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TIME-AWARE ALLOCATION OF CUSTOMS INSPECTION RESOURCES ACROSS RISK LANES: DECLARATION-LEVEL EVIDENCE FROM UZBEKISTAN

Kilichov Nazar Bafoyevich
Independent Researcher (PhD),
Customs Institute of the Customs Committee
under the Ministry of Economy and Finance
ORCID: 0009-0003-6447-0248
E-mail: nazarkilichov13@gmail.com

Abstract. This article examines how customs authorities can shorten clearance times without reducing the detection of violations by redistributing fixed inspection capacity across risk lanes. The empirical basis is a declaration-level dataset from the Customs Committee of Uzbekistan, comprising 8,000 declarations lodged at 12 customs posts during 2023–2026. A log-logistic accelerated failure time model shows that assignment to the red lane multiplies expected clearance time by 2.97, while pre-arrival lodging reduces it by 29.7%. A linear programming model is proposed to rank declarations by the number of detected violations per hour of additional clearance time. With the same 1,820 inspections and 786 detected violations, the model reduces the 90th percentile of clearance time by 21.3 minutes and by 64.2 minutes when combined with an increased share of pre-arrival declarations.

Keywords. customs control, risk management, risk lanes, clearance time, pre-arrival declaration, linear programming, Uzbekistan.

Аннотация. В статье исследуется, как таможенные органы могут сократить время выпуска товаров без снижения выявляемости нарушений за счёт перераспределения ограниченных ресурсов таможенного досмотра между коридорами риска. Эмпирическую базу составляют данные Таможенного комитета Узбекистана по 8 000 декларациям, поданным на 12 таможенных постах в 2023–2026 гг. Лог-логистическая модель ускоренного времени отказа показывает, что направление в красный коридор увеличивает ожидаемое время оформления в 2,97 раза, а предварительная подача декларации сокращает его на 29,7 %. Предложена модель линейного программирования, ранжирующая декларации по числу выявленных нарушений на каждый час дополнительного времени оформления. При неизменном количестве досмотров (1 820) и выявленных нарушений (786) модель сокращает 90-й процентиль времени выпуска на 21,3 минуты, а в сочетании с увеличением доли предварительного декларирования — на 64,2 минуты.

Ключевые слова. таможенный контроль, управление рисками, коридоры риска, время выпуска, предварительное декларирование, линейное программирование, Узбекистан.

INTRODUCTION

Stricter customs controls can delay the movement of goods, while excessive relaxation may affect revenue collection and security. Full implementation of the WTO Trade Facilitation Agreement would reduce trade costs by an average of 14.3% [24], and for landlocked countries, whose trade costs are approximately 30% higher, the implications are even more significant [4]. Uzbekistan's score in the UN Global Survey on Trade Facilitation increased from 84.95% in 2023 to 92.47% in 2025 [18]. However, in the 2023 Logistics Performance Index, Uzbekistan ranked 88th out of 139 countries overall and 74th in customs performance [23].

Border clearance time remains an important area for further improvement. In the first quarter of 2026, road imports spent an average of 6 h 15 min at border posts, while red-lane declarations required 28 h 16 min, compared with 5 h 16 min in the yellow lane [8]. In 2025, inspection hit rates at the six busiest truck border posts

ranged from 7.8% to 39.1% [9]. Such variation suggests opportunities to improve the allocation of inspection resources. Decree No. PF-174 of 27 August 2026 establishes the objective of reducing release times while maintaining effective customs controls [1].

The aim of this study is to substantiate a model for allocating inspection resources across risk lanes that accounts for the trade-off between control stringency and clearance time. The novelty of the study lies in incorporating time into the inspection selection rule: declarations are ranked by the expected number of detected violations per hour of additional clearance time, while ensuring that the number of detections, the number of inspections, and every quantile of clearance time remain at least as favourable as their current levels.

LITERATURE REVIEW

Becker considered the probability of detection as a policy instrument whose cost must be weighed against the social losses it prevents [5]. Mookherjee and Png demonstrated that optimal audits are random rather than deterministic [16], while Reinganum and Wilde analysed cut-off rules for audits [17]. In the customs context, this implies that no declaration should have a zero probability of inspection. The Revised Kyoto Convention defines risk management as the systematic application of procedures that direct customs controls towards higher-risk consignments [2], while the SAFE Framework requires automated risk targeting based on advance electronic data [3]. However, neither framework specifies how inspection resources should be allocated.

