

**Czech University of Life Sciences Prague**

**Faculty of Economics and Management**

**Department of Systems Engineering**



**Bachelor Thesis**

**Multicriteria Decision Making in Company Operations**

**Monika Filipová**

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# BACHELOR THESIS ASSIGNMENT

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Economics and Management

Thesis title

**Multicriteria Decision Making in Company Operations**

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## Objectives of thesis

This thesis seeks to enhance operational efficiency within the candy manufacturing and logistics sector. It will conduct an analysis of the current candy maturation process, evaluating its efficacy in terms of key factors. Additionally, alternative methods for the maturing process will be identified and assessed, and utilizing mathematical decision-making methodologies, the thesis will compare these alternatives to determine the optimal approach. By addressing these objectives, this thesis endeavors to contribute valuable strategies for improving efficiency in the logistics industry of candy manufacturing.

## Methodology

The Thesis involves exploring various methods, including their application and comparative analysis, utilizing insights from diverse authors in specialized literature. Data is initially gathered on the current candy maturation process and alternative transit methods to England, focusing on key factors. Subsequent analysis using mathematical decision-making techniques evaluates process efficiency and alternative feasibility. Comparison of alternatives against predefined criteria then identifies the most effective options. Through this structured approach, the thesis aims to generate valuable insights and strategies for enhancing efficiency in candy manufacturing and logistics.

## The proposed extent of the thesis

40

## Keywords

Supply chain optimization, Decision-making methods, Logistics management, Transportation logistics

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## Recommended information sources

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## **Declaration**

I declare that I have worked on my bachelor thesis titled " Multicriteria Decision Making in Company Operations" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 4.3.2026

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# Multicriteria Decision Making in Company Operations

## Abstract

This bachelor thesis analyzes the optimization of logistics processes in a manufacturing company, with a focus on increasing efficiency and reducing overall costs within the supply chain. The main objective of the thesis is to evaluate alternative logistics solutions and propose the most suitable option based on economic, environmental, and operational criteria.

The theoretical part introduces the fundamental concepts of logistics, supply chain management, and multi-criteria decision-making methods. Special attention is given to the role of logistics in company performance, cost structure, and cash flow management. The practical part applies selected multi-criteria evaluation methods to compare different logistics scenarios, considering factors such as transportation costs, time efficiency, product quality risks, environmental impact, and financial implications.

Based on the conducted analysis, the thesis identifies the most effective solution and justifies the recommendation regarding both short-term operational efficiency and long-term strategic sustainability. The results demonstrate the importance of systematic decision-making tools in logistics management and highlight their contribution to improving overall business performance.

**Keywords:** Supply chain optimization, Decision-making methods, Logistics management, Transportation logistics, Inventory management, Production planning, Food industry

# Multikriteriární rozhodování v provozu společnosti

## Abstrakt

Tato bakalářská práce se zabývá optimalizací logistických procesů ve výrobním podniku se zaměřením na zvýšení efektivity a snížení celkových nákladů v rámci dodavatelského řetězce. Hlavním cílem práce je zhodnotit alternativní logistická řešení a navrhnout nejvhodnější variantu na základě ekonomických, environmentálních a provozních kritérií.

Teoretická část představuje základní pojmy z oblasti logistiky, řízení dodavatelského řetězce a vícekriteriálního rozhodování. Detailněji je zpracován vliv logistiky na výkonnost podniku, uspořádání nákladů a řízení cash flow. Praktická část aplikuje vybrané vícekriteriální metody na porovnání různých logistických scénářů, přičemž zohledňuje faktory, jako jsou náklady na dopravu, časová náročnost, rizika spojená s kvalitou produktu, dopady na životní prostředí a finanční souvislosti.

Na základě provedené analýzy práce identifikuje nejefektivnější řešení a zdůvodňuje doporučení s ohledem na krátkodobou provozní efektivitu i dlouhodobou strategickou udržitelnost.

**Klíčová slova:** Optimalizace dodavatelského řetězce, Logistika, Rozhodovací metody, Dopravní logistika, Řízení zásob, Plánování výroby, Potravinářský průmysl

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# 1 Introduction

Decision-making is an important part of managerial practice, especially in logistics and supply chain management, where decisions often involve several possible alternatives and multiple evaluation criteria. These criteria may include costs, time, quality, environmental impact, and risk, which are often in conflict. Choosing the most suitable option therefore requires a careful and structured approach.

While simple decisions based on a single criterion can usually be made intuitively, real-world logistical problems are more complex. Increasing pressure on efficiency, delivery times, and quality makes it difficult to rely only on experience or intuition. For this reason, systematic decision-making methods are increasingly used to support clear and transparent evaluations of available alternatives.

Multi Criteria Decision Making (MCDM) methods offer tools for comparing several alternatives with respect to multiple criteria and their relative importance. These methods are widely applied in various fields, including logistics, economics, engineering, and environmental management. In supply chain management, MCDM methods are commonly used for tasks such as process optimisation, transport planning, and risk evaluation.

This bachelor thesis focuses on the application of multi-criteria decision-making methods to a logistics-related problem in supply chain management. The objective of the thesis is to evaluate selected decision alternatives and identify the most suitable solution based on economic, operational, environmental, and quality-related criteria. Particular attention is given to quality related risk, as it represents an important factor in the evaluated decision problem.

The thesis consists of a theoretical and a practical part. The theoretical part introduces the basic concepts of logistics from financial point of view and selected MCDM methods. The practical part applies the chosen method to a case inspired by real logistical conditions and discusses the obtained results, including a sensitivity analysis of the final ranking.

## 2 Objectives

The primary aim of this thesis is to develop a proposal for optimizing the maturation and transportation process of *Gleams* candy to improve operational efficiency within the manufacturing and logistics sectors. To achieve this, the thesis first identifies key inefficiencies in the current process, particularly focusing on lead time, inventory costs, and product quality. It then explores alternative solutions that integrate the maturation period with the transportation phase, ensuring that the required temperature range is consistently maintained throughout the journey. These proposed solutions are evaluated using MCDM techniques, with assessments based on economic efficiency, safety risk, quality risk, environmental impact, lead-time and cash flow implications. Ultimately, the thesis determines the most effective solution and provides a comprehensive recommendation aimed at enhancing the overall efficiency of the maturation and transportation process.

## 3 Methodology

This Thesis explores ways to optimize the logistics and maturation process of *Gleams* candy by identifying the most efficient transportation strategy. To achieve this, the research combines qualitative data collection with quantitative MCDM tools. The following research questions were formulated to guide the study:

*What are the main inefficiencies in the current maturation and transportation process?*

*Which alternative, considering economic and operational constraints, provides the optimal balance between cost, time, and product quality?*

The research is structured as a systematic analytical process, beginning with a detailed investigation of the current state of the supply chain. This phase was conducted through a series of interviews with the company's logistics manager, a member of Factory Leadership Team, whose 25 years of experience provided the necessary grounding for the study. These interviews focused on mapping the seven-day maturation period of *Gleams*, currently held in external warehouses, identifying specific inefficiencies such as excessive handling costs and capital tied in inventory. Based on these insights, five alternatives were formulated for evaluation: four (A1 - A4) integrating the maturation process into the transit period, while the fifth (A5) representing the current status.

The analysis relies on a two - step methodology to maintain high levels of objectivity and mathematical accuracy. First, Saaty's method is used to determine the importance (weights) of the chosen criteria. This involves creating a comparison matrix where each criterion is compared to others on a scale of 1 to 9 based on logistics expert ranking. To make sure these judgments are logical and consistent, the Consistency Ratio (CR) is calculated.

