Applying the Island Transport Equivalent to the Greek Islands

Discussion Paper

179 Roundtable

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ITF Discussion Papers

Cite this work as: Lekakou et al. (2021), "Applying the Island Transport Equivalent to the Greek islands", *International Transport Forum Discussion Papers*, No. 2021/02, OECD Publishing, Paris.

Acknowledgements

This discussion paper was written by Maria Lekakou, George Remoundos and Evangelia Stefanidaki. It benefitted from comments by Lucie Kirstein (ITF), Juliette Lassman (ITF) and participants of the Roundtable on Connecting Remote Communities, hosted in September 2019 by Transport Canada. Richard Venturi (ITF) provided editorial support.

The analysis presented in this paper draws on the work conducted in the context of the research project the Calculation Methods of Island Transport Equivalent for Greek Islands. This was in support of the General Secretariat of the Aegean and Island Policy, funded in part by the European Structural Funds and Programme of Public Investments.

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Introduction

Islands are by definition isolated, regardless of their size, population and level of development. Insularity is the term used to describe objective and measurable characteristics of islands, including small area size, small population (i.e. small market), isolation and remoteness, as well as unique natural and cultural environments (Spilanis et al., 2012). The term also includes a distinctive experiential identity – which is a non-measurable qualitative variable – expressing the special characteristics that distinguish islands. On the EU level, there is no definition for these. However, for statistical reasons Eurostat defines islands "as territories having: a minimum surface of 1 km^2; a minimum distance between the island and the mainland of 1 km; a resident population of more than 50 inhabitants; and no fixed link between the island and the mainland."

Island territories may have comparative advantages over other continental regions, especially with regard to the so-called blue economy (i.e. the exploitation and preservation of the marine environment). A growth model based on the maritime economy and the use of marine resources could provide an answer to the contemporary challenges of island development. It would shine a light on the importance of traditional maritime economic activities (e.g. fisheries and maritime transport), while diversifying island economies through innovation and advanced technologies to exploit untapped development potential. Despite the obvious link between island development and maritime economic activities, it appears that island economies are laggards when it comes to the blue economy.

Population size and the inability to achieve economies of scale, a lack of economic diversification and reliance on the public sector, a weak institutional capacity and high transport costs are some of the constraints hindering the potential benefits of the blue economy for island economies.

Besides concentration of economic activities and lack of economies of scale, other examples of negative impacts of insularity to islands' attractiveness come from the low effectiveness of the public services provided. But the most profound example of the negative influence of the geographical discontinuity of space is accessibility (Spilanis et al., 2012).

Transport is a key factor in the development of remote areas, given that islands are exclusively dependent on public transport, mainly maritime and air. Infrastructure and transport services both determine the level of provision of services of general economic interest (Bennett, 2006). The responsibility for services of general interest is shared between the European Union and its Member States. This shared responsibility stems from the principle under Article 16 of the EC Treaty (the treaty establishing the European Community), according to which the European Community and Member States must ensure, within the limits of their respective competences, their policies allow operators providing services of general economic interest to carry out their tasks. The right of Member States to impose specific public service obligations on economic operators and to ensure compliance therewith is also indirectly recognized in Article 86 (2) of the EC Treaty and implied through Council Regulation (EEC) No 3577/92. The latter recognises island cabotage, public services contracts and public services obligations, while distinguishing cruise services from regular passenger services and all matters related to vessel manning (based on the Regulation, all vessels except cruise ships carrying out island cabotage must comply with the manning requirements of the host state, while in any other cases flag state rules apply). Regulation secures fares, frequencies and competitive tendering procedures but does not foresee a minimum socially acceptable level of transport services (Eurisles, 2003; Chlomoudis et al., 2007). Under European Commission guidelines (2004/C 13/03), a Public Service Obligation (PSO) in ferry services must necessarily address problems of peripherality, insularity and/or economic disadvantage that would not normally be addressed without public intervention. A key point in addressing this inequality is the definition of quality and price levels of transport services and the guarantee of citizens' access to them.

This discussion paper introduces the Island Transport Equivalent, which can be used as a concept and mechanism to treat cost inequality. It is based on the notion that islanders should pay a corresponding fare to what mainland residents pay for equivalent surface transport services.

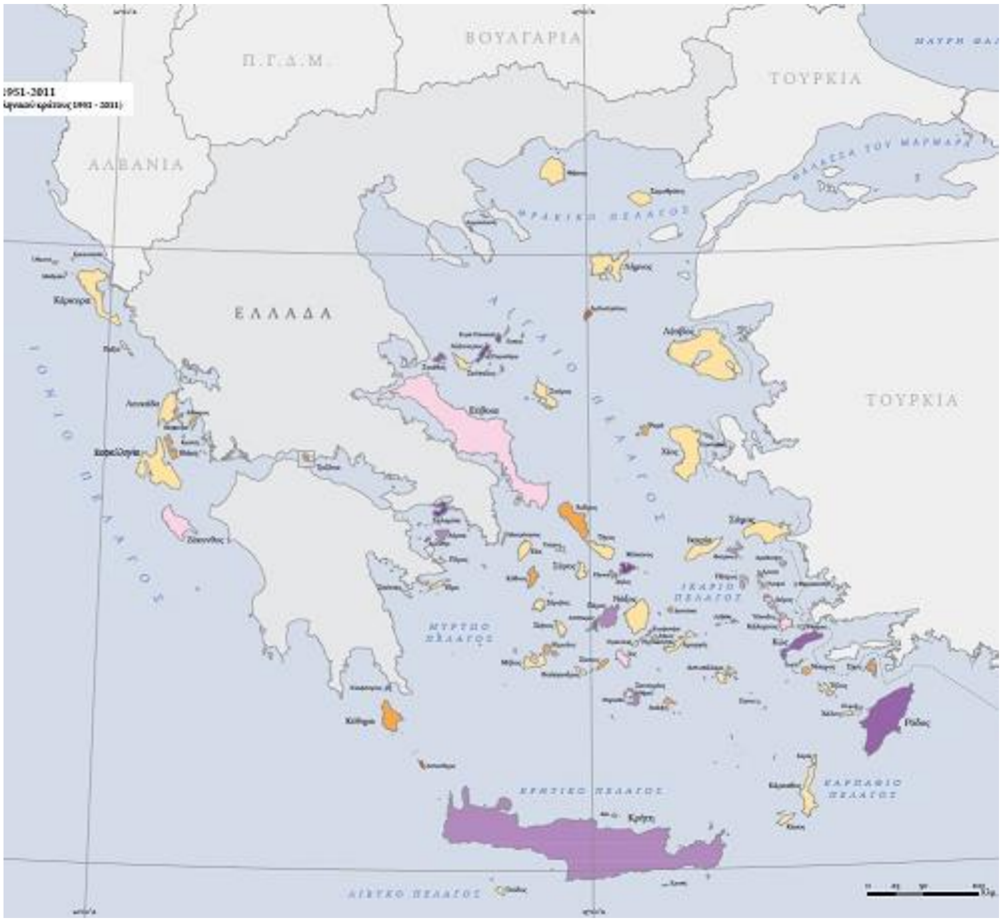
The transport equivalent concept has been applied in different countries. However, no homogeneous way of determining transport fares has been defined, and no specific trend has been recorded on how these fares are determined historically. The most important reason behind this is each country has a different transport network, different policy priorities and problems to solve. An example of implementation is the Road Equivalent Tariff (RET), based on the Norwegian fare system (Pedersen, 1974), which was applied on Scotland's local ferry lines. The rationale of RET is that users paying road toll are entitled to drive anywhere on the road network. To be equitable, the cost to the ferry user ought to be related to the cost of travelling along an equivalent length of road (Kay, 2009). Subsidies granted under the principle of territorial continuity in France are another relevant example. In this context, the aim is to facilitate access between different parts of France, mitigating the effects of territorial discontinuity with Corsica, where the corresponding maritime transport cost is determined on the basis of the cost of road transport at an equivalent distance (Carrese, Cuneo and Patella, 2015).

