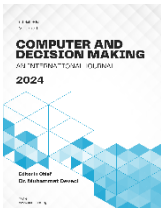
Computer and Decision Making

An International Journal

www.comdem.org
eISSN: 3008-1416



Inventory Classification with AHP and ABC Analyses: A Case Study for Dental Products Production

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ARTICLE INFO

Article history:
Received 9 August 2024
Received in revised form 9 September 2024
Accepted 10 September 2024
Available online 10 September 2024

Keywords:

Inventory Management, Analytic Hierarchy Proses, AHP, ABC analysis, Multi Criteria Decision Making.

ABSTRACT

This study explores the applicability of the Hierarchical Decision-Making Method (AHP) and Activity-Based Costing (ABC) analyses in the inventory management of dental products. The ABC analysis categorizes products into A, B, and C categories based on financial values. Category A products represent 80% of the total inventory value, while categories B and C represent 15% and 5%, respectively. These products are grouped according to their importance for stock tracking and control. The AHP analysis, on the other hand, ranks products based on criteria such as demand, price, delivery time, depreciation, and importance. The results from AHP showed that some products matched the ABC categories while others fell into different categories. These findings highlight that the combined use of AHP and ABC analyses allows for a more comprehensive and strategic approach to inventory management.

1. Introduction

In today's competitive business environment, achieving success and maintaining sustainable growth requires businesses to optimize their operations [1] continually. Reducing inventory costs under economic conditions is a significant strategic move for businesses. Effective management of inventory costs lowers production expenses and enhances competitive advantage [2]. This leads to increased profit margins and supports more sustainable growth. Lower inventory costs accelerate the capital cycle, improve liquidity, and enhance financial flexibility and resilience against unforeseen circumstances. Additionally, it enables more efficient management of production processes, allows for faster inventory turnover, and boosts customer satisfaction. It also saves warehouse space and inventory management [3].

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https://doi.org/10.59543/comdem.v1i.10487

In particular, the production and inventory management of dental products in the healthcare sector is a process that must be handled with precision, highlighting the need for a delicate balance between medical requirements and customer demands. Inventory management is a critical factor influencing a business's capital cycle. Effective inventory management strategies allow for cost reduction, increased operational efficiency, and enhanced customer satisfaction [4]. However, successful inventory management requires comprehensive analysis and strategic planning.

2. Inventory Management

Inventory management plays a critical role in production processes and is often significantly influenced by the share of inventory costs in product costs [1, 5]. Effective inventory management strategies are crucial for reducing costs, improving efficiency, and ensuring customer satisfaction. Proper inventory levels are essential for seamless operations. Excessive inventory increases costs and lowers profitability, while insufficient inventory can cause production disruptions and affect customer satisfaction. Managing inventory effectively helps balance supply and demand, thereby optimizing overall performance [6].

Inventory control is the process of managing stocks, which are one of the most important assets of a business, and this process plays a critical role in the company's success. Stocks represent the materials and products necessary for a business to manage its operations effectively [7]. Inventory control ensures that materials are provided at the right time, in the right quantity, and of the right quality. This process includes steps such as determining material needs, selecting appropriate materials, setting optimal inventory levels, scheduling order times, maintaining inventory records, and calculating minimum capital requirements [3, 8].

Effective inventory control is crucial for optimizing business performance. By addressing business demand and marketing issues, businesses can identify the ideal inventory levels. Successful inventory management maximizes profits, reduces costs, and enhances customer satisfaction. It involves managing inventory to meet customer demand with minimal cost and investment, thereby strengthening the relationship between inventory control and overall business performance [9].

Inventory control strategies may vary depending on the industry, the size of the business, and other factors. For example, the retail sector may require handling rapid demand changes, whereas the manufacturing sector may need to manage complex supply chains [1]. When establishing inventory control strategies, businesses should adopt a balanced approach. These strategies should aim to minimize inventory holding costs, enhance customer service levels, and strengthen the supply chain. Moreover, the use of technology and data analysis facilitates more accurate forecasting and more effective decision-making [10].

3. Literature Review

A significant amount of literature has been devoted to inventory classification, especially for spare parts, due to their critical role in maintenance activities. Proper management of spare parts is crucial for minimizing stock levels and reducing downtime. Effective classification helps balance inventory with demand, ensuring smooth repair processes and meeting organizational needs. One of the main challenges in spare parts management is classifying these items to improve decision-making. Various

methods for classifying inventory and spare parts have been explored, including mathematical approaches, artificial intelligence techniques, and multi-criteria decision-making methods. Among these, ABC analysis is the most fundamental and widely used technique due to its simplicity and ease of implementation [11]. Each inventory item has a unique value that diminishes over time, requiring companies to assess the importance of items relative to their operations. Effective inventory management necessitates an active control system. The ABC analysis offers a classification method based on item value and volume. This methodology, derived from the Pareto principle, suggests that a small percentage of items are highly valuable, while a large percentage are less valuable. Applying uniform control rates across all product categories is inefficient due to the varying costs associated with inventory and operations [12]. ABC analysis is favored in inventory and stock management because it simplifies classification among options. This method is especially crucial for businesses with diverse material groups, as it helps in classifying these materials effectively. The value of each item or material in inventory varies, typically represented by factors such as monetary value, sales velocity, demand pattern, and profitability [13]. Inventory represents the value and records of all items a business holds. In today's volatile and complex environment, effective inventory management is crucial for maintaining a competitive edge. ABC analysis is a tool derived from Pareto analysis, which is based on the 80/20 principle. This principle suggests that 20% of items account for 80% of the impact, such as sales, profit, or inventory value. In ABC analysis, items are classified into three groups: "A" for the most important items, "C" for the least important, and "B" for those in between. The terms "class of items" and "clusters" are used interchangeably in this context, reflecting the goal of classifying and clustering items based on their importance [14]. The ABC classification method helps businesses focus their inventory management efforts and allocate resources to the most critical inventory items. By doing so, businesses can minimize inventory costs while effectively managing critical stock [15].

