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Improving Costing in the Food Production and Service Industry Supply Chain (A Case Study Based on Activity-Based Costing)

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Abstract

In recent years, supply chain disruptions, rising raw material prices, and food inflation have exerted significant pressure on the profitability of organizations within the food production and service industry. In this context, accurately determining supply chain costs and optimizing cost management have become critical factors for ensuring organizational sustainability and competitiveness. However, in practice, many organizations continue to use traditional costing methods, which often fail to fully capture the indirect and hidden costs incurred throughout the supply chain process. The purpose of this study is to identify the cost structure within the supply chain of the food production and service industry and to explore opportunities for optimal cost management. Using a case study methodology, Sangyeopsal Express restaurant, operating in Ulaanbaatar, was selected as the research object. The Activity-Based Costing (ABC) method was used to determine costs, the Analytic Hierarchy Process (AHP) was used to evaluate the significance of expenses, and the Sphere Packing Approach (SPA) modeling was used to optimize costs. The research findings indicate that raw material procurement, labor costs, and utility expenses account for the majority of the total supply chain cost. By integrating ABC and SPA, the actual cost structure becomes transparent, enabling decision-making aimed at monitoring and reducing costs to feasible levels. This study investigates practical significance for refining supply chain cost calculations within the food production and service industry.

Keywords

Supply Chain, Cost Calculation, Activity-Based Costing (ABC), Analytic Hierarchy Process (AHP), Sphere Packing Approach (Set), Food Production and Service

1. Introduction

In the 21st century, globally dispersed supply chains are facing unprecedented risks (MacCarthy et al., 2022). Supply chain risk management has evolved significantly as a research field over the last two decades (Ho et al., 2015; McLennan & Group, 2022; Tang & Musa, 2011). The necessity of focusing on supply chain resilience has become increasingly evident since the global financial crisis that began in 2007 (Jüttner & Maklan, 2011). Major geopolitical events, such as the global pandemic and armed conflicts between nations, along with the resulting crisis conditions, have introduced fundamental changes that have reshaped the global supply chain landscape (Handfield et al., 2020).

The COVID-19 pandemic has fundamentally altered supply chains, causing massive shortages due to pre-pandemic demand levels, along with significant supply chain and logistics disruptions (Handfield et al., 2020; Ivanov & Dolgui, 2021). Consequently, issues surrounding supply chain management and efficiency have once again become a central focus for researchers. A supply chain is a network of organizations involved through upstream and downstream linkages in different processes that produce value in the form of products delivered to the final consumer (Christopher, 1992). Mentzer, DeWitt and Min et al. (2001) defined a supply chain as a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to customer. Although researchers have defined supply chains in various ways, these definitions can be categorized into three groups: management philosophy, implementation of a management philosophy, and management processes (Mentzer et al., 2001).

Supply chain management (SCM) adopts a systems approach, emphasizing the view of the supply chain not as a collection of fragmented parts performing individual functions, but as a single, integrated entity (Ellram, 1990). Therefore, SCM posits that every organization involved in the chain not only directly or indirectly influences the activities of other members but ultimately impacts the performance of the entire supply chain (Cooper et al., 1997). Langley and Holcomb (1992) suggested that the primary objective of a supply chain is to create customer value by coordinating all supply chain activities. While the value proposition of a supply chain previously focused on delivering the service desired by the customer at the lowest possible cost, it has become significantly more complex in the twenty-first century.

A supply chain process can be defined as a set of organized and measurable activities aimed at creating a product specifically designed for a particular customer or market (Brandenburg, 2018). Furthermore, the structure of a supply chain can be compared to a value chain (Cooper et al., 1997). The optimal allocation of limited resources among member organizations and business processes within the supply chain is a critical issue. Some researchers view supply chain management as the process of managing relationships, information, and materials to create value for the customer (La Londe & Masters, 1994). This process consists of specific activities organized correctly in time and space, characterized by a clear beginning and end, as well as defined inputs and outputs (Cooper et al., 1997; Ellram, 1990; Tyndall et al., 1998). Key processes within the supply chain include customer relationship management, customer service management, demand management, order fulfillment, procurement, product development and commercialization (Lambert et al., 1998). Successful implementation of these processes enables the supply chain to become customer-centric, allowing the organization to generate unique value and maintain operational efficiency (Mentzer et al., 2001).

