BMIJ
ISSN: 2148-2586

bmij (2023) 11 (1):310-319
doi: https://doi.org/10.15295/bmij.v11i1.2206
Research Article

Evaluation of the positive impacts of e-customs implementations on foreign trade by fuzzy AHP method

E-gümrük uygulamalarının dış ticaret üzerindeki olumlu etkilerinin bulanık AHP yöntemi ile değerlendirilmesi

Tuğçe Danacı Ünal[1]

[1] Assist. Prof. Dr., Bursa Technical University, Bursa, Türkiye, tugce.unal@btu.edu.tr

ORCID: 0000-0002-5480-2653

Abstract

This study aims to evaluate the positive impacts of e-customs implementations on international trade and rank these impacts hierarchically according to their importance weights. For this purpose, Fuzzy Analytical Hierarchy Process (AHP) method was applied to analyze the importance weights of each impact. Data were collected from the experts by conducting a survey prepared following the study's research method. Questionnaire forms were structured within the conceptual model framework created in line with the literature review and expert decisions. Questionnaires were sent via e-mail to the experts and fully completed seven of them were included in the analysis. Results of the study demonstrate that the Time criterion has the highest impact on e-customs implementations among the main criteria. Besides, the first three important impacts of e-customs implementations among the sub-criteria are ease of transactions, reduced bureaucracy, and faster transactions. The findings obtained from this study are supposed to contribute to the studies concerning e-customs applications.

Keywords: Fuzzy AHP, International Trade, E-Customs, Trade Facilitation

Jel Codes: C44, F19, O38

Öz

Bu çalışmanın amacı, e-gümrük uygulamalarının uluslararası ticaret üzerindeki olumlu etkilerini değerlendirmek ve bu etkileri önem ağırlıklarına göre hiyerarşik olarak sıralamaktır. Bu amaç doğrultusunda, her bir etkinin önem ağırlığını analiz etmek için Bulanık Analitik Hiyerarşi Süreci (Prosesi) (AHP) yöntemi uygulanmıştır. Veriler, çalışmanın araştırma yöntemine uyumlu olarak hazırlanan anketlerin uzman kişilere uygulanmasıyla toplanmıştır. Anket formları literatür taraması ve uzman kararları doğrultusunda oluşturulan kavramsal model çerçevesinde yapılandırılmıştır. Anketler uzman kişilere e-posta ile gönderilmiş ve bunlardan eksiksiz olarak doldurulan yedi tanesi analize dahil edilmiştir. Çalışmanın sonuçları, e-gümrük uygulamalarının ana kriterler arasında en yüksek etki ağırlığının Zaman kriterine ait olduğunu göstermektedir. Ayrıca, alt kriterler arasında e-gümrük uygulamalarının en önemli ilk üç etkisi sırasıyla işlem kolaylığı, bürokrasiyi azaltma ve işlemlerin daha hızlı gerçekleşmesi olarak belirlenmiştir. Bu çalışmadan elde edilen bulguların e-gümrük uygulamaları ile ilgili yapılacak çalışmalara katkı sağlayacağı düşünülmektedir.

Anahtar Kelimeler: Bulanık AHP, Uluslararası Ticaret, E-Gümrük, Ticaretin Kolaylaştırılması

JEL Kodları: C44, F19, O38

Submitted: 19/01/2023

Revised: 5/03/2023

Accepted: 14/03/2023

Online Published: 25/03/2023

Citation: Ünal, Danacı, T., Evaluation of the positive impacts of e-customs implementations on foreign trade by fuzzy AHP method, bmij (2023) 11 (1): 310-319, doi: https://doi.org/10.15295/bmij.v11i1.2206

Introduction

Foreign trade operations involve complex documentation and networks among different partners and authorities. Therefore, many countries endeavour to find solutions for facilitating trade across borders. Trade facilitation, defined by the World Trade Organization[1] (WTO) as the 'simplification, modernization and harmonization of export and import processes', became a crucial issue for the world trading system (WTO, 2023). Trade Facilitation Agreement (TFA)[2], which came into force in 2017, involves provisions concerning electronic transactions to expedite customs operations (WTO, 2023). Today electronic practices in customs operations have a vital role in facilitating international trade. Moreover, customs management is highly dependent on information technology, so developing an effective security customs information platform is crucial when considering the increase in operational pressure and business needs (Ding, 2016).

In 2020, the COVID-19 pandemic negatively affected the world economically, necessitating physical distance between people and isolating them from their social and business environments. This restriction has led to the use of the internet and computer-based systems mandatory in many business areas, notably international trade and contributed to the risen in the importance of e-customs practices in foreign trade transactions. Raus, Flügge, and Boutellier (2009) classify the key facilitators' adoption of e-customs solutions into four titles: benefit potential of the public sector, procedural improvements and streamlined business processes, avoidance of misinterpretations of standardized regulations and standardization of processes, messages, and data model. Furthermore, many international transactions are performed remotely, thanks to electronic network connections. Thus, employees can manage many stages of import and export operations with fewer documents and interpersonal interactions by using e-customs implementations which reduce the bureaucracy and complete the transactions faster with the minimum costs. For instance, in Türkiye, electronic (digital) customs practices such as electronic data interchange (EDI) program, single window (SW) & port SW systems, container & port tracking systems, and new computerized transit systems (NCTS) are applied with an effort to facilitate and expedite custom operations and decrease the customs costs (Ministry of Trade, 2023).

