https://doi.org/10.55343/CogSust.48

Application of specific tools of the Theory of Constraints – a case study

Ondrej Stopka
https://orcid.org/0000-0002-0932-4381
Department of Transport and Logistics, Faculty of Technology, Institute of Technology and Business in České Budějovice
České Budějovice, Czech Republic
stopka@mail.vstecb.cz

Vladislav Zitrický
Department of Railway Transport, Faculty of Operation and Economics of Transport and Communications, University of Žilina
https://orcid.org/0000-0003-2430-2479
Žilina, Slovak Republic
vladislav.zitricky@uniza.sk

Vladimír Ľupták
https://orcid.org/0000-0001-7550-5714
Department of Transport and Logistics, Faculty of Technology, Institute of Technology and Business in České Budějovice
České Budějovice, Czech Republic
luptak@mail.vstecb.cz

Mária Stopková
https://orcid.org/0000-0001-6436-4047
Department of Transport and Logistics, Faculty of Technology, Institute of Technology and Business in České Budějovice
České Budějovice, Czech Republic
stopkova@mail.vstecb.cz

Abstract

The Theory of Constraints is a management tool for continuously improving corporate performance. In the USA, it has been very successful, above all due to the contribution of a comprehensive assessment of the issues of managerial control. Its development has also been taking place in the Czech Republic. This paper aims to present the Theory of Constraints tools and then apply some of them to a specific enterprise in logistics activities. The findings in terms of detecting and widening the bottleneck afterwards should exert a positive impact on corporate performance. Current Reality Tree, Conflict Diagram and Future Reality Tree are applied in the paper to eliminate undesirable effects that prevent the enterprise from increasing its performance. Besides providing this specific enterprise with concrete solutions to identified issues, this study aims at depicting the procedure for implementing the methods of the Theory of Constraints, including specific results and benefits of the suggested solutions, along with the quantification of their costs, savings and throughput.

Keywords

Theory of Constraints, Current Reality Tree, Future Reality Tree, Conflict Diagram, streamlining, undesirable effects, desirable effects

1. Introduction

The benefit of the Theory of Constraints is a new perspective on enterprise management. Companies are established to generate profit, which is precisely what the Theory of Constraints is oriented towards, both from the point of view of the present and the future. Indicators other than profit are not considered significant within the Theory of Constraints, which focuses on a measurable enterprise indicator: the throughput. Revenue from the sale of a product or service, from which the invested funds are deducted, is considered a throughput. In the Theory of Constraints sphere, it makes no sense for an enterprise to perform activities that do not increase throughput.

https://doi.org/10.55343/CogSust.48

It is essential to understand the Theory of Constraints in today's business environment, which is characterised by intense competition and unstable conditions, both on the part of potential customers and suppliers and often even employees. A strong competitive environment encourages enterprises to improve continuously, directly related to a prompt response to market changes and prompt decision-making. A fundamental prerequisite for the success of an enterprise is its ability to adapt to changing market conditions. Top-quality management is undoubtedly essential for bringing an enterprise to its success. Ensuring the prosperity of an enterprise is a task that requires more and more effort, thorough analysis, planning, solving problems that have already arisen, and preventing problems. Enterprises can influence their success in the market by looking actively for the weaknesses that do not allow them to achieve higher productivity.

The founder of the entire concept of the Theory of Constraints (TOC) is *Eliyahu Moshe Goldratt (1990)*. He continues to develop the Theory of Constraints in cooperation with his colleagues and presents new findings in several successful books *(Goldratt, Cox, 1992), (Goldratt, Cox, 2016)*. Consulting companies also help enterprises apply the TOC tools in practice. Such an institute has also been operating in the Czech Republic since 1999. The basis of the TOC is a systemic analysis of an enterprise. An *enterprise* is understood as a complex of connected, interdependent processes. The purpose is to find a constraining element that does not allow higher system performance. TOC resolves the problem of limited system performance by finding a bottleneck and then expanding it. A correct solution to the key problem will ensure an increase in the performance of a given system. When a fundamental problem is eliminated, another bottleneck, a new system constraint, must be expanded to increase enterprise performance. Thus the improvement procedure based on TOC is a never-ending process.

This paper aims to present the Theory of Constraints tools and then apply some of them to a specific enterprise in logistics activities. The findings in terms of detecting and widening the bottleneck afterwards should exert a positive impact on corporate performance.

2. Literature review

This review mainly focuses on scientific articles that use individual techniques of the Theory of Constraints in the context of transport and logistics. *Simatupang et al. (2004)* deal with cooperation in a supply chain and discusses the benefits of cooperation in meeting customers' needs and applying the TOC approach in overcoming problems that may arise with cooperating parties in the supply chain. Meanwhile, *Gupta and Boyd (2008)* discuss that the Theory of Constraints can serve as a general theory in operations management. The paper first examines the links between TOC and core concepts/components of operations management and shows how the concepts can be integrated into TOC using examples from the published TOC literature. *Mabin and Balderston (2003)* present TOC as a multifaceted system methodology, offering breakthrough solutions, including their implementation, focusing on documented successful applications of TOC. *Kim et al. (2008)* provide an overview of TOC development from the point of view of the theory of knowledge, whereby they focus on thinking processes and analysing the nature of these processes. *Puche et al. (2016)* combine the application of Beer's Viable System Model (VSM; *Espejo, Harnden, 1989*) and Goldratt's Theory of Constraints (TOC). VSM defines the system structure of a supply chain and organises collaboration, while TOC implements system behaviour, i.e., integrates processes and defines performance measures. *Chronéer and Mirijamdotter (2009)* examine how supply chain management and the Viable System Model (VSM) can support and create effective use of information in product development and thus identify critical links in a supply chain. *Anderluh et al. (2020)* apply a model for the location selection of a midi-hub of a medium city centre in Vienna using an AHP (Analytic Hierarchy Process)-based decision-making support tool. For their research, it was also necessary to investigate the economic standpoint of the suggestions, which is documented by *Hlatká et al. (2017)*. This research implements the exact method in a specific manufacturing enterprise to optimise the distribution route and reduce operational transport costs. Like the previous ones, the study by Kauf et al. (2018) deals with a possible scenario for the desired supplier selection, but in this case, using the Analytical Hierarchy Process. *Hlatká et al. (2017)* apply a specific model for solving supplier shipment routing problems using one of the most widely used heuristic methods that solve vehicle routing tasks, namely the Clarke–Wright-algorithm. The European Journal of Social Sciences published by *Dinçer (2011)* focuses on the application of the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) and WSA (Weighting Sum Approach) methods in terms of a multicriteria decision analysis of economic activity for the EU states and candidate countries evaluated by these two techniques. In this perspective, a system managed through decision-

