

# Exploring the dynamics of seasonal goods supply chains: a critical realist perspective

## ABSTRACT

The purpose of this paper is to investigate the dynamics of a particular type of seasonal perishable goods supply chain under a critical realist perspective, i.e. to expose the underlying reasons for the intended and unintended behaviour of such a supply chain. For accomplishing this task, we have used a pluralistic retroductive research methodology consisting of a case study development and system dynamics simulation modelling. Overall, the paper shows how such an approach can be used for exploring and understanding dynamic operational phenomena in supply chains produced by underlying mechanisms associated with objects and their geo-historical context.

Keywords: supply chain, critical realism, retroduction, risk management

## 1. Introduction

Supply chain and logistics research has been dominated by the idea that their constituting activities are designable, i.e. they can be designed according to desired performances, thus undermining the role of human agency in the implementation of designs. In this perspective, there is an inherent assumption that managers responsible for supply-chain-related activities follow designs without questions and without being influenced by the context within which they live and work (Aastrup and Halldórsson, 2008). This “designability” of supply chains assumes a flat ontology of supply chain at the activity level which is based on regularity, which undermines the influence of any underlying social structures and their relations to agency. Indeed the use of

mathematical modelling tools used to explore and understand related supply chain phenomena that make use of this ontology and its presuppositions, regularly provide guidelines for optimised configurations by exposing specific behaviour otherwise unobservable. However these studies and their outcomes cannot be persuasive enough neither as explanations nor as prescriptions since their assumptions regarding human agency are based on closed-systems behaviouristic generalisations. In other words, they assume similar simplistic behaviours in different situations, e.g., all companies in the supply chain are aligned with the interests of the dominant /focal company, all measure performance in the same way using the same metrics, all are sensitive in the same degree to the same incentives, all perceive risk the same way, etc.

The importance of the role of human-related (emotional and other) capabilities of managers in the supply chain has not been entirely overlooked (Van Hoek *et al.*, 2002), and the importance of internal functional alignment as alignment of different organisational agencies in supply chain management has been stressed, but, so far, only under a meso-level behaviourist perspective (Van Hoek and Mitchell, 2006; Wu *et al.*, 2009). Behavioural studies, at the same level, concerning make versus buy decisions (Powel Mantel *et al.*, 2006), supply chain integration (Villena Martinez *et al.*, 2008), and supply chain dynamics (Yan Wu and Katok, 2006) have also been reported.

On the other hand, critical approaches to this essentially positivist supply chain management research paradigm, which also assumes that the interests of a focal organisation, as well as its strategy, are propagated unquestioned throughout the entire chain/network, include those originating from the philosophical domains of social constructionism (New, 2004) and critical realism (Faria and Wensley, 2002; Faria,

2004). Criticisms have been focused primarily on the dismissal of issues of power (New, 2004; Faria and Wensley, 2002; Faria, 2004) and context (Faria and Wensley, 2002; Faria, 2004). Taking into consideration these issues requires a set of different ontological assumptions that incorporate explicitly managerial agency and context, as well as a different epistemological stance that acknowledges subjectivity in social science research. Towards this end, the use of the case study research approach under a critical realist perspective has already been advocated (Easton, 2000; Harrison and Easton, 2002; Aastrup and Halldórsson, 2008) and used (Faria, 2004) for assessing the influence of contextual factors in supply chain performance, mainly those related to the different cultural environments in which suppliers and buyers operate.

However, under a critical realist perspective, in order to justify the existence of generative mechanisms as those responsible for the events observed in the course of time, methodologies and tools complementary to case study must be employed. Retroductive methodologies that are associated with critical realism, postulate (hypothetical) mechanisms that if they existed would generate the observed phenomenon (Mingers, 2006). Underlying mechanisms can be extracted and described using the case study method, while the (re)generation of the observed phenomenon can be achieved by modelling and simulating these mechanisms. In particular, the system dynamics methodology is a very suitable candidate for this task because it is able “to get beneath the surface to understand and explain why things are as they are, (and) to hypothesise the structure and mechanisms that shape the observable events” (Mingers, 2004a). In this way, system dynamics model structures and observed emergent behaviours become representations of a “stratified ontology” related to the phenomenon that the researcher-modeller tries to understand.

In this paper we use such a retroductive methodology to investigate the dynamics of perishable multi-seasonal goods distribution channel (downstream part of supply chain) under a critical realist perspective. More specifically, the paper deals with an excess-inventory-related problem, which is frequently observed in such systems. In addition to providing insights on how to deal with these problems, the purpose of the research presented is to investigate what causes them in reality, and to demonstrate the necessity, rationale and application of a pluralistic methodology, consisting of case study development and simulation modelling, for dealing with such issues of supply chain and logistics management. In the following sections, first, we present the specific supply chain issue and the related literature (section 2). We then concentrate on the philosophical basis (critical realism) of our research approach and its implications for supply chain management and logistics research (section 3). Following, in section 4, we present a case study of a sun protection and tanning products supply chain developed after field research, and the deconstruction of its main issues to expose the social structures and mechanisms that are responsible for the observed behaviours. We then use system dynamics modelling and simulation to express these mechanisms in more manageable way so that we can check the validity of the mechanisms, as well as to observe the results of a set of hypothetical structural interventions on them (section 5). We end the paper by discussing the research methodology and the results obtained and by drawing our conclusions (section 6).

