SHELF SPACE ALLOCATION PROBLEM (SSAP) IN THE RETAIL INDUSTRY: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

This article presents a comprehensive analysis of the Shelf Space Allocation Problem (SSAP) in the context of the evolving retail industry. The significance of this problem lies in its impact on consumer behavior, sales revenue, and overall shop profitability, with a particular focus on enhancing store performance through the optimization of shelf item placement. This review systematically integrates prior research by conducting a rigorous analysis of different approaches to SSAP, including mathematical models, heuristic strategies, and data-driven procedures. This study aims to synthesize key findings, identify knowledge gaps, and propose avenues for future research by compiling and evaluating several methodologies. This evaluation aims to acquire a thorough understanding of the various attributes of SSAP and their implications for retail operations. The primary data analysis examined a thorough selection of articles obtained through advanced search techniques on the Scopus and Mendeley databases. A total of 25 articles were included in the analysis. This article aims to provide a valuable resource for improving decision-making processes in the allocation of retail shelf space. It achieves this by compiling information on the main factors, challenges, and optimization techniques related to SSAP. The article's results offer valuable insights for supply chain management professionals and retailers. The proposition suggests that power dynamics within the supply chain influence the allocation of display space costs between suppliers and retailers. This article successfully identified optimal solutions across ten distinct scenarios and achieved an average profit ratio of over 99% by implementing various effective methodologies to address intricate optimization issues. Ultimately, this article contributes to enhancing retail performance, customer satisfaction, and strategic planning in the dynamic retail industry. This research highlights the significance of implementing adaptive and context-aware tactics to accommodate changing consumer preferences and market dynamics. Accordingly, it can enhance the effectiveness of shelf space allocation strategies and promote a competitive edge within the retail industry.

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1. INTRODUCTION

In the dynamic landscape of the retail industry, effective shelf space allocation stands as a pivotal factor in optimizing sales, enhancing customer satisfaction, and maximizing overall profitability (Jiang et al., 2018; Hossain, 2013; Gencosman, 2022). The Shelf Space Allocation Problem (SSAP) constitutes a critical challenge that retailers encounter as they strive to strategically position their diverse array of products within limited shelf real estate (Czerniachowska, 2021; Young et al., 2021; Hubner & Kuhn, 2023). As consumer preferences evolve, competition intensifies, and product assortments expand, the significance of mastering the art of shelf space allocation becomes increasingly evident (Vente et al., 2018; Hollenbeck & Giroldo, 2022; Becerril et al., 2018). The SSAP encompasses the intricate decision-making process of assigning products to specific shelf spaces to capitalize on various factors, such as product demand, product characteristics, brand visibility, and spatial constraints. Therefore, achieving an optimal shelf space allocation demands a delicate balance between accommodating the ever-changing demands of consumers and aligning with the retailer's broader business objectives (Flamand et al., 2018; Yang et al., 2017).

**Figure 1:** Sales Volume and Cumulative Percentage of Product Categories
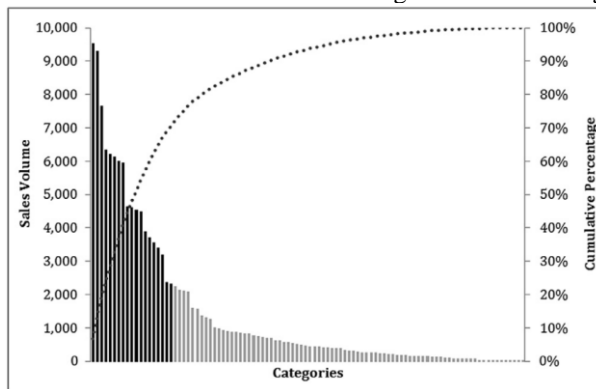
Source: Flamand et al. (2018).

This comprehensive review delves into the multifaceted dimensions of the SSAP, examining the underlying methodologies, mathematical models, and algorithmic approaches that researchers and practitioners have developed over time. By synthesizing and critiquing existing literature, this article aims to provide a structured understanding of the key elements contributing to effective shelf space allocation. Furthermore, it seeks to shed light on emerging trends and

challenges brought about by the integration of technology, the rise of e-commerce, and the increasing emphasis on personalized shopping experiences. Through a systematic analysis of the SSAP, this article aspires to offer valuable insights to both academia and industry. By comprehending the nuances of shelf space allocation strategies, retailers can enhance their operational efficiency and tailor their merchandising efforts to better cater to the preferences and behaviors of their target consumer segments. Ultimately, an in-depth exploration of the SSAP serves as a stepping stone toward informed decision-making, innovation, and continued advancement within the ever-evolving retail landscape.

