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Towards Effective Supply Chain Collaboration: TOC-based Approach to Identify
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Towards Effective Supply Chain Collaboration: TOC-based Approach to Identify and Address Core Conflicts[1]

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Resumen - Para lograr una cadena de suministro exitosa, es crucial que todos sus miembros colaboren. La colaboración en la cadena de suministro (CS) supone que todos los enlaces están dispuestos a colaborar y que no hay conflictos inherentes dentro de la red. En la práctica, puede que miembros u organizaciones dentro la cadena de suministro tengan conflictos y no logren la colaboración. Existe poca investigación práctica en el área, a pesar de que la necesidad de medidas de desempeño para asegurar la colaboración de la CS ha sido ampliamente reconocida en la literatura pertinente.

Esta investigación tiene como objetivo desarrollar redes hipotéticas de cadenas de suministro para identificar y resolver diferentes dilemas que surgen cuando los miembros de la misma colaboran. También busca desarrollar un marco conceptual de uso de teoría de las restricciones (TOC) y las nubes de evaporación para lograr que los miembros de la CS reconozcan que hay muchos beneficios al involucrarse en una colaboración en la cadena de suministros. Teniendo en cuenta a Holt y Button (2000) y Gupta y Andersen (2018), en este artículo se exploran una serie de conflictos que varían desde conflictos muy genéricos que ocurren en cada red de CS hasta otros más específicos. Estos incluyen pronóstico, precios, entrega, riesgo e intercambio de información. Primero, se aplicó uno de los procesos de pensamiento de TOC, evaporación de las nubes, para comprender el lado del miembro de la cadena de suministro (CS). Esta herramienta permitió una comunicación efectiva al persuadir a los participantes de la CS de que la administración de la misma requiere entender las necesidades y deseos de todos sus participantes. En segundo lugar, se modeló la evaporación de las nubes como una herramienta para convencer a los miembros inmediatos de la CS de que la solución al conflicto central de colaboración de la cadena de suministro llega en forma de medidas Rendimiento Dolar-Dia (TDD) e Inventario Dolar-Dia (IDD).

Palabras clave: *cadena de suministros, teoría de las restricciones, rendimiento dólar-Día, nubes de evaporación, comunicación efectiva*

Abstract – To achieve a successful supply chain, it is crucial that all supply chain members collaborate. However, this may be a difficult task to achieve because supply chain collaboration assumes that links are willing to cooperate and that there are no inherent conflicts happening within the supply chain network. In practice,

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organizations may not want to cooperate. Therefore, this paper identifies and addresses a number of dilemmas that arise when supply chain members involve in collaboration. These include forecasting, pricing, delivery, risk and sharing of information. In addition, this paper shows how evaporating clouds is used to expose the inherent dilemma of supply chain collaboration.

Further, this paper attempts to apply the TOC approach to overcome this core conflict. Specifically, it shows how evaporating clouds can be used as a tool to convince immediate supply chain members that the solution to the supply chain collaboration core conflict arrives in the form of TDD/IDD measures. These collaborative performance metrics, when implemented effectively, help in identifying the constraint(s) and thereby, encourage TOC-based continuous improvement efforts to generate value by increasing revenues and reducing overall costs simultaneously across an SC network.

Keywords: Supply chain, theory of constraints, dollar-day performance, evaporating clouds, effective communication.

Introduction

As global markets grow increasingly efficient, competition has experienced a change that makes it no longer occur between individual businesses but entire supply chains (Horvath 2001). A supply chain (SC) consists of multiple firms, both upstream (i.e., supply) and downstream (i.e., distribution). The concept of supply chain management carries within its definition a connotation of integration and management of organizations and activities through collaborative strategic alliances. As a matter of fact, this collaboration requires high levels of information sharing to create a value chain that would provide supply chain members (SCM) a sustainable competitive advantage.

The literature on supply chain collaboration (SCC) is relatively extensive in both business and academia, but not always appropriate because crucial aspects are often overlooked. Recent surveys conducted by Supply Chain Management Review and Computer Science Corporation has shown that collaboration is pointed out as the single most critical issue in SC, yet only about 35 percent of collaboration initiatives actually achieve an even moderately successful outcome. Perhaps, a rationale to this is that not all SC members have embedded collaborative values. You cannot collaborate with a party that lacks genuine desire to collaborate (Kampstra et al 2006).

Gupta and Andersen (2018) further analyzed this issue of SCC by modeling an illustrative supply chain network (SCN) of a well-known theory of constraints (TOC) case study termed as the ADF SC network. In this paper, the authors introduced TOC-based measures, Throughput Dollar-Days (TDD) and Inventory-Dollar Days (IDD), as a mechanism to provide visibility across the SCN, thus allowing participants to identify constraints that ensure proper

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coordination and cooperation among the SC members. However, a major limitation to this paper involves the assumptions underlying the implementation of these measures. One of the main assumptions includes that the SC network is cooperative and that partners are willing to collaborate and agree to work towards the general welfare of the SC. Nevertheless, in real life it might be very difficult to induce such a behavior among SC members. Thus, the first research question addressed in this paper is: What if a SC member within the SC network does not want to collaborate? To address this issue, this paper attempts to apply one of the TOC thinking process, evaporating clouds (EC), as a tool to understand the SC member's side. This approach has the potential to persuade participants within a SCN that SC management requires understanding the participant's needs and wants and that Evaporating Clouds provides us with the perfect tool to achieve such effective communication.

Furthermore, this brings us back to another important aspect, the Theory of Constraints and TOC-based performance measures. Research in this area has been growing rapidly in recent years and it has successfully demonstrated through real-life as well as simulated applications that local TOC-based measures mentioned above, Throughput and Inventory Dollar-Days (T/IDD), have the potential to improve the efficiency and effectiveness of SC networks significantly. In addition, even though the need for performance measures to ensure SC collaboration has been widely recognized in the pertinent literature and although there is substantial evidence of their success, they do not happen to be very popular (Gupta and Andersen 2018). As mentioned earlier, SCC assumes a fair amount of trust amongst the partners, but in practice, SC members may not want to collaborate (Simatupang et al 2004). A major reason for this arises from the fear of members to share sensitive information. Therefore, the second research question to be addressed in this paper is: How to propose TDD/IDD measures as necessary conditions to not only enhance SC collaboration but also build trust among the SC members? Likewise, to address this point in question, this paper proposes EC as a tool to convince immediate SC members that the solution to the supply chain collaboration issue arrives in the form of TDD/IDD measures. Besides, evaporating cloud will show that implementing these measures do not involve sharing sensitive information, on the contrary, when implemented effectively they help generate value by increasing revenues and reducing overall costs simultaneously across a SC network (Gupta and Andersen 2018).

