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Article

Empirical Identification of a Bimodal Seasonal Profile: Evidence from Bukhara Region, Uzbekistan

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Abstract: This study investigates the temporal pattern of foreign tourist arrivals to Bukhara region (Uzbekistan) between 2023 and 2025, with the aim of identifying and statistically verifying the form of seasonal fluctuations. The analysis draws on thirty-six monthly observations and applies a local-extrema test together with five complementary concentration indicators: the seasonality index, the Gini coefficient, the coefficient of variation, the Herfindahl-Hirschman index, and the peak-to-trough ratio. The results show that Bukhara region displays a clearly defined bimodal seasonal profile. Two non-adjacent peak clusters appear in April-May and September-November, separated by distinct winter and summer troughs. The peak-to-trough ratio falls within 5.66-7.02, the Gini coefficient ranges from 0.269 to 0.315, and the four-extremum structure recurs consistently in each of the three years. The bimodal classification is therefore a structural rather than a transient property of the destination. The paper offers a replicable diagnostic procedure for distinguishing seasonal forms and provides the first empirical confirmation of bimodality in a Central Asian heritage destination.

Keywords: Tourism Seasonality, Bimodal Profile, Bukhara, Cultural Heritage Destination, Gini Coefficient, Arid Climate

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1. Introduction

The uneven temporal distribution of demand has long been recognized as one of the most persistent structural challenges facing the global tourism sector. This concentration generates well-documented inefficiencies in capacity utilization, employment continuity, and the use of cultural and natural assets. Although academic study of this phenomenon dates back to the foundational work of BarOn (1975), most empirical contributions still focus on European cool-temperate or Mediterranean coastal settings, where a single summer maximum dominates the demand cycle. In contrast, inland heritage destinations operating under arid continental conditions have received much less systematic attention[1].

Bukhara region offers an instructive case for filling this gap. Foreign visitation has risen sharply in recent years, climbing from approximately 1.39 million in 2023 to roughly 2.70 million in 2025, an increase of nearly 95 per cent in three years. Yet the monthly distribution of these arrivals remains markedly uneven. Practitioners and regional administrators have long noted that summer months underperform relative to spring and autumn, but no peer-reviewed study has so far formally tested whether this informal observation matches the bimodal type described in the international classification of seasonal forms [2].

The conceptual gap addressed by the present analysis is essentially typological. Analytical templates routinely used in Central Asian tourism research implicitly assume a unimodal demand curve, even though no formal empirical test of this assumption has been carried out for any individual destination in the region. If the underlying form turns out to be bimodal rather than unimodal, this has important consequences for how standard concentration metrics (Is, CV, Gini, SR) should be interpreted. The same numerical value of any such indicator carries a different substantive meaning under a unimodal regime than under a bimodal one, and benchmarks calibrated on coastal or alpine evidence are no longer directly comparable. Establishing the seasonal form of the destination is therefore a logical first step before any further analysis of its temporal dynamics[3].

Against this background, the present article pursues two specific objectives. The first is to determine, using monthly visitor data for 2023-2025, whether tourism in Bukhara region follows a unimodal, bimodal, or multimodal pattern. The second is to quantify the depth and inter-annual stability of the observed pattern through a battery of complementary concentration indicators. The mechanism producing the observed shape, particularly the role of climatic factors and the appropriate functional form of the temperature-demand relationship, lies outside the scope of this paper and is addressed in a separate companion study[4].

2. Material and Methods

Data sources

The empirical core of the study consists of monthly counts of foreign tourist arrivals to Bukhara region for the calendar years 2023, 2024, and 2025, yielding thirty-six monthly observations in total. The series was obtained from the State Statistics Committee of the Republic of Uzbekistan and cross-checked against operational records held by the regional Tourism Committee. Three consecutive years constitute a relatively short observation window in absolute terms, but two considerations suggest that the panel is sufficient for the present analysis[5].

First, the focus of the analysis is descriptive. The diagnostic procedure aims to classify the seasonal form rather than to forecast its future trajectory, and three years are adequate provided that inter-annual stability is examined explicitly. Second, longer panels covering pre-pandemic and post-pandemic periods would conflate the structural seasonal pattern with the highly idiosyncratic dynamics of the 2020-2022 disruption. Restricting attention to the post-recovery period 2023-2025 yields a cleaner identification of the underlying form. To minimize any residual influence of the recovery trajectory, all relative indicators are computed annually rather than on the pooled series, and the inter-annual reproduction of the seasonal shape is treated as a separate object of analysis[6].

