The Comparison of Push and Pull Systems in Machine Made Carpet Industry: A Case Study from Türkiye[*]

Araştırma Makalesi /Research Article

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ABSTRACT: *A multitude of successive processes and systems have been developed in order to meet customer needs. Two of these systems are classified as push and pull systems. The mechanisms of production and distribution are subject to a constant paradigm shift between "production for supply (push)" and "production on demand (pull)". The present study measured and compared the values of different outputs resulting from the application of both push-based and pull-based systems in a company in Türkiye. Furthermore, the financial performance of the relevant systems was evaluated using the ENTROPY-COPRAS method. Despite the inherent advantages and disadvantages of both systems, the findings indicate that the pull system-based model is particularly well-suited to the relevant sector. This model is characterized by its fast, transparent, predictable and sustainable nature, while also ensuring the more sensitive and efficient use of resources. This study is pioneering in its approach, as it is the first to compare these two systems using different parameters for the machine-made carpet industry. In this context, it is hoped that it will contribute to the strategy development of industry players in terms of supply chain management, as well as to researchers.*

Keywords: *Supply chain management, Push-pull systems, Machine-made carpet industry.*

Makine Halısı Sektöründe İtme ve Çekme Sistemlerinin Karşılaştırılması: Türkiye'den Bir Vaka Analizi

ÖZ: *Müşteri ihtiyaçlarını karşılamak amacıyla çok sayıda ardışık süreç ve sistem geliştirilmiştir. Bu sistemlerden ikisi, itme ve çekme sistemleri olarak sınıflandırılmaktadır. Üretim ve dağıtım mekanizmaları, sürekli olarak "arz için üretim (itme)" ile "talep üzerine üretim (çekme)" yaklaşımları arasında paradigmal bir değişim geçirmektedir. Bu çalışma, Türkiye'de faaliyet gösteren bir şirkette hem itme temelli hem de çekme temelli sistemlerin uygulanması sonucunda elde edilen farklı çıktıların değerlerini ölçmüş ve karşılaştırmıştır. Ayrıca, ilgili sistemlerin finansal performansı ENTROPI-COPRAS hibrid yöntemi kullanılarak değerlendirilmiştir. Her iki sistemin doğasında bulunan avantaj ve dezavantajlara rağmen, bulgular çekme sistemi temelli modelin ilgili sektör için özellikle uygun olduğunu göstermektedir. Bu model; hızlı, şeffaf, öngörülebilir ve sürdürülebilir bir yapıya sahip olmasının yanı sıra, kaynakların daha duyarlı ve verimli bir şekilde kullanılmasını da sağlamaktadır. Bu çalışma, makine halıcılığı sektöründe söz konusu iki sistemin farklı parametreler temelinde karşılaştırıldığı ilk araştırma olması bakımından öncü niteliktedir. Bu bağlamda, hem sektörde faaliyet gösteren aktörlerin tedarik zinciri yönetimi stratejilerine katkı sağlaması hem de araştırmacılara yeni bir perspektif sunması öngörülmektedir.*

Anahtar Kelimeler: *Tedarik Zinciri Yönetimi, İtme-Çekme Sistemleri, Makine Halısı Sektörü.*

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1. Introduction

To gain a competitive advantage, companies must demonstrate flexibility, creativity, and innovation to adapt to changing conditions and respond effectively to customer needs (Wee et al., 2004; Çağlıyan et al., 2022). In pursuit of this goal, many organizations aim to reduce operational costs while maintaining the quality of their products and services. However, this cost-cutting approach may sometimes come at the expense of other critical factors, such as brand value, sustainability, operational efficiency, and pricing strategies (Gaur and Tyagi, 2022). In contrast, firms that prioritize improving service speed, flexibility, and responsiveness have been shown to simultaneously enhance customer satisfaction and order fulfillment performance (Teeravaraprug and Stapholdecha, 2004; Wee et al., 2009; Moh'd Anwer, 2022). In today's intensely competitive business environment, the ability to remain competitive increasingly depends on the establishment and effective management of supply chains that align with rapid technological advancements and evolving customer expectations. Supply chain management refers to the coordinated network of institutions involved in sourcing raw materials, converting them into intermediate and final products, and delivering these products to end-users through a distribution system. Nevertheless, the structure and management of supply chains—as well as the roles of key stakeholders—can vary considerably across industries and firms (Shukla et al., 2011). Furthermore, the design, planning, and execution of supply chains directly impact organizational performance. In this regard, it is particularly important to determine whether supply chain processes are driven by actual customer orders or are based on anticipated demand (Chopra and Meindl, 2013; Anwar et al., 2025). Supply chains are characterized by a series of interconnected processes, each designed to address the specific needs of customers. Two perspectives on these processes are the push and pull models (Chopra and Meindl, 2013).

The two concepts under discussion primarily differ in whether transactions are executed in response to actual customer orders or based on anticipated demand (Abadi et al., 2025). In the context of supply chains, push systems are initiated based on demand forecasts, making the process speculative and placing the inventory risk on the retailer (Reyes et al., 2024). Pull systems, by contrast, are triggered by real-time customer demand; in this case, the process is reactive, and the supplier bears the inventory risk (Cachon, 2004; Lariviere and Porteus, 2001; Lin et al., 2022). Both systems present distinct advantages and disadvantages (Chiang and Huang, 2021). The choice between them depends largely on a firm's production capacity, operational objectives, and its position within the supply chain. By aligning their strategy accordingly, businesses can reduce production costs and inventory levels while enhancing their responsiveness to customer demands (Zheng and Lu, 2009; Khedr and Sheeja Rani, 2024).

