

MODELLING TOURIST FLOWS TO UZBEKISTAN: A GRAVITY APPROACH

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ABSTRACT. This paper estimates the determinants of inbound tourist flows to Uzbekistan using a 2023 cross-section of 18 origin countries. Nested log-linear OLS specifications, HC3 robust standard errors and Poisson pseudo-maximum likelihood are employed. The contribution does not lie in applying the gravity model itself, which is well established in tourism research, but in identifying an Uzbekistan-specific regional concentration effect: the largest origin markets are simultaneously geographically close, contiguous, visa-free and culturally connected. Consequently, the baseline distance elasticity of -2.2 captures a composite spatial-regional effect and becomes unstable once controls are introduced. Of the six hypotheses, the negative distance effect is supported only in the baseline model, while cultural and social proximity is positively significant in PPML. Income, common border, visa-free access and direct flights are not statistically supported because of multicollinearity and insufficient variation. Comparison with prior tourism studies suggests that these deviations reflect the structure of the Uzbekistan sample rather than a rejection of general tourism-demand mechanisms. A testable digital-proximity extension and a two-stage framework linking predicted arrivals to tourism receipts and GDP effects are proposed.

Key words: inbound tourism; gravity model; Uzbekistan; distance; cultural proximity; PPML; multicollinearity; digital proximity.

JEL: C21, L83, Z32.

1. Introduction

Tourism matters for Uzbekistan not only as a source of foreign-currency earnings but also as a cross-sectoral driver of transport, the hotel business, food service, trade, cultural industries and regional employment. According to official data, 2.52 million guests were registered at hotels and similar accommodation establishments in 2023; 46.6% of them were citizens of CIS countries and other foreign states. The largest purposes of travel were leisure and recreation (984,400 stays) and business and professional trips (962,600) [15]. The strategic role of the sector is also enshrined in state policy: by 2030 the targets are to raise tourism's share of GDP from 3.5% to 7% and to double the annual inflow of foreign tourists from 10 to 20 million people [16].

For a landlocked country situated in the center of Eurasia, the structure of inbound flows is especially dependent on spatial accessibility. At the same time, Uzbekistan is linked to its neighboring states by a common border, shared history, language contacts, and migration and family networks. These features act in the same direction and are concentrated mainly within a single regional group of countries. This complicates the standard task of estimating individual coefficients: distance, contiguity, visa regime and cultural proximity partly measure one and the same latent factor of regional proximity.

The aim of the study is to determine which economic, spatial, institutional, transport and cultural-social factors are statistically associated with inbound flows to Uzbekistan, and how reliably their individual effects

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can be separated in a small cross-section. Six hypotheses are tested: H_1 — the income of the origin country is positively associated with the flow; H_2 — distance is negatively associated with it; H_3 — a common border increases the flow; H_4 — a visa-free regime increases the flow; H_5 — direct air service increases the flow; H_6 — cultural-social proximity increases the flow.

Applying the gravity model to tourism is not in itself a scientific novelty. The empirical novelty of this study lies in establishing that, for the Uzbekistan sample, the high baseline distance elasticity is not a stable “pure” transport effect, but reflects the combined action of distance, a common border and cultural-regional proximity. The second result is the identification of cultural-social proximity as the only positive factor that retains statistical significance in the PPML specification. The third result is a substantive interpretation of statistically insignificant coefficients through the sample’s saturation with visa-free regimes and direct flights, rather than a mechanical claim that the corresponding effects are absent.

2. Literature review and positioning of the study

The gravity model was originally proposed for the analysis of international trade [1], and its modern structural interpretation accounts for multilateral resistance [2]. In tourism the approach has been used for no less than fifteen years: K. Keum’s panel study demonstrated the applicability of gravity logic to international tourism flows [3], while C. Morley, J. RossellFi and M. Santana-Gallego derived a tourism-demand model from consumer behaviour [4]. The review by J. RossellFi and M. Santana-Gallego confirms that gravity specifications have become a stable direction in the analysis of international tourism [6]. Consequently, the research gap should be sought not in a repeated application of the method, but in a new data structure, a new identification problem, or a new substantive finding.

In broader panel samples, the origin country’s income usually has a positive effect, while distance has a negative one. For example, F. Yerdelen Tatoglu and H. Gul, using flow data from 30 countries to 14 major tourist destinations, established the significance of income and a negative dependence of arrivals on distance [7]. H_1 and H_2 therefore reproduce the findings of the core literature, but their confirmation for a single destination country and a single year is not automatic.