The Analytic Hierarchy Process (AHP) is particularly advantageous for decision-making across various sectors due to its adaptability in selection situations. It facilitates the use of both qualitative and quantitative criteria by leveraging the experience and knowledge of decision-makers. This flexibility is beneficial for researchers applying AHP's core steps to solve complex problems. AHP is commonly used not only as a direct method for multi-criteria decision-making but also as a tool for determining criteria weights in various integrated applications [16]. The initial studies focused on weapon systems and utilized the Fuzzy AHP (FAHP) method to select tactical land-sea missiles, helicopters for air attacks, and air defense projects aimed at countering these attacks. This approach incorporated linguistic variables for both subjective and objective judgments. The focus then shifted from aviation to land defense systems, emphasizing their effectiveness on the battlefield by integrating both subjective and objective assessments through the FAHP method. Additionally, the AHP method was employed to evaluate investments in naval assets, submarine fleets, military network sensors, and technology transfer activities within the defense industry. Many subsequent studies have continued to use AHP for decision support, contributing to the ongoing development of the literature [17]. The AHP (Analytic Hierarchy Process) method is a framework for prioritizing factors within a hierarchical

structure based on common criteria or attributes. It involves pairwise comparisons to rank the relative importance of options, making it applicable to both simple personal decisions and complex, capital-intensive choices. Its simplicity, clarity, and ease of use contribute to its widespread adoption for decision-making. Research on its theoretical aspects is ongoing, and AHP has been employed in various models, such as assessing risk factors in satellite assembly and evaluating security risks of satellite constellations. Additionally, AHP has been integrated with other methods, like logistic regression for landslide risk zones and fuzzy analytics for evaluating industrial sectors under free trade agreements (FTAs) [18].

4. METHODOLOGY

In the production process of dental laboratory equipment, identifying critical items for future effective management of resources is essential. In this context, the ABC analysis and the Analytical Hierarchy Process (AHP) methodologies have been chosen to classify strategically important elements in a hierarchical structure based on the company's revenue and profit margins. These methods aim to identify items that are rarely used and, therefore, have a detrimental effect on stock costs, with the goal of reducing or completely eliminating such items from inventory.

Additionally, operations are optimized to ensure that critical items are always available in stock to continuously meet customer needs. The company's stock costs are managed through the classification of items determined by in-depth analyses using ABC and AHP methods. This systematic approach ensures that inventory management is both cost-effective and capable of meeting demand effectively.

7.1. The classification of company inventory using ABC analysis

Based on the ABC analysis data for the company's inventory, there are a total of 95 different items. The results of the ABC analysis have classified these items into categories A, B, and C. These categories are determined according to the financial value and importance of the items in the stock. Table 1 shows the results of the ABC analysis.

Table 1. ABC Analysis Results of Company Inventory

NO	Product Name	Annual usage Quantity	Unit Price (TL)	Annual usage value (TL)	Cumulative usage value	Cumulative percentage %	ABC
1	Laminated Workbench and Drawer	460	1,200	552,000	552,000	8	A
80	ConicalDiamondInsertSleeve	1,200	350	420,000	972,000	14	A
81	PenMechanism	500	290	145,000	1,117,000	16	A
62	40x40 cm 5 mm ThickGlass	530	550	291,500	1,408,500	21	A
63	35x35 cm 5 mm ThickGlass	530	475	251,750	1,660,250	25	A

61	30x30 cm 5 mm ThickGlass	530	450	238,500	1,898,750	28	A
64	25x25 cm 5 mm ThickGlass	530	425	225,250	2,124,000	31	A
65	20x20 cm 5 mm ThickGlass	530	400	212,000	2,336,000	34	A
59	80x30 cm Satin-Finished 430 QualityStainless Steel Plate	450	200	90,000	2,426,000	36	A
60	20x20 cm Satin-Finished 430 QualityStainless Steel Plate	700	196	137,200	2,563,200	38	A
42	1 mm 430 QualitySatin-FinishedStainless Steel	300	190	57,000	2,620,200	39	A
2	Star HeadedScrew	5000	50	250,000	2,870,200	42	A
43	40 mm 4-Corner Yellow Bar	750	83	62,250	2,932,450	43	A
51	25 cm Carbon Stone	300	220	66,000	2,998,450	44	A
41	7 kg CastAluminumHead	200	220	44,000	3,042,450	45	A
49	1 HP 2900 RPM Electric Motor	920	600	552,000	3,594,450	53	A
53	M6 KnobScrew	2,600	23	59,800	3,654,250	54	A
54	M6 Allen Screw	2,600	20	52,000	3,706,250	55	A
3	Handle	3,000	20	60,000	3,766,250	56	A
69	10 mm Stainless Steel Pipe	320	116	37,120	3,803,370	56	A
55	M6 BakeliteHeadedScrew	5,000	16	80,000	3,883,370	57	A
91	5x5 cm ø 32 mm VacuumPlate	530	78	41,340	3,924,710	58	A
86	360-Degree RotatableGlassLock	1,200	26	31,200	3,955,910	58	A
44	40 mm RoundDerlin Bar	500	24	12,000	3,967,910	59	A
4	GasValve	1,200	100	120,000	4,087,910	60	A
5	DKP Sheet Metal	860	29	24,940	4,112,850	61	A
6	Rail	1,200	20	24,000	4,136,850	61	A
57	WaterInletValve	560	100	56,000	4,192,850	62	A
83	3/8 Air Control Pedal	1,200	136	163,200	4,356,050	64	A
92	1/20 mm DKP ColdIronFrame	600	120	72,000	4,428,050	65	A