## **2. The dynamics of the perishable multi-seasonal goods supply chain**

Perishable multi-seasonal goods are goods that are sold yearly, for specific time intervals, and for a limited number of periods (years). These products can be fashion-, or technology-sensitive, which means that are gradually substituted by more recent ones, usually introduced at the beginning of each season. In general, supply chains for seasonal goods differ according to product characteristics and the nature of associated demand (Fisher, 1997; Wong *et al.*, 2006). In industries with innovative products of highly unpredictable and variable demand, which may result in high obsolete inventories, lost sales and markdowns for the companies involved, the main supply chain management objective is to increase the responsiveness of the supply chain (SC), frequently by applying the appropriate information technology (Wong *et al.*, 2006). On the other hand, in industries such as the apparel industry, the main issue of concern is assortment, i.e. deciding the subset of all available designs that retailers process throughout the entire season (Smith and Agrawal, 2000; Caro and Gallien, 2007).

The cosmetics industry, which provides the case study for the research presented in this paper, is characterised by seasonality in both demand and financial gains. The majority of sales of brand name products and revenue yield takes place during the winter season (Kumar *et al.*, 2006), but there are some lower value products whose demand is associated with the summer season. These products are more sensitive to technological innovations. Sun protection and tanning (SPT) products belong to this category of seasonal consumer products. Their demand is relatively stable, as far as total volume is concerned, but their range is updated almost every year. As far as their distribution channels and related supply chains are concerned, in addition to distribution by large retailers in urban areas, a complementary channel exists in regions of high summer tourism. This channel relies on regional distributors/resellers which are responsible for

the supply to small sale outlets near tourist resorts. This supply-chain architecture implements the current cosmetics manufacturers' strategy of pruned product lines and cost reduction (Kumar *et al.*, 2006).

In the tourist resort distribution channel, resellers act as a buffer storage for SPT products, whose aggregate order quantity is determined and transmitted to the manufacturer well ahead of the beginning of the selling period. The relationship between the manufacturer and the distribution agents is fairly constant governed by medium-term (5-10 years) contracts open to a limited number of amendments. Transactions between them are minimal (vertical marketing system) for keeping costs low (Desai, 1996). The resellers offer storage and distribution services, as well as providing, indirectly through its ordering quantities, limited sales information. Product pricing is determined and imposed by the manufacturer who also provides sales incentives to distributors. The manufacturer has an end-of-season returns policy, sometimes fully refunding the resellers for returned products.

Given the relative stability of demand, and assuming the absence of rationing and over-ordering on the part of the manufacturer and its distributors, respectively, excessive inventory cannot be attributed to inadequate forecasting or distorted order transmission. The poor performance of the supply chain should rather be sought on the coordination and alignment of objectives and interests of the parties involved. The misalignment of interests in the supply chain as a source of long-term problematic performance has already been exposed, indicating the inability of companies to impose specific behaviours on other companies that have different cultures and beliefs. For many, the obvious way to "induce supply chain partners to behave in ways that are best for

everybody, companies have to create or modify monetary incentives” (Narayanan and Raman, 2004).

In fact, employing monetary incentives as a tool for aligning behaviours in the supply chain moves the issue to the Principal-Agent model/problem (Sappington, 1991), which presumes that incentives are similarly perceived and received by all agents independent of the context in which the recipient (employee or organisation) is embedded, the general objective of the “supply-chain designer” being to either maximise each partner’s profit individually at the expense of the other (no cooperation), or of all partners jointly in cooperation. As it is exemplified by the case we present in this paper, this is not always the case, and in order to explain specific phenomena experienced at the supply chain system level, deeper structures and their causal relations to the observed phenomena need to be identified and justified. As we will show in the following sections, the philosophical assumptions of critical realism and its associated retroductive pluralistic research methodology can contribute in this direction.

### **3. Supply chain management and critical realism**

Deterministic causality at the level of observed events and a unitary systems view are the main characteristics of the current supply-chain and logistics management research paradigm (Aastrup and Halldórsson, 2008). Deterministic causality at the observed events level originates from a norm of thinking where physical objects and their movement constitute the objects of the study. In conjunction with a systems view in which behaviours are governed by a ‘rule-based’ functionalism, this forms a belief that activity in supply chains is designable according to given performance objectives (New and Payne, 1995). Hence, in order for designs to be implementable, social agents’ acts

assumed to exhibit regularities, produced by unquestionably following the rules/behaviours that constitute the design. As Aastrup and Halldórsson, (2008) emphatically state: “(it is assumed that) the system has objectives (key performance objectives) but agents do not”. Their role is purely functional in the framework of the structure of the system (the supply chain) and they are not “open” to any contextual influences from the organisation’s environment (e.g. functional dominance) and external institutional setting (e.g. regional business culture), without having personal histories, unique identities, etc. This essentially positivistic approach to supply chain and logistics management has ontological and epistemological consequences, especially on the way quantitative and qualitative models are constructed and used in research. The results obtained using these models are assumed to have global validity and are thus considered sufficient for predicting behaviours of specific – usually optimality seeking – designs.

At the other end of the spectrum, in response to this extreme positivism, there are approaches associated with a social construction perspective on supply chain and logistics management. They maintain that the notion of supply chain is a social construction with interpretation flexibility. In it the different views of social actors serving specific interests and supporting specific power structures are accommodated (New, 2004). This view indirectly deconstructs the notion of supply chain and adheres to a very fluid ontology, overemphasizing the role of the subject in the research process. The danger is that specific social constructions may be legitimised on the basis of the acceptability of academic abstractions made to facilitate the study of specific issues. These abstractions are then adopted by specific parties having related interests and are



portrayed as reality. Then, as it frequently happens, they are used by academics and researchers to obtain new results and so on.

