

# TOWARDS THE ARIEL MODEL DEVELOPMENT

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## ABSTRACT

This paper reports on the research process to develop a comprehensive business process model of a dyadic relationship in the ARIEL project. The ARIEL project is an attempt to explore the relationship between business level buyer-supplier relationship management and operation level process management. The purpose of the model is to act as a decision support tool in evaluating different ways of configuring business processes between a buyer and supplier. The methodology used for model development consists of four stages: (1) evaluation of supply chain process frameworks; (2) development of the generic business process model and ontology model; (3) building specific case study models; and (4) development of the ARIEL model. While the first two stages are grounded in the work found in published literature the last two stages use empirical findings from industrial case studies. This paper outlines the research design and results of the first two stages.

**Keywords:** supply chain management, ARIEL model, research design

## INTRODUCTION

In today's harsh environment of global markets, technology advances, and mass customization of products and/or services every company has to reconcile its strategy with the overall supply chain strategy. The aim is total end to end supply chain integration. According to Ramadas and Spekman (2000) and Frohlich and Westbrook (2001) supply chain integration is associated with the high levels of performance and there is also economic rationale behind the integration as concluded by Håkansson and Persson (2004). Childerhouse and Towill (2003) argue that the key to supply chain integration is simplified material flow, according to Hammer (2001), and McAdam and McCormack (2001) the key is in business processes integration. Kirchmer (2004), Grieger (2004) and Cooper and Tracey (2005) hold that the major enablers of supply chain integration are information and communication technologies. Yet some researchers even doubt in supply chain integration efforts going on. Thereby, Davenport and Brooks (2004) claim that the time of progress towards complete supply chain integration can be measured in years or even decades while Lambert and Cooper (2000) assert that there is no need to pursue the total supply chain integration because companies in a supply chain are involved in different types of business process links, some are managed and monitored while the rest are non-managed and non-monitored. Also, according to Lambert and Cooper (2000) supply chain is more of a supply network than the chain which at the end of the day asks for different or relationship by relationship management approach (Lambert, 2004).

This paper reports on the research process to develop a comprehensive business process model of a dyadic relationship in the ARIEL (Accelerating Relationships through Information Exchange in

Logistics) project. This is an attempt to explore the relationship between business level buyer-supplier relationship management and operation level process management. The model integrates people, technology and processes at the operations level to generate different buyer-supplier configurations. The resource and process configurations are governed by the business agreement between the buyer and supplier. In studying the operation efficiency of the configurations, the dyad can review the business scenarios which could result in joint business improvements. This could facilitate building of a closer relationship between the involved parties. The purpose of the model is to act as a decision support tool in evaluating different ways of configuring business processes between the buyer and supplier. The ARIEL model is built with the time and cost calculation logic for business process configurations. This is supported by sharing product and process information provided by the information systems and other support data. The scope of the model encompasses material and information flow stages in a buyer-supplier relationship (Figure 1).

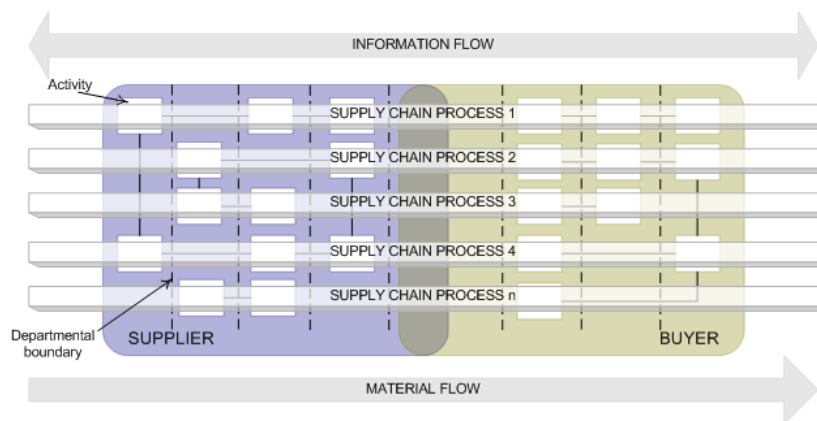


Figure 1 - Scope of the ARIEL model

The aim of the paper is to introduce the methodology used for the ARIEL model development to a wider research community.