E-customs applications are very important in facilitating international trade due to their positive effects in practice. However, there may be some negative effects due to weak electronic infrastructures or failure to integrate electronic systems. Therefore, this study is limited to only evaluating the positive effects of e-customs applications. In this context, this study aims to reveal the positive impacts of e-customs implementations on foreign trade and rank these impacts hierarchically according to their importance weights. The contributions of this study can be stated as follows: (1) this study constructs a new model concerning the impacts of e-customs practices, (2) to the best of my knowledge, this study may be the first one to evaluate the importance weights of positive impacts of e-customs implementations by using Fuzzy AHP with the geometric mean method, and (3) the findings of the study involve recommendations to practitioners in both public and private sectors to encourage and extend e-customs operations.

Literature review

Many studies concern information and communications technology (ICT), electronic systems, and SW systems in foreign trade operations. Most of them discuss e-customs practices and SW platforms in different economies such as Türkiye (Akbay, 2009; Dereli, 2014), Ukraine (Riaboi, 2015; Denysenko, 2020), Mexico (Schwaiger Calvo and Campos, 2017), Iran (Salehi, 2012; Shirsavar and Shirinpour, 2016), Tunisia (Sboui, You and Lee, 2018), Vietnam (Nguyen, Grant, Bovis, Nguyen and Mac, 2021), Croatia (Erceg, 2013), Europe (Henningsson and Henriksen, 2011), Emerging markets (Liu and Nath, 2013) and BRICS countries (Wang and Choi, 2019). Besides, some studies analyze electronic systems focusing on seaports (Heilig and Voß, 2017; Tijan, Jović, Jardas, and Gulić, 2019).

Several studies have reviewed the impacts of electronic systems and the internet on foreign trade transactions. Liu and Nath (2013) found significant positive effects of internet hosts and subscriptions on export and import operations in Emerging markets. Wang and Choi (2019) suggest that implementing ICT in international trade can result in less complex documentation processes, enhancing trade efficiency, increasing speed, and building guarantee systems and BRICS countries should increase the usage of ICT to improve their export volumes. Besides, Belu (2020) analysed the implementation of blockchain technology in customs activities and grouped the advantages of using blockchain

[1] For detailed information, please visit the web site of WTO, www.wto.org

[2] For detailed information, please visit the web site of WTO-Trade facilitation, www.wto.org/english/tratop_e/tradfa_e/tradfa_e.htm

technology as reducing waiting times at customs, facilitating international trade, conformity standards (full access to all product information), easier identification of the goods' origin (information storage), reducing the tax evasion (due to the increase in traceability and transparency), risk management and digitization of customs declaration (ease the managing documents).

In recent years, many studies have aimed to find solutions for trade facilitation problems and focused on e-customs applications, particularly SW systems and NCTS. Urciuoli, Hintsa, and Ahokas (2013) determine five drivers that have different variables for the usage of e-customs platforms as cost savings (communication costs, effective inspections, costs reduction), reliability (data quality and accuracy), time (faster access to data), usefulness (revenue collection, infringements detection, safety, and security, enhanced risk management) and ease of use (reduced personnel efforts). They use the systematic literature review to determine the drivers as well as theoretical frameworks based on TAM (Technology Acceptance Model), TRA (Theory of Reasoned Action), and the theory of DOI (Diffusion of Innovation). Raus et al. (2009) mention six topics regarding e-customs systems that are developed to achieve (1) import and export facilitation, (2) compliance and administrative costs reduction, (3) clearance time improvement, (4) application of the legislation and the control of goods, (5) collection of community duties and charges properly, and (6) a seamless flow of data between the parties and re-use of data. Similarly, Granqvist, Hintsa, and Männistö (2011) imply that implementation of e-customs practices should be driven by real benefits for the traders, involving export procedures facilitation, flexibility improvement in operations with customs, reduction in re-entering customs data during the declaration and providing an opportunity for a correct flow of data between the parties. Besides, Babaei, Javaheri, Dinarvand, and Mahdian (2014) indicate that the e-customs have positive efficacy since they make the export and import processes faster, ease access to information concerning costs and rules and provide extensive communications between the parties involved in customs operations. Shirsavar and Shirinpour (2016) also analyse the effect of e-customs on exportation and state that identifying new opportunities is influential in reducing transaction costs that lead to creating a competitive advantage and export development. Focusing on the SW system in their study, Martínez-Zarzoso and Chelala (2020) agree that single operational windows reduce the time and the number of documents required to complete foreign trade transactions. Moreover, Schwaiger Calvo and Campos (2017) note that an SW for trade in a specific country is influential in reducing time, cost and documents. Although Erceg (2013) discusses a different electronic system (NCTS) in customs, the findings of his study also support that implementation of NCTS positively impacts reducing the number and the duration of customs procedures and operating costs.