Figure 2: Retail Demand and Supply Chain Planning Framework
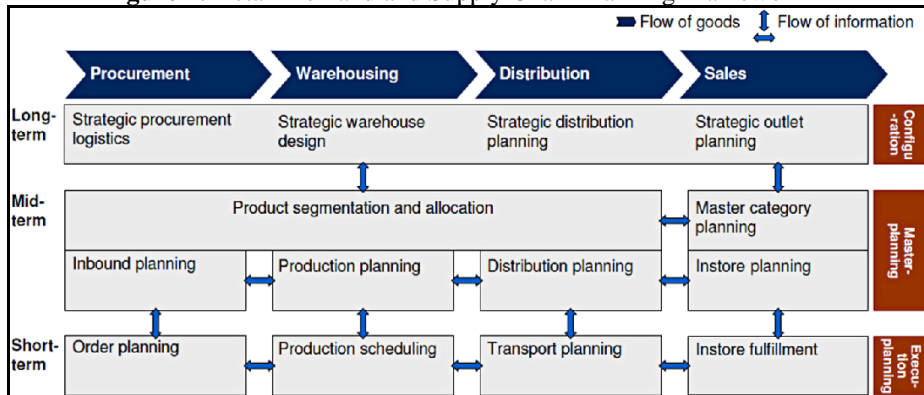
*Source:* Hübner and H. Kuhn (2012).

2.   LITERATURE REVIEW

This paper introduces a comprehensive framework to enhance retail operations and profitability for independent franchise retailers through the Category Management Decision Support Tool (CMDST). This tool integrates two category management models to strategically optimize aspects such as shelf space allocation, product assortment, review period, and order quantity to maximise net profit. As such, comparative analysis against prevailing industry practices (Ramaseshanm et al., 2008) underscores the robustness of these models, highlighting a substantial increase in net profit. Moreover, this work pioneers a novel approach to address the intricate challenge of managing restricted display areas within the grocery retail sector. Hence, incorporating consumer behavior, product switching, and substitution dynamics illuminates the genuine drivers of product demand (Reyes & Frazier, 2003). Another facet of this study is advancing a linear allocation model tailored for efficient shelf-space optimization in retail. In addition, the expansion of this model to accommodate product groupings and non-linear profit functions is a significant stride, bolstered by a hybrid methodology merging potent local search tactics and a metaheuristic approach.

This innovative strategy furnishes adaptable and effective solutions to both linear and non-linear quandaries, ushering in heightened shelf management efficiency, profitability, and superior planogram quality (Lim et al., 2004). Furthermore, the authors propose an innovative market

similarity model that utilizes the structural and geographical characteristics of the US retailing industry to forecast brand performance. According to this concept, it is proposed that similar marketplaces with common sellers or close vicinity are likely to result in similar sales outcomes for branded products. In contrast to basic forecasting methods like global-market averages, closest neighbour estimators, and local averages, this spatial model demonstrates superior performance by incorporating latent variables that exhibit cross-market correlations. As a result, it provides more precise estimates of price elasticities and produces more detailed predictions (Bronnenberg & Sismeiro, 2002). Moreover, this study explores the complexities of combined assortment design and shelf space allocation, specifically focusing on incorporating specialty products. This research article addresses complex subject matters by employing a non-linear integer programming methodology. The study aims to analyze the effects of cross-selling by utilizing real sales data obtained from Turkey's prominent grocery chain. Similarly, Angun and Ozkan (2015), the subsequent quantitative results and sensitivity studies offer useful insights into the consequences of implementing cross-selling tactics. Notably, the combined efforts of these contributions enhance the comprehension of category management, assortment planning, and shelf space optimization within the ever-changing retail environment.

Figure 3: Sensitivity of the Objective with Respect to the Cross-Selling Effect
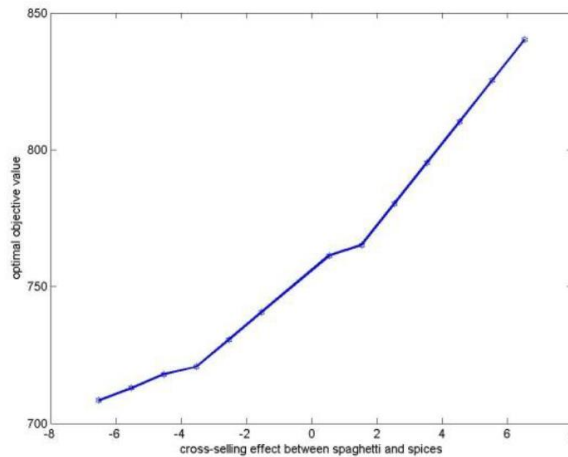
Source: Angun and C. E. Ozkan (2015).