Institutional barriers have also been shown to matter. L. A. Cantillo, using OLS and PPML estimates, showed that a traditional visa regime reduced international arrivals by approximately 21%, while more flexible visa forms had a smaller negative effect [8]. At the same time, estimating the visa effect requires a sufficient number of observations under both restrictive and liberal regimes. If nearly all countries in the sample share the same regime, the coefficient is determined by a handful of exceptions and becomes statistically unstable.

Cultural and social ties reduce the informational and psychological costs of travel. U. Khalid, L. Okafor and O. Sanusi showed that a common language and linguistic proximity increase international tourism flows [9]. L. Okafor, U. Khalid and K. Burzynska established the positive role of migration and language networks [10]. These findings provide the theoretical basis for H_6 and make it possible to interpret diaspora, shared history and linguistic proximity as channels that reduce intangible barriers.

Direct air service is usually regarded as an element of transport accessibility and of a route’s potential market. A counterfactual analysis based on an augmented gravity model shows that the presence of direct service can unlock additional demand, although the route’s sustainability depends on market size and other characteristics [17]. The positive sign expected for H_5 is therefore economically plausible, but its empirical estimation is not possible when there is almost no variation in the feature.

Digitalisation extends the traditional gravity model by lowering search, quality-verification and booking costs. E. Lopez-Cordova showed that internet penetration in origin countries and the development of digital tools in the destination country weaken spatial and informational frictions [11]. A. Guedes and co-authors distinguish digital adoption from virtual proximity; their results for Southern Europe show that virtual proximity, measured by search interest, can be a more stable factor than the overall level of internet use [12]. This matters for the present study: simply expanding the list of factors does not guarantee validity — a digital variable must have a clear economic meaning and sufficient variation.

The positioning of this study consists in comparing the general conclusions of the literature with the specific structure of flows to Uzbekistan. Unlike multi-country panels, this study considers a single destination country, a single year, and a small number of origin markets. This makes it possible to reveal the national configuration of factors, but at the same time limits the possibility of causal interpretation and of separating closely related effects.

3. Data and econometric strategy

The estimation is carried out on a cross-section of 18 origin countries for 2023. The unit of observation is the registered flow of visits from country i to Uzbekistan. If the official source counts trips rather than unique persons, the dependent variable is interpreted as the number of arrivals (visits) rather than the number of individual tourists.

$$\text{Tourists}_i = A \cdot \text{GDPpc}_i^\alpha \cdot \text{Distance}_i^{-\gamma} \cdot \exp(\eta_i)$$

$$\eta_i = \theta_1 \text{Border}_i + \theta_2 \text{VisaFree}_i + \theta_3 \text{DirectFlight}_i + \theta_4 \text{CulturalIndex}_i$$

The following equation is estimated in log-linear form:

$$\ln \text{Tourists}_i = \beta_0 + \alpha \ln \text{GDPpc}_i - \gamma \ln \text{Distance}_i + \eta_i + \varepsilon_i$$

Table 1. Model variables and expected signs

Variable	Notation	Measurement	Expected sign
Tourist flow	Tourists_i	number of visits	dependent
GDP per capita	GDPpc_i	US dollars per person	+
Distance	Distance_i	km	-
Common border	Border_i	1/0	+
Visa-free regime	VisaFree_i	1/0	+
Direct flight	DirectFlight_i	1/0	+
Cultural-social index	CulturalIndex_i	0–3	+

GDPpc_i characterises the purchasing power of the origin market and is taken from the World Development Indicators [14]. Distance_i is the great-circle (orthodromic) distance from Tashkent to the capital of the corresponding country, calculated from CEPII GeoDist data and geographic coordinates [13]. Border_i , VisaFree_i and DirectFlight_i take the value 1 if there is a common land border, a visa-free regime and regular direct service, respectively, in 2023. The exact percentage effect of a binary variable with coefficient θ equals $100[\exp(\theta) - 1]\%$.

The cultural-social index is formed as the sum of three binary components — linguistic proximity, a shared historical-institutional connection, and the presence of a notable diaspora network: $\text{CulturalIndex}_i = \text{Language}_i + \text{History}_i + \text{Diaspora}_i$. The index has an ordinal scale from 0 to 3. Its use requires a transparent coding protocol; the result is therefore treated as a preliminary association rather than a causal effect.