Numerous studies have compared push and pull systems across various sectors. The present study aims to conduct a comparative analysis of push- and pull-based systems within the machine-made carpet industry—a sector of significant

importance to Türkiye—in terms of transportation costs, profitability, inventory levels, and key financial ratios. No documented instances exist regarding the prior implementation of the push-pull system within the machinery carpet industry. Within the scope of our study, the concurrent implementation of these two systems across different brands of two companies under the same corporate group provides a valuable opportunity for comparison. In this regard, the study constitutes an original and meaningful contribution. In addition, both systems are evaluated through the hybrid ENTROPY-COPRAS method with a particular focus on financial performance, a critical factor for the economic sustainability of firms. A sensitivity analysis was also performed using multiple weight value combinations to assess the robustness of the results. The data for this study were collected from a manufacturing company that simultaneously implements both push and pull systems. This research is distinguished as the first to explore this topic within the machine-made carpet industry and adopts a comprehensive approach by incorporating a wide range of performance parameters. The subsequent sections of the paper include an overview of push and pull systems, a review of the relevant academic literature, the methodology employed, a brief introduction to Türkiye's machine-made carpet industry, detailed descriptions of the implemented push and pull systems, empirical findings, and concluding remarks.

2. Literature Review

2.1 Push and Pull Systems

The methods of production and distribution are in constant flux, shifting between production for supply (push) and production based on demand (pull) strategies (Minculete and Olar, 2016). The configuration of these systems directly influences the level and distribution of inventory-related risks. As outlined in the previous section, both push and pull systems have distinct advantages and disadvantages and determine when and where materials are transported within the production process (Raza and Govindaluri, 2021). In a push system, inventory levels are determined based on forecasted demand, making it heavily reliant on upstream information accuracy (Reyes et al., 2024). This approach enables managers to plan and control production activities more easily and can yield economies of scale in procurement and manufacturing. However, it also carries the risk of overproduction, leading to excess inventory and waste. In contrast, the pull system is aligned with a make-to-order approach, authorizing production only when actual demand arises. It is often seen as a strategic response to increasing uncertainty in demand patterns. Characterized by small lot sizes, low inventory levels, visual control methods, and enhanced communication, the pull system emphasizes efficiency and waste reduction (Choi et al., 2023; Hipolito et al., 2020). While it reduces unnecessary stock, its performance is highly sensitive to setup times, which can negatively affect overall efficiency and even lead to customer dissatisfaction if not managed properly (Oleskow-Szlapka and Sobic, 2008; Christopher, 2016).

The adoption of integrated supply chain information systems enabling the dissemination of real-time inventory data via retailer websites has led many

manufacturers and retailers to implement a vendor-managed pull system known as Vendor Managed Inventory (VMI) (Yang et al., 2018; Raza and Govindaluri, 2022). In a VMI-based pull system, the manufacturer assumes responsibility for production, inventory monitoring, and replenishment at the retailer's premises (Dong and Xu, 2002; Rashid et al., 2024). In contrast, Material Requirements Planning (MRP) is one of the most widely used push-based systems, while classical Kanban and Just-in-Time (JIT) are prominent examples of pull systems (Hopp and Spearman, 2004; Reyes et al., 2024). Recent technological advancements have enabled firms to incorporate machine learning–driven forecasting models and real-time automated decision-making systems into these supply chain processes (Ördek et al., 2024). Lim et al. (2017) proposed a set of strategies for the design of order fulfillment networks, highlighting the role of real-time inventory pooling in improving operational efficiency for online retailers. Similarly, Sarbjit (2017) classified key factors that companies should consider when choosing between push and/or pull strategies. These include demand variability, product pricing, competitive intensity, product life cycle stage, product variety, e-commerce infrastructure, perishability, degree of innovation, and the use of advanced information systems.

Some companies are using a mix of these two systems. A hybrid system is one where semi-finished products are made based on forecasts and then sent to the stock point. These products are then sent through supply chains by actual customer orders (Fowler et al., 2019). In other words, supply chains that use a push-pull strategy need to make semi-finished products using the push production mode and then store them at a stock location (i.e. a demand fulfilment point) within the supply chain (Zhang et al., 2018; Sarbjit, 2017). In designing an effective push-pull supply chain, two critical factors must be carefully considered. The preliminary stage of the study addresses the selection of appropriate locations for these points and the evaluation of required support systems. This support is based on the business's products, processes and organizational structure (Fowler et al., 2019). The second focus of the research examines methods for improving the management of customer delivery times in push-pull supply chain contexts.

2.2 Comparison of Push and Pull Systems
A wide range of studies have examined the relative merits of push, pull, and hybrid systems in the context of supply chain management. Zagursky and Slipukha (2019) identified the main characteristics of pull systems as flexibility, high service quality, and low inventory requirements. They emphasized that such systems shorten production cycles and increase inventory turnover. In addition, they stressed that the reliability of the pull approach largely depends on the timely delivery of high-quality materials. However, they also noted that demand monitoring remains unclear, and that demand fluctuations may lead to significant risks, including additional financial costs, storage constraints, and labor inefficiencies.

Cachon (2004) observed that pull systems generally result in larger order quantities compared to push systems, which translates into higher overall supply chain efficiency. Similarly, Sutee and Yarlagadda (2012), through simulation using ARENA, found that pull systems outperformed push systems in terms of production efficiency and finished goods inventory in a motorcycle manufacturing setting. Other scholarly works have focused on the cost implications and operational trade-offs between the systems. Vrat and Yenradee (1991) reported that push systems tend to raise total system costs and advocated a shift toward an optimal hybrid strategy. In a JIT-based simulated workshop environment, Li (2003) demonstrated that the push model had a slight advantage over the pull system, although the performance gap was marginal. Zheng and Lu (2009), employing simulation techniques, compared the two approaches with respect to inventory levels and order lead times, concluding that the optimal system selection should be aligned with a company's position in the supply chain and its operational goals. Oleskow-Szlapka and Sobic (2008) investigated the process of transitioning from push to pull systems and reported positive improvements in performance indicators. Using Taguchi and Response Surface Methodology, Chiadamrong and Kohly (2005) concluded that while push systems were more cost-effective in terms of machinery utilization, raw materials, and inventory, pull systems had advantages in minimizing machine downtime and penalty costs. Lastly, Puchkova et al. (2016) explored the two models under various operational scenarios—normal functioning, resource failures, and quality-related disruptions. Their simulations indicated that the pull system was optimal in the first two scenarios, whereas the push system performed better in the event of a quality loss.

