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Article

An Algorithm for Assessing The Competitiveness of Tourism Enterprises: A Benchmarking-Based Integral Index Approach

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Abstract: Destination-level competitiveness research has produced a rich set of macro- and mezo-level composite indicators, yet the firm — the unit that ultimately delivers the visitor experience — remains comparatively under-instrumented in the tourism competitiveness literature. This article develops and formalizes a micro-level algorithm for assessing the competitiveness of individual tourism enterprises, implemented in a purpose-built software tool, “BoburCalculator.” The algorithm rests on two operations applied uniformly across five enterprise modules — hotels, tour operators, restaurants and cafés, transport companies, and other tourism-related firms: benchmark normalization, in which each raw indicator is rescaled against the best-performing firm in the comparison set, and weighted integral aggregation, in which four module-specific normalized criteria are combined into a single competitiveness score bounded on [0,1]. For each module the article specifies the raw indicators (profitability, market share, occupancy, customer satisfaction, loyalty, digital-order share, human-capital quality, punctuality, safety, and capacity utilization, among others), the corresponding normalization formulas, and the resulting integral index. The transport module additionally incorporates an inverse (“fewer incidents is better”) normalization for safety, illustrating that the benchmarking logic generalizes to indicators with either monotonic direction. The algorithm’s structure is presented in both a staged and a modular flowchart implementation. The approach is positioned relative to composite-indicator methodology (Nardo et al., 2005; OECD/JRC, 2008; Saisana & Tarantola, 2002), benchmarking theory (Camp, 1989), and firm-level competitiveness frameworks (Man, Lau & Chan, 2002; Ambastha & Momaya, 2004), and is shown to complement, rather than duplicate, the macro- and mezo-level tourism competitiveness indices developed elsewhere in this dissertation. The article concludes with a discussion of weight-elicitation options (expert judgment, AHP), data-quality prerequisites, and the algorithm’s intended use as a decision-support and benchmarking tool for tourism enterprises and sectoral regulators in Uzbekistan.

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Keywords: tourism enterprise competitiveness; benchmarking; integral index; normalization; composite indicator; hospitality management; BoburCalculator; Uzbekistan.

1. Introduction

Tourism destination competitiveness research has, since Crouch and Ritchie (1999) and Dwyer and Kim [1], been pursued predominantly at the macro (national) and, more recently, mezo (regional) level, producing composite indices such as the World Economic Forum's Travel & Tourism Development Index and a growing family of national and regional benchmarking tools, several of which are developed elsewhere in this dissertation. These macro- and mezo-level indices are indispensable for cross-country and cross-region policy comparison, but they are, by construction, too aggregated to support

a decision a hotel manager, tour-operator director, or restaurant owner must make about their own enterprise's relative market position. What is missing is a parallel, micro-level instrument: a standardized, transparent, and computationally tractable method by which an individual tourism enterprise can benchmark its own performance against comparable firms operating in the same market segment and region.

This article addresses that gap by formalizing a micro-level competitiveness-assessment algorithm developed and implemented in a dedicated software application, "BoburCalculator." The algorithm applies a uniform two-step logic — benchmark normalization followed by weighted integral aggregation — across five distinct enterprise modules (hotels, tour operators, restaurants and cafés, transport companies, and other tourism-related firms), each instrumented with module-specific indicators chosen to reflect the dominant competitive dimensions of that business type: financial performance, market position, service quality, human capital, innovation, digital adoption, and, for transport specifically, safety and punctuality.

The purpose of this study is to: (1) formalize the mathematical structure of the benchmarking and integral-index algorithm in general form; (2) specify, for each of the five enterprise modules, the input indicators, raw formulas, and module-specific integral index; (3) situate the algorithm within the broader composite-indicator and firm-competitiveness literature; and (4) discuss the algorithm's practical implementation, including weight-elicitation methods and data-quality prerequisites, as a decision-support tool for tourism enterprises and sectoral regulators in Uzbekistan.

Literature Review

Firm-level competitiveness theory

Whereas destination competitiveness has been theorized chiefly through the resource-and-management lens of Crouch and Ritchie [2] and Porter's [3] diamond model, firm-level competitiveness research developed a parallel, more operationally oriented literature. Man, Lau and Chan [4] define small and medium enterprise competitiveness as the firm's capability to sustain advantage through the efficient use of resources relative to rivals, and propose a multidimensional measurement structure spanning financial, market, and capability indicators — a structure closely mirrored in the four-criterion module design adopted in Section 3. Ambastha and Momaya [5] similarly synthesize firm-competitiveness literature into resource-based, process-based, and performance-based dimensions, providing additional theoretical justification for combining financial (profit, revenue), operational (occupancy, capacity utilization), and quality (satisfaction, human capital) indicators within a single integral measure.