Even though several studies discussed the impacts of e-customs practices on foreign trade transactions, it is considered that new studies analysed in different aspects are needed for a better understanding of these crucial implementations and their prevalence in world trade. In this context, the subject of this study is limited to e-customs implementations and their positive effects by addressing two main research questions (RQs):

RQ1. What are the positive impacts of e-customs implementations on foreign trade?

RQ2. What is the ranking of the positive impacts of e-customs implementations hierarchically according to their importance weights?

Methodology

Data collection

This study obtained data on the effects of e-customs applications on foreign trade through the literature review and expert decisions. Firstly, a research model of the study was constructed due to the findings from the related studies and conceptual models in the literature. Then, the experts checked this model to categorize the sub-criteria under the appropriate main criteria. Then, a survey compatible with the research model was conducted on customs (assistant) consultants (experts) in Türkiye. Questionnaire forms were sent via e-mail and fully completed seven of them were included in the analysis. Since the AHP method also allows measuring one decision of a single expert, the number of questionnaire forms was accepted as adequate to obtain valid results. The reliability of the data will also be checked in the last stage of the analysis.

The sample of the study was selected by using the judgement sampling method. All participants of the survey were selected among customs (assistant) consultants. Most have ten years or more experience since they are considered to carry out the best evaluation of the impacts of e-customs implementations for both traders and government sides.

Fuzzy AHP method

This study employed the Fuzzy AHP method, which may be identified as integrating fuzzy numbers in the Analytical Hierarchy Process (AHP). Thus, the roots of the methodology are based on the AHP method. AHP is one of the multi-criteria decision-making methods developed by T. L. Saaty in 1971-1975 to model a problem in a hierarchic structure using pairwise comparisons (Saaty, 1987). The AHP method indicates how often more important one criterion is over another depending on the expert judgements through pairwise comparisons of the criteria (Saaty, 2008). Fuzzy numbers, on the other side, are used to overcome uncertainties in subjective expert decisions. They are indicated by placing the symbol "~" above them. A fuzzy set ($\tilde{A}$) is a class characterized by a membership function in which membership grades of each object range between 0 and 1 (Zadeh, 1965). Triangular fuzzy numbers are indicated with three values as $\tilde{A} = (a_1, a_2, a_3)$ (Figure 1), defined by membership functions ($\mu_{\tilde{A}}(x)$) (equation 1) and have the following conditions (Gani and Assarudeen, 2012: 527):

(1) a_1 to a_2 - increasing function

(2) a_2 to a_3 - decreasing function

(3) $a_1 \leq a_2 \leq a_3$

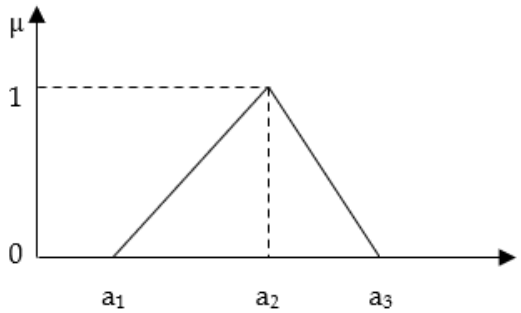

Figure 1: Triangular Fuzzy Number ($\tilde{A}$)

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x-a_1}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \frac{a_3-x}{a_3-a_2}, & a_2 \leq x \leq a_3 \\ 0, & x < a_1 \; and \; x > a_3 \end{cases} \quad (1)$$

Another important subject is determining the linguistic variables defined by Zadeh (1983: 173) as the variables of which values are words, not numbers, in general, linguistic labels of fuzzy sets. Therefore, fuzzy triangular numbers defined by linguistic variables and membership functions demonstrated in Table 1 (Hadi-Vencheh and Mohamadghasemi, 2011) are used in the calculations of this study.

