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Supply chains: what they are and the new problems they raise

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The term ‘supply chain’ has been, perhaps surprisingly, highly successful since it was proposed. This paper discusses the material and theoretical roots from which the concept arises, as well as its content and implications. It focuses especially on the question of whether the term is useful only to, say, put old wine into new wineskins or responds to a very different reality from that we had a few decades ago. The latter poses new problems, some of which are pointed out, whose resolution requires new theoretical and computational tools. The obvious inadequacy of the term to describe the reality it refers to is emphasised. Some challenges, opportunities and switchpoints for the future of the supply chain are listed as well.

Keywords: supply chain; supply chain management; logistics

1. Introduction

During the last sixty years, the titles of textbooks on supply, production, inventories and distribution have evolved from including merely ‘production management’ (Buffa 1961) to incorporating ‘production/operations management, logistics’, and more recently ‘supply chain management’ (SCM).

The expression ‘SCM’ was introduced by Oliver and Webber in 1982. Success was not immediate; for instance, supply chain does not appear in the index of the handbook *Logistics of Production and Inventory* (Graves, Rinnooy Kan, and Zipkin 1993). However, ‘a rapid surge in SCM publications occurred in the middle of the 1990s’ (Stock and Boyer 2009), going from the first appearing in a journal paper in 1985 (Houlihan 1985, according to Alfalla-Luque and Medina-López 2009) to 1105 papers published in referred journals in 2008 (only 49 in 1994), according to Stock and Boyer (2009). Significantly, de Kok and Graves (2003) published the handbook *SCM: Design, Coordination and Operation* in the same series where Graves, Rinnooy Kan, and Zipkin (1993) appeared 10 years before.

Nevertheless, 30 years after its introduction, ‘[...] there are too many definitions of SCM and there is a need for a single consensus definition’ (Stock and Boyer 2009). In addition, Naslund and Williamson (2010) state that ‘SCM is a concept that is gaining in popularity and importance. However, SCM is not a concept without problems. These include the lack of a universally accepted definition [...], issues with terminology and the relative lack of empirical evidence supporting the benefits attributed to SCM’. In response to Williamson (2008), who poses a certain number of provocative questions to SCM in the name of transaction-cost economics, Zipkin (2012) accepts that ‘SCM can indeed be faulted for inflated rhetoric, among other sins’.

Given that SCM has frequently been used as a synonym for logistics, operations management or purchasing or a combination of the three (Lambert, García-Dastugue, and Croxton 2005), one may wonder whether the new TLA (three letter acronym) really contains new useful ideas or is only a different way to name well-known problems. Although the debate over whether the supply chain (SC) concept adds something or not to logistics (Hall and Braithwaite 2001; Lambert 2001) is not extinguished (Frankel et al. 2008; Klaus and Müller 2012), the predominant view is that SCM includes logistics and therefore the term ‘supply chain’ refers to a genuinely new concept (Cooper, Lambert, and Pagh 1997; Russell 2007), which therefore presents new problems that require new specific methods and tools.

The rest of the paper is as follows. The next section analyses the material and theoretical roots of SC. In Section 3, the definitions of SC and SCM are discussed. Section 4 attempts to answer the question of whether the SC concept makes new contributions. Section 5 presents some new problems, challenges, opportunities and switchpoints related to SC. Finally, some conclusions are drawn.

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2. The roots

Just as Monsieur Jourdain, the main character of *Le Bourgeois Gentilhomme*, by Molière, spoke in prose without knowing it, we lived with, dealt with and researched into supply chains much before this expression was coined.

At the best of my knowledge, the first written description of an important supply chain is in Ford (1922), when the author, Henry Ford, depicts his River Rouge Complex (for instance, he says, 'It has [...] a turning-basin capable of accommodating any lake steamship; a short-cut canal [...] will give a direct connection by way of the Detroit River. [The] coal comes directly from our mines over the Detroit, Toledo and Ironton Railway, which we control [...] The steam power plant is thus fired almost exclusively from what would otherwise be waste products'.) Ford clearly designed the system for producing and distributing his cars as a whole, instead of considering the assembly plant or the parts of the system separately, as if they were independent.

In my opinion, Henry Ford must be considered the first significant designer and manager of a supply chain. This pushes back the origins of supply chains at least by one century.