At a conference of the Council of Supply Chain Management Professionals (CSCMP), practitioners expressed significant confusion regarding supply chain costing methods. Organizational management and professionals noted a lack of clear understanding on how to implement and manage the methodologies proposed as tools for cost reduction or supply chain performance enhancement. Furthermore, they emphasized their uncertainty in implementing, managing, and utilizing inter-organizational management accounting systems for effective decision-making.

The supply chain generates value from initial investments (Foster, 2016). By optimizing the chain that delivers value to the customer, organizations can achieve cost reduction, increased productivity, improved flexibility, shorter delivery lead times, higher profits, and enhanced customer loyalty (Stevenson, 2005). Neely (2002) emphasized that failure to focus on supply chain efficiency can lead to financial distress and, ultimately, bankruptcy. To increase supply chain efficiency, reduce costs, and improve operations, it is necessary to define the current state and measure supply chain performance. Since the process of collecting and analyzing data required for performance measurement demands significant time, capital, and effort, selecting metrics aligned with organizational goals is crucial to making the evaluation process more effective and less complex (Leon, 2016). Therefore, performance evaluation must be conducted in alignment with the organization's industry and the environmental conditions of the supply chain (Estampe, 2014). Performance indicators provide the opportunity to monitor, benchmark, evaluate, and plan the supply chain (Martin, 2018). Both financial and non-financial Key Performance Indicators (KPIs) can be used to measure supply chain performance. Non-financial KPIs include metrics such as product defect rates, order fulfillment accuracy, inventory turnover, and customer satisfaction (Leon, 2016). Financial KPIs evaluate capital utilization by measuring profitability, return on assets (ROA), and return on investment (ROI), while indicators such as profit margin, cost of goods sold (COGS), and economic value added (EVA) are used to measure profitability (Gunasekaran et al., 2001). Determining the key indicators for measuring supply chain performance remains a central focus for both researchers and management (Leon, 2016).

In 2017, Geodis, a global logistics provider, conducted a survey on Key Performance Indicators (KPIs) used in supply chain management. This study, which included 623 participants from 17 countries, identified the significance of measuring and managing performance through supply chain KPIs. According to the

Geodis study, 35% of supply chain professionals, senior management, and executives ranked "cost reduction" as a primary supply chain KPI. In terms of adoption and recognition, cost reduction was ranked as the second most important KPI. However, when optimizing supply chain costs, it is essential to consider potential issues related to other processes. In other words, costs should be reduced to a level that does not adversely affect the organization's core operations (Bragg, 2010).

2. Conceptual Approach

2.1. Supply Chain Costs

Supply chain costs encompass all expenses related to activities within the network, such as demand forecasting, inventory management, material handling, packaging, service support, site selection, procurement, transportation, and warehousing (Lambert et al., 1998). Therefore, a management accounting system is required to measure procurement, storage, and logistics costs at every level of the supply chain to determine the total cost (Boute et al., 2014). Cost modeling is utilized to analyze cost information derived from income statements, profit reports, balance sheets, and other financial documents (Sower & Sower, 2012). Among the models for cost accumulation and calculation, traditional costing and ABC are the most commonly used. While the traditional method focuses on direct costs related to the product, the ABC model identifies costs generated by the activities performed (Masters, 2018).

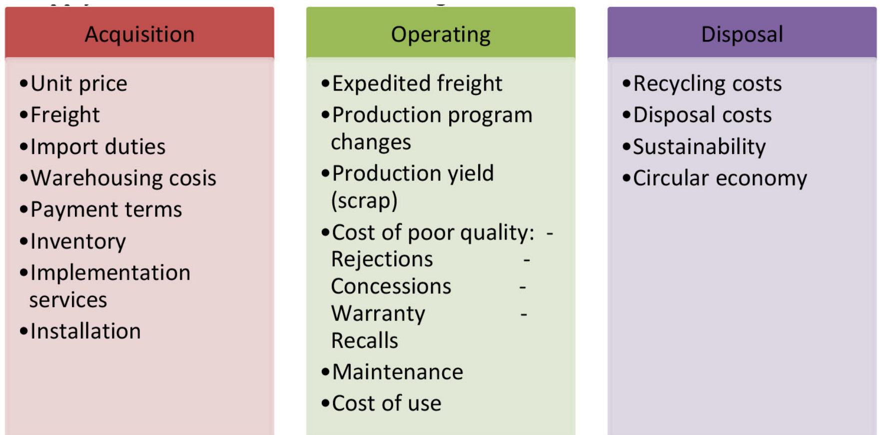
For many years, traditional costing models have been utilized by the majority of organizations (Pierce & Brown, 2006). Since this approach focuses solely on costs directly associated with the payment for goods and services, it often overlooks operational expenses such as marketing and distribution (Bailey et al., 2015). However, as supply chain costs are inherently variable, they should not be limited to the purchase price alone; rather, it is essential to identify all costs incurred throughout the supply chain process, starting from direct costs (Masters, 2018).