This paper develops a method for approaching islands' connectivity through a set of indices, where one of the most significant components is travel cost. In the Greek case, the issue of travel cost is tackled by the implementation of a government policy measure, the aforementioned Island Transport Equivalent (ITE), which is based on a methodological approach presented in the last part of this discussion paper.

Island communities in Greece

Greece is heavily dependent on maritime transport, and the existing network of sea connections ensures accessibility to the 120 inhabited islands of the country. Islanders constitute almost 13% of the national population, with half of them residing on the island of Crete. There are three main island clusters, administratively organised in peripheries, namely North Aegean, South Aegean Ionian islands and the island of Crete. The prolonged economic crisis has significantly impacted the island regions' economic and social conditions.

Figure 1. Map of Greece



Source: Spilanis and Kizos (2015), Atlas of the islands.

Since 2009, the Gross Domestic Product (GDP) of island regions in Greece has recorded a decline of more than 30%, with the Ionian islands and the North Aegean registering the highest reduction among the country's thirteen regions (43% and 40% respectively) (Eurostat, 2019a). In 2017, island economies generated 11.5% of the country's total GDP – a percentage that has remained stable since 2009 (Eurostat, 2019a).

Despite the islands' different characteristics in terms of size and resources, the economic structure is similar across island regions. Specifically, the primary sector has a rather limited contribution to regional gross value added (GVA), ranging from 2.5% (North Aegean) to 7.0% (Crete). All four island regions are highly dependent on the tertiary sector, with trade, transportation and tourism generating almost half of the sector's total value. In addition, there is a strong link between the local economy and public sector activities. In terms of employment, 13.8% of the country's total workforce is employed in island regions (Eurostat, 2019a). The North Aegean ranks third among the thirteen regions in Greece and first among the island regions in terms of unemployment rates (22.3%), while Crete has the lowest unemployment rate (13.4%) in Greece. With respect to the percentage of people at risk of poverty and social exclusion, all island regions – except the Ionian Islands – recorded higher percentages than the corresponding national average (31.8%). Crete has the second highest percentage of people facing poverty risk and social exclusion (37%), while Ionian islands have the lowest percentage (28%) (Eurostat, 2019b).

The coastal transport network in Greece

Greek coastal shipping is the largest shipping market in Europe, representing 16.9% of the total share (Eurostat, 2016). With 143 ports serving ferries, Greece has the densest ferry port network in Europe, followed by Denmark with 72 and Croatia with 62 (FEI, 2017).

Over the past few years, the Greek economic downturn has significantly affected the viability of the coastal transport network (CTN), which suffered a 46.0% decline in traffic volumes between 2009 and 2016 and a 44.0% reduction in the number of services offered (XRTC, 2018). The decline of available domestic income combined with the rise in fuel prices had a significant effect on the financial performance of coastal shipping companies and a direct impact on the volume and quality of services provided. In 2017, the coastal network was served by a total of 91 ships (-7.5% from previous year), with an average age of 13 years, while total traffic increased 10% (from 2016) due to the rise in inbound tourism (XRTC, 2018).

Following the liberalisation of coastal services in 2002, the market structure has not changed substantially. The limited number of operators – usually maximum two per line – in the main markets, indicates an oligopolistic structure. The sector is heavily concentrated with 11 shipping companies operating the main lines. During the last five years, two fundamental changes have been observed:

1. large companies listed on the Athens Stock Exchange have followed either a partnership strategy or a model of selling and purchasing equity packages in order to respond to competition pressures
2. a number of new but small players have entered the market, adding capacity on specific itineraries (XRTC, 2018).

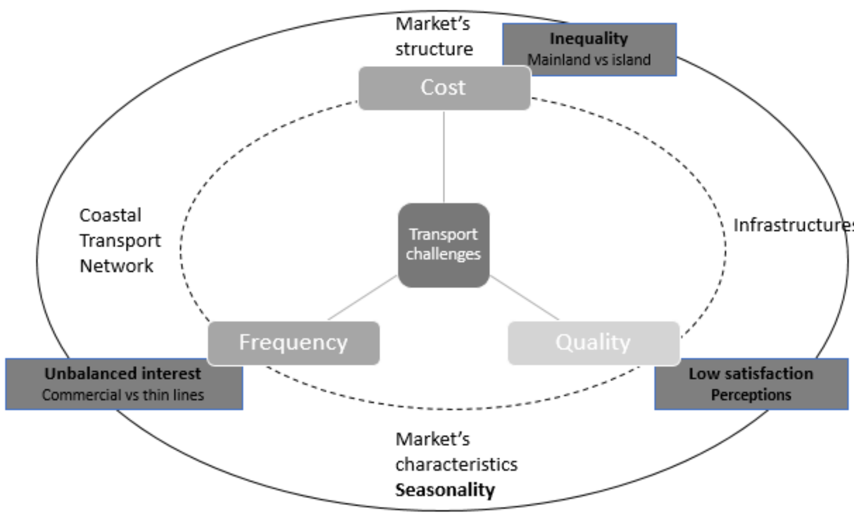
New market conditions have generated two investment trends: a trend towards listed companies where the majority of investment comes from non-shipping schemes, and a trend of newcomers, smaller family business structures that invest in new vessels. Based on the Annual Report on the Greek Ferry Market (2018), non-traditional companies recorded equal market share to listed ones, highlighting their dynamic role in the market.

The system is characterized by high seasonality: a third of annual traffic is recorded during the summertime. During the off-season, passenger traffic is limited and coastal shipping companies rely mostly on transporting of trucks. It is worth mentioning that almost 50% of transported trucks return unloaded, implying the limiting exporting capacity of the island economies.

Freight transport between islands and the Greek mainland takes place either via ferries operating regular routes or through commercial short-sea vessels. The first case refers to small quantities of packaged goods carried by independent transporters or privately-owned commercial vehicles, while the second refers to bulk cargoes, which can utilise part of or total capacity of a vessel. In practice, the carriage of small quantities to island destinations takes place through the ports of the Attica Region, mostly the port of Piraeus. This is due to the centripetal structure of the CTN, which does not involve a decentralised hub and spokes but mainly connections to the port of Piraeus. The existing system exerts negative pressure on island-mainland and interisland trade due to the double cost burdening imports and exports respectively. It is therefore not profitable to locate production on islands as they are too far from where raw materials are available.

Greek island transport challenges derive predominately from the structure of the CTN, the state of port infrastructures (degraded or significant improvements required), and the special characteristics of the market (supply and demand). Due to seasonality there is an unbalanced interest of companies to serve specific lines (i.e. commercial vs. thin lines). Seasonality also influences the qualitative characteristics of the services.

