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Araştırma Makalesi

A Simplified Inventory Classification Approach: Combining Multiple Criteria Using the BORDA Method

Basitleştirilmiş Bir Envanter Sınıflandırma Yaklaşımı: BORDA Yöntemi ile Çoklu Kriterlerin Birleştirilmesi

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Abstract

Traditional inventory classification approaches, such as ABC (Always Better Control), VED (Vital-Essential-Desirable), and their matrix forms, typically account for a limited range of inventory characteristics. Techniques like multi-criteria decision analysis, linear programming, and heuristic algorithms, which can consider more characteristics, require technical knowledge and expertise. However, the majority of small and medium-sized enterprises (SMEs) lack the staff capable of applying these methods. Therefore, a method that can accommodate numerous characteristics and is easy to use is necessary. This paper introduces a classification approach that combines multiple inventory characteristics using the BORDA method, specifically designed to assist SME managers with limited technical expertise. A dataset containing 47 stock keeping units (SKUs), including the average cost, annual cost, and lead time characteristics, is used to demonstrate the application of the proposed approach. The implementation reveals that the BORDA method provides a comprehensive and unbiased solution to inventory classification by systematically combining the rankings of various inventory characteristics. This approach simplifies the classification process by integrating multiple characteristics in a straightforward manner, making it particularly suitable for SMEs.

Keywords: SMEs, Inventory management, Inventory classification, BORDA method, Rank correlation

Jel Codes: C44, D81, M11

Öz

ABC (Always Better Control), VED (Vital-Essential-Desirable) gibi geleneksel envanter sınıflandırma yaklaşımları ve bunların matris formları envanterin sınırlı özelliklerini dikkate alabilir. Daha fazla özelliği dikkate alabilen çok kriterli karar analizi, doğrusal programlama ve sezgisel algoritmalar gibi teknikler ise teknik bilgi ve uzmanlık gerektirmektedir. Bununla birlikte, küçük ve orta ölçekli işletmelerin (KOBİ'ler) büyük çoğunluğu bu yöntemleri uygulayabilecek personele sahip değildir. Bu durumda, çok sayıda özelliği kapsayabilen ve kullanımı kolay bir yönteme ihtiyaç duyulmaktadır. Bu

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makale, KOBİ'lerin vasıfsız yöneticilerine yardımcı olmak için çeşitli envanter özelliklerini BORDA yöntemiyle birleştiren bir sınıflandırma yaklaşımı sunmaktadır. Önerilen yaklaşımın uygulamasını göstermek için ortalama maliyet, yıllık maliyet ve teslim süresi özelliklerini içeren 47 envanter kaleminden oluşan bir veri seti kullanılmıştır. Uygulama, BORDA yönteminin, çeşitli envanter özelliklerinin sıralamalarının sistematik kombinasyonu yoluyla envanter sınıflandırmasına tam ve tarafsız bir cevap verebileceğini ortaya koymaktadır. Bu yaklaşım sınıflandırma sürecini kolaylaştırmakta ve çok sayıda özelliği basit bir şekilde bir araya getirmektedir, dolayısıyla özellikle KOBİ'ler için uygundur.

Anahtar Kelimeler: KOBİ'ler, Envanter yönetimi, Envanter sınıflandırma, BORDA yöntemi, Sıra korelasyon

Jel Kodları: C44, D81, M11

Introduction

Inventory management is the key factor in operational efficiency, customer satisfaction and cost control. Technically, it is the procedure of purchasing the stock-keeping units (SKUs) at the right quantity, time and price (Singh, Rasania, & Barua, 2022). In this procedure, the decision-makers aim to maintain the inventory at a desirable level between the trade-off of stock-outs and overstocking. Nevertheless, the numerous SKUs and the fact that each SKU has different characteristics are the main problems of the implementing an individually optimized inventory policy. The classifying of SKUs by prioritisation makes it possible to solve this problem.

For this purpose, the traditional approaches commonly used in the literature are as follows: ABC, VED, XYZ, HML, and FSN. These approaches classify SKUs according to a specific characteristic. For example, the well-known ABC classification approach focuses on the monetary value of SKUs. In this approach, SKUs in class A constitute a small part of the inventory but have a large share in value. SKUs in class B are not as important as class A in terms of quantity, but are important in terms of value. SKUs in class C make up the majority of the inventory but individually have little value. The ABC approach guides decision makers on which SKUs they should focus more on based on their monetary value and helps to utilise resources effectively. As can be recognised, the fact that only one characteristic is considered when there are many others that can impact inventory management decisions is a weakness of traditional classification approaches. In order to tolerate this, matrix approaches combining two approaches are adopted in research. For example, the well-known ABC-VED matrix is a combination of ABC and VED. Since the VED approach focuses on the criticality level of SKUs, the ABC-VED matrix provides classification according to both the monetary value and the criticality level of SKUs. Such combined approaches in matrix form provide decision makers with a more detailed analysis by considering only two SKU characteristics. However, even the classification obtained by matrix approaches is not sufficient to represent the large number of characteristics that need to be considered in the complexity of inventory management.

In the inventory classification literature, advanced techniques such as multi-criteria decision analysis, linear programming and heuristic algorithms are used to consider more than two SKU characteristics (Xu, Fu, Chen, & Lai, 2022; Zhou & Fan, 2007; Saracoglu, 2022). These techniques enable the classification of SKUs by reducing all their characteristics to a single score. In this respect, they eliminate the disadvantages of traditional and matrix approaches. On the other hand, advanced inventory classification techniques may involve complex mathematical models or algorithms. The parameter tuning process required for an efficient classification is error prone. Since these processes require technical knowledge, advanced techniques are more difficult to implement than traditional approaches.

