DOI: 10.5281/zenodo.24109780
Link: https://zenodo.org/records/24109780

A COMPOSITE CUSTOMS SERVICE EFFICIENCY INDEX WITH HYBRID AHP-ENTROPY WEIGHTING: EVIDENCE FROM HOUSEHOLD APPLIANCE IMPORTS IN UZBEKISTAN (2016-2025)

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Abstract. *Customs administrations are usually judged by the revenue they collect, although traders care just as much about clearance time and the quality of digital services. The article proposes a composite Customs Service Efficiency Index (CSEI) that measures customs performance in four blocks at once: fiscal results, time and speed, control quality and risk, and digital service. The aim is to link the assessment of the customs service to the numerical targets of national strategies and to test the index on Uzbek data for 2016-2025. Eight indicators were normalised to the targets of Decrees PF-57 and PF-174 instead of the sample minimum and maximum, so the index shows how far the administration is from its own goals. Indicator weights combine expert weights from the analytic hierarchy process (consistency ratio 0.004) with entropy weights that reflect the observed variability of the data. In Uzbekistan the index rose from 0.374 in 2016 to 0.718 in 2025 and moved from the critical to the medium level. However, 93.9% of the increase came from the fiscal block. The time and speed block rose from 0.540 in 2020 to 0.727, while the digital service block fell from 0.471 in 2018 to 0.396 and remained the weakest. The ranking of years is robust to the weighting scheme (Spearman's $\rho = 0.988$). The results suggest that the composite value should be published together with its four block indices and that each block needs a target of its own. Implications are drawn for the control of household appliance imports, a segment exposed to undervaluation risk.*

Keywords: *customs service, efficiency, composite index, analytic hierarchy process, entropy weights, target-based normalisation, trade facilitation, Logistics Performance Index, household appliances, Uzbekistan.*

INTRODUCTION

Customs administrations collect revenue, protect the domestic market and provide services to traders at the same time, and each of these functions has its own measure of success. Time at the border is now treated as a trade cost in its own right. D. Hummels and G. Schaur showed that each day in transit is equivalent to an ad valorem tariff of 0.6-2.1% and that firms are willing to pay a premium for faster delivery [1]. International benchmarks such as the World Bank's Logistics Performance Index[1] (LPI) compare countries, but they do not tell a national customs administration how far it is from its own strategic targets [2].

Uzbekistan is a clear case for such measurement. Customs revenue reached UZS 76.2 trillion in 2025, 13.6 times more than in 2016, and made up about a quarter of state budget revenues. In the

[1]The Logistics Performance Index (LPI) is a World Bank benchmark that rates countries on a 1-5 scale by six components (customs, infrastructure, international shipments, logistics competence, tracking and tracing, timeliness), based on a survey of international freight forwarders.

same year, only 20% of declarations were processed without human intervention. National strategies contain explicit numerical targets. Decree PF-57 provides for reducing the share of inspected declarations from 21% to 15% by 2028 and for reaching at least 55th place in the LPI customs component by 2030 [3]. The "New Uzbekistan Customs-2030" Strategy approved by Decree PF-174 envisages import clearance in about 2 hours and a 60% share of automatic clearance [4].

Household appliances (HS headings 8415-8528) add a specific risk to these targets. In January-July 2025 alone, 893.7 thousand refrigerators, washing machines and air conditioners were imported, 80.6% of them from China, at average prices of USD 121-222 per unit. With such a narrow price range and many similar consignments, undervaluation is the main control risk, and the speed and predictability of clearance directly affect dealers' supply plans.

The scientific problem is that existing assessments of customs performance in Uzbekistan focus on revenue collection. Clearance time, control quality and digital services are monitored separately, if at all, and there is no single measure that combines them and shows the distance to the targets set by the state. Without such a measure, rapid revenue growth can hide stagnation in the quality of service.

The aim of the article is to develop a composite index that links the performance of the customs service to state targets and to test it on Uzbek data for 2016-2025. To achieve this aim, the study (1) defined a structure of four blocks and eight indicators with continuous annual series; (2) normalised the indicators to the targets of national strategies; (3) derived indicator weights by combining the analytic hierarchy process with entropy weighting and tested the consistency of expert judgements; (4) calculated the composite and block indices for 2016-2025 and decomposed the growth of the index by blocks; (5) tested the robustness of the results to the weighting scheme; and (6) formulated recommendations for customs reporting and for the control of household appliance imports.