The push-pull hybrid strategy has gained widespread adoption, particularly due to the rising prevalence of make-to-order production within supply chain production and distribution frameworks (Kim et al., 2012). This hybrid approach seeks to integrate the advantageous characteristics of both push and pull systems into a unified model (Oleskow-Szlapka and Sobic, 2008). Cochran and Kaylani (2008) applied push-pull control to production systems by optimizing a horizontally integrated, hybrid production line in a mass production setting, demonstrating superior performance relative to alternative systems. Similarly, Salum and Araz (2009) compared a dual-source constrained push-pull control system with a dual-source Kanban system, ultimately advocating for the push-pull control approach. Masuchun et al. (2004) investigated the impact of push and pull control strategies on performance in a stock-to-manufacture context, recommending a combined application of both strategies. Mahapatra et al. (2012) conducted a simulation-based comparison of pull and hybrid strategies within a three-tier supply chain, examining their effectiveness under varying conditions of demand uncertainty and delivery time variability. Their results indicated that the relative advantages of these strategies depend on the specific nature and degree of uncertainty, the inventory control policies implemented, and associated performance measures. Notably, the

hybrid strategy was linked to reduced inventory levels, whereas the pull approach enhanced order fulfillment rates.

Investigating the bullwhip effect under hybrid policy implementations, Lin et al. (2022) highlighted product return rates and demand frequency as critical factors influencing the choice between push and pull strategies. Their findings underscored the necessity of jointly considering order structure and product demand characteristics to mitigate the bullwhip phenomenon. Table 1 consolidates the core findings of the reviewed literature, offering a comparative view of push and pull system effectiveness across various industries

Table 1: Studies on Comparison of Push and Pull Systems

Resources	Research Areas/Industry	Better suited system
Sutee and Yarlagadda (2012)	Motorcycle manufacturing industry	Pull System
Vrat and Yenradee (1991)	Hard disk parts manufacturing industry	Pull System
Li (2003)	JIT	Push System
Zheng and Lu (2009)	Inventory levels and order completion time	Pull System
Chiadamrong and Kohly (2005)	Production line	Changeable according to metric
Puchkova et al. (2016)	Inventory management strategy	Pull System
Oleskow-Szlapka and Sobic (2008)	Manufacturing industry	Pull System
Cochran and Kaylani (2008)	Production line	Hybrid
Salum and Araz (2009)	Manufacturing industry	Hybrid
Masuchun et al (2004)	Manufacturing industry	Hybrid
Mahapatra et al. (2012)	Inventory management	Hybrid
Masuchun et al (2004)	Operational planning	Changeable according to metric
Lin et al. (2022)	Bullwhip effect	Changeable according to metric

Source: Illustrated by Authors

A review of the extant literature reveals a notable gap: there are no studies focusing on the machine-made carpet industry, despite its significant role in Türkiye's economy and its substantial contribution to international trade. In the context of supply chain and general business management, it is essential to evaluate and compare push and pull systems with respect to profitability, transportation costs,

inventory levels, and financial performance indicators. This study aims to address this gap by offering a comprehensive comparison of push and pull systems across these key performance dimensions, specifically within the context of the machine-made carpet industry.

3. Methodology
3.1 The ENTROPY Method

There are numerous subjective and objective methods for weighting criteria in decision-making problems. The ENTROPY method, developed based on the concept of information entropy introduced by Shannon in 1948, is an objective weighting method. In this context, the ENTROPY method does not require subjective evaluations from decision-makers and data related to decision alternatives is used in weighting (Ayçin, 2019). In recent years, this method has been employed in numerous studies (e.g., Wu et al., 2022; Mukhametzyanov, 2021; Nguyen et al., 2022; Wei et al., 2024; Singh, 2024; Bahçeci and Belgin, 2021; Eliyan et al., 2024).

As is the case with other MCDM methods, the initial step in this method is to create the decision matrix (X), as illustrated in Equation (1). In this expression, i and j represents the alternatives and criteria respectively.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \qquad i = 1,2,\dots m \quad j = 1,2,\dots n \tag{1}$$

In the second step of the method, the values in the matrix are normalised using Equation (2). The normalised values are denoted by (r_{ij}).

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{j} x_{ij}} \quad ; \forall j \tag{2}$$

In the third step of the method, the entropy values (e_j) of the criteria are calculated using Equation (3).

$$e_j = -1/\ln(n) \sum_{j=1}^{n} r_{ij} * \ln(r_{ij}) \quad ; \forall j \tag{3}$$

In the subsequent stage, elevated values of 'Degree of Diversification (d_j)' calculated using Equation (4) indicate that the distance between the alternative scores of the relevant criteria is also elevated.

$$d_j = 1 - e_j \qquad ; \forall j \tag{4}$$

The final step of the method is to calculate the weight values of the criteria (w_j). Equation (5) is utilised in this calculation (Alnıpak and Toraman, 2023).

$$w_j = \frac{d_j}{\sum_{i=1}^{n} d_j} \qquad ; \forall j \tag{5}$$

3.2 The COPRAS Method

The COPRAS (Complex Proportional Assessment) method was developed by Zavadskas, Kaklauskas and Sarka for the purpose of proportionally evaluating options in the context of criteria being profit or cost (Więckowski et al., 2024). The ultimate ranking is derived from the positive and negative ideal solutions (Wankhede et al., 2023). The fundamental principle underlying this approach is the recognition of the significance and precedence of decision units, exhibiting a direct and proportional dependency (Yeşil et al., 2025). The COPRAS method was selected for utilization in this study due to its systematic and structured approach, which provides practitioners with a framework for analysis. Additionally, it possesses the capacity to ascertain the percentage of similarity to the ideal by means of a comparative analysis of the alternatives (Podvezko, 2011; Alam et al., 2025). In recent years, this method has been employed in numerous studies (*eg.* Medetoğlu et al., 2023; Ch et al., 2024; Yeşil et al., 2025; Mohanrasu et al., 2024; Hezer et al., 2021; Radulescu and Radulescu, 2024; Goswami et al., 2021; Raudeliuniene et al., 2025). The following section provides a detailed exposition of the application process.