Diagnostic procedure

Following the typology developed by Butler (1994) and refined by Cuccia & Rizzo (2011), three principal forms of tourism seasonality are conventionally distinguished. The unimodal form has a single annual peak. The bimodal form has two distinct peaks separated by an intervening trough. The multimodal form has three or more peaks distributed across the calendar year. Identification of the relevant form for any given destination proceeds in two complementary steps[7].

The first step is a local-extrema test conducted directly on the monthly time series. For each calendar year, a local maximum is recorded whenever a monthly value exceeds both adjacent months by at least 30 per cent, and a local minimum is recorded under the symmetric condition. The destination is classified as bimodal when the year contains two local maxima and two local minima, and the ratio between any adjacent pair of extrema exceeds 1.8. This threshold is sufficient to rule out the possibility that the observed extrema arise from random fluctuations rather than from a genuine seasonal mechanism. Bimodality further requires that the two peaks be separated by at least one calendar month classified as either trough or transition; adjacent peak months alone are not sufficient[8].

The second step provides an index-based confirmation of the form initially identified at the extrema level. The classical seasonality index is computed as

$$Is = (\bar{y}t / \bar{y}a) \times 100\%$$

where ȳt is the mean count for month t across the three available years, and ȳa is the grand monthly mean across the same period. Months with Is above 130 per cent are classified as peak months. Months with Is below 55 per cent are classified as off-season months. The remaining months are transition months. Bimodality at the index level is then confirmed if the peak months form two non-adjacent clusters within the calendar year, separated by at least one transition or trough month. This configuration is incompatible with both the unimodal pattern, which would require a single contiguous high-season block, and the multimodal pattern, which would require three or more separated peak clusters[9].

Concentration metrics

Quantitative assessment of the depth of seasonality requires the simultaneous use of several complementary indicators, each capturing a different aspect of temporal concentration. The Gini coefficient G measures the divergence of monthly arrivals from a perfectly uniform distribution. It is interpreted on the conventional scale of Cuccia & Rizzo (2011), under which values below 0.10 denote weak seasonality, 0.10-0.20 moderate, 0.20-0.30 high, and values above 0.30 very high seasonality[10].

The coefficient of variation, defined as $CV = \sigma/\bar{x} \times 100\%$, captures relative dispersion across the twelve months. The Herfindahl-Hirschman index measures concentration in absolute terms; it is calculated on monthly market shares, with HHI = 833 corresponding to a perfectly uniform distribution among twelve months. The peak-to-trough ratio SR = max(month)/min(month) provides a transparent reading of the gap between the busiest and the quietest months. Finally, graphical analysis through the Lorenz curve yields the geometric foundation of the Gini coefficient and visualizes the deviation of the empirical monthly distribution from full equality[11].

3. Results

Local extrema and the four-point structure

Figure 1 reports the monthly distribution of foreign arrivals across the three calendar years under analysis, together with the share of each month in the 2024 annual total and the cumulative growth rate over the full observation window.

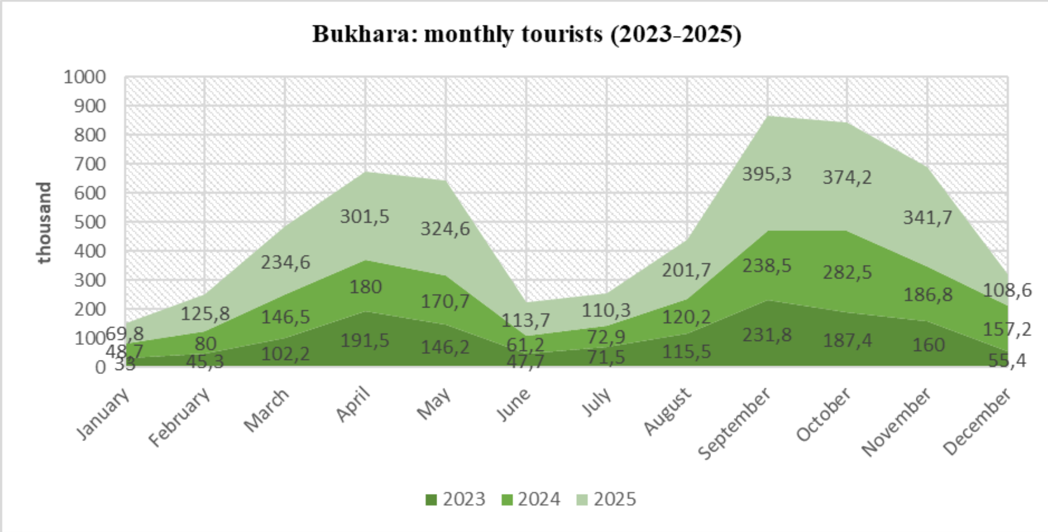

Figure 1. Monthly distribution of foreign tourist arrivals to Bukhara region, 2023-2025 (thousand persons)