Within the grocery retail sector domain, which exhibits a substantial annual sales figure of $2.5 trillion, the convergence of profitability and customer service difficulties calls for discerning approaches. One crucial aspect pertains to the distribution of shelf space among different products, as illustrated by commodities such as pickles or jelly. To effectively navigate this area, a formulation of non-linear integer goal programming is presented. Thus, this formulation aims to reconcile profitability and customer service factors, thereby equipping managers with ideal tools for decision-making. This decision support resource is highly valuable as it enables the consideration of intricate trade-offs in many managerial scenarios. Additionally, an alternate technique is also presented (Reyes & Frazier, 2007). Moreover, this paper aims to address a complex issue in the retail industry, specifically the allocation of shelf space. In this highly

competitive sector, success relies heavily on strategic product placement and effective utilization of shelf space.

This study focuses on developing solutions for the intricate challenge of allocating shelf space, considering factors such as shelf dimensions, product attributes, orientations, and various shelving arrangements. By employing an innovative approach, the complex non-linear puzzle transforms a manageable linear framework. In this context, binary variables transform, combining binary and continuous variables while adhering to the limits imposed by the store. The implementation of this strategic transformation results in an ideal allocation of products on shelves, a process that is closely associated with the goal of maximizing profits. Notably, the effectiveness of this strategy is confirmed through experimental validation, which utilizes a commercial CPLEX solver (Czerniachowska & Lutoslawski, 2022). With the rapid expansion of the retail industry, the complexity of managing product selection, shelf-space distribution, and replenishment decisions has become increasingly intricate. This study presents a profit-maximization model for retailers, which examines several elements, such as spatial and cross-space elasticities and the impacts of placement effects, to shed light on this subject matter. The model utilizes the flexible Mixed-Integer Non-Linear Programming (MINLP) approach, incorporating a combination of heuristic algorithms, namely tabu search and genetic algorithms, to effectively coordinate and achieve a cohesive solution. According to Kim and Moon (2021), the effectiveness and efficiency of these algorithms indicate their ability to enable merchants to make simultaneous decisions that enhance revenue streams. The prudent allocation of product shelf space is crucial for the success of the retail industry. As such, this study builds upon previous research by incorporating elements that enhance the realism of the domain, including issues such as the fluctuating demand for perishable products, price contracts, and cross-elasticities. Notably, the focal point of this discussion revolves around the dynamic context of film distribution within multiplexes, whereby a linear integer programming model emerges as a prominent guiding principle. The present model exhibits a radiant capacity, unveiling an 11% increase in revenue compared to existing methodologies. Furthermore, the stage is adorned with two agile greedy heuristics and a powerful genetic algorithm, with the latter being identified as the exemplary answer (Raut et al., 2009). Accordingly, this research collectively explores new boundaries in understanding the complex landscape of retail, enhancing it with strategic expertise and data-driven precision.

The present study endeavours to comprehensively understand the SSAP within the retail industry, encompassing its various aspects, methodology, and implications. The objective of this review is to address the research question: "What are the primary factors, challenges, and optimization methods related to SSAP in the retail industry, and how can this understanding contribute to the development of more efficient strategies for allocating shelf space, ultimately improving retail performance and customer satisfaction?" This article aims to offer valuable insights for scholars and professionals in the retail sector by comprehensively analyzing existing literature and empirical studies. Ultimately, it aims to contribute to developing improved shelf space allocation procedures that are more effective in meeting customer needs and preferences.

3. MATERIAL AND METHOD

3.1. *Identification*

The systematic review approach is divided into three fundamental stages, which were utilised to choose several relevant publications for this investigation. The first part comprises identifying keywords and searching for related phrases utilising thesaurus, dictionaries, encyclopaedias, and past research. After selecting all relevant terms, search strings for the Scopus and WOS databases (see Table 1) were created. During the initial step of the systematic review procedure, the present study project was able to effectively acquire 111 papers from both databases.