1. Production of decision matrix: Equation (6) illustrates the formulation of the decision matrix. Alternatives are represented by i. $(i = 1, 2, ..., m)$; criteria are represented by j. $(j = 1, 2, ..., n)$.

$$x_{ij} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \tag{6}$$

2. Normalization of decision matrix: Equation (7) is used for this process.

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{7}$$

3. Calculation of difficult normalized (weighted normalized) decision matrix: In Equation (8) w_j represents weight coefficients of criteria.

$$v_{ij} = r_{ij} * w_j \tag{8}$$

4. Determination of the sums of difficult normalized values: Equation (9) has been employed for profit criteria and Equation (10) for cost criteria. k is a quantitative metric that signifies the number of attributes that must be maximized to achieve the desired outcome where S_{+i} and S_{-i} values represent the level of goal achievement for the available alternatives. In the given context, it is demonstrated that achieving a goal is more likely to be successful when the larger S_{+i} is and the smaller S_{-i} is.

$$S_{+i} = \sum_{j=1}^{k} v_{ij} \tag{9}$$

$$S_{-i} = \sum_{j=k+1}^{n} v_{ij} \tag{10}$$

5. Calculation of alternatives' relative importances (Q_i): Equation (11) is used for this process. In this context, the larger Q_i is, the greater its relative importance.

$$Q_i = S_{+i} + \frac{S_{-min} * \sum_{i=1}^{m} S_{-i}}{S_{-i} * \sum_{i=1}^{m} (\frac{S_{-min}}{S_{-i}})} \tag{11}$$

6. Determination of utility degrees (U_i): This step constitutes the final ranking stage using Equation 12. Within the specified parameters of this context, it is the alternative with a score of 100 which is to be considered as the optimal option (Więckowski et al., 2024; Yeşil et al., 2025).

$$U_i = \frac{Q_i}{Q_{max}} * 100\% \tag{12}$$

3.3 Sensitivity Analysis based on Variation of Criteria Weight

The sensitivity analysis based on the variation of criterion weights (Rashid et al., 2021) is employed for the purpose of ascertaining the model's stability and robustness. To address this issue, adjustments have been made to the weight value of the most significant criteria (Demir and Aslan, 2021). The proportionality of the weights assigned to the other criteria is maintained by Equation (13). In the context of sensitivity analysis, w_c is defined as the change in weight, w_s is the weight of the the most significant criterion, w_c^0 is the original value of the changing weights and W_c^0 is the sum of the original weights that are being modified. $\propto_c$ is defined as weight coefficient of elasticity and calculated by Equation (14) (Yazdani et al., 2019).

$$w_c = (1 - w_s) * \left[\frac{w_c^0}{w_c^0}\right] = w_c^0 - \Delta x \propto_c \tag{13}$$

$$\propto_c = \frac{w_c^0}{W_c^0} \tag{14}$$

It is important to note that the value of $\propto_c$ for the most significant criterion is equal to '1' and Δx represents the amount of change. This change is implemented to the set of weights. It is implemented according to their respective elasticity coefficients (Yazdani et al., 2019). At this stage, the most important criterion is to limit the change in weight. The objective of this is to ascertain that the weight values are not negative. The limits for Δx are calculated according to Equation (15).

$$-w_s^0 \leq \Delta x \leq min\{w_c^0/\propto_c\} \tag{15}$$

Subsequent to the definition of limits for Δx, a new set of weight values is calculated using Equations (16) and (17). The criterion undergoing sensitivity analysis has a designated original weight, denoted by w_s^0 (Yazdani et al., 2019).

$$w_s = w_s^0 + \propto_s \Delta x \tag{16}$$

$$w_c = w_c^0 + \propto_c \Delta x \tag{17}$$

4. The Comparison of 2 Models in the Machinery Carpet Industry

In this section, two distinct production and distribution models are implemented in a real company operating within the relevant sector. The differences between these models are elucidated and numerical comparisons are conducted on various scales. Prior to the presentation of the relevant models, statistical basic data for machine carpeting in Türkiye is presented.

4.1 Machinery Carpet Industry in Türkiye

The global carpet trade is divided into three main categories: handmade, machine-made, and tufted carpets. These differ in production techniques, investment trends, costs, consumer profiles, usage purposes, market structures, and capital intensity. Handmade carpets are labor-intensive, and feature motifs derived from historical and cultural heritage, while machine-made carpets are capital-intensive technical textiles. According to 2024 data, Türkiye ranks as the second-largest global exporter with $2.86 billion in exports (TIM, 2025), leading the machine-woven carpet segment with $2.2 billion in exports, which is the focus of this study. Türkiye accounts for 46% of global demand in machine-woven carpets. The Turkish carpet industry is highly competitive, supported by a robust domestic market with over 5,000 retail outlets and dealerships, and more than 300 manufacturing facilities. The Southeastern Exporters Association of Türkiye (GAIB) reports 1,083 carpet exporters, including 300 manufacturers. Production employs fully computer-aided Van de Wiele looms capable of manufacturing carpets 4-6 meters wide and indefinitely long, with machines costing around 1 million Euros each (GAIB, 2022). The carpet sector plays a significant role in the Turkish economy. The firms analyzed under Model 1: push and Model 2: pull belong to the same corporate group and operate different brands produced in the same facility. With an estimated annual turnover of approximately $150 million, the company is among the top ten in Türkiye's machine-made carpet industry, despite the lack of publicly available revenue data for all competitors.

4.2 The Definitions of Model 1: Push and Model 2: Pull

This section delineates two disparate production and distribution strategies that have been implemented in one of the leading companies in the relevant sector operating in Türkiye. The first model is the traditional model. The second model was implemented later. In both models, products are manufactured in the same production facility.