93	1/20 mm DKP ColdIronBackCover	500	120	60,000	4,488,050	66	A
94	1/20 mm DKP ColdIron Top Cover	500	120	60,000	4,548,050	67	A
85	1 m 10 mm Elastic Profile	620	68	42,160	4,590,210	68	A
58	6 mm 30 cm SiliconeHose	900	33	29,700	4,619,910	68	A
7	VacuumHose	900	18	16,200	4,636,110	68	A
8	Bubble Wrap	230	150	34,500	4,670,610	69	A
9	AirGun	2,300	100	230,000	4,900,610	72	A
56	0.5 mm 40x20 cm EroxalAluminumPlate	560	69	38,640	4,939,250	73	A
10	2.5 mm Cable Insulator	1,500	12	18,000	4,957,250	73	A
11	Profile	400	100	40,000	4,997,250	74	A
90	LargeOliveRubber	3,500	5	17,500	5,014,750	74	A
12	1.5 mm Cable Insulator	5,400	10	54,000	5,068,750	75	A
13	Filter	1,200	65	78,000	5,146,750	76	A
14	1.5 mm KeyInsulator	5,400	9	48,600	5,195,350	77	A
15	Electronic Motor Control Board	100	100	10,000	5,205,350	77	A
45	3 mm AluminumBackPlate	2,400	76	182,400	5,387,750	80	A
16	3x1.5 mm Cable	600	45	27,000	5,414,750	80	A
77	2 mm x 35 cm NylonSilicone Cable	650	29	18,850	5,433,600	80	A
79	220 V 15 W 50 HzBulb	1,000	14	14,000	5,447,600	80	A
89	Small OliveRubber	3,500	3	10,500	5,458,100	81	B
17	Armrest	1,500	40	60,000	5,518,100	81	B
19	Tape FixtureLamp	600	50	30,000	5,548,100	82	B
18	GroundInsulator	5,400	7	37,800	5,585,900	82	B
50	SquareAccordion Switch	1,200	28	33,600	5,619,500	83	B
20	2x1.5 mm Cable	800	30	24,000	5,643,500	83	B
21	1x1.5 mm Multiple Wire	800	15	12000	5,655,500	83	B
22	WorkHair	2,400	50	120,000	5,775,500	85	B
73	1/15 Three-WayValve	350	43	15,050	5,790,550	85	B

84	2 mm SiliconeAirHose	600	31	18,600	5,809,150	86	B
72	1/8 6 mm ElbowAutomaticFitting	560	37	20,720	5,829,870	86	B
87	ConicalSiliconeInsert	780	11	8,580	5,838,450	86	B
74	1/4 Four-WayStraightFitting	150	33	4,950	5,843,400	86	B
23	Vacuum Port	2,400	50	120,000	5,963,400	88	B
76	Accordion Switch	1,200	20	24,000	5,987,400	88	B
75	1/4 6 mm StraightAutomaticFitting	650	30	19,500	6,006,900	89	B
24	AirLabel	3,000	10	30,000	6,036,900	89	B
46	40 mm PerforatedDerlinDrainagePath	350	24	8,400	6,045,300	89	B
82	6/8 SiliconeAirHose	200	12	2,400	6,047,700	89	B
25	Plaster Top Prism	3,000	18	54,000	6,101,700	90	B
26	Motor Foot	1,100	3	3,300	6,105,000	90	B
27	AirHose	2,300	35	80,500	6,185,500	91	B
95	6 mm GlassHinge	1,300	7	9,100	6,194,600	91	B
52	Black Foot	5,000	3	15,000	6,209,600	92	B
88	PerforatedPlasticFoot	5,000	3	15,000	6,224,600	92	B
28	Bet Bag	5,200	10	52,000	6,276,600	93	B
66	Top CoverforTube	650	16	10,400	6,287,000	93	B
68	ExternalCoverforTube	650	16	10,400	6,297,400	93	B
67	BottomCoverforTube	650	16	10,400	6,307,800	93	B
78	ItalianLampSocket	1,000	5	5,000	6,312,800	93	B
29	Plaster BottomPrism	230	15	3,450	6,316,250	93	B
47	1/4 8 mm AutomaticFitting	350	18	6,300	6,322,550	93	B
30	220 V 1200 RPM Motor	920	250	230,000	6,552,550	97	C
31	Samsung LED 14 W x3	650	50	32,500	6,585,050	97	C
70	1/8 SinteredMuffler	200	14	2,800	6,587,850	97	C
32	TableLeg	1,200	10	12,000	6,599,850	97	C

