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Research Article

Analysing the Purchasing Decision-Making for a Recycled Material Used Garment by Dematel Method

Burak Sarı[1], Derya Tama Birkocak[2], Meral İşler[3*]

[1]Bitlis Eren University, Faculty of Fine Arts, Department of Traditional Turkish Arts, Bitlis, Turkey, (ORCID: 0000-0003-3079-6153), bsari@beu.edu.tr
[2]Ege University, Faculty of Engineering, Department of Textile Engineering, İzmir, Turkey, (ORCID: 0000-0002-2720-2484), derya.tama@ege.edu.tr
[3*]Selçuk University, Faculty of Architecture and Design, Department of Fashion Design, Konya, Turkey, (ORCID: 0000-0002-9654-4664), meralisler@selcuk.edu.tr

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Abstract

Factors such as the change in technology, the unconscious use of resources, and the adoption of trends that trigger consumption have made the apparel industry one of the most resources consuming sectors. However, with the increasing awareness in the sector and consumers, concepts such as slow fashion, sustainable production, and recycled products have come to the forefront and the demand for these products has increased day by day. In this study, the factors affecting the purchase of textile products made from recycled materials were examined. For this purpose, 11 experts, working in the textile industry or academia with at least 1-4 years of experience were asked to comparatively evaluate the criteria that affect making the purchasing decision for a recycled materials used garment and the obtained data were analyzed with the DEMATEL method. In conclusion, it was determined that the highest impact in terms of prominence level was the *Environmental Impact (C5)*, and the lowest impact was the *Brand's Social Responsibility Projects (C3)*

Keywords: Sustainability, recycling, apparel production, multi-criteria decision making, DEMATEL.

Geri Dönüştürülmüş Materyallerden Üretilen Bir Giysinin Satın Alımını Etkileyen Faktörlerin Dematel Yöntemi İle Değerlendirilmesi

Öz

Teknolojide meydana gelen değişim, kaynakların bilinçsizce kullanımı ve tüketim anlayışını tetikleyen akımların benimsenmesi gibi faktörler, hazır giyim sektörünü, doğal kaynakların en çok tüketildiği sektörlerden biri haline getirmiştir. Bununla birlikte sektörde ve tüketicilerde bilinçlenmenin artması ile yavaş moda, sürdürülebilir üretim, geri dönüştürülmüş ürün gibi kavramlar ön plana çıkmış ve bu ürünlere olan talep her geçen gün artmıştır. Bu araştırmada geri dönüştürülmüş materyallerden üretilen ürünlerin satın alımını etkileyen faktörler incelenmiştir. Bunun için en az 1-4 yıl deneyime sahip, özel sektör ve akademide çalışantoplamda 11 adet uzman görüşüne başvurulmuştur. Uzmanlardan, geri dönüştürülmüş ürün satın alımına etki eden kriterlerin karşılaştırmalı olarak değerlendirilmesi istenmiş ve elde edilen veriler DEMATEL yöntemi ile analiz edilmiştir. Araştırma sonucunda incelenen kriterler arasında önem seviyesi açısından en yüksek kriterin Çevreye etki (C5) kriteri olduğu, en düşük kriterin ise Markanın sosyal sorumluluk projeleri (C3) kriteri olduğu tespit edilmiştir.

Anahtar Kelimeler: Sürdürülebilirlik, geri dönüşüm, hazır giyim üretimi, çok kriterli karar verme modeli, DEMATEL.

[*]Corresponding Author: bsari@beu.edu.tr

1. Introduction

It is predicted that resources will be depleted by 2050 as a result of the rapid increase in consumption in the world and this increase will continue exponentially every year [1].

The way to prevent this is to slow down the consumption and to ensure the effective, efficient and sustainable use of the resources. The concept of sustainable fashion, which has come to the forefront in last decades, is a hat term that includes the concepts of slow fashion, ethical fashion and ecological fashion. In the fashion industry, which has become the second largest pollutant industry in the world, it has become inevitable to make production in an ecological way. In this context, in addition to increasing the use of second-hand clothing, the issue of recycling wastes into clothing products has gained great importance. The amount of post-consumer waste generated every year in the world is 84 million tons [2]. This value corresponds to two-thirds of the textile products produced worldwide [3], however only 1% of this textile waste is recycled into a new clothing product [1].