https://doi.org/10.55343/CogSust.48

making is analysed by *Adetunji et al. (2018)*, where the authors introduce the criteria of an expert opinion into the methodology of managing system obsolescence using decision-making based on multiple criteria, precisely the TOPSIS method and the Monte Carlo simulation. The specific case study, carried out as part of their research work, was developed with the participation of military and civilian experts.

3. Methodology

3.1. Making up the Current Reality Tree (CRT)

Delineation of the area of analysis – determination of the area of the enterprise for which the research and tool application will take place. It is important to collect relevant information and enough of it so that the analysis has relevant, informative value.

Creating a list of entities – after determining the area to which the CRT will be applied, the undesirable effects that create various problems when trying to achieve better performance will be diagnosed. We refer to these entities as Undesirable Effects – UDEs.

A diagram of causes and consequences is created in which UDEs are connected according to Sufficiency Logic. A linear connection, specifically a V-connection, is created with multiple effects from one cause. UDEs are added gradually to a tree until all entities are included. 'Legitimacy reservations (if any) are also assigned to the entities.

Identification of the critical problem – the arrow that connects cause and effect does not lead to the primary causes, as they are input moments; at these points, a determination is made of up to which percentage it is responsible for each Undesirable Effect. A key problem is identified as the problem that causes at least 80% of undesirable effects. If the key problem is not found, common causes of input moments are sought. Once the key problem is found, it is expressed using the Conflict Diagram, with which the problem can be solved (*Guoping et al., 2006; Hua et al., 2006*).

3.2. Conflict Diagram Creation

The key problem is labelled D', the opposite of which is D. The Evaporating Cloud marks the change from 'what to change' to 'what to change it to'. Situation D and D' is the conflict. They cannot coexist. The application of the so-called Injections solves this discrepancy. The purpose of injections is to find a solution that achieves the objective without requiring the existence of D' or making D' invalid. When creating ideas on how to solve the situation, the creator must be uncompromising concerning the set objective. Whether an injection has been implemented correctly can be verified by checking that the conflict between D' and D has disappeared or that the simultaneous coexistence of these entities is possible (*Huang et al., 2012*).

3.3. Future Reality Tree (FRT)

The purpose of this diagram is to display the future situation of an enterprise and to check whether the injections have been implemented correctly, whether they have been sufficient and whether other undesirable effects have occurred. Some entities may appear, while others may disappear. The realisation of the Future Reality Tree consists of creating a basis for the tree, describing relationships using a sufficient cause and improving the quality of the tree (*Lowalekar and Rawi, 2017*)

4. Case study

The basis for creating the Current Reality Tree is to determine the analysis area, create a list of entities, and identify undesirable states. After these steps, the CRT can be processed.

Delineation of the area of analysis –where a survey and the application of the Theory of Constraints tools will take place is the area of textile waste collection. The survey will include routes, employees, owner access, collection points, textile handling, working hours, storage methods, loading and unloading to a replaceable truck body, and all the activities and conditions that affect the textile waste collection area.

Creating a list of entities –to create a list of entities, the enterprise owner, the logistics manager and also the employees and drivers, in this case, were interviewed. First of all, the issue of what problems the owner registers in textile waste collection, what leads to frequent turnover of employees, was analysed. Undesirable effects, by which weaknesses and problems in the company are detected, will be referred to as UDEs. The author asked about the causes of the identified problems, what their consequences are, and what the connections there are between them (*Mahto and Kumar, 2008; Sarkar et al., 2021*)

https://doi.org/10.55343/CogSust.48

Identified undesirable conditions (UDEs):

(1) **C**omplaints are made if the textile is damaged by moisture or is delivered contaminated to the contractual partner. In this case, the contractual partner will not pay for a part of the textile that is not in the required condition.

(2) **Increasing costs of servicing trucks** – long driving distances make it necessary to service vehicles more frequently.

(3) **Employee turnover** – employees in driver positions often leave. It is difficult for the owner to find new employees who can manage physically demanding work in the long term because drivers are also responsible for loading textiles, so they also fulfil the function of assistant drivers.

(4) **Time-consuming loading into the truck body** is time-consuming, related to its physical demands and the lack of handling equipment.

(5) **Work performed poorly by employees** – the owner has experience with employees who have stolen textiles or insufficiently sorted wet and dirty textiles, which can lead to the deterioration of a significant part of textile waste.

(6) **Long driving distances to the cities where the collection takes place –** the routes are not optimised in any way, and a driver does not have an exact determination of where a route should lead. The number of kilometres travelled is high (*Malhotra and Khandelwal, 2022*).

Based on the identified undesirable conditions, a diagram of the Current Reality Tree was created using the mentioned procedure (Figure 1):