33	Lamp Connector 2x0.75 mm	1,000	10	10,000	6,609,850	98	C
34	Lamp Post Cover	1,000	10	10,000	6,619,850	98	C
71	MetricHex Bolt	230	9	2,070	6,621,920	98	C
48	5 mm Silicone	100	8	800	6,622,720	98	C
35	Plexiglass	2,400	10	24,000	6,646,720	98	C
36	Cat'sEye 220 V	1,000	8	8,000	6,654,720	98	C
37	Terminal No:1	3,500	20	70,000	6,724,720	99	C
38	MicromotorCover	2,400	6	14,400	6,739,120	99	C
39	On-Off Switch 250 V	1,000	9	9,000	6,748,120	100	C
40	DIY Lamp 5 mm	1,300	20	26,000	6,774,120	100	C

According to Table 1, Category A products represent 80% of the company's stock value and include the most costly items. For example, the "Laminated Bench and Drawer" constitutes 8% of the stock value and requires detailed stock tracking and high-level control. Category B products cover 15% of the stock value and 30% of the number of items, including products such as "Small Olive Rubber" and "Armrest." These items should be managed with a balance between cost and availability. Category C products account for 5% of the stock value and 50% of the number of items. They are low-cost, high-quantity products, such as "Samsung LED 14W x 3." The management of these items should focus on reducing overall costs and avoiding excessive inventory.

Based on this data, Figure 1, the ABC Chart, illustrates the distribution of the company's inventory by cost and usage frequency. The slope of the chart reflects the importance levels of the inventory items and their contributions to the total stock value.

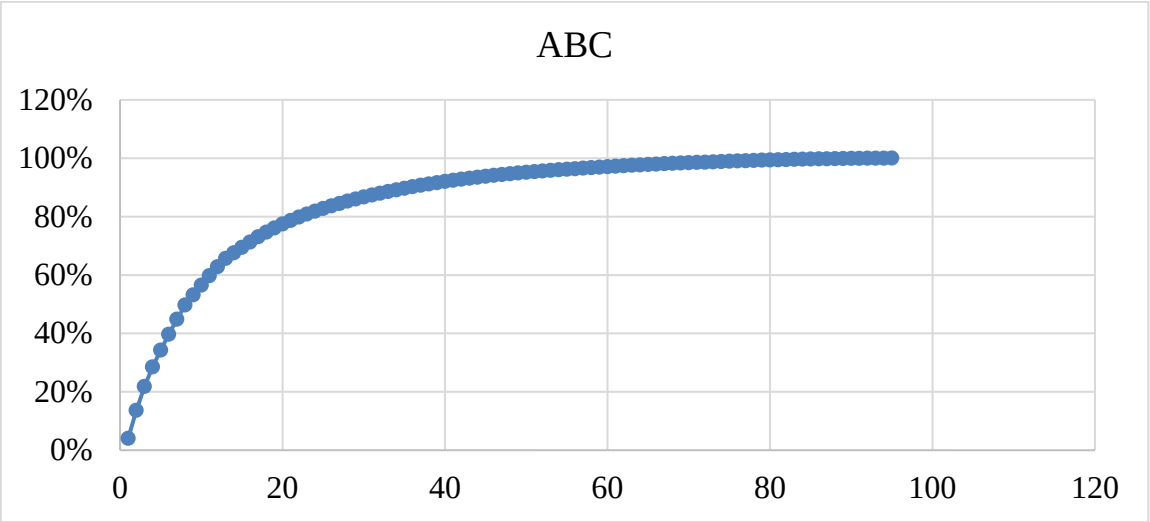

Figure 1. ABC Chart of Company Inventory

7.2. Inventory Turnover Ratio

The inventory turnover ratio is calculated using this formula:

Annual Sales Revenue represents the total sales revenue that the company has earned over a one-year period. The Average Inventory Value refers to the average value of the company's inventory throughout the year, usually determined by averaging the beginning inventory value with the ending inventory value.

$$\text{Inventory Turnover Ratio} = \frac{\text{Annual Sales Revenue}}{\text{Average Inventory Value}}$$

$$\text{Inventory Turnover Ratio} = \frac{15{,}364{,}328\ TL}{6{,}774{,}120\ TL} = 2.2$$

The result of this calculation shows that the inventory turnover ratio is approximately 2.2. This value indicates that the company's inventory turns over about 2.2 times per year. In other words, the company sells and replenishes its inventory approximately 2.2 times annually.

This inventory turnover ratio suggests that the company's inventory management is at a healthy level. It indicates that the company is managing its inventory effectively and is turning over its stock quickly to achieve optimal efficiency. This scenario could imply that the company's inventory management strategies are successful and that it is effectively meeting customer demand.

7.3. Classifying Company Inventory Using AHP

Step 1: Data Collection

A company that manufactures dental laboratory products has conducted a comprehensive AHP evaluation for inventory management. In this process, a preliminary classification based on traditional ABC analysis was carried out, and 95 different stock items were considered. According to the literature, especially in the multi-criteria ABC analysis approaches outlined by Partovi and Burton [20], factors such as price and demand are evaluated along with stockout cost, importance, depreciation, substitution possibilities, and common usage. These criteria are shown in Figure 2. They were carefully assessed by the company's expert team, and the importance of each criterion was determined using the consistent ranking methodology of AHP

