The Complexity Challenge:
A Case for Model-based Management

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Abstract

The purpose of this paper is to present a case study which illuminates the role of dynamic models as enablers of better general management in the face of complexity. That role is usually accounted for either by the logic of the models or by the process of building them, namely in group model-building. Here, the relationship and interaction of the two, model logic with modeling process, is considered. We maintain that the conceptual understanding of managers is the crucial lever for better management. Our focus is on the role of models in improving such understanding. The empirical base and object of reflection is a large case study from an ultra-complex firm, where a model-building and training venture was carried out. The main concern which aimed the project was to facilitate the ability of managers to cope with complexity and to enable effective organizational change. The venture enhanced the systemic view and awareness among participants of the project, and therefore proved to be a good investment in management quality. In essence, it was an important move toward model-based management. A core group had been captivated by the power of systemic thinking in general and the use of models in particular. A seed had been sown.

Keywords: Model-based management, general management, understanding, ultra-complex company, role of dynamic models, decision-making

1. Introduction: Purpose, propositions, and methodology

The purpose of this contribution is to present a case study which sheds light on the role of dynamic models as enablers of better general management. We reflect on a model-building venture carried out in collaboration with a large, ultra-complex industrial firm. The focus was on enhancing managers' understanding of that complexity, which "governed" the organization. In particular, the approach of building and using models to foster such understanding should be characterized as a powerful alternative to the dominant mode of non-systemic decision-making[1] (cf. Doerner 1996).

The question arises, however:, can an ultra-complex company afford to have its managers understand it? That question can already be answered: a company cannot afford *not* to have managers with such understanding. This answer is more than an epigram; it is a proposition founded on the Conant-Ashby-theorem: "Every good regulator of a system must be a model of a system" (Conant & Ashby 1981). In other words, the quality of the outcome of a process is determined by the quality of the model on which it operates. The results cannot be better than the model, except by chance. Therefore, good models - mental or formal models - are a must.

1.1 Propositions

Given these theoretically founded assumptions, our two interrelated propositions are:

1.) Conceptual understanding by managers is the crucial factor which enables effective management of complexity.

2.) A lack of such understanding is a strong driver of organizational failure.

The function of models has been addressed with different emphases. Modeling as learning (Lane 1994), and modeling as theory-building (Schwaninger & Pfisterer 2008) are but two examples. Models have also been proposed in many specialized domains of management science, from manufacturing (e.g. Henoch 2003) to information management (e.g. Speck 2001), environmental modeling (e.g. Smith & Smith), and many other areas.

Also, the various aspects of model-building processes have been explored in the literature. Since the nineties, group model building has become a frequently discussed subject, with significant theoretical groundwork (Richardson & Andersen 1995, Vennix 1996, Vennix 1997, Andersen & Richardson 1997, Andersen et al. 1997). Numerous group model-building ventures have been documented (e.g., Lane 1997, Campbell 2001, Luna-Reyes et al. 2006). A survey of group model-building studies is given by Rouwette et al. (2001).

[1] For a conceptualization of the attribute 'non-systemic', see footnote 3.

It is surprising that the use of models as a basis for general management has attracted only sparse attention in the abundant literature of that field.[2] Even though some general frameworks have been elaborated, the questions of what the role of models is in improving general management and how they can be used for that purpose have hardly been discussed. In particular, there is a lack of empirical evidence for exploring the concept of a model-based management[3]. With a view to attaining substantive insights we are focusing on this research gap.

1.2 Methodology

The case under review is a project in which a model prototype was developed and a workshop with executives of the client company was carried out. The purpose of the project was to help those involved to develop systemic thinking, in order to be better equipped for dealing with the complexity they faced in their work environment. In this context the use of formal models as a basis for management was an issue of particular interest to the initiator and gatekeeper of the project.

As a methodology we used a single-case study setting. The use of a single case as opposed to multiple case studies is indicated under specific circumstances. Rationales for a single case apply when it represents at least one of the following (Yin 2003: 41f.):

- a critical case
- an extreme or unique case
- a representative or typical case
- a revelatory case
- a longitudinal case.

The case we are dealing with fulfils three of these criteria. It is revelatory, as will be seen in the final discussion. Its is unique or even extreme. And at the same time it is typical, which is paradoxical On the one hand the case under study is somewhat unique, given the highly accentuated demand for systemic thinking on the part of the firm representatives involved, i.e. a receptive climate, which is extraordinary. On the other hand the firm itself is typical - large, dealing with high levels of external and internal complexity, with a highly differentiated organizational structure and conflicts between the organizational units. This justifies a single-case design.

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[2] There are exceptions, from authors who have theorized about models as a base for general management, e.g., Ulrich & Krieg (1972), Bleicher (1999), Rueegg-Stuerm (2005), Schwaninger 2006, Schwaninger & Janovjak (2007).

[3] In the literature several excellent case studies of System Dynamics (SD) applications supporting decision-making in organizations can be found. Typically they focus either on the logic of a model (e.g. Taylor & Dangerfield 2005) or on the process of model-building (e.g., Lane 1997). Our aim here is to cover the interaction of both of these aspects. The focus is on the role of models in providing a better understanding for enabling a better management, in the context of organizational change.

The procedure was of the action-research type. Action research is a concept of applied management research which synthesizes the approaches of science and consultancy (Probst & Raub 1995). The research objectives of a pertinent project are linked to the aim of achieving progress in the organization under study. Understanding and change form an intertwined process, in which a participatory procedure is of great importance (Whyte 1991). In such a process, practitioners and researchers learn together (Revans 1980). We are aware of a certain positivist critique of action research, namely, the reproach that its results are not generally valid. However, we adhere to the approach because it has the advantage of avoiding the chief weakness of positivist research, namely, its lack of deep understanding of complex phenomena (cf. von Hayek 1972).

Our main method of gathering data was the approach of participant observation, for example, in the process of group model-building and in the workshop which we are going to describe in more detail in sections 3 and 4. The observations were documented in detailed notes, while the results of group model-building crystallized in a model prototype, which was used later on in the workshop. The action-research type of setting gave us strong influence on the design of the process. Yet, due to time restrictions we had little opportunity to proceed with formal evaluations during the project. However, after the workshop we at least were able to carry out a follow-up with the initiator and gatekeeper of the project.

After this introduction, the case under study will be sketched out by way of the antecedents for cooperation and a description of the partner firm. A report on both a model-building venture and the complex model that was built will follow. We will then describe how the model was used to enhance understanding on the part of the managers. The paper will proceed with a conceptual discussion and conclude with a brief synopsis.

2. The case

In 2005 we were contacted by a high-level manager of the company which embodies the context of our case. For the sake of anonymity we are giving him the name 'Mr. Young', and we will call the company 'Topos'. He wanted to discuss with us the issue of complexity and the difficulty which Topos' managers had in dealing with it.

We agreed to meet at our institute. The first session brought together Mr. Young, head of organizational development at Topos, and a core of three managers, two of them with companywide responsibilities in the global supply chain, and one country manager. Representing the institute were the three authors of this contribution. We learned a lot about the company and how our visitors framed their issues of concern.

2.1 The company and its businesses

Topos is a leading company in a durable goods industry, with worldwide operations. It is ultra-complex in that it produces and markets 3500 different

articles, distributed among 26 brands. Its production volume amounted to 82 million units in 2005. It operated nine production facilities in the E.U. and further ones in the NAFTA countries and Asia. There were essentially four kinds of customers:

- Retailers
- Do-it yourself
- Fast fitter workshops
- Specialist workshops

The two main factors driving business volume were pricing and product availability. The latter was highly problematic. On the one hand, availability with the customers had to be immediate. Delays tended to be punished by customers with a shift to other suppliers. Order management had to be highly reliable, so that the required product was delivered accurately as soon as it became due. Shipments were either direct ("money shipments") or for replenishment (warehouses).

One out of many possible illustrations of the complexity in the supply chain is the Italian market. There, the term 'customers' applied to 2'900 points of delivery. 270 of these generated 90 per cent of total turnover.

2.2 Framing issues of concern

In the first meeting, as throughout our contacts during this project, Mr. Young gave sharp diagnoses and insightful analytical statements. He was not only a manager, but also a deep conceptual thinker. Early on, he gave an overview of the change concerning the kinds of management failures that had occurred over the past decades. In the sixties the passive failures dominated, i.e. failures due to factors to which management did not respond. In the seventies active failures took the lead, i.e. the faults in decisions and actions. Since the eighties, the main failures were cognitive, i.e. due to an insufficient understanding of complexities. This picture was inspired by a larger study, but Young claimed that it accurately represented the situation in his organization.