Model 1: Push. In this model, carpet orders are placed by the Regional Dealer based on estimates, without prior knowledge of which patterns will be preferred by end-users. Orders are dispatched to the factory via electronic mail at the commencement of each month. The manufacturing entity formulates production plans through the integration of orders from regional dealers, culminating in the execution of production within a span of two months. Thereafter, the finished products are disseminated to the regional dealers' warehouses in bulk. During this process, regional dealers submit payment checks collected from their sub-dealers

to the center as an advance, along with a seasonal purchase offer. If the payment check does not satisfy the requirements of the regional dealer, a new additional check is requested. The products are made available to sub-dealers in the warehouses of regional dealers and sub-dealers' orders are accepted.

Model 2: Pull. In this model, the manufacturer is responsible for the creation of the product collection, which is then presented directly to sub-dealers. Regional dealers are excluded and not involved in this process. In this context, the producer assumes full responsibility for channel management. In lieu of the distribution of a high number of products to sub-dealers in anticipation of demand, a limited quantity of each model and pattern is allocated to end customers. As the end customers order the models and designs together with their sizes, the relevant amounts are collected from the centralized POSs by credit card. The dealer invoices the progress payment (profit) amount to the center at the end of the relevant month and receives it in cash. In the event of a customer purchase, the sub-dealer's inventory is rapidly replenished through the utilization of the replacement method, thereby enabling the dealer to prioritize activities such as arrangement, display and sale without the encumbrance of stock. The products are delivered to the consumer with a fixed price guarantee. In this model, as in the pull system, the production and supply processes are initiated with customer orders. By evaluating the characteristics chosen as the discriminatory criteria of the distribution and sales process a comparison of both models according to various features is shown in Table 2 and Figure 1. In this model, products are produced only for a reasonable demand.

Table 2: Main Differences between Model 1 and Model 2

Characteristics	Model 1: Push	Model 2: Pull
Type of Product Order	Bulk (large quantity)	Retail (single item)
Payment Method	Post-dated bank check	Credit card
Shipment Type	Bulk (large quantity)	Single item (one by one)
Shipment to…	Regional dealer (wholesaler)	Sub Dealer
Delivery to the consumer from…	Sub Dealer	Sub Dealer
Consumer profile and CRM Data	Not Available	Available
Point of sale	Sub Dealer	Sub Dealer
Demand triggered by…	Regional dealer (wholesaler)	Consumer
Production plan formed by…	Estimation (Based on regional dealer orders)	Actual sales figures
Production cycle period	Quarterly	Monthly
Merchandising strategy	Comprehensive Stock (all models and sizes)	Display-Only Set (one of each)
Most similar to …	PUSH System	PULL System

Source: Authors

Based on Table 1, Model 1: push initiates production based on predicted consumer demand and moves towards the end user, whereas Model 2: pull starts from actual consumer demand and directs production accordingly. In the push system, production is forecast-driven, while in the pull system, it aligns precisely with known demand. Figure 1 illustrates the information flow for both models.

Figure 1: The Information Flows of Models
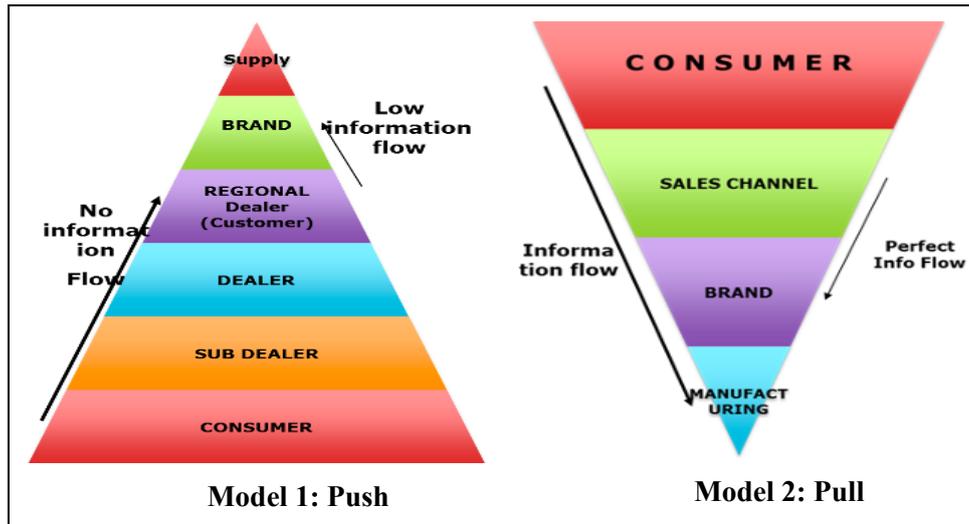
Source: Bebitoğlu, 2022: 189-192

Because of the utilization of multiple layers, Model 1: push exhibits inadequate information flow. Conversely, Model 2: pull displays markedly strong information flow due to the aggregation of data pertaining to end-users.

4.3 The Comparison and Figures of Model 1: Push and Model 2: Pull

In Model 1: push, where there is no direct contact with the customer and production is conducted according to the demand forecasts of regional dealers, full customer recognition is not possible. In this context, there are difficulties in creating value-added products with a customer focus and understanding the tastes of consumers. Moreover, due to the fact that the processes are not initiated in response to customer demand, idle stocks are formed in the region, as well as at sub-dealers and the manufacturer. It is evident that all shipments are made to the warehouses of regional dealers. Consequently, transportation costs remain low in comparison to Model 2: pull, due to the economies of scale. As illustrated in Table 4, while sales revenues are higher in this model, profitability remains at a lower level. "Model 1: push is considered a low-elasticity model, primarily due to high demand uncertainty.

