A multi criteria analysis method to measure islands’ connectivity

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Outline

- Our Scope
- The Greek case, a challenge for research
- Literature review
- Methodology
- Key points and further research
Our scope

Recognising the significance of sea transport for national cohesion and economy of coastal / island regions and therefore, the necessity for measuring its effectiveness,

We aim to evolve a methodology for the assessment of the level of islands’ connectivity, in terms of passenger ferry transportation, based on the theory of multi criteria analysis.
The Greek case, a challenge for research

- 13,500 km of coastline
- 6,000 islands (227 inhabited)
- Complex network of 200 ports
- 1/3 of EU annual transport capacity
- Market oligopoly
- Ro-pax and Pax vessels service
- Intense seasonality
The Greek case, a challenge for research

- Many islands with low commercial interest
- Heavy State intervention (subsiding itineraries)
- Minimum itineraries' frequency criterion
- No qualitative or quantitative aspects
- Lack of open data and documentation

IOBE, 2014

XRTC, 2015
The Greek case, a challenge for research

A participatory experiment:
The Greek case, a challenge for research

Some of the consultation's recommendations:

- Redesigning the **minimum islands’ connection** requirements
- Implementing joint or **multi modal transport systems**
- Establishing a “**coastal shipping observatory**”
- Allocating the **annual compensation** of the subsidized lines based on a **documented methodology**
- Elaborating a **5-year horizon study for the transport system** with emphasis on maritime and air domestic transportation
Literature review

- Connectivity measurements, in terms of passenger transport have extensively been applied to aviation.
- Maritime networks’ connectivity, and especially ports and cargo liner shipping, have been sufficiently studied, but no significant attention has been paid to island’s passenger ferry connectivity.
- The indicators that have already been developed are either just qualitative or quantitative and usually derive as a function of selected but rather limited parameters.
- The islands, mainly due to insularity, constitute a special case study regarding transport accessibility.
Literature review

Research gap:

The **measurement** of the relative **connectivity level** of an **island** with respect to its **transport needs**, through a documented method, taking into account the most appropriate **qualitative** and **quantitative** parameters.

Applicability:

Except from an alternative **scientific approach**, the method might be a **decision making tool** both for the **regulators** and the **operators**.
Methodology

A definition:

Connectivity is the *availability* of transport that enables people and goods to *reach* a range of *destinations* at a *reasonable* generalized cost in an *accountable* and *accepted* way.
The islands' level of connectivity in terms of passenger ferry transportation may be primarily estimated according to the following main attributes:

**Passenger ferry services**

**Islands' transport potential**
Methodology

**Island's Connectivity** = f(quantity ; quality) =
Transport Capacity * Performance Indicator

**Performance Indicator:**
An additive value function for a given ranking of specific criteria / sub criteria (Analytical Hierarchic Process) on a reference set of alternatives $A_R$ (islands), according to the UTA (UTilités Additives) multi criteria decision making methodology (Jacquet-Lagreze and Siskos, 1982)
Passenger Ferry Services

Island's Connectivity: \( IC = P \times u(g) \)

\[
IC = [FP + AP_{eq}] \times u(g) = [FP + c(g) \times AP] \times u(g) = FP \times u(g) + AP \times u(g) \times c(g)
\]

- \( P \) is the total number of the passenger transport capacity provided through the port(s) and airport(s) of an island.
- \( FP \) is the number of the ferries' passenger capacity.
- \( AP \) is the number of the airplanes' passenger capacity.
- \( AP_{eq} \) is the air (to sea) equivalent passenger capacity value.
- \( c(g) \) is a transport mode conversion factor.
- \( u(g) \) is the qualitative additive value function (performance indicator) of the transport services criteria \( g \).

\[
u(g) = \sum_{i=1}^{n} p_i \times \sum_{j=1}^{m} p_{ij} \times u_{ij}(g_{ij})
\]

