INVESTIGATING THE RELATIONSHIP BETWEEN STUDENT SATISFACTION CRITERIA: A HYBRID MODEL BASED ON DEMATEL AND CANONICAL CORRELATION ANALYSIS

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Abstract

This study aims to investigate the relationship between students' satisfaction criteria with a hybrid model, conducting both DEMATEL and Canonical Correlation Analysis. The dataset is obtained from Turkey University Satisfaction Survey (TUSS) 2020, consisting of a total of 192 universities and 39,386 students. TUSS has six factors, namely, "campus and the fulfilment of campus life", "academic support and interest", "richness of learning opportunities and resources", "personal development and career support", "satisfaction with the learning experience", and "satisfaction with the institution's management and operation". DEMATEL is conducted to understand the cause and effect relationship and group these factors into two categories as dependent and independent sets. To investigate the relationship between these sets more deeply, Canonical Correlation Analysis is (CCA) carried out. The results of CCA are interpreted through canonical weights, canonical loadings, canonical cross-loadings, the proportion of explained variance, and redundancy index. The findings of the study suggest that to increase the overall satisfaction towards the institution, academic support and interest, as well as personal development and career support, should be delved into very carefully.

Keywords: Student Satisfaction, Turkey University Satisfaction Survey, DEMATEL, Canonical Correlation Analysis.

JEL Codes: M19, C30, C44, I23.

ÖĞRENCİ MEMNUNİYETİ KRİTERLERİ ARASINDAKİ İLİŞKİNİN İNCELENMESİ: DEMATEL VE KANONİK KORELASYON ANALİZİ TEMELLİ BİR HİBRİT MODEL

Öz

Bu çalışma, çok kriterli karar verme (MCDM) tekniği ve çok değişkenli istatistiksel teknik ile özgün bir yaklaşım sunan hibrit bir model aracılığıyla, öğrenci memnuniyeti kriterleri arasındaki ilişkiyi araştırmayı amaçlamaktadır. Veri seti, 192 üniversite ve 39.386 öğrenciden oluşan Türkiye Üniversite Memnuniyet Anketi (TÜMA) 2020'den alınmıştır. TÜMA'nın altı faktörü vardır; "yerleşke ve yerleşke yaşamının doyuruculuğu", "akademik destek ve ilgi", "öğrenme imkan ve kaynaklarının zenginliği", "kişisel gelişim ve kariyer desteği", "öğrenim deneyiminin tatminkârlığı" ve "kurumun yönetim ve işleyişinden memnuniyet". DEMATEL, neden sonuç ilişkisini anlamak ve bu faktörleri bağımlı ve bağımsız kümeler olarak iki kategoriye ayırmak için uygulanmıştır. Bu gruplar arasındaki ilişkiyi daha derinlemesine incelemek için Kanonik Korelasyon Analizi (KKA) gerçekleştirilmiştir. KKA sonuçları, kanonik ağırlıklar, kanonik yükler, kanonik çapraz yükler, açıklanan varyans oranı ve gereksizlik indeksi ile yorumlanmıştır. Bu çalışmanın bulguları, kuruma yönelik genel

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memnuniyetin artırılması için akademik destek ve ilginin yanı sıra kişisel gelişim ve kariyer desteğinin çok dikkatli bir şekilde araştırılması gerektiğini göstermektedir.

Anahtar Kelimeler: Öğrenci Memnuniyeti, Türkiye Üniversite Memnuniyet Araştırması, DEMATEL, Kanonik Korelasyon Analizi.

JEL Kodları: M19, C30, C44, I23.

INTRODUCTION

"Students, so long taken for granted, have been recognized as the principal stakeholders in higher education and their own voice on their experiences is now being heard more clearly by institutions and governments."

Williams & Cappuccini-Ansfield (2007, p.159)

In parallel to several studies that show the important impact of student satisfaction on different outcomes such as student motivation and retention, higher education institutions delve into student satisfaction as to include contents in mission statements, goals, and promotional activities (Elliott & Shin, 2002). The crucial role of the students in assessing institutions is undeniable. Their opinions are extremely important and should be taken into consideration very carefully (Harvey, 1995).