Table 1: Fuzzy numbers, fuzzy linguistic variables, membership function

Fuzzy number	Linguistic variables	Membership function (Triangular Fuzzy Numbers)	Reciprocal Triangular Fuzzy Numbers
$\tilde{1}$	Equally important	(1, 1, 2)	(1/2, 1, 1)
$\tilde{2}$	Weakly important	(1, 2, 3)	(1/3, 1/2, 1)
$\tilde{3}$	More important	(2, 3, 4)	(1/4, 1/3, 1/2)
$\tilde{4}$	Strongly important	(3, 4, 5)	(1/5, 1/4, 1/3)
$\tilde{5}$	Absolutely important	(4, 5, 5)	(1/5, 1/5, 1/4)

Source: Hadi-Vencheh and Mohamadghasemi, 2011

Fuzzy Analytical Hierarchy Process (FAHP) with the geometric mean method proposed by Buckley (1985) was applied in this study since it captures the vagueness of the decisions when comparing two alternatives. Thus, more accurate results were expected to be obtained to rank the impacts (I_m) of e-customs operations in a hierarchy. The steps of the FAHP geometric mean method and empirical results are as follows:

Step 1: Structuring the decision hierarchy

The first step is defining the problem and structuring the decision hierarchy (Saaty, 2008). In a decision hierarchy, homogeneous elements are grouped in the same clusters (Saaty, 1987). The research model

of the study also figures the decision hierarchy in which the major impacts (criteria) and sub-impacts (sub-criteria) of e-customs applications are demonstrated (Figure 2).

Step 2: Structuring pairwise comparison matrices and obtaining one group decision

As previously mentioned, $\tilde{A}$ refers to a fuzzy triangular set structured by pairwise criteria comparisons (impacts). A pairwise comparison matrix of the criteria (impacts) is constructed by evaluating two criteria using triangular and reciprocal fuzzy numbers. In equation 2 (adapted from Hsieh, Lu, and Tzeng, 2004), $\tilde{a}_{12}$ shows the importance of criterion (impact) 1 [I_1= (l_1, m_1, u_1)] relative to criterion (impact) 2 [I_2= (l_2, m_2, u_2)] and $\tilde{a}_{21}$ gives the reciprocal of $\tilde{a}_{12}$; where *l, m, u* are the lower, middle and upper values.

$$\tilde{A} = \begin{array}{c} \\ I_1 \\ I_2 \\ \vdots \\ I_m \end{array} \begin{array}{c} \begin{array}{cccc} I_1 & I_2 & \cdots & I_m \end{array} \\ \begin{bmatrix} 111 & \tilde{a}_{12} & \cdots & \tilde{a}_{1m} \\ \tilde{a}_{21} & 111 & \cdots & \tilde{a}_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{m1} & \tilde{a}_{m2} & \cdots & 111 \end{bmatrix} \end{array} = \begin{array}{c} \\ I_1 \\ I_2 \\ \vdots \\ I_m \end{array} \begin{array}{c} \begin{array}{cccc} I_1 & I_2 & \cdots & I_m \end{array} \\ \begin{bmatrix} 111 & \tilde{a}_{12} & \cdots & \tilde{a}_{1m} \\ 1/\tilde{a}_{21} & 111 & \cdots & \tilde{a}_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{1m} & 1/\tilde{a}_{2m} & \cdots & 111 \end{bmatrix} \end{array} \quad (2)$$

Another crucial point is to achieve one group decision derivated from pairwise comparisons determined by data obtained from expert decisions. Saaty and Vargas (2013) suggest calculating the geometric mean of all individual judgements to construct a judgement for a group. When the multiple experts (judges, $J_1 \ldots J_n$) are employed to rank the criteria, each judge J_l produces a fuzzy positive reciprocal matrix $\tilde{A}_{kl} = \tilde{a}_{ij}^{kl}$ then the average fuzzy positive reciprocal matrices $\tilde{A}_k=[\tilde{a}_{ij}^{k}]$ are calculated as follows (Buckley, 1985: 240):

$$\tilde{a}_{ij}^{k} = (\tilde{a}_{ij}^{k1} \otimes \tilde{a}_{ij}^{k2} \otimes \ldots\ldots \otimes \tilde{a}_{ij}^{kn})^{1/n} \quad (3)$$

Step 3: Calculating the geometric mean of fuzzy comparison value ($\tilde{r}_i$) of each criterion by using equation (4) (Buckley, 1985).

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \ldots \otimes \tilde{a}_{im})^{1/m} \quad (4)$$

Step 4: Obtaining the fuzzy weights ($\tilde{w}_i$) of each criterion by using equation (5) (Buckley, 1985).

$$\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \ldots \oplus \tilde{r}_m)^{-1} \quad (5)$$

Step 5. Defuzzification of the weights

To determine the centre of the area (COA), which is a method of defuzzification of fuzzy ranking, the Best Nonfuzzy Performance value (BNP) of each fuzzy number ($\tilde{R}_i$) is calculated using equation 6 (Hsieh et al., 2004).

$$BNP_i = [(UR_i - LR_i) + (MR_i - LR_i)] / 3 + LR_i \quad \forall i \quad (6)$$

Where; UR – upper value, LR – lower value and MR – middle value of the fuzzy weights

Step 6: Normalizing defuzzified weights

Finally, the non-fuzzy weights of each criterion are normalized by equalling the sum of each column to 1, and the consistency of the results is checked. Saaty and Tran (2007) argue that the consistency ratio (C.R) of a pairwise comparison matrix measures the consistency of the set of judgements with the following equations and should be lower than 0,10:

$$\text{Consistency index (C.I)} = \mu = \frac{\lambda_{max} - n}{n-1} \quad (7)$$

$$\text{Consistency ratio (C.R)} = \frac{C.I}{R.I\ (Random\ index)} \quad (8)$$

where; λ_{max} is the maximum eigenvalue and the random index (RI) for nine criteria is 1,45.