In Model 2: pull, which is implemented without the intervention of regional dealers, there is an opportunity for more intense contact to be established with the end customer, thereby increasing customer satisfaction. In the absence of an intermediary between the regional dealers and the dealer, the margin of the regional dealers (22%) is retained by the manufacturer. The distribution of average revenues

per m2 generated in this process is illustrated in Table 3, while the financial structure and product flow are demonstrated in Figure 2. Although production per unit area remains constant across both models, the Model 2: pull yields higher profitability than the first. In the context of the model under consideration, it is evident that operational expenses are elevated. Conversely, this model is distinguished by enhanced flexibility and a reduction in stock levels. The manufacturer is thus enabled to formulate production plans with greater precision. The transportation, profit and income amount of both models based on years are shown in Table 4.

Table 3: Average Income Distribution by m2 for Models 1: push and Model 2: pull over the same 5-years period

Value Chain Appropriation	Model 1: Push	Model 2: Pull
Manufacturer	$20,00	$28,56
Regional Dealer Margin	$4,40	$0,00
Regional Dealer Extra Premium	$3,66	$0,00
Dealer	$16,84	$16,34
End-user price	$44,90	$44,90

As demonstrated in Table 3, Model 2: pull offers distinct financial advantages, namely the elimination of the intermediate regional dealer profit margin. In contrast, Model 1: push provides benefits such as a more robust sales channel structure and the capacity for advance ordering, attributable to the presence of the regional dealer layer. As illustrated in Figure 2, the operational and financial workflow of Model 2: pull is delineated.

Figure 2: Financial Structure and Shipment Process Flow of Model 2: Pull
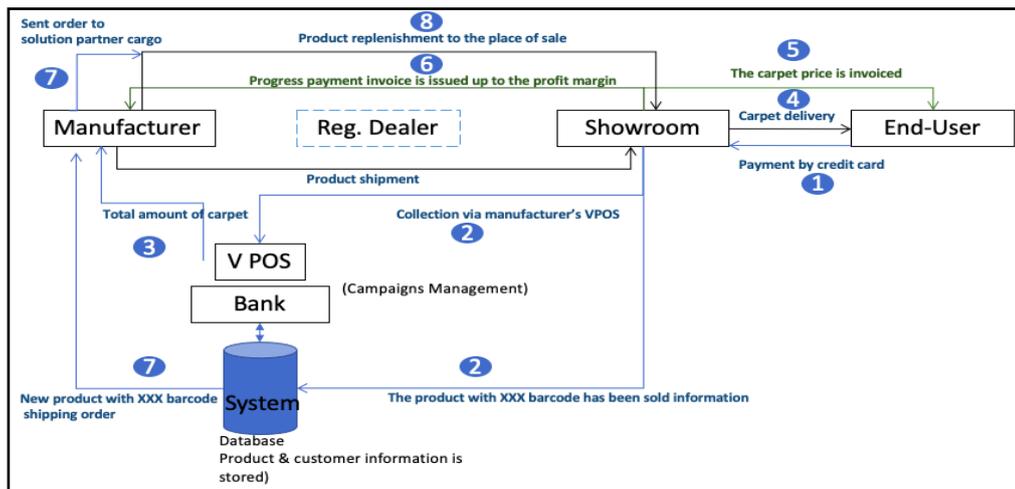
Source: Bebitoğlu, 2022: 196

The sequence of events pertaining to the sales and distribution procedure commences with the end-user, designated function number 1 and culminates with function number 8, which pertains to the shipment of the replenishment product that has previously been sold. As demonstrated in Table 4, although Model 1: push exhibits significantly higher sales revenues due to its strategy of selling to regional dealers in bulk, it demonstrates lower profitability in comparison to Model 2: pull, as previously outlined.

Table 4: Figures of Model 1: Push and Model 2: Pull

Years	Shipment (m2)		Sales ($)		Net Profit ($)		Net Profit (%)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2	Model1	Model2
1st	1.825.987	65.234	53.148.831	3.017.066	3.752.222	-2.224.295	7%	-
2nd	1.708.898	225.600	59.819.996	10.075.230	4.820.301	154.792	8%	2%
3rd	1.589.029	269.131	48.521.889	11.353.780	2.364.516	693.380	5%	6%
4th	1.658.754	332.446	49.693.399	12.327.918	2.260.467	1.534.807	5%	12%
5th	1.722.436	396.264	37.080.056	11.322.478	1.787.380	1.609.573	5%	14%

Model 2: pull can be advantageous even though it involves higher operating costs. In Model 2: pull, marketing costs are $2.30 per m2 higher because the consumer is contacted directly. There has been a significant jump in sales since the year Model 2: pull was implemented, with the same product being sold quickly. Although Model 1: push has higher sales figures on an annual basis as it has been in operation since 2005, the sales growth rate of Model 2: pull is higher and therefore the acceleration is greater. In addition to these criteria, the average financial ratios and share values calculated according to the two models are also criteria that should be emphasized. These are shown in Table 5.

Table 5: Average Financial Ratios and Inventory Values of Models

Metrics	Model 1: Push	Model 2: Pull
Operational Profit/Total Sales	3,5%	6,3%
Sales Incentives Costs/Total Sales	15,7%	14,3%
Operational Expenses /Total Sales	30,1%	39,4%
Gross Profit/Total Sales	33,6%	45,8%
Marketing Expenditures / Total Sales	22,8%	22,2%
Operational Expenditures / m2	$12,9	$16,6
Marketing Expenditures/ m2	$5,99	$8,29
Shipment costs/ m2	$0,94	$1,24
Annual Sales (m2)	1.410.000	257.076
Inventory-Stock (m2)	1.124.000	155.039
Inventory-Stock/ Annual Sales	0,80	0,60

The advantages of Model 2: pull, which has similarities with the pull system and is seen to be more advantageous in many respects than the other model, for the interested parties are shown in Figure 3.