Figure 2. Island transport challenges in Greece



Regulatory framework

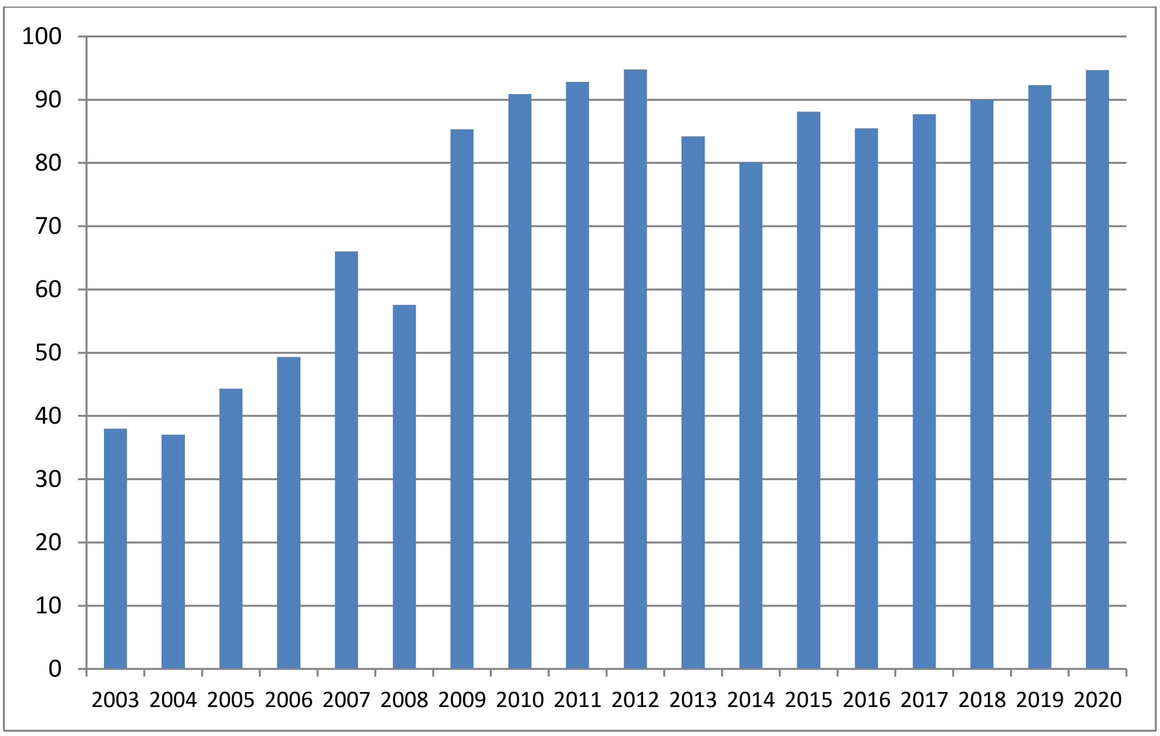
There are multiple references to the particularities of the islands and the outermost regions at the European level. European policies express the need to support these regions to ensure the economic and social cohesion of Europe, reduce spatial inequalities and create equal opportunities (Treaty of Lisbon, Treaty on the Functioning of the European Union, 2007). Regulation 3577/92 applies the principle of freedom to provide services to maritime transport within Member States. As such it is the first legal document at the European level to recognise the need for a specific policy for the islands in the context of the liberalisation of maritime transport. However, insularity as a specific condition has not yet been recognised, and as a result island regions have limited access to specifically-targeted EU funds.

Policy and legislation need to take into account these particularities. Nevertheless, an insularity clause has yet to be defined.

The liberalisation of coastal services in Greece, instituted by the lifting of cabotage restrictions, has led on the one hand to a high concentration in routes serving islands of commercial interest. On the other hand, it has resulted in a remarkable reduction, or even complete elimination in certain cases, of maritime services to islands with low transport demand. Law 2932/2001 is the main pillar of the institutional framework for coastal shipping, incorporating the provisions of EU Council Regulation (EEC) No. 3577 of 7 December 1992, applying the principle of freedom to provide maritime transport services within

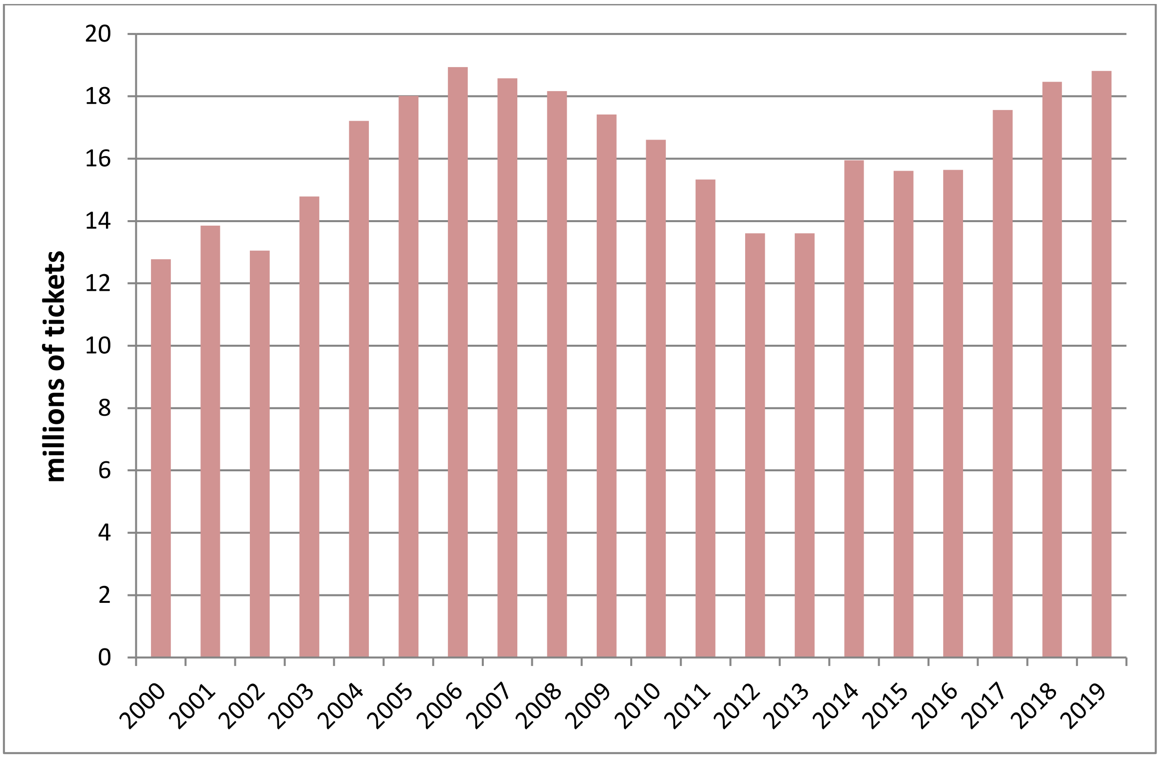
Member States (maritime cabotage). This law foresees state intervention in cases where certain islands do not have sufficient connection frequency by subsidising specific itineraries. Member States may implement public service obligations or conclude public service contracts in the interest of maintaining adequate cabotage services between the mainland and islands, and between islands. In Greece, thin lines are funded by the national budget (an extra aid from a 3% surcharge imposed on all unsubsidised commercial services was also provided until 2015). The annual subsidies allocated by the state to support the minimum passenger ferry connection requirements of the Greek islands and the total annual number of coastal ferry passenger tickets issued in Greece are shown in Figures 3 and 4.