The costs incurred throughout the supply chain are illustrated in the following **Figure 1**.

Sources: Bailey, Farmer, Crocker, Jessop, & Jones (2015). Procurement, principles & management.

Figure 1. The price-cost iceberg.

Just as only ten percent of an iceberg is visible above the water surface while ninety percent remains hidden beneath, the figure above illustrates that the initial purchase price typically represents only ten percent of the total supply chain cost. Cossio (2019, as cited in Nguyen, 2021) identified and categorized the hidden costs commonly encountered in supply chains, as shown in the following **Figure 2**.



Sources: Cossio (2019, as cited in Nguyen, 2021). Use total cost of ownership to optimize costs and increase savings.

Figure 2. Total cost of ownership.

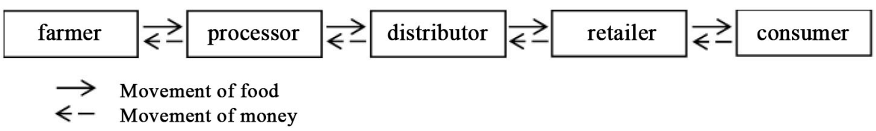
Traditional costing models tend to overlook operational expenses by focusing primarily on the costs associated with purchasing goods and services (Sower & Sower, 2012). Consequently, the ABC model, which calculates costs based on specific activities, is utilized to address this limitation (Nguyen, 2021). Some researchers argue that as supply chain costs decrease, a sustainable competitive advantage increases (Anklesaria, 2008). This sustainable competitive advantage benefits not only the supply chain as a whole but also enhances the profitability of its individual member organizations (Khalid, 2010).

Reducing costs is relatively simpler than increasing revenue. This is because increasing revenue involves significant uncertainties dependent on numerous factors, such as pricing policies, profit margins, competitor actions, and government regulations. In contrast, cost reduction is the most straightforward and widely accepted method for increasing profit and improving cash flow. Achieving cost reductions results in a lower cost base, a stable fixed-cost structure, and the mitigation of total cost increases during volatile conditions. Cost optimization is not a one-time event; rather, it must be a process of continuous improvement throughout the lifespan of an organization (Bragg, 2010). This is because an organization's financial health directly impacts its ability to purchase inventory, pay salaries and dividends, and sustain other daily operations (Leon, 2016). Furthermore, cost optimization is a continuous process of increasing efficiency and reducing costs based on structural and planning-driven improvements, rather than merely seeking short-term savings or immediate results (Uskert, 2019).

2.2. Costing in the Food Production and Service Industry Supply Chain

The food supply chain plays an indispensable role in ensuring food security, sustainability, and accessibility for the global population (Moseley & Battersby, 2020). The global food supply chain is a complex network comprising stakeholders and interconnected processes at all stages—production, processing, distribution, and consumption (Yadav et al., 2022). Disruptions in any part of this chain can have far-reaching impacts not only on businesses but also on consumers, local communities, and national economies (Kovács & Falagara Sigala, 2021). Mitigating risks within the food supply chain and managing food price volatility are of critical importance (Sharma et al., 2022). Unstable or high food prices, along with supply disruptions, increase poverty and malnutrition, posing significant socio-economic challenges (Wudil et al., 2022). Furthermore, rising food prices significantly affect producers, retailers, and consumers. Fluctuations and increases in input costs—such as energy, labor, and raw materials—impact the profitability of agricultural producers and food manufacturers within the supply chain (Kurowska et al., 2020). Food price volatility can hinder supply chain planning and investment decisions, leading to reduced efficiency and competitiveness in the agricultural and food industries (Sjah & Zainuri, 2020). Therefore, there is an urgent need to mitigate risks, effectively manage price fluctuations, and refine the food supply chain. To achieve this, it is necessary to introduce new approaches and technologies that enhance collaboration among all stakeholders, policy regulation, and overall adaptability and resilience (Umar & Wilson, 2021).