There is a growing interest in developing student feedback mechanisms in higher education institutions (Williams & Cappuccini-Ansfield, 2007). Due to the complex structure of higher education institutions from academic staff to management, higher education assessment has conflicts such as determining the level of student satisfaction and students' perception of the education quality (Zineldin et al., 2011). Measuring satisfaction can be assessed with a single-item or multi-item rating scale (Elliott & Shin, 2002).

Studies focusing on student satisfaction are carried out on a local, national, or worldwide based. Douglas et al. (2006) measure student satisfaction at a university in the United Kingdom. The result of the study states that teaching and learning aspects are the most important, whereas the physical facilities aspects are the least important. Butt & Rehman (2010) investigate student satisfaction at public and private universities in Pakistan. Similarly, classroom facilities are found to be the least important, while academic expertise is found to be the most influential factor. There are numerous studies on student satisfaction in Turkey. Tütüncü & İpekgil Doğan (2003) investigate the satisfaction levels of students at Dokuz Eylül University. In the study, quality of education is found to be the most influential variable and the most important factors among the determinants of education quality are the quality of the academic staff and the course structures, respectively. Naralan & Kaleli (2012) measure the expectations and satisfaction levels of undergraduate students at Atatürk University. As a result of the study, suggestions are made in line with the students' campus-related expectations such as improving social and cultural activities on the campus, tightening the security, and making internet access easier. Tayyar & Dilşeker (2012) investigate the relationship between service quality, image, student satisfaction, recommendation and loyalty among universities. In this context, student satisfaction is found to be

influential on loyalty and recommendation. To increase student satisfaction, focusing on activities that improve academic staff, internationalization and image are suggested.

In another study, the lecture room facilities, library facilities, accommodation facilities, employment facilities and entertainment facilities are found to be the factors affecting student overall satisfaction (Weerasinghe & Fernando, 2018). Similarly, Hanssen & Solvoll (2015) explore facilities that influence overall student satisfaction and find out that social areas, auditoriums and libraries are the most important. Kärnä & Julin (2015) find that factors related to the research and teaching aspects have the greatest impacts on overall satisfaction. Solinas et al. (2012) investigate factors affecting student satisfaction under three categories; motivations of students, services provided by universities and teaching capabilities. Wiers-Jenssen et al. (2002) emphasize the importance of academic quality among the factors that determine student satisfaction. In addition to that, they suggest that the social environment, physical infrastructure, and service quality of administrative staff are important. Elliott (2002) states that students' sense of belonging and provision of a high-quality education are the main factors in determining student satisfaction.

Students satisfaction criteria may change in different circumstances. Bolliger (2004) states the key factors of student satisfaction in online courses, which are instructor variables, technical issues, and interactivity. Other than evaluating the overall student satisfaction, some studies measure student satisfaction of a certain degree (e.g. PhD student satisfaction (Barnes & Randall, 2012; Dericks et al., 2019)) or a specific department such as business administration (Gibson, 2010; Letcher & Neves, 2010), informatics (Koilias, 2005), psychology (Green et al., 2015), and engineering (González-Rogado et al., 2014). Besides, some studies look at the aspects that have impacts on student satisfaction. The effects of academic departments (Umbach & Porter, 2002), classroom attributes (Yang et al., 2013), service quality and price fairness (Tuan, 2012), and academic environment and background characteristics (Karemera et al., 2003) on student satisfaction are examined.

Student satisfaction surveys, part of the quality assurance framework, have been used to improve overall satisfaction in universities by evaluating areas in need of improvement and rewarding areas of excellence (Grebennikov & Shah, 2013). Due to several opportunities that student satisfaction provides, institutions delve into satisfaction criteria more deeply. This study focuses on student satisfaction criteria from a different angle to investigate the relationship between satisfaction aspects. The rest of this study is structured as follows. The next session provides an overview of the Turkey University Satisfaction Survey. The methodology session gives dataset information and explains the analysis techniques, DEMATEL and Canonical Correlation Analysis. Finally, the findings of the analysis are given and the results are discussed.

1. TURKEY UNIVERSITY SATISFACTION SURVEY

University rankings according to various criteria have been carried out since the beginning of the 20th century. Turkey University Satisfaction Survey (TUSS), the most comprehensive university satisfaction survey conducted in Turkey, tries to draw attention to the processes and inputs of university

life such as education, campus life, management, and access to opportunities, which can be seen as important aspects of the university ecology. TUSS was first carried out in 2016 by the founders of the University Research Laboratory, Karadağ and Yücel (Karadağ & Yücel, 2017).