The object of the research is the customs service of the Republic of Uzbekistan. The subject is the methodology for measuring the efficiency of a customs administration with a composite index tied to national targets. The hypothesis is that the improvement of customs performance in 2016-2025 was driven mainly by fiscal indicators, while the time and digital dimensions lagged behind.

The novelty of the study lies in normalising indicators to the targets of national strategies rather than to sample extremes, in a hybrid AHP-entropy weighting scheme in which expert priorities limit the influence of volatile indicators, and in decomposing index growth by functional blocks.

LITERATURE REVIEW

The methodology of composite indicators[2] is standardised in the OECD-JRC Handbook. It sets out a sequence of steps: theoretical framework, selection of indicators, normalisation, weighting, aggregation and sensitivity analysis [5]. The Handbook recommends min-max normalisation for cross-country comparisons. In the annual series of a single administration, however, this method rescales all previous values whenever a new year is added, so earlier results cannot be compared with later ones. Where the state has set explicit targets, normalisation to the target is more appropriate, because the index then measures progress towards a fixed point.

International benchmarks follow a different route. The LPI is based on a survey of international freight forwarders [2], and the World Bank's Doing Business indicator "Trading across borders" was calculated for a single standard consignment [6]. Both are useful for comparing countries, but they capture perceptions or a stylised case rather than the actual flow of goods, and neither is linked to national targets. The estimate of the cost of time by Hummels and Schaur [1] explains why these benchmarks pay so much attention to clearance time, which a purely fiscal assessment of customs usually ignores.

Studies of efficiency in customs have followed two lines. Frontier methods, above all data envelopment analysis (DEA), estimate the relative efficiency of customs offices. A. Benazić applied

[2]A composite indicator is a single measure obtained by aggregating several normalised individual indicators with weights according to an underlying conceptual model.

DEA to Croatian customs offices and found substantial differences in their efficiency [7]. DEA, however, requires panel data on the inputs and outputs of individual offices, and such data are not published in Uzbekistan. The second line consists of rating indices. V.V. Popov proposed a rating of customs authorities based on normalised indicators of payment collection, arrears and additional charges, with fixed expert weights of 0.1-0.3 [8]. In Uzbekistan, A.R. Muqimov developed medium-term forecasts of customs revenue up to 2030 [9]. In both cases efficiency is reduced to the fiscal function: clearance time and digital services stay outside the assessment, and the consistency of expert weights is not tested. Z. Bobojonova, using the example of JSC "Uzbekistan Railways", proposed raising efficiency through an integration mechanism of singular and applied economics that combines theoretical efficiency criteria with applied indicators [10]. The CSEI follows the same logic, with the applied indicators tied to national targets.

Two families of weighting methods are widely used. The analytic hierarchy process (AHP)[3] of T.L. Saaty derives weights from pairwise comparisons and accepts them if the consistency ratio does not exceed about 10% [11]. Objective entropy weights[4] go back to C.E. Shannon's information theory [12] and give larger weights to indicators that vary more over time. Expert weights reflect policy priorities but ignore the data, while entropy weights reflect the data but ignore priorities.

The literature thus offers a standard procedure for building composite indicators, frontier methods that need office-level data unavailable in Uzbekistan, and fiscal ratings that leave out time and service. None of these approaches measures a national customs administration against its own strategic targets across all four functions, and none combines expert and data-driven weights. This article addresses that gap with a target-normalised index and a hybrid weighting scheme.

METHODOLOGY

The study used the OECD-JRC sequence for constructing composite indicators [5], the analytic hierarchy process, the entropy method and sensitivity analysis. Annual data for 2016-2025 were taken from official publications of the Customs Committee and the National Statistics Committee of Uzbekistan, the LPI database [2] and the Doing Business reports [6]. The targets came from Decrees PF-57 and PF-174 [3; 4].