Empirical application

Step 1: In this study, the decision hierarchy is constructed due to the criteria obtained from the literature review and expert decisions concerning the impacts of e-customs implementations (I) on foreign trade operations. Findings revealed a total of 9 impacts (sub-criteria) grouped under three main impact clusters (criteria) defined as (1) Cost, (2) Time, and (3) Reliability (Figure 2).

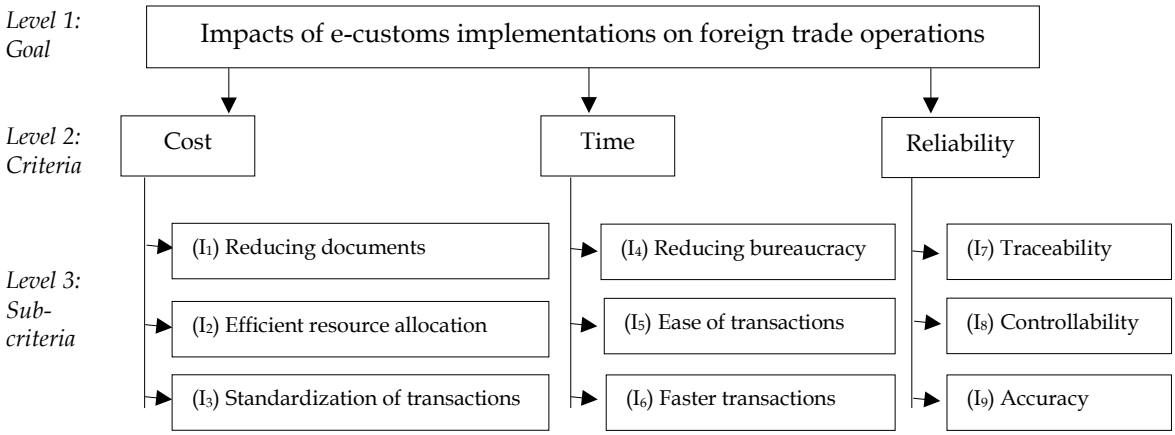

Figure 2: Decision Hierarchy of the Study

Source: Depicted by the author

The first cluster (main criterion) includes sub-criteria (reducing documents, efficient resource allocation, and standardization of transactions) regarding the *Cost*-related impacts of e-customs implementations. The second cluster contains sub-criteria concerning Time-related impacts (reducing bureaucracy, ease of transactions, and faster transactions). In contrast, the third cluster refers to *Reliability*-related impacts (traceability, controllability, and accuracy).

Step 2: The experts evaluate each criterion included in the decision hierarchy by comparing them with each other using a 1 to 5 scale (Table 1). After collected data is converted to fuzzy triangular numbers, a pairwise comparison matrix (Table 2) is obtained using equations 2 and 3.

Table 2: Pairwise comparison matrix

	I_1			**I_2**			**I_3**			**I_4**			**I_5**			**I_6**			**I_7**			**I_8**			**I_9**		
	l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
I_1	1.00	1.00	1.00	1.11	1.65	2.28	0.84	1.08	1.49	0.53	0.68	1.00	0.42	0.49	0.81	0.41	0.52	0.81	0.79	0.93	1.49	0.72	0.88	1.43	0.59	0.70	1.15
I_2	0.44	0.60	0.90	1.00	1.00	1.00	0.46	0.60	1.00	0.35	0.48	0.74	0.35	0.42	0.66	0.42	0.53	0.80	0.43	0.56	0.91	0.59	0.68	1.10	0.50	0.65	0.93
I_3	0.67	0.93	1.19	1.00	1.67	2.19	1.00	1.00	1.00	0.77	0.93	1.26	0.55	0.67	0.92	0.57	0.72	1.08	0.90	1.05	1.53	0.61	0.69	1.00	0.55	0.63	0.98
I_4	1.00	1.47	1.87	1.35	2.10	2.83	0.79	1.08	1.30	1.00	1.00	1.00	0.88	1.09	1.64	0.57	0.65	1.04	1.07	1.27	2.00	1.07	1.55	2.25	0.97	1.31	1.89
I_5	1.24	2.03	2.35	1.51	2.38	2.87	1.09	1.49	1.81	0.61	0.92	1.14	1.00	1.00	1.00	1.07	1.27	2.00	1.13	1.46	2.19	0.85	1.15	1.64	0.57	0.72	1.10
I_6	1.24	1.92	2.43	1.25	1.87	2.38	0.93	1.39	1.75	0.96	1.53	1.75	0.50	0.79	0.94	1.00	1.00	1.00	1.01	1.24	1.87	0.80	1.02	1.45	0.88	1.14	1.65
I_7	0.67	1.08	1.26	1.10	1.79	2.32	0.65	0.95	1.11	0.50	0.79	0.94	0.46	0.68	0.88	0.53	0.81	0.99	1.00	1.00	1.00	0.72	0.79	1.35	0.56	0.64	1.15
I_8	0.70	1.14	1.39	0.91	1.47	1.69	1.00	1.46	1.64	0.45	0.64	0.94	0.61	0.87	1.18	0.69	0.98	1.25	0.74	1.26	1.39	1.00	1.00	1.00	0.65	0.70	1.27
I_9	0.87	1.43	1.69	1.08	1.55	1.99	1.02	1.60	1.81	0.53	0.76	1.03	0.91	1.39	1.75	0.61	0.88	1.14	0.87	1.57	1.79	0.79	1.43	1.53	1.00	1.00	1.00