## METHODOLOGY

The methodology being used for the ARIEL model development consists of four stages which are briefly described below and presented in Figure 2.

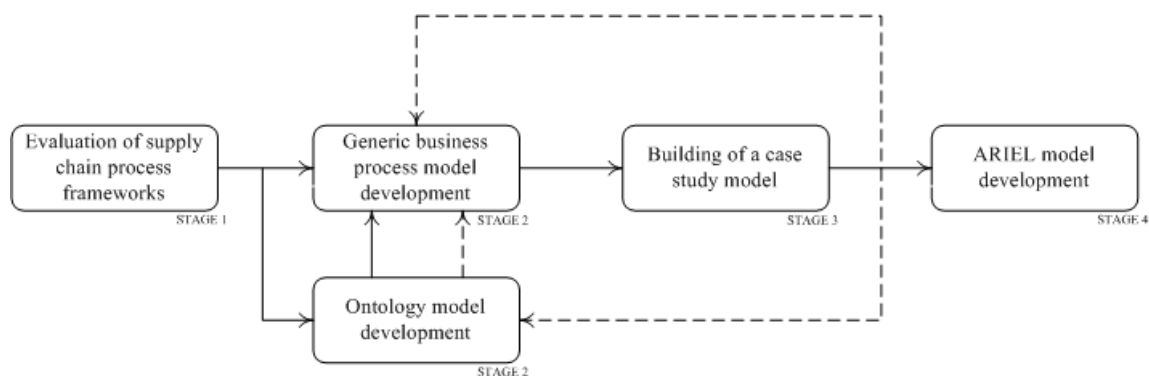


Figure 2 - ARIEL model development methodology

### Stage 1

The aim of the first stage is to establish the generic set of supply chain processes that should constitute Figure 1. An extensive literature review was conducted. Two supply chain process

frameworks, namely: Supply Chain Operations Reference (SCOR) model and Global Supply Chain Forum (GSCF) framework were selected based on nine evaluation criteria.

### *Stage 2*

The second stage develops the ontology model and generic business process model based on the framework selected in Stage 1. The ontology model has been developed with the aim to identify the information object classes and their interrelationships which define a dyadic relationship. A thorough semantic analysis of the two supply chain frameworks has been carried out. The classes identified have become building blocks of the generic business process model. A set of process maps is harmonised from the supply chain processes identified in the previous stage. Finally, the generic business process model was built by using the building blocks developed in the ontology model and supply chain process maps.

### *Stage 3*

The generic business process model will be used as a foundation for building specific case study models in this stage of the ARIEL model development methodology. The case study approach is used because it can provide the wealthy data needed to validate and further enrich the models developed. The outcomes from the case studies would be used first to validate supply chain processes of the generic business process model and second to enrich the ontology model which will consequently enrich the generic business process model (see Figure 2). At the moment of preparing this paper, the first (pilot) case study is about to start.

### *Stage 4*

The use of multiple case study approach from cross industry manufacturing sector will provide the rich data needed to build a robust model. The final ARIEL model will be a knowledge rich representation of dyadic relationships as a result of cross case study analysis.

The four stages of the ARIEL model development methodology have been agreed on among the project's team members. While the first two stages are grounded in the work found in published literature the last two stages use empirical findings from industrial case studies. In the next two sections the first two stages of the methodology are going to be elaborated in greater detail.

## **EVALUATION OF SUPPLY CHAIN PROCESS FRAMEWORKS**

The literature review came across a lot of papers where authors are proposing supply chain process frameworks. To mention a few, in Srivastava *et al* (1999) the authors were interested into how marketing can be infused in supply chain processes; Chopra and Meindl (2003) have proposed a supply chain process framework which is aligned with the new IT developments that support SCM; while Rudberg *et al* (2002) were interested in exploring functionalities of e-marketplaces for facilitating collaborative supply chain planning. In our preliminary research we also included the work of Melnyk *et al* (2000), Mentzer *et al* (2001), and Kotzab and Otto (2004). These papers were written with different aims and perspectives so they do not have the comprehensive nature of the two supply chain process frameworks we have identified, namely SCOR model and GSCF framework.