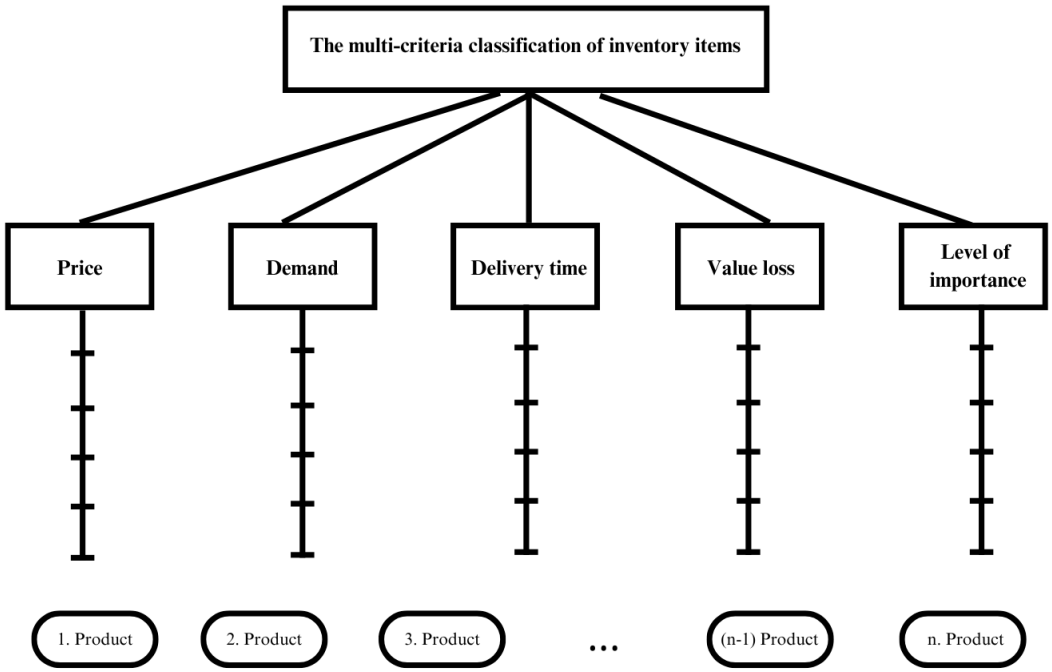

Figure 2: Multi-Criteria Decision-Making Hierarchy(Partovi ve Burton, 1993)

Step 2: Creation of the Pairwise Comparison Matrix and Calculation of the Consistency Ratio

In decision-making processes, one of the fundamental steps of the AHP methodology is the pairwise comparison matrix, which assesses the relative importance of decision factors. Inputs obtained from the company's inventory manager cover inventory management criteria such as price, demand, delivery time, stockout cost, and depreciation. Saaty's nine-point scale provides a systematic evaluation among these criteria and offers objective consistency in the decision-making process. For example, pairwise comparisons might be made to assess the impact of raw material price on demand or the priority of delivery time compared to stockout cost. These numerical comparisons are used to determine the relative weight and priority level of each criterion. The pairwise comparison matrix is provided in Table 2.

Table 2: Pairwise Comparison Matrix

Criterion	Demand	Price	Delivery time	Value loss	Level of
Demand	1	3	5	7	9
Price	1/3	1	3	5	7
Delivery	1/5	1/3	1	3	5
Value loss	1/7	1/5	1/3	1	3
Level of importance	1/9	1/7	1/5	1/3	1

According to the normalization matrix provided in Table 3, the weight vector for each criterion was calculated by dividing the row sums of the pairwise comparison matrix by the column totals. To normalize the matrix, the total for each column was computed, and each element was divided by the corresponding column total.

Table 3. Normalization Matrix

criterion	Demand	Price	Delivery time	Value loss	Level of importance
Demand	$\frac{1}{2.849} =$ $\mathbf{0.35}$	$\frac{3}{4.771} =$ $\mathbf{0.62}$	$\frac{5}{9.523} =$ $\mathbf{0.52}$	$\frac{7}{16.333} =$ $\mathbf{0.42}$	$\frac{9}{26} =$ $\mathbf{0.36}$
Price	$\frac{3}{2.849} =$ $\mathbf{0.11}$	$\frac{1}{4.771} =$ $\mathbf{0.20}$	$\frac{3}{9.523} =$ $\mathbf{0.31}$	$\frac{5}{16.333} =$ $\mathbf{0.30}$	$\frac{7}{26} =$ $\mathbf{0.28}$
Delivery time	$\frac{5}{2.849} =$ $\mathbf{0.07}$	$\frac{\frac{1}{3}}{4.771} =$ $\mathbf{0.07}$	$\frac{1}{9.523} =$ $\mathbf{0.10}$	$\frac{3}{16.333} =$ $\mathbf{0.18}$	$\frac{5}{26} =$ $\mathbf{0.20}$
Value loss	$\frac{7}{2.849} =$ $\mathbf{0.05}$	$\frac{\frac{1}{5}}{4.771} =$ $\mathbf{0.04}$	$\frac{\frac{1}{3}}{9.523} =$ $\mathbf{0.03}$	$\frac{1}{16.333} =$ $\mathbf{0.06}$	$\frac{3}{26} =$ $\mathbf{0.12}$
Level of importance	$\frac{9}{2.849} =$ $\mathbf{0.03}$	$\frac{\frac{1}{7}}{4.771} =$ $\mathbf{0.03}$	$\frac{\frac{1}{5}}{9.523} =$ $\mathbf{0.02}$	$\frac{\frac{1}{3}}{16.333} =$ $\mathbf{0.02}$	$\frac{1}{26} =$ $\mathbf{0.04}$

The average value of each row reflects the weight of the corresponding criterion. The criterion weights calculated using this method are shown in Table 4.