The CSEI was built as a two-level hierarchy of four blocks and eight indicators (Figure 1). Each block was represented by two indicators with a continuous annual series for 2016-2025.

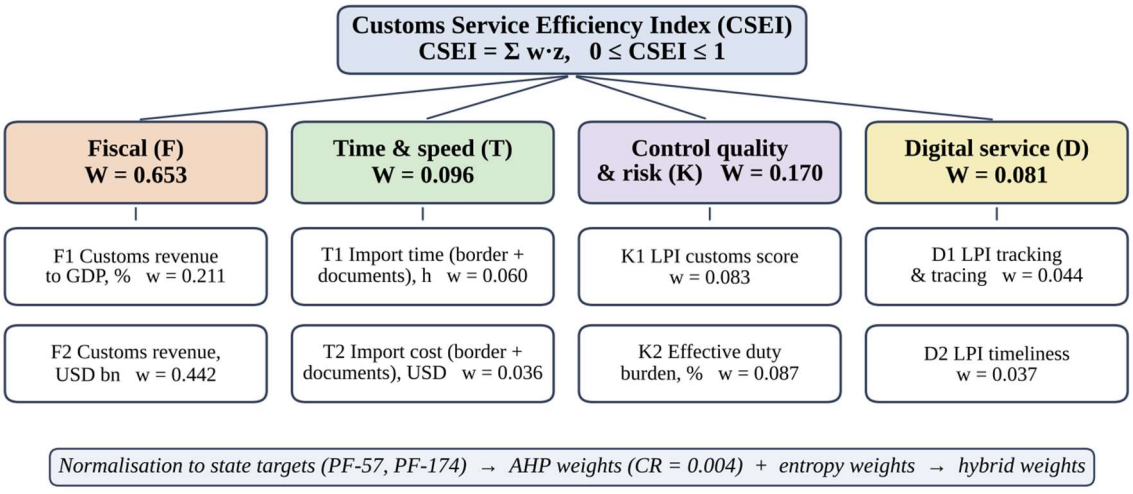


Figure 1. Structure of the Customs Service Efficiency Index[5]

[3]The analytic hierarchy process (AHP) is a multi-criteria decision method in which weights are derived from the principal eigenvector of a matrix of pairwise expert comparisons; the consistency of judgements is tested by the consistency ratio.
[4]An entropy weight is an objective weight that is larger for indicators whose values differ more across observations and therefore carry more information.
[5]Developed by the author. W is the final block weight and w the final indicator weight.

Indicators were normalised to the target value x_j^* according to their direction:

$$z_{tj} = \min(x_{tj}/x_j^*;\ 1), \quad z_{tj} = \min(x_j^*/x_{tj};\ 1), \quad z_{tj} = (x_{tj} - 1)/4, \tag{1}$$

where z_{tj} is the normalised value (0-1) of indicator j in year t. The first expression was applied to stimulants (F1, F2, K2), the second to destimulants (T1, T2) and the third to LPI scores on the 1-5 scale (K1, D1, D2). The targets and normalised values are given in Table 1.

Table 1.

CSEI indicators, targets and normalised values[6]

Indicator, unit	Block	Target	z, 2016	z, 2025
F1. Customs revenue to GDP, %	F	5.0	0.386	0.824
F2. Customs revenue, USD bn	F	8.0	0.236	0.757
T1. Import time (border and documentary compliance), hours	T	130.3	0.457	0.833
T2. Import cost (border and documentary compliance), USD	T	285.0	0.500	0.548
K1. LPI customs score, 1-5	K	5.0	0.330	0.400
K2. Effective duty burden, %	K	15.0	1.000	0.853
D1. LPI tracking and tracing, 1-5	D	5.0	0.262	0.350
D2. LPI timeliness, 1-5	D	5.0	0.458	0.450

The target for F1 was set at 5.0% instead of the 4.4% envisaged in PF-174 [4], because the actual ratio had already reached 4.63% in 2023 and a lower target would no longer distinguish between years. The target for T1 was set at 130.3 hours, half of the 2019 Doing Business value [6], and the target for T2 at half of the 2016 import cost. K2, the effective duty burden[7], was benchmarked against 15%, close to its 2016 level, and was used as an indicator of how fully customs value is declared.