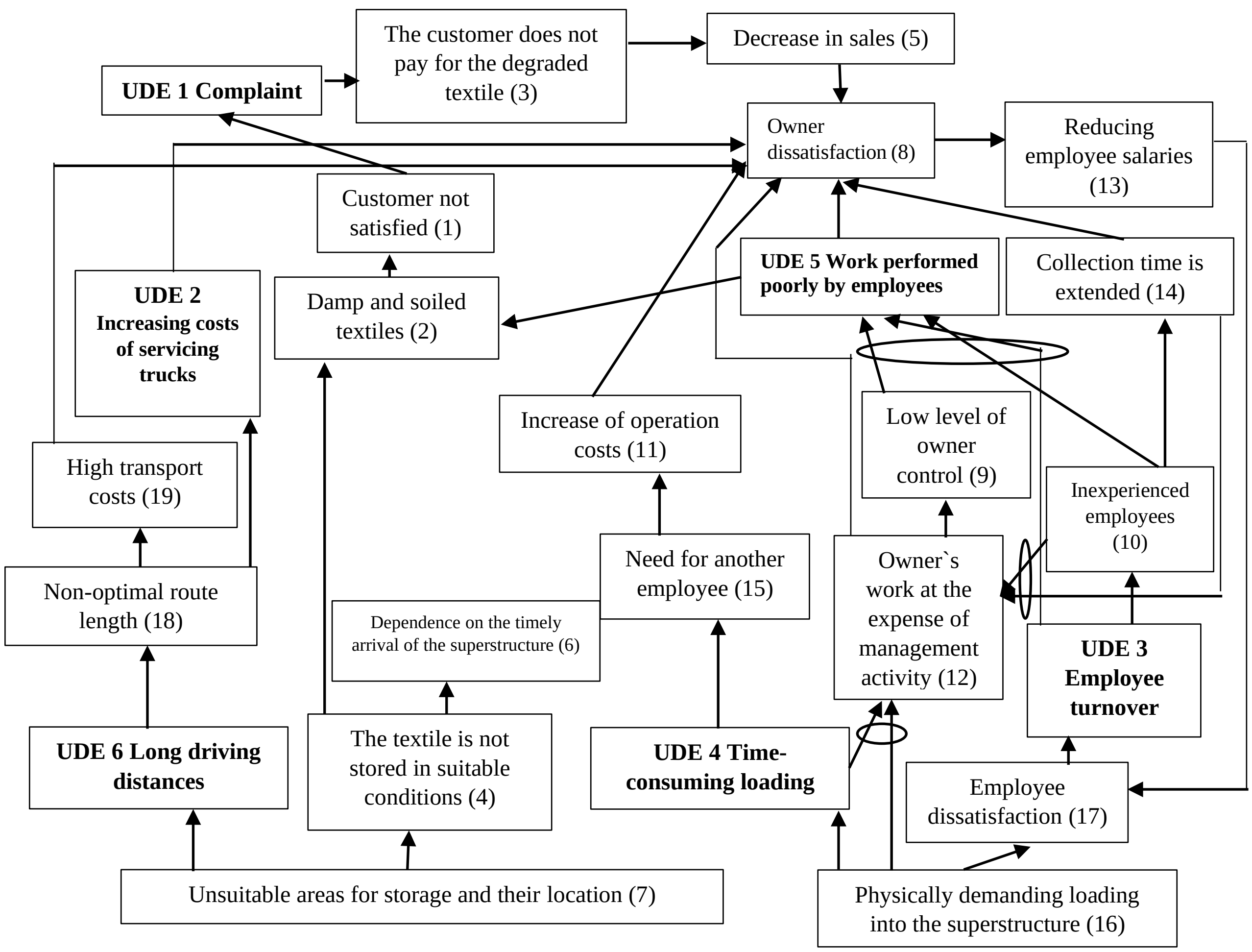

Figure 1: Current Reality Tree (CRT) diagram

https://doi.org/10.55343/CogSust.48

<u>Identification of key problems</u>

The procedure specified in the methodology has been used to identify any key problems. After the creation of the CRT, a check was made to see if there were any redundant branches in the tree, and all the inputs recorded in the diagram were marked. Two key problems were identified– unsuitable storage spaces and their location and physically demanding loading into the truck body. These problems cause the most undesirable effects.

The output of the Current Reality Tree is detailed in Table 1. The results arising from this diagram are summarised after that.

Table 1: Evaluation of the CRT

No.	Cause	Consequence	Description of the situation
UDE 1	1	3	If textile waste has deteriorated, the customer is unsatisfied and makes a complaint and does not pay for the deteriorated part.
1	2	UDE 1	The customer reclaims dirtied and wet textiles.
2	4	1	When textiles are not stored in suitable conditions, they can get wet and dirty, leading to customer dissatisfaction.
3	UDE 1	5	If a complaint is made, the customer will not pay for a part of the textiles that do not meet the quality the customer requires; therefore, the sales for the given month will decrease.
4	7	2,6	Textiles are not stored in suitable conditions since the enterprise's owner has not provided spaces corresponding to the requirements for storing textile waste. This fact results in dependence on the timely arrival of the truck. Otherwise, textiles are stored inappropriately, and their deterioration is risky.
5	3	8	The reason for the decrease in sales is that the customer does not pay for deteriorated textiles, which results in the owner's dissatisfaction.
UDE 5	9,10, UDE 3	8	The employees do poorly work for several reasons; their frequent turnover means that the employees are inexperienced and make mistakes, and checking their work by the owner is low.
6	4		As it is necessary to deliver textiles to the customer in the required condition and the storage spaces are not suitable, there is a specific dependence on the timely arrival of the truck. The existing warehouse cannot hold more than 1 ton of textile waste.
7		4, UDE6	Due to inappropriate warehouses, textiles are stored in inappropriate conditions.
UDE 6	7	18	Driving distances are long because the warehouse and the replaceable truck body are not located based on any logical determination; the warehouse and the truck body were located automatically in the city where the company is headquartered. It results in non-optimal routes.
8	5, UDE 2, 11, 12, UDE 5,14	13	As some employees do not complete their work, the owner has to help with collection or loading, which means that he often has to work overtime in order to be able to fulfil his managerial duties. Because of rising costs and work poorly done by his employees, he resorts to salary reductions.
9	12	UDE 5	The owner does not have time to check the work of the employees, which is one of the reasons for poorly done work.
10	UDE 3	14, UDE 5	The employees are inexperienced, do not know the routes well and cannot evaluate which textiles need to be dried before putting them in bags, the collection time is prolonged, and the work is done poorly.
11	15	8	Operating costs increase because loading onto the bodywork is time-consuming, and the driver often has to be assigned another worker to help him. These employees are then paid overtime. This fact causes the owner’s dissatisfaction.
UDE 4	16	12, 15	Loading into the truck body is time-consuming, so additional employees or the owner must help.
12	UDE 4, 16, 14	8,9, 10	The owner has to help with collections because loading is physically demanding and time-consuming, and the employees are inexperienced. These facts cause the owner’s dissatisfaction and the impossibility of carrying out checks, as he is swamped. If he helps with the collection, he has to catch up with his managerial duties in the following days.
13	8	17	Employees’ payments are reduced because the owner is dissatisfied with their work, which simultaneously leads to employee dissatisfaction.
14	10	8	As the employees are inexperienced, the collection time is prolonged, and the owner is dissatisfied.
15	UDE 4 11		An additional employee during loading is needed if loading is time-consuming, which results in increased operating costs.
16		UDE 4, 12, 17	Loading into the truck body is physically demanding, as the employees do not have any handling equipment. The consequences of physically demanding loading into the truck body result in tired and dissatisfied employees. The owner often has to be involved in helping out, and the physical demands also cause the loading into the truck body to be prolonged.
17	13,16	UDE 3	The employees are dissatisfied due to salary reductions and physically demanding work, leading to a turnover.