Regarding the academic world, the first relevant publication about what we now call supply chain is the book *Industrial Dynamics* (Forrester 1961), in which the author applies the ideas of system dynamics (Forrester 1958) to production-distribution activities using the language DYNAMO. Forrester's work is the origin of the famous Beer Game (<http://www.beergame.org>). Additionally, Forrester (1961) investigated the so-called bullwhip effect (Giard and Sali 2013; Lee, Padmanabhan, and Whang 1997), also known as the Forrester effect. He considered the supply chain (although he did not use this term) as a system and drew important consequences more than 50 years ago. As Mentzer et al. (2001) pointed out, Forrester foresaw that 'there will come general recognition of the advantage enjoyed by the pioneering management who have been the first to improve their understanding of the interrelationships between separate company functions and between the company and its markets, its industry and the national economy' (Forrester 1958, 2); even more, 'management is on the verge of a major breakthrough in understanding how industrial company success depends on the interaction between the flows of information, materials, money, manpower, and capital equipment. The way these five flow systems interlock to amplify one another and to cause change and fluctuation will form the basis for anticipating the effects of decisions, policies, organisational forms, and investment choices' (Forrester 1958, 37).

It is also worth mentioning that today the models by Balinski (1965) and Geoffrion and Graves (1974), among others, are fairly considered supply chain models.

A long time later, the expression 'SCM' appeared in the literature. There is a consensus that the first publication mentioning SCM is Oliver and Webber (1982). Its title, 'SCM: Logistics Catches Up with Strategy', is indeed suitable since it is an excellent synthesis of the ideas exposed by the authors. However, they define neither SCM nor supply chain. Both expressions are introduced as follows: 'Through our study of firms in a variety of industries [...] we find that the traditional approach of seeking trade-offs among the various conflicting objectives of key functions – purchasing, production, distribution and sales – along the supply chain no longer worked very well. We needed a new perspective and, following from it, a new approach: supply-chain management'. In this paper, the dominant idea is that management must be guided by the overall objectives of the firm rather than by local functional objectives: 'The strategic balance of supply and demand, based on firmwide objectives, and more particularly, its support by a systems approach that places a premium on the fast transfer and accessibility of information across functional barriers are all highly relevant. While 'natural' conflicts between functions may be inevitable, common and shared data encourage the development of a broader perspective on supply-chain management and foster decision making that is more likely to be keyed to the overall objectives of a business rather than to the local or parochial functional objectives that have tended to dominate in the past'. Note that the emphasis is therefore put on the inside of the firm instead of on its boundaries or agents outside them. As for the scope of supply-chain, the paper states that SCM 'covers the flow of goods from supplier through manufacturing and distribution chains to the end user', which is undistinguishable from the scope of logistics. Overall, it can be said that in the work of Oliver and Webber, who have the undoubted merit of being the first to write about SC and SCM, the corresponding concepts are only at an embryonic stage and closely related to logistics.

However, after a sluggish start, SC and SCM have enjoyed much success among academics, consultants and practitioners.

Which may be the reasons for that?

According to Mentzer et al. (2001), the reasons are many. Among them, these authors mention 'global sourcing, emphasis on time and quality based competition, and their respective contributions to greater environmental uncertainty'.

In fact, as discussed below, 'the term *supply chain* is somewhat of a misnomer, because a supply chain is often not a single or simple chain but a complex network' (Goetschalckx 2011, 495). In the context of the rise of the network

society (Castells 1996), it seems natural that firms become aware of being nodes of networks, so-called supply chains. The phenomenon of globalisation, which is not discussed here, and the increasing concern for the environment and sustainability are resulting in increasingly complex relationships between organisations and their users or customers, or other organisations (companies, charities, public administration, etc.).

The potential benefits that some of the literature associates with the adoption of the SCM paradigm also account for the popularity of SC and SCM. According to this literature, SCM allows decreasing costs (by reducing redundancies, inventory levels, lead times and demand uncertainties) and improving product quality and customer service.