Widdowson considers trade facilitation and customs control as independent dimensions [22]. Chalendard demonstrated, using transaction-level data, that risk-based selection outperforms random inspections [6], while Hammadi proposed a hybrid risk-assessment method for the customs supply chain [12]. The economic cost of time is well documented: one day in transit is equivalent to an ad valorem tariff of 0.6–2.1% [13], while each additional day of delay reduces trade by more than 1% [10]. Customs inspections have been shown to reduce exports in Uruguay [19], whereas a reduction in physical inspections increased imports in Albania without reducing revenue [11]. An area requiring further research is the development of a model in which the time cost of an inspection is incorporated directly into the selection rule. Existing systems, including Uzbekistan's, primarily rank declarations according to the probability of non-compliance.

RESEARCH METHODOLOGY

The study uses an anonymised dataset of the Customs Committee: 8,000 declarations lodged from 1 January 2023 to 29 June 2026 at 12 posts in 10 regions, with 48 variables, including stage time stamps, risk score, lane, inspection result and trader characteristics. Clearance time is counted from the later of goods arrival and declaration acceptance to release, following the WCO Time Release Study logic [20]; 23 unreleased declarations are right-censored. As the distribution is skewed, medians and percentiles are used.

After Kaplan–Meier estimation [14], clearance time was modelled with an accelerated failure time model [21]:

$$\ln T_i = \mathrm{x}_i'\beta + \sigma\varepsilon_i \qquad (1)$$

where T_i is the clearance time of declaration i, x_i the covariates (lane, pre-arrival lodging, AEO status, transport mode, post type, out-of-hours acceptance, goods and trader characteristics, year), β the coefficients and σ the scale. Exponentiated coefficients are time ratios. Errors are clustered by trader; a Cox model [7] and quantile regression [15] serve as robustness checks. The discriminating power of risk selection compares the hit rate of rule-based inspections h with the violation rate in random inspections b:

$$D = \frac{h}{b} \qquad (2)$$

Artificial intelligence (AI) tools were used to a limited extent, accounting for approximately 10% of the overall research preparation process. Their use was primarily confined to language refinement, technical editing, and structural support. The selection of research methods, analysis and interpretation of findings, formulation of scientific conclusions, and overall scientific responsibility remained entirely with the author.

ANALYSIS AND RESULTS

Control regime by lane. Of 8,000 declarations, 1,820 (22.8%) were inspected and 786 inspections revealed a discrepancy (Table 1).

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Table 1
Control regime by risk lane

Indicator	Green	Yellow	Red	Total
Declarations, %	49.7	30.7	19.6	100.0
Inspection rate, %	0.8	17.2	86.8	22.8
Hit rate of inspections, %	30.3	29.3	47.8	43.2
Median clearance time, h	1.09	1.51	3.31	1.40

Source: calculated by the author on the basis of Customs Committee data.

The hit rate in the yellow lane (29.3%) is nearly identical to that in the green lane (30.3%), indicating that the risk score has limited effectiveness in distinguishing high-risk declarations. For inspected declarations, the median clearance time of 218 minutes includes only 39 minutes of actual inspection, compared with 53 minutes of waiting for inspection and 104 minutes for decision-making and release. Therefore, the greatest potential for reducing clearance time lies in improving the waiting and decision-making stages rather than reducing the number of inspections. When the risk-lane thresholds were lowered in 2025 (from 58 to 55 for the yellow lane and from 70 to 67 for the red lane), the number of detected violations increased by 38.7%, while the 90th percentile of clearance time increased by 15.6%.

Econometric estimates. The log-logistic distribution provided the best fit (AIC = 23,139.5; σ = 0.3311). Table 2 presents the main time ratios.

Table 2
Accelerated failure time model of clearance time (n = 8,000)

Variable	β	z	Time ratio
Red lane (base: green)	1.0881	65.9	2.969
Yellow lane (base: green)	0.3262	25.3	1.386
Lodged before arrival	–0.3522	–27.2	0.703
Authorised Economic Operator	–0.1608	–6.8	0.852
Rail transport (base: road)	0.1973	13.7	1.218
Accepted outside working hours	0.1259	10.2	1.134
Terminal (base: border post)	–0.0696	–3.9	0.933

Source: calculated by the author. Standard errors clustered by trader; other controls not shown.

Red-lane declarations take 2.97 times longer than green-lane ones; pre-arrival lodging cuts time by 29.7% and AEO status by 14.8%. Quantile regression shows that control acts mainly on the tail: the red-lane ratio rises from 2.98 at the median to 3.55 at the 95th percentile, while the pre-arrival effect is stable (0.71–0.68). The two levers act on different stages and complement each other. Rule-based inspections found discrepancies in 695 of 1,569 cases (h = 0.443) and random ones in 36 of 95 (b = 0.379), giving D = 1.169 with a 95% interval of 0.92–1.57; the advantage of risk selection over chance is not yet proven.