Producers within the food supply chain include restaurants, cafes, and catering organizations engaged in food processing and packaging activities. The following **Figure 3** illustrates the complexity of the food production and service supply chain network.



Source: Harward lesson.

Figure 3. Movements of food and money in a simple food supply chain.

As illustrated in the figure above, food products pass through multiple stages from farmers to consumers within the food production and service supply chain. Market instabilities, such as fluctuations in raw material prices, exchange rates, and shifts in consumer demand, impact the sustainability and profitability of the food supply chain (Ihle et al., 2020). In addition to these challenges, risks such as rising labor costs due to a shortage of skilled workforce and increased transportation costs lead to higher prices for consumers and diminished corporate profitability (Fabian et al., 2023). Accounting plays a vital role in mitigating risks and managing food price volatility within the global food supply chain (Um & Han, 2021). As a science focused on measuring, analyzing, and communicating financial information, it provides essential tools and modeling for identifying, assessing, and responding to risks, as well as monitoring and managing financial performance and outcomes (Mio et al., 2022). Significant representatives of the food industry include restaurants, cafes, fast-food outlets, lounges, and BBQ eateries. For entrepreneurs operating in the restaurant industry, food inflation has emerged as the most severe challenge to business expansion (Do, 2023). Due to food price instability, supply chain disruptions, and market shortages, food inflation specifically affecting restaurants reached 8.8% annually as of March 2023 (Guinn, 2024). Consequently, restaurants have had to re-evaluate their management methods and approaches to mitigate the impact of inflation, recover costs, increase operational efficiency, and maintain customer satisfaction (Do, 2023). During periods of high food inflation, 79% of restaurants with high-performing supply chains reported revenue growth, demonstrating that supply chain management plays a critical role in overcoming challenges caused by surging food prices (Ross, 2023). Following the COVID-19 pandemic, business owners noted that the intensified impact of food inflation required food producers to pay significantly higher prices for core raw materials than before. Arshinder (2008) highlights that collaborative planning with suppliers prevents excess inventory and reduces production costs. This enables restaurants to withstand demand fluctuations, minimize waste, and maintain product quality. For restaurants, efficient inventory management is a fundamental factor in optimizing resource utilization and minimizing costs (Do, 2023). To implement optimal inventory management, let us consider the costs incurred at each stage of the food supply chain.

In implementing optimal inventory management within the food supply chain, it is effective to utilize advanced technologies, AI-based tools, and Automated Guided Vehicles (AGVs), alongside predictive analytics and optimization algorithms (Frohlich & Westbrook, 2001; Liu et al., 2013). While previous studies have extensively explored the theoretical aspects of supply chain and cost management, research that implements Activity-Based Costing (ABC) within the food production and service industry through real-world case studies and evaluates its effectiveness remains scarce. There is a lack of empirical research regarding the practical implementation of this methodology within the context of developing countries.

Research questions

The following questions were raised by conducting a literature review. These include:

- To what extent can Activity-Based Costing (ABC) be effectively implemented to define the cost structure within food production and service establishments?
- Is it possible to assess the importance of costs in the cost structure using the Multi-Criteria Decision-Making method (AHP)?
- Can the Sphere Packing Approach (SPA) be used to optimize the cost of food production and service industry?

Research objectives

The objective of this study is to identify the cost structure of primary and support activities in the food production and service industry supply chain and to demonstrate the feasibility of utilizing ABC, the Analytic Hierarchy Process (AHP), and SPA for cost optimization. The research was conducted using Sangyeopsal Express restaurant as a case study, proposing a viable methodology for calculating and reducing costs within the supply chain of the food production and service industry.