Block weights were determined by AHP. In the pairwise comparison matrix, the fiscal block was rated 3 times more important than the time and digital blocks and 2 times more important than the control block; the control block was rated 2 times more important than the time and digital blocks. The principal eigenvector and consistency were calculated as:

$$A \cdot w = \lambda_{max} \cdot w, \quad CI = (\lambda_{max} - n)/(n - 1), \quad CR = CI/RI, \tag{2}$$

which gave $\lambda_{max} = 4.010$, $CI = 0.003$ and $CR = 0.004$, about 25 times below the 0.1 threshold [11]. Entropy weights were calculated over $m = 10$ years:

$$p_{tj} = z_{tj}/\Sigma_t z_{tj}, \quad E_j = -(1/\ln m) \cdot \Sigma_t p_{tj} \ln p_{tj}, \quad e_j = (1 - E_j)/\Sigma_l (1 - E_l). \tag{3}$$

The final weights combined both sources in equal proportions, and the composite and block indices were computed as weighted sums:

$$w_j = 0.5 w_j^{AHP} + 0.5 \cdot w_j^{AHP} e_j / \Sigma_l w_l^{AHP} e_l, \quad \Sigma_j w_j = 1, \tag{4}$$

$$CSEI_t = \Sigma_j w_j z_{tj}, \quad I_{tk} = \Sigma_{j \in k} w_j z_{tj} \ / \ \Sigma_{j \in k} w_j, \tag{5}$$

where I_{tk} is the index of block k (F, T, K, D). The CSEI equals the sum of block indices weighted by the final block weights.

Target-based normalisation was chosen because it keeps past values stable when a new year is added and relates each indicator to an official goal. The hybrid scheme was chosen because neither expert nor entropy weights alone account for both policy priorities and data variability. In this scheme

[6]Compiled by the author based on official data of the Customs Committee and the National Statistics Committee of Uzbekistan, World Bank data [2; 6] and the targets of [3; 4].

[7]The effective duty burden is the ratio of customs payments actually collected to the customs value of imports. If it falls while legal rates stay the same, exemptions or undervaluation are growing.

the AHP weight enters twice, so an indicator without expert priority cannot dominate the index merely because it is volatile. The index was interpreted on a four-level scale: below 0.40 is critical, 0.40-0.59 low, 0.60-0.79 medium, and 0.80 or above high. Of the 80 cells of the data matrix, 45 were filled by linear interpolation between benchmark years, by carrying forward the last LPI survey value or by the author's estimates, so the index reflects the trend rather than exact annual changes. Robustness was tested by recalculating the index with AHP weights only and with equal weights and by comparing the rankings of years with Spearman's rank correlation.

ANALYSIS AND RESULTS

Weights. The results of the three weighting stages are given in Table 2. The lowest entropy was observed for F2 (0.961), whose dollar value increased 3.2 times, so its entropy weight reached 0.539. T2 has not changed since 2019, and its entropy weight does not exceed 0.005.

Table 2.

AHP, entropy and final weights of CSEI indicators[8]

Weight	F1	F2	T1	T2	K1	K2	D1	D2
AHP	0.228	0.228	0.070	0.070	0.131	0.131	0.070	0.070
Entropy	0.159	0.539	0.134	0.005	0.049	0.060	0.045	0.008
Final	**0.211**	**0.442**	**0.060**	**0.036**	**0.083**	**0.087**	**0.044**	**0.037**

In the final weights, the share of the fiscal block rose from 0.455 under AHP to 0.653, while the time, control and digital blocks received 0.096, 0.170 and 0.081 respectively.

Dynamics of the index. The CSEI increased from 0.374 in 2016 to 0.718 in 2025, or 1.9 times (Figure 2). It was at the critical level in 2016 and 2018, at the low level in 2017 and 2019-2021, and has been at the medium level since 2022. In 2025 it was still 0.082 points below the threshold of the high level.