Global fibre production has doubled, especially in the last 20 years, and is expected to increase by 30% in the next 10 years [4]. In the fashion industry, 47% of the initial fibre amount becomes waste though all processes (yarn production, fabric production, clothing production) until getting the clothing product [2]. In Figure 1, the distribution of the fibre types produced in the world in 2019 and the recycling rates of these fibres are presented. Polyester fibre accounts for more than half of the world fibre production and is recycled at a very small rate of 14%.

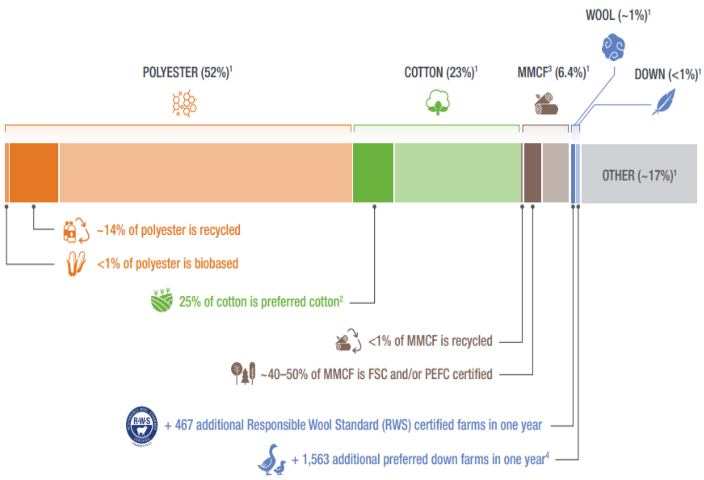

Figure 1. Global fibre production data for 2019 [4]

Textile wastes are the wastes from a large number of processes related to the fibre, textile and apparel manufacturing industries, consumers, and the commercial and service industries. Textile wastes are generally collected under two main groups as industrial wastes and post-consumer wastes (Figure 2) [3]. Pre-consumer textile wastes are generally industrial textile wastes and are materials in various forms moved away at different production stages. Post-consumer textile wastes are the wastes that are intended to be removed after being put into use by the customer, due to the end of their life cycle or not wanting to be used any more [5].

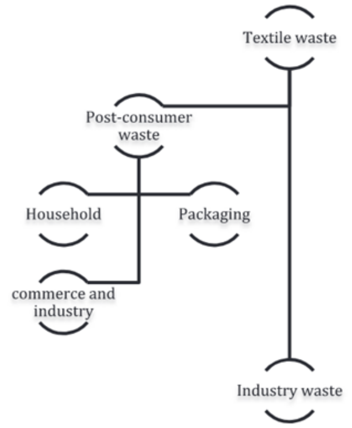

Figure 2.Textile waste categories [3]

There are two different recycling methods; “closed loop recycling” and “open-loop recycling”. Recycled materials obtained by open loop recycling are materials that do not have the quality to be used in the production of clothing in the textile industry and constitute the raw material of another industry (car upholstery, insulation material, etc.) [6]. Closed loop recycling is the collection of post-consumption wastes of textiles and afterwards the production of yarn from these wastes to be used in new clothes [7].

Dönmez and Türker (2017) examined the sound insulation properties, heat insulation properties and electromagnetic shielding properties of textile surfaces obtained by recycling textile wastes, through a literature review. It was seen that, recycled textile surfaces did not show requiring performance for the specific areas [8]. Ersoy and Zıraplı (2014), in their review article, focused on the importance given by the Turkish yarn industry to recycling and the benefits of recycling as well [9]. Telli and Babaarslan (2016) aimed to produce denim from recycled yarns without compromising on quality [10]. Yılmaz et al. (2017) investigated the quality of ring and open-end yarns produced from recycled cotton fibres [11]. On the other hand, Khan et al. (2015) carried out a study on the recycling of flat strips collected from carding machines in spinning mills before being pressed with a baling press machine. In their study, they also estimated the properties of cotton/waste blended rotor yarn using the TAGUCHI OA experimental design [12]. Telli and Babaarslan (2017) obtained yarns by open-end method from recycled cotton fibres from cotton waste generated during yarn production and recycled fibres from PET bottle wastes [13]. Kurtoğlu Necef et al. (2013) carried out a study on the recycling of fabric scraps produced in apparel production. They manufactured fabrics with a 50% blend ratio of virgin polyester yarns and recycled cotton yarns, afterwards analysed the properties of these fabrics [14]. Leonas (2017) examined the use of recycled products in the fashion industry and home textiles [15]. In their study, Celep et al. (2016) produced yarns obtained from virgin cotton and recycled cotton yarns with blending ratios of 100% and 50%, and examined the thermal comfort properties of single jersey fabrics produced using these yarns [16]. Vadicherla and Saravanan (2015) investigated the thermal comfort properties of 15 single jersey fabrics produced from recycled polyester and cotton blended yarns at different mixing ratios, density and loop length [17]. In their study on sustainable fashion, Ayanoğlu and Anaç (2017) aimed to minimize the waste generated in the production processes of textile products by including new design ideas [18]. Kurtoğlu Necef et al. (2020) evaluated the fashion industry in terms of sustainability and explained the recycling, reuse and reduction (3R) strategies by giving examples [19]. Akdemir and Korkmaz (2021) evaluated the effect of the sustainability concept on the fashion and textile industry and its reflection on art products [20]. Erdem and Doğan (2020) evaluated the sustainability challenges in the textile and apparel industry using the DEMATEL technique, which is one of the multi-criteria decision-making techniques. They found out that the criteria that had the most impact on the others were poor infrastructures and complex supply chain [21].

