+EM \quad (2)$$

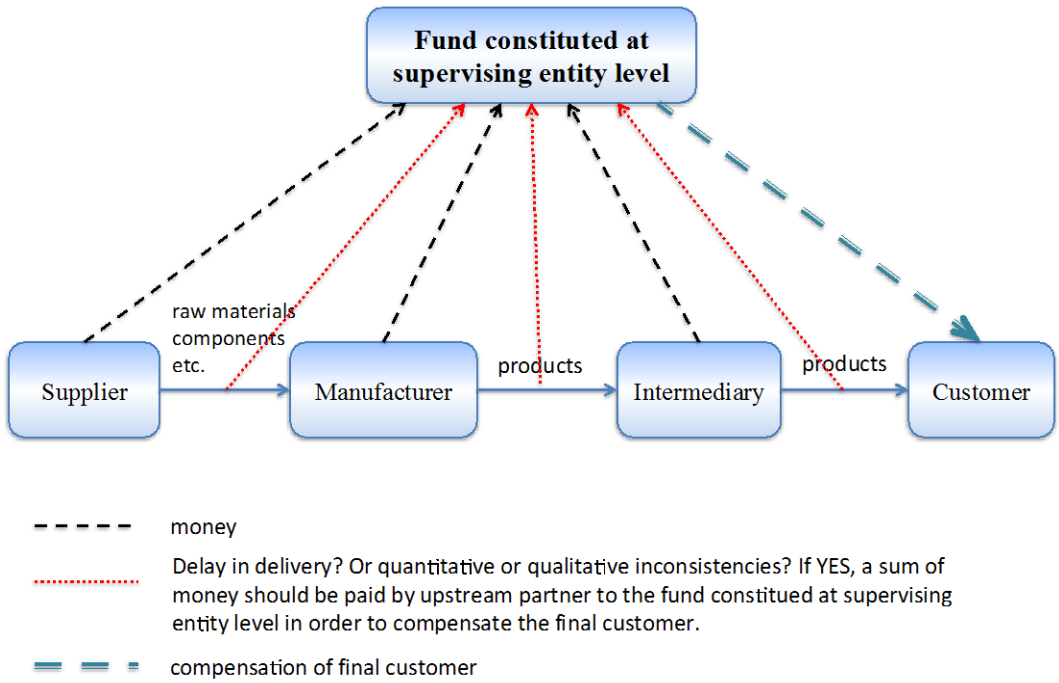
where :

TM – supply chain level constituted fund (at the level of the supervising institution);

NM – „normal money"– money paid regularly by every supply chain level partner;

EM – „exceptional money" – money paid as penalties.

The smaller EM is the more efficient the supply chain level operations carry themselves out.



Source: Bîzoi, C.G., Şipoş, G.L., 2014

Figure 3 - Creation of a fund at supervising entity level for compensating clients for delays in deliveries, qualitative or quantitative inconsistencies

Having in mind the eventual penalties which need to be paid in case of quantitative inconsistencies delivered to downstream partners, the supply order cost, and the storage

cost we will present a model to determine the economic batch, which needs to be supplied and the supply frequency. The supply batch must be sized, so as within a supply cycle, to prevent the lack of production necessary materials, in order to obtain the products in the downstream partner or final customer solicited quantity. In this model the penalty factor (unavailability) - (P_f) is:

$$P_f = \frac{C_p}{C_s + C_p} \quad (3)$$

where:
C_p – cost of penalties
C_s – cost of inventories

The storage cost implies certain constraints, such as the obsolescence during the storage period, quantitative and qualitative depreciations, and storage fees. The supply costs' economic function at the level of a supply cycle is:

$$C_c = C_l + \frac{n}{2} \times D \times C_s + n \times p \quad (4)$$

where :
Cc – supply cycle costs
C_l – supply order cost
n – supplied batch size
D – supply period (number of days between two successive supplies)
p – price per unit

The supply order costs include all utilities costs. For a management period, the economic function of a supply order costs is:

$$C_p = \left(C_l + \frac{n}{2} \times D \times C_s \right) \times w + N \times p \quad (5)$$

where :
Cp – supply costs for a given time
N – size of the required order for a period
y – supply frequency, obtained using the following calculus:

$$w = \frac{N}{n} \text{ or } w = \frac{T}{D} \quad (5.1)$$

T – time frame

Given the calculation formula (w), the supply costs' economic function at the level of the entire time frame T is:

$$C_p = \frac{N}{n} \times C_l + \frac{n}{2} \times T \times C_s + N \times p \quad (6)$$

We obtain the minimum of the objective function by equalising the first degree derivative (in accordance with n) with 0:

$$C_p^{'}(n)=-\frac{N\times C_l}{n^2}+\frac{1}{2}\times T\times C_s=0 \quad (7)$$

The level of the optimum batch can be calculated:

$$n^*=\sqrt{\frac{2\times N\times C_l}{T\times C_s}} \quad (8)$$

Given the value of the supplied batch (n*), the optimum frequency is:

$$w^*=\frac{N}{n^*} \quad (9)$$

In this case, the level of the optimum batch (OB*) is equal to the level of the supplied batch (n*). When a partner within a supply chain does not consider the supply fluctuation, he will learn that he has a lower level of the inventory then the he needs (actually, the level of the batch is reduced compared to the normal level, through the penalty factor). The economic function of the supply cost is:

$$C_p=\frac{N}{n}\times C_l+\frac{n}{2}\times T\times C_s\times P_f+N\times p \quad (10)$$

The optimum level of the supplied batch is:

$$n^*=\sqrt{\frac{2\times N\times C_l}{T\times C_s}}\times\frac{1}{\sqrt{P_f}} \quad (11)$$

The level of the optimum inventory is:

$$OB^*=n^*\times P_f \quad (12)$$

4. CONCLUSIONS

The activities carried out at supply chain level must always aim and have the effect of satisfying the customer. All logistic activities must ensure that the final customer receives the appropriate product in duly time, in requested quantity and at the appropriate price.

Acting on a competitive market, all supply chain partners must acknowledge the importance of customer loyalty. Therefore in order to gain and maintain their loyalty, they must agree towards a supply chain governance. Our proposed model aims to trigger a compliant supply chain partner behaviour, which could lead to the satisfaction of final customers. Moreover, on one hand, our model discourages opportunistic behaviour, and breach of contract provisions, and on the other hand, it transfers the eventual individual advantages obtained by a partner, in the case in which another partner breaches the contractual provisions to the final customer, in order to maintain his loyalty. Repeated sanctions in the form of penalties paid to the supply chain constituted fund represent

incentives for respecting contractual provisions, and the long-term loyalty of customers represents the reward for such behaviour.

CAVEAT

We need to further research if the creation of this fund will trigger the anticipated behaviour in partners at the level of a supply chain if it will determine compliant behaviour, in which partners do not feel the drive towards opportunistic behaviour. Also, we must research if the other similar model proposed by one of the present authors (Cristian-Gabriel Bîzoi and Gabriela Lucia Sipos) triggers both the loyalty of the customers and the compliant behaviour.

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