3. Research Methodology

This study employs a case study methodology, which allows for an in-depth examination of organizational operations and an assessment of the effectiveness of specific methodologies within a particular context. Researchers emphasize that this approach is particularly suitable for explaining complex phenomena (Falks, 2018). To analyze the entire supply chain of the food production industry, Sangyeopsal Express restaurant, operating in Ulaanbaatar, Mongolia, was selected as the research object. The study encompasses the primary and support activities of the restaurant's supply chain, examining costs incurred during procurement, storage, production, logistics, and delivery to the customer. The scope is focused on identifying costs that directly and indirectly impact the restaurant's daily operations, as well as classifying and evaluating them using the Activity-Based Costing (ABC) method. The research utilized both primary and secondary data sources. Collected through semi-structured interviews with the restaurant's management, finance, and operations staff. The interview framework was developed based on supply chain management theory and established models from previous studies, specifically those used by Mentzer et al. (2001) and Seuring and Müller (2008). Gathered from organizational financial statements, procurement documentation, inventory records, and relevant internal rules and regulations.

The following methodologies were utilized in this study to achieve the research objectives:

- Supply Chain Mapping: Used to define the complete supply chain structure of food production and service organization.
- Activity-Based Costing (ABC): Utilized to calculate cost components. The objective of the ABC method is to enhance the transparency of cost information and to better classify expenses incurred throughout various processes (Kenton, 2020).

The following points were taken into account when using the ABC method.

These include:

- When using the ABC method, the cost of production and services was calculated by classifying the organization's costs, distinguishing them into direct and indirect production costs, and determining and distributing the cost drivers for distributing indirect costs.

- The costs of food production enterprises include the cost of services in an indistinguishable manner along with food production. When distributing this, the cost drivers are determined for each element.

- The total restaurant costs were analyzed based on the income and expense indicators expressed in the financial statements of the research object for the last 3 years and classified into costs directly attributable to food production and other service costs. If the direct costs of food production include food materials and the salary of the cook, the salaries of the supply materials, waiters and other service staff who are involved in supporting the operation and cannot be directly attributed to production and services, but are classified as indirect costs, and sales revenue, number of customers, and useful area are selected as cost drivers.

- The costs that constitute the cost were identified and their importance was assessed using the multi-criteria decision-making method (AHP). A total of 5 experts, including 2 operations directors and 3 heads of planning departments with more than 5 years of experience in the food industry, participated in the AHP analysis. The experts were selected based on their industry experience, supply chain knowledge, decision-making skills, experience, and practical understanding of the organization's operations. In the first stage of the assessment, each expert filled out a pairwise comparison table individually, and in the next stage, a consensus was reached through discussion and consensus through the Delphi method. To confirm the reliability of the AHP analysis, a consistency ratio was performed, and CR = 0.08 was obtained. This showed that the importance weights of the costs obtained through the AHP analysis were statistically reliable and did not have logical contradictions.

Sphere Packing Approach (SPA): Employed to optimize supply chain costs, using the methodology proposed by Enkhbat. R and utilized in his 2016 work, Global Optimization Approach to Malfatti's Problem. Based on the results of theoretical research, expert analysis, and accounting report data of Sangyeopsal Express restaurant, variables were determined for the five costs shown in Table 2. The following is a policy to determine the range of possible values of these five costs without exceeding the total cost of the restaurant. The mathematical model for calculating the optimal cost of Sangyeopsal Express restaurant using the packing problem is expressed as the following general formula.

$$r \to \max$$
$$\begin{cases} d_1 \le \langle a^1, x \rangle + r\|a^1\| \le b_1 \\ d_2 \le \langle a^2, x \rangle + r\|a^2\| \le b_2 \\ \cdots \\ d_n \le \langle a^n, x \rangle + r\|a^n\| \le b_n \end{cases} \quad (1)$$

$$\|a^i\| = \sqrt{\sum_{i=1, j=1}^{n} \left(a_1^i\right)^2} \quad i = \overline{1, n} \quad (2)$$

where: x_i—symbol denoting the ith type of cost

a_i —the i^{th} element of the matrix

a_i —coefficients of the i^{th} cost variable

b_i —upper bounds of the i[th] cost

d_i —lower bounds of the i[th] cost

$\|a_i\|$ —the norm of the coefficients in the i[th] column.