Figure 3: Advantages of Each Parties in Model 2

Source: Bebitoğlu, 2022: 198

5. Data Analysis and Findings

In this section, the financial performance of the the push (A1) and pull (A2) systems, which were compared in the previous section according to different parameters, was analysed using the hybrid ENTROPY-COPRAS method. The financial ratios were weighted using the ENTROPY method, while the system performances were evaluated using the COPRAS method. For the purpose of this study, the ratios (Operational Profit/Total Sales (C1), Sales Incentives costs/Total Sales (C2), Operational Expenses/Total Sales (C3), Gross Profit/Total Sales (C4), Marketing Expenditures/Total Sales (C5), Inventory-Stock/ Annual Sales (C6)) employed in various studies (Gül and Kaygın, 2024; Medetoğlu et al., 2023; Dayı and Adaiem, 2024) for financial performance evaluation, as indicated in Table 5, have been utilised.

5.1 Weightening of Criteria by ENTROPY Method

The decision matrix, which comprises the evaluated alternatives and evaluation criteria, is presented in Table 6. It is evident from the calculations performed in Excel that criteria C1 and C4 are profit criteria, while C2, C3, C5 and C6 are cost criteria.

Table 6: Decision Matrix

Nature of Criteria	Profit	Cost	Cost	Profit	Cost	Cost
	C1	C2	C3	C4	C5	C6
A1	0,350	0,157	0,301	0,336	0,228	0,800
A2	0,630	0,143	0,394	0,458	0,222	0,600

In the initial phase of the analysis, the criteria were weighted employing the ENTROPY method, with the decision matrix shown in Table 6. For this purpose, the decision matrix was normalized using Equation (2). The values obtained from this analysis are presented in Table 7.

Table 7: Normalized Values

Crit. \ Alt.	C1	C2	C3	C4	C5	C6
A1	0,357	0,523	0,433	0,423	0,507	0,571
A2	0,643	0,477	0,567	0,577	0,493	0,429

In the third stage of the ENTROPY method, Equation (3) was applied to the normalized values in order to calculate the entropy values (e_j) of all criteria. The values obtained from this analysis are presented in Table 8.

Table 8: Entropy Values of Criteria

	C1	C2	C3	C4	C5	C6
e_j	0,940	0,998	0,987	0,983	1,000	0,985

In the subsequent phase of the analysis, the "Degree of Diversification (d_j)" values were determined using Equation (4). The values obtained are shown in Table 9.

Table 9: Criteria's Degrees of Diversification

	C1	C2	C3	C4	C5	C6
d_j	0,05971	0,00157	0,01296	0,01710	0,00013	0,01477

In the final stage of the analysis, weight values for each criterion shown in Table 10 were calculated using Equation (5).

Table 10: Weight Values of Criteria

	C1	C2	C3	C4	C5	C6
w_j	0,562	0,015	0,122	0,161	0,001	0,139

It was determined that the two most significant criteria were operational profit/total sales (C1) and gross profit/total sales (C4), in that order, as evidenced by the weight values obtained. The ranking of the relevant weights is as follows: C1 > C4 > C6 > C3 > C2 > C5.

5.2 Evaluation of Systems by COPRAS Method

In this section, the financial performance of the systems is evaluated using the COPRAS method. The weight values calculated in the previous section are also used. The values utilized in the COPRAS method are shown in Table 11.

Table 11: Decision Matrix

Nature of Criteria	Profit	Cost	Cost	Profit	Cost	Cost
w_j	0,562	0,015	0,122	0,161	0,001	0,139
	C1	C2	C3	C4	C5	C6
A1	0,350	0,157	0,301	0,336	0,228	0,800
A2	0,630	0,143	0,394	0,458	0,222	0,600

Based on Table 11, the difficult normalized values were calculated using Equations (7 and 8) and shown in Table 12.

Table 12: Weighted Normalized Values

	C1	**C2**	**C3**	**C4**	**C5**	**C6**
A1	0,2007	0,0077	0,0528	0,0681	0,0006	0,0795
A2	0,3613	0,0071	0,0691	0,0928	0,0006	0,0596

The relative importance and utility degree values of the alternatives are shown in Table 13. These values were calculated by applying Equations (9, 10, 11 and 12).

Table 13: Relative Importance Values and Utility Degrees of Alternatives

	S_{+i}	S_{-i}	$\dfrac{S_{-min}}{S_{-i}}$	Q_i	U_i	Ranking
A1	0,2688	0,1406	0,9698	0,4052	68,1275	2
A2	0,4542	0,1364	1,0000	0,5948	100,0000	1
	$\sum S_{-i} =$	0,2770	$S_{-min} =$	0,1364		

The findings of the study indicate that the pull system emerges as the superior alternative (0,5948>0,4052) with respect to the financial ratios employed. Utilizing these values, the Utility Degrees demonstrate that the push system exhibits a maximum similarity of 68,1275% to the pull system. The outcomes in terms of performance can also be said to be consistent with the comparisons made in Section

4.3. The findings of the present study are consistent with those of earlier research, including studies by Oleskow-Szlapka and Sobic (2008) and Vrat and Yenradee (1991).

5.3 Sensitivity Analysis

In this section, sensitivity analysis based on the variation of criterion weights was performed to check the stability and robustness of the model. For the purpose of this, the $\propto_c$ of C1, calculated as the most significant criterion according to the ENTROPY method, is assigned as 1 and the values for other criteria were calculated using Equation (14). The relevant values are shown in Table 14. Subsequently, the maximum and minimum limits for weight change (Δx) based on C1 was calculated (($-0,5621 \leq \Delta x \leq 0,438$). The application of Equations (16) and (17) to various values within this range resulted in the determination of new sets of weight values for each criterion. The sum of the weight values obtained in each scenario should be 1. The values obtained from this analysis are presented in Table 15. It is important to note that when the value of Δx is zero, the weight value of each criterion remains at its original value.

Table 14: Weight coefficient of elasticity for changing weights

Criteria	Values of $\propto_c$
C1	1,0000
C2	0,0338
C3	0,2785
C4	0,3675
C5	0,0028
C6	0,3175

A re-evaluation of the alternatives (push and pull systems) was conducted using the COPRAS method, based on 12 different data sets shown in Table 15. The evaluations revealed that the A2 (Pull System) outperformed the A1 (Push System) in all scenarios. In this context, no changes were observed in the ranking of the alternatives.