Although not very often invoked, another reason is the failing of the academic claim that practitioners adopted the 'scientific' integrating sense of logistics. Still now, Webster's dictionary defines logistics first as 'the aspect of military science dealing with the procurement, maintenance, and transportation of military matériel, facilities, and personnel' and second as 'the handling of the details of an operation'. Moreover, most people do not even identify logistics with operations management but with no more than warehouses, pallets and trucks. Thus, another expression was needed to transmit the idea that management must try to optimise the overall objectives of the firm rather than particular objectives of its functional areas.

3. The concepts: supply chain and SCM

There are many definitions of SCM while direct definitions of SC are scarce, although it is true that most definitions of SCM contain a more or less explicit definition of SC. Likewise, many definitions of SC include a definition of SCM. Stock and Boyer (2009) review 173 definitions of SCM that the authors consider 'unique' in the sense that they contain at least a differentiating element and attempt to develop a 'consensus definition', including all the elements they detected in the definitions studied, i.e. activities (material/physical, finances, services and information flows), benefits (value creation, efficiencies and customer satisfaction) and constituents or components.

This shows that there are no generally accepted definitions of supply chain or SCM. Cooper, Lambert, and Pagh (1997) wrote about 'the confusion that exists' concerning SCM and its relation with logistics. Fourteen years later, Mentzer et al. (2001) could still say that 'there remains considerable confusion' as to the meaning of SCM. Both Gibson and Mentzer (2005) and Stock and Boyer (2009) advocate a consensus definition, indicating that such a definition did not exist at the time of publication of these papers.

This situation is unfortunate since, without a commonly accepted definition or an agreement on the essential attributes of a supply chain, it is very difficult to properly develop a new – or not so new in this case – research field. Particularly, in order to discuss whether the concept of supply chain contributes to management with genuinely new elements, an agreement on its contents is essential.

A particularly interesting point, in this respect, is the difference, if any, between SCM and logistics. 'In early definitions, the term SCM was used, or perhaps misused, synonymously with traditional definitions of logistics management. However, the consensus today seems to be that SCM is somewhat more than logistics' (Stock and Boyer 2009). The starting point of Cooper, Lambert, and Pagh (1997), which has the significant title of 'SCM: More Than a New Name for Logistics', is the question of whether SCM is 'an extension of logistics, the same as logistics, or [...] an all-compassing approach to business integration'. Hall and Braithwaite (2001) ('The Development of Thinking in Supply Chain and Logistics Management') and Lambert (2001) ('The SCM and Logistics Controversy') are two relevant exponents of this debate.

As SCM has frequently been used as a synonym for logistics, operations management or purchasing or a combination of the three (Lambert, García-Dastugue, and Croxton 2005), it is not surprising that many definitions include the relationships of SC with logistics. Even such a recent book as Goetschalckx (2011) begins, speaking of logistics and shifts to SC using as a bridge the sentence 'Very closely related to logistics is the concept of a supply chain'. In fact, many definitions of SC could be taken, with some nuances, as good updated definitions of logistics. For instance, those in Christopher (1998) and Li (2007) or that in Goetschalckx (2011): 'A supply chain is an integrated network of resources and processes that is responsible for the acquisition of raw materials, the transformation of these materials into intermediate and finished products, and the distribution of the finished products to the final customer'.

In spite of its name, SC is usually described as a network (Christopher 1998; Govil and Proth 2002; Lambert, García-Dastugue, and Croxton 2005; Mabert and Venkatamaram 1998; Stock and Boyer 2009, among others). Although sometimes supply chains are described as multitier networks, it is obvious that this point of view is unnecessarily restrictive since many supply chains are not, in fact, tiered networks and may have even one or more closed loops.

A certain number of authors include the goals or the achievements of the supply chain in their definitions. Groosse (2000) says that 'the result is a product or service that is high-quality, low-cost, delivered quickly to the marketplace, and achieves customer satisfaction'. According to Govil and Proth (2002), 'a supply chain is a global network of organisations that cooperate to improve the flows of material and information between suppliers and customers at the lower

cost and with the high speed. The objective of a supply chain is customer satisfaction' (this definition is included also in Dolgui and Proth (2010), and, with some slight variants – the main one is that 'global' is not in the definition any more – in Dolgui and Proth (2006); of course, many supply chains are global, while others are not). Finally, Stock and Boyer (2009) state that SCM is 'the management of a network of relationships within a firm and between interdependent organisations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing and related systems that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximising profitability through efficiencies, and achieving customer satisfaction'.