Table 1: The Search String

Scopus	TITLE-ABS-KEY ((shelf AND space AND allocation AND problem OR ssap) AND (retail* OR market OR profit* OR sale*)) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2023)) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (LANGUAGE, "English"))
WOS	((shelf AND space AND allocation AND problem OR ssap) AND (retail* OR market OR profit* OR sale*)) (All Fields) and English (Languages) and 2019 or 2020 or 2021 or 2022 or 2023 (Publication Years) and Article (Document Types)

3.2 *Screening*

Duplicate papers should be eliminated during the initial screening round. The first phase excluded 18 publications, while the second phase evaluated 59 articles based on multiple inclusion and exclusion criteria devised by academicians. The first criterion was literature (research papers), which is the major source of practical information. Furthermore, the review focused solely on publications written in English. In all, 94 articles were rejected based on criteria. The review was likewise confined to English-language publications. Therefore, it is crucial to remember that the strategy was only valid from 2019 to 2023.

3.3. *Eligibility*

A total of 41 articles have been produced for the third level, which is known as eligibility. At this point, all article titles and essential material were extensively assessed to ensure that the inclusion criteria were met and that the papers fit into the current study with the current research goals. As a result, 16 publications were eliminated since they were out of the field, the title was insignificant, the abstract was unrelated to the study's purpose, and there was no full-text access. Finally, 25 papers are ready for evaluation.
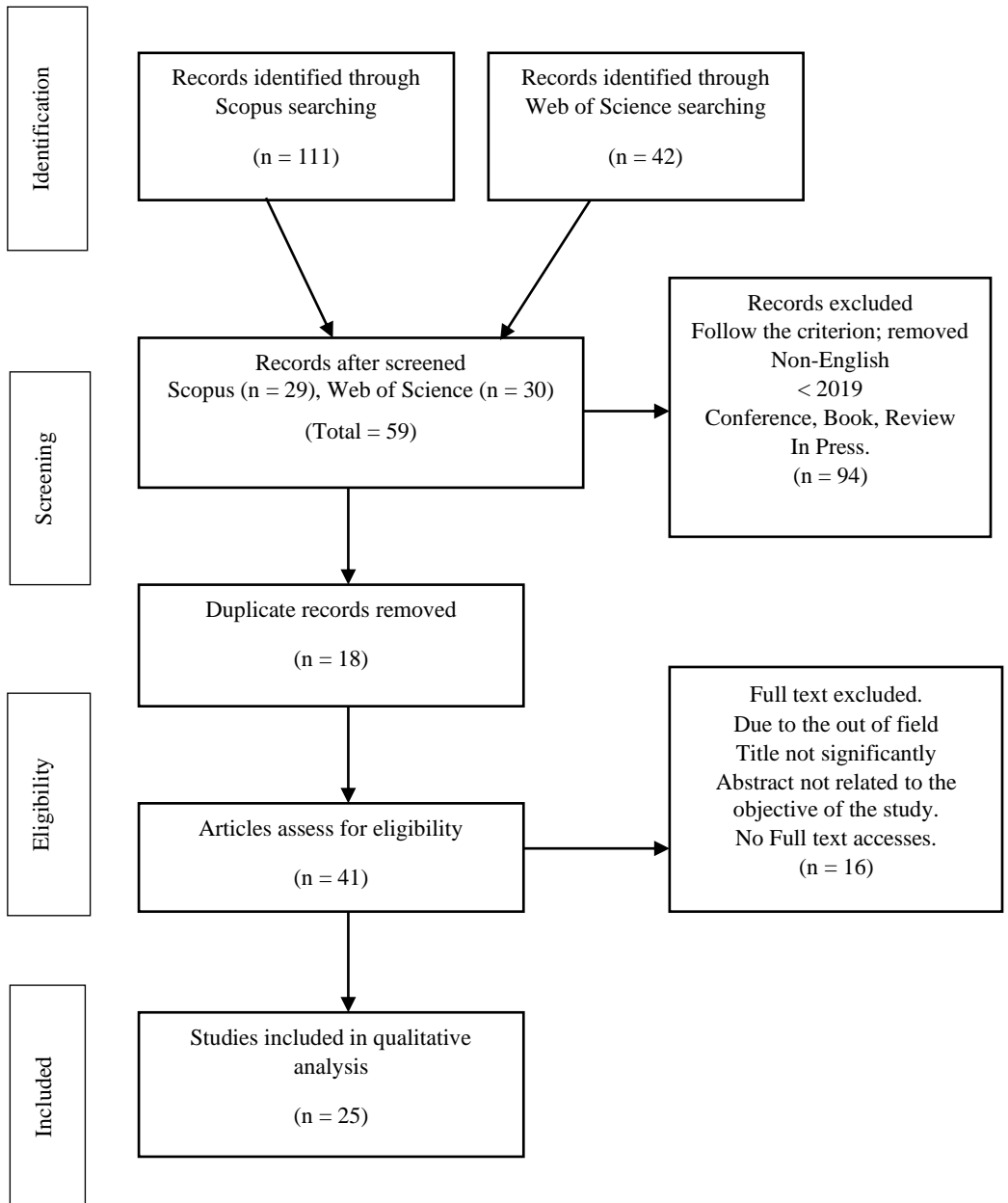
Table 2: The Selection Criterion Is Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline	2019 – 2023	< 2019
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press