Table 15: Data Set of New Criteria Weights

Scenario	Δx	C1	C2	C3	C4	C5	C6	Ranking of A1	Ranking of A2
S1	-0,5621	-	0,0338	0,2785	0,3675	0,0028	0,3175	2	1
S2	-0,5	0,0621	0,0317	0,2612	0,3447	0,0026	0,2978	2	1
S3	-0,4	0,1621	0,0283	0,2333	0,3079	0,0023	0,2660	2	1
S4	-0,3	0,2621	0,0249	0,2055	0,2712	0,0020	0,2343	2	1
S5	-0,2	0,3621	0,0215	0,1776	0,2344	0,0018	0,2025	2	1
S6	-0,1	0,4621	0,0182	0,1498	0,1977	0,0015	0,1708	2	1
S7	0	0,5621	0,0148	0,1219	0,1609	0,0012	0,1390	2	1
S8	0,1	0,6621	0,0114	0,0941	0,1242	0,0009	0,1073	2	1
S9	0,2	0,7621	0,0080	0,0663	0,0874	0,0007	0,0755	2	1
S10	0,3	0,8621	0,0047	0,0384	0,0507	0,0004	0,0438	2	1
S11	0,4	0,9621	0,0013	0,0106	0,0139	0,0001	0,0120	2	1
S12	0,438	1,0000	-	-	-	-	-	2	1

6. Conclusions

In today's business landscape, commercial success no longer depends on one-time or bulk sales, but rather on building long-term customer relationships. Instead, it is about forging long-term relationships by acquiring valuable insights about consumers, encompassing their demographics, psychographics, purchasing habits, preferences and economic status, as well as their potential for future engagement. Digitalization has necessitated alternative logistics strategies to meet consumers' customized and immediate demands. In the contemporary business environment, pull systems are gaining prominence. These systems are characterized by the direct activation of demand from consumers, as opposed to the traditional approach of demand being triggered by the various elements of the value chain, extending from production to shipment. A comprehensive understanding of consumer preferences, coupled with the ability to predict demand and maintain stringent quality standards, offers significant advantages in the streamlining of traditional production management processes, enhancing their efficiency. The utilization of push or pull systems within the domains of production and distribution represents a pivotal area of interest for individuals engaged in the realm of supply chain management. It is acknowledged that a variety of methodologies are employed across diverse sectors within this domain. The present study aims to describe and compare two distinct production and distribution models (push and pull based) applied in a company operating within the machine-made carpet sector in terms of transportation costs,

profitability, stock levels and financial ratios. Moreover, the financial performances of the relevant systems were evaluated using the hybrid ENTROPY-COPRAS method. In this context, present study is unique in that it is the first study to compare these two systems in various aspects with different parameters in the relevant sector.

The findings suggest that the pull system-based model is more suitable for the sector, as it has been demonstrated to be faster, more transparent, more predictable, more sustainable and, most importantly, allows for a more responsive and efficient use of resources. Moreover, the conventional push-based model has been shown to exhibit certain disadvantages regarding customer service management, elevated inventory levels, future uncertainties and diminished profitability for the manufacturer, despite its high turnover and convenience. The present findings are in accordance with the studies conducted by Choi et al. (2023) and Hipolito et al. (2020). In the machine-made carpet sector, the utilizations of intermediate layers with restricted access to consumers in the forecasting of consumer demand engenders a substantial accumulation of surplus inventory. A salient issue, particularly in the context of physically voluminous and transferable commodities such as carpets, pertains to the inability to efficiently liquidate such excess inventory. This has been demonstrated to result in the inefficient use of resources. In the pull-based system, orders are placed directly by the end user rather than via regional distributors. These results in raw materials being procured in quantities appropriate to the orders, thus enhancing efficiency and profitability. Despite the marked disparity in sales volumes between the two models, the second model, which exhibits lower sales, demonstrates higher profitability. Following the implementation of the ENTROPY method for the purpose of performing criterion weight analysis, it was determined that the most significant criterion among the six in question was Operating Profit/Total Sales (C1). The findings of the financial performance evaluation conducted using the COPRAS method and based on financial ratios indicate that the pull system is a superior option, with the push system lagging by approximately 32% in terms of utility degree. Furthermore, in sensitivity analyses based on 12 different data sets, the pull system consistently ranked first.

If the genesis of hand-woven carpet production is regarded as a significant milestone, the heritage of the carpet industry can be traced back millennia. Consequently, it can be regarded as a sector that adheres to conventional methodologies. However, with the advent of innovative technology and production methodologies, machinery carpet industry has remained vibrant and continues to exert a strong commercial and social appeal. It may be posited that this dynamic sector requires alternative approaches to continue as a vibrant and growing entity. However, the implementation of push-pull systems has not been previously encountered in the industry. The use of push and pull systems by two brands affiliated with the same corporate group and produced in the same factory during the same period has provided a significant opportunity for comparison. The results obtained from this comparison are considered valuable. As machine-made carpet

sector constitutes an important export item for Türkiye, it is hoped that this study, which is the first of its kind on the subject and compares two fundamental systems considering many parameters, will contribute to professionals working in the sector and developing strategies, as well as to researchers and the existing literature. The geographical constraints and the fact that the measurements reflect a specific period are undoubtedly the most significant limitations of the study. Despite the use of computer-aided, high-tech looms and auxiliary equipment, the machine-made carpet industry can still be considered relatively conservative in mindset, largely due to its roots in the traditional handwoven carpet sector. The push model necessitates a fundamentally different approach to production, sales, and marketing. While it showed relative advantages in this comparison, its widespread adoption across the industry may be unrealistic without a broader shift in business mindset. As it demands a shift in business mentality, it is more likely to be implemented by firms under financial pressure that are seeking to improve profitability rather than as a general industry practice. In this context, extending the study and subsequently drawing comparisons between companies situated in a variety of different countries would be of considerable benefit.

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