In this context, small enterprises such as SMEs, which do not employ professionals with sufficient technical knowledge, are unlikely to utilise advanced inventory classification techniques that can take into account many characteristics. On the other hand, matrix approaches, which can take into account at most two characteristics, are not sufficient for effective inventory management of SMEs. This motivates the need for an approach that allows numerous characteristics to be considered in the simplest possible way.

In this paper, a simple classification approach is proposed to fulfil this need. The rationale behind the proposed approach can be briefly explained as follows. Traditional inventory classification approaches first rank (prioritise) and then classify SKUs according to a characteristic. By combining the rankings of traditional approaches, it is possible to obtain a composite ranking. The classification arising from the composite ranking is not inferior to advanced classification techniques by taking into account many characteristics, but also appeals to managers with limited technical expertise with a simple combination procedure. Thus, the approach plays a pragmatic role in increasing operational efficiency and cost-effectiveness by positioning itself between complexity and accessibility. On the other hand, the disadvantages of the approach can be mentioned as follows. The simplicity of the rank combining process may lead to missing the nuances inherent in SKU characteristics. And for the same reason, it may lack the complexity needed to handle challenging inventory management scenarios, especially those involving dynamic market conditions or diverse product portfolios. Considering the pros and cons of the proposed approach, it can be stated that the benefits of the approach vary depending on the business requirements and the level of technical knowledge of the decision makers. While it may be attractive for small organisations due to its simplicity and ease of use, it may be inadequate for larger and more complex organisations. Nevertheless, the adaptability of this method may be a perfect solution for some companies. Thus, it is necessary for every organisation to evaluate the appropriateness of this approach in relation to its needs and resources.

The rest of the study is organised as follows. Section 2 outlines inventory management and inventory classification. Section 3 addresses the challenges of SMEs related to inventory management. Section 4 introduces the proposed inventory classification method, while Section 5 presents its implementation with a well-known benchmark dataset. Section 6 contains the conclusions of the research.

A brief overview of inventory management

Inventory management involves controlling the flow of goods through the supply chain (Bathool, 2022). The main objective is to ensure that the right amount of inventory is available at the right time, in the right place and at the right cost (Singh et al., 2022). The advantages of good inventory management can be listed as the maintenance of operational efficiency, the increase of customer satisfaction and the cost control. These advantages can be described as the following. Operational efficiency can be achieved by minimising stock-outs and overstocking by optimising inventory levels (Shin, Wood, & Jun, 2016). Customer satisfaction can be achieved by maintaining adequate inventory levels so that demand can be met quickly (Ayllon-Lorenzo, Cardenas-Maciel, & Cazarez-Castro, 2019). Conversely, out-of-stocks have a negative impact on customer satisfaction through lost sales and disappointed customers (Li, Lu, Lu, & Huang, 2023). By having the right products available at the right time, businesses can enhance their reputation for reliability and responsiveness and encourage long-term customer loyalty (Hassan & Zahran, 2023). Cost control is concerned with opportunity cost and waste. Excess inventory ties up capital, incurring opportunity cost (Jones & Tuzel, 2011). And furthermore, it causes carrying costs such as storage, insurance and obsolescence (Nnamdi, 2018). Effective inventory management aims to strike a balance between stock-outs and overstocking.

Inventory Classification Approaches

Traditional inventory classification approaches are techniques that allow decision makers to sort and prioritise SKUs into manageable groups (Qaffas, Ben HajKacem, Ben Ncir, & Nasraoui, 2023). Some of the well-known ones are: ABC, VED, XYZ, HML, and FSN. ABC classifies SKUs based on their importance, with Class A being very important, Class B moderately important, and Class C relatively unimportant (Kaabi, 2022). VED, on the other hand, classifies SKUs as vital, essential, or desirable based on criticality (Shah, Davda, Parikh, & Bala, 2015). XYZ focuses on the variability of demand, with Class X having constant demand, Class Y having moderate variability, and Class Z having high variability (Trubchenko et al., 2020). HML classifies SKUs as high, medium, or low based on their unit price or value (Jadhav & Jaybhaye, 2020). FSN evaluates SKUs based on their movement speed, classifying them as fast-moving, slow-moving, or no-moving (Tambunan, Syahputri, Rizkya, Sari, & Cahyo, 2018). The strengths of these approaches are that they clearly identify the SKUs that should be focussed on. However, the fact that each approach considers only one characteristic cause other important characteristic to be ignored.

Matrix approaches are the initial choice of researchers who aim to solve more than one attribute at the same time. The main reason for the use of matrix approaches is the ability to conduct a more detailed analysis by taking into account of the multiple SKU characteristics at the same time (Gizaw & Jemal, 2021). To illustrate, in the ABC-VED matrix, SKUs classified as "AV" are the high-value and critical items and thus need to be closely monitored and the management has to be proactive to avoid stock-outs or operational disruptions. On the contrary, SKUs that are labelled as "CD" may get less attention because they are of lower risk or of lower values. Although matrix approaches are more inclusive than the traditional categorisation approaches, they are still not enough to solve the problem of inventory diversity.

The above-mentioned limitations have led researchers to the more advanced methodologies such as multi-criteria decision making (Xu et al., 2022), optimisation (Zhou & Fan, 2007) and heuristic algorithms (Saracoglu, 2022) which gives a better understanding of the inventory system and provides a more stable solution. This is the main reason for the multi-criteria inventory classification literature (Elevli & Dinler, 2023; Qaffas et al., 2023). Though these cutting-edge techniques solve the problems of the traditional and matrix methods by bringing in many characteristics in the classification, they have a number of drawbacks as well. The difficulties that are faced in this case are the huge computing power that is needed to solve the large-scale optimisation problems (Cheng, Ting, & Yang, 2014).