More specifically, the paper is organized as follows: In the second section, we briefly discuss the literature on supply chain from a general as well as TOC-perspective and explore the benefits and importance behind collaboration. In the third section, we introduce general dilemmas of supply chain collaboration and propose evaporating clouds as an approach to resolve it. In the fourth section, we introduce a simple case study, the ADF supply chain network and present a more specific conflict of SCC. In the fifth section, we present the core

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conflict of supply chain collaboration and explore how it develops from the previous dilemmas explored. In addition, we introduce Goldratt's TOC-based measures as a mechanism to collaborate and suggest EC as a tool to convince members that T/IDD measures build trust among SC members and improve supply chain performance without sharing sensitive information. Finally, we conclude our paper discussing limitations and some possible future research directions.

Literature review

From a conventional perspective, there seems to be a universal agreement on what supply chain means. Gibson et al, in the book "The Definitive Guide to Integrated Supply Chain Management", provides useful supply chain definitions that share similar features:

- From Christopher Martin L. (1992), supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer.
- From the Council of Supply Chain Management Professionals (2010), the material and informational interchanges in the logistical process, stretching from acquisition of raw materials to delivery of finished products to the end user. All vendors, service providers, and customers are links in the supply chain.
- From Coyle, Langley, Novak, and Gibson (2013), a series of integrated enterprises that must share information and coordinate physical execution to ensure a smooth, integrated flow of goods, services, information, and cash through the pipeline.

One important feature shared by these definitions is the concept of an integrated network or system (Gibson, Hanna, Deffee, & Chen 2014).

From a conceptual theory of constraints perspective, supply chain focuses on three separate but interrelated areas: the *methodology* employed to manage the SC constraints, the *measures* that drive the members as well as the network as a whole and the *mindset* of supply chain members (Boyd and Gupta 2004). Conceptually speaking, senior management across the SC is required to address all the three dimensions of TOC (3Ms) - methodology, measurements and mindset in order to achieve successful SCC. Gupta et al. (2010) states that the first dimension, *methodology,* comprises the following five-step-focusing process to manage the constraint that limits a SC network's ability to increase throughput:

1. IDENTIFY the system constraint(s).
2. Decide how to EXPLOIT the system's constraint(s).
3. SUBORDINATE everything else to the above decision.

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4. ELEVATE the system's constraint(s).
5. GO BACK to step 1, but DON'T allow INERTIA to cause a system constraint.

The second dimension refers to the TOC *mindset* of *Throughput World Thinking* (TWT) that promotes initiatives consistent with the ultimate goal of a company that is to "make money now as well as in the future". Such organizational mindset views SC members' profitability as a requirement to achieve collaboration. In addition, it stipulates that there are at least two necessary conditions that must be adhered to: (i) Providing a satisfying work environment for employees now as well as in the future and (ii) Providing satisfaction to the market now as well as in the future (Gupta et al 2010). Finally, TOC proposes three company-wide *measurements*: (i) Throughput: A measure of money coming in; (ii) Inventory: A measure of money stuck inside the company; (iii) Operating Expenses: A measure of money going out. These global measures are required to determine whether or not the system is accomplishing the goal of making money and ultimately demonstrate that SC members will not earn their share of profit until a part or component is sold to the end customer (Simatupang et al, 2004; Gupta and Andersen, 2018).

Reports from simulated as well as real world practice, show that the need for cooperative supply chains has given rise to the field of SC collaboration. The concept of collaboration is increasingly referred to as somewhat of a "Silver Bullet" in many areas of SC management (Kampstra et al., 2006). By the term supply chain collaboration, we refer to as a long-term relationship where participants generally cooperate, share information, and work together to plan and even modify their business practices to improve joint performance (Ralston 2014). In the literature available, many researchers have contributed with similar definitions to the collaborative supply chain. Simatupang, et al. (2004), suggests "two or more independent firms working together to align their supply chain processes with the aim of creating value to end customers and stakeholders with greater success than acting alone". Kohli and Jensen (2010), define a collaborative supply chain as "a win/win arrangement that is likely to provide improved business success for both parties". Cao and Zhang (2011), describe SC collaboration as "a partnership process of two or more independent firms that work closely to plan and execute supply chain operations towards shared goals and mutual benefits". A common feature that can be derived from all definitions is that SCC amongst business units or independent organizations often provides larger benefits than working in isolation. Simatupang et al (2004), states that when all participants in the chain integrate and act as a homogeneous entity, performance is enhanced throughout the chain as profit improves from the matching of supply and demand.

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The benefits for investing in supply chain processes and cross-chain relationships are many. As companies move from a functional excellence focus towards a collaborative one, the SC becomes more dynamic and capable of achieving fundamental organizational goals (Gibson et al 2014). Over the years, many benefits from SC collaboration have been documented for all links within the SC network. The available literature recognizes some of the benefits as clearer division of responsibility among partners, improved end-customer satisfaction, reduced lead times, enhanced information visibility, and significant cost reductions. Similarly, there are obstacles that prevent SC links from fully enjoying the benefits of collaboration. Some of the obstacles include fear of external pressure, concern about trust, increased operational complexity, fear of failure and exposure to competition, (Kohli and Jensen 2010).

Eliyahu Goldratt, the originator the Theory of Constraints (TOC), developed a set of techniques collectively known as the Thinking Processes (TP). These techniques were proposed to address the three fundamental questions that an organization must ask to identify and resolve core business problems (i) What to change; (ii) What to change to; and (iii) How to cause the change (Goldratt 2010). Gupta et al (2011) states that the thinking process begins with the identification of the symptoms of problems that need to be eliminated, also known as the undesirable effects (UDEs). Next, the current reality tree (CRT) tool is used to depict the cause and effect relationships between the UDEs. Then, a second tool, known as evaporating clouds, is used to identify, and display all elements of the conflict, identify underlying assumptions that cause the conflict to exist and develop solutions that invalidate one or more of the assumptions. Following, a Future Reality Tree (FRT) is used to test the proposed solutions to ensure that they will actually result in the resolution of the conflict. The fourth tool is the prerequisite tree which identifies obstacles to implementing solutions and determines how to overcome those obstacles. To conclude the process, a transition tree is developed to create a logical, step by step implementation plan. The advantage offered by these tools is that they can be used collectively to address major conflicts, or as 'stand-alone' tools to address specific aspects of the conflict.