Situated somewhere in the middle between positivism and social constructionism is critical realism that accepts the relative independence of an ontological domain from the domain of observed events. That is, it accepts that there exists an independent world of reality (the *domain of the real*) containing generative mechanisms (of the observed events), which exist in activated or non-activated form independent from the observer. Mechanisms create events which themselves constitute the *domain of the actual*, which also exists independent of the observer. What the observer experiences from the domain of the actual constitutes the *empirical domain*.

The obvious question raised by any supply chain scholar might be “what constitutes reality in the study of supply chains, since materiality and physical laws are absent in decision making and management practice?”. Social constructions do exist and some of them may be (re)defined and/or influenced/alterd by management researchers. However, as Sayer (2004) indicates “this presupposes that there are practices or constructions which exist independently of those which (the researchers) can influence”. Those that cannot be influenced, effectively, constitute the domain of the real in supply chain management research. The aim of the researchers involved is to link the generative mechanisms of the domain of the real to the actual events observed through causal analysis.

*Causal powers* and *liabilities* of which the domain of the real is constituted of are the main issue of the aforementioned analysis. Causal powers of social and natural objects

(or structures) represent their abilities to do things, their ability to activate a mechanism. On the other hand, liabilities represent inherent limitations to do so. Hence, an object of a specific structure possessing a specific set of causal powers and liabilities will produce under specific conditions specific events. In other words, there is a contingent relation between the objects causal powers and the events created (Sayer, 1992). After adopting a critical realist perspective on supply chain management, the research objective becomes that of identifying material and social objects and their link to the domains of the actual (events) and empirical. The greater the contribution of social elements on the production of events by the structure, the more difficult becomes the definition/approximation of the behaviour of the generating mechanisms and the definition of causal links.

In order to define causal links, usually, the researcher relies on a retroductive (abductive inference) process. In this, the researcher postulates a hypothetical mechanism(s), or structure(s), that if it existed would generate the observed phenomenon (events). The resulting trial and error process may be informed by field research and descriptive modelling and experimentation. The latter are used for defining the mechanism by developing appropriate conditions of intrinsic and extrinsic closure. Clearly, the ideal set-up for revealing causal powers and liabilities is the accomplishment of experiments. Being able to control and (re)define the conditions of closure will be the stronger claim of revealing the real, based on prediction (Sayer, 1992) and, eventually, through the justification of prediction.

Hence, a pluralistic research methodology comprising of the development of a case study in connection with experimentation may be quite appropriate for revealing causal

powers of supply-chain-related structures. In the study of supply chains, at the organisational and inter-organisational level, mechanisms and structures are the result of organisational characteristics such as culture, power distribution, etc., and are responsible for the production of events and performances manifested at the supply chain system level, e.g. delays in deliveries, excessive inventories, stockouts, etc. A critical realist perspective on supply chain management looks beyond correlations among system-level variables (e.g. how a delay at some point of the system causes a stockout at some other) to reveal the reasons that these events and their possible correlations exist. For instance, although there is a consensus on the effect of incentives at the system level, it is logical that identical incentives can be received and treated differently by different people, in different organisations, in different countries, etc. To reveal the effects of the specific supply chain reality on the effectiveness of incentives, a researcher has to investigate the causal powers of the objects and their context that constitute this reality. This may be accomplished by developing a case study in a methodological way, as it is shown in the following section.

## **4. Case development and presentation**

### **4.1 The process of case development**

Company A is a large cosmetics manufacturer with global presence. Its subsidiary in Greece (AG thereafter – name disguised) is a semi-autonomous legal entity responsible for the marketing and distribution of A's product range, which includes the sun protection and tanning (SPT) line. A significant role in the overall supply chain of AG is played by the regional agent/reseller distribution channel that mainly concerns retailing outlets situated in islands with tourism. The regional agents place orders of aggregate quantities at the end of the summer season, but the product mix and the SKU

management policy is determined by AG at the beginning of each calendar year. At the same time, promotion policies and incentives to distributors for achieving coordination and profit maximisation for both parts (amount of the down payment, the returns/refund policy, as well as the mark-up) are also decided by AG. In effect, these are the incentives provided by AG to the distributors.

A problematic situation that was observed in this part of the supply chain concerned the existence of a persistent returns inventory, independent of year and product mix. This inventory (end of season returns) amounted to about 30% of the total volume of the orders placed to AG by regional agents and distributors. Frequently, part of this inventory became obsolete as it past its expiry date. Given that the aggregate demand has been fairly stable from year to year, the exploration of the root of the problem was initially targeted around the way decisions concerning quantities and assortments were made by the regional resellers and AG's managers.

To analyse this situation and reveal the mechanisms responsible for the excessive inventory, initially the notion of supply chain had to be deconstructed. This would reveal the intrinsic contradictions that prevail in the usual system-level black box theoretical analyses. In such analyses, the customer-supplier relations are considered around the dipole of cooperation on the one hand, and of intentional or unintentional non - cooperation on the other(different perception of demand and ordering). Inevitably, any attempt to deconstruct the supply chain focuses on the elimination of this dipole towards the investigation of the realities that are behind the engagements of people and the organisations that they represent in commercial and other exchange relationships.