The allocation model. The model takes the inspection probability π_i of each declaration as the decision variable and minimises the additional time caused by inspections:

$$\min_{\pi} \sum_{i=1}^{N} m_i\,(TR-1)\pi_i \qquad (3)$$

subject to keeping detections and inspections at current levels D_0 and K_0 and to bounds that keep selection random:

$$\sum_{i=1}^{N} q_i\,\pi_i \geq D_0, \qquad \sum_{i=1}^{N} \pi_i \leq K_0, \qquad \pi_{\min} \leq \pi_i \leq \pi_{\max} \qquad (4)$$

where q_i is the probability of a discrepancy if inspected, m_i the expected time without inspection and TR the time ratio of an inspection. A further constraint forbids any quantile of clearance time from worsening:

$$\sum_{i \in S(t)} \pi_i \leq B(t), \qquad S(t) = \{i : m_i \leq t < m_i \cdot TR\} \qquad (5)$$

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where $S(t)$ holds declarations that cross time t only if inspected and $B(t)$ is their current number of inspections; it is set for the median and the 75th, 90th and 95th percentiles. The problem is a linear programme; without quantile constraints its solution ranks declarations by

$$\frac{q_i}{m_i} \to \max \qquad (6)$$

The probability of a discrepancy was estimated from the risk score s by a logistic model:

$$q(s) = \frac{1}{1 + \exp\left(-\left(\beta_0 + \beta_1 s + \beta_2 \frac{(s-60)^2}{100}\right)\right)} \qquad (7)$$

with $\beta_0 = -2.1166$, $\beta_1 = 0.02739$, $\beta_2 = -0.03651$; further, $TR = 1.751$, the median $m = 1.25$ h, $\pi_{\min} = 0.02$ and $\pi_{\max} = 0.95$ (Table 3).

Table 3
Solution of the allocation model (1,820 inspections and 786 detections in all variants)

Variant	Median, h	P75, h	P90, h	P95, h	Total time, h
Current allocation	1.301	1.872	3.705	3.916	13,864
A: no quantile constraints	1.427	2.083	2.811	3.561	13,393
B: median constraint	1.294	2.301	2.940	3.596	13,528
C: all quantile constraints	1.293	1.880	3.351	3.738	13,646

Source: calculated by the author.

Variant A achieves the greatest time savings but increases the median clearance time by 7.6 minutes, while Variant B increases the 75th percentile. Only Variant C improves or maintains all clearance time quantiles: the 90th percentile decreases by 21.3 minutes, and total clearance time is reduced by 218 hours. The model reallocates inspections towards the 60–70 risk-score band (increasing the inspection probability from 0.30 to 0.40) and away from the 70–80 band (reducing it from 0.86 to 0.78). This is because detections per hour peak in the middle bands (0.273–0.290) and are lowest in the highest band (0.214), where declarations also require the longest clearance times.

Increasing the number of detected discrepancies from 750 to 786 requires an additional 491 minutes per discrepancy. Valued at 0.6–2.1% of a 292.8-million-soum consignment per day of delay [16], this represents 0.60–2.10 million soums, which is below the median additional assessment of 2.395 million soums. The current level of customs control is therefore justified, while opportunities for further improvement lie in the allocation of inspection resources. When combined with an increase in the share of pre-arrival declarations from 41.8% to 70%, the model reduces the 90th percentile of clearance time by 64.2 minutes, exceeding the sum of the individual effects (21.3 and 39.3 minutes), and decreases total clearance time by 12.5%.

CONCLUSION AND RECOMMENDATIONS

Customs clearance time can be reduced while maintaining effective control. The primary opportunity for improvement lies in the allocation of inspections rather than their overall number. Incorporating the time cost of inspections into the selection rule reduces the 90th percentile of clearance time by 21.3 minutes, or by 64.2 minutes when combined with pre-arrival lodging. The estimated lane coefficients represent conditional associations, while the 29.7% reduction associated with pre-arrival lodging should be interpreted as an upper bound.

Recommendations:

1. Expand random control inspections to at least 643 per year within existing resources to assess the discriminatory power of risk-based selection.
2. Incorporate expected clearance time without inspection into the risk-management system and determine inspection probabilities based on the ratio of detection probability to time cost.
3. Apply inspection probabilities using a random number generator, ensuring a minimum inspection probability of 0.02 for every declaration.

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4. Evaluate customs posts quarterly based on detected violations, clearance time quantiles, traders' costs, and revenue, accepting changes only when none of these indicators deteriorates.

5. Implement the proposed model alongside mandatory pre-arrival lodging of transit declarations.

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