For the purpose of this paper, we are going to make use of the evaporating clouds as a standalone tool to address the dilemma of SC Collaboration. The name of this tool portrays the capacity of the tool to resolve or evaporate a conflict by fulfilling the needs and wants of both sides of the conflict. Figure 1 below depicts the structure of an evaporating cloud as well as the questions that must be addressed to fill out each one of the boxes.

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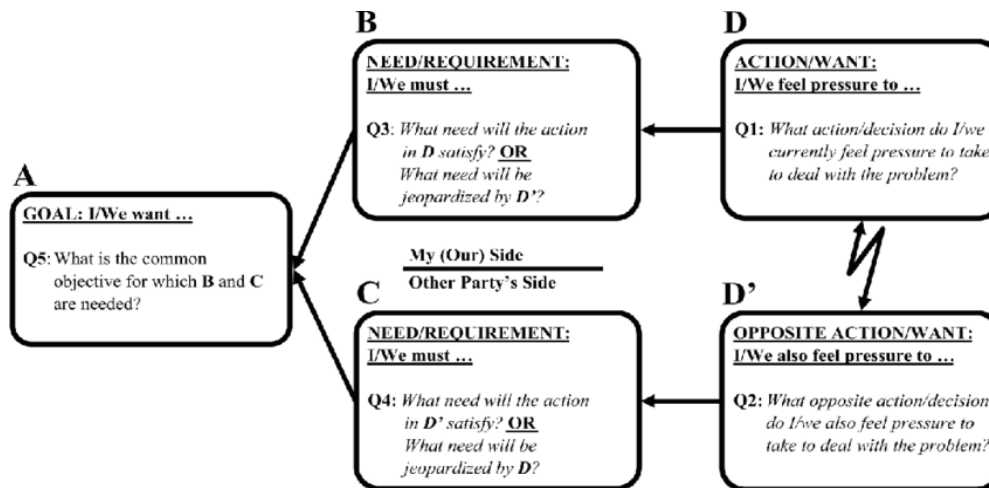Volumen 2, número 14, 2021 julio-diciembre

Figure 1. Evaporating Cloud structure.

An Evaporating Cloud has three steps:

1. Entities: These are the wants, needs and goals that you are working on. Drawing these five elements (A, B, C, D, D') is the first step of visualizing the conflict and articulating the conflict.

2. Assumptions: This step involves uncovering assumptions for each of the five arrows: A-B, A-C, B-D, C-D' and D-D'.

3. Injections: This help burst the assumptions surfaced in the earlier step. To eliminate the conflict (e.g., evaporate the cloud) we develop injections, a potential solution, that break at least one of the arrows connecting the objective, needs and wants.

The cloud is a logical diagram that represents the problem through five boxes (A, B, C, D and D'), referred to as entities, that are connected through the logic of cause and effect. Entities D and D' represent two opposing wants or actions, entities B and C represent the respective needs to be satisfied and entity A represents the common objective for which B and C are needed. Similarly, the upper side of the cloud, with entities B and D, represent one side (e.g. my side) of a conflict, while the lower side of the cloud, with entities C and D', represent the 'other party's side (Gupta et al 2011). In addition, to properly communicate the cloud, it should be read from left to right, starting with the objective. The initiator of the cloud generally read the other party's side first and then his/her side. As an example, the cloud from Figure 1 would be read as follows:

> In order to [A], I must [C]. In order to [C], I must [D'].
> But in order to [A], I must also [B]. In order to [B], I must [D].
> I can't both [D] and [D']

The purposes of this paper are twofold: The first is to demonstrate Goldratt evaporating cloud (EC) as a simple, structured approach to SC collaboration. The second is to propose EC as a tool to convince immediate Supply Chain members that TDD/IDD measures arrive as a potential solution to take care of SC's collaboration core problem and also build trust among SC members.

Conflict of Supply Chain

To achieve a successful Supply Chain, it is crucial that all SC members collaborate. However, as we have mentioned in previous sections, in real life this may be a difficult task because there are some dilemmas that prevent the SC from happening in an effective manner. Holt and Button (2000) explore a number of general conflicts that arise when chain members involve in collaboration. These conflicts are so generic that they apply to almost any SC network. These dilemmas include forecasting, pricing, delivery and risk.

First, we can look at the forecasting dilemma. Each member within the SC attempts to forecast both the expected sales (demand) for the part they produce and their raw material requirement. However, this can be hard to achieve when considering a high variability system (Holt and Button, 2000). Figure 2 below depicts the evaporating cloud for the forecasting dilemma.

Should Supply Chain links hold a large inventory or limit themselves to a small inventory?

B: Not miss an order

D: Hold large inventory

A: Be profitable

C: Keep costs low

D': Limit to a small inventory

In order to *Be profitable* I must *Not miss an order* and in order to *Not miss an order* I must *Hold large inventory*. But, in order to *Be profitable* I must also *Keep costs low* and in order to *Keep costs low* I must *Limit to a small inventory*. I can't both *Hold large inventory* and *Limit to a small inventory*.
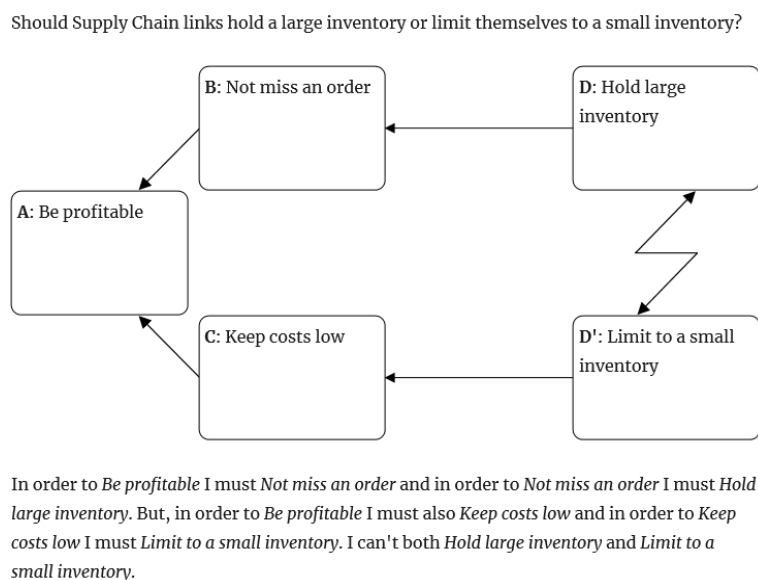
Figure 2. Evaporating cloud of forecasting dilemma.