Benchmarking and normalization methodology

The practice of benchmarking — systematically comparing a firm's performance against the best-performing comparator in a defined peer group — was formalized as a management discipline by Camp [6], who established the "compare against the best" principle that underlies the max-normalization rule applied throughout the algorithm presented in Section 3. The composite-indicator methodology literature provides the formal apparatus for combining multiple normalized indicators into a single index: Nardo et al. [7], [8] and the OECD/JRC [9] Handbook on Constructing Composite Indicators set out the standard sequence of indicator selection, normalization, weighting, and aggregation that the present algorithm follows at firm level, while Saisana and Tarantola [10] provide the robustness and sensitivity-analysis vocabulary (in particular, the dependence of composite rankings on weighting-scheme choice) that is revisited in the Discussion section in relation to expert-weight elicitation.

Service quality and sector-specific performance measurement

Several of the module-specific indicators employed in Section 3 draw on established sector-specific measurement traditions. The customer-satisfaction and service-quality indicators used in the hotel, restaurant, and transport modules are conceptually grounded in the SERVQUAL framework of Parasuraman, Zeithaml and Berry [11], which identifies the gap between expected and perceived service quality as the central determinant of customer evaluation. The digital-adoption indicators used in the restaurant and "other firms" modules reflect the smart-tourism literature on technology-enabled service

delivery [12], [13], while the loyalty and repeat-customer indicators used in the tour-operator module draw on relationship-marketing literature linking customer retention to long-run firm competitiveness.

Table 1 summarizes the principal theoretical and methodological contributions underlying the algorithm developed in this article.

Table 1
Comparative Summary of Selected Studies Underlying the Micro-Level Algorithm

Author(s), Year	Focus	Method	Relevance to This Algorithm
Camp (1989)	Benchmarking theory	Management framework	"Compare against the best" principle underlying max-normalization
Man, Lau & Chan (2002)	SME competitiveness	Multidimensional framework	Financial/market/capability structure mirrored in module design
Ambastha & Momaya (2004)	Firm competitiveness synthesis	Literature review/framework	Resource-process-performance dimensions justify mixed indicator types
Parasuraman, Zeithaml & Berry (1988)	Service quality (SERVQUAL)	Conceptual/empirical model	Basis for satisfaction indicators in hotel, restaurant, transport modules
Nardo et al. (2005)	Composite indicator construction	Methodological handbook	Standard sequence: selection, normalization, weighting, aggregation
OECD/JRC (2008)	Composite indicator handbook	Methodological handbook	Normalization-method taxonomy applied at firm level
Saisana & Tarantola (2002)	Composite indicator robustness	Sensitivity analysis	Weighting-scheme sensitivity informs Discussion on weight elicitation
Buhalis & Amaranggana (2015)	Smart tourism technology	Conceptual model	Basis for digital-adoption indicators (DIG)

Source: compiled by the author based on the literature reviewed above.

In sum, the literature provides three complementary foundations for a micro-level tourism competitiveness algorithm: a theoretical justification for combining financial, operational, and quality dimensions (firm-competitiveness theory); a formal normalization-and-aggregation procedure (composite-indicator methodology); and sector-specific indicator definitions grounded in established service-quality and technology-adoption research. Section 3 operationalizes these foundations into a five-module algorithm.

2. Materials and Method

General approach: benchmark normalization and integral aggregation

The algorithm assesses tourism enterprises at the micro (firm) level. For each module (hotels, tour operators, restaurants/café, transport companies, and other tourism firms), a set of indicators is computed for every enterprise i , the enterprises are then benchmarked against one another (compared to the maximum observed value within the module), and a bounded $[0,1]$ integral index is produced.

Benchmark (normalization) principle. If a given raw indicator for enterprise i is $I_{i,raw}$, it is normalized against the maximum value observed within the comparison set:

$$I_{i,norm} = I_{i,raw} / \max_j(I_{j,raw}), \text{ if } \max_j(I_{j,raw}) > 0; I_{i,norm} = 0 \text{ otherwise. (1)}$$

Under this rule the best-performing enterprise in the set approaches a normalized value of 1, while all others are positioned proportionally within $[0,1]$.