The company was doing very well; sales and profits had grown consistently for years. Mister Young had his eye on the future. For him, the problems of the firm were not manifest but latent. His concern was that the current short-termism of managers and their lack of understanding, paired with non-systemic[4] decisions, would sooner or later bring the company into trouble. His vision was to foster systemic thinking and provide to the company managers more adequate tools for coping with complexity. Talking about 'tools', Mr. Young emphasized that he envisioned a wide-spread use of formal models to enhance systemic thinking.

[4] The attribute 'non-systemic' here is used in connection with reductionist, unidimensional thinking. It refers to a mentality which tends to be punctual and superficial, and which focuses on the short term while neglecting the long term, being devoid of a deeper understanding. Non-systemic thinking is linked to an interventionist behaviour which by and large neglects structural interrelationships and therefore leads to unintended side-effects.

The context in which the Topos managers operated had remarkable features which impinged on their behavior. The managers were confronted with an exceedingly high complexity. This complexity arose from both the pronounced market-orientation and the high flexibility which the company upheld, despite its large size and even though it operated with a highly differentiated supply chain, and on a worldwide scale. These were marked strengths, but they made it hard for the individual actors to keep track of the implications of their decisions and actions.

A survey within the company about problems in the supply chain raised a number of issues:

- Complexity: This was the first keyword. It was often used in relation with the assertion that the firm managed too many brands. But many different uses of the term 'complexity' were to be found - there was no common understanding.
- Interventionism: Managers often intervened in the area of discretion of lower-level staff.
- Lack of an appropriate forecasting tool: the forecast-driven production model was less and less adequate, because it was no longer able to forecast market behavior adequately. In the end all "forecasting" was done manually.
- Conflicts:, Frictions continuously arose between the decentralized units in the markets, which must satisfy the customer, and the central staff, who orchestrate inputs from the regions.
- Response to complexity: One of the managers summarized the point as follows: "The actors in the organization have experience, but they lack a process with which to handle the complexity of the supply chain."

How did managers deal with these difficulties? Our interlocutors reported a recurrent pattern of behavior: When problems arose, higher managers or even top managers were invoked for help. More exactly, they were called upon to make a decision. They did not dislike that at all, so they took decisions all the time. For example, one top manager often had to decide about which order to give priority over others - in the case of large batches to be produced. The fact is that there were managers who had to take most of their operating decisions about issues they did not properly understand.

This was less the problem of insufficient data, and more a problem of inadequate mental models. As Mr. Young put it: "People do not think in loops, but in short-term cause-effect relations. In other words they do not have a proper understanding of the implications of their decisions."

Let us summarize this pattern of decision-making. Higher managers of Topos - not all, but many of them - act as if they were superbrains - with complete knowledge and fully abreast of events. They decide as if they commanded maximum transparency of the situation. They appear to know everything, but

they hardly understand anything[5]. Even if they have a certain awareness of the complicated characteristics of the supply chain, the complexity associated with the setting is generally underestimated and not properly understood. The final outcome for these agents is that they commonly suffer from a kind of double blindness[6]. Mr. Young gave the poignant assessment: "They do not even know that they don't know. But that is exactly what they must understand."

2.3 Constructive proposals

This last sentence, - "they must understand" - was the key to the further evolution of our project and the progress it bred.

The core team under Mr. Young had ideas of what was needed. First of all, they pleaded for a diffusion of systemic thinking among the managers. They were systems thinkers ("systemists") themselves, Mr. Young in particular. So they sensed a need for more conceptual and reflective thinking in their organization. The need that should be met was, by and large, characterized in the following way: Managers - if they were aware of it or not - needed to be aware of the consequences of their decisions and actions. They needed a proper approach to penetrate mentally the situations in which they were immersed. They had to reflect upon what was going on and to understand the interrelationships of multiple determinants of events. More exactly, they ought to become able to discern the structures underlying behavior patterns occurring around them and in the firm at large. These overall requirements should be met by conveying systemic thinking to these managers.

But our interlocutors, Mr. Young in particular, did not stop there. They also wanted an operational tool to support that systemic thinking. The discussion soon converged on the idea of a simulation model which would allow them to represent the important parameters and variables, track the consequences of decisions, etc. Mr. Young insisted on a tool that would primarily foster understanding of patterns and interrelationships, not the precision of decisions.

What was the best way of proceeding from there? Mr. Young proposed a workshop in which systemic concepts would be taught. We agreed, but how should the requirement of a quantitative tool be met? We suggested that a simulation model be developed and presented at the workshop.

2.4 Steps taken

A preliminary decision was taken. The Topos managers envisioned a workshop with key people, to be held several months later. Until that time, a model prototype to be used in the workshop, should be developed conjointly between key persons at Topos and ourselves. Shortly thereafter, we got the official mandate to develop the model prototype and to prepare the workshop.

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[5] For the relationship between knowing and understanding, see: Ackoff (1999: 170)

[6] The term 'double blindness' refers to the second-order problem, which von Foerster described as "… we don't see that we don't see" (1984: 4).

A group model-building process ensued, on which we will elaborate in section 3.

Six months after the initial session a three-day management workshop took place, which we will describe in some detail in section 4. It is mainly by means of that workshop that we are now going to anchor our reflections around the idea of model-based management in the face of complexity.

3. The Model

3.1 Group Model-Building

Right after getting the assignment, we embarked on designing a stock-and-flow diagram which (in our view) reflected the structure of Topos in a high-level, conceptual way (Figure 1). In the second meeting with the core group (the gatekeeper and three other executives), the diagram was discussed. That was the beginning of an interaction between us and a handful of knowledgeable people in the company. Several group model-building workshops followed on site, with small groups of executives who had key roles in the supply chain of the company, and alternated with "back office" programming at our institute. The workshop was planned in parallel. The product was a large corporate model prototype, which will be described below.

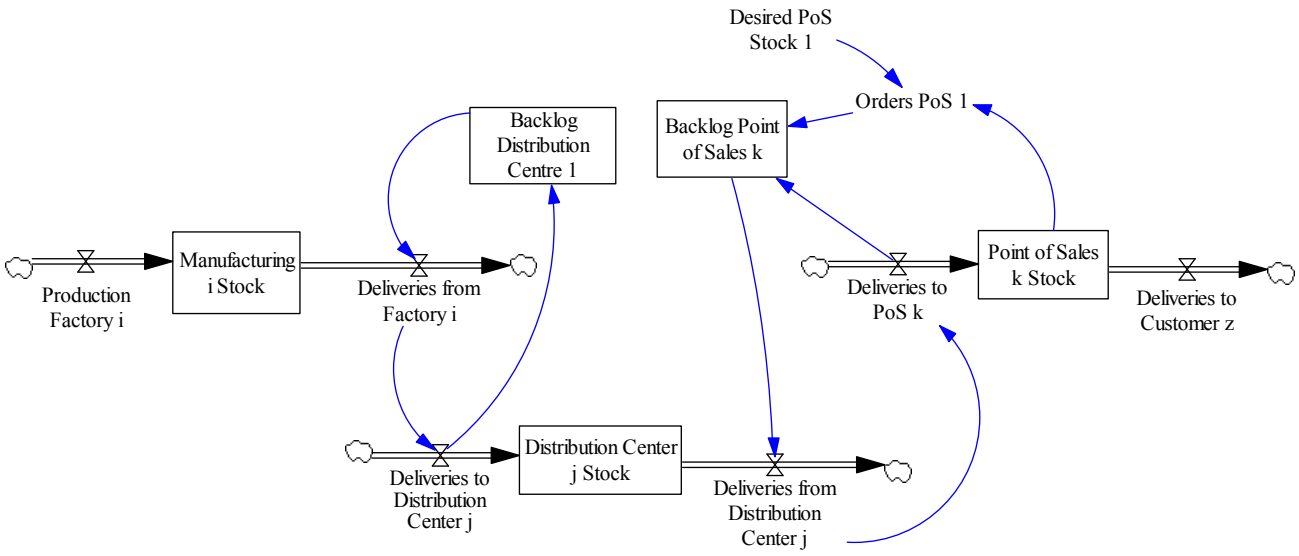

Figure 1 – High-level stock-and-flow diagram

3.2 The Model prototype

The purpose of this section is to describe the model, its scope, its boundaries and our justification for the main decisions made in these respects.