Challenges for SMEs

SMEs have a number of challenges planning and implementing advanced inventory classification techniques because of the limited resources they have at their disposal; they are also likely to lack the specialized staff dedicated to inventory management (Drakeley & Perera, 2022; Kittisak, 2023; Serna-Ampuero, Arias-Navarro, & Quiroz-Flores, 2022; Teerasoponpong & Sopadang, 2022). Traditional and matrix methods, if utilised to some extent, may however not be enough to give way to successful inventory management for SMEs. Traditional methods are likely to be overly simplistic, however, matrix methods may risk losing the view of product dependencies in inventory. The problems SMEs are facing are the complexity of inventory management software by that they need in a user-friendly manner, training programmes and associations with consultants or experts in the field (Sabah Salih, Ghazi, & Aljanabi, 2023). Through these capacities, SMEs can optimize their workflow and business performance in an environment of ever-changing markets.

An SME dealing with inventory management issues is the point where the research, based on the literature, shows different problems. The studies conducted have shown that SMEs often take a hard knock when it comes to inventory control and may end up with either excess inventory of goods or stock outs (Narayanapillai, 2010). Such problems could involve profitability directly and it has been confirmed by the research of Gorondutse et al. (2016) that SMEs have a significant negative relationship between profitability and the days of the inventory cash conversion cycle. In addition to the above, the absence of focus on inventory optimization and the unprofessional way SMEs run their businesses or managers cause make the situation worse (Drakeley & Perera, 2022; Panda, Nanda, & Panda, 2021).

The COVID-19 pandemic demands SMEs to revise their inventory management strategies which call for re-adjustments of operations in the new circumstances (Abdelfattah, Malik, Al Alawi, Sallem, & Ganguly, 2023; Zimon, Babenko, Sadowska, Chudy-Laskowska, & Gosik, 2021). Acquiring the real issues that accompany inventory management and having alternative approaches available is vital for SMEs in order to promote their performance (Muffee, 2021). Small firms should adopt the efficient inventory management techniques to obtain the highest profitability and to increase the operability of the business (Alam, Thakur, & Islam, 2024). Moreover, as SMEs it is difficult to cope with real-time information which allows them to do inventory control properly that may definitely impact overall business success rate (Sapry & Yusof, 2019). Implementation of costing procedures is usually hampered by an absence of understanding which function plays the role of generating immediate profits (Johnson & Ruankaew, 2017). To counter these problems, SMEs shall set lead times reduced, suppliers collaboration, and workplace practices improvement among their supply chain management practices (Thakkar, Kanda, & Deshmukh, 2009).

This literature underscores that optimal inventory management is very important for SMEs to increase profitability, to overcome the challenges as for example the COVID-19 pandemic, and to optimize their

whole business. Addressing inventory control, real-time information management, and supply chain drivers in small businesses contribute to the improvement on competitiveness and sustainability of these enterprises in the market.

Proposed Simple Classification Approach

The inventory classification approach proposed in this research aims to meet the needs of SMEs by striking a balance between complexity and accessibility in inventory management. The rationale behind this approach is to obtain a composite ranking by combining the rankings of different traditional inventory management approaches, thus providing an uncomplicated but comprehensive and practical tool for SMEs.

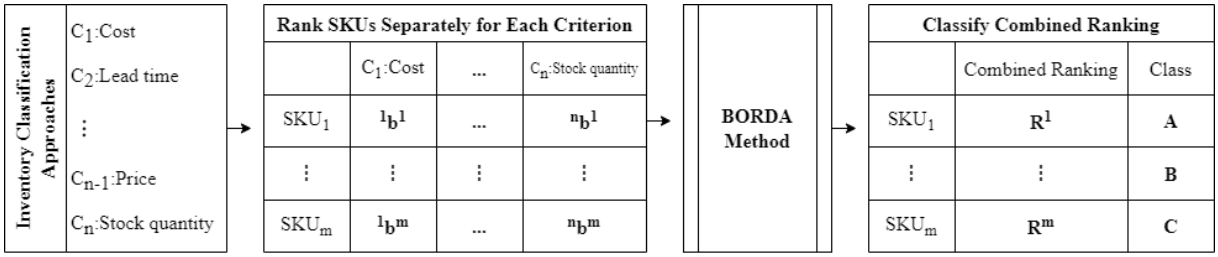

Figure 1: Flow of the proposed approach

The flow in the proposed approach is diagrammed in Figure 1. In brief, the proposed approach involves the decision maker obtaining information about the characteristics of each SKU and ranking them according to these characteristics. These rankings are then combined using the Borda method, a technique that aggregates individual preferences to create a composite ranking. The SKUs are then classified according to this combined ranking.

The pros and cons of the suggested inventory classification method can be discussed as the following. It gives the decision makers a complete picture by classifying SKU characteristics, thus, they can make the right decision. Besides, the use of the BORDA method eliminates the possibility of the biases by the systematic and unbiased combination of the individual SKU rankings. The SKU classification based on the combination of the ranking makes the classification easier and simplifies the identification of the high performing SKUs. On the contrary, the proposed approach could be a reason for the oversimplification since it is based on the SKU characteristics ranking and thus, it might not be possible to describe the interactions between different characteristics. The method is applicable to the easy decisions, but may find it difficult in complex business issues. In particular, the specialized or niche products, the proposed approach may not work, and it will result in the misclassification of the products or the overlooking of the important factors. To sum up, although the suggested method is a straightforward way of SKU classification, its oversimplification and lack of sophistication may be the reason why it is not applicable in the complex business world.

BORDA method

The Borda method, named after Jean-Charles de Borda, is a voting system based on ranking candidates according to preference. It is a technique used to produce the final ranking by considering the rankings of alternatives in different preference lists (Özkaya, 2022). This technique is the way to combine the results of the ranking conducted by the decision-makers to find the final rankings (Mahindarta & Wardoyo, 2019).