The consideration of the supply chain at the micro-level of individual agency and social relations is the first step towards this direction. The supply chain participant (agent) is more than a rational *homo economicus* and requires a more complex sociological and psychological analysis. This can be done by adopting a social *practice* perspective. The basis of the social practice theory is the claim that there is a practical rationality rooted in the concrete detail of the daily life (Bourdieu, 1990), and that daily life and practical activity cannot be detached from wider social, cultural and historical developments – the context or structure (Giddens, 1984). It is important to note, however, that although daily life is generally associated with routine behaviours, the contradictions of social life can activate change (Feldman, 2000). Thus, agency (human activities, or *praxes*) determines structure (context) as structure influences agents' behaviour (Giddens, 1984). Moreover, following Bhaskar (1989), this duality of structure (rigid and fluid) is complemented by the duality of praxis, according to which action is constituted by both motivated production and unmotivated reproduction of structure. In other words, structure is both condition and consequence, while the consequences of action (including inaction) are both motivated and unmotivated (Lawson, 1997)

Having said that, the analysis of supply chain for developing an investigative and demonstrative case, under the prism of social practice, can concentrate on the identification and analysis of *practitioners*, *praxes* and *practices* and their interaction (Whittington, 2006). This will facilitate the structured development of the case study under the critical realist perspective by gathering and representing information in an organised manner, i.e. it will guide the identification of structures/objects and their causal powers and liabilities. Clearly, practitioners can be associated with objects, practices define the set of causal powers and liabilities associated with objects, whereas

praxes define temporally and spatially the sources of the production of events as products of interaction and condition instantiation. Compared to the *actors, resources and activities* (ARA) model (Häkansson and Johanson, 1992) which concentrates on a-contextual interactions, the social practice model is more suitable for the structured investigation and representation of the social environments of each individual actor, as well as the context within which interaction take place.

In the general supply chain management domain, as well as in the specific case that we present in this paper (company AG), practitioners are the managers responsible for the specific product range (SPT products in our case), those involved in purchasing, promotions, order management, warehouse management, etc., as well as the corresponding managers of the distribution company (if they exist). As far as the regional resellers are concerned, clearly, due to their small size, frequently, the owner and other non-specialist managers, such as the finance manager, are engaged in the management of the supply and distribution. *Praxes*, on the other hand, are common activities that, in effect, enact relations between the managers of the two organisations. Such praxes include the initial negotiation of the mark up margin (commission) for the distributor, the placement of an order, the dispatch of an order, the presentation of a new product line, etc. In addition to supplier-customer engaging praxes, there are also praxes specific to each participant organisation. They include: stock monitoring, estimation/calculation of order quantity, development of discount policies, formulation of finance strategy, etc. Finally, as far as practices are concerned, they are directly influenced by the wider social environment/context and, as it was already indicated, they determine how praxes/activities are accomplished. The specific social and cultural environment of specific geographic regions, the usual practices of an industrial sector,

the habits and norms of managers having the same or similar educational background, as well as the specific organisational characteristics, influence the way common, or idiosyncratic to each organisation, activities are executed. Practices influence praxes and cause events at the supply chain system level, such as deliveries, inventories, etc., to have specific structural and temporal characteristics. The way managers perceive risk, how they prioritise tasks, their degree of freedom in decision making and other related attributes are all influenced by practices that, in one way or another, constitute the content within which agents/practitioners behave.

Based on the above, it becomes clear that the development of the case study structurally followed an inquiry procedure based on supply chain management practitioners, practices and praxes/activities. For the development of the specific SPT products case that we present in this paper, the managerial activity related to supply chain and logistics management at AG was observed, interviews with managers involved in supply chain processes were performed and recorded following a *practitioners-praxes-practices* structure. The same happened almost in parallel at the premises of three indicative regional distributors. Visits, on-site observations and interviews were used for describing the situation consistently, as far as the tools used for estimating demand, placing orders and developing incentives, and the logic behind their selection and mode of use, were concerned.

#### **4.2. The AG case and its critical realist explanation**

From the initial visits to AG and the three distributors, it became clear that the managerial practices of the two forms of organisations differed significantly. In brief, AG's managers that were responsible for supply chain decisions and activities had a

marketing orientation and background that influenced significantly their behaviour and decision making. The assignment of responsibilities according to specific products, or groups of similar products, resulted in having a narrow focus, concentrating on *their* products only, giving particular emphasis on the smoothness of their introduction and renewal cycles. Work was accomplished in a small, short-term project basis. The organisational culture of AG did not directly promote internal employee competition, but such a competition was apparent at the middle managers level, presumably because of the possibilities of a future promotion. The organisation-oriented stress was amplified by the stressful way of everyday living in the capital and the professionals' labour market intense competition. These made AG's supply chain managers overambitious, focusing on short-term results, usually the time horizon of decision making being a season – winter, summer, holiday, etc. Living in a complex social environment, they viewed the products they managed in their most complex perspective: shape, packaging, properties of contents, ingredients, handling, etc., and they were inclined towards the promotion of their latest version, the new product with the most attractive package, etc. Their attitude was reinforced by the fact that their perception of the products was built on the basis of their appearance and handling in small quantities in an office environment (as opposite to large quantities in a warehouse environment).

On the other hand, the regional distributors lived and worked in more traditional and relatively static environments, they did not face direct competition on the basis of product characteristics and pricing but rather on relationships with retailers, as far as the SPT products were concerned, they handled products in very large quantities without being used to pay much attention to their characteristics. They considered them



just as an economic entity, a sunk cost and a potential for profit. Their language mostly included terms that described space in warehouses ('one palette of Px near the corner will be dispatched by the end of the week') and reserved capital ('I am losing money as this part of the warehouse remains full') for all the products of AG, and not for each one individually. As it will be detailed below, the demand estimation given to AG was based more on financial risks calculation, rather than on the monitoring of the retailing points sales. These risks were where the incentives of AG (advance payment requirements and commission mark up) were aiming at.