Afterwards, the TOPSIS method is applied to rank the formulated alternatives. This process begins with the creation of a decision matrix, where each alternative is assigned a value for every criterion. Because these values often use different units, such as Euro amounts, number of days, or risk levels, the data is next normalized to a comparable scale. Normalized values are then multiplied by the weights calculated by Saaty's method to reflect the real importance of each factor.

The principle of the method lies in identifying the "Positive Ideal Solution," which represents the best possible values achieved across all alternatives, and the "Negative Ideal Solution," representing the worst. For each alternative, the geometric distance to both of these points is calculated. The final ranking is then determined by a closeness coefficient ( $C_i$ ), which measures how close an alternative is to the ideal result while being as far as possible from the worst case scenario. This approach ensures that the chosen strategy is the most balanced and efficient choice for the company.

To ensure the robustness of the solution, a detailed sensitivity analysis is afterwards calculated. This stage serves as a practical test by examining how the final ranking changes when the importance of criteria varies. The analysis was performed in a series of steps: the weight of the most influential criterion (based on criteria weights calculated by Saaty's method) was varied within a range of  $\pm 25\%$  from its initial value, while the weights of all other criteria were recalculated based on their original proportions. This proportional redistribution ensures that the relative ratios between the remaining criteria stay constant and that the sum of all weights always equals 1.0. For each specific change in weight, the entire TOPSIS algorithm was fully recalculated, including the weighted normalized matrix and the final closeness coefficients ( $C_i$ ).

In the final step of the sensitivity analysis, results were compared across all the scenarios to identify the 'break-even point' at which the ranking of the leading alternative changes. This enables a systematic evaluation of the solution's stability under changing conditions. The study concludes by defining the safety margin of the recommendation,

showing how much the company's priorities can shift before a different logistics strategy becomes more effective. This approach ensures that the final recommendation is not just a static calculation, but a reliable tool for strategic decision-making in a changing market environment.

## 4 Literature Review

### 4.1 Logistics, and its financial aspects

Every organisation has to move materials. Manufacturers have factories that collect raw materials from suppliers and deliver finished goods to customers. Most of us live in towns and cities and eat food brought in from the country. When the books are ordered from a website, a courier delivers them to a house door, and when a mobile phone is bought, it has probably travelled around the world to reach its user. Every time a rent is bought, lease, hire or borrow anything at all, someone has to collect it and deliver it. Logistics is the function responsible for this movement (Waters, 2019).

Modern definitions, such as that provided by Christopher (2016), describe logistics as a strategic management function. This involves the integrated control of procurement and material flows with the ultimate goal of maximizing profitability (Hanne & Dornberger, 2017b).

In the global economy, logistics has evolved from a purely operational task into a critical source of competitive advantage. As Christopher (2016) notes, logistics management is no longer just about the efficient movement of goods, but rather about the strategic coordination of the entire supply chain to meet customer requirements more effectively than the competition. This strategic dimension necessitates a seamless integration of information and material flows to enhance overall business performance. At the heart of an organisation are the operations that create and deliver the operations products. These operations take a variety of inputs and convert them into desired all the activities that create an organisation's products outputs. Logistics manages the flow of inputs from suppliers, the movement of materials through different operations within the organisation, and the flow of materials out to customers.

Moving materials into the organisation from suppliers is called inbound or inward logistics; moving materials out to customers is outbound or outward logistics; moving materials within the organisation (often described as collecting from internal suppliers and delivering to internal customers) is materials management (Waters, 2019).

In the context of modern business practices, logistics is understood more broadly than just the internal movement of materials.

The trend towards wider definitions of logistics has been incorporated in the idea of what is today called supply chain management. In particular, this concept has been motivated by the awareness that many logistic processes are not just relevant in a considered company but that such processes should also be considered at suppliers and customers for providing a good product or service to end customers. Moreover, from the viewpoint of involved companies, it often makes sense to plan these activities in an integrated way to recover the contribution of the partners in the supply network and to maximize their added value (Hanne & Dornberger, 2017a).

According to Donald Waters (2019), logistics, as an expensive function, has a clear impact on an organisation's financial performance. In the example of Konigshaven Schlessar it is shown that any savings in logistics costs give an immediate increase in profit. In this light, the Institute of Supply Management estimate that every 1% saved in materials delivery cost gives the same benefit as a 5% increase in sales.

Financial importance of logistics from a company's return on assets (ROA) is shown, defined as the pre-tax profit divided by the value of assets employed.

$$\text{Return on assets} = \text{profits earned} / \text{assets employed}$$

This gives a measure of how well an organisation's resources are used, and higher values usually suggest better performance.

Assets are described as either current (cash, accounts receivable, stocks, etc.) or fixed (property, plant, equipment, etc.). Both of these depend on logistics. For instance, improving the flow of materials reduces the amount of stock held, and this lowers the value of current assets. Similarly, improving the utilisation of facilities and equipment reduces the amount needed, thereby reducing fixed assets (Waters, 2019).

Beyond the impact on ROA, logistics performance is a primary driver of overall shareholder value. This is achieved by accelerating the cash-to-cash cycle, which represents the time between paying for raw materials and receiving payment, thereby minimizing the requirement for working capital. This acceleration not only enhances liquidity but also improves the company's ability to generate value for its investors (Lambert and Burduroglu, 2000).

Moreover, logistics efficiency significantly contributes to better cash flow management. As Christopher (2016) underlines, by improving the flow of materials and reducing lead times, companies can further lower their inventory levels. This reduction not only decreases storage costs but also frees up capital that would otherwise be tied up in stock. The freed-up capital can then be allocated to other critical business operations, thereby improving the company's liquidity and overall financial health.

The importance of lead time reduction is further described in supply chain research focusing on agility. Christopher & Towill (2001) highlights that shorter lead times enhance supply chain responsiveness and flexibility, which are critical in dynamic market environments. By reducing time delays across the supply chain, companies can lower safety stock levels and minimize inventory-related costs. This contributes not only to operational efficiency but also to improved financial performance through better utilization of resources.

Beyond general lead time reduction strategies, modern logistics also focuses on structural solutions such as cross-docking, to eliminate unnecessary storage stages. According to Mavi et al. (2020), modern logistics increasingly applies cross-docking strategies to reduce warehousing activities and improve efficiency. Cross-docking represents a distribution approach in which goods are directly transferred from inbound to outbound transportation with minimal or no storage time. A systematic literature review highlights that such systems contribute to shorter lead times, lower inventory holding costs, and improved coordination within the supply chain. By eliminating unnecessary storage stages, companies can reduce capital tied up in inventory and enhance overall operational responsiveness.

While logistics plays an essential role in managing the internal flow of materials within an organization, it is part of a broader system known as supply chain management.

## **4.2 Supply chain management**

Cooper and Ellram (1993) define Supply chain management (SCM) as “an integrative philosophy to manage the total flow of a distribution channel from the supplier to the ultimate user” (Cooper & Ellram, 1993; Hanne & Dornberger, 2017c).

Stock et al. (2010) provides definition of SCM, referring to it as the planning and managing of sourcing, procurement, conversion and logistics. This process requires cooperation between supply chain members such as suppliers, intermediaries and customers.

To achieve this level of cooperation, a shift from traditional transactional relationships toward long-term strategic partnerships is essential. A core element of this integration is real-time information sharing, which serves to prevent the "bullwhip effect." This phenomenon describes a situation where minor fluctuations in customer demand cause increasing instability as they move upstream through the supply chain, often leading to inefficient inventory management. By synchronizing these activities, the entire network can operate as one integrated unit (Mentzer et al., 2001).