As can be seen from Figure 2, the conflict to address is whether if supply chain links should hold a large inventory or limit themselves to a small inventory.

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Second, consider the pricing problem. The volume of sales to the consumer are related to price. All links in the SC want higher volumes. To achieve the high volumes, everyone in the supply chain pressures everyone else to cut their prices so the final product costs less. On the other hand, for the individual links to stay in business, they can't lower the price much (Holt and Button, 2000). Figure 3 on the next page depicts the evaporating cloud for the pricing dilemma.

Should the Supply Chain pressure everyone to cut their prices, or should individual links raise their prices?

B: Achieve high volumes of sales

D: Cut prices

A: Be profitable

C: Stay in business

D': Raise prices

In order to *Be profitable* I must *Achieve high volumes of sales* and in order to *Achieve high volumes of sales* I must *Cut prices*. But, in order to *Be profitable* I must also *Stay in business* and in order to *Stay in business* I must *Raise prices*. I can't both *Cut prices* and *Raise prices*.
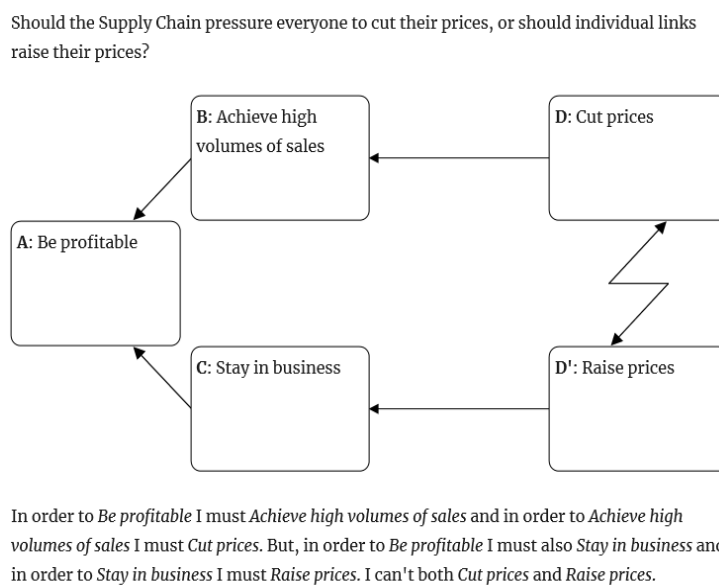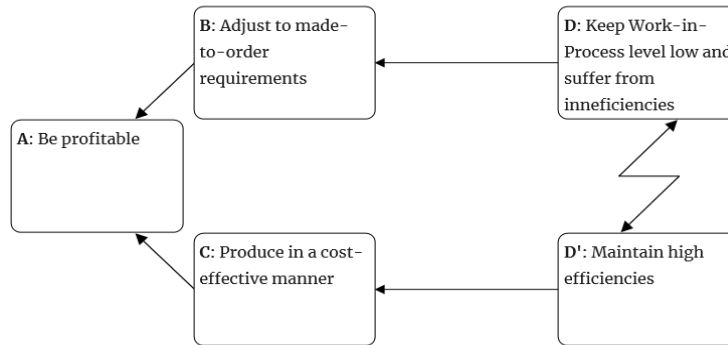
Figure 3. Evaporating cloud of pricing dilemma.

As can be noticed from Figure 3, the conflict to address is whether if the SC should pressure every member to cut their prices or if individuals links should raise their prices.

Third, we can examine the problem of delivery. Today's consumer wants things fast. For the SC to effectively move made-to-order things quickly through the chain the work-in-process levels must be very low. Keeping the work-in-process level low translates into low efficiencies. On the other hand, for the individual link to produce in a cost-effective manner, the link must have high efficiencies (Holt and Button, 2000). Figure 4 below depicts the delivery problem.

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Should the Supply Chain keep WIP levels low and suffer from inefficiencies, or individual links should produce in a cost-effective manner and maintain high efficiencies?

B: Adjust to made-to-order requirements

D: Keep Work-in-Process level low and suffer from inneficiencies

A: Be profitable

C: Produce in a cost-effective manner

D': Maintain high efficiencies

In order to *Be profitable* I must *Adjust to made-to-order requirements* and in order to *Adjust to made-to-order requirements* I must *Keep Work-in-Process level low and suffer from inneficiencies*. But, in order to *Be profitable* I must also *Produce in a cost-effective manner* and in order to *Produce in a cost-effective manner* I must *Maintain high efficiencies*. I can't both *Keep Work-in-Process level low and suffer from inneficiencies* and *Maintain high efficiencies*.

Figure 4. Evaporating cloud of delivery problem.

As can be seen from Figure 4, the conflict to address is whether if the supply chain should keep the Work-in-Process levels low which means individual links will suffer from inefficiencies, or if individual links should produce in a cost-effective manner and have high efficiencies.

Last, consider the element of risk. All businesses take risk. To profit when market demand is up, the SC must have products ready. In order to have products ready the SC must take substantial risks. On the other hand, for the SC to deliver products smoothly, individual links must be very dependable. In order to be very dependable, the links must not take substantial risks (Holt and Button, 2000). Figure 5 below depicts the risk dilemma.

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Should the Supply Chain take substantial risk and have products ready, or links should be
very dependable and not take substantial risks to deliver products smoothly?
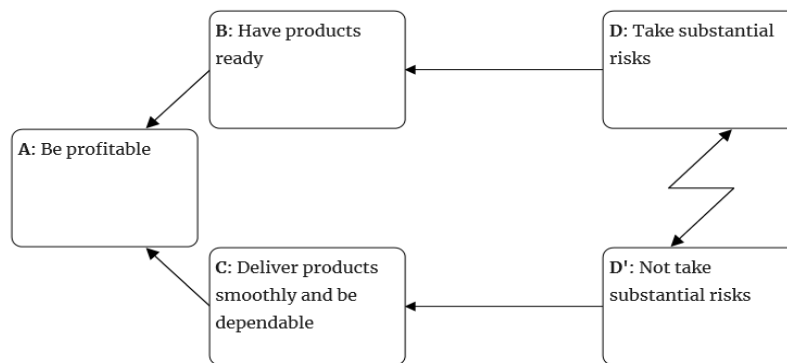
In order to *Be profitable* I must *Have products ready* and in order to *Have products ready* I must
Take substantial risks. But, in order to *Be profitable* I must also *Deliver products smoothly and
be dependable* and in order to *Deliver products smoothly and be dependable* I must *Not take
substantial risks*. I can't both *Take substantial risks* and *Not take substantial risks*.