Five specifications are estimated. Model 1 contains only income and distance. Model 2 adds border, visa-free regime and direct service. Model 3 includes the cultural index. Model 4 repeats the full OLS specification with HC3-robust standard errors, which are preferable for a small sample. Model 5 estimates the conditional mean in multiplicative form using PPML:

$$E(\text{Tourists}_i | X_i) = \exp(X_i' \beta)$$

PPML does not require the dependent variable to follow a Poisson distribution; the method is used as a pseudo-maximum-likelihood estimator and is robust to certain forms of heteroskedasticity [5]. The ordinary R^2 of OLS and the pseudo- R^2 of PPML are not directly comparable.

Digitalisation is not mechanically included in the current estimation. Uzbekistan's national level of digitalisation is identical for all 18 observations of a single year and is fully absorbed by the constant. An econometrically meaningful digital variable must vary either across origin markets or over time — for example, internet penetration in the origin country, search interest in Uzbekistan, the availability of an e-visa, the share of online bookings, or the reach of digital advertising in that country.

4. Results

Table 2. Descriptive statistics

Variable	N	Mean	St. dev.	Minimum	Maximum
Tourists _i	18	359,011	674,334	12,400	2,155,200
ln Tourists _i	18	11.10	1.79	9.43	14.58
GDPpc _i	18	24,589	21,942	1,150	82,000
ln GDPpc _i	18	9.59	1.22	7.05	11.31
Distance _i	18	3,658	2,534	308	10,464
ln Distance _i	18	7.89	0.94	5.73	9.26
Border _i	18	0.22	0.43	0	1
VisaFree _i	18	0.83	0.38	0	1
DirectFlight _i	18	0.94	0.24	0	1
CulturalIndex _i	18	1.00	1.28	0	3

Flows are extremely heterogeneous: the maximum value is roughly 174 times the minimum. At the same time, the binary features show weak variation. A common border is present for 4 of the 18 countries, a visa-free regime for 15, and direct air service for 17. Consequently, the coefficients on VisaFree_i and especially DirectFlight_i are effectively identified by a handful of exceptions and cannot be estimated with high precision.

4.1. Multicollinearity

In the full model, the variance inflation factors are approximately $VIF_{\ln \text{Distance}} \approx 33$, $VIF_{\ln \text{GDPpc}} \approx 15$ and $VIF_{\text{Border}} \approx 8.2$. Multicollinearity means that the explanatory variables carry similar information, so the model cannot reliably separate their individual contributions. A high VIF does not necessarily reduce the model's joint explanatory power, but it inflates standard errors, makes coefficients sensitive to the composition of the sample, and can change their signs. In this case, about 97% of the variation in log distance and 93% of the variation in log income is reproduced by the other regressors of the full specification.

The loss of significance of distance after the controls are included therefore does not mean that space has ceased to affect travel. The more accurate conclusion is that, in the Uzbekistan sample, distance is difficult to separate from neighbourhood, cultural proximity and the regional structure of flows.

4.2. Model estimates

Table 3. OLS and PPML estimation results

Variable	Model 1 OLS	Model 2 OLS	Model 3 OLS	Model 4 OLS- HC3	Model 5 PPML
ln GDPpc _i	0.56 (0.40)	0.20 (0.76)	0.21 (0.96)	0.21 (1.6)	-0.10 (0.64)
ln Distance _i	-2.2*** (0.57)	-1.2 (1.7)	-0.86 (1.9)	-0.86 (3.2)	-0.50 (1.2)
Border _i	—	1.4 (2.3)	0.74 (3.5)	0.74 (5.7)	-0.60 (1.5)
VisaFree _i	—	-0.21 (0.61)	-0.54 (0.73)	-0.54 (1.2)	-0.32 (0.57)
DirectFlight _i	—	0.34 (0.49)	0.16 (0.62)	0.16 (13)	0.15 (0.39)
CulturalIndex _i	—	—	0.55 (0.89)	0.55 (1.3)	1.2** (0.57)
Constant	23*** (1.7)	18** (7.8)	15* (8.1)	15 (19)	15*** (4.9)
N	18	18	18	18	18
R ² / pseudo-R ²	0.66	0.68	0.71	0.71	0.83

*Note: standard errors are shown in parentheses; *, **, *** denote statistical significance at the 10%, 5% and 1% levels, respectively. HC3-robust standard errors are reported for Model 4. The PPML pseudo-R² is not directly comparable with the OLS R².*

The baseline estimate is $\ln \text{Tourists}_i = 23 + 0.56 \ln \text{GDPpc}_i - 2.2 \ln \text{Distance}_i$. The distance coefficient is negative and significant at the 1% level. All else equal, a 1% increase in distance is associated with a decrease in flow of approximately 2.2%. However, after institutional and cultural variables are added, the magnitude of the coefficient falls to 0.86 in OLS and to 0.50 in PPML, and its statistical significance disappears. This pattern confirms that the baseline coefficient captures not only transport costs but also regional proximity.