Figure 3. Annual state aid for ferry connections in Greece, in millions of EUR



Source: Ministry of Maritime Affairs and Insular Policy, 2020.

Figure 4. Annual number of coastal ferry passenger tickets in Greece



Source: Hellenic Statistical Authority, 2020.

The ticket demand curve (Figure 4) shows a decline towards the end of the last decade that lasts for almost the entire period of the peak of the economic crisis in Greece. It has gradually begun to return to the levels of previous years over the last couple of years as the economy stabilises. As shown in Figure 3, the corresponding level of state aid seems to be strongly related to the ticket demand curve, proving to a certain extent the subsidy system in Greece reacts to the economic situation.

Under the current legal framework, the applied minimum passenger ferry connection requirements consist of the following principles:

- Island ports which are capitals of a prefecture should be connected with mainland ports, with at least one main line three times a week throughout the year
- Other islands should be connected with the capital of their prefecture, with domestic lines at least three days a week throughout the year.
- Islands belonging administratively to the same region should be connected with the island where the regional administration is located, directly or indirectly, at least one day per week throughout the year.

A drawback is these minimum connection requirements are solely dependent on the itineraries' frequency, without specifying further quantitative or qualitative criteria, such as ships' carrying capacity, fare cost, travel time, quality of passenger services or even the associated environmental impact. Furthermore, relevant requirements lack adequate documentation since these are horizontally applied to all cases, irrespective of the size, level of insularity and connectivity status of each island.

The reform of the stated minimum requirements framework is a critical condition for reengineering a viable and efficient ferry system. Lekakou and Remoundos (2015) investigated perceptions of island stakeholders and experts on the factors considered essential for the restructuring of the coastal shipping network in Greece. They conclude that there is a need for a decision-making tool where minimum requirements are assessed as a documented function of insularity, depending on multiple factors (distance, size, isolation, accessibility, population, gross domestic product [GDP], seasonality, economic growth, etc.). This could replace the existing empirical method, which relies on frequency as a single dimension parameter. In order to make the system effective, the regulator should specify standards (e.g. ship's capacity) for the services provided (Lagoudis et al., 2011) and monitor performance (Lekakou and Remoundos, 2015). Such a decision-making tool should be based on indices predicated on well-documented data measuring the relevant parameters of island connectivity.

Building the islands' connectivity indices

A clear definition of connectivity is essential, and ideally it includes the term accessibility. Without an explicit determination of connectivity and its basic parameters, the analysis of its impact on transport and the economy is not meaningful, and its measurement might be considered as essentially arbitrary. A review of the relevant literature suggests connectivity has a multi-dimensional nature, and it is rather difficult to offer a precise single definition that can be applied for detailed analysis. Fundamentally, connectivity relates to the ability and ease with which destinations may be reached from potential points of origin and vice versa. It captures how they are linked, both spatially and temporally. The value of connectivity is affected by other characteristics, such as the relative importance of the destinations served and the cost of accessing them. Connectivity could be defined as the availability of transport that enables people and goods to reach a range of destinations at a reasonable generalised cost (Oxera, 2010). Accessibility is a general term used to describe the ease by which a location can be reached by a specific group of people (Karampela et al., 2014). It determines the locational advantage of an area relative to others. Thus, connectivity may be further defined as the level of accessibility of a destination at a reasonable generalised cost, including travel time and financial cost.

Connectivity measurements for passenger transport have extensively been applied to aviation. Maritime network connectivity, and especially ports and cargo liner shipping, have also been sufficiently studied. In contrast, although insularity and island accessibility have been thoroughly considered and analysed, virtually no significant attention has been paid to island passenger ferry connectivity. Moreover, the indicators that have already been developed are usually a function of selected but rather limited parameters. Hence there is a need to measure island connectivity with respect to residents' transport needs, through the development of appropriate indices. They should serve as useful decision-making tools both for the regulating authority and for the passenger-ferry operators rather than simply a means of describing network properties.

Island connectivity is defined as a function of two values, a quantitative one and a qualitative one.

Rather than the number of links to other nodes (ports), the most appropriate quantitative connectivity value of an island is the total carrying capacity provided within a specified time period. Total carrying capacity reflects the aggregate passenger seats supplied by all available transport means regularly operating between the island in question and a particular destination or cluster of destinations within a specified time period.

The qualitative value is essentially an additive value function of all the criteria considered for the assessment of the quality attributes of transport services.

Following the methodology of Lekakou and Remoundos (2018), the connectivity of an island, IC, may be expressed by the following generalized function:

$$I = P * u(g) \qquad (1)$$

Where *P* is the sum of the total number of the passenger capacity provided through the port(s) and airport(s) of an island from (inbound calls) or to (outbound calls) a specified destination or group of destinations, and *u(g)* is the qualitative additive value function of a set of *n* number of criteria *g* ($g_l, g_2, \ldots, g_n$), considered for the assessment of the quality of transport services.

FP may be further defined as the sum of the total passenger capacity (number of seats) provided by passenger ferries and *AP* as that provided by airplanes. Although the quantitative measurement of *AP* and *FP* is similar (i.e. the same units), there is an obvious difference of the quality of the characteristics of the respective means of transport. Assuming a suitable additive value function *c(g)* which converts the number of air transport passenger capacity to an equivalent number of passenger ferry capacity, and taking into account the corresponding qualitative comparison of air against sea transport with respect to the set of criteria *g*, equation (1) is formulated as follows:

$$IC = [FP + c(g) * AP] * u(g) = FP * u(g) + AP * u(g) * c(g). \qquad (2)$$

It can then be determined *u(g)* through multi criteria decision-making methodology and the so called UTA (*UTilités Additives*) method proposed by Jacquet-Lagreze and Siskos (1982). This method aims at inferring one or more additive value functions from a given ranking on a reference set of alternatives A_R. The method uses special linear programming techniques to assess these functions so that the ranking(s) obtained through these functions on A_R is (are) as consistent as possible with the given one (Jacquet-Lagreze and Siskos, 2001). The criteria aggregation model in UTA is assumed to be an additive value function of the following form (Keeney and Raiffa, 1976):

$$u(g) = \sum_{i=1}^{n} p_i * u_i(g_i). \qquad (3)$$

It is subject to normalization constraints:

$$u_i(g_{i*}) = 0, u_i(g_i^{*}) = 1 \text{ and } \sum_{i=1}^{n} p_i = 1, \text{ fo } i = 1, 2, \ldots n \text{ r.}$$

Where u_i, $i = 1, 2, \ldots, n$, are non-decreasing real valued functions, named marginal value or utility functions, which are normalised between 0 and 1, and p_i is the weight of u_i and g_i^* and g_{i*} are respectively the most and less preferred value (grade) on the criterion *i*. Both the marginal and the global value functions have the monotonicity property of the true criterion.