https://doi.org/10.55343/CogSust.48

Table 1: Evaluation of the CRT (continued)

No.	Cause	Consequence	Description of the situation
UDE 2	19	8	Vehicle servicing costs are increasing because the routes are not determined rationally; therefore, the number of kilometres driven is high. The enterprise is small, so it uses no software to optimise the routes. The drivers drive at their discretion. Increasing costs lead to the owner's dissatisfaction.
18	UDE 6	UDE 2, 19	Long driving distances are the cause of sub-optimal route length, which results in increasing vehicle servicing and transport costs. Since the employees do not have an exact procedure for the collection (in which city they should start and where they should end) and the enterprise does not use any software, the length of the routes is not determined frugally.
19	18	8	As the routes are not determined frugally, there are unnecessary transport costs, resulting in the owner's dissatisfaction with the current state.

Conflict Diagram (Evaporating Cloud)

The solution of the key problems will be determined using the Conflict Diagram, based on which injections will be designed and implemented (*Richnák, 2022*).

Injection 1 – Unsuitable spaces for storage and their location

The key problem of an unsuitable warehouse lies in its insufficient capacity. The warehouse now only holds three tons of textile waste. The problem arises when the truck body is replaced a week later. At that moment, approximately 9.6 tons of textile waste need to be stored until the truck body arrives. This delay happens relatively often, and there is no place to store textile waste afterwards. Figure 2 presents the solution through the Conflict Diagram.

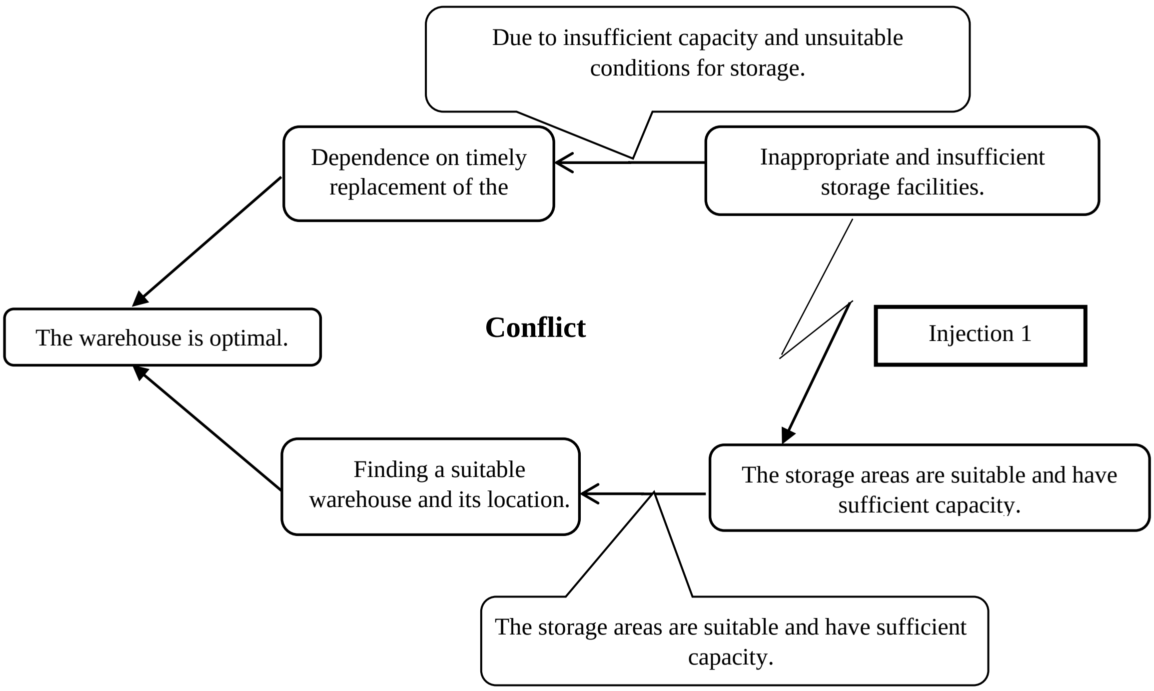

Figure 2: Injection 1

The problem will be solved by renting a new warehouse, the capacity of which will correspond to the amount of textile waste. The minimum amount of textiles that need to be stored in the event of delayed arrival of a new truck body is 9.6 tons – it would be advisable to find a warehouse where the capacity reserve would be at least half a ton. In order to make maximum

https://doi.org/10.55343/CogSust.48

use of this constraint, in addition to finding a new place for the warehouse in terms of space, a place will also be searched for in terms of a rational location about the cities in which the collection takes place and the driving distances to these cities. For this purpose, the centre-of-gravity method will be used. Afterwards, routes to the new warehouse will be determined, where the replaceable truck body will be driven.

Injection 2 – Loading into the truck body is physically demanding and time-consuming

Physical demands result in employee turnover and are related directly to the time required for loading. There is a problem with the lack of handling equipment that would make the work easier. The following injection in Figure 3 describes how to eliminate the key problem (Šimek et al., 2021).