Figure 5. Evaporating cloud of the element of risk.

As can be noticed from Figure 5, the conflict to address is whether if the supply chain should take substantial risks and have products ready, or if the individual links should be very dependable and not take substantial risks to deliver products smoothly.

Frequently, individual SC members tend to make decision on their own interest rather than the interest of the SC as a whole. As mentioned earlier, Gupta and Andersen (2018) modeled an illustrative supply chain network (SCN) of a well-known theory of constraints (TOC) case study termed as the ADF SC network. In this paper, the authors introduced TOC-based measures as a mechanism to identify constraints that ensure proper coordination and cooperation among the SC members. Nevertheless, a major limitation to this paper are the assumptions underlying the implementation of these measures as will be further addressed in the following section.

Simple case study: The ADF Supply Chain Network

Gupta and Andersen (2018) explore the supply chain collaboration conflict by modeling an illustrative supply chain network (SCN) of a well-known theory of constraints (TOC) case study termed as the ADF SC network. Figure 6 on the next page depicts this SC network consisting of five independent firms (SCG, SCW, SCC, SCB and SCM), each consisting of its own value chain and adding value to three end products (FGA, FGD and FGF) with the SCB firm as the constraint firm.
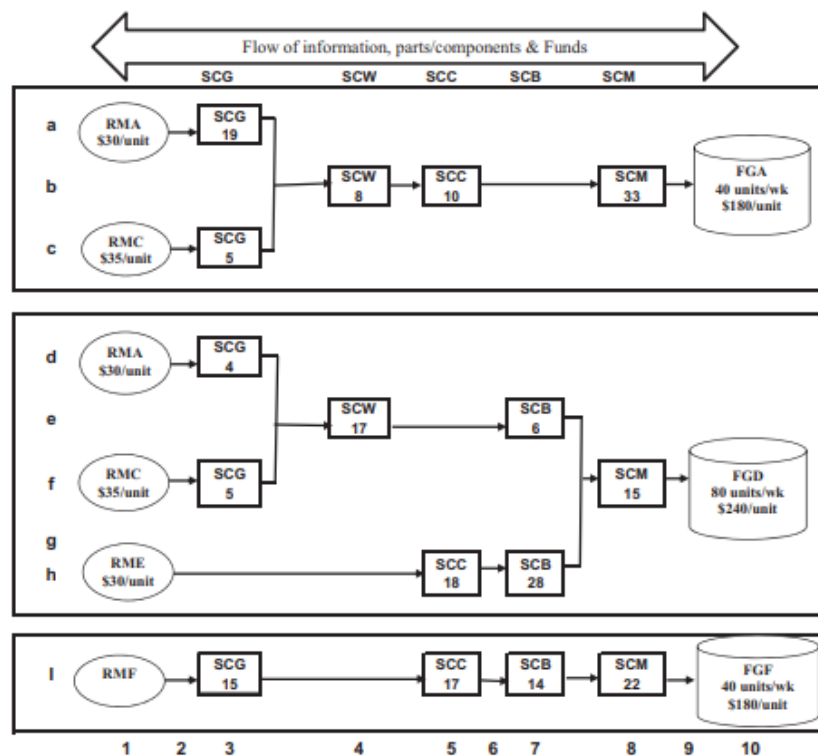
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Figure 6. Product-process view of the ADF supply chain network.

As can be seen for Figure 6, raw materials RMA, RMC, RME and RMF, worth $30/unit, $35/unit, $30/unit and $65/unit, respectively, are processed and value is added by the immediate SC member and, finally, three finished products (FGA, FGD and FGF) are produced and sold at $180, $240 and $180, respectively.

Gupta and Andersen (2018) show theoretical throughput, operating expenses and net profit for each firm as well as for the overall ADF SC network for one period. Similarly, available capacity and processing time estimates for each SC member are also calculated. After performing the analysis, the results show that the SC network as a whole will not be able to produce the required periodic product-mix because one of the SC members, SCB, does not have enough capacity, i.e. it is a constraint or bottleneck. Therefore, the authors discuss the implementation of TOC-based measures, Throughput and Inventory Dollar-Days (T/IDD), as an approach to improve the performance of the whole supply chain network significantly. Conceptually speaking, throughput dollar-days measures the effectiveness of a member in fulfilling the customer requirement, meaning failures to deliver specific products by specific dates (e.g. The reliability of product delivery by calculating the penalty for late deliveries). On the other hand, inventory dollar-days measures the efficiency of a supply chain member in terms of its resource utilization, meaning the value of inventory and the time it stays within an area (e.g. the penalty for building excessive inventory). These collaborative performance

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metrics are required to guide participating members in evaluating whether or not their actions are truly contributing to the global goal of making money (Simatupang et al 2004). However, implementing them require SC members to share certain information that they might consider sensitive. Therefore, as already mentioned, a major limitation to this paper is that it assumes SC members are willing to collaborate. However, companies might not be willing to share sensitive information because it increases their exposure.