### *SCOR model*

The SCOR model is produced by Supply-Chain Council (<http://www.supply-chain.org>), the global organisation which is open to membership from all companies. SCOR captures the Council's view on supply chain management and links business processes, metrics, best practices and technology. The model is organised around five primary management processes: (1) plan; (2) source; (3) make; (4) deliver; and (5) return. It is described on three process levels. Besides the five primary processes the SCOR model also distinguishes three process types: planning, execution, and enable. By using

the process building blocks and process levels the model can be used to describe supply chains that are very simple or very complex.

*GSCF framework*

The framework is developed and validated by Global Supply Chain Forum with the intent to provide common understanding about supply chain processes. It is developed to describe the standard set of supply chain processes which could be used both between researchers and practitioners. The framework consists of eight processes which were identified by the GSCF’s members. The processes are: customer relationship management process (Croxtton *et al*, 2001), customer service management process (Bolumole *et al*, 2003), demand management process (Croxtton *et al*, 2002), order fulfilment process (Croxtton, 2003), manufacturing flow management process (Goldsby and García-Dastugue, 2003), supplier relationship management process (Croxtton *et al*, 2001), product development and commercialization process (Rogers *et al*, 2004), and returns management process (Rogers *et al*, 2002).

An evaluation framework was formulated to identify and extract the generic set of supply chain processes from the two frameworks. The literature review was further extended to verify the appropriate evaluation criteria. The choice of the evaluation criteria was guided by the purpose, objective and scope of the ARIEL model.

*The evaluation criteria*

The evaluation criteria used to evaluate two previously mentioned frameworks are presented in Table 1. It consists of nine items arranged into three groups.

*Table 1 - Evaluation criteria*

<b>C#</b>	<b>Process related criteria</b>
<b>1</b>	Business process definition adopted in a framework
<b>2</b>	Further specification and specialisation of a framework’s processes
<b>3</b>	Supply chain process levels and decision variables addressed in a framework
<b>4</b>	Intra- and inter-company process coordination capability of a framework
<b>5</b>	Information sharing ability of a framework
	<b>Scope related criteria</b>
<b>6</b>	Vertical and horizontal scope of a framework
<b>7</b>	A framework’s ability to represent the role of a third party
	<b>Modelling related criteria</b>
<b>8</b>	A framework’s ability to describe processes from different views
<b>9</b>	A framework’s ability to allocate cost of activities

*Summary of the evaluation results*

When the frameworks were analysed with the criteria, the results were diverse (Grubic *et al*, 2007). Both frameworks have specific advantages and common shortcomings. The common shortcomings found are: lack of social consideration, almost non existing anatomy of information flow, and limited support and representation of third parties, specifically third party logistics providers (3PLs). The specific advantage of the SCOR model is its good coverage on process’ inputs and outputs and its relationship with other processes, while the GSCF framework is better in process levels and decision variables, intra- and inter-process coordination, vertical and horizontal scope, and ability to describe processes from different perspective. The other rather subtle advantage of the GSCF framework over the SCOR model is in its approach to SCM. The SCOR model focuses on improving the transactional efficiency between supply chain partners, while the GSCF framework is concerned with building supply chain relationships.

The GSCF framework has been adopted as the foundation for the generic set of supply chain processes in the ARIEL model. The following five processes of the GSCF framework form the generic set: order fulfilment process, demand management process, manufacturing flow management process, returns management process and customer service management process. These five processes reflect the material and information flows in dyadic relationships and constitute the process backbone.

## **ONTOLOGY MODEL DEVELOPMENT & GENERIC BUSINESS PROCESS MODEL DEVELOPMENT**

The main results of the previous stage are decisions on what constitutes generic set of supply chain processes and the decision to use both frameworks as the comprehensive references on supply chain processes. While the former provided an input for the design of supply chain process maps which will form the process backbone of the generic business process model, the latter was used as an input for the semantic analysis conducted to develop the ontology model. The process to develop these two models is represented as separate tasks in Figure 2. When the development of ontology model was underway, an analysis of the five supply chain processes produced the specific process maps.