The practices and activities (praxes) of AG managers were contingent on the type of product (or SKU, in a more logistic jargon) they were managing. The entire SPT product range that was managed each season was divided into three sectors that could be considered equivalent to three mega-SKUs. Each group (SKU) was treated differently. The first (SKU1) contained newly introduced (current season) products, or product lines. Intense promotional effort was put on this SKU and the aim was to maximise the sales and revenues of these products at the expense of the other (older lines). A second group (SKU2) contained products that had already been in the market for at least one year, and were considered mature. Sales of these products were declining and not contributing much to the total SPT products' revenue. Finally, there were products at the end of their life-cycle which were about to be withdrawn at the end of the season (SKU3). The strategy of AG was to advertise heavily and promote SKU1, while providing incentives to resellers for promoting themselves the older SKUs to the retailers.

AG used two promotional instruments for the SPT products with respect to the resellers: the amount of *advance payment* as a percentage of the reseller's/distributor's cost of order, paid upon receipt of the order, and the profit *margin/commission* as the difference between the buying price paid by the reseller and the maximum selling price allowed for the reseller for selling to the retailers. Promotions and incentives varied according to the three groups of products. The overall objective was to balance AG's risk and cash flow with resellers' incentives. For the older product lines (SKU3) it was anticipated that the reseller would not order much and that additional effort was required on its part for moving them to the retailing points. Therefore, a relatively large amount of advance payment was requested by and a large margin was offered to the resellers. On the opposite side of the spectrum, for the newly introduced products that were heavily advertised, it was anticipated that the reseller will order large amounts and it was estimated that no additional effort was required on its part for promoting them to the retailers. Hence, a relatively small amount of advance payment was required and a short margin was offered. For the product lines between the two extremes intermediate strategies were followed. Both promotional instruments (advance payment and margin) were set annually for each group of products (SKU) on the basis of the previous year's returns by the resellers. An increase in the returns for a particular group of products (SKU) caused an increase in its related margin for the following year's orders. Advance payment followed the opposite logic. An increase in returns was followed by a decrease in advance payment in the succeeding year.

Regarding the attitude and behaviour of resellers, it was observed that the orders placed and the promotion effort put by them were only partially dependent on the incentives provided by the manufacturer (AG). The resellers did not care about individual

products, or product lines, and their associated incentive schemes, but they were principally concerned about the financial risk associated with the entire order. The orders placed by resellers had a retrospective and opportunistic bias since they were based on past profits only, i.e. they were influenced by the AG's promotion policies of the previous year only. Ordering behaviour was characterised by the existence of a sort of reference point (Feigenbaum *et al.*, 1996) which was moving up and down according to the previous year's financial performance. The reference point indicated the change in attitude as far as risk taking was concerned. The reference point was perceived, more or less, as it is suggested by the prospect theory of Kahneman and Tversky (1979). Perceived risks were mainly financial risks associated with the capital reserved for the advance payment. When revenues were below the reference point set, the resellers were ready to undertake more risks (order more) to gain what it was "lost" in the previous season. In contrast, when targets had been reached, the resellers were not taking risks for receiving more. A similar philosophy was associated with the amount of effort put in selling/promoting the suntan protection products to the retailing points. When the target of getting back the advance payment was reached, the selling effort was slowed down. Otherwise, the promotion effort was kept at the same level. This attitude, however, resulted in promotion of the new products (stocking shelves with new products) that were selling easier and neglecting older ones until the reference point was reached. After that, in addition to the diminishing effort, the general demand was declining and absorbed by the dynamics of the new products. As a result, older SKU were left in stock and returned to AG at the end of the season.

The above observations suggested the existence of two event-producing mechanisms. The first (M1) was related to AG's promotion policies which were biased towards new

products, whereas the second (M2) concerned the resellers' risk management attitude with respect to a variable reference point. The hypothesis put forward is that the interaction of these two mechanisms is the reason for the existence of the excess inventory in the downstream part of the supply chain of the SPT goods producing company (AG) – the event observed (Figure 1).