Integral index. Within each module, four selected core criteria are combined as a weighted sum:

$$\text{Integral}_i = w_1 \cdot I_{1,i,norm} + w_2 \cdot I_{2,i,norm} + w_3 \cdot I_{3,i,norm} + w_4 \cdot I_{4,i,norm} \quad (2)$$

where $w_1 \dots w_4$ are weights (for example, 0.3, 0.3, 0.2, 0.2) that may in practice be set by expert judgment, the Analytic Hierarchy Process (AHP), or another multi-criteria weighting method.

Hotel module

Inputs: annual revenue (D); annual cost (X); tourists served by the firm (T_{firm}); total regional tourist flow (T_{region}); occupied rooms ($R_{occupied}$); total rooms (R_{total}); satisfied customers ($Q_{satisfied}$); total survey respondents (Q_{total}); qualified staff ($S_{qualified}$); total staff (S_{total}).

Net profit: $\Pi = D - X$. Market share: $MS_{raw} = T_{firm} / T_{region}$. Occupancy rate: $OR_{raw} = R_{occupied} / R_{total}$. Customer satisfaction: $SAT_{raw} = Q_{satisfied} / Q_{total}$. Human capital: $HR_{raw} = S_{qualified} / S_{total}$. After max-normalization of MS , OR , SAT , and HR , the hotel integral index is $\text{Integral}(H)_i = w_1 \cdot MS_{i,norm} + w_2 \cdot OR_{i,norm} + w_3 \cdot SAT_{i,norm} + w_4 \cdot HR_{i,norm}$.

Tour operator module

Inputs: annual revenue (D); annual cost (X); loyalty-program returning customers (C_{return}); total customers (C_{total}); new tour packages (P_{new}); total packages (P_{total}); tourists served (T_{served}); destinations served (D_{est}); partner guides, partner hotels, and partner transport organizations ($G_{partner}$, $H_{partner}$, $T_{partner}$).

Net profit: $\Pi = D - X$. Loyalty coefficient: $LOY_{raw} = C_{return} / C_{total}$. Innovative-package share: $INN_{raw} = P_{new} / P_{total}$. Market scale: $MS_{raw} = T_{served}$. Destination coverage: $DST_{raw} = D_{est}$. Partnership network: $PAR_{raw} = G_{partner} + H_{partner} + T_{partner}$. After normalization, $\text{Integral}(T)_i = w_1 \cdot LOY_{i,norm} + w_2 \cdot INN_{i,norm} + w_3 \cdot MS_{i,norm} + w_4 \cdot PAR_{i,norm}$, with DST_{raw} reported separately and available for inclusion as a fifth weighted criterion if desired.

Restaurant/café module

Inputs: annual revenue (D); annual cost (X); positive customer feedback ($O_{positive}$); total feedback (O_{total}); digital orders (B_{online}); total orders (B_{total}); experienced staff ($S_{experienced}$); total staff (S_{total}); average daily receipt ($Cheque_{day}$); daily customer count (N_{day}).

Profit ratio: $PR_{raw} = (D - X) / D$. Satisfaction index: $SAT_{raw} = O_{positive} / O_{total}$. Digital-order share: $DIG_{raw} = B_{online} / B_{total}$. Experienced-staff share: $HR_{raw} = S_{experienced} / S_{total}$. Average daily receipt and daily customer count are reported directly. After normalization, $\text{Integral}(R)_i = w_1 \cdot PR_{i,norm} + w_2 \cdot SAT_{i,norm} + w_3 \cdot DIG_{i,norm} + w_4 \cdot HR_{i,norm}$.

Transport module

Inputs: on-time trips during the year ($Q_{on-time}$); total trips (Q_{total}); accidents during the year ($H_{incident}$); negative tourist feedback ($O_{negative}$); total tourist feedback (O_{total}); passengers served (P_{served}); transport capacity, vehicles $\times$ seats (Cap).

Punctuality: $PUN_{raw} = Q_{on-time} / Q_{total}$. Incident frequency: $ACC_{raw} = H_{incident} / Q_{total}$ (a "lower is better" indicator). Satisfaction (from negative feedback): $NEG = O_{negative} / O_{total}$, $SAT_{raw} = 1 - NEG$. Load factor: $LOAD_{raw} = P_{served} / Cap$.