The objective function aims to maximize the radius of the range of possible values for the allocation of five types of costs without exceeding the total cost, or to plan costs in the most stable and risk-tolerant way. The constraints are defined as the maximum and minimum allowable values for five types of costs.

The collected data were classified, aggregated, and systematized to calculate the costs of each individual activity and define the overall cost structure. The results calculated via the ABC method were analyzed in comparison with traditional costing results to identify cost variances and discrepancies.

4. Results of the Research

The ultimate Supply Chain of Sangyeopsal Express restaurant has the following stages.

Suppliers and Sourcing

- Ingredients:
    - Meat, vegetables, spices, and primary food products.
- Packaging Materials:
    - Food boxes, plastic containers, paper bags, disposable utensils, etc.

These will be transported to the restaurant via Logistics Providers.

Logistics Providers

- Inbound Logistics:
    - Delivering ingredients and packaging to the restaurant.
- Outbound Logistics:
    - Delivering ready-to-eat food from the restaurant to customers.
    - Delivery companies and 3PL service providers will be involved.

Restaurant

- Main Operations
    - Receive ingredients, record them in the Inventory or warehouse, prepare and process them, and produce them into dishes.
- Inventory Management:
    - Optimized management of inventory storage, usage, and reordering.

Customers

- End users who receive food orders.
- Services can be provided in the form of delivery or on-site service.

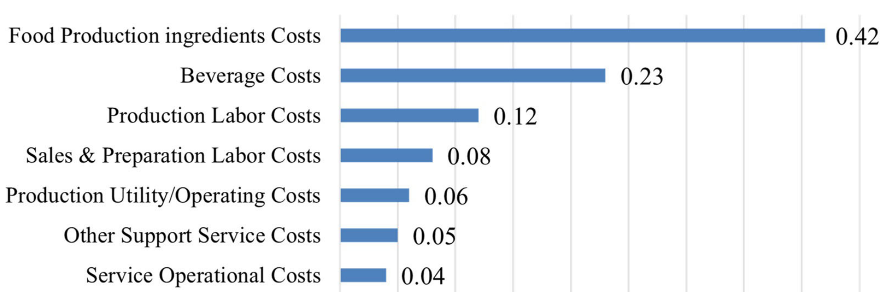
Based on the analysis, the supply chain framework is composed of the following primary stages: raw material procurement, inventory storage, production preparation, food manufacturing (processing), and distribution to the end consumer. It was determined that specific activities occur within each of these stages, resulting in both direct and indirect costs associated with each respective operation. Sangyeopsal Express restaurant creates value through a combination of logistics, operations, marketing, and services, from the supply of ingredients to the final service to the customer. Supporting activities are strategic tools that support the efficiency, quality, and consistency of the main activities. According to accounting data, 78.7 percent of Sangyeopsal Express restaurant's revenue comes from food production and 21.23 percent from beverage sales. Therefore, the costs incurred for each of the main and supporting activities discussed above are shown in the following Table 1.

Table 1. Sangyeopsal Express restaurant costs by type of operation.

Activity	Category	Cost Example
Inbound Logistics	Main	Transportation costs, warehouse rent, refrigerators
Main Operations	Main	Cooking staff salaries, equipment depreciation
Outbound Logistics	Main	Delivery driver salaries, fuel, boxes
Marketing Sales	Main	Advertising, app fees, incentives
Services	Main	Service staff salaries, utility costs
Supply	Support	Supplier contracts, material cost increases
Technology Development	Support	POS systems, software, ordering platforms
Human Resource Management	Support	Employee incentives, training, uniforms
Organizational Structure	Support	Finance software, rent, management costs

Sources: Authors' Elaboration.

The existing information system within the restaurant was found to be inadequate for providing the necessary level of granularity for comprehensive cost and expenditure analysis. To address this limitation, an expert panel was convened to evaluate the cost components within the supply chain of Sangyeopsal Express using the Analytic Hierarchy Process (AHP). This methodology enabled the determination of the relative importance and weight of various cost categories, identifying the most critical factors requiring management focus. The results of this hierarchical evaluation and the subsequent weight distribution of costs are illustrated in the following Figure 4.



Sources: AHP analysis results.

Figure 4. Percentage of expenses at Sangyeopsal express restaurant.