3.4. Data Abstraction and Analysis

This study employed an integrative analysis as one of its assessment techniques to examine and consolidate several quantitative research designs. The proficient study aimed to identify relevant issues and subtopics. The data collection phase served as the primary stage in formulating the subject. Figure 4 illustrates the meticulous examination conducted by the researchers on a compilation of 25 articles, with the purpose of identifying assertions or content relevant to the concerns addressed in the present study. The authors subsequently conducted a comprehensive examination of the latest significant research on shelf space allocation within the retail business. The examination of study techniques and research findings is currently under scrutiny.

The primary author cooperated with additional authors in the framework of this research to establish thematic categories derived from the collected data. Throughout the data analysis process, a log was maintained to document all analyses, perspectives, inquiries, or other cognitive reflections pertaining to the interpretation of the data. The authors additionally analyzed the data to detect any discrepancies within the process of theme design. It is essential to acknowledge that the authors engage in mutual resolution if there are disparities between the subjects. To address any potential discrepancies in the process of theme design, the writers conducted a thorough analysis and comparison of the obtained outcomes. As a result, the formulated thoughts underwent modifications to ensure their cohesiveness. The examinations were conducted by two specialists, Wan Munirah Ariffin, who specializes in mathematical modeling, and Muhammad Shahar Jusoh, who specializes in management, to ensure the authenticity of the problems. The expert review step was conducted to ascertain each sub-theme's clarity, significance, and appropriateness by establishing domain validity. Following this, the authors have implemented revisions based on reader input and professional commentary. Ultimately, the established themes were modified to ensure consistency. Including the expert review step in the research process validated the clarity, significance, and sufficiency of each sub-theme within the study by establishing domain validity. The author has implemented modifications in response to feedback and expert suggestions.

Figure 4: Flow diagram of the proposed search study

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┌──────────────┐   ┌────────────────────────┐   ┌────────────────────────┐
│              │   │ Records identified     │   │ Records identified     │
│ Identification│  │ through Scopus         │   │ through Web of Science │
│              │   │ searching              │   │ searching              │
│              │   │                        │   │                        │
│              │   │ (n = 111)              │   │ (n = 42)               │
└──────────────┘   └────────────────────────┘   └────────────────────────┘
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Records identified through Scopus searching

(n = 111)

Records identified through Web of Science searching

(n = 42)

Records after screened Scopus (n = 29), Web of Science (n = 30)

(Total = 59)

Records excluded Follow the criterion; removed Non-English < 2019 Conference, Book, Review In Press.

(n = 94)

Duplicate records removed

(n = 18)

Full text excluded. Due to the out of field Title not significantly Abstract not related to the objective of the study. No Full text accesses.

(n = 16)

Articles assess for eligibility

(n = 41)

Studies included in qualitative analysis

(n = 25)

Identification

Screening

Eligibility

Included

Source*:* Moher et al. (2009).

4. RESULTS AND DISCUSSION

Recent research has provided valuable insights into optimizing shelf space utilisation in retail stores. It has been discovered that efficient strategies, such as category management and planogram optimization, can significantly increase sales and profitability. The use of advanced data analytics and machine learning techniques has made these strategies more adaptable to changing market dynamics. This is particularly crucial in the evolving retail landscape driven by e-commerce and omnichannel retailing. At the same time, the research also emphasizes the importance of considering factors beyond product placement, such as sustainability and perishable goods management. Overall, there is a need for continued research in this area to develop innovative solutions for the challenges facing the industry. Thus, 25 articles were extracted and analyzed employing the search technique. All papers were classified into three categories: Shelf Space Allocation Models and Optimization Techniques, Impacts and Effects of Shelf Space Allocation, and Integrated Retail Planning and Management.

4.1. *Shelf Space Allocation Models and Optimization Techniques*

In this theme, articles regarding space allocation models and optimization techniques are explored and summarized below.