First, let us consider the conflict of sharing TDD/IDD values. In order to maximize profitability of the SC network, TDD/IDD values must be shared with SC members. On the other hand, to protect the profitability of individual SC members, individual links must not share TDD/IDD values with SC members. Figure 7 below depicts the T/IDD information sharing conflict.

should supply chain members share or not share TDD/IDD values across the SC ?
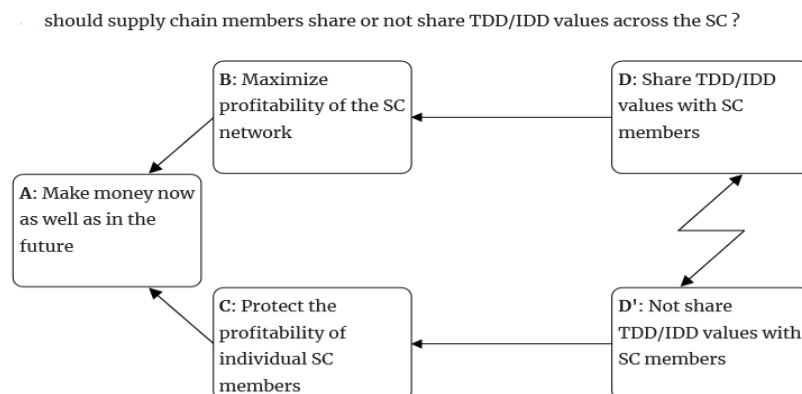
In order to *Make money now as well as in the future* we must *Maximize profitability of the SC network* and in order to *Maximize profitability of the SC network* we must *Share TDD/IDD values with SC members*. But, in order to *Make money now as well as in the future* we must also *Protect the profitability of individual SC members* and in order to *Protect the profitability of individual SC members* we must *Not share TDD/IDD values with SC members*. we can't both *Share TDD/IDD values with SC members* and *Not share TDD/IDD values with SC members*.

Figure 7. Evaporating cloud of information sharing dilemma.

As can be seen from Figure 7, we have a dilemma. Should supply chain members share TDD/IDD values with SC members or not share? It is important to mention that once T/IDD measures are shared, other SC member will immediately deduce whether if your company is a bottleneck or not. Therefore, this can be considered a risk by some companies. But in reality, it is sensitive in the sense that if you do not trust the SC member, you will not share that you have a bottleneck. However, if there's true collaboration, all partners involved will benefit from the implementation of these measures and it will bring the supply chain performance to a higher level by achieving a win-win solution for all participating members.

TOC-based Approach to Identify and Address the Core Conflict of SCC

Taking into consideration both Holt and Button (2000) and Gupta and Andersen (2018), we explored a number of conflicts that vary from very generic conflicts that occur in every SC Network to more specific ones. These include forecasting, pricing, delivery, risk and T/IDD information sharing. As can be noticed, members of supply chains face many conflicts between the efficient operation of the individual unit and the demands of membership in the supply chain. Supply chains deliver products to consumers. Consumers are becoming more and more demanding. Consumers want better products, faster delivery, and less expensive products. The importance of identifying all these dilemmas is that they have something in common. As a matter of fact, they can be summed up as one generic core conflict between making decisions in the interest of the supply chain as a whole and making decisions in the interest of the links. An evaporating cloud can be developed to capture and describe this conflict as shown in Figure 8 below.
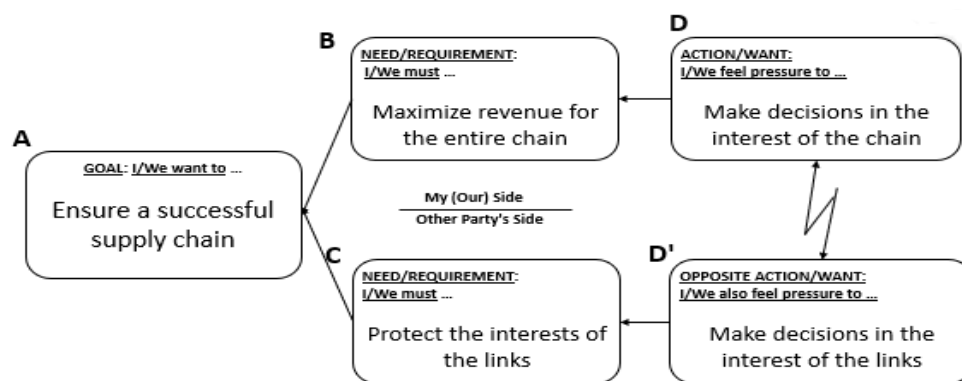

Figure 8. Generic core conflict of supply chain collaboration.

As explained in the literature review, there are three steps to evaporating clouds: Entities, assumptions and injections. From Figure 8 we can observe that entities are in place. Therefore, we must continue to uncover assumptions for each of the arrows.

The upper path of the diagram can be read as follows: In order to "Ensure a successful supply chain", I must "Maximize revenue for the entire chain". A rationale for this is that a SC really only makes a sale when the final customer consumes the product. Reading on, in order to "Maximize revenue for the entire chain", I must "Make decisions in the interest of the chain" because making decisions in the interest of the chain will result in high volume of sales and the current decision of protecting the interest of the links is causing both inventories to pile up and operating expenses to increase.

The lower path of the diagram can be read as follows: In order to "Ensure a successful supply chain", I must also "Protect the interests of the links". A rationale to this is that chain members

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get benefits from collaboration only if their individual company profitability is enhanced. Further, in order to "Protect the interests of the links", I must "Make decisions in the interest of the links" because making decisions in the interest of the chain requires sharing information that may be considered sensitive and this increase SC members exposure. In addition, making decision in the interest of the links provide us with the opportunity to take initiatives for our own benefit.

The diagram dilemma can be read: "Making decisions in the interest of the chain is in direct conflict with making decisions in the interest of the links" because we cannot do both things at the same time since decisions in the interest of the chain are different than decisions in the interest of the links. Figure 9 on the next page summarizes the assumptions surfaced for each of the arrows.
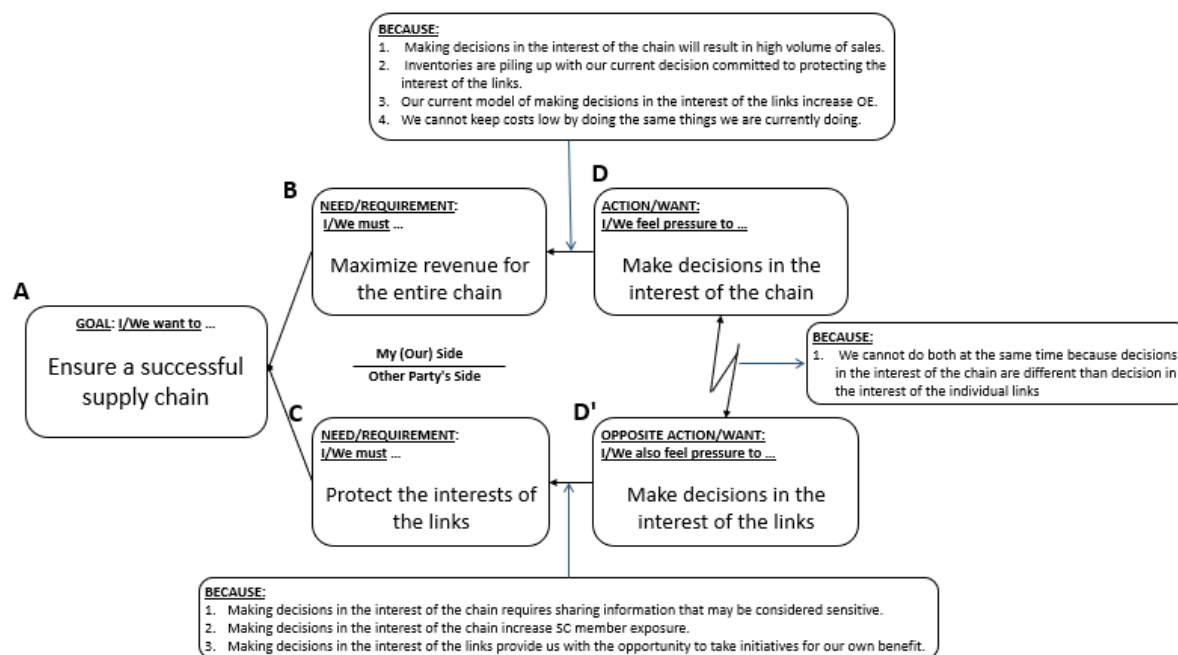