### *Ontology model development*

The ontology definition adopted in our work is based on Gruber (1993) and Genesereth and Nilsson (1987). According to Gruber (1993) “an ontology is a formal specification of a shared conceptualization”, while Genesereth and Nilsson (1987) continue and define the conceptualization as “the objects, concepts and other entities that are assumed to exist in some area of interest and their inter-relationships.” Building on these definitions, the high level process of developing ontology of a domain consists of identifying and designing concepts and their inter-relationships. Sharman *et al* (2004) argue that the concept is a relevant idea either abstract or generic and that concepts are usually associated with other concepts by means of relationships. In the ontology research community the term class is often used instead of concept with the distinct meaning from the term class as used in object-oriented programming (Noy and McGuinness, 2002). A class represents a collection of characteristics or slots of a construct from the domain and a template for creating instances. Further, a class can be either an abstract or concrete class. The difference is that an abstract class cannot be used for creating instances. The functionality of an abstract class is clear when the property of inheritance is introduced. Inheritance allows hierarchical modelling when creating ontologies; e.g. a class can have many subclasses which inherit its slots from the superclass. Also, a class can have many superclasses and subclasses at the same time.

When the ontology of a domain is developed it can serve multiple purposes. Noy and McGuinness (2002) have stressed following purposes:

- To enable sharing of common understanding of the information among people and software agents;
- To enable reuse of domain knowledge;
- To make domain assumptions explicit;
- To separate domain knowledge from the operational knowledge; and
- To analyze domain knowledge.

There is no “one and correct” methodology for developing ontologies (Noy and McGuinness, 2002), the best one can do is to follow a set of guidelines (Kishore *et al*, 2004). In the ARIEL ontology model development, the process loosely followed the seven step approach proposed by Noy and McGuinness (2002).

### *STEP 1. Determine the domain and scope of the ontology*

The domain and scope of the ontology model is explicitly defined by the domain and scope of the ARIEL model. ARIEL's domain is logistics and SCM while the scope is determined by the material and information flow stages in a dyadic relationship. The scope of the model has been further narrowed in the previous stage when the generic set of supply chain processes which support material and information flows has been identified.

### *STEP 2. Consider reusing existing ontologies*

Both the research and practice communities realise the role ontologies can play in solving issues such as the lack of common understanding or system inter-operability. At the same time the interest and application of ontology principles has attracted researchers from many disciplines (Kishore *et al*, 2004), so it is always useful to check what has been done elsewhere so to avoid re-inventing the wheel (Uschold and Gruninger, 1996). Some research has similarities to the ARIEL project, but when closely examined it revealed different scope, domain or perspective.

### *STEP 3. Enumerate important terms in the ontology*

When developing ontology it is helpful to make a list of terms which are pertinent to the domain. According to Noy and McGuinness (2002) one should not be worried if there are some overlaps of concepts or whether the term in the list included is concept, slot or a relationship between multiple concepts. The overall aim is to get a comprehensive list of terms relevant to the domain. The enumeration of terms had been conducted separately for both the SCOR and GSCF models. Examples of terms we found in the SCOR model are: metrics, business rules, carrier or planning data; and from the GSCF framework these examples include: functional areas, goal, revenue, sales person, etc. The total list of terms resulting from the analysis of both frameworks has 1682 items which when the duplicates were removed counts at 1230 items.

### *STEP 4. Define the classes and the class hierarchy*

The list of terms which resulted from the previous step was too large to grasp so they were categorised in classes as a preliminary step to defining the relevant classes and their hierarchy. In the preliminary list there were 26 classes and some of them are: plan, system, product or service, metric, asset, program, or strategy. For each class the ARIEL team agreed on definitions which reflect the scope and our understanding of the domain. When analysed again some of the preliminary classes were out of the scope so they were removed from the list. Then each class of the remaining classes was further scrutinised with the aim of finding the relationships with other classes. As a result of this, some new concepts arose. The definition of classes and their hierarchy started after all the preliminary classes and their inter-relationships had been developed.

Uschold and Gruninger (1996) state that there are three approaches one can choose when developing a class hierarchy:

1. Top-down approach which imposes rather high-level classes;
2. Bottom-up approach which could result in a large number of somewhat unconnected classes;
3. Middle-out offers a balanced or combined approach in developing classes.

Each of these approaches has specific advantages and drawbacks and each will probably be used to some extent in any ontology development endeavour. For our ontology model development we used all three approaches and the result was total list of 62 classes either abstract or concrete. On the highest level they are arranged into two abstract classes: *Supply\_Chain\_View* and *General\_View*. All the classes of the ontology model referenced from this point will be in italic.