The model we developed together with the client had to capture the complexity of the situation sufficiently well, yet at the same time needed to be simple enough so that it could be used for live runs in the workshop setting. We therefore decided to keep the structure intact and, for the purpose of simplification, to cut down on the number of markets portrayed and products handled. Early on in the project we decided that trying to fully capture the complexity of the system under study in the model, while technically possible, was not in the best interest of providing insights in the workshop setting. With around 40 markets, some subdivided into as many as three regions, several thousand products, a multitude of factories and distribution centers in different countries, etc., the data requirements of a complete model would have been enormous. On the one hand, gathering the data and processing it in a way to feed the model successfully would have taken more time than was available for the project. On the other hand, the general usability, and the ability of the workshop participants to quickly test the sensitivities of model inputs onto the overall system, would have been hampered. Therefore we decided to reduce complexity at the level of both the number of markets, products and production facilities. Seasonality was kept in the model, the demand for different products being in line with a historic trajectory. As the aim was not to provide better forecasts our simplifications, which led to a better usability and a quicker roll out of the model, were justified.

There are two main sections to the model, namely the production section (see Figure 2) and the retail section (see Appendix 1) – the latter replicated for each of the chosen markets. In essence it has a similar structure to the Beer Game (developed by Jay Forrester) but with different rules of interaction between the various players and the possibility of a central authority overriding the model-generated decisions. Below we will describe the structure chosen in more detail, starting from the production side to the end customer.

3.2 Production

The purpose of the model was to capture the complexity of the supply chain and the implications thereof. Therefore, it was outside the model's scope to be comprehensive on the production side. We included three main factories, where most of the goods sold in the chosen markets originate. Instead of having the production schedule model influenced, we decided on the simpler option of importing a production schedule such as would be used in the real organization. The default option was then for the model to read in production schedules, for the various products for each of the factories, from an external file. Some products were produced in one factory only, while others were produced in all three. In order to enable some variation, additional levers were added, enabling us to shift output between products and factories in the model itself. This feature was needed in order to simulate managerial intervention, which as already mentioned, could occur throughout the supply chain.

The imported production values would represent an inflow into the factory warehouse stock. The model included a mechanism for the warehouse stock replenishment to a predetermined level, depending on the current and past

order situation. As a priority, though, replenishing the factory stock was considered last.

It is from there that actual orders placed by the retail section get filled. There is a clear priority which stipulates from which factories the orders are to be filled. It depends on whether the factory is producing the product, on the distance to the market in question and the price at which the factory can produce. In addition, having the relevant product in stock is considered better than having to produce it in a factory, which is closer. As in the case of the production schedule, here, too, there was a possibility of changing the priority of the orders manually and overriding the default model assumptions.

To summarize, the production module captured the relevant inputs into the system. At the same time we tried to keep it both as simple as possible and roughly as transparent as the real production scheduling would be to people not directly engaged in it.

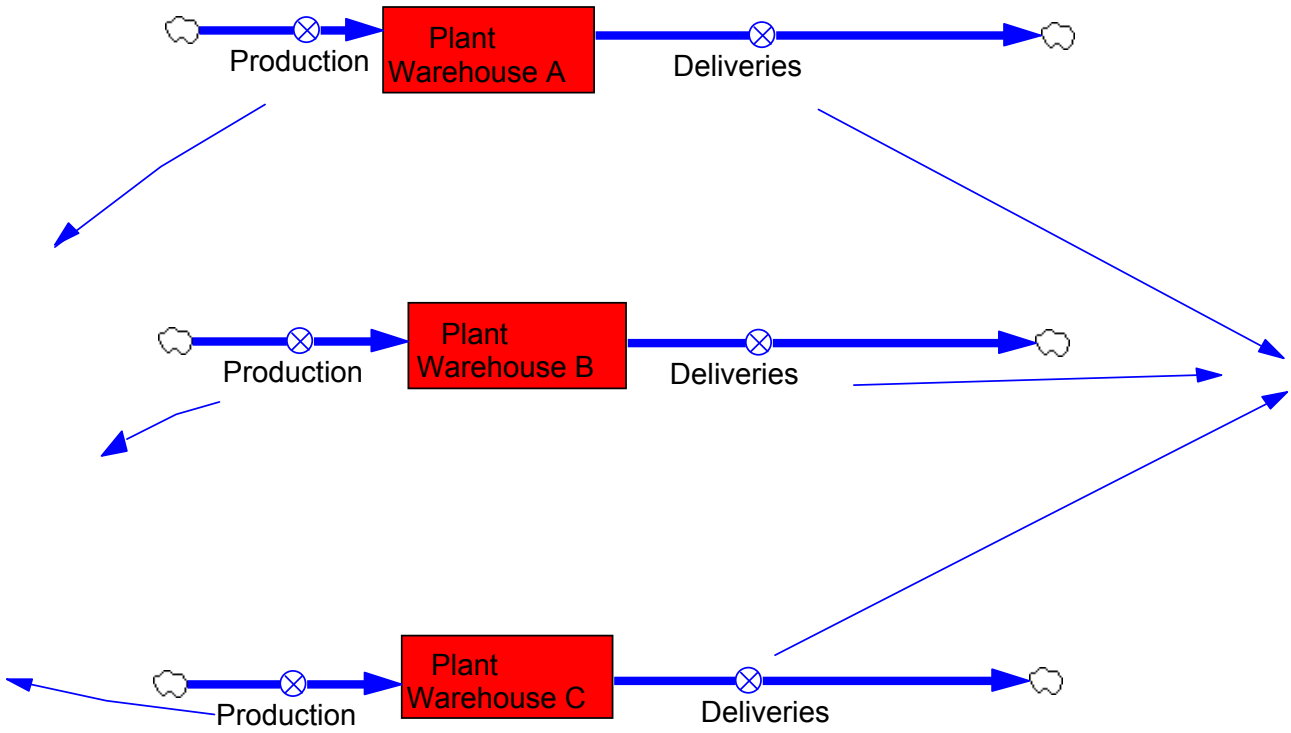

Figure 2 – The production module as used in the workshop model

3.3 Retail section

The retail section was by far the most complex part of the model, since the managers involved in the workshop spend most of their time and effort on this part of the business. .

Effort was focused on making it follow the real system as closely as possible. This included the following distribution channels:

- Controlled distribution – in effect a distribution network under Topos' direct ownership
- Regional distribution centres (RDCs) – centres (with their own stock) owned by Topos (therefore with some information transparency), which take care of distributing the products to smaller customers
- Wholesalers
- Retailers
- Specialized outlets, which usually deal in this type of product only
- Purchasing groups – an amalgamation of retailers or specialized outlets, which by forming a purchasing group get larger volumes and therefore preferential treatment.

While the first three distribution channels are usually supplied directly from the factory, the latter ones get their products from the regional distribution centres, thereby introducing another level of delay into their deliveries. The regional distribution centres can also supply wholesalers or controlled distribution outlets in case this proves faster – i.e. when there is no stock at the factory which could be shipped out directly, but the RDCs have some.

Each of the distribution outlets has two ordering options. They either hold a direct-end user order, which needs to be fulfilled, or their order is aimed at replenishing their own stock to a level they feel comfortable with. The former has clear priority. While generally, priority wise, it is the wholesalers and RDCs, who get the highest level, a delivery for a fixed order to a retailer, for instance, will get prioritized over stock replenishment for them.

In a similar fashion to the Beer game, all the outlets have their specific hardwired ordering algorithms (again modifiable for scenario testing), which operate on the basis of past and current demand, the current stock levels or potential backlog.

The final orders, coming from the market, could either be randomly generated or read in from an external source. We chose the latter option, with sample orders from a past season in the respective markets represented in the model. This made validation easier and proved hardly less random. As the model's purpose was to show the structure and complexity to management rather than to inform future forecasting, a truly random ordering system was not considered essential.

Various modules of all customers in the model (for any of the markets represented) is depicted in Appendix 1.

Between the stocks of the various distribution channels and those of the factories, there is an added layer of delay arising from the transit time – from either the factory or an RDC to the distribution channel. Varying the delay time allows us further scenario testing, primarily due to the effect of faster deliveries.

In addition, the impact of *force majeure* events, which could delay transport for significantly longer than is standard, could be assessed.

3.4 Discussion of the Model

The model was not designed for answering specific questions on policy decisions. It was, for the time being, developed as a tool for the workshop. This resulted in a focus on structural correctness over the ability to populate it.

We therefore chose a discrete conveyor delay as opposed to an exponential delay. While this made the model outputs more mechanistic, they were at the same time more in line with what the management of Topos experienced in real life.

In the final event, the main purpose of the model, to represent the complexity of the real system – which even in this simplified version was not easy to handle - was achieved. The model consists of 45.413 equations, consisting of 21.456 stocks, 20.257 flows and auxiliaries and 3.699 constants. This large number of elements stems from using subscripts to represent 48 different combinations of brand and two product-type differentiations – the number of drawn objects in the model is less than 1.000.