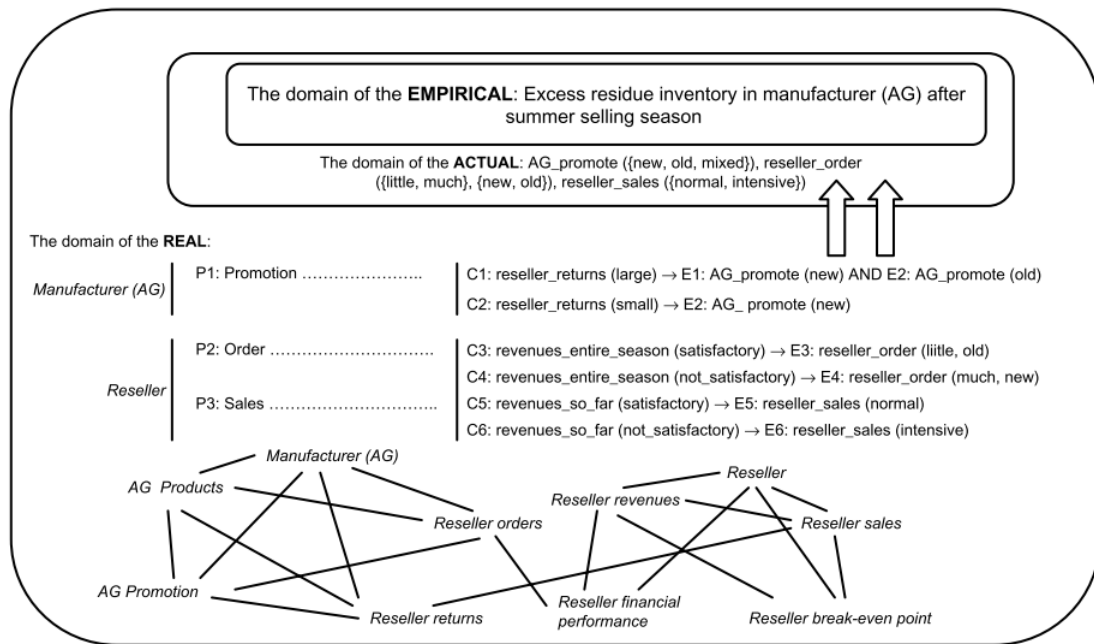


Figure 1. Objects, mechanisms and their interaction and the production of events

In order to justify the existence of these mechanisms and to assess their part of responsibility in the generation of the observed event (returns inventory), a system dynamics simulation model was constructed. The model was built on the basis of the assumption that it represents the mechanisms produced by the objects and their geo-historical context. In the following section we describe the model built to facilitate our retroductive research methodology, and the results obtained after its simulation.

## 5. System dynamics modeling and simulation

Based on quantitative and qualitative information gathered, a system dynamics simulation model of a three-tier (manufacturer/central warehousing, distributor/reseller, retailer) supply chain was constructed. During the course of the modelling process questions were raised demanding a second round of field research within the company, as well as with resellers. The results of this field research were used to calibrate the model and to enrich the case study. Nevertheless, the model of Figure 2 and the results obtained using this model incorporate only relative quantities for reasons of anonymity and confidentiality.

Inventories at every stage of the supply chain were represented as stocks (*Inventory\_company*, *Inventory\_reseller*, and *Inventory\_retailers\_on\_islands*) with rate variables between them for modelling the delivery/shipment and distribution. Arrays were used in the model to portray three separate SKUs: *SKU\_1*, *SKU\_2*, *SKU\_3*.

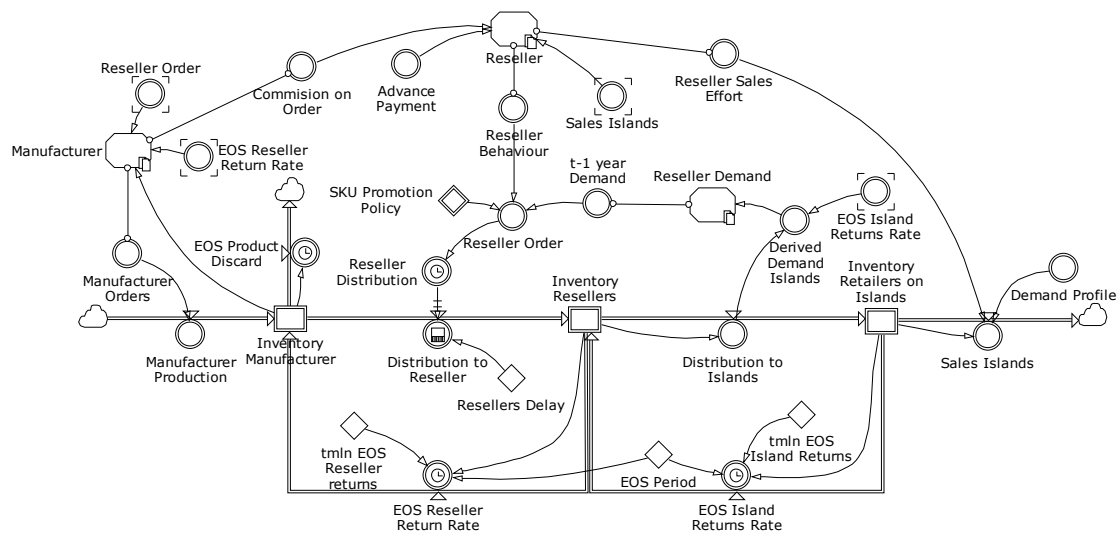


Figure 2 The system dynamics model of AG's downstream supply chain

The model implements the accomplishment of a SPT goods movement cycle in a year. Goods are produced and stored at the manufacturer (*Inventory\_company*), then shipped to resellers (*Inventory\_reseller*) and, finally, to the retailers (*Inventory\_retailers\_on\_islands*). From there, a part is returned to the reseller at the

end of the sales season, and later to the company. The supply chain cycle period implemented in the model is one year. The reseller's orders are based on past years' demand ( $t-1\_demand$ ), on the company's promotion policy for the specific SKU, and are placed in accordance with their specific risk management policy, which is assumed to be in line with the claims of prospect theory. As a result, the options of the reseller are confined to either ordering the same amount as in the previous year, or to order more. In order to make a decision (*Reseller\_decision*), the reseller takes into account its financial performance over the past season which is a function of the sales on the islands (*Sales\_islands*), the end-of-season returns (*EOS\_island\_returns\_rate*), the commission that it receives on order (*Commission\_on\_order*) and the payment to be made upon receipt of the order (*Advance\_payment*). This performance is the cumulative sum of the aforementioned variables, so the decision is taken at the end of the season. By modelling the ordering behaviour of the reseller on the basis of its seasonal profit as it is compared to its past performance, a non-fixed *strategic reference point* (Fiegenbaum *et al.*, 1996) is incorporated in the model. The reference point is revised annually, moving upwards as profits increase and downwards as profits decrease. Profiles with varying degrees of risk aversion have been implemented in the model as shown in Figure 3. On the horizontal axis is the annual percentage change in the reseller profit in year  $t$  with respect to year  $t-1$ . On the vertical axis is the order behaviour of the reseller (greater than one for an increase or lower than one for a decrease) with respect to sales made in year  $t-1$  is represented.