The local-extrema test was first applied to the 2024 series, which was chosen as the most stable of the three years for purposes of initial inspection. The test identifies two well-defined local maxima and two corresponding local minima within the calendar year. The maxima fall in April (180.0 thousand) and October (282.5 thousand), with the autumn peak considerably larger than the spring one. The intervening minima fall in June (61.2 thousand) and at the symmetric winter position in January (48.7 thousand). The same four-point configuration recurs in 2023 and 2025, although the absolute level rises in step with the overall trend in those years[12].

The pairwise ratios between adjacent extrema take the values 3.70 (Jan→Apr), 2.94 (Apr→Jun), 4.61 (Jun→Oct), and 1.80 (Oct→Jan). All four ratios meet or exceed the 1.8 threshold imposed by the diagnostic procedure, which confirms that the local extrema reflect a genuine seasonal mechanism rather than incidental month-to-month variation.

The aggregate magnitudes implied by this configuration are striking. The four peak months (April, May, September, and October) together account for 49.9 per cent of annual arrivals in 2024, while the four off-season months (January, February, June, and July) jointly account for only about fifteen per cent of the annual total. The strongest single month, October 2024 with 282.5 thousand arrivals, exceeds the weakest single month, January 2024 with 48.7 thousand, by a factor of 5.80. This places the destination well within the upper range of intensities reported in the comparative tourism-seasonality literature[13].

Seasonality indices and the bimodal structure

The local-extrema test in Section 3.1 establishes the existence of four turning points in the calendar year, but formal classification under the international typology requires confirmation through index-based analysis. Computation of the seasonality index Is on the three-year average, with the grand monthly mean ȳa equal to 162.1 thousand, yields the values reported in Table 1. The twelve months are grouped according to the conventional thresholds for peak (Is > 130 per cent), transition (55 per cent ≤ Is ≤ 130 per cent), and off-season (Is < 55 per cent) zones.

Table 1. Seasonality index by month, Bukhara region (2023-2025 average)

Month	ȳt (thousand)	Δ_seas	Relative dev., %	Is, %	Zone
January	50.5	−111.6	−68.8	**31.2**	*Trough*

February	83.7	−78.4	−48.4	**51.6**	*Trough*
March	161.1	−1.0	−0.6	**99.4**	*Transition*
April	224.3	+62.3	+38.4	**138.4**	*Peak*
May	213.8	+51.8	+31.9	**131.9**	*Peak*
June	74.2	−87.9	−54.2	**45.8**	*Trough*
July	84.9	−77.2	−47.6	**52.4**	*Trough*
August	145.8	−16.3	−10.0	**90.0**	*Transition*
September	288.5	+126.5	+78.0	**178.0**	*Peak*
October	281.4	+119.3	+73.6	**173.6**	*Peak*
November	229.5	+67.4	+41.6	**141.6**	*Peak*
December	107.1	−55.0	−33.9	**66.1**	*Transition*

Three substantive observations follow directly from Table 1 and together establish the bimodal classification of the destination. First, the peak zone (Is > 130 per cent) comprises five months: September (178.0), October (173.6), November (141.6), April (138.4), and May (131.9). However, these months form two clearly separated clusters rather than a single contiguous high-season block, with March, June, July, August, and December lying between them. The average Is across the five peak months is 152.7 per cent.

Second, the off-season zone (Is < 55 per cent) contains four months: January (31.2), February (51.6), June (45.8), and July (52.4). These months split into a winter pair (January-February) and a summer pair (June-July), with a mean off-season Is of 45.2 per cent. Third, the three transition months (March, August, December) are distributed asymmetrically around the calendar. They serve as bridges between the peak clusters and the troughs rather than connecting the two peak clusters into a unified high-season block[14].