While the model was laid out in a highly transparent fashion and is easy to navigate, even the overall view of the model, which did not include all the subscripted variables in a visible format, very clearly impressed the message of system complexity upon an observer.

In addition to the overview of the complete model, separate model views of smaller subsections of the model were constructed. These were used as didactic tools to familiarise workshop participants with the model structure in a less daunting fashion. Apart from four participants, who were involved in the construction of the model, everybody else has seen it for the first time on the day of the workshop.

Finally, management cockpits with key levers at the control of management, important scenario assumption levers and most important outputs (as seen by management) became part of the model, making the handling of the model easier. In fact, even the participants who saw the model for the first time did not feel overwhelmed when they were confronted with it in the workshop.

4. Application and reflection

4.1 The management workshop

The management workshop united roughly 20 key persons of the company: higher and top managers from different aspects of the firm, belonging to six different countries across Europe. The mix was well taken. About half the participants came from the regional market organizations, and the other half

from the headquarters. All were involved with the supply chain, dealing with sales, demand management, pricing, etc.

The goals of the workshop were "a) to generate a common understanding of the complexity which has to be handled to satisfy customers, b) to explore the consequences of decisions in this context, by means of a dynamic model, and c) to experience the systems approach as a powerful means of dealing with complexity effectively."

The three-day event evolved along the following lines: At the beginning Mr. Young, who presided over the workshop, made a compelling statement about the need for a systemic approach to complexity management and the need of models to improve management. The first module was a brief introduction followed by the Fishbanks game, to convey systemic thinking in an intuitive way. The second module was dedicated to basics of systemic thinking, including the discussion of systems archetypes. In the third module, participants made themselves familiar with the principles and functioning of simulation models, using the corporate simulation model presented in the last section. The fourth and last module was then dedicated to the development of qualitative models of corporate issues, e.g. brand management, competitive challenges and problems in the operations of the supply chain. This led to an intensive discussion, which gave us the opportunity to reframe certain issues in the light of systems concepts, and various scenarios were discussed. Finally, implications were derived. The workshop concluded with a prospective outlook. Mr. Young made the point that the issues raised in the workshop would be taken up by the organization development unit at Topos.

4.2 Group discussions and scenario generation

The purpose of the workshop was a) to generate a common understanding of the complexity which has to be handled in order to satisfy customers, and b) to explore the consequences of decisions in that context by means of the simulation model.

As mentioned, after a theoretical introduction on complexity and systems theory the participants were involved in hands-on tasks so as to know and play with the corporate simulation model in two sessions. Here, the participants got acquainted with the model which was used as a vehicle for learning. For most of the session, reduced, i.e. simplified versions of the corporate model were used. The full corporate model was presented and discussed only at the end.

These sessions highlighted structure-behavior relationships focused on the supply chain of the firm, the impacts of decisions in a complex environment, the possibilities of developing "controlled experiments" and in general the understanding of the potential of modeling and simulation tools for supporting interaction and shared learning in a complex setting with multiple interrelationships. The model gave the possibility of "playing" with several variables, either directly or via a special cockpit with relevant levers and graphical displays of modes of behavior.

Before participants played with the model, and in order to drive the sessions with the simulation model, the next questions helped to guide the thinking process: Which are the main feedback loops in the structure? What kind of feedback loops are they? Are there potential delays? Where do they come from? Which key variables can identify the performance of what factor you are interested in? What would be the expected behavior? Which are the variables that you can potentially affect? How do you think that the performance will change? For the purposes of these sessions there were two models available. One model included constant rates (production, orders) and another one was based on real-world input data. The cockpit allowed one to change various variables and showed the behavior of relevant stocks. The managers were asked to achieve the best possible results for their corresponding station and to confront them with their initial expectations. Two four-hour sessions were devoted to work on these tasks. High interest and enthusiasm were constant characteristics among the participants. By the end of the second session the managers were familiar with the model and all its characteristics, that is, the highly complex environment for taking decisions which they were immersed in. Issues such as feedback structures, non-linearities and delays, among others, were now directly connected with their daily working environment in which they routinely take decisions. At the end, the simulation results obtained were compared to those based on the real-world data input.

What was gained in these sessions? According to the feedbacks they delivered to us, the participants had come to understand the nature of modeling and simulation. They had in particular become conscious of the complexity their company and its actors faced. Furthermore they had gained insights into the role of interventions and their impact in a complex, closed-loop system with endogenous causes and delays. Finally, the session was an eye-opening experience about the necessity for a good model and the dangers of failure implied by a deficient model. One of the participants - a high-level manager whom we call Mr. Hickling - brought it to the point.: "Currently the company is very successful. However, if we do not develop a new understanding of our dynamic structures and how they work, we will run into severe problems."

After the two sessions with the simulation model, the longest but also the most important session took place. There, arguments and proposals of the participants were connected. Scenarios and possible courses of action were discussed; these scenarios will be introduced next. This final part would show if the discussions and activities regarding systemic thinking and the use of the simulation model could be connected with the practical issues that managers were facing every day. Indeed, this session was designed to target the practical and direct relevance of simulation models for the firm in the context of decision making given the complex setting implied by the supply chain. The managers were divided into sub-groups of six to seven persons in order to address different aspects related to the concrete concerns of the supply chain that they had in mind.

A first group raised several options for dealing with the complexity they were starting to recognize ahead of them, e.g. the task of assigning distribution responsibility to OEMs (Original Equipment Manufacturers) in order to save

costs and services (around ordering, logistics and B2B advertising), to charge for services, to move production to low cost locations (including to consider locations of OEMs production), to push innovation, to reduce the number of brands, to increase market power, to switch to larger retail channels, to proceed with a complete restructuring of the supply chain, to sell one of the main divisions of the company, among others. As this list shows, this brainstorming session included issues of different levels, ranging from very detailed interventions to large scale plans for the restructuring of the whole supply chain. As will be shown, these concerns would be addressed in systemic terms by the managers. In the following, we describe three qualitative models built in the groups, with the help of CLDs (Causal Loop Diagrams)

One of the recurrent worries among the managers had to do with the large number of brands, which leads to enormous complexity and impinge on decision making, forecasting, sales and availability. These matters were worked over by one of the groups; the result was a causal loop diagram (see Fig. 3). Various aspects in particular of this diagram should be highlighted: (i) The managers recognized several feedback structures; and (ii) they acknowledged the very possibility that the apparently successful business model could be incorrect.

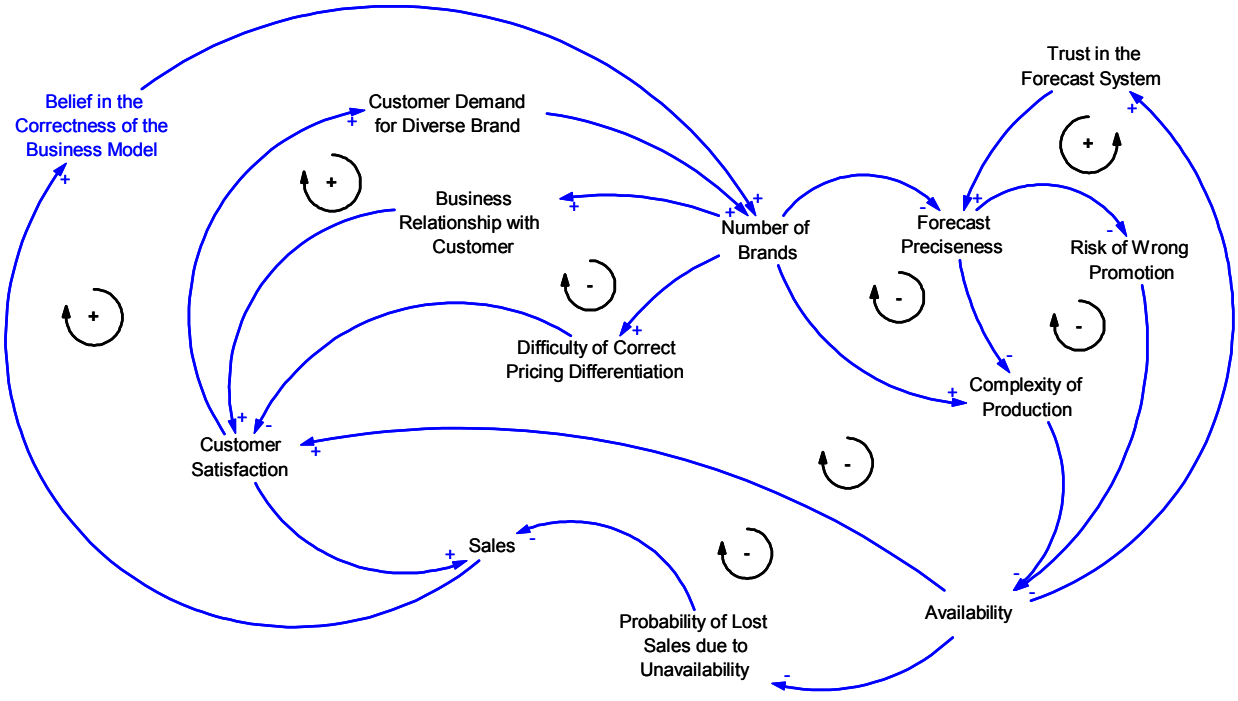

Figure 3

A view of the dynamics of branding:

A challenge to the established business model.