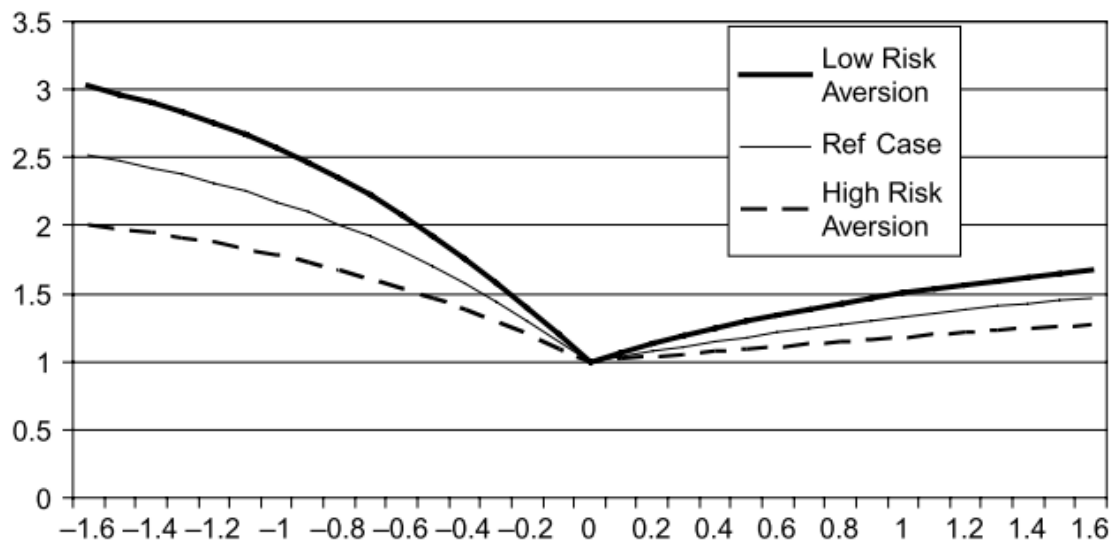


Figure3. The reseller's ordering behaviour profile

The commission on order and advance payment levels are set annually by the manufacturer, based on inventory returns from the reseller, for each SKU individually. An increase in returns of a specific SKU causes a proportional increase in the corresponding commission given to that SKU for the following year.

The default commission figures used in the model for SKU\_1, SKU\_2 and SKU\_3 were 8%, 10% and 12%, respectively. Clearly, the logic behind this choice was to model the preferential promotion of older SKUs. The percentage change of commission in relation to the returned inventory varies based on the logic that the manufacturer increases the commission for the products returned so that at the end it needs to discard as little inventory as possible. As it was indicated in the previous section, the advance payment incentive operates in the opposite manner.

The actual demand profile for each one of the three SKUs is assumed constant for each year with differing amplitudes according to the specific product (SKU) maturity. This

is the result of the variable *ease\_of\_sales*, the latter being a function of the promotional effort (advertisement) of the manufacturer. This implies that new products (if they exist) sell faster than older ones independently of the effort of the reseller. Consequently, any variance in sales is solely due to the availability of inventory and the reseller's sales effort (*sales\_effort*). In the model, this effort modulates the retailer's sales as it is assumed that full effort is required on the part of the reseller/distributor to cover the nominal demand, provided that sufficient inventory exists at the point of sales. The sales effort falls when the agent has captured financial gains amounting to a value equal to the strategic reference point set on the basis of the previous year's sales and the advance payment.

The model was first simulated for different values of advance payment with the percentage of the commission set to the above default values. Eleven simulations were executed for an equal number of advance payment values. The simulated time was fourteen (14) years. Figure 4 depicts the results of the simulations for the three different risk profiles of Figure 3. The graphs indicate that when the reseller is conservative (low risk aversion), the returns at the end of the season as a percentage of the year's earlier orders are higher. This makes sense as in reaching low reference points, the percentage of new products sales to the total amount of sales is higher producing a relatively higher returns inventory of older SKUs. In every case, our assumptions are reproduced as the inventory is close to 30% of the initial reseller's order. Thus, the hypothesis postulated in the description of the case study of AG in Section 4, according to which the observed inventory was the result of the interaction of the two mechanisms – promotional bias of new products by AG and incentives to resellers to promote older ones (M1), and



overlooking of these incentives by the resellers to opportunistically manage their financial risks (M2), can be considered as true.