Tablo 4. Weights of criteria

Criterion	Weight
Demand	0.45
Price	0.23
Delivery time	0.15
Value loss	0.09
Level of importance	0.05

The criterion weights obtained from the pairwise comparison matrix is used to assess the consistency of the decision-making process. The Consistency Ratio (CR) indicates how consistent the evaluations are and is expected to be below the acceptable threshold of 0.1. As a result of the calculations, CR = 0.0375 was found, indicating that the matrix is highly consistent. This result confirms that the evaluations by the company's experts are reliable, and the results are valid. The obtained criterion weight vector is w = [0.457, 0.239, 0.158, 0.095, 0.050], which highlights that the demand criterion is the most prioritized factor in inventory management.

Step 3: Adapting the Five-Point Scale to Saaty's Nine-Point Scale

The scores on the five-point scale have been mapped and converted to Saaty's nine-point scale. This transformation facilitated the determination of the necessary numerical values for pairwise comparisons and allowed the obtained weight values to be used in determining the relative importance of inventory items. During the hierarchical structure formation process, these weight values were used to rank the importance of stock items and establish a decision-making hierarchy for the selection process. The criterion scores for the products on the nine-point scale are shown as an example in Table 5.

Table 5. Product Criterion Scores (Nine-Point Scale)

NO	Products	Demand	Price	Delivery time	Value loss	Level of importance
1	Laminated Workbench and Drawer	9	7	7	7	9
2	Screw	9	5	5	3	7
3	Handle	9	5	7	3	5
4	Gaz valve	5	5	3	5	7
5	Cold-Rolled Steel Sheet	7	3	3	3	3
6	Rail	7	5	5	3	5
7	Vacuum hose	7	5	7	5	5
8	Bubble wrap bag	3	5	5	7	3

The criterion weights obtained from the pairwise comparison matrix is used in calculating the consistency ratio. This ratio indicates how consistent and reliable the decision-making process is. The consistency ratio measures the extent to which subjective judgments are consistent in the decision-making process and keeping it below an acceptable threshold enhances the reliability of the decision matrix. A high consistency ratio indicates inconsistencies among evaluations and suggests that decision-makers may need to reassess the relative importance of certain criteria.

In transitioning from the five-point scale to Saaty's nine-point scale, the weight values reflecting the relative importance of the criteria were calculated as [0.36, 0.28, 0.20, 0.12, 0.04]. The highest weight of 0.36 served as the reference for adjusting the other values. The scale values used in pairwise comparisons were set at 1.00, 0.78, 0.56, 0.33, and 0.11, resulting in a consistency ratio (CR) of 0.0375, which ensures high consistency. These weights provide a scientific and quantitative foundation for inventory management decisions.

ThecalculationsfortheConsistencyRatio (CR) areprovidedbelow.

Consistency Index $(CI) \rightarrow CI = \frac{\lambda_{max}-n}{n-1}$ and in this regard $CR = \frac{CI}{RI}$

$\lambda_{max} = 5.167$ $veRI = 1.12$ $(n = 5)$ in this context;

$CI = \frac{5.167-5}{5-1} = 0.042,$

$CR = \frac{0.042}{1.12} = 0.0375$ has been calculated as.

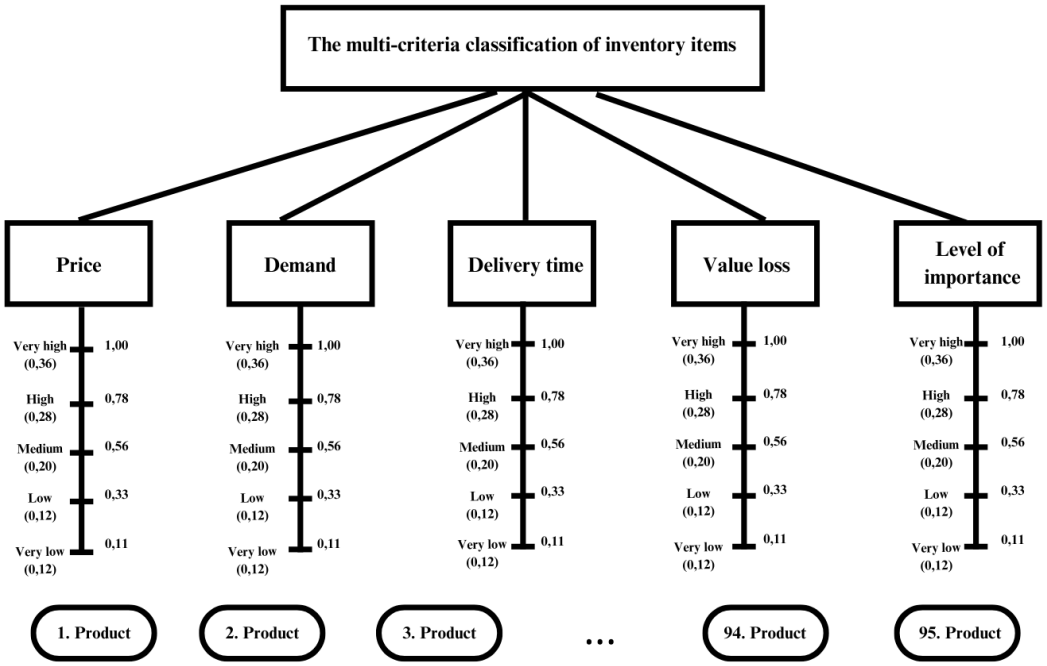

Figure 3. Multi-Criteria Classification of Inventory AHP Decision Hierarchy

Step 4: Calculation of AHP Score Values

In the AHP process, the first step is to determine the relative weight of each criterion, and the weight vectorw=[0.457,0.239,0.158,0.095,0.050]which sums to 1, has been calculated. Pairwise comparisons are made using Saaty's 1-9 scale, where 1 denotes equal importance and 9 denotes absolute importance. The data for the first 12 items on the 1-9 scale for inventory are provided in Table 6.