Table 3: Shelf Space Allocation Models and Optimization Techniques

Authors (year)	Title	Finding
Ishichi et al. (2019)	Shelf-space allocation model with demand learning	Propose a dynamical framework for making shelf-space display decisions in which space elasticity and potential demand are evaluated sequentially utilizing the most recent data for each product's display space and sales.
Kim and Moon (2021)	Integrated planning for product selection, shelf-space allocation, and replenishment decisions with elasticity and positioning effects	The findings demonstrate the usefulness and efficiency of these algorithms by comparing the outputs to the MINLP optimum solution for small data sets and the algorithm performances for big data sets. The solution techniques anticipate supporting a simultaneous decision-making process for retailers to maximize revenue.
Düsterhöft, Hübner & Schaal (2020)	A practical approach to the shelf-space allocation and replenishment problem with heterogeneously sized shelves	The findings of a field test in which model solutions were used in practice reveal how one of Germany's major grocery retailers was able to raise its earnings across multiple categories and outlets by 9.1% on average compared to a control group by adopting the technique.

Karki, Guthrie, and Parikh (2021)	Joint determination of rack configuration and shelf space allocation for a retailer	Researchers developed and solved an optimization model for JRC-SSA based on Particle Swarm Optimization. The JRC-SSA can boost a retailer's earnings by up to 10.1% when compared to a typical 7-foot-high rack set at a 90-degree angle. At low space costs, acute-angled racks tend to boost impulsive profit over 90° racks. Shorter racks appear dominant for low restocking costs.
Czerniachowska, Hernes, and Lutosławski (2023)	A linearization approach to solving a non-linear shelf space allocation problem with multi-oriented capping in retail store and distribution centre	Researchers provide a linearization approach that may be used to linearize models with capping and thereby find an optimum solution. The computational experiments compare the quality of outcomes provided by non-linear versus linear models. The suggested approach does not add to the complexity of the initial non-linear issue.
Zheng et al. (2023)	A data-driven model-assisted hybrid genetic algorithm for a two-dimensional shelf space allocation problem	The research findings reveal that the suggested DMA-HGA offers a better solution and higher accuracy when compared to the benchmarking techniques discussed. Finally, managerial insights for the 2DSSAP are presented based on the extensive parameter discussion.
Czerniachowska and Hernes (2020)	A genetic algorithm for the shelf-space allocation problem with vertical position effects	Provide a realistic shelf-space allocation model with vertical position effects based on a genetic algorithm, with the goal of maximizing store profit. The model's validity is demonstrated through sample problems and comparisons with the CPLEX solver.
Czerniachowska et al. (2021)	Genetic algorithm for the retailers' shelf space allocation profit maximization problem	Computational results suggest that the proposed approach yields efficient results in a short amount of time, and the developed complex shelf space allocation model, which considers multiple shelf, segment, and product attributes, as well as product capping and nesting allocation rules, is highly practical. The suggested technique enables merchants to earn larger store profits based on the real merchandising standards.
Chen, Weng, and Liu (2020)	Teaching-Learning-Based Optimization (TLBO) with variable neighborhood search to retail shelf-space allocation	The study's findings reveal that the suggested TLBO-VNS algorithm outperforms previous algorithms in terms of solution performance while employing fewer control parameters. As a result, the suggested TLBO-VNS algorithm

		has a high potential for solving SSAP.
Czerniachowska and Hernes (2021)	Simulated annealing hyper-heuristic for a shelf space allocation on symmetrical planograms problem	To tackle the planogram profit maximization issue, we provide a simulated annealing technique incorporating improvement and reallocation processes. Experiments are based on synthetic data sets developed in accordance with real-world situations. Using the CPLEX solver, the efficiency of the developed algorithm was estimated.
Yu, Maglasang, and Tsao (2020)	A reduced variable neighborhood search-based hyperheuristic for the shelf space allocation problem	The numerical analysis demonstrates that the proposed HyRVNS outperforms independently developed customized low-level heuristics in terms of both fitness and stability.
Czerniachowska (2022)	A genetic algorithm for the retail shelf space allocation problem with virtual segments	The suggested method's efficiency was assessed using the CPLEX solver. Computational investigations indicate that this strategy yields excellent results for both small and big product numbers in a reasonable amount of time.
Khatami (2021)	A new hybrid optimization algorithm for the optimal allocation of goods on shop shelves	The results of a costly experimental phase reveal that the suggested method outperforms other stated algorithms in the literature. Furthermore, the findings demonstrate the suggested algorithm's appropriateness and advantages in identifying high-quality solutions as well as its resilience.
Czerniachowska, Michalak, and Hernes (2023)	Heuristics for the shelf space allocation problem	As a result, the model uses four types of constraints: shelf constraints, product constraints, multi-shelves constraints, and category constraints. To address the planogram profit maximization challenge, researchers offered six heuristics. Research was conducted using data sets developed based on current real-world retail situations. The CPLEX solver was used to estimate the effectiveness of the specified heuristics.
Czerniachowska and Hernes (2021)	A heuristic approach to shelf space allocation decision support, including facings, capping, and nesting	Experiments were conducted using data gathered from real-world retail prices. 45 examples were evaluated to estimate the performance of the suggested technique. Among these, the suggested technique