As literature review shows, many studies on recycling the pre-consumer as well as the post-consumer textile wastes and on analysing the physical and comfort properties of the recycled materials are exist in literature, moreover studies are still carried out in this field.

The aim of this study was to evaluate the interdependent relations among the criteria that are effective on the consumer buying process of a product manufactured from recycled materials. In this context, 11 experts in the field of "sustainability in textiles and apparel" were asked to give comparative scores to the determined criteria. The obtained data was analysed by usind DEMATEL method.

2. Material and Method

2.1. DEMATEL Method

Making the right choice among alternative decisions is the primary success condition for many sectors, and Multiple Criteria Decision Analysis (MCDA) methods are used by different decision makers for a flexible and subjective evaluation between criteria in the decision process. The problem is solved by the evaluation created for more than one option within the range of criteria determined by the decision maker. MCDA methods are based on mathematical comparisons between criteria and are used in many fields such as social sciences, economics and psychology [22]. The three basic steps used in MCDA methods are as follows [23];

- Determination of preference criteria and alternatives
- Mathematically determining the importance of criteria among each other and the effects of alternatives on other criteria
- Establishing the ranking of each alternative with the obtained data

DEMATEL (Decision Making Trial and Evaluation Laboratory) method, one of the MCDA methods, was created by the Geneva Research Center of the Battelle Memorial Institute between 1972-1976. DEMATEL method reveals the cause-effect relationships between criteria groups in a complex system using mathematical matrices and diagrams. In addition to revealing the interdependent relations of the criteria examined by the decision makers, it also fulfills the tasks of determining the important criteria for the decision and creating an impact map that includes the dependent relations of the criteria [24].

DEMATEL method is a flexible MCDA technique that can be used in many areas and has been also preferred for different applications in the textile industry. Comparative analysis studies were carried out with the DEMATEL method within the scope of many different subjects of the textile industry, such as sustainability practices in textile production [21, 25, 26], selection of raw materials [27], supplier selection [28], consumer behavior [29], environmentally friendly production [30], circular economy principles [31] and work accidents in textile factories [32].

Process steps in DEMATEL method;

Step 1: Creating the initial average matrix ***A***

Experts were asked to make comparisons between two different criteria using the scale indicated in Table 1. Using the obtained values, a matrix of n x n dimensions (n =number of criteria, H=number of experts) with diagonal element values of "*0-zero*" waas created for each expert. The answer matrix created for experts was in the form $\boldsymbol{S}^{(h)} = \left[s_{ij}^{(h)}\right]_{nxn}$ (h=1,2,…H). H The matrix $\boldsymbol{A} = \left[a_{ij}\right]_{nxn}$ that constitutes the average of the scores given by each expert was also called the initial average matrix and was obtained by using *Eq. 1* [33].

$$a_{ij} = \frac{1}{H}\sum_{h=1}^{H} s_{ij}^{(h)},\ i,j = 1,2,\dots,n \qquad (Eq.1)$$

Table 1.DEMATEL method rating scale for pairwise comparison between criteria

Scores	Influence Level
0	No influence
1	Low influence
2	Medium influence
3	High influence
4	Very high influence