For instance, in the case of the global value function the following properties hold: $u[g(a)] > u[g(b)] \leftrightarrow a > b \ (preference)$

$$u[g(a)] = u[g(b)] \leftrightarrow a \sim b \ (indifference).$$

If each individual criterion g_i is defined by a set of sub-criteria g_{ij} ($i = 1, 2, \ldots, n$ and $j = 1, 2, \ldots, m$), the additive value function for criterion g_i may then be given by the following formula:

$$u_i(g_i) = \sum_{j=1}^{m} p_{ij} * u_{ij}(g_{ij}). \qquad (4)$$

Where u_{ij}, (*i = 1, 2, … n* and *j = 1, 2, … m*) are also utility functions, which are normalised between 0 and 1, and p_{ij} is the weight of u_{ij} and g_{ij}^* and g_{ij*} are respectively the most and less preferred value (grade) on the sub-criterion *j* of criterion *i*.

Following equations (2), (3) and (4), the island connectivity (IC_{rts}) of island *r*, (*r = 1, 2, … k*) on a cluster of islands A_r (alternatives), within a specified time period *s* (e.g. the summer season, where 1 May ≤ s ≤31 October, or the winter season, where 1 November ≤ s ≤30 April) in year *t*, is now derived by the following formula:

$$IC_{rts} = FP_{rts} * \sum_{i=1}^{n} p_i * u_{rts_i} + AP_{rts} * \sum_{i=1}^{n} p_i * u_{rts_i} * c_i. \qquad (5)$$

Where FP_{rts} is the sum of the number of the passenger capacity of all ferries arriving to the port(s) of island *r* ($r = 1,2, \dots k$) from a specified origin (inbound calls) and/or departing from the island's port(s) to the same origin (outbound calls), within a specified time period *s*, in year *t*.

p_i is the weight of u_{rts_i}, or else the weighting factor of criterion *i* ($0 \leq p_i \leq 1$ and $\sum_{i=1}^{n} p_i = 1$, for $\mathrm{i} = 1, 2, \dots \mathrm{n}$), equal to the corresponding priority, deriving from Analytic Hierarchy Process (AHP) analysis (pairwise comparison matrix of the family criteria *g(i),* considered for the assessment of the quality of passenger ferry transport service).

$u_{rts_i} = \sum_{j=1}^{m} p_{ij} * u_{rts_{ij}}$ is the additive value function or the performance indicator of criterion *i* (*i = 1, 2, … n*) on the quality of passenger ferry transport for an island *r* within a specified time period *s* in year *t*,

p_{ij}, is the weighting factor of sub-criterion *j* of criterion *i* ($0 \leq p_{ij} \leq 1$ and $\sum_{j=1}^{m} p_{ij} = 1$, for $\mathrm{i} = 1, 2, \dots \mathrm{n}$ and $\mathrm{j} = 1, 2, \dots \mathrm{m}$), equal to the corresponding priority deriving from AHP analysis (pairwise comparison matrix of the family sub-criteria *g(ij)* considered for the assessment of the quality of passenger ferry transport services with respect to criterion *i*),

$u_{rts_{ij}} = \mathrm{e}_{(\mathrm{rts})\mathrm{ij}} / \mathrm{e}_{(\mathrm{rts})\mathrm{ijmax}}$ is the performance indicator of sub-criterion *j* of criterion *i* (for $\mathrm{i} = 1, 2, \dots \mathrm{n}$ and $\mathrm{j} = 1, 2, \dots \mathrm{m}$, while $0 \leq u_{rts_{ij}} \leq 1$) for an island *r*, within a specified time period *s*, in year *t*,

$\mathrm{e}_{(rts)ij}$ is the most appropriate chosen index for the measurement of the performance of sub-criterion *j* of criterion *i* ($\mathrm{i} = 1, 2, \dots \mathrm{n}$ and $\mathrm{j} = 1, 2, \dots \mathrm{m}$), for an island *r* ($\mathrm{r} = 1, 2, \dots \mathrm{k}$), within a specified time period *s*, in year *t*, where the value of the index increases proportionally to the augmentation of the *i* criterion performance,

$\mathrm{e}_{(rts)ijmax}$ is the maximum value of $\mathrm{e}_{(rts)ij}$ ($\mathrm{i} = 1, 2, \dots \mathrm{n}$ and $\mathrm{j} = 1, 2, \dots \mathrm{m}$) of all *k* islands *r* ($\mathrm{r} = 1, 2, \dots \mathrm{k}$), within a specified time period *s* for a specified reference year *t* or number of years (e.g. *t* = 2001, 2002, … 2017),

AP_{rts} is the sum of the number of the passenger capacity of all passenger aircrafts arriving at the airport(s) of island *r* ($\mathrm{r} = 1, 2, \dots \mathrm{k}$) from a specified origin (inbound calls) and/or departing from the island's airport(s) to the same origin (outbound calls), within a specified time period *s* in year *t*,

$\mathrm{c}_i = \frac{CA_i}{CS_i}$ is the transport mode conversion factor on criterion *i* ($\mathrm{i} = 1, 2, \dots \mathrm{n}$) for the conversion of the air passenger capacity to a passenger ferry equivalent capacity value, reflecting how much predominant air transport is when compared to sea transport (or vice versa) with respect to criterion *i*.

CA_i and CS_i are the corresponding priorities of two alternatives, air as opposed sea transport, respectively, with respect to criterion *i* ($\mathrm{i} = 1, 2, \dots \mathrm{n}$ and $\mathrm{CA}_i + \mathrm{CS}_i = 1$), resulting from AHP analysis (pairwise comparison matrix).

The Island Connectivity Index may then be defined as ICI_{rts} for an island *r* ($r = 1, 2, \dots k$ and $0 \leq ICI_{rts} \leq 1$) , within a specified time period *s* in year *t* as follows:

$$\mathrm{ICI_{rts}} = \frac{\mathrm{IC_{rts}}}{\mathrm{IC_{rtsmax}}} \qquad (6)$$

Where $\mathrm{IC_{rts}}$ is the island connectivity of the subject island, derived by equation (5),

$\mathrm{IC_{rtsmax}}$ is the maximum value of $\mathrm{IC_{rts}}$ of all *k* islands ($\mathrm{r} = 1, 2, \dots \mathrm{k}$), within a specified time period *s* for a specified reference year *t* or number of years (e.g. *t* = 2010, 2011, … 2017).

A similar approach may be used to define the islands' transport potential, essentially reflecting the islands' transport needs, again as a function of two values, a quantitative and a qualitative. The most common quantitative value of transport potential of an island is the number of its inhabitants. For islands that are tourist destinations this quantitative value may be differentiated during the peak season by adding the number of the island's available hotel beds to the number of the island's permanent residents. The qualitative value is an additive value function of all the criteria considered for the assessment of the quality attributes of the transport potential of an island. Therefore, the transport potential, *IP*, of an island may be expressed by the following generalised function:

$$\mathrm{IP} = \mathrm{N} * \mathrm{v(f)} \qquad (7)$$

Where$\mathrm{N}$ is the size of the island's population (in the winter season), or the gross sum of the island's population, plus the total available beds in all the island's tourist accommodation establishments (in the summer season), and $\mathrm{V(f)}$ is the qualitative additive value function of the family of *n* number of criteria *f* ($\mathrm{f_l, f_2, \dots f_n}$), considered for the assessment of the quality of the transport potential of an island related to the islands' transport needs.