Besides, the Borda method is applied in other fields other than voting and decision-making. It is exactly in the citation of academic journals, the analysis of the risk perception, and the economic operation evaluation of active distribution networks which has been used in (Ma & Zhang, 2020; Qu, Wei, & Li, 2021; Zhao & Zhu, 2023). The Borda method is a very handy instrument that helps in the combination of the rankings and preferences of different fields; thus, it is a systematic and structured way to the aggregation of the information and the final ranking or decision.

The Borda method thinks that every ranking method is of the same weight. This technique is founded on a scoring system in which the first of the m alternatives in each ranking is given a decreasing value

of $m-1$, the second $m-2$ and the last alternative is given a value of 0. The last ranking is done by putting the alternatives in the descending order of the scores obtained in all rankings.

Step 1: For each technique (k), the score of each alternative is calculated.

$$b_i^k = M - r_i$$

r_i = Order of alternative i

M = Total number of alternatives

b_i^k = The score of alternative i in the k technique

Step 2: The scores calculated for each technique of the alternatives are summed.

$$BS_i = \sum_k b_i^k$$

In this study, the BORDA method is favored for its simplicity and ability to combine multiple criteria in an unbiased way. By systematically merging the rankings of various SKU attributes, it offers decision-makers a more balanced and objective classification. For businesses with limited technical expertise, like SMEs, this straightforward approach enhances the method's practicality, enabling effective decision-making without the need for complex mathematical models. When compared to other techniques, it becomes evident that methods such as linear programming or heuristic algorithms, often used in the literature, can yield more sophisticated results. These methods rely on intricate models that demand a high level of technical knowledge and computational power. In contrast, the BORDA method integrates multiple criteria without requiring optimization processes, making it a more accessible and user-friendly option—especially advantageous for SMEs with limited technical resources.

However, the simplicity of the BORDA method also introduces some limitations. It may not fully account for the interactions between different attributes, potentially leading to inaccurate or insufficient categorization of certain SKUs. In situations involving dynamic market conditions, extensive product ranges, or highly specialized product categories, more advanced and detailed methods might be necessary. Therefore, while the BORDA method provides a suitable solution under specific conditions, it may not be sufficient for more complex inventory management needs.

Implementation

The implementation of the proposed inventory classification approach was carried out with the benchmark dataset (Table 1) used in the inventory classification literature (Flores, Olson, & Dorai, 1992; Hadi-Vencheh, 2010; Ng, 2007; Ramanathan, 2006; Torabi, Hatefi, & Saleck Pay, 2012).

Table 1: Data Set

SKUs	Average Unit Cost	Annual Cost	Lead Time
S1	49,92	5840,64	2
S2	210,00	5670,00	5
S3	23,76	5037,12	4
S4	27,73	4769,56	1
S5	57,98	3478,80	3
S6	31,24	2936,67	3
S7	28,20	2820,00	3
S8	55,00	2640,00	4
S9	73,44	2423,52	6
S10	160,50	2407,50	4

SKUs	Average Unit Cost	Annual Cost	Lead Time
S11	5,12	1075,20	2
S12	20,87	1043,50	5
S13	86,50	1038,00	7
S14	110,40	883,20	5
S15	71,20	854,40	3
S16	45,00	810,00	3
S17	14,66	703,68	4
S18	49,50	594,00	6
S19	47,50	570,00	5
S20	58,45	467,60	4
S21	24,40	463,60	4
S22	65,00	455,00	4
S23	86,50	432,50	4
S24	33,20	398,40	3
S25	37,05	370,50	1
S26	33,84	338,40	3
S27	84,03	336,12	1
S28	78,40	313,60	6
S29	134,34	268,68	7
S30	56,00	224,00	1
S31	72,00	216,00	5
S32	53,02	212,08	2
S33	49,48	197,92	5
S34	7,07	190,89	7
S35	60,60	181,80	3
S36	40,82	163,28	3
S37	30,00	150,00	5
S38	67,40	134,80	3
S39	59,60	119,20	5
S40	51,68	103,36	6
S41	19,80	79,20	2
S42	37,70	75,40	2
S43	29,89	59,78	5
S44	48,30	48,30	3
S45	34,40	34,40	7
S46	28,80	28,80	3

SKUs	Average Unit Cost	Annual Cost	Lead Time
S47	8,46	25,38	5

The dataset consists of 47 SKUs and contains the average cost, annual cost and lead time characteristics of each SKU. Table 2 shows the results of the implementation stages of the proposed approach. For each characteristic, SKUs are ranked in descending order of importance for inventory classification (Rank Column). Then, the scores of the SKUs were calculated for each of the characteristics (*b* Column). The scores are summed to obtain Borda Scores (BS Column) which are the basis for the final ranking (Combined Rank Column). In the classification process, the percentiles suggested by Iqbal and Malzahn (2017) were used. Accordingly, the first 7 SKUs were classified in class A (15%), the next 12 SKUs in class B (25%) and the remaining 28 SKUs in class C (60%).