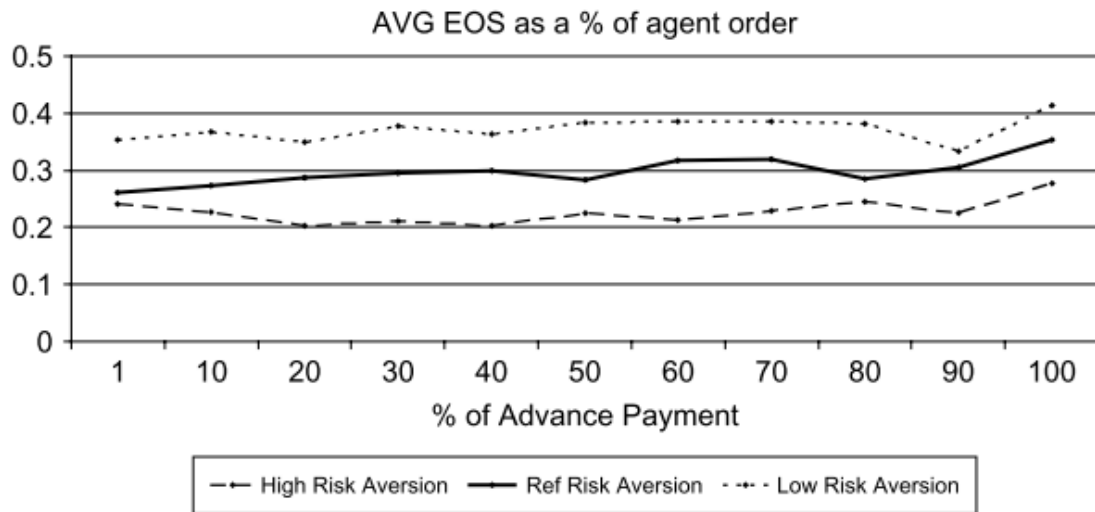


Figure 4 Average end of season returns as percentage of reseller's orders

When additional incentives in the form of increased commission were introduced, the inventory profiles for the same values of advance payment, for the same number of simulations were significantly higher. What the simulations demonstrated was that the crux of the problem laid in the decisions the reseller made and the way it managed its financial risk, irrespectively of the incentives of the manufacturer.

## 6. Discussion and concluding remarks

Supply chain research has been dominated by a positivistic philosophical basis, hence the prevailing underlying assumption of “designability”, its “flat” ontology of regularities producing and being produced by correlated events, as well as its epistemological basis of deduction as a result of empirical research methods (inferential statistics) and/or predictive modelling. This philosophical stance has already been criticised from different perspectives and a critical realist ontology and epistemology have been proposed as alternatives. However what these mean in practice has not been

demonstrated thoroughly, especially as far as the use of systems and management science approaches, such as simulation modelling, in the production of new knowledge for supply chain management is concerned. This is despite the fact that over the last decade, the use of simulation modelling for the development of organisation and management theory has attracted significant support (Davis, *et al.*, 2007; Harrison, *et al.*, 2007), in addition to its long time use in the practice of management (Fowler, 2003).

Simulation modelling, as an instrument for the production of novel scientific knowledge, situated between pure deductive and inductive methods, can overcome the limitations of traditional approaches as far as their ability to analyse multiple interdependent processes operating simultaneously is concerned. Moreover, simulation modelling can facilitate the surfacing of emergent properties of “linked substantive propositions” (Nadel, 1962) which are not directly deducible from the structure itself. Simulation modelling has been extensively used in supply chain and logistics research, however mostly over a positivistic philosophical base, i.e. as a digital laboratory where experimentation is carried out in controlled conditions for deducing globally valid laws to be later used to predict behaviours and to help in the design of supply chain and logistic systems. Under a critical realist perspective of supply chain, the role of simulation modelling is different. It is that of explanation and understanding rather than prediction (Mingers, 2004b). That is, to facilitate the understanding of the underlying causal mechanisms, in the framework of a retroductive methodology, where the (hypothetical) mechanism is explicitly represented in an “executable” model that produces its consequences in the course of time.

In this paper, we have employed such a simulation model to accomplish a critical realist perspective in the management of perishable seasonal goods downstream supply chains. We have used a system dynamics model, in conjunction with the development of a case study, for constructing the mechanisms responsible for the events observed. Using this retroductive methodology we have found that the persisting inventories frequently observed in a downstream supply chain of uneven participants, as far as size and diversification of business activity is concerned, are principally due to the different social contexts that modulate their interests resulting in different priorities. In our case, the managers of a multinational manufacturer headquartered at the capital city were managing product lines, whereas the regional distributors being isolated from the complexity of modern life and management techniques were managing financial risk. Their only points of contact, their *socialization* (Cousins *et al.*, 2006), were around the processes of ordering and the communication of incentives. In fact, these were the only points of contact of the two different worlds – too narrow in bandwidth, as far as organisational information and culture is transmitted, too short in time to account for any dynamics, and, most important, unidirectional, from the manufacturer to the resellers. As a result, the managers of the manufacturer wanted to concentrate on new product lines and leave the promotion of the older ones to the resellers providing (according to them) the appropriate incentives. However the resellers wanted to reduce their financial risk as soon as possible, directly or indirectly, and they promoted new lines because they were selling easier generating cash faster. The interaction of these two mechanisms, i.e. the biased strategy of the manufacturer towards the promotion of new products and the opportunism in risk management of the resellers, was responsible for the persistent returns of inventory that were observed.

The absence of relational capital explains why the misalignment persists irrespective of the different incentives offered by the manufacturer: the underlying mechanisms remain intact. And, although different perceptions in supply chain management have been recognised as a source of misalignment long time ago (Harland, 1996), the reasons for the existence of the different perceptions, which are in fact the real reasons for the misalignments, have not researched extensively. Instead, OR-based models have been employed to assess the effect of different models based on assumptions of regularity, closeness and, sometimes, extreme behaviourism. In the work presented in this paper, we tried to expose the real reasons for such misalignments and to demonstrate how a critical realist perspective with its associated research methodology can help in this direction.

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