The quantitative gap between the highest and lowest indices reaches 178.0 / 31.2 = 5.71 on the three-year average. Under the BarOn-Butler classification scheme, ratios above 4.0 fall into the category of "very strong seasonality." However, the two-peak / two-trough configuration documented above is incompatible with the unimodal frame on which that benchmark rests. Instead, it corresponds precisely to the bimodal pattern identified by Cuccia & Rizzo (2011) in their study of Sicilian heritage destinations. To the best of our knowledge, this is the first peer-reviewed empirical confirmation of bimodality for any Central Asian heritage destination. The finding suggests that the bimodal classification, previously documented mainly in Mediterranean cultural settings, extends naturally to the arid continental context of Inner Asia.

Concentration metrics and the Lorenz curve

Beyond the qualitative classification of the seasonal form established in Sections 3.1 and 3.2, a complete characterization of the depth of seasonality requires the simultaneous use of several concentration indicators. Table 2 reports four such indicators (the Gini coefficient, the coefficient of variation, the peak-to-trough ratio, and the Herfindahl-Hirschman index) for each of the three calendar years under analysis. It also provides the three-year mean values and identifies the months classified as peak and trough in each year[15].

Table 2. Concentration metrics for Bukhara region tourism, 2023-2025

Indicator	2023	2024	2025	Three-year mean
Gini coefficient	0.315	0.269	0.284	0.289
Coefficient of variation (CV), %	55.5	47.7	50.4	51.2
Peak-to-trough ratio (SR)	7.02	5.80	5.66	6.16
Herfindahl-Hirschman index	1,090	1,023	1,045	1,053

Peak month	September	October	September	-
Trough month	January	January	January	-

Each of the four indicators places Bukhara region in the upper part of the distribution of intensities reported in the comparative international literature. The Gini coefficient lies on the boundary between the "high" and "very high" categories of the Cuccia & Rizzo (2011) scale across all three years. The CV exceeds 47 per cent throughout, well above the 25-45 per cent band typically reported for European cultural-tourism destinations. The SR ratio remains above 5.6 even at its lowest point, which indicates a pronounced gap between the busiest and the quietest months. The HHI sits roughly twenty-five per cent above the uniform-distribution benchmark of 833. Taken together, these indicators show that the depth of seasonality in Bukhara region is high in absolute terms and consistent with the upper end of the international distribution, despite year-on-year fluctuations.

A second observation concerns the temporal dynamics of the four indices. The Gini coefficient follows a V-shaped trajectory across the three years (0.315 → 0.269 → 0.284), and the coefficient of variation reproduces this V-shape almost exactly (55.5 → 47.7 → 50.4 per cent). The dip recorded in 2024 is fully attributable to an isolated December anomaly, in which monthly arrivals reached 157.2 thousand against an inter-annual December average closer to 90 thousand. Once that anomaly receded in 2025, both the Gini coefficient and the CV moved back upward[16].

Crucially, this transient smoothing did not alter the underlying form. The same four extreme months reappear in each of the three years, the pairwise ratios between adjacent extrema remain above the 1.8 threshold throughout, and the bimodal signature is essentially invariant. The implication is that the bimodal classification is a structural rather than a transient property of the destination. Single-year movements in the headline concentration indices should therefore not be over-interpreted as evidence of a change in seasonal form.

Cumulative inspection of the Lorenz curve reinforces this conclusion. The four lowest-ranked months together account for only 15.1 per cent of annual arrivals, against the 33.3 per cent that would be expected under a uniform monthly distribution. By contrast, the two strongest months (September and October 2024) absorb 29.9 per cent of the annual flow, almost double the 16.7 per cent benchmark of equality. The widest gap between the empirical Lorenz curve and the equality diagonal reaches 19.7 percentage points at the fifth-month cumulative position, and it is precisely the geometric area enclosed between the empirical curve and the diagonal that mathematically generates the observed Gini value. The visual signature of the curve, with a flat early segment followed by a sharp bend in its upper portion, is itself characteristic of bimodal rather than unimodal regimes. It therefore provides an independent graphical confirmation of the classification reached through index analysis.

4. Discussion

The empirical analysis converges on two principal propositions about the character of tourism seasonality in Bukhara region. The first is a typological proposition relating to the classification of the destination. The second is a structural proposition relating to the stability of the observed shape over time.