Table 2: Ranking and Classification Results

SKUs	Average Unit Cost		Annual Cost		Lead Time		BORDA Method		
	Rank	*b*	Rank	*b*	Rank	*b*	BS	Combined Rank	Class
S2	1	46	2	45	9	38	129	1	A
S13	5	42	13	34	1	46	122	2	A
S9	9	38	9	38	5	42	118	3	A
S14	4	43	14	33	9	38	114	4	A
S10	2	45	10	37	19	28	110	5	A
S29	3	44	29	18	1	46	108	6	A
S28	8	39	28	19	5	42	100	7	A
S8	19	28	8	39	19	28	95	8	B
S18	23	24	18	29	5	42	95	8	B
S23	5	42	23	24	19	28	94	10	B
S5	17	30	5	42	27	20	92	11	B
S31	10	37	31	16	9	38	91	12	B
S15	11	36	15	32	27	20	88	13	B
S19	26	21	19	28	9	38	87	14	B
S22	13	34	22	25	19	28	87	14	B
S20	16	31	20	27	19	28	86	16	B
S1	22	25	1	46	39	8	79	17	B
S3	41	6	3	44	19	28	78	18	B
S12	42	5	12	35	9	38	78	18	B
S39	15	32	39	8	9	38	78	18	C
S33	24	23	33	14	9	38	75	21	C
S40	21	26	40	7	5	42	75	21	C
S6	34	13	6	41	27	20	74	23	C
S16	27	20	16	31	27	20	71	24	C
S7	38	9	7	40	27	20	69	25	C

SKUs	Average Unit Cost		Annual Cost		Lead Time		BORDA Method		
	Rank	*b*	Rank	*b*	Rank	*b*	BS	Combined Rank	Class
S35	14	33	35	12	27	20	65	26	C
S38	12	35	38	9	27	20	64	27	C
S45	31	16	45	2	1	46	64	27	C
S27	7	40	27	20	44	3	63	29	C
S17	44	3	17	30	19	28	61	30	C
S21	40	7	21	26	19	28	61	30	C
S34	46	1	34	13	1	46	60	32	C
S37	35	12	37	10	9	38	60	32	C
S24	33	14	24	23	27	20	57	34	C
S26	32	15	26	21	27	20	56	35	C
S4	39	8	4	43	44	3	54	36	C
S43	36	11	43	4	9	38	53	37	C
S32	20	27	32	15	39	8	50	38	C
S36	28	19	36	11	27	20	50	38	C
S30	18	29	30	17	44	3	49	40	C
S44	25	22	44	3	27	20	45	41	C
S11	47	0	11	36	39	8	44	42	C
S25	30	17	25	22	44	3	42	43	C
S47	45	2	47	0	9	38	40	44	C
S42	29	18	42	5	39	8	31	45	C
S46	37	10	46	1	27	20	31	45	C
S41	43	4	41	6	39	8	18	47	C

Considering that a manager with limited technical expertise will make an inventory classification decision with the traditional approach by considering only one of the SKU characteristics, ranking correlation based on SKU characteristics is important. In addition, the correlation of BORDA ranking with other characteristics provides information about the comprehensiveness of the proposed approach. In this context, the Spearman Rank Correlation coefficients shown in Table 3 contain interesting findings. Table 3 shows how the rankings obtained by BORDA method correlate with other rankings. A high correlation indicates that the BORDA ranking is compatible with other methods and provides a balanced classification by considering different characteristics. A low correlation, on the other hand, shows that the BORDA method can work independently of rankings based on specific characteristics and offers a broader perspective. This shows that the method provides an effective classification in various scenarios by combining different criteria.

Table 3: Ranking Correlation Results

	Average Unit Cost	Annual Cost	Lead Time
Proposed Model	0,702	0,554	0,554
Average Unit Cost		0,143	0,177
Annual Cost			-0,108

The first striking point is the low correlation between the SKU characteristics. There is a positive but weak correlation between average unit cost and annual cost and lead time, while there is a negative and weak correlation between annual cost and lead time. This finding indicates that the classification determined by considering only one characteristic is insufficient to represent the other characteristics of SKUs.

The second striking point is that the BORDA ranking has a positive and moderate relationship with other rankings. This finding indicates that the proposed approach creates a balance between SKU characteristics. While this balance causes a weakness in capturing the superior performance of the SKUs in other characteristics, on the other hand, it allows for the representation of other characteristics of the SKUs according to the classification based on only one characteristic.

The ability of the proposed classification approach to balance and represent all features is also shown in Table 4, which shows the comparison of the classifications. In addition, analysing the classes to which the SKUs belong on the horizontal axis provides clues as to how considering a single characteristic may mislead the decision maker. For example, while S28 is in class A in BORDA classification, it is in different classes in classifications based on other characteristics. A similar example is S18. The main reason for results such as these is the position of SKUs in the ranking. For example, if a SKU ranked in class C in the ranking according to any characteristic is ranked in a position close to class B, it is possible that it is ranked in class B in the BORDA ranking. This situation emphasises the consensus feature of BORDA ranking.

Table 4: Classification Comparison of the Proposed Approach and Traditional Approaches

SKUs	BORDA Method	Average Unit Cost ($)	Annual Cost ($)	Lead Time
S2	A	A	A	B
S9	A	B	B	A
S10	A	A	B	B
S13	A	A	B	A
S14	A	A	B	B
S28	A	B	C	A
S29	A	A	C	A
S1	B	C	A	C
S3	B	C	A	C
S5	B	B	A	C
S8	B	B	B	C
S12	B	C	B	B
S15	B	B	B	C
S18	B	C	B	A

SKUs	BORDA Method	Average Unit Cost ($)	Annual Cost ($)	Lead Time
S19	B	C	B	B
S20	B	B	C	C
S22	B	B	C	C
S23	B	A	C	C
S31	B	B	C	B
S4	C	C	A	C
S6	C	C	A	C
S7	C	C	A	C
S11	C	C	B	C
S16	C	C	B	C
S17	C	C	B	C
S21	C	C	C	C
S24	C	C	C	C
S25	C	C	C	C
S26	C	C	C	C
S27	C	A	C	C
S30	C	B	C	C
S32	C	C	C	C
S33	C	C	C	B
S34	C	C	C	A
S35	C	B	C	C
S36	C	C	C	C
S37	C	C	C	B
S38	C	B	C	C
S39	C	B	C	B
S40	C	C	C	B
S41	C	C	C	C
S42	C	C	C	C
S43	C	C	C	B
S44	C	C	C	C
S45	C	C	C	A
S46	C	C	C	C
S47	C	C	C	B