Figure 9. Evaporating cloud with assumptions.

Continuing on, the last step to evaporating clouds is to come up with the injections. As mentioned earlier, to eliminate the conflict (i.e., evaporate the cloud) we develop injections, a potential solution, that break at least one of the arrows connecting the objective, needs and wants. Figure 10 below depicts the injections to each assumption.

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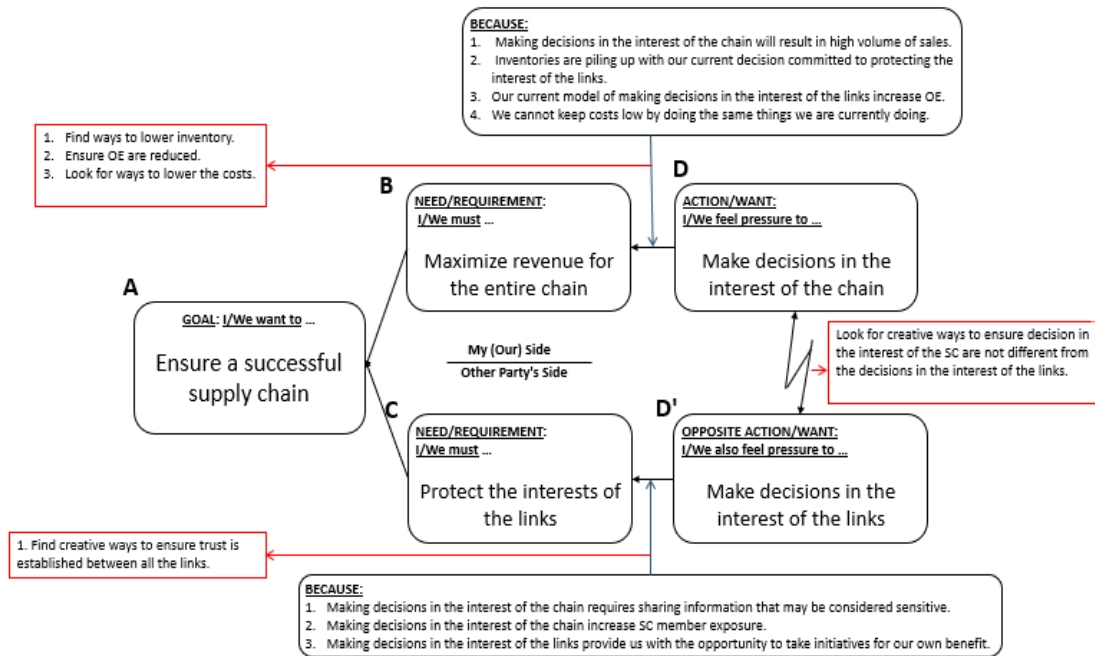Volumen 2, número 14, 2021 julio-diciembre

Figure 10. Evaporating cloud with entities, assumptions and injections.

Table 1 below summarizes the assumptions and injections for the evaporating cloud of the core conflict faced by supply chain collaboration.

Table 1. Summary of assumptions and injections to SCC core conflict.

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Relation	Assumption(s)	Injection(s)
D-D'	We cannot do both at the same time because decisions in the interest of the supply chain are different than decisions in the interest of the individual links.	1. Look for creative ways to ensure decisions in the interest of the supply chain are not different from the decisions in the interest of the links.
B-D	1. Making decision in the interest of the chain will result in high volumes of sales. 2. Inventories are pilling up with our current decision committed to protecting the interest of the links. 3. Our current model of making decisions in the interest of the links increase Operating Expenses. 4. We cannot keep costs low by doing the same things we are currently doing. 5. Consumers expect their supplier to have products ready, and making decisions in the interest of the chain results in effectively moving orders quickly through the chain.	2. Find ways to lower Inventory. 3. Ensure Operating Expenses are reduced. 4. Look for ways to lower the costs.
C-D'	1. Making decisions in the interest of the chain requires sharing information that may be considered sensitive. 2. Making decisions in the interest of the chain increase SC member's exposure, thus jeopardizing their need to stay in business. 3. Making decisions in the interest of the links provide us with the opportunity to take initiatives for our own benefit. 4. Protecting the interests of the links requires the link to produce in a cost effective manner, thus maintaining into high efficiencies.	1 and 2. Find creative ways to ensure trust is established between all the links.

As can be noticed from Table 1, injections are often the opposite to assumptions. To resolve the dilemma of SC collaboration, the chain members need to attack the logical D – D' arrow of Figure 9 (or alternatively the B – D or the C – D' arrows).