First, the diagnostic procedure deployed in Sections 3.1 and 3.2 places Bukhara region unambiguously within the bimodal category of the international classification of seasonal forms. Two well-separated peak clusters appear in the calendar year: a spring maximum centered on April-May and a deeper autumn maximum extending across September-November. They are interrupted by two distinct trough periods, located in June-July and January-February respectively. None of the three diagnostic criteria considered is consistent with a unimodal classification. The local-extrema test identifies four turning points rather than the two that a unimodal pattern would require. The Is profile produces two non-adjacent clusters of months above the 130 per cent threshold rather than a single contiguous high-season block. The cumulative Lorenz curve does not fold around a single peak. To the best of our knowledge, this is the first peer-reviewed empirical confirmation of bimodality for any heritage destination in Central Asia. The finding lends support to the broader conjecture that the bimodal pattern previously documented in Mediterranean cultural settings is not specific to that region but extends to other arid heritage contexts in which extreme summer temperatures depress, rather than stimulate, demand.

Second, the bimodal shape proves to be a structural rather than a transient property of the destination. Inspection of the V-shaped trajectory of both the Gini coefficient and the coefficient of variation across the three years shows that fluctuations in the headline depth of seasonality leave the underlying form intact. The same four extreme months recur in each of the three years examined, the pairwise ratios between adjacent extrema remain above the 1.8 threshold throughout, and the temporary smoothing observed in 2024 is fully explained by an isolated December anomaly that subsequently receded. Two consequences follow from this stability of the bimodal signature. The bimodal character of the destination cannot be attributed to short-term post-pandemic recovery dynamics, since it is reproduced in each of the three post-recovery years. Equally, any apparent improvement in the concentration indices observed in a single year does not by itself indicate a change in seasonal form. Long-term monitoring of the destination should therefore focus on the persistence of the four extrema rather than on the headline value of the Gini or CV index for any individual year.

Three principal limitations of the present analysis should be acknowledged, each suggesting a corresponding direction for further research. First, the observation window is restricted to three calendar years. This restriction was partly a deliberate choice, made in order to avoid conflating the structural seasonal pattern with the highly idiosyncratic dynamics of the 2020-2022 disruption, and partly a result of data availability, since longer post-recovery panels are not yet available. Once such panels emerge, formal time-series decomposition will allow explicit separation of the structural seasonal component from any residual cyclical recovery dynamics. Second, the diagnostic procedure deployed here is descriptive rather than explanatory. It identifies and confirms the bimodal form but does not formally model the mechanism that produces it. A companion study currently in preparation addresses precisely this question through a comfort-zone temperature regression. Third, the analysis is conducted at the regional level on aggregated foreign-arrival data. Sub-regional variation, intra-monthly variation, and the behavior of domestic tourists may exhibit additional structural features that the present design, because of its level of aggregation, cannot detect.

5. Conclusion

Drawing on three years of monthly foreign-arrival data, this paper has examined the temporal character of tourism seasonality in Bukhara region and produced two principal findings. The seasonal profile of the destination is bimodal: two non-adjacent peak clusters located in April-May and September-November alternate with two off-season periods (June-July and January-February), and the resulting four-extremum structure is reproduced across all three years of the observation window. The depth of seasonality is high relative to the international distribution, with a Gini coefficient ranging from 0.269 to 0.315, a coefficient of variation between 47.7 and 55.5 per cent, a peak-to-trough ratio between 5.66 and 7.02, and a Herfindahl-Hirschman index above 1,000 in every year examined.

The contribution of the paper is primarily diagnostic. By combining a local-extrema test, an index-based confirmation procedure, and a battery of complementary concentration indicators, the analysis offers a replicable diagnostic procedure for identifying the seasonal form of arid heritage destinations and distinguishing it from the unimodal patterns that dominate the international literature on European coastal and alpine settings. The empirical confirmation of bimodality in a Central Asian heritage destination establishes a baseline against which future studies of seasonal character can be calibrated, including comparative work with other arid heritage regions and longitudinal monitoring of changes over time.

Several directions for further research follow naturally from these results. The diagnostic procedure could be applied to other arid heritage destinations in Central Asia, the Middle East, and North Africa in order to test the broader generality of the bimodal hypothesis. Once longer post-pandemic data series become available, the structural component of seasonality could be formally separated from any residual cyclical recovery dynamics through standard time-series decomposition. A natural extension of the present analysis is to investigate the climatic and institutional mechanisms that generate the observed bimodal shape, a task taken up in a companion study now under preparation. Finally, the long-run interaction between climate change and the depth and timing of the bimodal peaks merits sustained investigation, given the sensitivity of arid heritage destinations to extreme summer temperatures.

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