TUSS has created a university ranking based on student satisfaction and sought answers to the following questions (Karadağ & Yücel, 2017):

- Do universities in Turkey satisfy their students in the terms of their learning experience?

- Do universities present the space and human relationship at a satisfactory level by creating a fulfilling and attractive campus life?

- Going beyond attendance and covering subjects, do universities give academic support for students and attention to the academic difficulties their students face?

- Can the demands of the students be met quickly at a satisfactory level in terms of the administration and operation of the university?

- Are the universities' learning environment, opportunities, and resources rich and sufficient?

- Can students' personal development and future careers be supported?

Seeking this information, TUSS gives comprehensive knowledge for students' satisfaction towards universities in terms of different aspects such as learning experience, campus life, academic support, management, opportunities, and personal development. Since 2016, the report, which is prepared based on the sample participants' results collected from universities, is published on the website (Uniar, 2021). The sample was determined in five stages for the latest published report, TUSS-2020 (Karadağ & Yücel, 2020):

- Stage 1: Based on the statistics of the Council of Higher Education (YÖK) in 2019-2020 academic year, a total of 192 state and foundation universities were determined (state:125, foundations:67).

- Stage 2: Taking into account the distribution of the total number of students in universities by faculty types and gender, the sample size to be reached for each faculty type (in terms of gender) was calculated.

- Stage 3: Universities were divided into 10 main and 5 sub-categories according to their undergraduate student size, and the minimum sample size to be reached for each university was calculated.

- Stage 4: The minimum sample size to be reached for the faculties of each university was calculated by considering the faculty and gender ratios within each university.

- Stage 5: Using quota sampling, data were collected from at least 75 students from each university students (the number varies depending on the size of the university) by using dynamic software Application with questionnaires applied from 1 March and 30 April.

The data are collected with the Student Satisfaction Scale consisting of six factors. The ranking is made by calculating the General Satisfaction Score with a maximum of 600 and a minimum of 60 by

adding the scores of each university in six fields. Universities are classified in the 6-point range. Levels are named A+, A, B, C, D, and FF (Karadağ & Yücel, 2020). The factors and their explanations are given in Table 1.

Table 1. Contents of the Student Satisfaction Scale

Factor	Content
Satisfaction with Learning Experience	Satisfaction with the courses and their contents, the interest of the instructors, the validity of the exams, the student-oriented climate, the teaching methods and approaches in the classroom
Campus and the Fulfilment of Campus Life	The attractiveness of the campus environment, social facilities, dormitory's facilities and quality, ease of transportation, security, aesthetics and usability of the physical spaces, the environment where the campus is located
Academic Support and Interest	Accessibility to lecturers and counsellors, finding help in learning difficulties, sensitivity to students' academic questions and their problems.
Satisfaction with the Institution's Management and Operation	Student affairs, exam schedules, academic calendar, codetermination, access to administrators, effectiveness, and sensitivity of the administrative function
Richness of Learning Opportunities and Resources	Library, research resources, laboratories, centers, research facilities, special study areas, academic support units
Personal Development and Career Support	Certificates, career, and orientation, personal competence enhancement activities, courses for students, employment prospect and support

Source: Karadağ & Yücel, 2017

2. METHOD

2.1. Dataset and Variables

The dataset is collected from TUSS-2020 Report, the latest published results, consisting of a total of 192 state and foundation universities. Usable data are collected from 39,386 students (female: %52.1, male: %47.9).

The factors of the Student Satisfaction Scale are separated into dependent and independent groups by conducting the DEMATEL technique. The distribution of variables by groups is given in Table 2. After determining the groups and their variables, Canonical Analysis is carried out to find out the relationship between these groups.