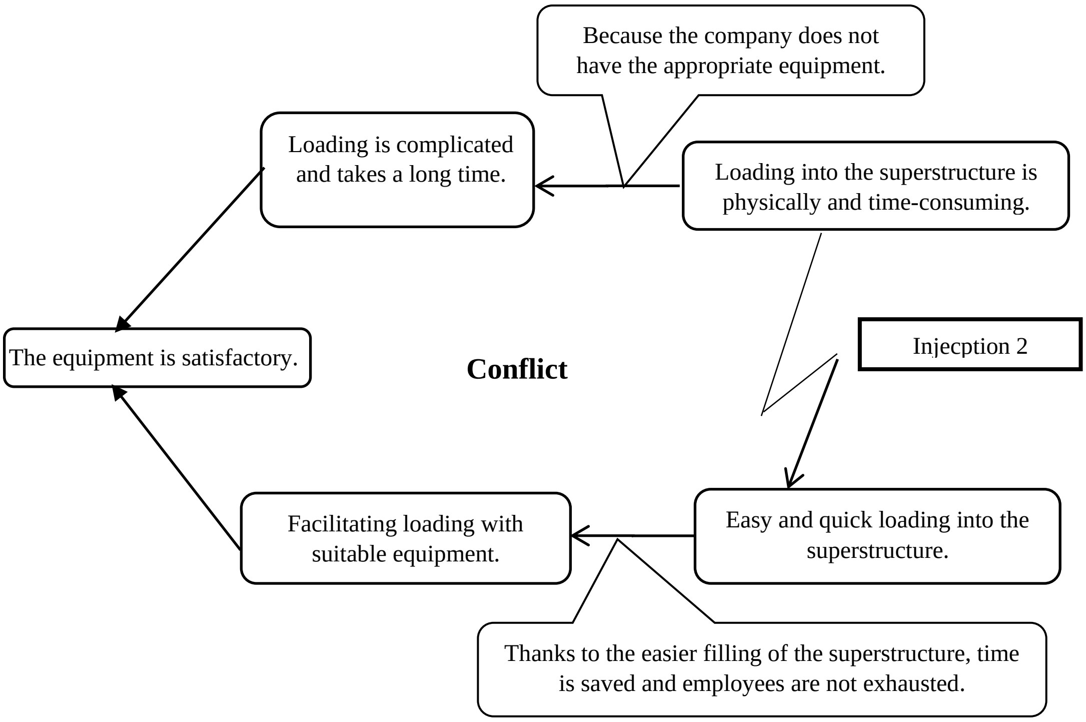

Figure 3: Injection 2 (source: authors)

The solution to eliminating the problem of physically demanding loading is to purchase a belt conveyor. A belt conveyor makes work easier for the employees and reduces the time spent on handling bags of textiles. Implementing Injection 2 will increase performance, although an investment in a belt conveyor will be required.

Summary of injections

Breaking down TOC and the methods used to make changes, TOC is based on two types of logical thinking. According to this logic, the key problem of unsuitable storage space must be solved so that the new space is sufficient in terms of space and conditions for storing textile waste and, at the same time, is optimally located. A necessary condition for removing restrictions is to ensure a warehouse with optimal parameters and is rationally located. It is necessary to think not only about the warehouse space but also about its location. The problem of physically demanding loading into the truck body can be characterised by insufficient handling equipment, i.e. insufficient resources. In order to facilitate and speed up the employees' work, it would be advisable, in consultation with the enterprise's owner, to purchase a belt conveyor for transporting bags of textiles to the replaceable truck body. Whether all the problems have been removed will be checked by the Future Reality Tree (*Skrúcaný et al., 2021; Poliak et al., 2022*).

https://doi.org/10.55343/CogSust.48

The output of implementing Injection 1

The implementation of Injection 1 solved several problems. The main problem was the insufficient warehouse and its inappropriate location. Using the centre-of-gravity method, it was determined that the town of Týn nad Vltavou is a logical place for the location of the warehouse. In connection with this change, new routes have been laid out. The total distance driven has been shortened by 111 km per week. Resolving undesirable effects through this change will be entered into the Future Reality Tree (FRT) (*Kubanova et al., 2022; Baric and Zeljko, 2021*).

Injection 2 – Suggestion of a belt conveyor for loading into the replaceable truck body

In order to load bags of textile waste into the replaceable truck body to facilitate the work, an inclined belt conveyor with a traction element is needed. The weight of a bag is 20 to 30 kilograms, and the maximum dimensions of the bags used are 700 × 1100 mm. The upper edge of the replaceable truck body is 4.85 cm high. 85 cm are the legs on which the truck body is placed. The required length of the belt conveyor is 6 meters – based on consultation with a specialised company. The width of the conveyor, according to the dimensions of the bags, must be at least 80 cm. A suitable conveyor is an inclined belt conveyor that can be permanently located in outdoor conditions. The price of such a conveyor is around 150,000 CZK. The best and most comfortable variants of belt conveyors for the needs of the enterprise cost around half a million CZK. The purchase prices of new belt conveyors are significantly higher than second-hand ones. The price of second-hand belt conveyors that meet the enterprise's needs is around 40,000 CZK.

The average weight of a bag of textiles is 25 kilograms. The quantity of bags that are transported on individual routes is recorded in the following Table 2.

Table 2: Time required for loading into the truck body with a belt conveyor

	Number of bags	Time to transport bags by belt conveyor to the truck body	Time to arrange bags in truck body	Total time for loading bags into one truck body
Route 1	136	34 min.	45 min.	1 hour 19 min.
Route 2	126	31.5 min.	42 min.	1 hour 13.5 min.
Route 3	123	31 min.	41 min.	1 hour 12 min.
Total	392	1 hour 36.5 min.	131 min.	3 hour 44.5 min.