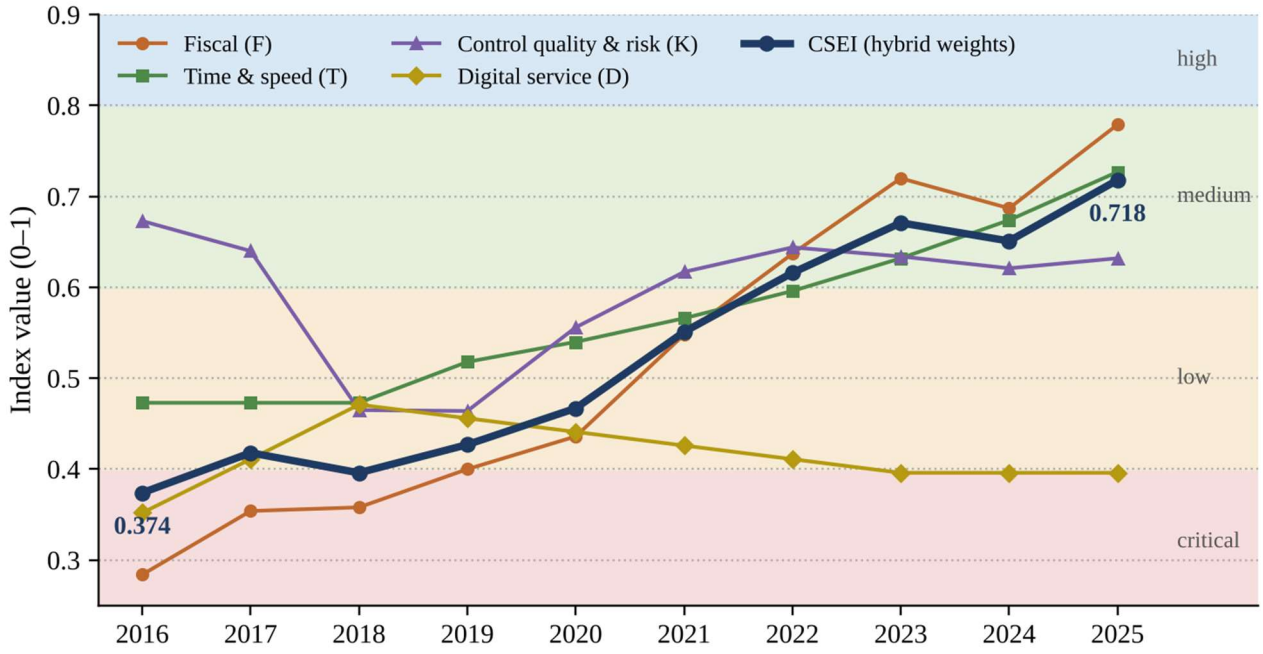


Figure 2. Dynamics of the CSEI and its blocks in Uzbekistan, 2016-2025[9]

The blocks moved in different directions. The fiscal block rose from 0.284 to 0.779 and became the leader in 2023. The time and speed block grew continuously from 0.540 in 2020 to 0.727 in 2025, after the introduction of the "Single Window" and risk-based processing of declarations. The

[8]Calculated by the author.
[9]Calculated by the author based on Table 1 indicators and formulas (1)-(5).

control quality and risk block fell from 0.673 to 0.465 in 2018, when imports grew by 37.6% after currency liberalisation and the effective duty burden dropped to 9.7%; by 2025 it had recovered to 0.632. The digital service block peaked at 0.471 in 2018 and declined to 0.396 in 2023-2025, as the LPI tracking component fell from 2.71 to 2.40 points and the timeliness component from 3.09 to 2.80 points [2]. The gap between the highest and the lowest block was 0.389 points in 2016 and 0.383 points in 2025; the control block led in 2016 and the fiscal block in 2025.

International benchmarks show a similar picture for time and control. In Doing Business 2020, Uzbekistan ranked 152nd in "Trading across borders" [6], and the CSEI time block in 2019 was 0.518, slightly above half of the target level. In the LPI 2023, the country's overall score rose to 2.60 and it ranked 88th, but in the customs component it ranked only 140th [2], far from the 55th place set by PF-57 [3]; the normalised K1 value did not exceed 0.400.