Table 2. Independent and Dependent Variables

Independent Variables	Dependent Variables
X_1: Campus and the Fulfilment of Campus Life	Y_1: Satisfaction with the Learning Experience
X_2: Academic Support and Interest	Y_2: Satisfaction with the Institution's Management and Operation
X_3: Richness of Learning Opportunities and Resources	
X_4: Personal Development and Career Support	

2.2. Model Building

2.2.1. DEMATEL Method

Decision making trial and evaluation laboratory (DEMATEL), which was proposed by Gabus and Fontela (1972), is a multiple criteria decision making (MCDM) method that aims to reveal and analyze the causality relationship between complex factors. This method differs from other MCDM methods due to its ability to distinguish between variables affecting and affected. In this context, the method transforms the relationship between the causes and effects of the factors into a comprehendible structural model (Wu & Lee, 2007).

The steps of DEMATEL are listed below (Gabus & Fontela, 1972; Ayçin, 2020):

Step 1: Obtaining The Direct-Relation Matrix: The direct relation matrix is a matrix obtained by pairwise comparisons in terms of influences and directions between criteria. There are a total of five effect degrees: 0, 1, 2, 3, and 4. These degrees represent "no influence", "very low influence", "low influence", "high influence", and "very high influence", respectively. The representation of the matrix is as follows:

$$D = \begin{bmatrix} d_{11} & d_{1j} & d_{1n} \\ \vdots & \vdots & \vdots \\ d_{i1} & d_{ij} & d_{in} \\ \vdots & \vdots & \vdots \\ d_{n1} & d_{nj} & d_{nn} \end{bmatrix} \tag{1}$$

Each element in the matrix shows the degree of influence of a variable on any other variable. For example, d21 indicates the degree of influence of "Variable 2" on "Variable 1". Since a variable does not affect itself, the diagonal elements of the matrix will be zero.

Step 2: Obtaining The Normalized Direct-Relation Matrix: In this step, the values in each row and each column of the matrix are added up one by one. The matrix is normalized by dividing each element of the matrix by the maximum of these values. The following equations are used in the normalization process:

$$X = s.D \tag{2}$$

$$s = \min \left[\frac{1}{\max_i \sum_{j=1}^{n} |d_{ij}|} \right] , \left[\frac{1}{\max_j \sum_{i=1}^{n} |d_{ij}|} \right] \tag{3}$$

Step 3: Obtaining The Total-Relation Matrix: At this stage, the direct relationship matrix normalized in the previous stage is transformed into the total effect matrix shown in Equation (5) by using the formula in Equation (4).

$$T = X + X^2 + \cdots + X^h = X(I - X)^{-1} \tag{4}$$

$$T = \begin{bmatrix} t_{11} & t_{1j} & t_{1n} \\ \vdots & \vdots & \vdots \\ t_{i1} & t_{ij} & t_{in} \\ \vdots & \vdots & \vdots \\ t_{n1} & t_{nj} & t_{nn} \end{bmatrix} \tag{5}$$

Step 4: Determining the Affecting and Affected Variables: d_i for each row and r_j for each column are computed using the equations below. Then $(d_i + r_j)$ and $(d_i - r_j)$ values are calculated.

$$d_i = \sum_{j=1}^{n} t_{ij} \qquad D = \begin{bmatrix} d_1 \\ \vdots \\ d_i \\ \vdots \\ d_n \end{bmatrix}_{n \times 1} \tag{6}$$

$$r_j = \sum_{i=1}^{n} t_{ij} \qquad R = [r_1 \quad \cdots \quad r_j \quad \cdots \quad r_n]_{1 \times n} \tag{7}$$

To determine the affecting and affected variables, the decision is made according to the following situations:

- The variable with a high $d_j + r_j$ value is more related to other variables and the lower $d_j + r_j$ value is less related to the other variables.

- The variable with a positive $d_j - r_j$ value is in the affecting group and the variable with a negative $d_j - r_j$ value is in the affected group.

2.2.2. Canonical Correlation Analysis

Canonical Correlation Analysis (CCA), which was proposed by Hotelling (1936), is a multivariate statistical technique. Hotelling (1936) investigated the relationship between reading ability (X) and arithmetic ability (Y) by using an example of four variables (reading speed: X_1, reading power: X_2, arithmetic speed: Y_1, and arithmetic power: Y_2) from a sample of 140 seventh-grade school children.

The CCA aims to identify and measure the relationships between two groups of variables (Johnson & Wichern, 2007). Each group has at least two variables, since if one group has only one variable then a t-test or regression analysis can be applied. Theoretically, CCA can be applied to more than two groups, but in general, CCA is conducted to investigate the two groups' relationships (Thompson, 2000).