Figure 1 represents a simplified model of supply chain:

Figure 1 Overview of the Supply Chain



Source: (Scribd, 2023)

*Raw materials* refer to the basic components that are sourced from suppliers and used to produce finished goods.

*Suppliers* or *vendors* are those who supply raw materials, components, and subassemblies, or various modules of the final products to the assembler of the final products.

A supplier of components, subassemblies, or a module may also be the manufacturer or fabricator of them.

*Producers* or *assemblers* are those who assemble the finished products from components and subassemblies or modules supplied by the suppliers.

*Distributors* are those who receive the finished products from the producers and distribute them among the retailers in the target marketplace.

*Retailers* are those who receive the finished product from the distributors and sell them directly to customers.

*Customers* are those who buy the finished product directly from the retailer and ultimately consume the product (Bandyopadhyay, 2015).

A company uses a variety of processes, machinery, equipment, labor, and materials for making and distributing products. To be profitable, a company must organize all these factors to make the right goods at the right time at top quality, and do so as economically as possible. It is a complex problem, and it is fundamental to have a good Manufacturing Planning and Control (MPC) system for achieving profitability and competitiveness (Bandyopadhyay, 2015).

Frohlich & Westbrook (2001) further suggest that such systems should not function in isolation; rather, they should be part of a broader integration strategy. Their research demonstrates that firms which synchronize their internal processes with both suppliers and customers significantly outperform those that focus only on internal or one-sided integration.

As Burgess et al. (2023) highlights, that ensuring high quality and consistent availability of raw materials is particularly challenging in food supply chains. This difficulty arises from multiple points of potential variation and quality loss throughout the chain. Recent literature highlights the need for systematic quality management across the supply network. Such practices must integrate quality control at every stage, from sourcing and transport to processing and distribution. Without such coordinated practices, inconsistencies in supply quality can reduce operational efficiency and increase the risk of product loss or customer dissatisfaction, which ultimately threatens profitability and competitiveness.

This complexity is further explored by Akkerman, Farahani, and Grunow (2010), who highlights that food distribution differs from other supply chains due to the continuous degradation of product quality. They discuss that operational decisions in this sector cannot rely on cost efficiency alone; instead, 'quality decay' must be integrated as a fundamental constraint to guarantee both food safety and economic sustainability.

In the light of the above, supply chain management is essential across the candy manufacturing processing sector. Timing and coordination are critical to ensuring that raw materials arrive on time and in good condition. Delays or inconsistencies in the supply chain can lead to higher costs, lower quality, and reduced efficiency, making it a key focus for many companies.

## **5 Multicriteria Decision-Making Analysis**

### **5.1 Introduction to Multicriteria decision making methods**

Decision making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker. Making a decision implies that there are alternative choices to be considered, and in such a case we want not only to identify as many of these alternatives as possible but to choose the one that best fits with our goals, objectives, desires, values, and so on. (Fülöp, 2001)

Real-world decision problems are typically characterized by the presence of multiple criteria that may be conflicting, incommensurable, or difficult to evaluate simultaneously. MCDM provides a structured framework that enables decision makers to systematically evaluate alternatives by considering several criteria at the same time, rather than relying on a single objective (Triantaphyllou, 2000).

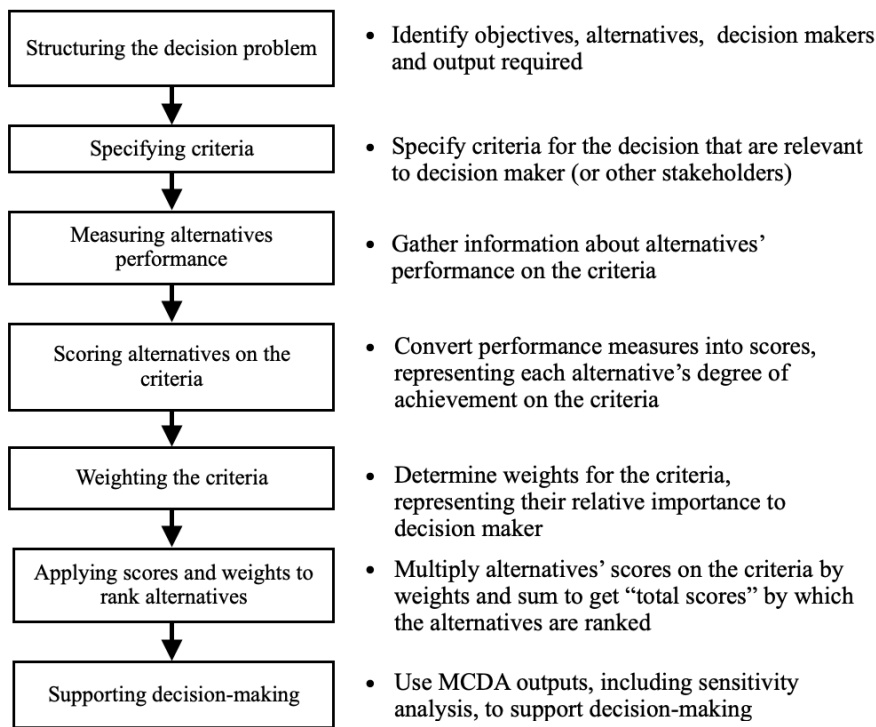
This perspective aligns with the broader field of MCDM, as Kahraman et al. (2015) explain, real-world decision-making problems are usually too complex to be considered through the examination of a single criterion that will lead to the optimum decision. MCDM is an advanced field of operations research. It focuses on developing methodologies to solve complex problems that involve multiple conflicting criteria and objectives.

According to Zavadskas, Turskis and Kiss (2010) selecting an optimal logistics configuration is a classic multicriteria problem because the objectives are often contradictory; for instance, the goal of minimizing transportation costs usually conflicts with the requirement for high delivery frequency and flexibility. MCDM methodologies allow decision-makers to mathematically model these trade-offs and identify solutions that represent the best possible compromise between economic efficiency and service levels.

### **5.2 Steps in the MCDA Process**

The objective of the decision-maker is to maintain a high level of objectivity by employing various methods and approaches. To ensure the MCDA process is accessible and comprehensible to general users, Hansen and Devlin have outlined it as a series of clearly defined steps (Hansen & Devlin, 2019) (see Figure 2).

Figure 2 Steps of MCDA process



Source: (Hansen & Devlin, 2019b)

### 5.3 Framework for MCDA Modeling

As Cinelli et al. (2020) explain, the main steps in MCDA include defining the decision problem, specifying criteria, measuring the performance of alternatives, weighting the criteria, and finally applying an aggregation method.

#### 5.3.1 Specifying criteria

Once the problem is defined, the next step is to identify the criteria. By these criteria, the alternatives will be evaluated, and therefore, they should reflect the decision's goals, be relevant and measurable.

Criteria are mainly divided into two groups:

**Quantitative:** Quantitative criteria are inherently measurable and objective, often expressed in numerical terms such as costs, time, or physical units. These criteria ensure consistency and reliability in the decision-making process, as they are not influenced by personal perspective or interpretation.

**Qualitative Criteria:** In contrast, qualitative criteria are subjective in nature and cannot be directly expressed as numerical values. It is also not possible to measure value of this kind of criteria objectively. For their use in models, it is necessary to convert them into a quantitative form. (Cinelli et al., 2020)

### **5.3.2 Measuring Alternatives' Performance**

In this step, data is completed to evaluate how each alternative satisfies the identified criteria. This involves quantitative measures such as costs, CO2 emissions or lead-time, or qualitative assessments like safety risk or quality risk (Cinelli et al., 2020).