First of all, the proposed injections to break the B – D arrow include to find ways to lower inventory, ensure operating expenses are reduced and look for ways to lower the costs. But how do we achieve these injections? This is where TOC-based approach comes into place. Our proposal is to implement the throughput-oriented management philosophy known as Throughput World Thinking (TWT). A robust production planning and scheduling approach must be developed. For example, producing Just-In-Time to have a very limited WIP (i.e. DBR and BM). In addition, we are proposing to device new continuous improvements to identify and eliminate constraints which significantly increase revenue without increasing operating expenses. For a "for profit" supply chain, the constraints would be whatever keeps the chain members from generating more profits (Simatupang et al 2004). Such SC has at least one constraint otherwise infinite profit would result. The constraint-based approach recognizes the importance of identifying the constraints that prevent the links from achieving overall profitability. Simatupang et al (2004) states that constraints can be both physical and non-physical. Physical constraints include raw material shortages, limited capacity resources and lack of customer demand. On the other hand, non-physical constraints include obsolete procedures, measures and training. The improvement process focused on the constraint can be

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summarized as follows: (i) the profitability of the SC is determined and dictated by the constraint, (b) a better profitability can be achieved through better exploitation of the system's constraint and, finally, (iii) when the constraint is removed, the SC moves to a higher level of profitability, and immediately encounters a new constraint. As explained in the literature review section, this focusing process is the first dimension of TOC known as the methodology of Five-Focusing-Step. Once again, the steps involve (i) IDENTIFY the system constraint(s); (ii) Decide how to EXPLOIT the system's constraint(s); (iii) SUBORDINATE everything else to the above decision; (iv) ELEVATE the system's constraint(s) and (v) GO BACK to step 1, but DON'T allow INERTIA to cause a system constraint.

Second of all, the proposed injections to break the C – D' arrow is to find creative ways to ensure trust is established between all the links. The success of SCC depends very much on how each party abides by the collaborative scheme. Collaborative performance metrics are necessary to guide SC members in evaluating whether or not their actions are contributing to the global goal of making money. Therefore, we propose to device a new performance measurement system, meaning to use Goldratt's measures of "Throughput", "Inventory", "Operating Expenses" as applied to the total supply chain, and derivatives thereof, which drive the appropriate synchronization actions of members. In addition, we propose two performance metrics that can be used to measure how well individual members executes de global plan: Throughput dollar-days and Inventory dollar-days. Besides using these measures to control SC operations, they can also be used to judge how other links contribute to global metrics. All the information we need is to calculate TDD/IDD values. If products are getting stuck somewhere in the SC (bottleneck), then it does not make sense for members to keep shipping products. Eventually, the bottleneck company will go bankrupt and other members will lose market. So, it is in the interest of links to identify where the bottlenecks are. T/IDD values provide us with an approach to identify constraints. Then, TOC-based approach explained above can be taught to them and links will be able to ship more because there will no longer be bottlenecks.

Finally, the proposed injection to break the D – D' arrow is to look for creative ways to ensure decisions in the interest of the supply chain are not different from the decisions in the interest of the links. The breakthrough solution is that each member of the supply chain shares in the profit and the risk of the supply chain. Holt and Button (2000) states that this injection aligns the strategy of the chain and the tactics of the links. Individual SC members can participate in the chain as much as they desire without severe outside pressures. Individual links can contribute to the competitiveness of the supply chain. At the same time, individual links become more independent and can take more control over their own future. Local improvement not only benefits locally, but also benefits the whole chain. Benefits of the whole chain also benefit the individual links (Holt and Button 2000).

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Table 2 on the next page summarizes all the assumptions, injections and TOC-based framework as an approach to accomplish the goal of convincing immediate Supply Chain members that TOC-based measures (TDD/IDD) arrive as a potential solution to take care of SC's collaboration core problem, enhance the performance of the SC and also build trust among its members.

Table 2. Summary of assumptions, injections and super injections to SCC core problem.

Relation	Assumption(s)	Injection(s)
D-D'	We cannot do both at the same time because decisions in the interest of the supply chain are different than decisions in the interest of the individual links.	1. Look for creative ways to ensure decisions in the interest of the supply chain are not different from the decisions in the interest of the links.
B-D	1. Making decision in the interest of the chain will result in high volumes of sales. 2. Inventories are pilling up with our current decision committed to protecting the interest of the links. 3. Our current model of making decisions in the interest of the links increase Operating Expenses. 4. We cannot keep costs low by doing the same things we are currently doing. 5. Consumers expect their supplier to have products ready, and making decisions in the interest of the chain results in effectively moving orders quickly through the chain.	2. Find ways to lower Inventory. 3. Ensure Operating Expenses are reduced. 4. Look for ways to lower the costs. - Develop a robust production planning and scheduling approach. Produce Just-in-time to have very limited WIP and FG (I.e. DBR and BM). - Devise new continuos Improvements and philosophy (Five Focusing Steps (FFS) to significantly increase revenue without increasing OE) - Implement Throughput-World Thinking. (Throughput Orientated Management Philosophy) SUPER-INJECTION
C-D'	1. Making decisions in the interest of the chain requires sharing information that may be considered sensitive. 2. Making decisions in the interest of the chain increase SC member's exposure, thus jeopardizing their need to stay in business. 3. Making decisions in the interest of the links provide us with the opportunity to take initiatives for our own benefit. 4. Protecting the interests of the links requires the link to produce in a cost effective manner, thus maintaining into high efficiencies.	1 and 2. Find creative ways to ensure trust is established between all the links. -Device new performance measurement system (T, I, OE, and T/IDD) SUPER-INJECTION

Conclusions, limitations and future research directions

Even though the need for performance measures to ensure SCC has been widely recognized in the pertinent literature, not much practical research has been done in this area. This paper has provided the conceptual framework for using evaporating clouds and TOC approach to assist the SC members to realize that the benefits from involving in supply chain collaboration are many.

First, we have applied one of the TOC thinking process, evaporating clouds, to understand the SC member's side. This tool provided us with the perfect approach to achieve an effective communication by persuading participants within a supply chain network that SC management requires understating the participants needs and wants.

Second, we have proposed evaporating clouds as a tool to convince immediate supply chain members that the solution to the supply chain collaboration core conflict arrives in the form of TDD/IDD measures. These collaborative performance metrics have been presented to encourage the individual links to contribute to the goal of optimizing SC profitability. In addition, evaporating cloud demonstrated that implementing these measures do not necessarily involve sharing information that may be consider sensitive. On the contrary, when implemented effectively they help in identifying the constraint(s) and thereby, initiating TOC-based continuous improvement efforts to generate value by increasing revenues and reducing overall costs simultaneously across an SC network.

Finally, a major limitation to this paper is the use of a hypothetical SC network. We suggest that experiments evaluating the benefits and challenges of incorporating TOC-based measures be devised using realistic supply chain networks.

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