Using the multi-criteria decision-making methodology, following the same approach for the definition of IC_{rts}, the equation (7) can now be formulated properly, deriving the Island Potential (IP_{rts}) of an island *r* ($\mathrm{r} = 1, 2, \dots \mathrm{k}$) on a reference set of islands A_r(alternatives), within a specified time period in the reference year t, with the following formula:

$$\mathrm{IP}_{rts} = \mathrm{N}_{rts} * \sum_{i=1}^{n} q_i * v_{rts_i} \qquad (8)$$

Where N_{rts} is the size of the population of island *r* (*r* = 1, 2, … *k*) (in the winter season), or the gross sum of the island's population plus the total available beds in all the island's tourist accommodation establishments (in the summer season), within a specified time period *s*, in year *t*.

q_i, is the weight of v_{rts_i}, or the weighting factor of criterion *i* ($0 \leq q_i \leq 1$ and $\sum_{i=1}^{n} q_i = 1$, for $\mathrm{i} = 1, 2, \dots \mathrm{n}$), equal to the corresponding priority deriving from the Analytic Hierarchy Process (AHP) analysis (pairwise comparison matrix of the family criteria *f(i)*, considered for the assessment of the quality of the island transport potential).

$v_{rts_i} = \sum_{j=1}^{m} q_{ij} * v_{rts_{ij}}$ is the additive value function, or the performance indicator of criterion *i* (*i* = 1, 2, … n) for quality of island transport potential for an island *r*, within a specified time period *s* in year *t*. q_{ij}, is the weighting factor of sub-criterion *j* of criterion *i* ($0 \leq q_{ij} \leq 1$ and $\sum_{i=1}^{m} q_{ij} = 1$, for $\mathrm{i} = 1, 2, \dots \mathrm{n}$ and $\mathrm{j} = 1, 2, \dots \mathrm{m}$), equal to the corresponding priority deriving from the AHP analysis (pairwise comparison matrix of the family sub-criteria *f(ij)* considered for the assessment of the quality of island transport potential with respect to criterion *i*).

$v_{rts_{ij}} = \mathrm{h}_{(rts)ij} \,/\, \mathrm{h}_{(rts)ijmax}$ is the performance indicator of sub-criterion *j* of criterion *i* ($\mathrm{i} = 1, 2, \dots \mathrm{n}$ and $\mathrm{j} = 1, 2, \dots \mathrm{m}$, while $0 \leq v_{rts_{ij}} \leq 1$) for an island *r*, within a specified time period *s* in year *t*.

$\mathrm{h}_{(rts)ij}$ is the most appropriate chosen index for the measurement of the performance of sub-criterion *j* of criterion *i* ($\mathrm{i} = 1, 2, \dots \mathrm{n}$ and $\mathrm{j} = 1, 2, \dots \mathrm{m}$) for an island *r* ($\mathrm{r} = 1, 2, \dots \mathrm{k}$), within a specified time period *s* in year *t*, where the value of the index increases proportionally to the augmentation of the *i* criterion performance.

$\mathrm{h}_{(rts)ijmax}$ is the maximum value of $\mathrm{h}_{(rts)ij}$ ($\mathrm{i} = 1, 2, \dots \mathrm{n}$ and $\mathrm{j} = 1, 2, \dots \mathrm{m}$) of all *k* islands *r* ($\mathrm{r} = 1, 2, \dots \mathrm{k}$), within a specified time period *s* for a specified reference year *t* or number of years (e.g. *t* = 2001, 2002, … 2017),

Accordingly, the Island transport Potential Index, IPI_{rts}, may be defined for an island *r* ($\mathrm{r} = 1, 2, \dots, \mathrm{k}$ and $0 \leq \mathrm{IPI}_{rts} \leq 1$), within a specified time period *s* in year *t*, as follows:

$$\mathrm{IPI}\ _{rts} = \frac{\mathrm{IP}_{rts}}{\mathrm{IP}_{rtsmax}} \qquad (9)$$

Where IP_{rts} is the transport potential of the subject island, derived by equation (8), IP_{rtsmax} is the maximum value of IP_{rts} of all *k* islands ($\mathrm{r} = 1, 2, \dots \mathrm{k}$), within a specified time period *s* for a specified reference year *t* or number of years (e.g. *t* = 2010, 2011, … 2017).

Finally, an index expressing the relevant level of an island's connectivity with respect to its transport potential (available transport capacity with respect to the actual transport needs of the island) for a specific reference year (compared to the performance of the rest of the islands in question) or number of years (for one or more islands) can be created. Therefore, the Island Connectivity Adequacy Index, $ICAI_{rts}$, for an island *r* ($\mathrm{r} = 1, 2, \dots, \mathrm{k}$ and $0 \leq ICAI_{rts} \leq 1$), within a specified time period s in year *t*, is represented by the following ratio:

$$\mathrm{ICAI}_{rts} = \frac{\mathrm{ICI}_{rts}}{\mathrm{IPI_{rts}}} \qquad (10)$$

Where ICI_{rts} is the island connectivity index, derived by equation (6), and IPI_{rts} is the island transport potential index, derived by equation (9).

In order to allow comparisons between criterion scores, these scores are to be normalised, especially since a cardinal multi-criteria analysis method is used. The normalisation is carried out by dividing each score by the sample's maximum value. This method has the advantage that the highest score always receives a value equal to 1 after normalisation. The other scores range between 0 and 1. The scores have the property of a ratio scale, i.e. both cardinality and proportionality are respected. The closer the scores are to 1, the better they are; the closer to 0, the worse they are.

When one wants to include an additional action or alternative in the analysis, the normalised scores, however, may need to be revised (De Brucker et al., 2004). This approach was applied for the normalisation of the performance indicators ($u_{rts_i}, v_{rts_i}, u_{rts_{ij}}, v_{rts_{ij}}$) of the sets *g(i)*, *f(i)* and *g(i,j)*, *f(ij)* of the criteria and sub-criteria respectively, as well as for the formulation of ICI and IPI normalized indices. It should be also highlighted that all performance indicators are comparative and dimensionless, taking values between 0 and 1, where the larger the value of the indicator the greater the performance of the corresponding measured criterion (or sub-criterion) with respect to meeting its objective.

The proposed methodology provides an assessment of each island's level of connectivity, taking into account its transport potential, by comparing its performance with the corresponding performance of the relatively best connected island or with the island's best yearly performance, recording in this way the rate of the islands' progress**.** All the suggested indices do not constitute absolute measurements of an attribute performance of a specific alternative (e.g. an island's connectivity index in a specific reference year), but they reflect the relative value of this alternative compared to the respective values of all the designated alternatives (e.g. the values of the connectivity index of all the islands of the cluster in question in the same reference year or the connectivity index values for a number of years for the island in question). Therefore, the attained values of the proposed indices may change accordingly to any variation of the sample of the available alternatives. For instance, the attained value (score) of ICAI for a specific island for 2017 compared to the respective yearly scores of the last decade might differ from the corresponding score of the same island for the same year compared to the relevant scores for the last twenty years. Respectively, the attained scores of IPI or ICI for a specific island in a given reference year may vary depending on the islands and/or reference years comprising the sample of the available comparable alternatives. It is not recommended to define an absolute value of an ideal island's performance in order to use it as a ceiling since continuous improvement is always a challenge.