Step 2: Normalize ***A*** to have the direct-relation matrix ***D***

Direct relation matrix ***D*** was obtained by normalizing the matrix $\boldsymbol{A} = \left[a_{ij}\right]_{nxn}$. In the normalization process, the value obtained using *Eq. 2* (α= the largest of the row or column total values) was divided by each element of the ***A*** matrix to form the D matrix. Each element of the matrix ***D*** must satisfy the condition of "$0 \le d_{ij} \le 1$" [33].

$$a = max\left(max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}, max_{1\le j\le n}\sum_{i=1}^{n} a_{ij}\right) \quad (Eq.2)$$

Step 3: Compute the total relation matrix ***T***

Eq. 3 was used to calculate the total relationship matrix. The matrix specified as ***I*** was an identity matrix of n x n dimensions [33].

$$T = D + D^1 + D^2 + \cdots + D^\infty = \lim_{n\to\infty} D + D^1 + D^2 + \cdots + D^z = D(I-D)^{-1} \qquad (Eq.3)$$

Step 4: Determining the ***R*** and ***C*** values using the total relation matrix ***T***

In the matrix T, the sum of the row values of each criterion gives the R value, and the sum of the column values of eachcriterion gives the C value. Formulas for these values were given in Eq. 4 and Eq. 5 [24].

$$R = \left[\sum_{j=1}^{n} t_{ij}\right]_{nx1} = [r_i]_{nx1} \qquad (Eq.4)$$

$$C = \left[\sum_{i=1}^{n} t_{ij}\right]_{nx1} = [c_j]_{nx1} \qquad (Eq. 5)$$

Step 5: Cause-Effect Diagram

The values used in the Cause-Effect diagram are $\boldsymbol{R_{ij}} + \boldsymbol{C_{ij}}$ and $\boldsymbol{R_{ij}} - \boldsymbol{C_{ij}}$. The $\boldsymbol{R_{ij}} + \boldsymbol{C_{ij}}$ values form the horizontal axis of the diagram, while the $\boldsymbol{R_{ij}} - \boldsymbol{C_{ij}}$ values form the vertical axis. The $\boldsymbol{R} + \boldsymbol{C}$ values were called as "*prominence*" and show the strength of the effects given and received of criterion. The $\boldsymbol{R} - \boldsymbol{C}$ values were called "*relation*" and show the net effect that the criterion contributes to the system. If $\boldsymbol{R} - \boldsymbol{C}$ was a positive value, the relevant criterion had a net effect on other criteria and was grouped as a "*cause*". If $\boldsymbol{R} - \boldsymbol{C}$ was a negative value, the relevant criterion was affected by all other criteria and was grouped as an "*effect*" [24].

Step 6: Impact Relation Map (IRM) Diagram

For the IRM diagram that expresses the relations of the criteria in the system with each other, the average of all the elements in the matrix $\boldsymbol{T}$ was calculated and the threshold value was determined. With the threshold value, bilateral evaluations were made for each criterion in the matrix $\boldsymbol{T}$, and the impact directions between the two selected criteria were determined.

Step 7: Calculating the weights of the criteria

Eq. 6 was used to calculate the weights of the criteria [24]

$$w_i = \frac{R_i + C_i}{\sum_{i=1}^{n} R_i + C_i} \qquad (Eq. 6)$$

2.2. Dataset Properties

The influential criteria on the consumer buying behavior of a garment made from recycled fibers were given in Table 2. In the process of determining the criteria, experts were interviewed and criteria were selected according to expert opinions.

Table 2.Summary of the criteria

Code	Criteria	Description
C1	Price	Selling price of the product
C2	Recycled Fiber Ratio	The amount of recycled fiber contained in the product
C3	Brand's Social Responsibility Projects	Social responsibility activity that the brand selling the product will carry out on behalf of the consumer if the product is purchased
C4	Ethical Production	Working in fair and humane conditions for the personnel involved in all production stages of the product
C5	Environmental Impact	The potential harm that the processes applied in all production stages of the product may cause on the environment
C6	Mixture with Other Eco-Friendly Raw Materials	The use of natural or synthetic fibers obtained by environmentally friendly production techniques by mixing them with recycled fibers for manufacturing of the product.
C7	Performance	It refers to the features such as clothing comfort, product end-of-life, and etc. that the product will provide to the consumer during its use.