Because safety should be evaluated on a “fewer incidents is better” basis, an inverse normalization is applied: with $A_{\max} = \max_j(ACC_{j,raw})$,

$$SAFE_i = 1 - ACC_{i,raw} / A_{\max}, \text{ if } A_{\max} > 0; \text{ SAFE}_i = 1 \text{ if } A_{\max} = 0. \quad (3)$$

If no enterprise in the comparison set recorded an accident ($A_{\max} = 0$), safety is set to 1 for all firms. The transport integral index is then $Integral(Tr)_i = w_1 \cdot PUN_{i,norm} + w_2 \cdot SAFE_i + w_3 \cdot SAT_{i,norm} + w_4 \cdot LOAD_{i,norm}$, illustrating that the benchmarking logic generalizes cleanly to indicators of either monotonic direction.

Other tourism-related firms module

Inputs: customers served (M_{served}); digital orders ($B_{digital}$); total services (B_{total}); experienced staff ($S_{experienced}$); total staff ($Stotal$); average daily per-customer receipt (Cheque day); daily visitors (N_{day}).

Market share within the module: $M_{total} = \sum_j M_{served,j}$, $SHARE_i = M_{served,i} / M_{total}$. Digital-order share: $DIG_{raw} = B_{digital} / B_{total}$. Experienced-staff share: $HR_{raw} = S_{experienced} / Stotal$. Estimated daily revenue: $REV_{raw} = \text{Cheque day} \times N_{day}$. After normalization, $Integral(O)_i = w_1 \cdot Si_{norm} + w_2 \cdot DIG_{i,norm} + w_3 \cdot HR_{i,norm} + w_4 \cdot REV_{i,norm}$.

Table 2
Summary of the Five Enterprise Modules and Their Integral-Index Criteria

Module	Core Criteria (Weighted)	Direction	Reported but Not Weighted
Hotels	Market share, occupancy, satisfaction, human capital	All maximizing	Net profit
Tour operators	Loyalty, innovative-package share, market scale, partnership network	All maximizing	Net profit, destination coverage
Restaurants/cafés	Profit ratio, satisfaction, digital-order share, experienced-staff share	All maximizing	Average receipt, daily customers
Transport	Punctuality, safety (inverse), satisfaction, load factor	Safety inverse; others maximizing	—
Other firms	Market share, digital-order share, experienced-staff share, estimated revenue	All maximizing	—

Source: compiled by the author from the BoburCalculator algorithm specification.

3. Result and Discussion

Software implementation

The algorithm described in Section 3 has been implemented as a standalone desktop application, “BoburCalculator,” which accepts module-specific raw indicator inputs for an arbitrary number of enterprises, performs max-normalization within the comparison set, and computes module integral indices using user-adjustable weights. Figure 1 presents the modular implementation of the assessment model, in which each enterprise type (hotel, tour operator, restaurant/café, transport, other firm) is processed through an independent, parallel module sharing the common normalization-and-aggregation core described in Section 3.1; a staged (sequential) implementation variant, in which all enterprises pass through a common ordered pipeline of data input, normalization, weighting, and ranking regardless of module, is also available within the same application.

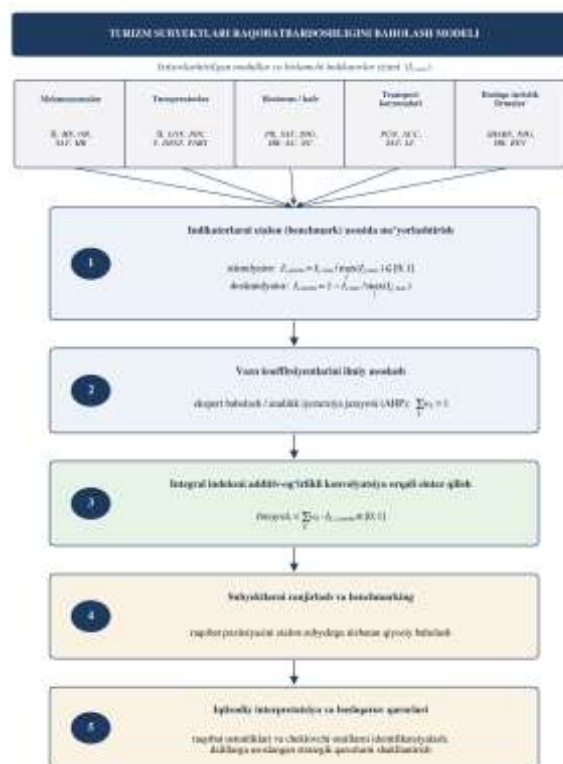


Figure 1. Tourism enterprise competitiveness assessment model implemented in the BoburCalculator application (modular variant). Source: author's development.