Based on theoretical research, expert analysis, and restaurant management reports, the variables for the five costs of Sangyeopsal Express restaurant are shown in the following cost Table 2.

Table 2. Variables and their descriptions.

Variables	Cost	Description
x1	ingredients-food (material)	Ingredients needed for food production
x2	Ingredients-beverage (material)	Ingredients needed to support food production
x3	salary-food	Salary of employees involved in food production
x4	salary-other	Salary of employees in units other than food production
x5	utilization	Food production and operation support costs

Sources: Authors' elaboration.

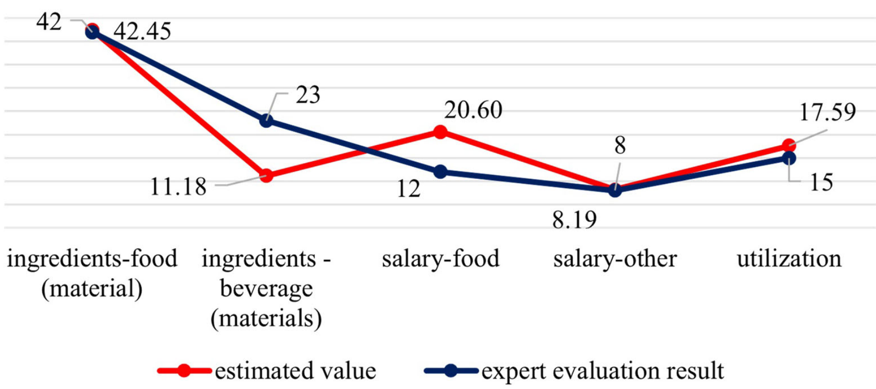
The quantitative data required for the mathematical optimization model were systematically derived from the organization's financial accounting reports. This empirical dataset served as the foundation for defining the parameters of the Sphere Packing Approach to determine the optimal cost structure. The following Table 3 presents the calculated ranges for these optimal cost values, providing a benchmark for efficient resource allocation within the supply chain.

Table 3. Range, radius, and center value of the optimal value of student workload calculated by mathematical model, in million tugriks.

Cost	Variables	r*	Optimal value (x*)	Cost	
				MIN	MAX
ingredients-food (material)	x1*	4.5	510.5	506	515
Ingredients-beverage (material)	x2*		134.5	130	139
salary-food	x3*		247.7	243.2	252.2
salary-other	x4*		98.5	94	103
utilization	x5*		211.5	207	216
	Total		1202.7	1192.64	1212.77

Sources: Authors' elaboration.

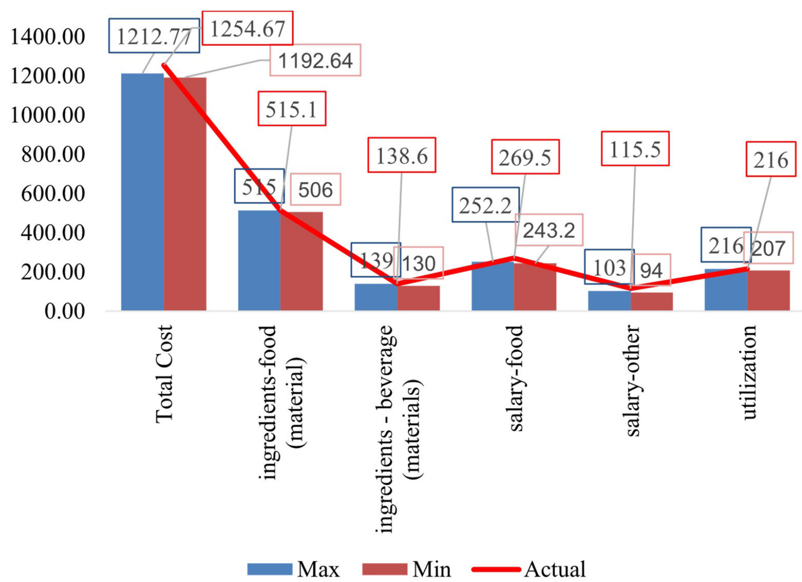
The optimization analysis conducted using the SPA model determined that the optimal annual cost structure for the organization consists of 510.5 million MNT for food production, 134.5 million MNT for beverage production materials and 247.7 million MNT for production staff salaries. Additionally, administrative and other support staff salaries were calculated at 98.5 million MNT, while utility and operational expenses accounted for 211.5 million MNT. The subsequent Figure 5 illustrates a comparative analysis between these optimized cost proportions and the benchmarks derived from industry expert evaluations, highlighting the model's strategic alignment with industry standards.