However, my opinion is that goals should not be part of the definition since the question of what are, or must be, the goals of a company or of a supply chain is a controversial one, making it even more difficult to reach a consensus. Moreover, there are many kinds of supply chains with probably different objectives (compare, for instance, the supply chain of a car-manufacturing company to that of the Red Cross or to a military supply chain). Therefore, including the objectives of the supply chain in its definition may be unnecessarily restrictive.

In fact, it is not clear that every supply chain has, as a whole, its own objectives. It would rather seem that as many objectives as partners might coexist in the supply chain (for instance, the goal of a supplier of components to a car manufacturer is probably to satisfy the car manufacturer rather than car users).

The question of the goals of a supply chain is intimately related to its consideration as an extended enterprise ('this multi-company group, functioning as one extended enterprise, makes optimum use of shared resources'; Groosse 2000) and to the idea, now a commonplace, that nowadays competition is no more between companies but between supply chains (for instance, Stadtler and Kilger 2008 state that SCM has 'the aim of improving competitiveness of a supply chain as a whole'). Nonetheless, it is hard to adopt the idea that a supply chain is an extended enterprise when different decision-makers coexist with their own objectives inside of it, as the actual components of a supply chain are generally different companies. Likewise, it seems more realistic to consider that competition is between firms leading their respective supply chains than between whole supply chains. These leading firms decide who belongs and who does not belong to their supply chains. In fact, a company may form part of more than one supply chain and may have different objectives in the different supply chains it belongs. A different question is that, in order to be competitive, a company must lead and manage well a good supply chain.

An important point is whether or not customers are included in the definition of supply chain. This is explicit in some definitions, as that of Chopra and Meindl (2012): 'A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer and suppliers, but also transporters, warehouses, retailers and even customers themselves. Within each organisation, such as a manufacturer, the supply chain includes all functions involved in receiving and filling the customer request. These functions include, but are not limited to, new product development, marketing, operations, distribution, finance and customer service'. The consideration of customers as members of the supply chain provides a clear differentiation between logistics and SCM since in the former the customer is seen as the destination of the flow of materials only. Instead, customers must be seen as partners and this has two implications. First, actual customers must be selected from potential ones; meeting all the demand is not mandatory, contrary to what is assumed in most supply chain models. Second, the design of the supply chain must consider customers as members of it. Note, however, that in some supply chains, strictly speaking, there are not customers, but users (public services), beneficiaries (charities) or targets (military supply chains).

Although, even in the framework of logistics, reverse flows have been a matter of study for many years and reverse logistics has been defined in different ways, Stock and Boyer (2009) point out that 'interestingly, the vast majority of definitions identified flow only as a one-way process. Either material flows one-way from the supplier to the consumer or information flows one-way from consumer to supplier'. However, in most supply chains, direct and reverse material and information flows coexist.

As many other concepts, supply chain admits diverse valid definitions, since the level of detail or the emphasis on one or another element may depend on the specific purposes of the authors (for instance, the definition in a textbook – such as Chopra and Meindl 2012 – may be more extensive than the definitions in research papers).

From the above discussions, one may conclude that a supply chain is the network of entities that collaborate in order to obtain, deliver and maybe recover a product or a set of products. The management of a supply chain, which may include its design, is concerned with the people, material, information and financial flows between the entities that belong to the supply chain and with the operations that have to take place in some of them. Usually, one of these entities (a firm, a public body or a NGO, for instance) leads the supply chain, i.e. decides about its configuration and establishes the main rules concerning its running.

4. What is new in SC? challenges, switchpoints and topics to work at

There is no general agreement on the usefulness of the concepts SC and SCM.

Naslund and Williamson (2010) are rather pessimistic about SCM: '[...] is complex, it is often yet still poorly defined and it includes innumerable concepts and ideas that need clarification. The supply chain does not have clear roles or rules, nor does it have measurement or reward systems. How can such a structure possibly be managed?'

Even a defender of SCM says that 'SCM can indeed be faulted for inflated rhetoric, among other sins' (Zipkin 2012).