		discovered answers in 34 situations, while CPLEX found solutions in only 23. The profit ratio of the suggested strategy is 94.57% on average, with the lowest and greatest values of 86.80% and 99.84%, respectively.
Gencosman and Begen (2022)	Exact optimization and decomposition approaches for shelf space allocation	According to the researchers, IP1/IP2 effectively identifies ideal solutions for real-world cases and can boost the profit of the local bookshop by up to 16.56%. IP1/IP2 can solve instances with 100 products in minutes and up to 250 goods (assigned to 8 rows x 160 columns) in 1800 seconds. This precise 2-stage IP1/IP2 solution strategy may help tackle comparable problems such as webpage design display, product family allocation in grocery shops, and flyer advertising.
Czerniachowska, Wichniarek, and Zywicki (2022)	Heuristics for Dimensioning the Shelf Space on the Rack with Vertical and Horizontal Product Categorization in the Distribution Centre with Zone Picking	The computational results indicate that the new heuristics can produce higher-quality answers. Both heuristics may identify optimum solutions without investigating the whole solution space in 10 of 15 tests. The answers obtained using heuristics for the remaining test sets are more than 92.58%.

4.2   *Impacts and Effects of Shelf Space Allocation*

This theme focuses on the impacts and effects of shelf space allocation. The table below summarizes the articles' findings related to the selected theme.

Table 4: Impacts and Effects of Shelf Space Allocation

Authors	Title	Finding
Çetin, Mersereau, and Parlaktürk (2020)	Management and effects of in-store promotional displays	The findings provided useful guidance to retailers in effectively leveraging promotional displays. They highlighted the significance of considering the broader ramifications on store traffic and demand for other products when making display decisions. This improves both academic understanding and practical decision-making in the retail industry.

Edirisinghe and Munson (2023)	Strategic rearrangement of retail shelf space allocations: Using data insights to encourage impulse buying	The main finding is that, in terms of the potential to generate multiple types of impulse purchasing (visibility-driven purchasing, present-shelf impulse, and past-aisle impulse), our strategic rearrangement technique consistently outperforms visually rearranging shelf space allocations. Several existing allocation techniques use multi-level association rule mining, while exceeding the profit potential of a more traditional unchanged (one-level) allocation technique in many cases. The findings also emphasize the necessity of a retailer picking the most effective shelf space rearrangement method based on its customers' attributes, particularly their discretionary income level and familiarity with the shop layout.
Guohua (2017)	Shelf space allocation and coordination in the supply chain with unequal channel power structures	Decentralised supply chains result in higher retail prices and less shelf space allocation for retailers, indicating inefficiencies in pricing and space allocation. The supplier-Stackelberg supply chain leads to lower prices and more shelf space allocation, highlighting channel power structures' impact.

4.3 *Integrated Retail Planning and Management*

This theme explored integrated retail planning and management and is summarized in Table 5.

Table 5: Integrated Retail Planning and Management

Authors (Year)	Title	Finding
Czerniachowska, Wichniarek, & Żywicki (2023)	Industry Expertise Heuristics for Dimensioning Shelf Space of Rack Storage Location in a Distribution Centre with Zone Picking	Two strategies were developed, and the archived results were compared with the CPLEX solver. The typical profit ratios of both heuristics are large, approaching 99%. Heuristics discovered optimum solutions in 10 situations. Thanks to the heuristic criteria, the total number of alternative solutions tested for the biggest