The correlation calculated by CCA is based on a linear combination of one group's variables and the other group's variables. In the analysis, the pair of linear combinations that have the largest correlation are determined. Afterwards, all pairs uncorrelated to the selected pair are determined and the same process (specifying the pair of linear combinations that have the largest correlation) is repeated between them. Canonical variables are the pairs of linear combinations. Correlations of canonical variables are called canonical correlations (Johnson & Wichern, 2007).

Mathematically, it can be represented as follows (Tacq, 1997):

$$X^* = a_1X_1 + a_2X_2 + \cdots + a_pX_p \tag{8}$$

$$Y^* = b_1Y_1 + b_2Y_2 + \cdots + b_qY_q \tag{9}$$

Where, X^* is a linear combination equation of one set (X; containing p variables), Y^* is a linear combination equation of the other set (Y; containing p variables), and r_c is the correlation between them. In CCA, a_i and b_i values are estimated such that the correlation between X^* and Y^* (r_c) is maximized. The canonical variable pairs and the canonical correlation coefficient are calculated as the number of variables in the group, whichever of the X and Y groups has fewer variables (s = Min (p, q)). Each of the obtained canonical variable pairs, (X_1^*, Y_1^*), (X_2^*, Y_2^*), …, (X_s^*, Y_s^*), represents an independent dimension in the relationship between two variable groups (Manly & Alberto, 2016).

CCA lacks giving information about the explained variance between the X and Y sets. The square of the canonical correlation (eigenvalue) gives information about the common variance between canonical variables. Thus, the redundancy index is calculated to overcome this issue (Van Den Wollenberg, 1977). If the index is close to 1, it shows that the Y's variance (or X) being shared with the X (or Y) is significant (Mazuruse, 2014).

This technique is popularly used since in reality there are multiple causes and effects. Analyzing just one variable or set can not be enough to seek relational information. In addition to that, CCA is much more sensible than conducting univariate tests due to the inflation of experiment-wise (Type I) error rates (Thompson, 2000).

3. RESULTS / FINDINGS

3.1. DEMATEL Results

The DEMATEL method is applied to determine which of the six factors in the TUSS are affecting (independent) and which are affected (dependent) variables. With this aim, the following direct relation-matrix (Table 3.) is obtained by obtaining the opinions of an expert.

Table 3. The Direct Relation-Matrix

	CL	AS	LO	PD	LE	IM
CL	0	2	2	2	4	4
AS	0	0	3	1	4	3
LO	0	1	0	1	4	4
PD	0	0	0	0	3	2
LE	0	0	0	0	0	2
IM	2	0	0	0	0	0

The variables are abbreviated as follows for an easy representation of the matrix:

- **CL:** Campus and the Fulfilment of Campus Life
- **AS:** Academic Support and Interest
- **LO:** Richness of Learning Opportunities and Resources

- **PD:** Personal Development and Career Support
- **LE:** Satisfaction with Learning Experience
- **IM:** Satisfaction with the Institution's Management and Operation

After applying the steps of DEMATEL, the affecting and affected variables, in other words, independent and dependent variables are determined (Table 4.).

Table 4. Affecting and Affected Variables

	D_i	R_j	$D_i + R_j$	$D_i - R_j$	**Effect Group**
CL	1.3789	0.3314	1.7103	1.0475	Affecting
AS	1.0501	0.2730	1.3231	0.7771	Affecting
LO	0.8955	0.4321	1.3276	0.4634	Affecting
PD	0.4108	0.3579	0.7686	0.0529	Affecting
LE	0.1756	1.3480	1.5236	-1.1724	Affected
IM	0.3172	1.4857	1.8028	-1.1685	Affected

As can be seen in Table 4., the findings of the DEMATEL method show that four variables are affecting and two variables are affected variables (hereafter referred to as independent and dependent variables).