Conclusion

Inventory management is concerned with managing the balance between stock-outs and overstocking. Since it is difficult to implement an optimal inventory policy for all products in the inventory, inventories are classified according to their importance. Inventory classification can be done with traditional approaches by considering a single characteristic such as monetary value, and lead time. However, a single characteristic is not sufficient to represent all the characteristics of the inventory. For this purpose, multi-criteria inventory classification approaches are adopted. These approaches can process many characteristics of the inventory with algorithms that require intensive calculation and expertise. SMEs have difficulty in employing personnel capable of applying multi-criteria inventory classification approaches. This situation emphasises the need for an inventory classification approach that can handle the multifaceted nature of inventory but is simple to use.

In this research, we present a method that enables classification by the combined ranking that results from the mixture of the rankings of the inventory characteristics used in the traditional approaches with the BORDA method. The suggested way of doing things is a combination of the individual ranking in a systematic and unbiased manner to eliminate the possible biases and at the same time, it helps the decision makers to make the better decisions.

The proposed method is demonstrated using the benchmark dataset that is used in the inventory classification literature. The relations of the combined ranking obtained by the BORDA method and the rankings based on other features show that the proposed method can cover other methods but cannot capture the extreme cases. Taking into account the fact that the objective of the proposed approach is to be a functional and accessible tool for enterprises such as SMEs, it is clear that it meets the expectations of it by combining a large number of features in a simple way.

The classification provided by the BORDA method can serve as a valuable tool for simplifying inventory management decisions in SMEs. This approach can be easily integrated into processes like stock management, reordering decisions, and optimizing inventory costs. Its simplicity enables SMEs to develop effective inventory strategies, even with limited resources. The systematic and unbiased nature of the classification process also promotes more efficient resource use.

The BORDA method is particularly well-suited for small businesses and environments with limited technical expertise. It offers an ideal solution for SMEs by allowing SKUs to be classified without the need for complex algorithms or extensive datasets. This method is especially effective in stable or less volatile markets, where its simplicity helps speed up decision-making, saving both time and costs in day-to-day inventory management.

However, the BORDA method may not be the best choice in every situation. It may fall short when dealing with more complex SKU interactions or rapidly changing market conditions. For example, in large enterprises with extensive product ranges or in dynamic markets, the simplicity of the BORDA method may be inadequate. In such cases, more sophisticated methods that require detailed analysis might be necessary to achieve better results in inventory management. Therefore, it's important to carefully consider the specific circumstances before applying the BORDA method.

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Research Article

A Simplified Inventory Classification Approach: Combining Multiple Criteria Using the BORDA Method

Basitleştirilmiş Bir Envanter Sınıflandırma Yaklaşımı: BORDA Yöntemi ile Çoklu Kriterlerin Birleştirilmesi

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Genişletilmiş Özet

Envanter yönetimi, operasyonel verimlilik, müşteri memnuniyeti ve maliyet kontrolü açısından önemli bir süreçtir. Teknik olarak bakıldığında doğru miktar, zaman ve fiyattan stok tutma birimlerinin (SKU'ların) temin edilmesini içeren bir prosedürdür. Bu prosedürde, karar vericiler stoksuz kalma ve aşırı stoklama arasında dengeyi korumaya çabalarlar. Bu her bir SKU için optimal envanter politikası yürütmekle mümkündür. Ancak, envanter sayısının fazlalığı nedeniyle her SKU için ayrı envanter politikasının takip edilmesi mümkün değildir. Bu durumda envanter sınıflandırma yoluyla SKU'lar benzer özelliklerine göre homojen az sayıda sınıflara ayırmak envanterin etkin olarak yönetilmesine imkan tanımaktadır.

Envanter sınıflandırması literatüründe yaygın olarak kullanılan geleneksel yaklaşımlar şunlardır: ABC, VED, XYZ, HML ve FSN. Bu yaklaşımlar, SKU'ları belirli bir özelliğe göre sınıflandırır. Örneğin, ABC sınıflandırma yaklaşımı, SKU'ların parasal değerine odaklanır. Bu yaklaşımda, A sınıfındaki SKU'lar envanterin küçük bir kısmını oluşturur ancak değer açısından büyük bir paya sahiptir. B sınıfındaki SKU'lar miktar açısından A sınıfı kadar önemli değildir, ancak yine de değer açısından önemlidir. C sınıfındaki SKU'lar envanterin çoğunluğunu oluşturur ancak bireysel olarak az değere sahiptir. ABC yaklaşımı, karar vericilere SKU'ların parasal değerine göre daha fazla odaklanmaları gereken SKU'ları belirlemesinde rehberlik eder ve kaynakları etkili bir şekilde kullanmalarına yardımcı olur. Ancak, envanter sınıflandırma kararını SKU'ların pek çok özelliği etkiliyor olmasına rağmen sadece bir özelliğin dikkate alınıyor olması, geleneksel sınıflandırma yaklaşımlarının bir zayıflığıdır. Bu durumu tolere etmek için, herhangi iki geleneksel yaklaşımı birleştiren matris yaklaşımları araştırmalarda benimsenmektedir. Örneğin, ABC ve VED yaklaşımlarının birleşimi olan ABC-VED matrisi. VED yaklaşımı SKU'ların kritiklik düzeyine odaklandığından, ABC-VED matrisi SKU'ları hem parasal değere hem de kritiklik düzeyine göre sınıflandırır. Bu tür birleşik yaklaşımlar, matris formunda, sadece iki SKU özelliği dikkate alınarak karar vericilere daha detaylı bir analiz sunar. Ancak, matris yaklaşımlarla elde edilen sınıflandırma bile, envanter yönetimi karmaşıklığında dikkate alınması gereken çok sayıda özelliği temsil etmek için yeterli değildir. Bu sınırlamalar, araştırmacıları çok kriterli karar verme, optimizasyon ve sezgisel algoritmalar gibi daha gelişmiş tekniklere yönlendirmiştir. Bu teknikler çok sayıda SKU özelliğini çeşitli algoritmalarla işleyerek karar vericinin sınıflandırmasına hazırlarlar. Ancak avantajlarına rağmen yoğun teknik bilgi ve uzmanlık gerektirir. Bazı durumlarda bu dezavantajlar bu teknikleri kullanılmasında en büyük engeldir.