Step 3-4-5: Fuzzy weights ($\tilde{w}_i$) and non-fuzzy weights of each sub-criterion reported in Table 3 are calculated using equations 4, 5, and 6, respectively.

Table 3: Weights of sub-criteria

	$\tilde{r}_i$			**$\tilde{w}_i$**			**w_i**
	l	*m*	*u*	*l*	*m*	*u*	**Defuzzified weights**
I_1	0.68	0.82	1.21	0.06	0.09	0.17	0.1063
I_2	0.48	0.60	0.88	0.04	0.06	0.13	0.0771
I_3	0.72	0.88	1.19	0.06	0.10	0.17	0.1087
I_4	0.94	1.22	1.67	0.08	0.13	0.24	0.1501
I_5	0.97	1.29	1.69	0.08	0.14	0.24	0.1542
I_6	0.92	1.27	1.61	0.08	0.14	0.23	0.1487
I_7	0.66	0.90	1.17	0.05	0.10	0.17	0.1069
I_8	0.73	1.02	1.28	0.06	0.11	0.19	0.1183
I_9	0.83	1.25	1.48	0.07	0.13	0.21	0.1390

Step 6: Non-fuzzy weights of each criterion are normalized to obtain the rankings of the main criteria and sub-criteria (Table 4). Lastly, the consistency of the judgement (pairwise comparison) matrix is checked, and the consistency ratio is found to be smaller than 0,10, which shows that the study results are acceptable.

Table 4: Rankings of Main Criteria and Sub-Criteria

		Normalized weights (w_i)		**Ranking**	
Criteria	*Sub-criteria*	*Criteria*	*Sub-criteria*	*Criteria*	*Sub-criteria*
Cost	I_1	0.2633	0.0958	3	8
	I_2		0.0695		9
	I_3		0.0980		6
Time	I_4	0.4084	0.1353	1	2
	I_5		0.1390		1
	I_6		0.1340		3
Reliability	I_7	0.3284	0.0964	2	7
	I_8		0.1067		5
	I_9		0.1253		4

Results

Results of the study for RQ1 show that findings obtained from the literature and expert decisions hover mostly around the impacts of e-customs (sub-criteria) as *reducing documents, efficient resource allocation, standardization of transactions, reducing bureaucracy, ease of transactions, faster transactions, traceability, controllability,* and *accuracy*. After that, these impacts were categorized under the main impact groups (criteria) as *Time, Cost,* and *Reliability* according to impact similarities.

The results related to RQ2 indicate that the *Time* criterion has the highest impact on e-customs implementations, with a weight of 0.4084 among the main criteria. The second effective main criterion is *Reliability* (0.3284), followed by *Cost* (0.2633) criterion. As the sub-criteria are analysed, findings reveal that the first three important impacts of e-customs implementations are ease of transactions (0.1390), reducing bureaucracy (0.1353), and faster transactions (0.1340). In contrast, the least important ones are efficient resource allocation (0,0695), reducing documents (0,0958) and traceability (0,0964), respectively (Figure 3).

Figure 3: Importance Weights of Impacts

Time-related impacts (*ease of transactions, reducing bureaucracy,* and *faster transactions)* are not only the most important ones but also have relative importance weights to each other. Similarly, many studies (Urciuoli et al., 2013; Schwaiger Calvo and Campos, 2017; Martínez-Zarzoso and Chelala, 2020) also support that time-related factors are one of the important issues of e-customs. Besides, the study of Raus et al. (2009) points out that procedural improvements and developed business processes are among the facilitators of adopting a standardized e-customs solution, which benefits time savings.

Accuracy, controllability, and traceability impacts under *Reliability*-related impacts have moderate importance in e-customs operations. However, Urciuoli et al. (2013) argue that enhanced risk management, increased safety and security, data quality and accuracy are the variables having the highest scores, respectively, in measuring the drivers of the usage of electronic data exchange in customs. Similarly, Raus et al. (2009) identify that one of the benefits of e-customs solutions is higher accuracy in the data processing.