A significant part of this step is **converting qualitative criteria into quantitative values**. This is essential because decision-making often involves comparing alternatives based on both objective data (quantitative) and subjective judgments (qualitative). One common technique is to use scoring systems or rating scales, where qualitative assessments are assigned a numerical value based on predefined categories.

According to Hansen & Devlin (2019), Consistency and accuracy in this step are crucial to ensure a fair comparison.

### **5.3.3 Weighting the criteria**

#### **Saaty's Pairwise Comparison Method**

Statistics show that the most used method worldwide is Saaty's pairwise comparison method. Probably the reason is that it is easy to understand and learn, and it is not mathematically complex (Munier & Hontoria, 2014).

Developed by Thomas Saaty in the 1970s at the Wharton School of the University of Pennsylvania, the Analytic Hierarchy Process (AHP) is a multi-criteria decision analysis (MCDA) method that begins by breaking down decisions into a hierarchical structure of a decision-making goal, criteria and alternatives (Hansen & Ombler, 2008).

A key component of Saaty's method is the pairwise comparison matrix. This matrix is created with help of scale of relative importance:

Table 1 Scale of relative importance

Intensity of importance	Definition
1	Equal importance
3	Moderate importance
5	Strong importance
7	very strong importance
9	extreme importance
2, 4, 6, 8	Intermediate values

Source: (Saaty, 2002)

This assessment is carried out through a series of pairwise comparisons between the criteria by asking questions such as: “How much more important is criterion A compared to criterion B?” A key feature of the Saaty’s method is that these pairwise comparisons are evaluated using a nine-point scale of preference intensity, ranging from “equally important” (ratio = 1) to “extremely more important” (ratio = 9) (Hansen & Ombler, 2008).

*The following description of the Analytic Hierarchy Process (AHP), including the construction of the pairwise comparison matrix and the consistency evaluation using the Consistency Index (CI) and Consistency Ratio (CR), is based on the methodological explanations provided by Kumar et al. (2022).*

The matrix is structured with rows and columns representing the criteria being evaluated. Each entry in the matrix reflects the relative importance of the criterion in the row compared to the criterion in the column, using a predefined scale of relative importance mentioned in the line of the above. For example, if  $C_1$  is more important than  $C_2$ , the entry at  $(C_1, C_2)$  would be 3. Conversely, the reciprocal value,  $1/3$ , would be placed at  $(C_2, C_1)$ , indicating that  $C_2$  is moderately less important than  $C_1$ .

The diagonal of the matrix contains ones, as each criterion is equally important to itself. The matrix is then used to calculate the priority weights for each criterion. To do this, the first step is to normalize the matrix, which means dividing each value in a column by the total sum of that column. This ensures that all the values are proportionally scaled and can be compared fairly. Once the matrix is normalized, the next step is to calculate the row averages. For each criterion, the normalized values across all columns are summed and then divided by the total number of criteria (in this case, four). These row averages represent the priority weights for each criterion.

Saaty's matrix represented:

<i>Criterion</i>	$C_1$	$C_2$	$C_3$	$C_3$
$C_1$	1	3	5	1
$C_2$	1/3	1	1/3	2
$C_3$	1/5	3	1	1/2
$C_4$	1	1/2	2	1

(1)

When using the Saaty's matrix, it is also necessary to calculate its consistency.

This involves computing the **Consistency Index** ( $CI$ ) using the formula:

$$CI = (\lambda_{max} - n) / (n - 1) \tag{2}$$

where  $\lambda_{max}$  is the largest eigenvalue of the matrix, and  $n$  is the number of criteria. A low  $CI$  indicates that the pairwise comparisons are consistent and valid for decision-making. And  $n$  being the number of criteria.

The **consistency ratio** ( $CR$ ) is used to assess the rationality of entering the weights of the criteria. This parameter is generally used with a requirement of  $CR < 0.1$ .  $CR$  is defined as follows:

$$CR = CI / RI \tag{3}$$

Where:

$CR$  is Consistency Ratio

$CI$  is Consistency Index

$RI$  is Random Index, representing the average consistency index of randomly generated pairwise comparison matrices of size  $n$ .

This process ensures the priority weights are reliable and the pairwise comparisons are logically consistent, forming a solid foundation for decision-making. If the calculated consistency ratio exceeds the acceptable threshold ( $CR \geq 0.1$ ), the pairwise comparison matrix is considered inconsistent. In such a case, the decision-maker need to re-evaluate the pairwise comparisons and revise the judgments to improve logical consistency. Only after achieving an acceptable level of consistency can the resulting priority weights be considered valid for further analysis. (*Kumar et al., 2022*).

## 5.4 Methodology of the TOPSIS Approach

In decision-making processes that involve multiple, often conflicting criteria, selecting the optimal solution requires a structured and systematic approach. In this chapter, the multi-criteria decision-making method TOPSIS is introduced as a suitable approach for optimizing the candy production and distribution process.

According to Chakraborty (2011), as cited in Pandey, Komal, et al. (2023), several MCDM techniques, including AHP, TOPSIS, VIKOR, ELECTRE, PROMETHEE, and MOORA, can be compared based on criteria such as computational time, methodological simplicity, stability of results, and the type of information provided by the method. The general comparison of these approaches is illustrated in Figure 3. Based on this analysis, TOPSIS is often considered a suitable method due to its relatively low computational complexity, ease of application, and stable results (Chakraborty, 2011).

Figure 3 Comparison between several decision-making method

MCDM methods	Computational time	Simplicity	Mathematical calculation	Stability	Information type
MOORA (Chakraborty 2011)	Very low	Very simple	Minimum	Good	Quantitative
AHP (Bolturk and Kahraman 2018)	Very high	Very critical	Maximum	Poor	Mixed
TOPSIS (Yu et al. 2019)	Moderate	Moderately critical	Moderate	Medium	Quantitative
VIKOR (Mir et al. 2016)	Less	Simple	Moderate	Medium	Quantitative
ELECTRE (Akram et al. 2019)	High	Moderately critical	Moderate	Medium	Mixed
PROMETHEE (Behzadian et al. 2010)	High	Moderately critical	Moderate	Medium	Mixed

Source: (Chatterjee & Chakraborty, 2016)

TOPSIS is an MCDM approach that ranks and chooses the appropriate alternative from a group of alternatives by using several criteria. This method ranks alternatives from best to worst. The best alternative among the available alternatives is the closest one to the positive-ideal solution or the farthest one from the negative ideal solution (Pandey, Sharma, et al., 2023).

The following section follows the standard TOPSIS procedure as described by Park et al. (2025):

### Step 1. Selection of alternatives and criteria

Data extraction is performed based on the alternatives and criteria selected, and the retrieved information is integrated with the opinions of experts and decision makers.

The collected data is organized into a **decision matrix**, where each row represents an alternative (option being evaluated), and each column corresponds to a criterion (evaluation factor) (Pandey, Sharma, et al., 2023).

To define the problem:

Let  $\{A_1, A_2, \dots, A_m\}$  be the set of **m alternatives** under evaluation.

Let  $\{C_1, C_2, \dots, C_n\}$  be the **n criteria** used for assessment.

Each criterion has an assigned **weight** ( $w_1, w_2, \dots, w_n$ ) that reflects its importance, with values ranging between **0 and 1** and a total sum of **1**.

### Step 2: Constructing the Decision Matrix

The decision matrix **A** is structured as follows:

$$A = [a_{ij}] m \times n \quad (4)$$

where  $a_{ij}$  represents the value of alternative  $A_i$  for criterion  $C_j$ , expressed as a specific numerical value, represents the value of alternative  $i$  with respect to criterion  $j$ , expressed as a numerical value,  $m$  denotes the number of alternatives,  $n$  denotes the number of criteria.