Island Connectivity Index: \( ICI = \frac{IC}{IC_{max}} \)
## Methodology

### Passenger Ferry Services' index (ICI) criteria and sub criteria:

<table>
<thead>
<tr>
<th>Criteria $g_i$</th>
<th>Sub criteria $g_{ij}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINANCIAL COST</td>
<td>Fare cost - Cost for accessing port - Cost for &quot;on board&quot; services</td>
</tr>
<tr>
<td>TIME</td>
<td>Trip duration - Consistency of timetables - Access time to ports</td>
</tr>
<tr>
<td>ACCESSIBILITY</td>
<td>Number of itineraries - Frequency of itineraries - Number of transits - Number of interconnected destinations</td>
</tr>
<tr>
<td>QUALITY OF SERVICES</td>
<td>Ship’s accommodation - On board services - Information services - Ticket purchase facilities</td>
</tr>
<tr>
<td>SOCIAL COST</td>
<td>Ships’ environmental performance - Ships’ age - Corporate social responsibility of passenger ferries’ operators</td>
</tr>
</tbody>
</table>
Island's Transport Potential

Islands' Potential: \[ IP = N \cdot v(f) \]

\( N \) is the size of the island’s population (winter season), or the gross sum of the island’s population plus the total available beds in all the island’s tourist accommodation establishments (summer season)

\( v(f) \), is the qualitative additive value function (performance indicator) of the transport potential of an island related to the islands’ transport needs criteria \( f \)

\[ v(f) = \sum_{i=1}^{n} q_i \cdot v_i(f_i) \cdot \sum_{j=1}^{m} q_{ij} \cdot v_{ij}(f_{ij}) \]

Island Transport Potential Index: \[ IPI = \frac{IP}{IP_{\text{max}}} \]

Island Connectivity Adequacy Index: \[ IPI = \frac{ICI}{IPI} \]
Methodology

**Islands' Transport Potential index (IPI) criteria and sub criteria:**

<table>
<thead>
<tr>
<th><strong>Criteria</strong> $f_i$</th>
<th><strong>Sub criteria</strong> $f_{ij}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEVELOPMENT</td>
<td>Per capita income - (Un)employment rate - Entrepreneurship rate</td>
</tr>
<tr>
<td>TOURISTIC</td>
<td>Interest for visiting - Availability of cultural sites, touristic areas and resorts - Multitude of cultural, athletic and touristic events and activities - Availability of hosting, catering and entertainment services</td>
</tr>
<tr>
<td>INFRASTRUCTURE</td>
<td>Adequacy of ports - Internal transport system - Existence of airport - Public services</td>
</tr>
<tr>
<td>LOCATION</td>
<td>Remoteness and isolation - National interests</td>
</tr>
</tbody>
</table>
Methodology

Estimating the weights of criteria and sub criteria using AHP

**Number of stakeholders per professional qualification**

- NGO or other Body: 4
- Academic: 5
- Company: 3
- Sea man: 2
- Public Administration: 3
- Free Lancer: 1

**Educational attainment of stakeholders**

- PhD: 33%
- MSc: 28%
- Tertiary: 39%

**Stakeholders' professional experience**

- <10 years
- 10÷20 years
- >20 years

**Stakeholders' perception for the applicability of the method**

- Companies: 4
- Islands: 4
- State: 8

**NGO or other Body**

**Public Administration**

**Sea man**

**Company**

**Academic**

**Free Lancer**

**PhD**

**MSc**

**Tertiary**

**<10 years**

**10÷20 years**

**>20 years**
Methodology

Weights for Passenger Ferry Services Criteria

PASSENGER FERRY SERVICES CRITERIA
Inconsistency=0.02

- Financial Cost: 0.300
- Time: 0.211
- Accessibility: 0.196
- Quality of Services: 0.155
- Social Cost: 0.138
Methodology

Weights for Passenger Ferry Services Sub Criteria

**FINANCIAL COST**
Inconsistency=0,04

- **Fare Cost**: 0,597
- **Cost for accessing port**: 0,267
- **Cost of on board services**: 0,137