3.2. Canonical Correlation Analysis Results

SPSS (Version 25.0) is used to carry out Canonical Correlation Analysis. The proposed model for CCA is given in Figure 1.
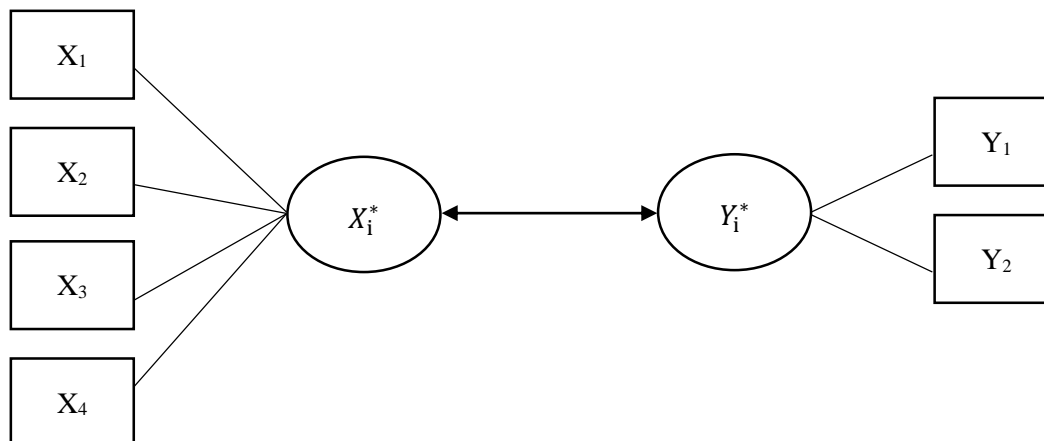

Figure 1. The Model for CCA

CCA is conducted based on the two dependent variables (Y_1: Satisfaction with the Learning Experience, Y_2: Satisfaction with the Institution's Management and Operation) and the four independent variables (X_1: Campus and the Fulfilment of Campus Life, X_2: Academic Support and Interest, X_3: Richness of Learning Opportunities and Resources, X_4: Personal Development and Career Support) to evaluate the relationship between these variable sets. The findings of CCA are interpreted based on

canonical weights, canonical loadings, canonical cross-loadings, the proportion of explained variance, and redundancy index.

3.2.1. Correlation Findings

First of all, correlations between independent variables, correlations between dependent variables, and correlations between dependent and independent variables are given in Table 5. When the correlations between independent variables are examined, it is seen that the highest relationship is between X_2 and X_4 (%90.56), "academic support and interest" and "personal development and career support". Also, it is observed that the relationships between variables X_1 and X_3, X_2, and X_3 and X_3 and X_4 are also quite strong (86.52%, 86.69%, and 88.23%). The lowest correlation is between X_1 and X_4, namely "campus and the fulfilment of campus life", "personal development and career support" variables. According to the results of the dependent variables, the relationship between "satisfaction with learning experience" and "satisfaction with the institution's management and operation", is found to be 84.68%. Therefore, it can be said that there is a strong relationship between them. The last correlation table shows that there are strong positive relationships between the Y_1 variable (satisfaction with learning experience) and X_2 (academic support and interest), X_3 (richness of learning opportunities and resources), and X_4 (personal development and career support), respectively 92.43%, 82.58%, and 91.1%. Finally, satisfaction with the institution's management and operation (Y_2 variable) has a strong relationship with academic support and interest (85.33%) and personal development and career support (82.80%).

Table 5. Correlations among the Variables

Correlations Between Independent Variables			
	X_1	X_2	X_3	X_4
X_1	1.0000	0 .7725	0.8652	0.7534
X_2	0.7725	1.0000	0.8669	0.9056
X_3	0.8652	0.8669	1.0000	0.8823
X_4	0.7534	0.9056	0.8823	1.0000

Correlations Between Dependent Variables		
	Y_1	Y_2
Y_1	1.0000	0.8468
Y_2	0.8468	1.0000

Correlations Between Dependent and Independent Variables			
	X_1	X_2	X_3	X_4
Y_1	0.7586	0.9243	0.8258	0.9110
Y_2	0.6758	0.8533	0.7637	0.8280

3.2.2. Canonical Correlations and Test Results

In this study, Wilks's Lambda (λ) is conducted as it is the most common test to assess the model (Sherry & Henson, 2005). There are two pairs of canonical variables in the study that provide two canonical correlation coefficients (s = min (4,2) = 2). To interpret the results of Bartlett's Wilks's Lambda Test results, the null hypothesis can be stated as follows:

$$\mathbf{H_0}: \rho_1 = \rho_2 = 0$$

The alternative hypothesis states that at least one of the canonical correlations is non-zero. As shown in Table 6., only the first canonical correlation coefficient is found to be significant (p = 0.00 <0.05). Therefore, only the results for the first canonical variable are interpreted.