At the stage of obtaining the criteria data, 11 experts were asked to give comparative scores to the criteria. The evaluation team consists of experts working in the production, purchasing and planning departments of the textile industry and working as academicians in universities. The information of the experts who made a comparative evaluation between the criteria as a decision maker was shown in Table 3.

Table 3.Demographic variables of experts

Variables	Groups	Frequency	Percent (%)
Sex	Woman	7	64
	Man	4	36
Age	27-34	4	36
	35-42	4	36
	43-50	3	27
Education Level	Bachelor Degree	5	45
	Master's Degree	2	18
	Doctorate Degree	4	36
Work Experience (year)	1-9	4	36
	10-17	3	27
	18-25	4	36

3. Results and Discussion

3.1. Data Analysis

Initial average matrix (***A***) containing the mean values of the comparison matrices taken from 11 experts according to the determined criteria was given in Table 4.

Table 4.Initial average matrix (A)

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	0.000	1.909	2.636	3.091	3.091	2.818	3.455
C2	2.545	0.000	2.182	2.455	3.000	2.455	2.727
C3	1.455	1.182	0.000	3.091	2.727	2.636	1.818
C4	2.455	1.636	2.909	0.000	2.818	2.636	2.273
C5	2.545	2.818	3.182	3.182	0.000	3.091	2.364
C6	2.273	3.000	2.455	2.364	3.636	0.000	2.455
C7	3.091	2.364	1.273	1.455	2.182	3.000	0.000

In order to normalize the initial average matrix (***A***), the operations specified in the second step were performed. The obtained normalized direct-relation matrix (***D***) was shown in Table 5.

Table 5.Normalized direct-relation matrix (D)

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	0.000	0.109	0.151	0.177	0.177	0.161	0.198
C2	0.146	0.000	0.125	0.141	0.172	0.141	0.156
C3	0.083	0.068	0.000	0.177	0.156	0.151	0.104
C4	0.141	0.094	0.167	0.000	0.161	0.151	0.130
C5	0.146	0.161	0.182	0.182	0.000	0.177	0.135
C6	0.130	0.172	0.141	0.135	0.208	0.000	0.141
C7	0.177	0.135	0.073	0.083	0.125	0.172	0.000

After the normalization process, the operations stated in the third step were applied in order to form the total relation (***T***) matrix. The matrix created with the calculated values was presented in Table 5. Threshold value of matrix ***T*** was calculated (*t* value=1.006). If the criterion values were higher than the threshold value, those values were indicated as using bold font in Table 5.

Table 6.Total relation matrix (T)

Criteria	C1	C2	C3	C4	C5	C6	C7
C1	0.932	0.955	**1.084**	**1.154**	**1.254**	**1.201**	**1.133**
C2	0.985	0.789	0.989	**1.048**	**1.163**	**1.101**	**1.026**
C3	0.810	0.740	0.753	0.943	1.005	0.967	0.854
C4	0.944	0.842	0.987	0.889	**1.115**	**1.069**	0.969
C5	**1.065**	1.001	**1.118**	**1.169**	**1.115**	**1.221**	**1.094**
C6	**1.014**	0.975	**1.044**	**1.090**	**1.240**	**1.024**	**1.056**
C7	0.921	0.828	0.855	0.906	**1.023**	**1.022**	0.801

R and ***C*** values were obtained by using Eq.4 and Eq.5 for the Cause-Effect diagram of the matrix ***T***. The ***R***, ***C***, ***R+C*** and ***R-C*** values of the criteria were given in Table7. In addition, the weights of the criteria were calculated using Eq.6 and the information including the weights and effect rankings were added to Table 7.

Table 7. R, C, R+C, R-C and W values of matrix T

Criteria	R	C	R+C	R-C	W	Rank	Impact
C1	7.713	6.671	14.383	1.042	0.146	3	Cause
C2	7.100	6.130	13.230	0.970	0.134	6	Cause
C3	6.072	6.830	12.902	-0.758	0.131	7	Effect
C4	6.815	7.199	14.014	-0.384	0.142	4	Effect
C5	7.783	7.915	15.699	-0.132	0.159	1	Effect
C6	7.444	7.604	15.048	-0.161	0.153	2	Effect
C7	6.356	6.933	13.289	-0.577	0.135	5	Effect

For the Cause-Effect diagram created with the data determined in Table 7, the method stated in the fifth step was used.