Küçük ve orta ölçekli işletmelerin (KOBİ'lerin) gelişmiş envanter sınıflandırma tekniklerini planlama ve uygulama konusunda bir dizi zorlukla karşılaştıkları bilinmektedir. Bu zorlukların başında, sınırlı kaynaklara sahip olmaları gelmektedir; ayrıca genellikle envanter yönetimine odaklanmış uzman

personel eksikliği problem vardır. Geleneksel ve matris envanter sınıflandırma yöntemleri, belirli bir ölçüde kullanılmalarına rağmen, KOBİ'ler için yeterli değildirler. Geleneksel yöntemler genellikle fazla basit olabilirken, matris yöntemleri yeterli ölçüde kapsayıcı değildir. KOBİ'lerin karşılaştığı sorunlar arasında, kullanıcı dostu karmaşık envanter yönetim yazılımları, eğitim programları ve alanında uzman danışmanlar veya uzmanlarla ilişkiler bulunmaktadır. Ancak bu sayede, KOBİ'ler pazarların sürekli değişen ortamında iş akışlarını ve iş performanslarını optimize edebilirler.

Envanter yönetimi konusundaki sorunlar, KOBİ'lerin karşılaştığı en önemli konulardan biridir. Yapılan araştırmalar, KOBİ'lerin genellikle envanter kontrolünde zorluklar yaşadıklarını ve ya fazla envanter ya da stok sıkıntıları ile sonuçlanabileceklerini göstermektedir. Bu nedenle, KOBİ'lerin bu zorluklarla başa çıkabilmeleri ve başarılı bir envanter yönetimi stratejisi geliştirebilmeleri için uygun destek ve çözümler sağlanması önemlidir. Bu durumda, birçok özelliği kapsayabilen ve kullanımı kolay bir yönteme ihtiyaç duyulmaktadır.

Bu çalışma, KOBİ'lerin vasıfsız yöneticilerine yardımcı olmak amacıyla, BORDA yöntemiyle çeşitli envanter özelliklerini birleştiren bir sınıflandırma yaklaşımını tanıtmaktadır. Önerilen envanter sınıflandırma yaklaşımı, KOBİ'lerin ihtiyaçlarını karşılamayı hedefleyerek envanter yönetiminde karmaşıklık ile erişilebilirlik arasında bir denge kurmayı amaçlamaktadır. Bu yaklaşımın mantığı, farklı geleneksel yaklaşımların sıralamalarını birleştirerek bir bileşik sıralama elde etmektir. Böylece, çok sayıda özelliği dikkate alarak gelişmiş sınıflandırma tekniklerinden aşağı kalınmazken, aynı zamanda basit bir birleştirme prosedürü ile karar vericilere hitap ederek karmaşık matematiksel modellere veya algoritmalara ihtiyacı ortadan kaldırır. Bu yaklaşım, karmaşıklık ile erişilebilirlik arasında konumlanarak işletmelerin operasyonel verimliliğini ve maliyet etkinliğini artırmada pragmatik bir rol oynamaktadır. Önerilen yaklaşımın avantajlarına ek olarak, dezavantajları da bulunmaktadır. Sıralama birleştirme sürecinin basitliği, SKU özelliklerindeki ince detayları gözden kaçırma riski taşıyabilir. Aynı nedenle, özellikle dinamik pazar koşullarını veya çeşitli ürün portföylerini içeren zorlu envanter yönetimi senaryolarını ele almak için gereken karmaşıklığı sağlamada yetersiz olabilir. Önerilen yaklaşımın avantajları ve dezavantajları göz önüne alındığında, yaklaşımın faydalarının işletme gereksinimlerine ve karar vericilerin teknik bilgi seviyesine bağlı olarak değişebileceği söylenebilir.

Bu araştırmada önerilen envanter sınıflandırma yaklaşımı, KOBİ'lerin envanter yönetiminde karmaşıklık ve erişilebilirlik arasında denge kurmayı amaçlamaktadır. Bu yaklaşımın mantığı, farklı geleneksel envanter yönetimi yaklaşımlarının sıralamalarını birleştirerek bir bileşik sıralama elde etmektir, böylece KOBİ'ler için karmaşık olmayan ancak kapsamlı ve pratik bir araç sunmaktadır. Önerilen yaklaşımın akışı şöyle özetlenebilir. İlk olarak karar vericinin her SKU'nun özellikleri hakkında bilgi edinmesini ve bu özelliklere göre sıralamasını içerir. Bu sıralamalar daha sonra Borda yöntemi kullanılarak birleştirilir; bu teknik, bireysel tercihleri birleştirerek bir bileşik sıralama oluşturur. SKU'lar daha sonra bu birleşik sıralamaya göre sınıflandırılır.