According to the findings of the literature review, previous research (Lekakou and Remoundos, 2015) and a thorough examination and classification of the relevant criteria considered for the evaluation of the passenger transport systems' performance, a list of passenger ferry services quality criteria and their corresponding sub-criteria can be defined (Table 1).

Table 1. Quality evaluation criteria and sub-criteria for passenger ferry services

		Sub-criteria g_{ij}			
Criteria g_i	Travel cost	Fare	Cost of accessing port	Cost of on-board services	-
	Time	Trip duration	Consistency of timetables	Access time to ports	-
	Regularity	Number of itineraries	Frequency of itineraries	Number of transits	Number of interconnected destinations
	Quality of services	Ship's accommodation	On-board services	Information services	Ticket purchase facilities
	Social cost	Ships' environmental performance	Ships' age	Corporate social responsibility (CSR)	-

The criteria and their relevant sub-criteria for the evaluation of the quality attribute of the islands' passenger transport potential with respect to transport needs are illustrated in Table 2.

Table 2. Quality evaluation criteria and sub-criteria for islands' transport potential

Criteria f_i	Sub-criteria f_{ij}			
Development	Per capita income	(Un)employment rate	Entrepreneurship rate	-
Touristic attractiveness	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
Infrastructure	Adequacy of ports	Internal transport system	Existence of airport	Public services
Location	Remoteness and isolation	National interests	-	-

The consultation with experts and stakeholders ranking the key performance criteria (Lekakou and Remoundos, 2015) revealed the most important factor is associated with travel cost, while in the pre-financial crisis period the duration of the trip was the most critical factor. The implementation of the Island Transport Equivalent resulting in a reduction of the islanders' travel cost reflects this development.

The Island Transport Equivalent methodological approach

In 2017, the Greek Government implemented specialised policy measures aimed at strengthening island territories' cohesion and improving socioeconomic conditions, especially for remote insular regions, which have been severely affected by the economic recession. The Island Transport Equivalent was selected as an appropriate policy tool to increase island accessibility and growth potential and improve the quality of life and attractiveness of islands.

The Island Transport Equivalent was launched in July 2018 as a pilot programme and foresaw discounts for the transportation of goods and people from/to 49 Greek islands. In 2019, the measure was expanded to most Greek islands. The new measure aims at offsetting the extra cost of transportation of residents and cargo to all the islands. It replaces the former system, which consisted of government aid to thin routes with low commercial interest.

The ITE aims at measurable impacts on accessibility, affordability, quality of life, development and attractiveness of the islands, while the former scheme guaranteed only a minimum level of connection frequency.

The law equates the cost of travel by sea with the cost of land travel via intercity bus service (KTEL). This directly benefits island residents by rebating ferry tickets for people traveling to the mainland for business to reach key services or commuting.

While in the former system beneficiaries were maritime companies, the Island Transport Equivalent benefits households whose members are Greek citizens or foreigners holding a valid residence permit and the person's (or the spouse's) tax domicile on an island.

The measure also applies to the transport of goods to and from the islands. Companies must submit several documents to benefit from the discount.

In the first stage, the cost of the measure was estimated at EUR 60 million. As of 1 January 2019, when the measure covered all islands except Crete, Evia and Lefkada, the cost was estimated at EUR 150 million per year.

Based on the current state of the CTN, two models have been developed by the authors for approaching fair pricing for the maritime transport of people and goods to and from the islands: the Island Transport Equivalent for Passengers (ITEP) and the Island Transport Equivalent for Commodities (ITEC).

The mathematical formulas and assumptions adopted for both models are described in this section.

The ITEP model

Since the allocated total annual subsidies for the beneficiary islands are given, a simplified model for calculating subsidies per beneficiary for passenger ferry services is derived under the following assumptions:

Islanders should not have to pay a ticket price higher than the one calculated according to the reference value per kilometre, corresponding to the transport cost by bus on mainland state-subsidised lines.

The subsidy for each islander per trip is the difference between the price of an economy class ferry ticket and the price calculated according to the reference value per bus-kilometre. Where the latter is equal to or higher than the former after any applicable discount – which is possible because there is no common rate per nautical mile – the subsidy is nil.

The maximum subsidy amount for each island is proportional to the distance between the island's port and either the mainland's port of call or the regional capital's port of call (provided the island is not the capital of the region).

The annual subsidy amount for each island is commensurate with its insularity (e.g. peripherality, isolation, lack of infrastructure, etc.).

The beneficiaries' annual subsidy amount can be attributed in increments at specific intervals within the reference year (e.g. every six months or quarter) or aggregated at the end of the reference year.

The following definitions are given:

N_i, the population of permanent residents of island i (i = 1,2, ... k), according to the most recent official population census.

B_i, the percentage (%) of the residents of island *i* eligible for a subsidy; if income criteria are set, *Bi* is the percentage of island *i* residents with a declared annual income underneath the limit set.

NBi equals *Bi* times *Ni* divided by the number of permanent residents of island *i* (*i* = 1,2, ... *k*) eligible for a subsidy.

TFS, the annual total subsidy provided (datum) for beneficiary residents of all islands *k* for the reference year.

RVM, the reference value (€/km) corresponding to domestic travel cost by bus.

RVP, the reference value (€/km) corresponding to intraregional travel cost by bus.

DMi, the total average distance in nautical miles (nm) between the port(s) of island *i* and mainland port(s) (directly or indirectly).

DPi, the total average distance in nautical miles (nm) between the port(s) of island *i* and its region's capital's port(s) (directly or indirectly).

FMi, the average cost of the economy class ferry ticket for the transport service between island *i* and the mainland.

FPi, the average cost of the economy class ferry ticket for the transport service between island *i* and its region's capital.

p1, *p2*, the relative significance indices of an island to the mainland and its region's capital, respectively (*p1* + *p2* = 1), under the assumption that those indices correspond to the relative importance of transport connectivity to the mainland when compared to the region's capital of the islands. Indices' values may be estimated either through public consultation or by a deterministic statistical approach, using actual transport data reflecting the travel trends of residents.

Ci, the island *i*'s insularity index (*Ci*≥1.0). The value of 1.0 corresponds to the island with the largest insularity index. The estimation of this indicator requires further research because it is considered to be driven by many parameters (Spilanis et al., 2012). However, considering that the size of the island's population is a representative indicator of insularity, the values contained in Table 3 have been preliminarily used for the scope of this research.

$TFMi = FMi - RVMi * DMi$ is the ferry ticket subsidy for a trip between island *i* and the mainland.

$TFPi = FPi - RVPi * DPi$ is the ferry ticket subsidy for a trip between island *i* and the capital of its region.

$PLi = TB * Ci * 2 * (p1 * DMi * RVMi + p2 * DPi * RVPi)$ is the amount of the maximum annual budgeted subsidy of each beneficiary of an island *i*.

$TB = TFS/\sum_{i=1}^{k}[\mathrm{NBi} * \mathrm{Ci} * 2 * (\mathrm{p1} * \mathrm{DMi} * \mathrm{RVMi} + \mathrm{p2} * \mathrm{DPi} * \mathrm{RVPi})]$ is the average annual number of the beneficiaries' round trips covered by the annual datum, *TFS*.