### Step 3. Normalisation of the decision matrix

Since criteria values may have different units, normalization ensures comparability. The most common approach in TOPSIS is vector normalization:

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^m a_{ij}^2}} \quad (5)$$

where:

$r_{ij}$  is normalised value of alternative  $i$  with respect to criterion  $j$

$a_{ij}$  is the original value in the matrix

$a_{ij}^2$  is squared original value used in the normalisation process

$i$  is index of alternatives ( $i = 1, 2, \dots, m$ ),

$j$  is index of criteria.

#### Step 4: Weighted Normalized Decision Matrix

Each normalized value is then multiplied by its respective criterion weight:

$$V_{ij} = w_j \times r_{ij} \quad (6)$$

Where:

$V_{ij}$  is weighted value of alternative  $i$  with respect to criterion  $j$

$w_j$  is weight of criterion  $j$

This ensures that the more important criteria have a greater impact on the final ranking.

#### Step 5: Determine the Positive and Negative Ideal Solutions

This step identifies the **best** and **worst** possible alternatives by defining the **Positive Ideal Solution (V+)** and **Negative Ideal Solution (V-)**.

**Positive Ideal Solution (V+):** The best possible values for each criterion

**Negative Ideal Solution (V-):** The worst possible values for each criterion

They are calculated as follows:

$$V_+ = [(max v_{ij}; j \in J), (min v_{ij}; j \in J'), i = 1, 2, \dots, m] = \{v_{+1}, v_{+2}, \dots, v_{+n}\} \quad (7)$$

$$V_- = [(min v_{ij}; j \in J), (max v_{ij}; j \in J'), i = 1, 2, \dots, m] = \{v_{-1}, v_{-2}, \dots, v_{-n}\} \quad (8)$$

where:

$V_+$  and  $V_-$  is positive or negative ideal solution

$v_j^+$  is value of the Positive Ideal Solution for criterion  $j$ ,

**Benefit criteria (J):** Higher values are better (e.g., performance, quality).

**Cost criteria (J'):** Lower values are better (e.g., price, pollution).

#### Step 6: Calculate the Separation Measures

Each alternative's distance from both the PIS and NIS is calculated using the **Euclidean distance formula**:

$$S_i^+ = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^+)^2}, i = 1, 2, \dots, m \quad (9)$$

$$S_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2}, i = 1, 2, \dots, m \quad (10)$$

where:

$S_i^+$  is the distance from the Positive Ideal Solution (PIS),

$S_i^-$  is the distance from the Negative Ideal Solution (NIS).

### **Step 7: Compute the Relative Closeness Coefficient and Rank Alternatives**

The final ranking is based on the **relative closeness coefficient** ( $C_i$ ), which measures how close each alternative is to the ideal solution:

$$C_i = S_i^- / (S_i^+ + S_i^-) \quad (11)$$

where:

$C_i$  is relative closeness of alternative  $i$  to the ideal solution.

$C_i$  ranges between **0 and 1** (1 being the best).

Alternatives are ranked in **descending order** of  $C_i$ , with the highest value indicating the most favourable option.

## **6 Current Process Analysis**

### **6.1 Description of the Current Maturation Process:**

The anonymized company specializes in the production of confectionery products branded as *Gleams* in the Czech Republic. Upon completion of the manufacturing phase, the *Gleams* are transported to an external warehousing facility. This facility is equipped to handle the specific requirements of the product maturation process, which is a critical step in ensuring product quality and compliance with regulatory standards.

According to company guidelines established by the product management team, the *Gleams* must undergo a maturation period lasting seven days. During this time, the products are subjected to a controlled maturation environment with temperatures regulated between 19°C and 25°C. This controlled environment is designed to facilitate the optimal development of the product's texture and flavour, aligning with both internal quality benchmarks and external customer expectations. Specifically, the maturation process ensures that the candies achieve the right level of firmness; without it, the candies would remain too hard, making them unsuitable for customers.

Following the completion of the maturation period, the *Gleams* are then transported from the external warehouse to a distribution centre located in Birmingham, England. This logistical operation involves approximately 1800 truckloads annually. Upon arrival in Birmingham, the distribution centre takes custody of the products, managing their storage and subsequent distribution to various customers.

### **6.2 Identification of Inefficiencies:**

#### **6.2.1 Negative Impact on Cash Flow:**

The current process involves a significant financial outlay related to the storage and handling of *Gleams* during their seven-day maturation period in the external warehouse. This extended warehousing phase ties up capital in inventory, which could otherwise be invested or used for operational improvements. The costs associated with the external storage facility, combined with the opportunity cost of having capital tied up in inventory, negatively affect the company's cash flow.

### **6.2.2 Extended Lead Time to Market:**

The seven-day maturation period, coupled with the additional transportation time to Birmingham, extends the overall lead time to market. This delay can reduce the company's ability to respond swiftly to market demands and trends. A prolonged lead time means that new product variations or promotions may take longer to reach consumers, potentially impacting market competitiveness and customer satisfaction.

### **6.2.3 Higher Safety Stock Levels**

To guard against supply chain disruptions and ensure there is always enough product available, the company must keep higher safety stock levels. This is necessary because of the long time needed for maturation and transportation. However, holding more inventory leads to higher costs for storage and increases the risk that some of the stock may become outdated or unsellable.

### **6.2.4 Decreased Freshness:**

The current process involves an additional step of maturation in the external warehouse, which can impact the freshness of the *Gleams*. The longer the products are held in the supply chain before reaching the end consumer, the greater the risk of a decline in quality and freshness. For confectionery products, maintaining optimal freshness is crucial for consumer satisfaction and product reputation.

### **6.2.5 Increased Stock in Pipeline:**

The current process results in a higher volume of stock in the pipeline due to the extended maturation period and the transportation delay. This increased stock in transit and storage means that more products are held at various stages of the supply chain, potentially leading to inefficiencies and higher overall inventory levels.

## **6.3 Impact on Overall Operations:**

The current process of manufacturing and distributing *Gleams* presents several inefficiencies that negatively impact the overall supply chain. The extended seven-day maturation period, combined with the transportation time, significantly lengthens the lead time to market. This delay reduces the company's ability to quickly meet customer demand

and respond to market changes. Additionally, the need to maintain higher safety stock levels due to these extended times increases inventory holding costs and elevates the risk of stock obsolescence.

Furthermore, the prolonged duration in the supply chain can compromise the freshness and quality of the *Gleams* by the time they reach consumers. The capital tied up in inventory during the maturation process also exerts pressure on the company's cash flow, limiting financial flexibility. Moreover, the increased stock in the pipeline due to these inefficiencies inflates overall inventory levels, which adds to the complexity and costs associated with inventory management.

## **7 Alternative Solutions**

To enhance the efficiency of the maturation and transportation process for *Gleams*, several alternative solutions have been proposed. The core idea behind these solutions is to optimize the overall process by transferring a portion of the maturation period from the external warehouse to the transit phase. By allowing the candies to mature partially during the journey to England, the process can be streamlined, potentially reducing lead times and storage costs. However, this shift introduces the critical challenge of maintaining and monitoring the required temperature range of 19-25°C throughout the transportation phase. Therefore, each proposed solution not only focuses on this transition but also addresses the methods by which temperature control can be effectively managed during transit to ensure that the maturation process remains consistent, and the product quality meets both internal standards and customer expectations.