Table 6. Scale Values for Company Inventories

No.	Products	Demand	Price	Delivery time	Value loss	Level of importance
		(0.457)	**(0.239)**	**(0.158)**	**(0.095)**	**(0.050)**
1	Laminated Workbench and Drawer	1.00	0.78	0.78	0.78	1.00
2	Screw	1.00	0.56	0.56	0.33	0.78
3	Handle	1.00	0.56	0.78	0.33	0.56
4	Gaz valve	0.56	0.56	0.33	0.56	0.78
5	Cold-Rolled Steel Sheet	0.78	0.33	0.33	0.33	0.33
6	Rail	0.78	0.56	0.56	0.33	0.56
7	Vacuum hose	0.78	0.56	0.78	0.56	0.56
8	Bubble wrap bag	0.33	0.56	0.56	0.78	0.33
9	Air gun	0.56	0.56	0.78	0.78	0.78
10	2,5mm cable lug	1.00	0.33	0.33	0.33	0.33
11	Profile	0.56	0.78	0.56	0.56	0.56
12	1,5mm cable lug	0.78	0.33	0.33	0.33	0.33

The AHP score is calculated by multiplying the criterion scores of each inventory item by the specified weights. The general formula is:

$$AHPScore = \sum_i (w_i \times x_i)$$

$$= (Demand \times criterionweight) + (Price \times criterionweight) + (Deliverytime \times criterionweight) + (Valueloss \times criterionweight) + (Level\ of\ importance \times criterionweight)$$

n this formula, wiw_iwi represents the criterion weights, and xix_ixi represents the criterion scores of the inventory items. For example, the AHP score is obtained by multiplying the criterion scores for

demand, price, delivery time, depreciation, and importance with their respective criterion weights. The calculated AHP scores are presented in Table 7, ranked according to the size of the company's inventory.

Table 7. AHP Score Values of Company Inventories

No.	Products	AHP Score
1	Laminated Workbench and Drawer	0.89
3	Handle	0.77
2	Star Nut Head Screw	0.74
81	Pen Mechanism	0.74
14	Key Lug 1.5mm	0.70
7	Vacuum Hose	0.69
79	220V Bulb 15W 50Hz	0.68
49	1 HP 2900rpm Electric Motor	0.67
53	M6 Knob Screw	0.67
18	Ground Lug	0.67
42	1mm 430 Quality Satin Stainless Steel	0.65
86	360-Degree Rotating Glass Lock	0.64
54	M6 Allen Screw	0.64
6	Rail	0.63
55	M6 Bakelite Headed Screw	0.63
10	2.5mm Cable Lug	0.63
24	Air Label	0.63
9	Air Gun	0.62
43	40mm 4-Sided Yellow Bar	0.62
90	Large Olive Rubber	0.61
89	Small Olive Rubber	0.61
41	7kg Cast Aluminum Head	0.61
80	Conical Diamond Cutting Sleeve	0.61
11	Profile	0.61
60	20x20cm Satin 430 Quality Stainless Steel Plate	0.60
62	40x40cm 5mm Thick Glass	0.60
59	80cmx30cm Satin 430 Quality Stainless Steel Plate	0.60
26	Motor Foot	0.59
45	3mm Aluminum Back Plate	0.59
51	25cm Carbon Stone	0.59
44	40mm Round Delrin Rod	0.59
63	35x35cm 5mm Thick Glass	0.58
61	30x30cm 5mm Thick Glass	0.56
46	40mm Perforated Delrin Drain Path	0.55
25	Plaster Top Prism	0.55
64	25x25cm 5mm Thick Glass	0.54
69	10mm Stainless Steel Pipe	0.54
21	Multi-Tl 1x1.5mm	0.54
33	Lamp Channel 2x0.75mm	0.53
19	Strip Light Fixture	0.53
65	20x20cm 5mm Thick Glass	0.53
58	6mm 30cm Silicone Hose	0.53
5	DKP Sheet Metal Kp	0.53
12	1.5mm Cable Lug	0.53
4	Gas Valve	0.53