The managers started with the issue of the number of brands and how this key variable is influenced by the belief in the correctness of the actual business model. After including the impact on issues such as relationships with customers, forecasting, availability, and sales, the managers identified the reinforcing feedback loop (marked with “R1”) that propels the number of brands as long as the business model is taken as right and as somehow unmodifiable. In particular, the impact of this insidious feedback loop was one of the lessons that was recognized by the managers themselves: as long as the business relationships with customers and their consequent satisfaction go smoothly,, then sales increase ― a typical situation for this firm given its position in the market and its captive customers ― so that the conviction that the assumptions and the way to act were “correct” was being increasingly reinforced in the mental models of the managers, a belief that was apparently deeply entrenched in the decision-making process but not properly recognized before. Now, however, such a belief was being challenged through the discussion. The managers discussed the very possibility that this apparently virtuous cycle could indeed be vicious; what if the business model has flaws, or what if the number of brands is reduced? For instance, this last question led to the recognition that a consequent increase in availability and therefore a rise in customer satisfaction with a boost in sales could be indeed possible. After a while the managers were discussing things solely in terms of interacting feedback processes and the linking of structure with behavior.

A second discussion was held by a different group of managers. The issue at hand was the effect of what they called “punctual intervention” in the supply chain when unexpected demand comes up. With that expression they referred to the practice of managing shortages by favoring the main customers (the larger ones, the older ones) over the non-preferred customers. In a debate on the benefits and problems of that procedure, the managers elaborated a CLD which revealed the fact that this was a non-systemic approach to the supply chain. The result is depicted in Fig. 4.

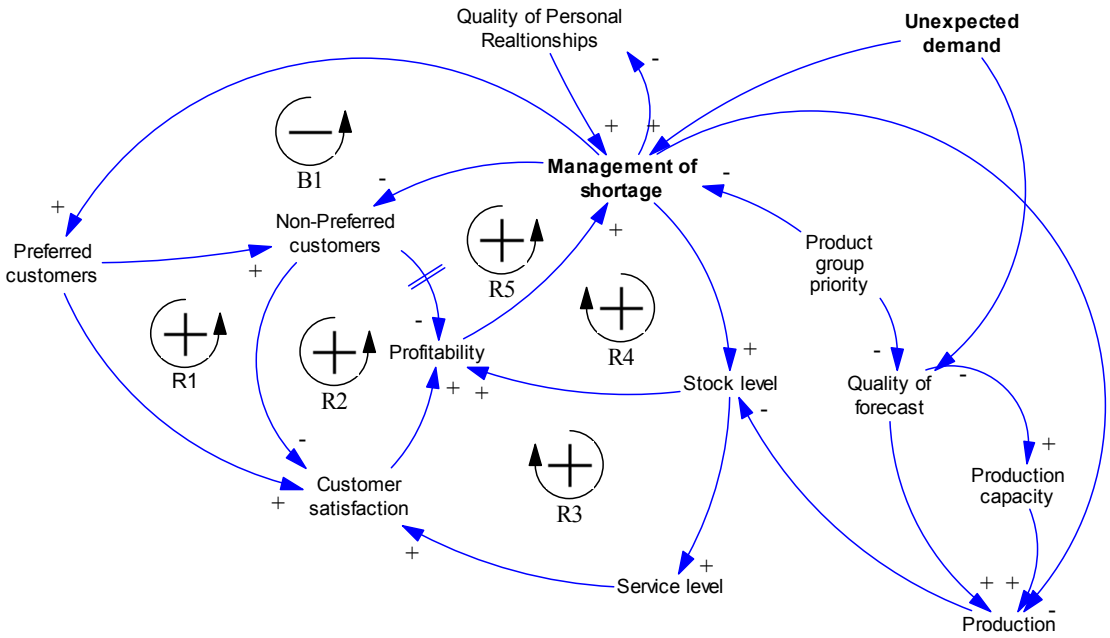

Figure 4

Effect of "punctual" intervention in the Supply Chain.

The version of the managers of the firm.

In particular the managers underlined how the reinforcing loops R1, R2, R3, and R4 could be deceiving; in the short run these dynamics accounted for the “punctual interventions” made in the supply chain in order to respond to unexpected changes in the environment; such actions led to profitability thanks to the preferred customers; in the meantime, however, the reinforcing loop R5 was also on its way, but with an important delay so that its impact cannot be easily seen except over the longer term. In any case, the effect of R5 was countervailed by the balancing loop B1. The discussion of how R5 interacted with the other loops as related to strategic goals and to shorter-term issues, e.g. forecasting and production, led to revising this traditional practice of “punctual intervention” that was customarily being held in the firm. A further exploration with a computer model of these aspects was one of the tasks that the managers wanted to address in the future.

In a third group of managers the consequences of changes in the environment was explored, with an emphasis on competitors. Since the company is firmly established in the market, questions regarding the competition had not been addressed from a complexity and systems perspective, which was the topic of the workshop. This group of managers considered what they called an “attack on Central Europe” (see Fig. 5); this scenario arose as one of the possible settings that they could face in the future.

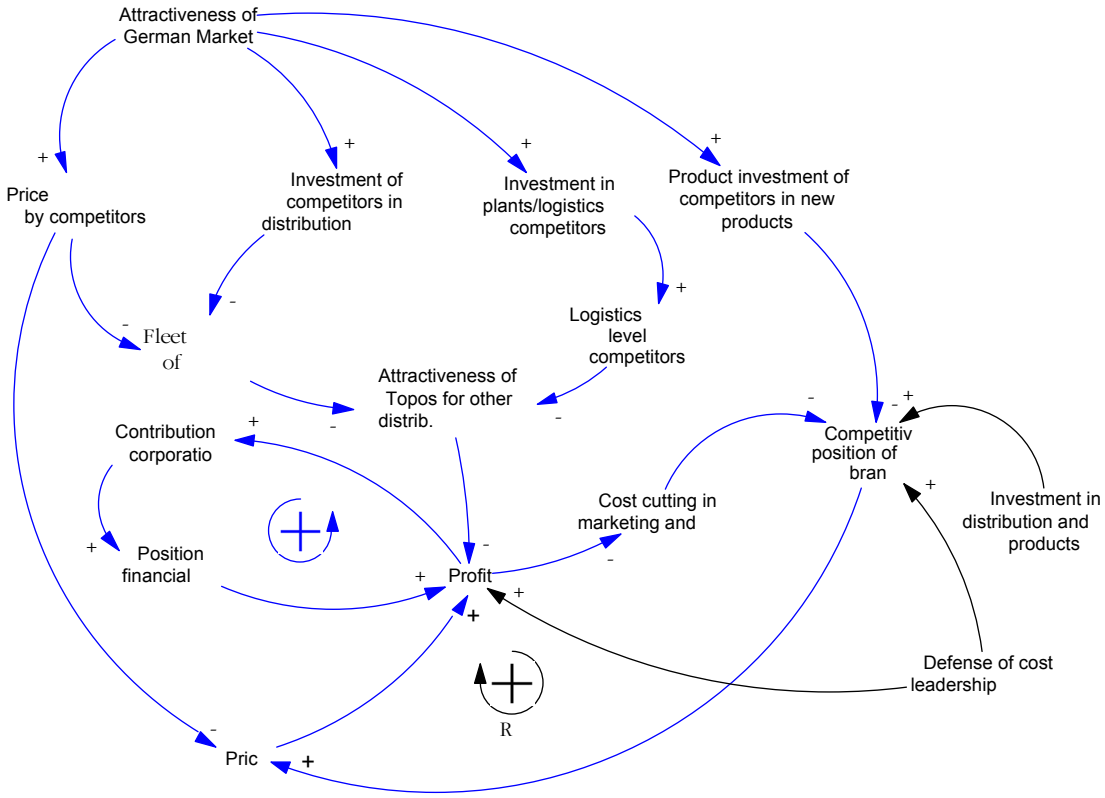

Figure 5

Attack on Central Europe. What could be done?