Income has a positive sign in OLS but is insignificant in all specifications; in PPML the sign becomes negative. This result should not be interpreted as a negative effect of prosperity. In the sample, large flows are formed above all by neighbouring countries, whereas the wealthiest markets are often distant. The strong association of income with distance

and regional affiliation makes it impossible to isolate an independent income elasticity.

The coefficients on common border, visa-free regime and direct service are statistically insignificant. For the visa regime and direct flights, the main reason is the absence of an adequate control group: the visa-free regime applies to 15 countries, and direct service to 17. The negative estimates for Border_i and VisaFree_i in PPML therefore have no substantive causal interpretation.

The cultural-social index is positive in every model in which it is included, and becomes significant in PPML: the coefficient is 1.2 with a standard error of 0.57 ($p \approx 0.038$). Formally, $\exp(1.2) \approx 3.3$, meaning that a one-point increase in the index is associated with a conditional mean flow approximately 3.3 times higher. Because of the ordinal scale, the small N , and the correlation with neighbourhood, this result should be understood as a strong statistical association rather than a precise causal magnitude.

5. Hypothesis testing and comparison with prior studies

Table 4. Hypothesis status and comparative interpretation

Hypothesis	Result in this study	Comparison and interpretation
H ₁ : income (+)	Not supported	In panel models, income is usually significant [7]. For Uzbekistan the effect is masked by a combination of lower incomes and larger flows from neighbouring countries; the VIF for income is 15.
H ₂ : distance (-)	Partially supported	Consistent with [3, 7] in the baseline model. The loss of significance after the controls are added shows a composite regional, rather than a purely transport-related, distance effect.
H ₃ : common border (+)	Not supported	The sign is unstable. Four neighbouring countries are simultaneously close both culturally and geographically; a separate border effect is not identified.
H ₄ : visa-free regime (+)	Not statistically supported	Visa restrictions have previously been shown to reduce flows [8]. In the current sample 15 of 18 countries are visa-free, so there is insufficient variation to test the effect.
H ₅ : direct flight (+)	Not statistically supported	The transport literature points to a positive potential from direct connectivity [17], but 17 of 18 markets already have a direct flight; a control group is virtually absent.
H ₆ : cultural proximity (+)	Partially supported	A positive and significant coefficient in PPML is consistent with research on language, migration and diaspora [9, 10], but it is insignificant in OLS and is not causal.

The comparison shows that the “non-confirmation” of H₁, H₃, H₄ and H₅ is not a new economic law for Uzbekistan. It means that the available cross-section does not contain sufficient independent variation to separate the corresponding effects. The national specificity is expressed in the overlap of several types of proximity: geographical proximity is almost automatically accompanied by a common border, cultural ties and a large flow. As a result, the standard regressors compete to explain one and the same cross-country variation.

Two findings are, in fact, confirmed. First, distance materially constrains the flow in the baseline model, but this estimate is not robust to the inclusion of regional controls. Second, cultural-social proximity is positively associated with the flow in PPML. The remaining hypotheses should be regarded not as refuted, but as unidentified given the available data.

6. Scientific novelty and national specificity

The scientific novelty consists in identifying, for Uzbekistan, an effect of combined regional proximity. The baseline distance coefficient of -2.2 cannot be interpreted as an isolated elasticity of transport costs: once border and the cultural index are included, it falls by more than half and loses significance. This demonstrates that large flows from Central Asia are shaped not by a single factor, but by a cluster of spatial, cultural and institutional ties.

The second new finding is an asymmetry in the identifiability of factors. The cultural-social index retains positive significance in PPML, whereas the visa-free regime and direct-service indicators cannot be estimated because they cover almost the entire sample. This allows a more precise formulation of the national specificity: liberalised access and transport connectivity are already typical characteristics of Uzbekistan's principal markets and therefore, in a single cross-section, do not explain the differences between them. The differences are more strongly related to the depth of cultural-social networks and to overall regional position.

The third result is methodologically interpretative in nature: statistical insignificance is distinguished from the absence of an economic effect. This conclusion matters for studies with a small number of countries, because a mechanical expansion of the list of regressors can reduce precision and even undermine the model's substantive validity.