91	5x5cm Ø32mm Vacuum Sheet	0.52
93	1/20 mm DKP Cold Rolled Iron Back Cover	0.52
92	1/20 mm DKP Cold Rolled Iron Case	0.52
83	3/8 Air Control Pedal	0.52
94	1/20 mm DKP Cold Rolled Iron Top Cover	0.52
36	Cat's Eye 220V	0.51
34	Lamp Post Cover	0.51
50	Square Accordion Switch	0.51
23	Vacuum Nozzle	0.51
35	Plexiglass	0.50
57	Water Inlet Valve	0.50
70	1/8 Sintered Muffler	0.49
48	5mm Silicone	0.49
87	Conical Silicone Plug	0.48
76	Accordion Switch	0.48
75	1/4 6mm Straight Automatic Fitting	0.48
31	Samsung LED 14Wattx3	0.47
28	Bet Bag	0.47
77	2mm x 35cm Nylon Silicone Cable	0.47
74	1/4 Four-Way Straight Connector	0.47
85	1m 10mm Elastic Profile	0.47
82	6/8 Silicone Air Hose	0.47
30	Motor 220V 1200 rpm	0.47
15	Electronic Motor Control Board	0.46
16	TTR Cable 3x1.5mm	0.46
20	TTR Cable 2x1.5mm	0.46
8	Bubble Wrap	0.46
27	Air Hose	0.44
56	0.5mm 40x20cm Eroxal Aluminum Plate	0.43
29	Plaster Under Prism	0.43
84	4/6 2mm Silicone Air Hose	0.43
17	Armrest	0.42
13	Filter	0.41
40	DIY Lamp 5mm	0.41
47	1/4 8mm Automatic Fitting	0.41
39	On/Off Switch 250V	0.39
37	Terminal Block No:1	0.37
52	Black Foot	0.37
66	Tube Top Cover	0.36
95	6mm Glass Hinge	0.36
72	1/8 6mm Elbow Automatic Fitting	0.36
67	Tube Bottom Cover	0.36
68	Tube Outer Cover	0.36
22	Work Sheet	0.32
32	Table Leg	0.32
71	Metric Under Bolt	0.32
78	Italian Lamp Socket	0.32
73	1/15 Three-Way Valve	0.32
88	Perforated Plastic Foot	0.27
38	Micromotor Cover	0.27

7.4. Results

ABC analysis categorizes inventory into A, B, and C categories based on their financial value, determining management priorities. Products in the A category account for 70-80% of the total inventory value and are considered of the highest importance. Products in the B category contribute 15-20%, while C category products make up 5-10%, and are regarded as having lower importance. For example, products like "Laminated Workbench and Drawer" and "Handle" have been identified as high financial importance in the A category of the ABC analysis.

On the other hand, the AHP (Analytic Hierarchy Process) analysis evaluates products based on various criteria (demand, price, delivery time, depreciation, and importance). This analysis determines the relative importance of each criterion and calculates the total AHP score for each product. For instance, "Laminated Workbench and Drawer" ranks high in both AHP and ABC analyses, indicating its high importance from both strategic and financial perspectives.

The differences between AHP and ABC analyses stem from their evaluation criteria. ABC analysis assesses products solely based on their financial value, whereas AHP analysis considers multiple criteria to establish strategic priorities. Consequently, some products may rank in the A category in ABC analysis but have lower rankings in AHP analysis, and vice versa. For example, "Ground Lug" ranks high in AHP analysis but is in the B category in ABC analysis. This situation reflects a high strategic importance but lower financial value.

Combining both analyses provides a comprehensive evaluation of products' financial and strategic importance. Products that rank highly in both analyses, such as "Laminated Workbench and Drawer" and "Pen Mechanism," confirm their significant strategic and financial importance. This combination offers a more effective approach for optimizing inventory management strategies.

In conclusion, using both ABC and AHP analyses together allows for a better balance between financial value and strategic priorities of products. This approach is crucial for determining the best inventory management strategies and achieving more comprehensive and effective results in decision-making processes.

8. CONCLUSION

This study aimed to address the challenges faced by a company in the dental laboratory products sector regarding inventory management by utilizing AHP (Analytic Hierarchy Process) and ABC methods for stock classification. The inventory was assessed from both financial and strategic perspectives and classified according to the results of the ABC and AHP analyses.

According to the ABC analysis, products were classified into three categories: Category A, which constitutes 80% of the total inventory value, Category B, which accounts for 15%, and Category C, which represents 5%. Category A products are strategically the most important and require detailed tracking, frequent order reviews, and high levels of control. Category B products hold moderate strategic importance and should be managed with a balance between cost and availability. Category C products are low-cost and high in quantity, necessitating a cost-reduction approach in stock management.

The AHP analysis ranked products based on criteria such as strategic importance, demand, price, delivery time, and depreciation. Most of the top 10 products in the AHP analysis were also in Category

A according to the ABC analysis, indicating that these products hold high priority both strategically and financially. For example, "Laminated Workbench and Drawer" and "Pen Mechanism" were identified as high-priority items in both analyses, demonstrating their significant strategic and financial importance.

From an inventory management perspective, the company's annual sales revenue was determined to be 15,364,328 TL, and the average inventory value was 6,774,120 TL, with an inventory turnover rate of approximately 2.2. This indicates that the company cycles its inventory approximately 2.2 times per year, reflecting a healthy level of inventory management.

The observed differences between AHP and ABC analyses highlight the need to consider both strategic and financial priorities. For instance, the "Ground Lug" product is ranked high strategically in the AHP analysis but falls into Category B in the ABC analysis. This discrepancy illustrates the differences between strategic importance and financial value. While AHP focuses on strategic priorities through a multi-criteria approach, ABC solely evaluates financial importance based on stock value.

In conclusion, combining both analysis methods provides the best strategic decision-making approach. Products in Category A according to the ABC analysis that also rank high in the AHP analysis are considered significant from both stock management and strategic perspectives. This study has facilitated the improvement of the company's inventory management strategies and operational efficiency.

Conflicts of Interest

The authors declare no conflicts of interest.

Acknowledgement

This research was not funded by any grant.

This study is derived from the master's thesis titled "Stock Classification with AHPand ABC Approaches in Dental Products Production" accepted on July 02, 2024, under the supervision of Assist. Prof. İlkay SARAÇOĞLU in the Department of Industrial Engineering at Haliç University's Graduate Institute, by Soufiane Mifdal.

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