Illustrative interpretation

Because the algorithm is designed to be applied to enterprise-specific operational data that individual firms typically treat as commercially sensitive, this article presents the algorithm's formal structure and software implementation rather than a numerical case application; a parallel empirical application using anonymized data from a sample of Samarkand-region hotels and tour operators is reserved for a separate, data-access-cleared study. Nonetheless, the structure of the algorithm itself yields several interpretable properties. First, because every raw indicator is normalized within its own comparison set rather than against an absolute external benchmark, the integral index is comparison-group-dependent by design: a firm's score reflects its standing relative to the specific peer set entered into the application (for example, hotels within one region, or within one star-category), not an absolute international standard. Second, the bounded [0,1] range and the additive weighted-sum aggregation rule mean that a firm's integral index can be decomposed back into its four weighted components, allowing managers to identify which specific dimension (financial, market, quality, or human-capital) is driving — or constraining — their relative competitive position. Third, the transport module's inverse safety normalization (equation 3) demonstrates that the underlying max-normalization logic of equation (1) generalizes to “lower is better” indicators without requiring a structurally different aggregation rule, a property that extends naturally to other risk-type indicators (for example, customer-complaint rates or staff-turnover rates) that future versions of the algorithm could incorporate.

Discussion and Policy Implications

The algorithm developed in this article occupies a level of analysis — the individual tourism enterprise — that is structurally distinct from, and complementary to, the macro (national) and mezo (regional) competitiveness indices developed elsewhere in this dissertation. Where the macro-level Travel & Tourism Development Index benchmarking and the mezo-level Integral Regional Tourism Competitiveness Index aggregate information across an entire country or region to inform national and regional policy, the micro-level algorithm presented here is designed to inform a single firm's own strategic

decisions and to support sectoral regulators and tourism development funds in benchmarking individual loan or subsidy applicants against their immediate competitive peer group — for example, in allocating the subsidized lending and tax-incentive instruments discussed in connection with cluster development [14], [15], [16], [17].

A central methodological choice, consistent with the robustness literature of Saisana and Tarantola [10], concerns the weights $w_1...w_4$ applied in equation (2). The illustrative weighting scheme (0.3, 0.3, 0.2, 0.2) used in the BoburCalculator default configuration reflects an expert-judgment allocation favoring market-position and financial criteria over quality and human-capital criteria; this allocation is adjustable, and the Analytic Hierarchy Process offers a more formally documented alternative for sectoral regulators who require a transparent, pairwise-comparison-based justification for whatever weighting scheme is ultimately adopted, particularly where index outputs will inform the allocation of public financial instruments rather than purely internal management decisions.

Data quality is the algorithm's principal practical constraint. Because every module relies on enterprise self-reported operational counts (room-nights, customer feedback counts, trip counts, accident counts), the integrity of the resulting integral index depends entirely on the accuracy and comparability of firm-level reporting; this is a generic limitation of firm-level benchmarking exercises rather than one specific to the present algorithm, but it implies that any policy use of the index (for example, in allocating preferential credit) should be paired with basic data-verification procedures, particularly for self-reported satisfaction and safety indicators where misreporting incentives are strongest [18], [19], [20].

4. Conclusion

This article has formalized a micro-level tourism enterprise competitiveness algorithm built on two operations — max-based benchmark normalization and weighted integral aggregation — applied consistently across five enterprise modules (hotels, tour operators, restaurants/cafés, transport companies, and other tourism firms), and implemented in a dedicated software application, BoburCalculator. The algorithm fills a level-of-analysis gap in the tourism competitiveness literature, complementing the macro- and mezo-level composite indices developed elsewhere in this dissertation with an instrument operating at the level individual enterprises and sectoral regulators can act on directly.

Three conclusions follow. First, the benchmarking logic of equation (1), grounded in Camp's (1989) "compare against the best" principle, generalizes across enterprise types and indicator directions, including the inverse safety normalization required for the transport module. Second, the four-criterion weighted-sum structure of equation (2) is theoretically consistent with firm-competitiveness frameworks (Man, Lau & Chan, 2002; Ambastha & Momaya, 2004) that organize competitiveness along financial, market, and capability dimensions. Third, the algorithm's practical value depends on two conditions external to its mathematical structure: a defensible, ideally formally documented weighting scheme (for example, via AHP), and reliable underlying enterprise data — both of which should be addressed before the algorithm is used to inform the allocation of public financial instruments.

Future research should pursue an empirical application of the algorithm to an anonymized panel of Uzbekistan tourism enterprises across all five modules, a formal AHP-based weight-elicitation exercise involving sectoral experts, and a sensitivity analysis, following Saisana and Tarantola (2002), of firm rankings under alternative weighting and normalization schemes.

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