7. Practical relevance and forecasting

The results make it possible to segment origin markets. Neighbouring countries form the core of short-stay, family, medical, event-related and cross-border tourism; for them, convenient overland routes, repeat visits and regional tourism packages are priorities. For culturally connected but more distant markets, pilgrimage, educational and historical-cultural products are promising. For distant, high-income markets, product quality, international promotion, connecting and direct transport accessibility, and the reduction of digital information barriers are decisive.

The gravity model can be used for conditional forecasting of flows by origin country under scenario changes in the visa regime, flight frequency, digital promotion and other variables. However, the current model cannot directly forecast GDP: its dependent variable is the number of visits. Assessing additional economic growth requires a second stage linking the forecast of arrivals to tourist spending and a sectoral multiplier:

$$\Delta \text{Receipts} = \sum_i \left(\hat{T}_i^{\text{scen}} - \hat{T}_i^{\text{base}} \right) \cdot \text{Spend}_i$$

$$\Delta \text{GDP}_{\text{tour}} = m \cdot \Delta \text{Receipts}$$

where $\hat{T}_i^{\text{scen}}$ and $\hat{T}_i^{\text{base}}$ are the scenario and baseline forecasts of the flow, Spend_i is the average spending of one visitor from country i , and m is a multiplier obtained from a tourism satellite account or an input-output model. Without such data, a claim about a specific increase in GDP would be methodologically unfounded. Nevertheless, the proposed two-stage scheme shows how the results of the gravity model can be built into national tourism and infrastructure planning.

8. Digital extension and limitations of the study

For further analysis it is proposed to move to an "origin country – year" panel and to include a bilateral digital-proximity term:

$$E(\text{Tourists}_{it} | X_{it}) = \exp \left(X'_{it} \beta + \delta \text{DigitalProximity}_{it} + \mu_i + \lambda_t \right)$$

$\text{DigitalProximity}_{it}$ could combine: the share of internet users in the origin country; search interest in Uzbekistan; the reach of advertising for the national tourism brand; the use of e-visas and online booking; and the availability of official content in the language of the relevant market. Unlike a general "digitalisation index," such an indicator has a genuinely bilateral meaning, varies both across countries and over time, and directly reflects the reduction in information costs. Prior research shows that digital tools can weaken the role of distance and language barriers [11], but the effect of virtual proximity and of overall internet penetration is not always the same [12].

The main limitations of the present estimation are: $N = 18$; a single year of observations; possible mixing of recreational, business, family and other travel purposes; an approximate cultural index; the endogeneity of direct flights and visa policy; weak variation in the binary features; and strong multicollinearity. The results therefore characterise the structure of associations in 2023, rather than the causal effects of government policy.

Robustness checks should include sequential exclusion of countries (leave-one-out), models without Border_i and without CulturalIndex_i , decomposition of the cultural index into its components, alternative distance measures, robust regression, and comparison of out-of-sample OLS and PPML errors. When the database is expanded, it would be worthwhile to account for the exchange rate, relative prices, population, flight frequency and fares, hotel infrastructure, and external shocks.

9. Conclusion

The study has shown that the structure of inbound flows to Uzbekistan is consistent with general gravity logic, but is distinguished by a high concentration of interrelated factors. In the baseline OLS model, distance has a strong negative coefficient of -2.2; however, after common border, visa regime, direct service and cultural proximity are added, its magnitude shrinks and loses statistical significance. The initial estimate therefore reflects a composite effect of spatial and regional proximity.

Of the six hypotheses, H_2 is partially confirmed, since the negative distance effect is robust only in the baseline model. H_6 is also partially confirmed: cultural-social proximity is positively significant in PPML but not in OLS. H_1 , H_3 , H_4 and H_5 are not statistically supported. Unlike larger panel studies, this reflects not a refutation of the role of income, border, visas and air connectivity, but the small sample, multicollinearity and weak variation of the features.

Uzbekistan's national specificity lies in the fact that its largest markets are simultaneously close, contiguous, visa-free and culturally connected. The scientific contribution of the paper consists in identifying this identification configuration and in providing a more accurate interpretation of insignificant coefficients. In practice, the model can be used for market segmentation and scenario forecasting of arrivals, but assessing the impact on GDP requires a separate stage using spending data and sectoral multipliers. The model's prospective development lies in panel data and bilateral digital proximity, rather than in a formal expansion of the number of factors.

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