In this situation, the competitors would recognize the high attractiveness of the German market. As a consequence, the most likely courses of actions were indicated as investments in distribution coverage and in new products. These possibilities, alongside price aggressiveness and other alternatives such as investment in logistics, would endanger the profit of the firm, mainly through the impact on distribution channels and with price erosion of their own brand. The subsequent cost cutting in marketing and R&D would lead to the dynamics propelled by the reinforcing loop R1. As a result, the managers came up with two main alternatives in order to intervene: on the one hand with direct investment in distribution and new products, and on the other hand with protection of the cost leadership position that characterizes the firm. The issue to highlight was the recognition by the managers that these types of decisions were exerting pressure on the insidious reinforcing of loop R1 so as to convert it into a virtuous cycle in the event of such scenario.

So much for the examples.More important, this type of systemic approach was recognized by the managers as a more complete and “wiser” way of facing complexity. Discussions converged on a new view which the participants gradually adopted: among others, thinking in terms of feedback processes

(dynamic worldview), the prominence of long-term concerns, operational thinking (in terms of recognizing behavior as explained by system structure as opposed to factors/events thinking), were characteristic of this final part of the workshop. This new view also implied that behaviors were now endogenously explained – as a function of internal actors who manage the policies of the system - instead of conceiving such behaviors as driven by external forces.

As far as the computer model (expounded in section 3) is concerned, it was demonstrated in the workshop and run with selected scenarios. It was not yet fully explored on that occasion, even though the importance of computer modeling and simulation was understood by the participants as having importance for a common understanding of the issues faced by the company.

In sum, however, our conclusion is that, in this case, the work with qualitative models, i.e., the elaboration of the Closed Loop Diagrams, was more effective than the presentation of the quantitative model. This was due in the first place to the time restrictions, first of all in the workshop itself but also in the preparation phase, which had not allowed us to involve more than a handful of the participants in the model-building activities. The model prototype impressed the managers during the workshop, but it was not used in the company thereafter.

4.3 Follow-up

Three follow-up interviews with managers of the company were conducted between March and July 2007.[7] In March and May 2007, i.e., one and a half years after the workshop, two follow-up telephone interviews with Mr. Young were carried out. The first conversation was held to convey a general picture of the evolution of the state of systemic thinking in the organization under study. The interviewee reported that the workshop had led to "cognitive improvements". He maintained that the participants' awareness, understanding and systemic thinking in the face of complex issues had generally improved. But Mr. Young also observed: "The action still lags behind the thinking".

In the following, he argued that more managers of the company should be trained in system dynamics and systemic thinking so that a critical mass for the "new paradigm" could form. He told us that he intended to convene a second workshop, like the first one but with a different set of participants, and asked us if we were ready to engage in such a project.

The second interview gave us an opportunity to focus on the current status in a more detailed fashion. "All in all, the impact of the project on the day to day management of the business has been minimal." He gave two reasons: "First of all, the new logistics executive – a former CEO assistant – is exclusively interested in cost-cutting and claims that the whole system is rather simple – he does not grasp the complexity at all. Second, as a result of that, much of the organization is in a permanent fire-fighting mode. This means that they do not have the time to experiment and assess how to integrate the approach presented in the seminar into their daily routines, in spite of the participants

[7] The duration of these interviews was of 20, 30 and 60 minutes respectively. All of them were excerpted.

wanting to do so. The presence of permanent fire-fighting also quite clearly indicates that the simple cost-cutting approach does not work sufficiently well."

A personal conversation with Mr. Young and Mr. Hickling in July 2007 added some significant insights about structural and cultural factors inhibiting the switch towards a systemic management of complexity. The two managers gave us a detailed view of the routines which dominate patterns of behavior. First of all, the measurement of the different units in the supply chain induces counterproductive behaviors in several ways. For example, production is assessed only in terms of the overall production volume - the more, the better. Therefore, producing the right articles is not of much interest. Production always tends to produce what it can fabricate in the largest volume and with the lowest rate of machine resetting. This leads to heavy shortages of certain products, even over years. Another example is higher management's permanent concern to minimize inventories. This leads to punctual interventions which minimize production and even cause bottlenecks, despite substantial fixed orders for the final product. A second problem is the possibility of intervening in the supply management system on the part of different parties - production, marketing, etc. As the system does not provide any transparent feedback, organisational learning in this case is excluded. Finally, given the general situation of the company - growth and high profits over the last three years - managers want to stick to their old recipes for success.

The large model had never been used after our workshop. Furthermore, the managers had not yet been able to hone their skills in causal loop thinking to an extent that would make it possible for them to use it as a standard approach in their repertoire. On the bright side, Mr Young maintained that some of the participants showed an awareness of the importance and power of the systemic approach, most importantly Mr. Hickling and Mr. Tortoni (names anonymized), besides Mr. Young himself. In addition, two other people in the corporate headquarters had been made aware of the approach and had come to believe in it. Also, three future executives were attending an iSee training seminar[8] in London, so they would have a basic grasp of System Dynamics (SD). A simulation software package was about to be acquired by the company.

Mr. Young insisted that the level of frustration in not being able to pursue such tools for managing complexity was rising, and that he and his colleagues were in the process of thinking about whether to organize a debriefing of the workshop with 3-4 people, followed possibly by a one-day review dedicated to the question of how to proceed from there.

On balance these results are not spectacular, but at least they indicate that an interest in systemic thinking and dynamic modeling had been aroused, and that some potential exists within the company for pursuing this approach in the future.

[8] iSee is the company that provides iThink, a software for SD modeling and simulation.

5. Conclusion

At this stage we can get back to our initial propositions and come to our conclusions.

The initial propositions were based on the Conant-Ashby theorem, which posits that the quality of the outcome of a (management) process is determined by the quality of the underlying model. Consequently, in the first proposition we pointed out the fundamental importance of conceptual understanding for enabling managers to cope with complexity. In the other proposition we stated that a lack of such conceptual understanding is a strong driver of organizational failure.

We checked ways to reject these propositions. The main argument in this vein was that the Topos company should show bad performance given the weakness of the models underlying its management. There were several instances of evidence which annihilated these attempts of falsification. We cannot claim that we are "proving" the propositional statements made above. This would not be possible, anyway. However, the case analysis presented here has brought forward several points which underpin the propositions, at least in an indicative sense.

First of all, the eye-opening quality of the workshop sessions in which quantitative and qualitative model-building and simulation were explored was mentioned time and again to us by the participants. They emphasized that a learning effect was taking place. Therewith, they pointed out the importance of conceptual understanding.[9]

Second, four of the managers contributed substantially to the development of the corporate model, while 20 sacrificed time in order to participate in the workshop. In conjunction with informal statements they gave, these are indicators of the relevance of "theoretical" understanding as well.

Third, as already detailed in the report on the workshop, the participants were very impressed by their conceptual discoveries when building the CLDs in the last session. They attributed high importance to this new way of thinking for their managerial activities.

Fourth, the managers explored the power of simulation to carry out multiple and controlled experiments, with the capacity to “play” with different levels of difficulty at hardly any cost, and they learned a lot that way.

Fifth, the clear picture of their own company as a high-performing organization menaced by competition, but even more by complexity itself, appeared to worry the participants. They knew that the destiny of the organization hinged on the quality of the models on which they operated. And, as the statement of Mr. Hickling (quoted in section 4.2) corroborates, at least some of them were aware of the portentous potential of flawed models.

Sixth, and perhaps most important, the follow-up after about 1,5 years showed that the project was highly valued by our partner from the company, in terms of

[9] We are aware of the limitations of such self-reported assessments by the participants. However, we have no way of triangulating these assessments other than using our own judgment, which gets to the main conclusions as the participants in their comments.

cognitive improvement of the managers who had participated. This valuation was expressed in the intention of the company to repeat the workshop in order to increase the number of managers with a systemic understanding. The follow-up also indicated that a direct impact of the first workshop on day to day operations had not been ascertained. Even so, a handful of managers were aware of the power of systemic thinking and dynamic modeling, and were interested in pursuing it within the company.

Finally, we will end with a number of insights which can be cast in the form of recommendations. These do not comprise a scientific theory, but a set of heuristic principles, which ought to prove helpful when it comes to the formation of a model-based management.