Decomposition and sensitivity. Of the 0.344-point increase in the index, 0.323 points (93.9%) came from the fiscal indicators F1 and F2 and 0.024 points from the time block, while the combined contribution of the control and digital blocks was slightly negative (Figure 3a).

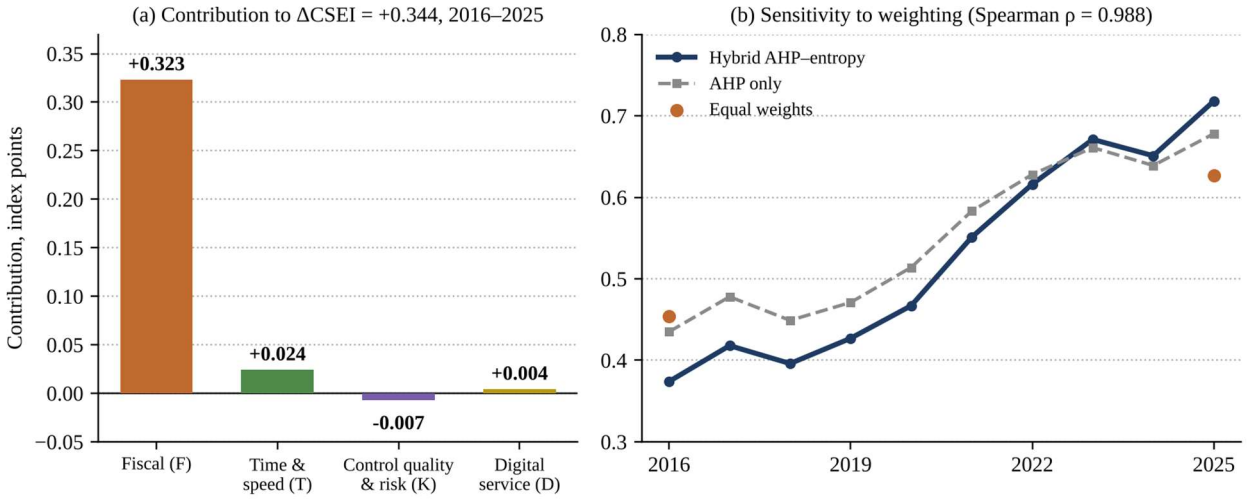


Figure 3. Decomposition of CSEI growth (a) and sensitivity of the index to the weighting scheme (b)[10]

Sensitivity was tested with two alternative weight sets (Table 3). The absolute level of the index depends on the weight of the fiscal block, but the direction of change and the ranking of years do not: the Spearman rank correlation between the hybrid and AHP-only series is 0.988 (Figure 3b).

Table 3.

CSEI values under alternative weighting schemes[11]

Weighting scheme	2016	2025	Growth, times
Hybrid AHP-entropy	0.374	0.718	1.9
AHP only	0.435	0.678	1.6
Equal weights (1/8)	0.454	0.627	1.4

The final weights also determine how far each block can move the index. Raising the digital block from 0.396 to 0.600 would increase the CSEI by only 0.017 points, and bringing the time block to its target would add no more than 0.026 points. An additional USD 1 billion of customs revenue would raise the index by 0.055 points through F2.

DISCUSSION

The study set out to link the assessment of the customs service to national targets, and the

[10]Calculated by the author.
[11]Calculated by the author.

results confirm the hypothesis stated in the introduction: efficiency in Uzbekistan improved mainly along the fiscal dimension. This agrees with the fiscal emphasis of the rating approaches of V.V. Popov [8] and A.R. Muqimov [9], but the CSEI also shows what those approaches leave out. The quality of service perceived by traders has not improved since 2018. The author's separate estimates put the elasticity of customs payments with respect to the value of imports in national currency at 0.931, so fiscal growth largely reflects import volumes and the exchange rate rather than management decisions as such. Measuring time, as D. Hummels and G. Schaur argue [1], therefore corrects the picture given by fiscal indicators.

Hybrid weighting kept the expert priorities but carried the variability of the data into the index, and this strengthened its fiscal orientation. As a result, the service blocks have little leverage over the composite value, while an extra billion dollars of revenue moves it three times more than a large improvement in digital service. The index should therefore be published together with its four block indices, and targets should be set for each block separately. Otherwise the composite value will mask stagnation in service quality.