The time to load the bags of textile waste into the replaceable truck body was measured and recorded on each route. A specialised company recommended a belt conveyor with a speed of 1 meter in 3 seconds, and the driver could load about four bags on it per minute. The method of loading bags in the truck body is specific, and the bags must be trampled in. After every 30 bags, the belt conveyor should stop, and the bags should be levelled and trampled in. A worked manages to do this operation in 10 minutes. A comparison of the original time spent loading into the truck body with the time when using a belt conveyor is shown for individual routes in the following Table 2. The comparison is made with data for newly designed routes with a new location of the warehouse, i.e. with data from Table 3:

Table 3: Time savings using a belt conveyor

	Loading time into the truck body		
	Without belt conveyor	With belt conveyor	Savings
Route 1	2 hours 33 min.	1 hour 19 min.	1 hour 14 min.
Route 2	2 hours 22 min.	1 hour 14 min.	1 hour 8 min.
Route 3	2 hours 19 min.	1 hour 12 min.	1 hour 7 min.
Total	7 hours 14 min.	3 hours 45 min.	3 hours 29 min.

Source: own creation

With a belt conveyor, there would be a significant reduction in the time required for loading. More than an hour would be saved on collection day.

The output of implementing Injection 2

The second key problem was insufficient handling equipment for loading into the truck body. In the current situation, drivers have to load the entire volume of textiles manually, which is demanding both physically and in terms of time. This

https://doi.org/10.55343/CogSust.48

problem can be solved with suitable handling equipment. A belt conveyor would make work easier and, at the same time, reduce loading time. A reduction in employee turnover is expected, as most employees justify leaving their job positions due to physical demands and length of working hours (*Salamakhina et al., 2021*).

Evaluating the Future Reality Tree (FRT) diagram

In order to show the condition after the implementation of the injections and also to check whether the injections have solved the given problems found in the Current Reality Tree, the Future Reality Tree was created (Figure 4):

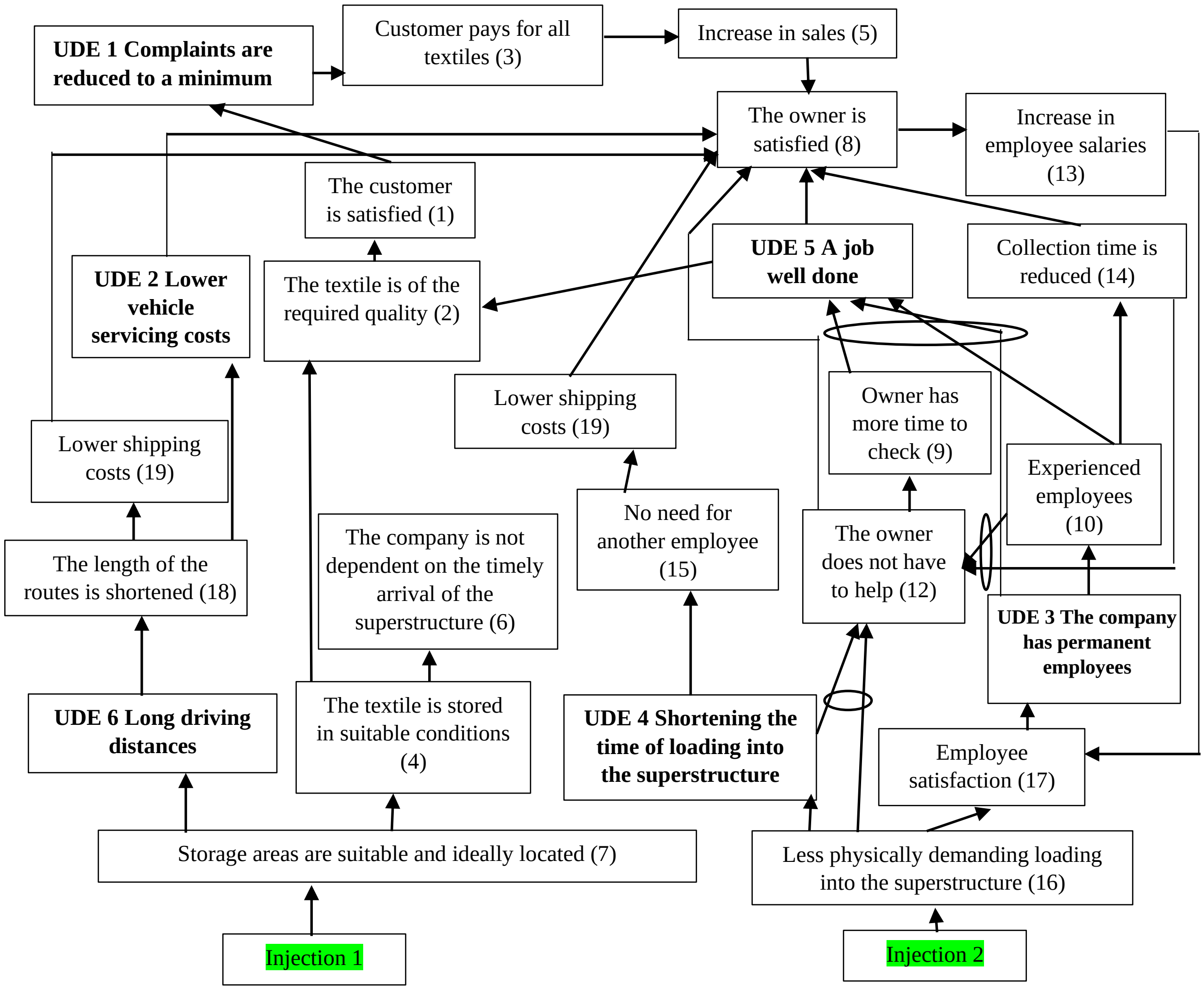

Figure 4: FRT

The Future Reality Tree expresses the desired condition, the condition after the implementation of the injections.

Desirable effects (DEs): 1 Complaint are reduced to a minimum. 2 Lower vehicle servicing costs. 3 Reduced employee turnover. 4 The time required for loading into the truck body is reduced. 5 The employees will do their work well, and the damage caused by them is minimal. 6 The driving distances to collection cities are shortened (*Klapita, 2022*).

Evaluation of the FRT

Injection 1 has solved the key problem of the inappropriate warehouse, including its irrational location. This problem was followed by undesirable entities, of which there were 15. A suitable location for a new warehouse was determined using the centre-of-gravity method, and a warehouse in a specific town of Týn nad Vltavou was also suggested, including its size and the specific premises where the warehouse with the required parameters located.

https://doi.org/10.55343/CogSust.48

A new location for the warehouse was determined using the centre-of-gravity method, which directly related to streamlining the routes. Thus the continuity of the individual cities on the routes must be determined, leading to more efficient service for the given cities. The saving in kilometres stems primarily from the change in the location of the central warehouse.