### **7.1 Use of Temperature Loggers in Trucks:**

In this solution, temperature loggers would be placed between the pallets in the truck. These loggers are devices that monitor and record the temperature during transit. Upon delivery in Birmingham, the loggers would display either a green light, indicating that the temperature was consistently within the required range, or a red light, signalling a deviation that could mean the *Gleams* did not fully mature. This approach provides a straightforward method to ensure temperature compliance, with immediate feedback upon delivery.

## **7.2 Regular Temperature Monitoring by Drivers:**

Another approach involves the transportation company equipping each truck with devices that allow drivers to regularly send temperature readings to a centralized server. An employee at the Birmingham warehouse would then monitor these readings to ensure that the temperature remains within the required range throughout the journey. If the *Gleams* arrive under-matured due to temperature fluctuations, they would be placed in a holding area in the Birmingham warehouse, where the maturation process could be completed at the appropriate temperature. This method allows for real-time monitoring and the flexibility to address issues as they arise.

## **7.3 Temperature Monitoring Managed by the Czech Facility:**

This solution mirrors the previous one, with the key difference being that the responsibility for monitoring and managing the temperature data lies with an employee at the Czech manufacturing facility, rather than in Birmingham. The Czech team would oversee the entire maturation and transportation process, ensuring that the temperature remains within the specified range. This centralization of responsibility could streamline the process and ensure greater consistency in temperature management.

## **7.4 Responsibility Delegated to the Transport Company:**

In this option, no active temperature monitoring is conducted by the company. Instead, the transportation company assumes full responsibility for maintaining the correct temperature range throughout the journey. They would be held accountable for any deviations and the potential impact on the maturation process. This solution shifts the burden of temperature control entirely to the logistics provider, potentially reducing operational complexity for the company but increasing reliance on the transport partner's capabilities.

## **7.5 Maintaining the Current Process:**

The final alternative is to retain the existing process, where the full seven-day maturation period occurs in the external warehouse before the *Gleams* are transported to Birmingham. This option avoids the complexities of monitoring and controlling temperature during transit but does not address the inefficiencies currently present in the process.

## 8 Selection of evaluation criteria

Based on the analysis of the current process and its inefficiencies, as well as the goals of optimization, the following criteria were selected to evaluate the proposed alternatives.

**Economic efficiency** - Evaluates the potential for cost reduction, especially through savings on external storage and transportation expenses.

**Quality risk** - Represents the level of risk each alternative poses to maintaining the required product quality standards during transportation.

**Safety risk** - Assesses how likely it is that safety problems could occur during transportation, such as equipment failure or loss of temperature control.

**Environmental impact** - Considers the ecological footprint of each solution, including CO<sub>2</sub> emissions and energy consumption.

**Lead time** - Measures the total time from production to delivery at the UK distribution centre, directly influencing responsiveness to market demand.

**Cash flow impact** - Evaluates how the solution affects the company's liquidity by reducing capital tied up in inventory.

## 9 Multicriteria Evaluation of Proposed Solutions

To compare the proposed alternatives objectively, a combination of the Analytic Hierarchy Process (AHP) and the TOPSIS method was applied. AHP was used to determine the relative importance (weights) of the evaluation criteria identified in Chapter 7. This method relies on pairwise comparisons and enables the decision maker to express subjective preferences in a structured, mathematically consistent manner.

Once the criteria weights were obtained, they were incorporated into the TOPSIS procedure to determine the most suitable solution among the five proposed alternatives. TOPSIS evaluates how close each alternative is to the ideal solution while simultaneously considering its distance from the worst-case scenario. The method is appropriate in this context because the evaluated criteria include both benefits (e.g., reduced lead time, lower environmental impact) and risks (e.g., safety risk, quality risk), which must be considered at the same time.

## 9.1 Determination of Criteria Weights

To calculate the relative importance of the evaluation criteria, the Saaty's pairwise comparison method was applied. The pairwise comparison matrix was completed by the logistics manager of the anonymised company, who has more than 25 years of professional experience within the organisation. Her long-term involvement in the supply chain operations, combined with deep knowledge of internal processes, product requirements, and organisational priorities, ensures that the resulting judgments accurately reflect the company's real decision-making logic.

The evaluator assessed each pair of criteria according to Saaty's 1–9 scale, expressing how strongly one criterion is preferred over another.

*Table 2 Pairwise comparison matrix and criteria weights (Saaty's method)*

Criteria	Econ.eff.	Quality risk	Safety risk	Environm.imp.	Lead time	Cash flow	Norm.	weight
Economics efficiency	1	1/2	4	5	3	2	1,98	0,2594
Quality risk	2	1	3	6	3	2	2,45	0,3211
Safety risk	1/4	1/3	1	2	1/3	1/4	0,49	0,0643
Environmental impact	1/5	1/6	1/2	1	1/4	1/5	0,31	0,0402
Lead time	1/3	1/3	3	4	1	1/2	0,93	0,1225
Cash flow	1/2	1/2	4	5	2	1	1,47	0,1924
sum:	4,2833	2,8333	15,5000	23,0000	9,5833	5,9500	7,6276	1,00

Source: own processing

Based on this matrix, geometric means were calculated to summarise the overall preference for each criterion across all pairwise comparisons. These values were then scaled to obtain the final weight vector, representing the relative importance of each criterion in the decision-making process.

*Table 3 Weighted sum vector and  $\lambda$ -values for consistency verification*

Criteria	Econ.eff.	Quality risk	Safety risk	Environm.imp.	Lead time	Cash flow	weighted sum	$\lambda$ -values
Economics efficiency	1	0,50	4	5	3	2	1,6306	6,2862
Quality risk	2	1	3	6	3	2	2,0265	6,3106
Safety risk	0,25	0,33	1	2	0,33	0,25	0,4056	6,3096
Environmental impact	0,20	0,17	0,50	1	0,25	0,20	0,2469	6,1386
Lead time	0,33	0,33	3	4	1	0,50	0,7660	6,2509
Cash flow	0,5	0,5	4	5	2	1	1,1860	6,1630
<b>average</b>								6,2431

Source: own processing

To verify the consistency of the pairwise comparison matrix, the weighted sum vector and the  $\lambda$ -values were calculated for each criterion. These  $\lambda$ -values indicate how closely each criterion's priority aligns with the overall weight vector. The maximum eigenvalue  $\lambda_{\max}$ , obtained numerically using the software, as the average of the  $\lambda$ -values, reached approximately 6.24. This value was used to calculate the consistency index (CI), which measures the consistency of the evaluator's judgments.

The consistency index was as defined in equation (2)

where  $\lambda_{\max}$  represents a numerical value calculated by the software from the comparison matrix, which is required for the consistency index formula. The symbol  $n$  refers to the number of criteria included in the matrix. For this matrix, the resulting consistency index reached approximately **0.048**.

The consistency ratio ( $CR$ ) was then calculated using Equation (3) by dividing the consistency index by the corresponding random index ( $RI$ ). The value of  $RI$  was taken from Saaty's table of average random indices, where the appropriate value for a matrix with six criteria is **1.24**. Using this value resulted in a consistency ratio of  $CR = 0.039$ , confirming that the comparison matrix is consistent.

## 9.2 TOPSIS – Evaluation of Alternatives

After determining the criteria weights using the Saaty's method, the next step of the analysis involved evaluating the five proposed alternatives using the TOPSIS method. The aim of this step was to identify the alternative that is closest to the ideal solution and furthest from the worst-case scenario.

The first phase of the TOPSIS method consisted of constructing a decision matrix, in which each alternative was assessed against the six evaluation criteria defined earlier. The evaluation was carried out by the company's logistics manager, who assigned scores to each alternative using a five-point scale. For benefit-type criteria, higher values indicate more favourable performance, whereas for cost-type criteria, higher values represent higher risk or a less favourable outcome.