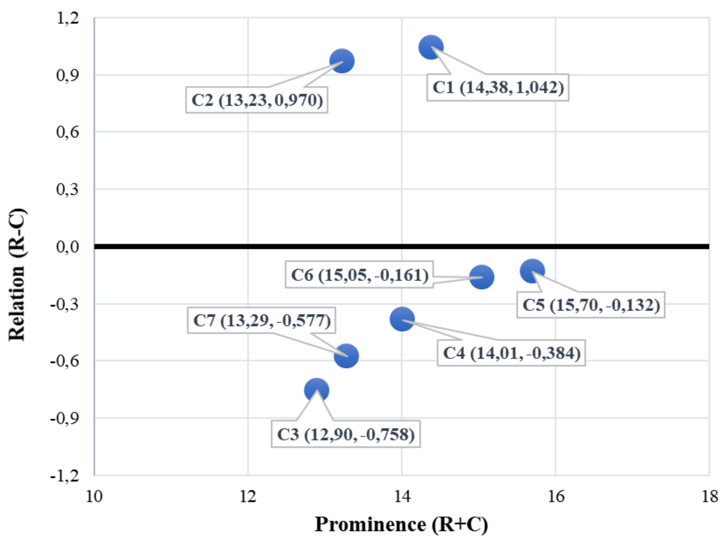

Figure 3.Cause-Effect diagram of matrix T

The values specified in Table 6 were used for the Impact Relation Map (IRM) diagram of the T matrix. According to the bilateral evaluation between the criteria, the impact relations was mapped in the parameters higher than the threshold value.

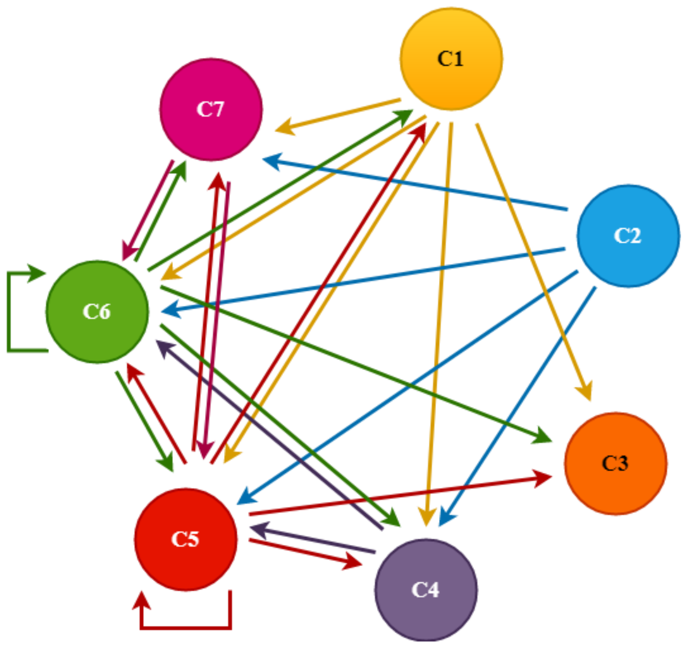

Figure 4.Impact relation map (IRM) diagram

3.2. Discussions

In the study, the interdependent relations among the criteria that are effective on the consumer buying process of a product manufactured from recycled fibers were examined using the DEMATEL method. The prominence analysis of the criteria was applied based on the *R+C* values [28, 34, 35, 36]. According to the *R+C* values calculated in Table 7, it had been determined that the most important criterion was the *Environmental Impact (C5)*. Moreover, the least important criterion according to *R+C* values was the *Brand's Social Responsibility Projects (C3)*. As can be seen in the diagram in Figure 1, the prominence prioritization of all the evaluated criteria was *C5>C6>C1>C4>C2>C3*. Based on the criteria weights specified in Table 7, it had been calculated that, the most effective criterion in terms of consumer purchasing behavior of a product consisting of recycled fibers were *Environmental Impact (C5)* and *Mixture with Other Eco-Friendly Raw Materials (C6)*, which were the most related to the sustainability concepts, and these two criteria were very close to each other. The *Brand's Social Responsibility Projects (C3)* criterion, on the other hand, was the lowest level in terms of importance and therefore it was separated from other criteria.