### *STEP 5. Define the properties of classes-slots*

The class hierarchy consisted of class taxonomies and their definitions pertinent to a domain would be semi-informal ontology according to Uschold and Gruninger (1996). What is needed in this step

is to model the classes' internal structure or defining slots of a class. Slots sometimes referred to as attributes (Sharman *et al*, 2004) are used to embody some semantic information relevant to the class. These might be in the form of properties that indicate e.g. name or they can even be used to represent a relationship with an instance of another class. For example an organisation in the supply chain is at the same time *Buyer* and *Supplier*, which buys some *PartGroup* and/or *ServiceGroup* from its suppliers in order to transform these inputs into *ProductGroup* and/or *ServiceGroup* for its buyers. The example presents the relationship between an instance of the class *Organisation* which could have many instances of the *PartGroup*, *ServiceGroup* and *ProductGroup* classes. There is no recipe which could clarify how to define the properties of a class. In ARIEL besides the results of analysis described in the previous step, the domain knowledge and experience were also used.

### STEP 6. Define the facets of the slots

The facet of a slot represents different features a value of the slot can take. This could correspond to the value type (e.g. Integer, Float, String, Instance, etc.), allowed values, or number of items which can be associated with the value of a slot (Noy and McGuinness, 2002). For example, the class *Equipment* of the ontology model has a slot called "is\_input\_to\_Activity" which defines an activity where an instance of this class is used as an input. The slot can take multiple instances of the class *Activity* which means that the same equipment might be used in many activities.

The ontology model was developed in Protégé software (<http://protege.stanford.edu/>) and is presented in Figure 3.

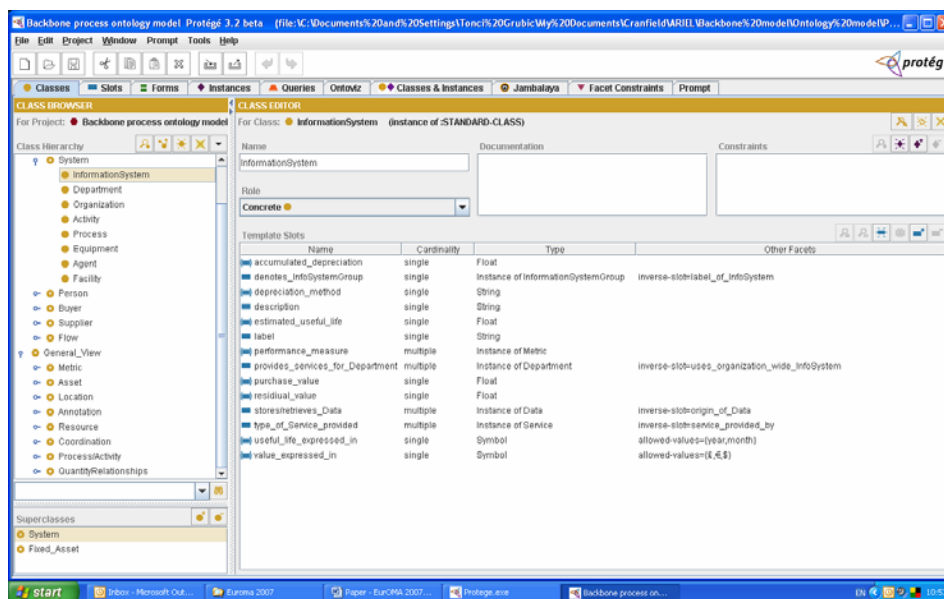


Figure 3 - The ontology model

### STEP 7. Create instances

At the end when all the bits and pieces of the ontology model are in place, individual instances of classes in the hierarchy could be created. The ontology model was validated among the ARIEL project team members with the help of an example that represents a real supply chain situation.

Built in this way the ontology model not only has become a library of building blocks used for the generic business process model development but also a knowledge representation and acquisition tool which is going to be used and further validated in the case studies.