*Table 4 Decision matrix for evaluating alternatives using the TOPSIS method*

Alternative	Econ. eff.	Quality risk	Safety risk	Environm. imp.	Lead time	Cash flow
A1	5	2	2	1	4	5
A2	4	3	3	1	4	5
A3	3	5	5	1	4	5
A4	2	2	2	2	4	5
A5	1	1	1	5	5	2
<b>Sum<sup>2</sup></b>	55	43	43	32	89	104
<b>√Sum</b>	7,4162	6,5574	6,5574	5,6569	9,4340	10,1980

Source: own processing

### **Evaluation of economic efficiency and operational risks**

In assessing economic efficiency, the logistics manager considered the direct and indirect costs associated with each alternative. Alternative A1 (Use of temperature loggers) was rated most positively, as it requires only a single temperature logger per truck at a cost of €10 per shipment. With approximately 1,800 truckloads dispatched annually, the total additional cost amounts to €18,000, which is relatively low compared to other options.

Alternatives A2 (Regular monitoring by drivers) and A3 (Monitoring by Czech facility) were evaluated as less economically efficient due to labour related costs. In particular, A3 requires dedicated employee at the Czech manufacturing facility to continuously monitor temperature data, resulting in higher operational expenses. The lowest economic efficiency score was assigned to A5 (Maintaining the current process), which continues to rely on a full seven-day maturation period in an external warehouse and therefore generates the highest storage-related costs.

Quality and safety risks were assessed separately. Alternative A1 achieved low risk scores because temperature deviations can be identified using temperature loggers, even if corrective action is taken after delivery. Alternatives A2 and A3 were assigned with risk due to their reliance on manual reporting or remote monitoring, which increases the likelihood of delays, communication errors, or human failure. The highest levels of both quality and safety risk were attributed to A3, reflecting the challenges of managing the process remotely from the Czech facility. The current process (A5) was considered stable in terms of process reliability, but its overall performance was negatively affected by other criteria such as cash flow and lead time.

### **Environmental impact, lead time, and cash-flow considerations**

Environmental impact was assessed primarily with respect to transport-related CO<sub>2</sub> emissions. In all evaluated alternatives, products are transported to the United Kingdom, which represents a common baseline and does not differentiate the options. Approximately 1,800 truckloads are transported annually, and this transport activity is present in every scenario.

The key difference between the alternatives lies in the use of the external warehouse. In the current process (A5), products are first transported from the manufacturing facility to an external storage location, where they remain for the full maturation period, and are after that transported to the UK. This additional handling and intermediate transport step increase the overall environmental impact of the process.

In contrast, alternatives A1- A4 reduce the need for the external warehouse by shifting part of the maturation process into the transport phase. As a result, these alternatives require fewer transport movements and less storage, leading to a lower environmental impact compared to the current process. This difference was reflected in the environmental impact ratings used in the decision matrix.

As a result, A1- A3 were evaluated as environmentally superior to the current process, while A5 received the lowest score in this criterion.

Lead time and cash-flow impact were assessed using similar logic. Alternatives that shorten or remove the seven-day maturation period enable faster delivery to the UK distribution centre and reduce the amount of capital tied up in inventory. As a result, A1- A4 achieved higher scores in both criteria, whereas A5, which maintains the longest lead time and the highest inventory levels, was rated least favourably.

*Table 5 Normalized decision matrix for the TOPSIS evaluation*

Alternative	Econ. eff.	Quality risk	Safety risk	Environm. imp.	Lead time	Cash flow
A1	0,6742	0,3050	0,3050	0,1768	0,4240	0,4903
A2	0,5394	0,4575	0,4575	0,1768	0,4240	0,4903
A3	0,4045	0,7625	0,7625	0,1768	0,4240	0,4903
A4	0,2697	0,3050	0,3050	0,3536	0,4240	0,4903
A5	0,1348	0,1525	0,1525	0,8839	0,5300	0,1961

Source: own processing

## TOPSIS calculation and final ranking of alternatives

Following normalization of the decision matrix, the normalized values were multiplied by the criteria weights obtained from the AHP method, resulting in the weighted normalized matrix. Afterwards, the positive ideal solution and the negative ideal solution were determined, and the distances of each alternative from these reference points were calculated.

Table 6 Weighted normalized matrix and distance measures for the TOPSIS method

Alternative	Econ. eff.	Quality risk	Safety risk	Environm. imp.	Lead time	Cash flow	S+	S -	C <sub>i</sub>
A1	0,1749	0,0979	0,0196	0,0071	0,0520	0,0943	0,0516	0,2146	<b>0,8061</b>
A2	0,1399	0,1469	0,0294	0,0071	0,0520	0,0943	0,1066	0,1581	<b>0,5972</b>
A3	0,1049	0,2449	0,0490	0,0071	0,0520	0,0943	0,2121	0,0944	<b>0,3080</b>
A4	0,0700	0,0979	0,0196	0,0142	0,0520	0,0943	0,1172	0,1653	<b>0,5853</b>
A5	0,0350	0,0490	0,0098	0,0355	0,0649	0,0377	0,1536	0,2002	<b>0,5659</b>
<b>A<sup>+</sup> (ideal)</b>	0,1749	0,0490	0,0098	0,0071	0,0649	0,0943			
<b>A<sup>-</sup> (worst)</b>	0,0350	0,2449	0,0490	0,0355	0,0520	0,0377			

Source: own processing

The relative closeness coefficient  $C_i$  was then computed for each alternative. The results indicate that alternative A1 (Use of temperature loggers) achieves the highest closeness coefficient, making it the most desirable solution. It is followed by A2 (Regular monitoring by drivers) and A4 (Responsibility delegated to the transport company). Alternative A5 ranks fourth, while A3 (Maintaining the current process) achieves the lowest closeness coefficient and is therefore the least favourable option.

Table 7 Final ranking of alternatives

Alternative	C <sub>i</sub>
A1	0,8061
A2	0,5972
A4	0,5853
A5	0,5659
A3	0,3080

Source: own processing

Overall, the TOPSIS analysis confirms that transferring a portion of the maturation process from the external warehouse to the transportation phase, particularly through the use of temperature loggers, offers the most balanced solution in terms of cost efficiency, risk management, environmental performance, and financial impact.

## 10 Sensitivity Analysis

Although the input data and the initial pairwise comparisons used for the AHP weighting were provided by the logistics manager of the company, who had access to all relevant operational, financial, and technical information, the resulting evaluation still reflects the preferences of a single decision maker. To test the robustness of the proposed solution a sensitivity analysis was performed.

The purpose of this analysis is to evaluate the stability of the final TOPSIS ranking in response to changes in criteria weights. By modifying the weights and observing whether the ranking remains stable, it is possible to evaluate the reliability of the decision - making outcome under different perspectives.

### 10.1 Design of the sensitivity scenarios

To verify the stability of the multicriteria evaluation and ensure that the final recommendation is not sensitive to subjective weight settings, a **one-way sensitivity analysis** was performed. The analysis focuses on the Quality Risk criterion, which was identified by the AHP method as the most significant factor with a weight of 0,3211.

The sensitivity testing was structured into two phases:

**Interval Analysis:** The weight of Quality Risk was varied within a range of (0,24 – 0,52) to simulate standard adjustments in decision-maker preferences.

**Break-even Identification:** To find the stability limit of the current ranking, additional scenarios were modelled by increasing the weight further until a change in the top position occurred.

As described above, Quality Risk, was varied within a range of  $\pm 25\%$  from its initial value. To maintain the consistency of the model, a proportional redistribution was applied afterwards to the remaining criteria. This indicates that as the weight of Quality Risk was adjusted, the weights of all other criteria were scaled up or down while maintaining their original relative ratios, and their total sum was always equal to 1.