It is worth bearing in mind these opinions, since they express inadequacies or shortcomings in the way the literatures deals with SC and SCM, and indicate some improvement directions: proposing definitions, clarifying concepts and avoiding rhetoric.

Notwithstanding this, my opinion is that SC and SCM are and may be even more helpful in designing, understanding and managing present and future supply–production–distribution–recovery systems (is there a better option than referring to them as supply chains or supply networks?) They may also be useful in teaching, researching into and thinking about these systems.

Indeed, an effort should be made to replace the expressions *supply chain* and *SCM* with the more suitable ones *supply network* and *supply network management*, respectively. I, however, keep on using SC and SCM in this paper.

The semantic field of 'logistics' is too narrow to encompass the reality at hand. Despite the efforts made by academia to give a wider meaning to it, the fact is that logistics is associated with movement of materials, warehouses and vehicles. Therefore, the word logistics should be replaced when referring to the whole system of activities and flows. Supply chain and SCM are the expressions now available to replace the term logistics in these circumstances. Thus, it is clear that SC and SCM, which are certainly 'very close to logistics' (Goetschalckx 2011) since they include logistics, are more than logistics, even though some definitions of SC and SCM do not reflect this adequately. Hence, SC-SCM is an updated attempt to give a systemic view of activities and flows that occur when supplying, producing, distributing and recovering.

Moreover, supply chain and SCM add to logistics 'research, promotion sales, information gathering, research and development, product design, new product development, and total systems/value analysis', according to Mentzer et al. (2001). In addition, they add finances and internal and external services in general. Therefore, they stress the importance of integrating the decisions corresponding to diverse functional areas.

The supply chain concept emphasises the importance of relationships with suppliers and customers, as both are elements of SC. In addition, the developments around the idea of SC celebrate, sometimes in a rather overstated way, the possibilities of cooperation and competition between the elements of SC.

SC-SCM reflects, or helps to highlight, new features of real systems of activities and flows and gives rise to new desired properties of systems, such as resilience or liability (Bhamra, Dani, and Burnard 2011; Klibi, Martel, and Guitouni 2010; Vljajic, van der Vorst, and Haijema 2012).

More clearly than logistics, SC and SCM suit to both manufacturing and services, as well as to other kinds of activities, for example in the agriculture or the military fields. Humanitarian logistics (Tomasini and Van Wassenhove 2009; Van Wassenhove 2006) is also an important emerging topic.

SC-SCM is a suitable framework to deal with flows associated with reverse logistics and closed loops.

As Mentzer et al. (2001) point out, an important implication of the SC concept is that 'any one organisation can be part of numerous supply chains'. In fact, any one organisation can even lead many supply chains, because supply chains may be different for different products or families of products. Of course, this same organisation may also be a non-leading member of other supply chains.

Therefore, actual supply chains and their conceptualisation give rise to a certain number of challenges and opportunities for both practitioners and academics. There are, too, many important switchpoints concerning real supply chains.

Seven years ago, Kouvelis, Chambers, and Wang (2006) foresaw quite accurately that the main emerging topics regarding SCs would be:

- Risk management specifically related to supply chain disruptions stemming from man-made or natural disasters.
- Closed-loop SCs.
- Use of RFID in SCs.

More recently, Stock, Boyer, and Harmon (2010) suggested the following topics:

- Service SCs.
- Product returns.

- Hunger relief, disaster response.
- Minimisation of SC disruptions and uncertainties.
- Strategic partnerships and alliances.
- Relationships between SC members.
- SC performance measurement.

Despite referring to logistics and not to supply chain, Wieck et al. (2012) enumerate and discuss a number of what they call switchpoints, many of them concerning supply chains and their management. Among them, the most relevant are:

- Raw material sources: secondary or primary sources?
- Recycling cycles: central or local recycling?
- Cost of fuel: extreme bottleneck or timely rescue?
- Supply chains: globalisation or regionalisation?
- Business clusters: industry or regional clusters?
- Shopping behaviour: home shopping or local retailing?
- Last mile networks: bundle or separate networks?
- Level of sustainability: opportunity for distinction or homogeneous standard?
- Driver for sustainability: demand or regulations?
- Type of environmental regulations: mandatory limits or financial instruments?