Table 6. Canonical Correlations and Test Results

	Canonical Correlation Coefficient (r)	Eigenvalue (r^2)	Wilk's Lambda	Chi-SQ	DF	Sig.
1	0.951	0.9044	0.094	443.463	8.000	0.000
2	0.123	0.0151	0.985	2.842	3.000	0.417

The first canonical function shows the relationship between the first dependent canonical variable and the first independent canonical variable, and this relationship gives the maximum correlation coefficient (0.951). The square of the canonical correlation coefficient is equal to the eigenvalue. The eigenvalue is the proportion of explained variance by the independent variable in the dependent variable and the proportion of explained variance by the dependent variable in the independent variable. It is shown that 90.44% of the variance between the two sets of variables is explained by the first canonical correlation and 1.51% by the second canonical correlation.

3.2.3. Canonical Weights

Due to its meaningful results, standardized canonical weights are interpreted. The first independent canonical variable and first dependent canonical variable are the categorical variables that make the relationship between independent variables and dependent variables the highest. The canonical correlation coefficient showing the degree of this relationship is 0.951.

Table 7. Standardized Canonical Coefficients of the Independent & Dependent Variable Set

	X_1	X_2	X_3	X_4
Standardized Canonical Coefficients for the Independent Set				
X_1^*	-0.126	-0.607	0.180	-0.479
X_2^*	-1.696	1.151	2.075	-1.654

	Y_1^*	Y_2^*
Standardized Canonical Coefficients for the Dependent Set		
Y_1	-0.796	-1.704
Y_2	-0.232	1.866

The first canonical variable pair is obtained with the following equations:

$$X_1^* = -0.216X_1 - 0.607X_2 + 0.18X_3 - 0.479X_4$$

$$Y_1^* = -0.796Y_1 - 0.232Y_2$$

Taking into account the absolute sizes, it is obtained that the order of contribution of independent variables to the first dependent canonical variable is X_2 X_4, X_3, and X_1.

Therefore, while the independent variable with the highest contribution is academic support and interest; personal development and career support ranked second, richness of learning opportunities and resources ranked third, and campus and the fulfilment of campus life ranked fourth.

3.2.4. Canonical Loadings

Canonical loadings give the simple linear correlation coefficient between the original variable and its canonical variable. Therefore, it enables the determination of the original variables that contribute the most to canonical variables and canonical correlation coefficient. The canonical loads for the variable sets are given in Table 8.

Table 8. Canonical Loadings of the Independent & Dependent Variable Set

	X_1	X_2	X_3	X_4
Canonical Loadings for the Independent Variable Set				
X_1^*	-0.800	-0.982	-0.877	-0.964
X_2^*	-0.257	0.143	0.147	-0.058

	Y_1^*	Y_2^*
Canonical Loadings for the Dependent Variable Set		
Y_1	-.992	-.124
Y_2	-.906	.423

The order of contribution of original variables in the independent set to the first independent canonical variable is X_2 X_4, X_3, and X_1. Therefore, it is seen that academic support and interest provide the highest contribution, while campus and the fulfilment of campus life provide the lowest contribution. The original variables that contribute the most to the first dependent canonical variable are Y_1 and Y_2, respectively. Therefore, it is seen that the variable that makes the most contribution is satisfaction with the learning experience.

3.2.5. Canonical Cross-Loadings

Canonical cross-loadings show the simple correlation coefficient between original independent variables and dependent canonical variables, and original dependent variables and independent canonical variables.

Table 9. Canonical Cross-Loadings of the Independent & Dependent Variable Set

	Cross-Loadings for the Independent Variable Set			
	X_1	X_2	X_3	X_4
Y_1^*	-0.761	-0.934	-0.834	-0.917
Y_2^*	-0.031	0.017	0.018	-0.007
	Cross-Loadings for the Dependent Variable Set			
	X_1^*	X_2^*		
Y_1	-0.944	-0.015		
Y_2	-0.862	0.052		

As given in Table 9., independent original variables contributing to the first dependent canonical variable are X_2 X_4, X_3, and X_1, respectively. The most contributing independent variable is academic support and interest. The dependent variables contributing to the first independent canonical variable are Y_1 and Y_2, respectively. Therefore, satisfaction with the learning experience gives the most contribution.