Cause-Effect groups of all criteria obtained by evaluating the R-C values in Table 7;

<u>Cause group</u>: Criteria with positive *R-C* values were the criteria that had a direct net effect on other criteria and were seen at the top of the Cause-Effect diagram given in Figure 1. Among all criteria, *Price (C1, 1.042)* and *Recycled Fiber Ratio (C2, 0.970)* were elements of the cause group. In parallel with previous studies [28, 34], *Price (C1)* was the most effective criterion in the cause group.

<u>Effect group</u>: Criteria with negative R-C values were the criteria affected by other criteria and were located at the bottom of the Cause-Effect diagram given in Figure 1. The criteria in this group were listed from lowest to highest as the *Brand's Social Responsibility Projects (C3*, *-0.758)*, *Performanc e(C7*, *-0.577)*, *Ethical Production(C4*, *-0.384)*, *Mixture with Other Eco-Friendly Raw Materials (C6*, *-0.161)* and *Environmental Impact (C5*, *-0.132)*. Especially the *Brand's Social Responsibility Projects (C3)* were the most affected criteria from other criteria. Similar to other studies [26], *Environmental Impact (C5)* was the strongest element of this group due to its effects on other criteria, although it was included in the effect group.

The IRM diagram was prepared with the data in Table 6, which includes the comparison of the values of the matrix ***T*** with the threshold value of the matrix ***T***. According to the IRM diagram (Figure 2), the criteria *C1* and *C2* in the cause group seemed to be effective on other parameters. In particular, *C2* was affected by four different criteria *(C4, C5, C6 and C7)* but was not affected by any factor. Furthermore, *C1*, the strongest member of the cause group, was effective on five different criteria *(C3, C4, C5, C6 and C7)*, while C5 and C6 criteria had effects on *C1*.

Based on the IRM diagram of the criteria in the effect group, the *C3* criterion, which was the lowest effective criterion of this group, could not show any effect on any criterion and it was determined that it was affected by three different criteria *(C1, C5 and C6)*. Other low-impact criteria in the effect group were determined as *C7* and *C4*, respectively. Similarly, *C7* and *C4* were found to be effective on two different criteria (C5 *and* C6) and were affected by four different criteria *(C1, C2, C5 and C6)*. *C5* and *C6* are the elements that had the most impact on the criteria in the effect group and had effects on all criteria except *C2*.

4. Conclusions and Recommendations

In parallel with the increase in population in the world, resource consumption for different needs of people is increasing. The demand for resources has now reached the level of 1.5 times the resources of the Earth. Therefore, in recent years, there has been an awareness of reducing consumption rates in production sectors and preferring recycling products [37]. Various initiatives are carried out to support the recycling of consumers and to purchase environmentally friendly products by consumers [38]. The textile industry is also one of the production sectors, and thanks to the recycling carried out in textiles, companies can reduce their costs such as raw material and waste management, increase their profitability and prevent nature pollution [39]. By using recycled raw materials, the amount of virgin raw materials used in the production of new products remains low and decreases in the use of water, energy and chemicals belonging to the virgin raw material production chain [40].

Considering the increasing interest in recycling products, this study analyzed the criteria affecting the purchasing process of a product containing recycled fibers. The DEMATEL method was used for the analysis of the criteria evaluated comparatively by the experts. Diagrams were created to visualize the effects of seven criteria and the relationships between these criteria. It was determined that the highest impact in terms of prominence level was the *Environmental Impact (C5)*, and the lowest impact was the *Brand's Social Responsibility Projects (C3)* in the system. According to the results obtained from the Cause-Effect analyzes, it was observed that the *Price (C1)* and *Recycled Fiber Ratio (C2)* in the cause group had a dominant effect on the other criteria. In addition, it had been determined that the *Brand's Social Responsibility Projects (C3)*, which was in the effect group, had the lowest impact level among other criteria and was affected by other criteria. The evaluation results of the Impact Relation Map (IRM) diagram indicated that the *Recycled Fiber Ratio (C2)* was not affected by any criteria and the *Brand's Social Responsibility Projects (C3)* did not affect any criteria. It has been concluded that the *Price (C1)*, *Environmental Impact* (C5) and *Mixture with Other Eco-Friendly Raw Materials(C6)* were effective on five different criteria and had significant effects on consumer behavior in the purchasing process.

In addition to this study, in which the purchasing process of a recycled product was investigated, further studies aim to increase the number of criteria, perform more detailed analysis by using different MCDA methods, use hybrid methods, and work with specific product groups.

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