1. Models are indispensable: What in particular has been fleshed out in the case study is that models are a crucial device for improving general management, not only a help in functional areas such as accounting, sales, information management, etc. Models are key, and they should be formed with great care. They have to incorporate high-level understanding, and they should be valid representations of the realities they are supposed to reflect. Remember Conant-Ashby: be meticulous about the quality of the models you use.

2. Mental models as complexity attenuators: Mental models, i.e. models of the qualitative SD type as described in part 4, are enormously powerful for the first approximation of a complex problem. They enable one to work out crude structures encompassing essential variables and their interrelationships, as well as feedback cycles and delays. In this way, complexity is attenuated in a very efficient manner. The limits of this efficiency are the abstractness of these models and their lack of specificity, which only formal, operational models can provide. One can make prolific use of them, and especially employ them in groups, when a shared understanding is pursued. They are a formidable vehicle for group model-building and for challenging the mental models with which we take decisions every day.

3. Formal models as variety amplifiers: Formal models such as the quantitative SD model described in part 3 have the advantages which compensate for the weaknesses of the merely qualitative models. They provide more precise representations than those can do. They can also be tested more efficiently and therewith reach higher accuracy. Furthermore, they can speed up the learning cycle. However, their level of generality is limited. They are focused, a fact which can lead them to suffer from a certain narrowness. Altogether, formal models can become powerful amplifiers of the behavioral repertory of actors in organizations, in other words of eigen-variety, i.e. of the capacity to cope with complexity. Managers should make use of formal models and try to improve them continually.

4. Combinations as powerful pairs: In practice, normally both quantitative and qualitative models are needed,. One should not shun the additional cost incurred by the building of good models. In the case of good SD models the relation of benefit to cost should - according to a famous planner and author (Gälweiler 2005) - be at least 10:1. We do not know of any better investment that one might make.

Acknowledgement

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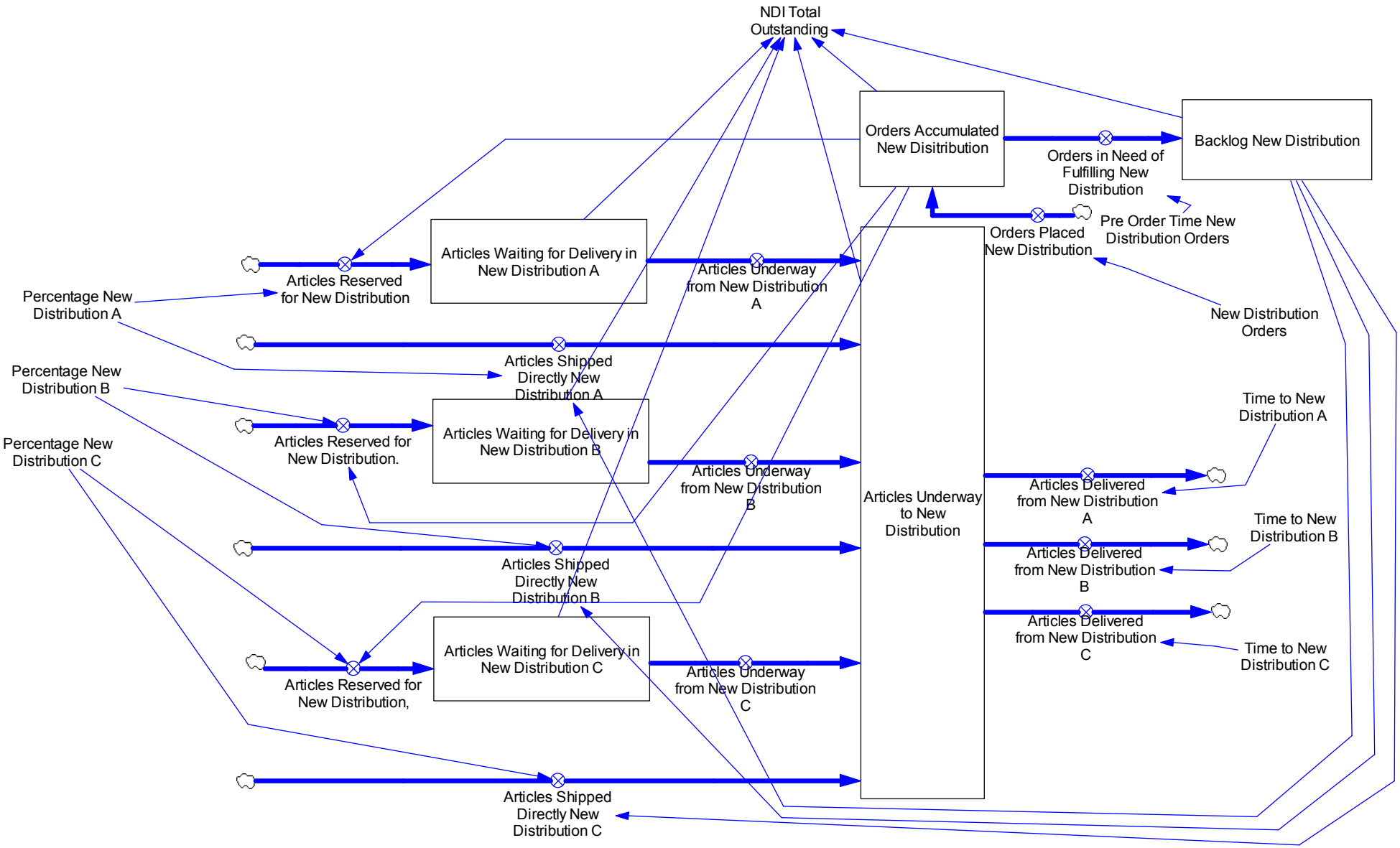
Appendix 1