Önerilen envanter sınıflandırma yönteminin avantajları ve dezavantajları şu şekilde tartışılabilir. SKU özelliklerini sınıflandırarak karar vericilere tam bir resim sunar, böylece doğru kararı almalarını sağlar. Ayrıca, BORDA yönteminin kullanımı, bireysel SKU sıralamalarının sistematik ve tarafsız bir şekilde birleştirilmesiyle önyargı olasılığını ortadan kaldırır. Sıralamanın birleştirilmesine dayalı SKU sınıflandırması sınıflandırmayı kolaylaştırır ve yüksek performans gösteren SKU'ların belirlenmesini basitleştirir. Bununla birlikte, önerilen yaklaşım, SKU özellikleri sıralamasına dayandığı için aşırı basitleştirme nedeni olabilir ve bu nedenle farklı özellikler arasındaki etkileşimleri açıklamak mümkün olmayabilir. Yöntem, kolay kararlar için uygundur ancak karmaşık iş problemlerinde zorluk yaşayabilir. Özellikle, uzmanlaşmış veya niş ürünlerde, önerilen yaklaşım çalışmayabilir ve ürünlerin yanlış sınıflandırılmasına veya önemli faktörlerin göz ardı edilmesine neden olabilir. Sonuç olarak, önerilen yöntem SKU sınıflandırması için basit bir yol olmasına rağmen, aşırı basitleştirme ve sofistike olmaması kompleks iş dünyasında uygulanabilir olmamasının nedeni olabilir.

Borda yöntemi tercihe göre adayları sıralayan bir oy verme sistemidir ve farklı tercih listelerindeki alternatiflerin sıralamalarını dikkate alarak final sıralamayı oluşturan bir bilgi birleştirme tekniğidir. Borda yöntemi, karar verenler tarafından yapılan sıralamaların sonuçlarını birleştirmek için kullanılan bir tekniktir. Bu yöntem, sadece oy verme ve karar alma alanlarında değil, aynı zamanda akademik dergilerdeki alıntılarda, risk algısının analizinde ve aktif dağıtım ağlarının ekonomik işletme

değerlendirmesinde de kullanılmıştır. Farklı alanlardaki sıralamaları ve tercihleri bir araya getirerek bilgiyi yapılandırmak ve nihai sıralamayı veya kararı oluşturmak için sistematik ve yapılandırılmış bir yol sunan Borda yöntemi, çok yönlü ve kullanışlı bir araçtır.

Borda yöntemi, her sıralama yönteminin aynı ağırlığa sahip olduğunu düşünmektedir. Bu teknik, her bir sıralamadaki m alternatifin birinci sırasına $m-1$ azalan bir değer, ikinci sırasına $m-2$ ve son alternatife 0 değeri verilerek bir puanlama sistemine dayanmaktadır. Tüm sıralamalardan elde edilen puanlara göre alternatiflerin azalan sıraya konulmasıyla son sıralama yapılır.

Borda yöntemi, farklı sıralamaların birleştirilmesi ve tercihlerin yapılandırılması konusunda etkili bir araç olup, karar verme süreçlerinde kapsamlı ve dengeli sonuçlar elde etmek için kullanılmaktadır. Bu yöntem, karar vericilerin farklı tercihleri ve sıralamaları bir araya getirerek nihai bir karar verme mekanizması oluşturmalarına yardımcı olmaktadır.

Önerilen envanter sınıflandırma yaklaşımının uygulaması, envanter sınıflandırma literatüründe test verisi olarak kullanılan bir veri seti ile gösterilmiştir. Veri seti, ortalama birim maliyet, yıllık maliyet ve teslim süresi gibi özelliklere sahip 47 SKU'yu kapsamaktadır. İlk aşamada, SKU'lar bu özelliklere göre sıralanmış ve puanlanmıştır. Daha sonra, bu puanların toplanmasıyla Borda Skorları elde edilmiş ve nihai birleşik sıralama oluşturulmuştur. SKU'lar, literatürde önerilen yüzdelikler temel alınarak A, B veya C sınıflarına ayrılmıştır. Buna göre en üstteki %15'lik dilim A sınıfına, sonraki %25 B sınıfına ve geriye kalan %60 C sınıfına yerleştirilmiştir.

Birleştirilmiş sıralama ve özellikler bazındaki sıralamaların korelasyonu incelenmiştir. Spearman Rank Korelasyon katsayıları, önerilen yaklaşım hakkında ilginç bulgular ortaya koymaktadır. SKU özellikleri arasında düşük bir korelasyon olduğu görülmüştür; bu durum, yalnızca bir özellik temel alınarak yapılan sınıflandırmanın yetersiz olduğunu göstermektedir. Ancak Borda sıralaması, diğer sıralamalarla pozitif ve orta derecede bir ilişki göstermektedir. Bu da Borda yönteminin çeşitli özellikleri temsil etmede daha başarılı olduğunu göstermektedir. Sınıflandırmaların karşılaştırılması, Borda yönteminin farklı SKU özelliklerini dengeleyen bir uzlaşma sıralaması sağladığını vurgulamaktadır. Bu yaklaşım, yalnızca bir özelliği dikkate alarak yapılabilecek potansiyel yanlış sınıflandırmaları önleyebilir. Borda yönteminin tüm özellikleri dengelemesi ve temsil etmesi, KOBİ'ler için envanter sınıflandırmasında etkinliğini göstermektedir.

Bu çalışma, Borda yöntemini kullanarak önerilen envanter sınıflandırma yaklaşımının KOBİ'lerdeki vasıfsız yöneticiler için değerli bir araç olduğunu ortaya koymaktadır. Sınıflandırma sürecini basitleştirerek ve aynı anda birden fazla özelliği dikkate alarak, bu yaklaşım, küçük ve orta ölçekli işletmelerde envanter yönetimi için pratik ve etkili bir çözüm sunmaktadır.