The specific weight configurations for all analysed scenarios are detailed in Table 8 below.

*Table 8 Weight redistribution scenarios for the Quality Risk criterion*

Economics effic.	Quality risk	Safety risk	Environm. impact	Lead time	Cash flow	SUM
0,2904	<b>0,2400</b>	0,0720	0,0450	0,1372	0,2154	1,00
0,2828	<b>0,2600</b>	0,0701	0,0438	0,1336	0,2098	1,00
0,2751	<b>0,2800</b>	0,0682	0,0427	0,1300	0,2041	1,00
0,2675	<b>0,3000</b>	0,0663	0,0415	0,1264	0,1984	1,00
0,2598	<b>0,3200</b>	0,0644	0,0403	0,1227	0,1928	1,00
0,2522	<b>0,3400</b>	0,0625	0,0391	0,1191	0,1871	1,00
0,2446	<b>0,3600</b>	0,0606	0,0379	0,1155	0,1814	1,00
0,2369	<b>0,3800</b>	0,0587	0,0367	0,1119	0,1757	1,00
0,2293	<b>0,4000</b>	0,0568	0,0355	0,1083	0,1701	1,00
0,1911	<b>0,5000</b>	0,0473	0,0296	0,0903	0,1417	1,00
0,1834	<b>0,5200</b>	0,0454	0,0284	0,0866	0,1361	1,00

Source: own processing

The practical application was performed in Excel, where each weight change represented a unique scenario. For every scenario, the entire TOPSIS procedure was recalculated, including the update of the weighted normalized decision matrix and the determination of new distances to the ideal solutions. The resulting Closeness Coefficients ( $C_i$ ) were then recorded and compared to track the stability of the ranking.

## 10.2 Results of the Sensitivity Analysis

The results of the analysis confirm that the decision model is highly robust. Throughout the initial testing range of  $\pm 25\%$  the ranking remained completely stable, and **Alternative A1** consistently maintained its first-place position with a significant lead. Table 9 provides a detailed overview of the sensitivity analysis results by presenting the closeness coefficients of all alternatives for different values of the Quality Risk weight. The table illustrates how the performance of each alternative changes with increasing importance of the Quality Risk criterion and allows comparison of their relative ranking across scenarios.

Table 9 Sensitivity analysis results for Quality Risk criterion

Quality risk	A1_Ci	A2_Ci	A3_Ci	A4_Ci	A5_Ci	The best_Ci	The best Alternative
0,2400	0,8348	0,6433	0,3801	0,5268	0,4717	0,8348	<b>A1</b>
0,2600	0,8271	0,6312	0,3616	0,5416	0,4962	0,8271	<b>A1</b>
0,2800	0,8198	0,6195	0,3435	0,5562	0,5198	0,8198	<b>A1</b>
0,3000	0,8129	0,6083	0,3259	0,5705	0,5426	0,8129	<b>A1</b>
0,3200	0,8065	0,5978	0,3089	0,5845	0,5647	0,8065	<b>A1</b>
0,3400	0,8006	0,5890	0,2953	0,5987	0,5846	0,8006	<b>A1</b>
0,3600	0,7950	0,5788	0,2767	0,6109	0,6063	0,7950	<b>A1</b>
0,3800	0,7900	0,5704	0,2615	0,6232	0,6261	0,7900	<b>A1</b>
0,4000	0,7854	0,5626	0,2470	0,6348	0,6451	0,7854	<b>A1</b>
0,5000	0,7684	0,5333	0,1828	0,6829	0,7304	0,7684	<b>A1</b>
0,5200	0,7116	0,7765	0,6723	0,1481	0,5604	0,7765	<b>A2</b>

Source: own processing

The identified and highlighted break-even point, where a change in the top position occurs, was found at a weight of **0.52** for the Quality Risk criterion. This represents a major increase of more than 60% from the original AHP weight. Since such a significant shift in importance is unlikely in a real-world context, the analysis proves that the selection of **Alternative A1** is reliable and remains the optimal solution even with significant variations in criteria weights.

## 11 Discussion

The results of the multi-criteria analysis demonstrate that the current logistics process for Gleams candy is not the most effective, primarily due to excessive lead times and tied-up capital during the maturation phase. By applying the TOPSIS method, Alternative A1 (the use of temperature loggers during transit) was identified as the most effective solution. The transition to this "maturation-on-the-move" approach is recommended as it helps eliminate the key inefficiencies identified in the practical part of this thesis, mainly by improving cash flow and reducing the overall time to market.

The main advantage of the proposed solution is the simplicity of the "green light/ red light" feedback system, which provides immediate quality assurance upon delivery in Birmingham without requiring continuous remote monitoring by employees. Furthermore, the reduction in intermediate handling and storage leads to a lower environmental footprint and improved product freshness. However, a potential disadvantage is that the monitoring remains passive. If a temperature deviation occurs early in the journey, it is only discovered upon arrival, which may lead to the need for additional maturation time in the UK facility or, in worst case scenarios, product quality issues. To mitigate these risks, the company could consider an initial pilot phase where loggers are combined with occasional spot-checks by drivers (A2) to ensure the cooling and heating systems are functioning correctly.

Finally, it is important to consider the stability of these results. An interval-based sensitivity analysis was performed to examine how variations in criteria weights influence the final ranking of alternatives. The analysis confirmed that Alternative A1 remains the preferred option across a wide range of tested scenarios, indicating a high level of robustness of the decision model. A change in the ranking occurs only when an exceptionally strong emphasis is placed on quality-related risk. This suggests that the recommended solution is reliable under realistic variations in decision-maker preferences, while still acknowledging that extreme external conditions, such as substantial changes in energy or transportation costs, could affect the economic performance of individual alternatives in the future.

## 12 Conclusion

This bachelor thesis focused on optimizing the maturation and transportation process of confectionery products to improve operational efficiency within the logistics system of an anonymized manufacturing company. The primary objective was to identify inefficiencies in the existing process and to evaluate feasible operational solutions that could reduce lead time, inventory costs, and negative cash-flow impacts while maintaining product quality and safety.

The theoretical part of the thesis provided an overview of logistics and supply chain management, with particular emphasis on their financial aspects and introduced the principles of multicriteria decision making. Particular attention was given to the Saaty's pairwise comparison method and the TOPSIS method, which formed the practical part of the thesis.

In the practical part, the current maturation process was analysed and key inefficiencies were identified. Based on this analysis, a set of alternative solutions proposed by the company was evaluated. These alternatives focused on shifting part of the maturation process from the external warehouse to the transportation phase in alignment with the required temperature conditions.

The evaluation was carried out using a combination of the Saaty's pairwise comparison method and the TOPSIS method. Criteria weights were determined based on expert judgment provided by the company's logistics manager, and the TOPSIS method was subsequently applied to rank the alternatives according to their relative closeness to the ideal solution. The results indicated that **alternative A1, the use of temperature loggers in trucks, represents the most suitable solution**, as it achieved the highest relative closeness coefficient and showed balanced performance across all evaluated criteria. The robustness of this outcome was tested using an interval-based sensitivity analysis, in which the criteria weights were varied within defined ranges. While the closeness coefficient values responded to these changes, the ranking of the preferred alternative remained stable, indicating that the selection of Alternative A1 is not sensitive to moderate changes in criteria weights.

Overall, the findings demonstrate that the application of multicriteria decision-making methods provides a structured and transparent approach to evaluating practical business decisions. These methods support informed decision-making in logistics and supply chain management.



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