Part of the system of retail for a specific country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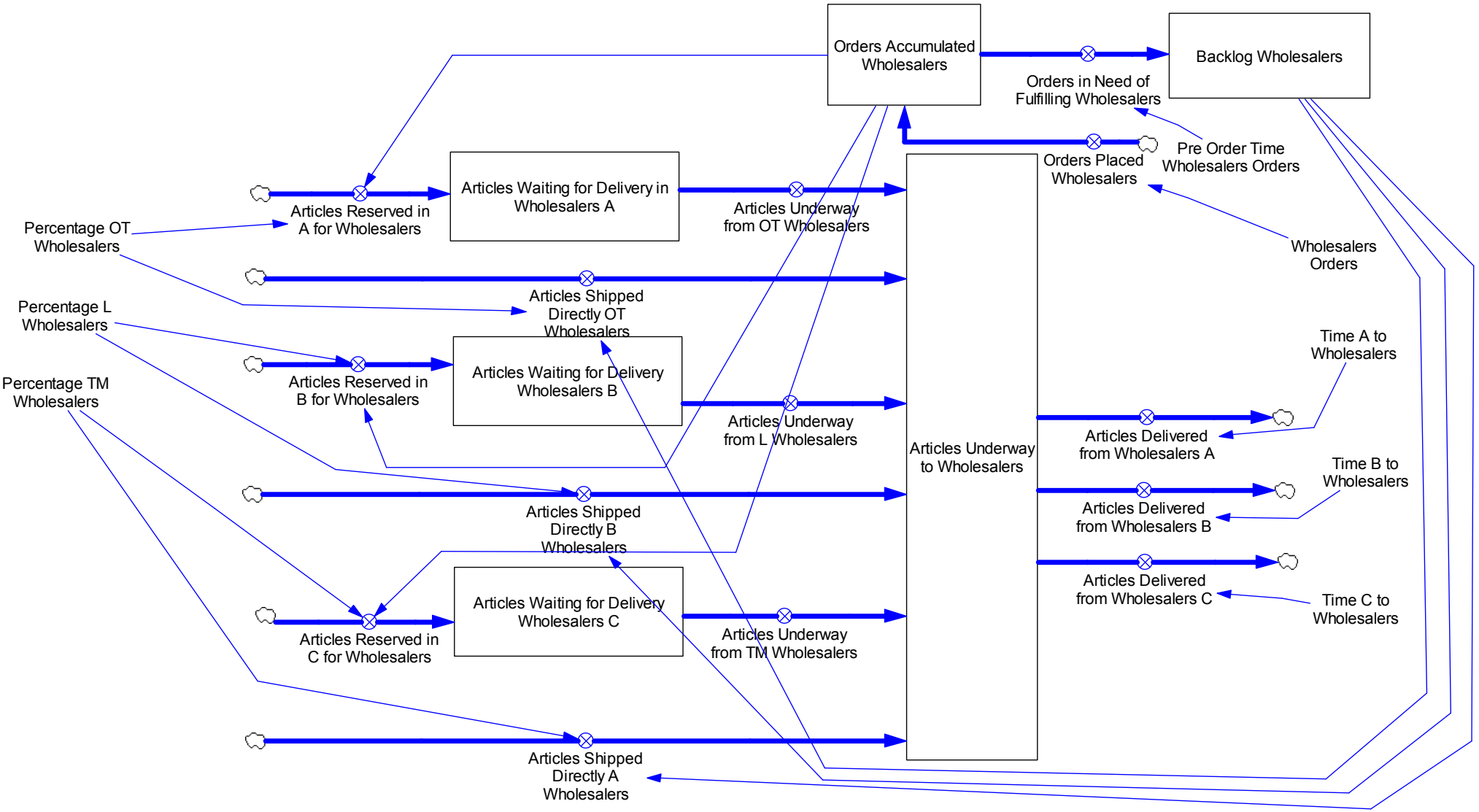
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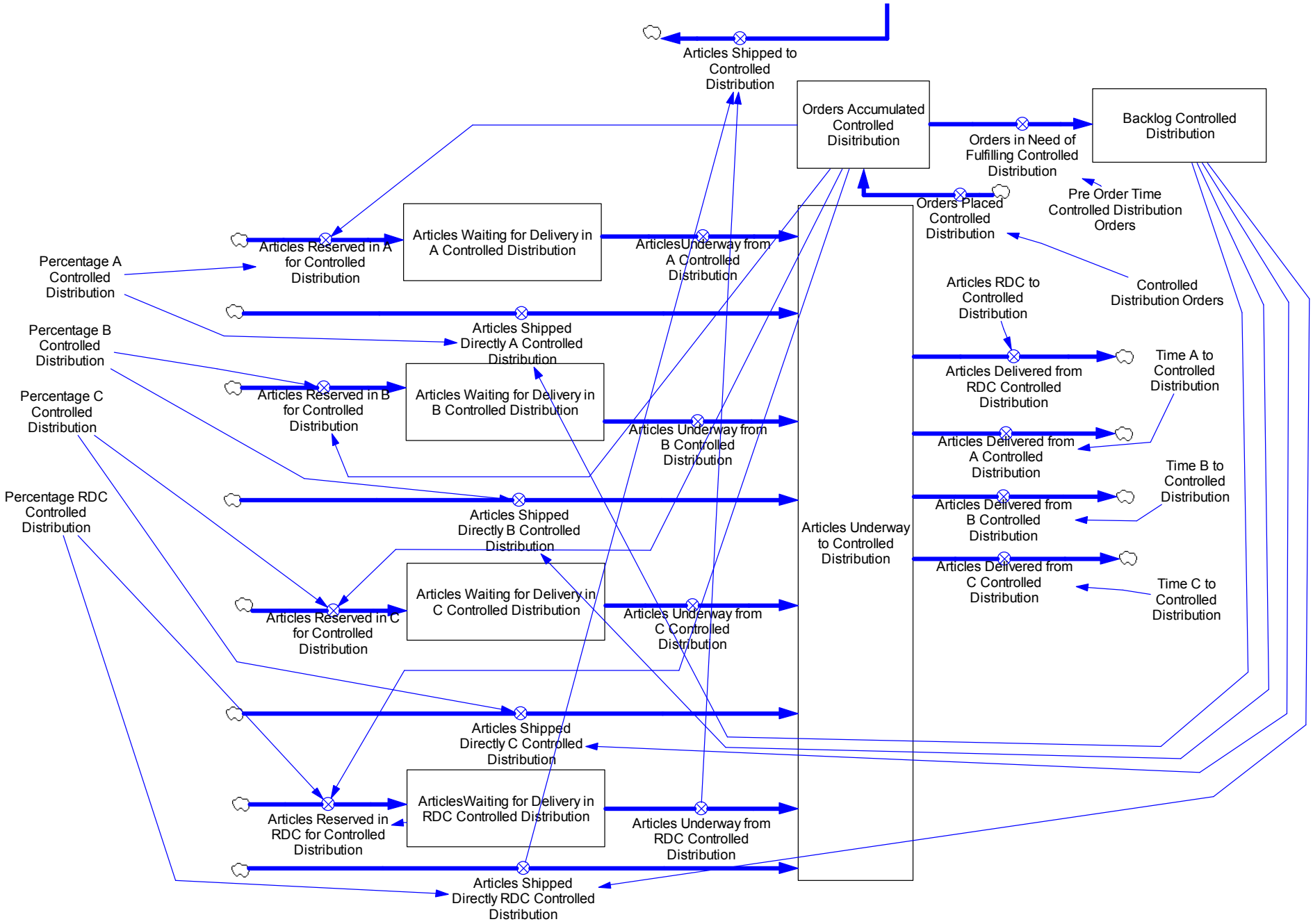
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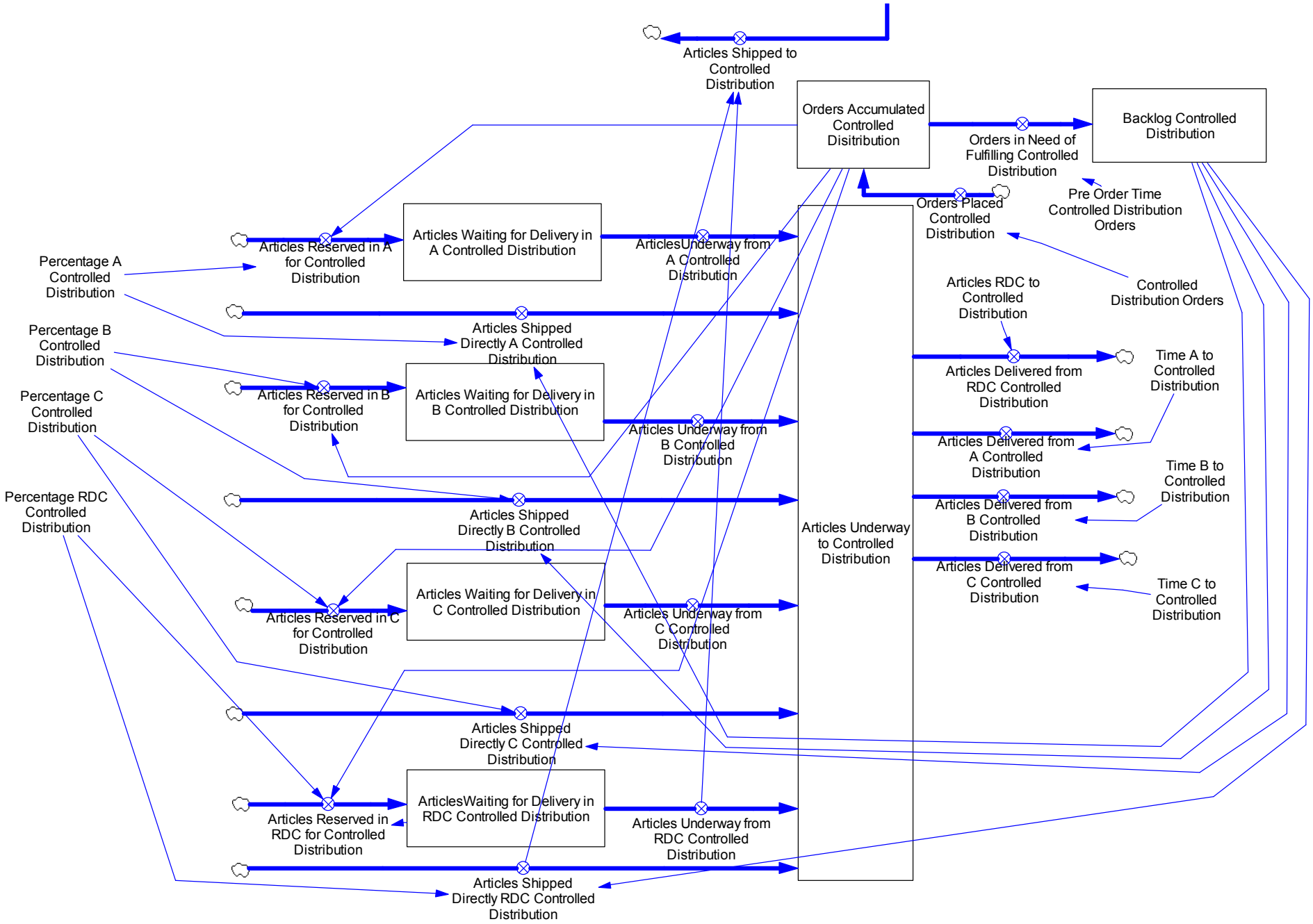
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