Injection 2 has been implemented to eliminate the problem of physically demanding the loading of textile waste into the replaceable truck body. The solution to this injection is the acquisition of a belt conveyor, which will significantly facilitate the work during loading, thereby eliminating a significant part of the undesirable effects. The course of the Future Reality Tree is detailed in the following Table 4:

Table 4: Course of the FRT

No.	Cause	Consequence	Description of the situation
Injection 1		7	A new warehouse is rented at an ideal location.
Injection 2		16	A belt conveyor makes loading more straightforward and faster.
1	2	UDE 1	The customer is satisfied because their requirements are met,
2	4	1	Textiles arrive at the contractual partner in the condition they require.
UDE 1	1	3	Complaints are reduced.
3	UDE 1	5	The contractual partner accepts the entire delivery of textile waste.
4	7	2,6	A sufficient and suitable warehouse relieves the enterprise of the problem of dependence on the timely arrival of the truck body, and the goods go to the customer in the required quality.
5	3	8	There is an increase in sales.
6	4		The storage spaces allow the storage of all textiles if the truck body's replacement does not occur on the agreed day.
7		UDE 6, 4	The new warehouse location will shorten distances and improve textile storage conditions.
8	UDE 2, 5, UDE 5 11,12, 14, 19	13	As costs are eliminated, and the employees work well, the owner is satisfied and willing to increase their salaries.
UDE 5	UDE 3, 9, 10	8	Work is done well.
9	12	UDE 5	The owner has more time to check the employees' work.
UDE 3	17	UDE5, 10	Employee turnover is low.
10	UDE3	UDE 5, 12, 14	The employees are experienced.
11			Reduction of operating costs.
UDE 4	16	12, 15	Loading time is reduced.
12	UDE 4, 16	8,9	The owner does not have to help out for employees and has enough time to manage the enterprise.
13	8	17	Increasing the salary of the employees increases their satisfaction.
14	10	8,12	The collection time is reduced.
15	UDE 4	11	The employee does not need to hire another assistant driver or pay overtime to another employee for help with loading.
16		UDE 4, 12, 17	Loading into the truck body is facilitated, loading time is reduced, the owner has more time to manage the enterprise, and the employees are more satisfied.
17	16	UDE 3	The employees are satisfied because loading into the truck body is not so physically demanding.
UDE 6	7	18	The route is shorter compared to the original condition.
18	UDE 6	19, UDE 2	Thanks to the reduced number of kilometres driven, the transport costs and servicing of the vehicles are lower.
UDE 2	18	8	Low vehicle service costs are a positive indicator, which leads to the owner's satisfaction.
19	18	8	Lower costs lead to an improvement in the enterprise's financial situation, which makes the owner satisfied.

5. Conclusion

The objective of the paper was to analyse an enterprise's current situation in logistics activities to apply the tools of the Theory of Constraints to increase performance in the given area of business.

The success or failure of the enterprise is in the hands of the enterprise's management. The management's effort is to make the best possible use of the invested capital, for which various management tools can be used. Unlike other management methods, the Theory of Constraints focuses on the bottleneck, which is the limiting element of the enterprise's throughput. Such a point can be found in every enterprise because its existence means a particular limitation of performance, which would be infinite without the bottleneck.

https://doi.org/10.55343/CogSust.48

At first the Current Reality Tree was first created. It was used to identify key issues. These issues were analysed by applying the Conflict Diagram. Specific practical solutions were then suggested to eliminate and maximise the use of these problems. The centre-of-gravity method was used to solve the problems, after which the specific required warehouse size was designed for textile waste storage needs. Based on the new location of the warehouse, ideal routes to serve the cities were recommended. Another key problem was eliminated by suggesting a belt conveyor, which will facilitate the employees' work and reduce the loading time. Whether all the undesirable entities were solved or not was ascertained and confirmed by the Future Reality Tree, which presents the ideal state of the given system after implementing the required changes.

The following suggestions are the greatest benefit of applying specific tools of the Theory of Constraints for the enterprise.

- The new location of the warehouse brought mileage savings and helped significantly to increase the throughput.
- A new storage space, thanks to which the enterprise will not have complications associated with insufficient storage space in the event of a late arrival of an empty replaceable truck body, and the risk of textile deterioration will be eliminated, and the number of complaints will be reduced.
- The purchase of a belt conveyor will ensure an improvement in conditions for the employees, a reduction in the physical demands of loading into the replaceable truck body, and thus a reduction in employee turnover and inexpertly performed work is likely. Last but not least, this suggestion will reduce the time required for loading, leading to lower costs for employee overtime.

Acknowledgement

The VEGA Agency supports the paper by Project 1/0798/21, "The Research on the Measures to Introduce Carbon Neutrality in the Rail and Water Transport" that is solved at Faculty of Operation and Economics of Transport and Communications, University of Zilina.

This research was also funded by the SVV project 02SVV2325, funded by the Ministry of Education, Youth and Sports, Czech Republic.

References

Adetunji, O., Bischoff, J., Willy, C. J. (2018). Managing system obsolescence via multicriteria decision making. *Systems Engineering*, 21(4), 307–321.DOI: https://doi.org/gdxsk4

Anderluh, A., Hemmelmayr, V. C., Rüdiger, D. (2020). Analytic hierarchy process for city hub location selection-the Viennese case. Paper presented at the *Transportation Research Procedia*, 46, 77–84. DOI: https://doi.org/gh38bm

Baric, D., Zeljko, L. (2021). Multicriteria Decision-Making on Road Transport Vehicles by the AHP Method. *The Archives of Automotive Engineering – Archiwum Motoryzacji*, 94(4), 17–26. DOI: https://doi.org/j4g3

Chronéer, D., Mirijamdotter, A. (2009). Systems thinking benefits in supply change management: An illustration of the viable systems model in a supply chain. *International Journal of Intelligent Systems Technologies and Applications*, 6(3-4), 227–248. DOI: https://doi.org/cdqdkf

Dinçer, S. E. (2011). Multicriteria analysis of economic activity for european union member states and candidate countries: TOPSIS and WSA applications. *European Journal of Social Sciences*, 21(4), 563–572.