Sources: Authors' elaboration.

Figure 5. Analysis of cost proportions and expert evaluation.

Based on the figure above, a comparison between the share of estimated costs in the total cost of Sangyeopsal Express and industry expert evaluations indicates that food production material and operational costs are consistent with industry standards. However, food production support costs are relatively low, whereas labor costs for production staff are disproportionately high. The following Figure 6 illustrates a comparative analysis of the minimum, maximum, and actual current cost values.



Sources: Authors' elaboration.

Figure 6. Comparison of estimated and actual costs.

Based on the comparison between the estimated and actual cost values, the annual expenditure of Sangyeopsal Express restaurant exceeds the maximum threshold of the estimated cost range. This discrepancy is likely attributable to high labor costs within the food production process. Therefore, by implementing appropriate cost management methodologies in this specific segment of the supply chain—namely, the food production activity, and aligning expenditures within the feasible estimated range, the organization will be able to achieve its target profit levels.

5. Conclusion

The supply chain encompasses the flow of materials, information, capital, and services from raw material suppliers to the end consumer. Effectively managing this flow enhances organizational value for customers and other stakeholders (Turban & King, 2003). Supply chain management (SCM) consists of interconnected elements, including infrastructure, business processes, and management frameworks (Stock & Lambert, 2001).

Based on the synthesis of previous research and the findings of this study, the primary objectives of SCM are to reduce total costs, optimize operations, minimize errors, and support data-driven decision-making. Therefore, it is emphasized that decision-makers must adopt a holistic view of total supply chain costs, including labor, capital, operational efficiency, inventory, and tax expenses—rather than focusing solely on the purchase price of a product.

The results derived from managers in the food production industry indicate that integrating various cost management approaches for effective supply chain management can have a positive impact on decision-making. Furthermore, by allocating costs using the Activity-Based Costing (ABC) method based on historical data from Sangyeopsal Express restaurant and applying the SPA to the cost components of food production, a framework is established for making decisions aimed at monitoring and reducing costs to feasible levels.

Therefore, the answers to the three questions raised earlier were resolved as follows.

- Given the significant fluctuations in material, labor, and temporal requirements across diverse product lines, the implementation of **Activity-Based Costing (ABC)** is hypothesized to enhance the accuracy of cost allocation, thereby facilitating more rational and data-driven managerial decision-making.
- The Consistency Ratio (CR = 0.08) of expert evaluation is statistically significant, which shows that the weight of the importance of costs determined by AHP analysis is statistically reliable and does not have logical contradictions. Therefore, it is believed that it is possible to determine the relative importance of cost types using the AHP method and prioritize the costs that require management attention.
- The Sphere Packing Approach (SPA) method answers the question of how to fit a certain number of spheres into a given range without overlapping or intersecting each other, with the largest possible volume. The center value x^*

and radius r^* obtained from the study calculated the possible cost range, and showed that the total cost could be kept within the range of 1192.64 - 1212.77 million tugriks. The cost values and the share of the 5 types of costs calculated by SPA are consistent with the actual restaurant cost data and expert assessments. Therefore, the SPA method can be considered a suitable mathematical tool for managing the costs of food production and service establishments at an optimal level.

6. Discussion

Cost control must be implemented based on the results of the SPA. Various established methods exist for monitoring and reducing costs. These include controlling material costs through Economic Order Quantity (EOQ), enhancing labor cost efficiency by increasing productivity, and reducing fixed costs per unit of product or service through economies of scale by expanding production and operations. The results of this solution, which is based on the specific material of each cost component embedded in the total cost of products and services, can serve as a robust foundation for making optimal management decisions.

7. Research Limitations

Although this study was conducted on a specific site, it has proposed a general methodology that can be applied to the food production and service industries. Depending on the scale and type of company's operations, there may be many or few types of expenses, and the amount may fluctuate, but we believe that if the operator is chosen wisely and technical errors are avoided, there should be no problems.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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