Note that many of these switchpoints revolve around sustainability and, more precisely, around the crucial question of the exhaustion of fossil fuels and consequent increase in price. To what extent are global supply chains compatible with extremely high prices of extremely scarce fuels?

Summing up, both practitioners and academics face new problems coming from both actual supply chains and the corresponding academic approach:

- *Design*: There is a lack of methods and tools to design supply chains (Melnik et al. 2009; Melnyk, Narasimhan, and DeCampos 2013). The fact that supply chains usually are networks and sometimes global networks makes it more difficult to optimise the configuration of the system. As it is known, even the location and the strategic capacity planning of a single plant involve many complex decisions and a hierarchical approach is often necessary to deal with them reasonably. When designing a supply network, we will need of course the help of mathematical models. However, before formulating and solving the model, a lot of decisions have to be taken, concerning, among others, the products and their modularity; the production tasks and their distribution (which is more complex than the disjunction make-or-buy); the kind of distribution network; and the modalities of the reverse logistics, if any. To do all these rightly, a method is required and to define it, there is still a lot of work to do.
- *Uncertainty*: Uncertainty is always present when designing and managing any production or logistic system and even a part of it. It may concern, for instance, the demand or the evolution of the technology available for performing a specific function. The design of a global supply network, however, must consider, among others, the uncertainty relative to demographic and political evolutions in the world, the forecasts about the scarcity of some raw materials and the future prices of oil and other sources of energy. These factors may have a radical influence on the design of the network, including the change from a global pattern to a set of local supply chains more or less interconnected.
- *Risk management*: Everybody and everything must face up to risks. A global supply chain must face up many and very important risks, coming from nature, from external human agents or from the inside of the supply chain itself. There is a need to identify the sources of risk (as for instance the complexity of the product: Inman and Blumenfeld 2013) and to define methods and tools to avoid and manage it and its consequences (Melnik et al. 2009). In order to do this, the meaning and the limits of the terms liability, robustness, responsiveness and resilience should be carefully clarified.
- *Integration*: One important implication of logistics and, even more, of supply chain is the need to integrate the decisions corresponding to diverse functional areas. However, usually, in the industry and in the academia as well, decisions are considered separately or in a hierarchical way, which leads to suboptimal decisions. Therefore, there is a need to adapt the structures and decision-making procedures of the organisations and provide them with the appropriate tools.
- *Cooperation and coordination*: Although there is a very active research on these topics, many aspects are in need to be explored, since there are many kinds of possible coordination (concerning, at least, the relations of the leading organisation of the supply chain with suppliers, distributors, retailers and customers).

- *Supply chains of services*: Logistics and therefore supply chain suggest movement and transformation of materials. Most publications on supply chains deal with manufacturing supply chains. The vast field of services remains largely unexplored from the point of view of the supply chain. Disaster relief and humanitarian logistics are two closely related motivating fields, connected also with risk management.
- *Closed-loop supply chains*: The effects of introducing closed loops into supply chains may have a great complexity, since the reverse flows, in general, present uncertainties concerning quantity, quality, time and space and these introduce uncertainty in the whole supply chain.
- *Diversity and harmonisation of objectives*: The fact that an organisation can belong to diverse supply chains, in which one of them possibly with specific objectives, gives raise to the problem of harmonising these diverse objectives, which, at first sight, does not coincide with the classical multiobjective decision problem, since in the case we are speaking about the decision-maker who assume, let us say, different personalities, each one of them with different sets of objectives.
- *Measure of the performance of the supply chain*: It is well known that defining methods and measures to assess the performance of the supply chain or that of one of its parts is an active non-closed field of research (see Akyuz and Erkan 2010).
- *Teaching supply chain*: Since the concept of supply chain provides a new manner of seeing production, distribution and recovering processes, the way to teach them should be completely revised. It is not enough to introduce in textbooks the term supply chain, while keeping the old approaches conceived more or less 50 years ago. A complete reengineering of courses and textbooks is required (Corominas 2010). This task is neither easy nor brief and will need many contributions to be completed.

5. Conclusions

Since supply chains are really supply networks, the expression ‘supply chain’ does not describe the reality it refers to accurately. However, the term is useful to practitioners and academics because it transcends the framework of logistics, thus contributing to highlighting new, even emerging or foreseeable, features and problems.

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