Espejo, R., & Harnden, R. (1989). The viable system model: interpretations and applications of Stafford Beer's VSM. *John Wiley & Sons Inc*.

Goldratt, E. M. (1990). Theory of constraints (pp. 1-159). Croton-on-Hudson: North River.

Goldratt, E. M., & Cox, J. (1992). The goal: a process of ongoing improvement. *Routledge*.

Goldratt, E. M., & Cox, J. (2016). The goal: a process of ongoing improvement. *Routledge*. Second Rev. Ed., North River Press Publishing Corporation, Great Barrington, MA.

Guoping, L., Runhua, T., Zhansheng, L., Huangao, Z. (2006). Idea generation for fuzzy front end using TRIZ and TOC. Paper presented at the ICMIT 2006 Proceedings – *2006 IEEE International Conference on Management of Innovation and Technology*, 2, 590–594. DOI: https://doi.org/bcqf93

Gupta, M. C., Boyd, L. H. (2008). Theory of constraints: A theory for operations management. *International Journal of Operations and Production Management*, 28(10), 991–1012. DOI: https://doi.org/b34ms8

Hlatká, M., Bartuška, L., Ližbetin, J. (2017). Application of the Vogel approximation method to reduce transport-logistics processes. Paper presented at the *MATEC Web of Conferences*, 134. DOI: https://doi.org/j4g4

Hua, Z-S., Coulibaly, S., Wang, W. (2006). TOC and TRIZ based product design method and its application. *Jisuanji Jicheng Zhizao Xitong/Computer Integrated Manufacturing Systems*, *CIMS*, 12(6), 817-822.

Huang, W., Hou, L., Zhao, N., Lin, W. (2012). Product innovation and evaluation based on TOC and TRIZ. *Advanced Materials* Research, 421, 709–712. doi:10.4028/www.scientific.net/AMR.421.709.

Kauf, S., Tłuczak, A. (2018). Allocation of logistic risk-investment in public-private-partnership - use of fuzzy TOPSIS method. Paper presented at the *MATEC Web of Conferences*, 184. DOI: https://doi.org/j4g5

Kim, S., Mabin, V. J., Davies, J. (2008). The theory of constraints thinking processes: Retrospect and prospect. *International Journal of Operations and Production Management*, 28(2), 155–184. DOI: https://doi.org/ddk3sk

https://doi.org/10.55343/CogSust.48

Klapita V. (2022). Simulation as Tool for Logistic Chain Optimization. *Transport Technic and Technology*, 18(2), 15–20. DOI: https://doi.org/j4g6

Kubanova, J., Kubasakova, I., Poliak, M. (2022). The Comparison of the Risks and Forwarding Company Performance Compared to Average Performance in Selected EU Markets. *Archives of Automotive Engineering*, 95(1), 32–52. DOI: https://doi.org/j4g7

Lowalekar, H., Ravi, R. R. (2017). Revolutionising blood bank inventory management using the TOC thinking process: An Indian case study. *International Journal of Production Economics*, 186, 89-122. DOI: https://doi.org/f938wb

Mabin, V. J., Balderstone, S. J. (2003). The performance of the theory of constraints methodology: Analysis and discussion of successful TOC applications. *International Journal of Operations and Production Management*, 23(5–6), 568–595. DOI: https://doi.org/b6mmrt

Mahto, D., Kumar, A. (2008). Application of root cause analysis in improvement of product quality and productivity. *Journal of Industrial Engineering and Management*, 1(2), 16–53. DOI: https://doi.org/bhjtf6

Malhotra, S., Khandelwal, M. (2022). Solving XpressBees logistics problem by using exact and heuristic method. *LOGI – Scientific Journal on Transport and Logistics*, 13(1), 37–48. DOI: https://doi.org/j4g8

Poliak, M., Beňuš, J., Lăzăroiu, G. (2022). Violations of Social Regulation and Traffic Accidents in Road Freight Transport. Archives of Automotive *Engineering*, 97(3), 51–59. DOI: https://doi.org/j4g9

Puche, J., Ponte, B., Costas, J., Pino, R., De La Fuente, D. (2016). Systemic approach to supply chain management through the viable system model and the theory of constraints. *Production Planning and Control*, 27(5), 421–430. DOI: https://doi.org/j4hb

Richnák, P. (2022). Current perspectives on development of industry 4.0 in logistics of machinery and equipment industry in Slovakia. *LOGI – Scientific Journal on Transport and Logistics*, 13(1), 25–36. DOI: https://doi.org/j4hc

Salamakhina, E., Poliakova, A., Tomaszewska, I., Gašparík, J. (2021). Research of the TQM evaluation in a service company. *The Archives of Automotive Engineering – Archiwum Motoryzacji*, 93(3), 27–37. DOI: https://doi.org/j4hd

Sarkar, D., Jha, K. N., Patel, S. (2021). Critical chain project management for a highway construction project with a focus on theory of constraints. *International Journal of Construction Management*, 21(2), 194–207. DOI: https://doi.org/j4hf

Simatupang, T. M., Wright, A. C., Sridharan, R. (2004). Applying the theory of constraints to supply chain collaboration. *Supply Chain Management*, 9(1), 57–70. DOI: https://doi.org/bm7tsv

Skrúcaný, T., Kendra, M., Čechovič, T., Majerník, F., Pečman, J. (2021). Assessing the energy intensity and greenhouse gas emissions of the traffic services in a selected region. *LOGI – Scientific Journal on Transport and Logistics*, 12(1), 25–35. DOI: https://doi.org/j4hg

Šimek, L., Cempírek, V., Gross, P. (2021). Can B2B implementation enhance competitiveness of logistic companies in coronavirus economic recession? *LOGI – Scientific Journal on Transport and Logistics*, 12(1), 1–12. DOI: https://doi.org/j4hh