		instance decreased from 1.33 10156 to 1.19 107.
Hübner, Düsterhöft, & Ostermeier (2021)	Shelf space dimensioning and product allocation in retail stores	The findings demonstrated that including shelf dimensioning into product allocation yields up to 5% better earnings than benchmarks available in the literature. We demonstrated how to enhance planning and increase the retailer's profit margin by up to 7% through a case study.
Ostermeier, Düsterhöft, & Hübner (2021)	A model and solution approach for store-wide shelf space allocation	Researchers divided the problem into two hierarchically interconnected subproblems, demonstrating that the proposed solution strategy works effectively and offers solutions relevant to major problems in retail practice. In a case study with a big European retailer, we demonstrated that our strategy may increase store profitability by 3.2%. In addition, researchers simulated data to generalize our findings and obtained management insights.
Sajadi and Ahmadi (2022)	An integrated optimization model and metaheuristics for assortment planning, shelf space allocation, and inventory management of perishable products: A real application	GAMS BARON solver was utilized to solve the suggested model on small and medium sizes. However, since the issue is NP-hard, an evolutionary (GA) and an efficient local search vibration damping optimization (VDO) technique were presented. A real-world case study was investigated to assess the model's efficacy and capabilities. Furthermore, numerous test problems of various sizes were constructed and solved using the suggested metaheuristic solvers to demonstrate the efficient performance of proposed methods in tackling large-scale cases.
Gecili and Parikh (2022)	Joint shelf design and shelf space allocation problem for retailers	The findings revealed that depending on the product-family form variance, shorter shelf lengths might boost store profit by up to 37%. Increased within-family form variety can lead to increased revenue. Furthermore, if the product and planogram dimensions have a common

component or multiple, more compact planograms may be produced, minimizing empty space and boosting a retailer's profit.

The study on shelf space allocation models and optimization methods uncovers many deficiencies and novel discoveries. Critical deficiencies include the need for real-time adaptation across diverse retail contexts, enhanced integration of different algorithms, an emphasis on extending beyond specialized retail formats, more product-specific customization, and the integration of consumer behaviour data into optimization models. New research suggests that dynamic allocation improves the accuracy of decisions (Ishichi et al., 2019), integrated methodologies can increase retail profits by as much as 9.1% (Kim & Moon, 2021). Hybrid algorithms are more accurate and efficient than traditional methods (Zheng et al., 2023), while vertical product positioning increases store profits (Czerniachowska & Hernes, 2020). Models with multiple constraints produce better shelf allocation results (Czerniachowska et al., 2023). Nevertheless, these findings offer significant insights and underscore areas requiring more investigation.

5.   CONCLUSION

This study introduces a dynamic paradigm for shelf-space displays that integrates sequential assessments of space elasticity and predicted demand. The efficacy of the method is illustrated by means of a comparative analysis with MINLP, both for small-scale and large-scale datasets. A field trial conducted at a German grocery store revealed a significant boost of 9.1% in revenues. The research paper also presents a novel optimization model, JRC-SSA, which exhibits a 10.1% increase in retailer profitability compared to conventional 90-degree racks. The authors present a set of linearization techniques for models that include capping constraints, such as data-driven model assisted hybrid genetic algorithm (DMA-HGA). These methods offer essential managerial insights for effectively tackling the 2DSSAP problem. The research paper also presents a novel shelf-space allocation model that utilizes a genetic algorithm, namely (TLBO-VNS), to tackle the issues associated with SSAP effectively. The present study formulates and assesses a simulated annealing methodology utilizing the CPLEX solver. The results indicate that HyRVNS outperforms custom low-level heuristics in terms of performance. The methodology described in this study employs a mix of restrictions and six heuristic strategies to maximize profit in the context of planogram optimization. Furthermore, this study examines several strategies for reorganizing shelf space with the aim of enhancing impulsive purchasing behavior. In addition, the findings provide valuable insights for retailers and supply chain management professionals. Moreover, the proposition posits that the allocation of shelf space costs between suppliers and retailers is influenced by power dynamics within the supply chain. Additionally, various effective methodologies have been implemented to tackle intricate optimization issues, leading to an average profit ratio of over 99% and the successful identification of optimal solutions across ten distinct scenarios.

This comprehensive review of the SSAP in the Retail Industry provides insights into the complex issues that retailers have when attempting to optimize their strategies for allocating shelf space. As such, this statement highlights the significant impact that effective SSAP solutions have on improving a retailer's financial performance, inventory control, and customer contentment. This article provides unique insights into the newest methodology and best practices in the field, making it a great resource for merchants. Concurrently, this underscores the urgent requirement for additional investigation and advancement in the field of SSAP among researchers, fostering the creation of innovative algorithms and approaches to tackle the changing dynamics of the retail industry.

ACKNOWLEDGEMENT

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