Although many studies support a noticeable cost decrease using e-custom implementations (Schwaiger Calvo and Campos, 2017; Erceg, 2013), the cost criterion in this study emerged as the least important main criterion. Besides, many studies emphasise the reduction of documents as an important effect (Martínez-Zarzoso and Chelala, 2020; Schwaiger Calvo and Campos, 2017). Surprisingly, it was ranked lower in this study. This may be because all documentation has not yet been processed electronically in e-customs applications in Türkiye. In addition, standardization of transactions was found to have low importance among the others. The customs consultants' perception of this criterion may be low because they think this results from the first two sub-criteria (ease of transaction and faster transactions). They may consider that easy and faster transactions will enable standardization. Moreover, time and reliability-related impacts are more important since they are involved in the control mechanisms of customs practices and have high workloads.

Conclusion

Developments in ICT are rapidly advancing in all areas of the world. In particular, the widespread use of internet connections and computer network systems allows many operations to be performed more efficiently and productively for both micro and macro scales. Single Window (SW) and automation systems are primary examples of e-customs implementations and provide many advantages for private and public authorities engaged in international trade operations. As a result, they are widely implemented, particularly by developed countries, to reduce cost and time-related problems.

This study aims to explain the impacts of e-customs applications on foreign trade by ranking them to the extent of their importance weights. According to the customs (assistant) consultants, the findings indicate that time and reliability-related impacts are more important than cost-related impacts. Undoubtedly, e-customs applications have important effects, particularly in the making transactions faster and safer. It is considered that customs procedures and processes will be faster and more reliable by disseminating digital customs applications in Türkiye. As a result, transactions will be carried out in a safer environment by minimizing faults. Accordingly, this will be crucial in increasing Türkiye's competitiveness in international trade. Although the cost effect appears to be the least important, reducing documents and procedures by e-customs applications will reduce transaction costs, particularly for businesses. This criterion may also be considered important for the private sector.

The limited number of experts and time are the limitations of the study. However, different findings can be obtained if future studies address this issue considering different authorities involved in foreign trade transactions in different regions. This study is supposed to contribute to similar studies on the subject in the future and the practitioners in both private and public sectors.

Peer-review:

Externally peer-reviewed

Conflict of interests:

The author has no conflict of interest to declare.

Grant Support:

The author declared that this study had received no financial support.

Acknowledgement:

The author would like to thank all the experts who contributed to this study by taking their valuable time to fill out the questionnaire forms.

Ethics Committee Approval:

Ethics committee approval was received for this study from Manisa Celal Bayar University, Social and Humanities Scientific Research and Publication Ethics Committee on 16/07/2021 and 2021/07 meeting/document number.

References

Akbay, O. S. (2009), "Computerization of Foreign Trade Transactions: A Case Study of Turkey", Trakia Journal of Sciences, Vol. 7(3), 43-47.

Babaei, D., Javaheri, N., Dinarvand, H., and Mahdian, M. J. (2014), "The Role of E-Customs in Promotion of Lorestan-Iran Customs", Kuwait Chapter of the Arabian Journal of Business and Management Review, Vol. 3(7), 341-353.

Belu, M. G. (2020), "Blockchain Technology and Customs Procedures", Romanian Economic Journal, Vol. 23(78), 13-26.

Buckley, J. J. (1985), "Fuzzy Hierarchical Analysis", Fuzzy Sets and Systems, Vol. 17(3), 233-247.

Denysenko, M. P. (2020), "Management Technologies for Enhancing Integrated Processes in The Customs and Logistics Services Sector", Bulletin of The Kyiv National University of Technology and Design. Economic Sciences Series, Vol. 3(147), 57-66.

Dereli, D. D, (2014), "E-Gümrük Uygulamasının Türkiye ile Avrupa Birliği Arasındaki Ticarete Etkisi", Yönetim ve Ekonomi Araştırmaları Dergisi, Vol. 12(24), 250-261.

Ding, N. (2016), "Research on Constructing the Information Platform of Customs", In Proceedings of the 22nd International Conference on Industrial Engineering and Engineering Management 2015, Qi E., Shen J., Dou R. (eds), 547-557, Paris: Atlantis Press.

Erceg, A. (2013), "The New Computerized Transit System and E-Customs Influence on Savings in Transit Time and Costs", Business Logistics in Modern Management, 13, 143-152.

Gani, A. N., and Assarudeen, S. M. (2012), "A New Operation on Triangular Fuzzy Number for Solving Fuzzy Linear Programming Problem", Applied Mathematical Sciences, Vol. 6(11), 525-532.

Granqvist, M., Hintsa, J. and Männistö, T. (2011), "E-Customs Study: Private Sector Views on Potential Benefits of Further Electronic Customs Developments in Switzerland", In 1st Workshop on IT Innovations Enabling Seamless and Secure Supply Chains, WITNESS 2011, 49-59.