3.2.6. The Proportion of Explained Variance

The explained variance ratio shows the part that the canonical variables in the dependent or independent set explain in the variables in the related set. It is calculated by taking the average of the squares of the canonical loads of each canonical variable in the related set. Table 10. shows the proportion of explained variance for the independent and dependent variable sets.

Table 10. The Proportion of Explained Variance of the Independent & Dependent Variable Set

The Independent Variable Set		The Dependent Variable Set	
X_1^*	0.826	Y_1^*	0.903
X_2^*	0.028	Y_2^*	0.097
Total	0.854	**Total**	1.000

Since the second canonical variable is not significant, it is obtained that the sum of only the variance explained by the first canonical variable in the independent set is 0.826. The sum of the proportion of explained variance for the dependent or independent variable set is 1 if the number of variables in that set is equal to the number of canonical variables, which is the case for the dependent variable set.

3.2.7. Redundancy Index

The part of the variability in the dependent (or the independent) variable set explained by the independent (or the dependent) variable set is interpreted with the Redundancy Index.

Table 11. Redundancy Index of the Independent & Dependent Variable Set

The Independent Variable Set		The Dependent Variable Set	
X_1^*	0.747	Y_1^*	0.817
X_2^*	0.000	Y_2^*	0.001
Total	0.747	**Total**	0.818

81.8% of the total variability in the dependent variables can be explained by independent variables. The proportion of the first independent canonical variable to explain the change in the dependent variables is 81.7%. Also, the proportion of the first dependent canonical variable explaining the change in independent variables is 74.7%.

4. DISCUSSION AND CONCLUSION

Numerous studies have been conducted to measure student satisfaction in higher education. In this study, variables obtained from TUSS-2020 Report are investigated to comprehend the relationship between students' satisfaction criteria by a hybrid model of DEMATEL and Canonical Correlation Analysis. The findings suggest that "satisfaction with the learning experience" and "satisfaction with the institution's management and operation" are affected by "campus and the fulfilment of campus life", "academic support and interest", "richness of learning opportunities and resources", and "personal development and career support".

"Academic support and interest" and "personal development and career support" come to the fore as the variables that most affect the overall satisfaction ("satisfaction with the learning experience" and "satisfaction with the institution's management and operation"), whereas "campus and the fulfilment of campus life" give the lowest contribution. These results are supported by the findings of Douglas et al. (2006) and Butt & Rehman (2010) since the facilities are found to be the least important

aspect that affects student satisfaction in these studies. Similarly, in Elliott (2002), Wiers-Jenssen et al. (2002), Tütüncü & İpekgil Doğan (2003), and Kärnä & Julin (2015) studies, academic quality and teaching aspects have the greatest impacts on overall satisfaction.

The findings of the study show the cause and effect relationships between the student satisfaction criteria that may suggest different sights. First, "satisfaction with the learning experience" and "satisfaction with the institution's management and operation" are affected by "academic support and interest" and "personal development and career support" at the most. Based on this finding, to increase the overall satisfaction towards the institution, dwelling on meeting students' academic and career expectations can be suggested. It may have a direct effect to increase the students' satisfaction. Another important implication of the findings is that "satisfaction with the learning experience" has an important effect on campus life, academic support, learning opportunities, and personal development. This finding is reasonable since it is directly related to the teaching approaches and the quality of the courses & assessments. As a final point, to the best of our knowledge, no research has been done about TUSS and this is the first study that examines student satisfaction aspects' relationships in a different perspective with a hybrid model consisting of multiple criteria decision making (MCDM) technique (DEMATEL) and multivariate statistical technique (Canonical Correlation Analysis).

The current study has some limitations. First, this study is based on a report conducted in Turkey. New studies could be carried out based on surveys applied in different countries or globally. Second, the current study does not evaluate the rankings of the universities. Cluster analysis may be applied to investigate the separation of universities. Additionally, future studies may take several years of data into account and compare findings over years.

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