### Generic business process model development

At the same time of ontology model development, the analysis of the five processes of the GSCF framework which form the generic set of supply chain processes was also started. The aim of the analysis was to develop specific process maps. When the maps and ontology model are ready, they could be blended into the generic business process model. The five processes represented in the generic business process model are:

1. Customer Service Management process: represents a company's face to the customer (Bolumole *et al.*, 2003) and through this process a customer can e.g. place an order, get information about a product availability or order status, place a return request, etc.
2. Demand Management process: is concerned with balancing the demand with the supply chain capabilities. It includes forecasting the demand and synchronising it with production, procurement and distribution (Croxtton *et al.*, 2002).
3. Manufacturing Flow Management process: relates to developing a manufacturing plan, assuring the means for its execution and control (Goldsby and García-Dastugue, 2003).
4. Order Fulfilment process: involves generating and filling customer orders (Croxtton, 2003).
5. Returns Management process: is concerned with managing the returns, reverse flows, gatekeeping and avoidance (Rogers *et al.*, 2002).

These processes should not be perceived in isolation but as highly interdependent processes which cut across multiple departments in a company and across companies of a supply chain. When the process maps were defined, these were validated with experience and knowledgeable colleagues at Cranfield University. The resulting process maps offer a good starting point needed to build an understanding about supply chain processes in a dyadic relationship. The resulting model has been developed in Enterprise Modeller software (<http://www.enterprisemodeller.com>). In Figure 4 the order fulfilment process of the generic business process model as developed in Enterprise Modeller is presented.

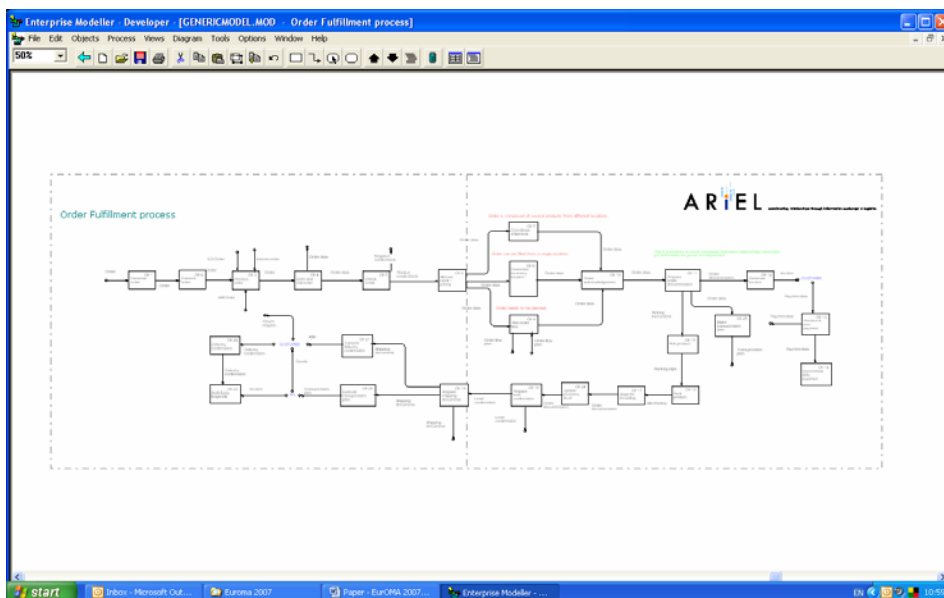


Figure 4 - The order fulfilment process of the generic business process model

The software enables modelling and representing processes through multiple views (e.g. resources consumed by a process, departments which support execution of a process, etc.). The biggest advantage of the tool is its functionality to define custom objects and associations among them. A modelling framework could be built in this way which supports specific model



development needs. The latter functionality allowed the representation of the ontology model into the generic business process model.

## CONCLUSION

The paper started by building a case which takes generic buyer-supplier relationship as the basic unit in the supply chain integration effort. By exploring the operation level processes in a buyer-supplier relationship the involved parties might identify opportunities which could be exploited if the companies decide to build a closer relationship. For this purpose development of the business process model of a dyadic relationship has been proposed whose development methodology is elaborated in the paper. The model development methodology is consisted of four stages where the first two stages are grounded on the work found in published literature while the last two stages use empirical findings from industrial case studies. At this point of research the first two stages have been finished and preparations for the first case study are on the way. The result of the first two stages is the generic business process model which is built as a set of supply chain processes that support material and information flows in a dyadic relationship. It has been built by the help of constructs developed in the ontology model of a dyadic relationship. The ontology model speeds up the business process model development and enables robust representation of any buyer-supplier relationship. The novelty of this approach is in the coupling of ontology engineering and business process modeling. Built in this way the model could expand the boundary of supply chain operations management towards business practice and scenario analysis.

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