The LPI and Doing Business rest on an expert survey or a single standard consignment [2; 6]. The CSEI puts fiscal, time, control and digital indicators on one scale and relates them to national targets, so it complements these international benchmarks rather than replacing them.

For household appliances, low values of the time and digital blocks cost more than for the average importer. The segment consists of numerous repetitive consignments of standard goods, and predictability of delivery determines inventory and dealer supply plans. The effective duty burden fell from 15.6% in 2016 to 12.8% in 2025, whereas the author's scenario estimates put the legal burden for the main appliance types at 35.5-67.4%. This suggests that the reserve of the control block lies in price profiling and the management of exemptions rather than in the rates.

The study has several limitations. A large share of the data matrix consists of interpolated cells. F2 is expressed in nominal dollars, which inflates its entropy weight. The index is calculated for the country as a whole rather than for a segment. Building a segment version of K2 and T1 for HS headings 8415-8528 is a direction for further research.

CONCLUSION

This study proposed a comprehensive Customs Service Efficiency Index (CSEI) designed to assess the effectiveness of customs administration in Uzbekistan through an integrated and multidimensional approach. The index incorporates eight key performance indicators grouped into four functional blocks: fiscal performance, time efficiency, customs control and digital services. The indicators were normalised against the strategic targets established by national policy documents PF-57 and PF-174, ensuring alignment with the country's customs modernisation priorities. A hybrid weighting methodology combining the Analytic Hierarchy Process (AHP) and entropy method was applied to balance expert judgments with the statistical characteristics of the indicators. The resulting consistency ratio of 0.004 confirms the high internal consistency of the expert assessments and supports the methodological reliability of the proposed framework.

The empirical findings demonstrate a substantial improvement in the overall efficiency of Uzbekistan's customs administration between 2016 and 2025. During this period, the composite CSEI increased from 0.374 to 0.718, indicating a transition from the critical efficiency category to the medium efficiency category. This positive trend reflects the cumulative effects of customs reforms, improvements in administrative procedures and institutional modernisation. Furthermore, the robustness analysis revealed a strong correlation between the annual rankings obtained under alternative weighting approaches (Spearman's $\rho = 0.988$). This result suggests that the observed long-term improvement is not highly sensitive to the selected weighting methodology, thereby strengthening the credibility and comparability of the index results.

Despite the considerable improvement in the composite index, the analysis revealed significant structural imbalances between the four functional blocks. The fiscal component accounted for 93.9% of the total increase in the composite index, demonstrating that the overall improvement was driven predominantly by fiscal performance rather than balanced institutional development. In

contrast, the digital services block declined from 0.471 to 0.396 and remained the weakest component throughout the assessment period. Moreover, the disparity between the functional blocks did not decrease over the ten-year period, indicating the persistence of structural weaknesses in customs administration. These findings highlight the importance of moving beyond improvements in aggregate performance and adopting a more balanced reform strategy that prioritises digital transformation, service accessibility, administrative transparency and operational efficiency.

Based on the findings, it is recommended that the Customs Committee of Uzbekistan institutionalise the proposed CSEI as a regular instrument for performance monitoring, strategic planning and evidence-based decision-making. Beginning in 2027, the Committee should incorporate the composite index and its four functional block indices into its annual performance reports and ensure the publication of all eight underlying indicators by 1 March each year. In addition, separate strategic targets should be established for 2030, including an increase in the digital services block index to at least 0.600 and an improvement in the overall CSEI to above 0.800. Particular attention should be given to strengthening digital customs infrastructure, expanding electronic service delivery and improving the interoperability of customs information systems. Furthermore, systematic annual data collection on import values, customs payments and clearance times for household appliance commodity headings should be introduced. Such data would enable the development of a sector-specific version of the CSEI, facilitating more detailed assessments of customs performance across individual commodity groups. The proposed measures would contribute to more transparent, measurable and balanced customs administration reforms while establishing a sustainable framework for monitoring progress towards Uzbekistan's long-term strategic objectives.

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