Hadi-Vencheh, A., and Mohamadghasemi, A. (2011), "A Fuzzy AHP-DEA Approach for Multiple Criteria ABC Inventory Classification", Expert Systems with Applications, Vol. 38(4), 3346-3352.

Heilig, L. and Voß, S. (2017), "Information Systems in Seaports: A Categorization and Overview", Information Technology and Management, 18, 179-201.

Henningsson, S. and Henriksen, H. Z. (2011), "Inscription of Behaviour and Flexible Interpretation in Information Infrastructures: The Case of European E-Customs", The Journal of Strategic Information Systems, Vol. 20(4), 355-372.

Hsieh, T. Y., Lu, S. T., and Tzeng, G. H. (2004), "Fuzzy MCDM Approach for Planning and Design Tenders Selection in Public Office Buildings", International Journal of Project Management, Vol. 22(7), 573-584.

Liu, L. and Nath, H. K. (2013), "Information and Communications Technology and Trade in Emerging Market Economies", Emerging Markets Finance and Trade, Vol. 49(6), 67-87.

Martínez-Zarzoso, I. and Chelala, S. (2020), "The Impact of Single Windows on Trade", The World Economy, Vol. 43(10), 2549-2573.

Ministry of Trade (2023), "Dijital Gümrük Uygulamaları", https://ticaret.gov.tr/gumruk-islemleri/dijital-gumruk-uygulamalari, (Access date: 03.01.2023).

Nguyen, H. T., Grant, D. B., Bovis, C., Nguyen, T. T. L., and Mac, Y. T. H. (2021), "Factors Affecting Efficiency of Electronic Customs and Firm Performance in Vietnam", Journal of Asian Finance, Economics and Business, Vol. 8 (2): 0151-0164.

Raus, M., Flügge, B. and Boutellier, R. (2009), "Electronic Customs Innovation: An Improvement of Governmental Infrastructures", Government Information Quarterly, Vol. 26(2), 246-256.

Riaboi, V. (2015), "E-Customs as A Part of E-Government: State, Problems and Prospects (Ukrainian Experience)", Customs Scientific Journal, Vol. 5(2), 68-74.

Saaty, R. W. (1987), "The Analytic Hierarchy Process - What It is and How It is Used", Mathematical Modelling, Vol. 9 (3-5), 161-176.

Saaty, T. L. (2008), "Decision Making with the Analytic Hierarchy Process", International Journal of Services Sciences, Vol. 1(1), 83-98.

Saaty, T. L., and Tran, L. T. (2007), "On The Invalidity of Fuzzifying Numerical Judgments in The Analytic Hierarchy Process", Mathematical and Computer Modelling, Vol. 46(7-8), 962-975.

Saaty, T. L. and Vargas, L. G. (2013), "The Analytic Network Process", In Decision Making with The Analytic Network Process, 1-40, Boston, MA: Springer.

Salehi, M. (2012), "Barriers to E-Customs in an Emerging Economy: The Case of Iran. Management", 7(2): 129-153.

Sboui, H., You, K.B and Lee K.H. (2018), "A Study on Designing Novel Solutions of Paperless Office-Focus on Tunisian e Customs Systems", International Journal of Hybrid Information Technology, Vol. 11(3), 23-28.

Schwaiger Calvo A., and Campos C. (2017), "Mexico: Single Window for Foreign Trade", In: Digital Government, Falk S., Römmele A., Silverman M. (eds), 85-103, Cham: Springer.

Shirsavar, H. A. and Shirinpour, M. (2016), "The Effect of Electronic Customs Administration on Facilitating The Export Activities of Export Companies Based in Gilan, Iran", Intellectual Economics, Vol. 10(2), 114-121.

Tijan, E., Jović, M., Jardas, M., and Gulić, M. (2019), "The Single Window Concept in International Trade, Transport and Seaports", Pomorstvo, Scientific Journal of Maritime Research, Vol. 33(2), 130-139.

Urciuoli, L., Hintsa, J. and Ahokas, J. (2013), "Drivers and Barriers Affecting Usage of E-Customs - A Global Survey with Customs Administrations Using Multivariate Analysis Techniques", Government Information Quarterly, Vol. 30(4), 473-485.

Wang, M. L., and Choi, C. H. (2019), "How Information and Communication Technology Affect International Trade: A Comparative Analysis of BRICS Countries", Information Technology for Development, Vol. 25(3), 455-474.

WTO (2023), "Trade facilitation", https://www.wto.org/english/tratop_e/dtt_e/dtt-tradfa_e.htm, (Access date: 03.01.2023).

Zadeh, L. A. (1965), "Fuzzy Sets", Information and Control, Vol. 8 (3), 338–353.

Zadeh, L. A. (1983), "Linguistic Variables, Approximate Reasoning and Dispositions", Medical Informatics, Vol. 8(3), 173-186.