**TIME**
Inconsistency=0,00

- **Trip duration**: 0,501
- **Consistency of timetables**: 0,333
- **Access time to port**: 0,174
Methodology

Weights for Passenger Ferry Services Sub Criteria

**ACCESSIBILITY**
- Frequency of itineraries: 0.372
- Number of itineraries: 0.298
- Number of interconnected destinations: 0.179
- Number of transits: 0.152

Inconsistency = 0.00

**QUALITY OF SERVICES**
- Ship’s accommodation: 0.309
- Ticket purchase: 0.259
- On board services: 0.253
- Information Services: 0.178

Inconsistency = 0.01

**SOCIAL COST**
- Ship’s environmental performance: 0.538
- Corporate social responsibility: 0.258
- Ship’s age: 0.204

Inconsistency = 0.00
Methodology

Weights for Islands' Transport Potential Criteria

**ISLANDS' TRANSPORT POTENTIAL CRITERIA**

Inconsistency = 0.01

- **Development**: 0.295
- **Infrastructure**: 0.259
- **Location**: 0.240
- **Touristic attractiveness**: 0.206
Methodology

Weights for Islands' Transport Potential Sub Criteria

**DEVELOPMENT**
Inconsistency=0,04

- Enterpreneurship rate: 0,392
- Unemployment rate: 0,308
- Per capita income: 0,300

**INFRASTRUCTURE**
Inconsistency=0,00

- Adequacy of ports: 0,375
- Internal transport system: 0,228
- Existence of airport: 0,207
- Public services: 0,190

**LOCATION**
Inconsistency=0,00

- Remoteness and isolation: 0,505
- National interests: 0,495

**TOURISTIC ATTRACTIVENESS**
Inconsistency=0,00

- Availability of hosting, catering and entertainment services: 0,307
- Availability of cultural sites, touristic areas and resorts: 0,277
- Multitude of cultural, athletic and touristic events and activities: 0,211
- Interest for visiting: 0,205
Methodology

Transport Mode Priorities and Correlation

Priorities (Sea or Air travel) per passenger ferry services' criterion

- **Financial Cost**: Sea; 0.232, Air; 0.768
- **Time**: Air; 0.298, Sea; 0.702
- **Accessibility**: Sea; 0.387, Air; 0.613
- **Quality of Services**: Air; 0.449, Sea; 0.551
- **Social Cost**: Sea; 0.281, Air; 0.71

Transport mode priorities with respect to pass. ferry services criteria

\[ C(g) = \frac{0.422}{0.578} = 0.73 \] [air/sea conversion factor]

Graph showing the comparison between Sea and Air transport in terms of various criteria.
Key points

- The methodology introduces a **novel** but **simple** and **reliable** approach for the estimation of an islands' relative connectivity level.

- All performance indicators are **comparative** and **dimensionless**.

- The selection of the applicable **criteria** and the estimation of their weights, as well as, the choice of the most appropriate **performance indicators** may be **adjusted** on the specific characteristics of the **islands** under review.

- The proposed connectivity indexes may provide a **decision making tool** for the policy makers with respect to the islands’ transport.

- The **availability** and the systematic and consistent collection of **statistics and data** from reliable sources is absolutely essential.
Further research

- Collection and processing of data for the estimation of the connectivity indexes for a group of Greek Islands (case study)
- Developing a decision making algorithm for the allocation of passenger ferry subsidies
- Evaluating the existing regime for the allocation of passenger ferry subsidies in comparison with the proposed decision making algorithm (case study islands)
Further research

The research process

Identification of the question and objectives of the research → Literature Review → Development of the indices’ mathematical formula → Determination of the criteria/sub criteria, weights and performance indicators → Research process

Promulgating of the findings and proposals → Evaluating the existing subsidies regime (case study islands) in comparison with the proposed model → Developing a decision making method for the allocation of passenger ferry subsidies → Assessing connectivity for a selected group of islands (Case study) → Further Steps
...Keep Ithaca always in your mind. Arriving there is what you are destined for...

[C.P. Cavafy, Ithaka]