Table 3. Insularity index assumption

Islands' insularity category	Population	*Ci*
1η	< 1 000 residents	1.0
2η	1 001 – 3 000 residents	0.9
3η	3 001 – 5 000 residents	0.8
4η	5 001 – 15 000 residents	0.7
5η	15 001 – 30 000 residents	0.6
6^{η}	> 30 000 residents	0.5

The ITEC model

The ITEC model is used to estimate annual subsidies granted to island-based enterprises that have an exporting or importing activity (products, raw materials, etc.) essential to their operation. The ITEC includes all medium, small and very small island enterprises in manufacturing, wholesale and retail.

Table 4. Definition of the size of a company

Size of company	Number of employees	Annual turnover (million EUR)	Total annual balance sheet (million EUR)
Medium	<250	<50	<43
Small	<50	<10	<10
Very Small	<10	<2	<2

Source: Commission Recommendation, 2003/361/EC.

The subsidy is calculated as a function of the distance between the island port(s) and the mainland port(s), the quantity of commodities traded over a certain time period and the type and size of the company.

Similarly to ITEP, a reference value deriving from the road travel cost per kilometre for the transport of goods is determined for the calculation of the corresponding sea transport cost. The reference value is the difference between a weighted average cost of road transport and the corresponding average sea transport rate. The calculation formulas are: $CRTE = \frac{\sum_{w=1}^{m} \mathrm{TRCw}}{m}$ is the Commodities Road Transport Equivalent, where *TRCw* is the value of road transport cost in EUR/tonne/km of each *w* measurement, (*w* = 1, 2, ... m), while m is the number of measurements. $CSTEj = \frac{\sum_{x=1}^{n} \mathrm{TSCxj}}{n}$ is the Commodities Sea Transport Equivalent per island *j* (*j* =1, 2,…*k*), where *TSCxj* is the value of sea transport cost in EUR/tonne/km of each *x* measurement, (*x* = 1, 2, ...*n*) for every *j* island, while *n* is the number of measurements.

A company's subsidy per lading bill *z* (*z* = 1, 2,…*q*) for an island *j*, is calculated as follows: $Czj = (BLzj - CRTE * Qzj * Dj) * S$, where *BLzj* is the value of lading bill *z* in EUR for island *j*. *Qzj* is the volume of cargo transported as recorded in lading bill *z* for island *j*. *Dj* is the distance in nautical miles between island *j* and the destination corresponding to lading bill *z*, and *S* is the subsidy rate based on the company's turnover and region. For NUTS (Nomenclature of Territorial Units for Statistics) 2 regions, *S* may be estimated according to Table 5.

Table 5. Companies' rate of subsidy (NUTS 2 Regions)

	Medium companies	Small companies	Very small companies
Regions (NUTS 2)	0.6	0.8	1

Therefore, the annual total available budget *P* for subsidizing all *j* islands is calculated as follows: $P = \sum_{j=1}^{k} Pj$, where $Pj = Dj * (CSTEj - CRTE) * Qj$ is the maximum annual subsidy amount (grant ceiling) per island *j* and *Qj* is the annual maximum quantity of transported commodities subsidised per island *j.*

Implementation of the Island Transport Equivalent in Greece

The results of the ITEP and ITEC model testing in the Greek islands are outlined in this section.

Implementation of the ITEP model

Before implementing the model, the cost of maritime transport is calculated for all island residents expected to move within one year via ferry. Both the cost of subsidising tickets according to the ITEP methodology and the total cost of the above tickets for all the beneficiaries are estimated. A scenario taking into account the number of island residents expected to travel by air is also examined.

The islands included in the cost estimation are those currently serviced by at least one ferry line with a population of less than half a million. Under this limitation, the island of Crete was initially excluded.

The data and core assumptions of the cost estimation model include: the number of passengers travelling to and from islands in the year 2016 (by sea and air) provided by the Hellenic Statistical Authority (the reliability [expected increase] of this figure cannot be predicted in advance before the implementation of ITEP), and ferry ticket prices used for the calculations corresponding to economy class ticket prices for the reference year 2016.

The reference values of the corresponding road transport by bus are defined by ministerial decisions.

A summary of the results of the ITEP annual cost estimation in the case of the Greek islands is presented in Table 6.

Table 6. Annual estimated cost for the application of ITEP to the Greek islands

	Annual Cost (Million €)			
p1/p2	Full subsidy (sea transport passengers only)	Full subsidy (sea and air transport passengers)	ITEP subsidy (sea transport passengers only)	ITEP subsidy (sea and air transport passengers)
1/1	135	187	59	77
7/3	175	246	78	103
1/0	234	336	109	144

According to the above assessment, fully subsidising annual sea transport cost for all island permanent residents would cost between EUR 135 million (a 1:1 travel distribution ratio) and EUR 234 million under the assumption that all residents travel to and from the mainland. If the residents using air transport were to select the maritime transport alternative due to the full subsidy regime and the high economic incentive, an average increase in the annual cost of some 40% would be expected, with an estimated maximum value of more than EUR 336 million.

In the case of an ITEP subsidy where all trips are to and from mainland destinations, the total subsidy is estimated at EUR 109 million. However, considering a significant number of trips are inter-island, the total cost does not exceed EUR 80 million (EUR 78 million in the case of a 7:3 p1/p2 ratio). It is estimated at EUR 60 million in the case of equally distributed passenger flows (p1/p2 = 1/1). Finally, taking into account the ITEP subsidy would likely shift a significant proportion of air-borne passengers to sea transport, the estimated annual cost would range between EUR 77 million and EUR 144 million.

Implementation of the ITEC model

The assessment of the cost of implementing ITEC revealed a significant lack of statistical data relative to the transport of cargo and goods to and from Greek island destinations. Available data provide the gross and net weight of goods transported, as well as the number of vehicles, while no specialised data exist concerning the type of cargo transported, packaging type per destination, or type of company. The lack of data required the formulation of a number of assumptions to be able to estimate the cost of applying ITEC:

the reference network is the coastal transport network and the means of transport is the conventional cargo and roll-on/roll-off (known as ro-ro) vessels (ferries carrying wheeled cargo, e.g. cars, trucks and trailers)

bulk cargo shipments are not included in the cost estimate process

costs were estimated on the basis of ro-ro and general cargo freight transport data for the reference year 2016.

According to the calculations, the annual cost of implementing the ITEC subsidy to the Greek islands, as shown in Table 7, is almost EUR 64 million.

Table 7. Annual estimated cost of the application of ITEC to the Greek islands

Total gross load (tonnes)	Total net load (tonnes)	Average subsidy (EUR/tonne/km)	Total annual subsidy (EUR)
5 210 403	4 263 419	0.11	63 772 627

Expected results of the implementation of ITEP and ITEC

The implementation of ITEP and ITEC subsidy models is expected to have positive effects on Greek islands, both in terms of economic growth and social and territorial cohesion.

The reduction in transport costs as a result of the application of ITEC is expected to have a positive impact on the economic activity of island-based companies by increasing their competitiveness. Although competitiveness is a multi-factor function, dependent on economic conditions and the institutional environment, the transport costs of either raw materials or final products constitute a core component of companies' operating costs. Although data accurately documenting the share of transport costs in operating costs is lacking for Greek companies, there is a shared perception among social partners that sea transport costs significantly weigh on the final prices of goods.

Agricultural and manufacturing companies are burdened both with the transport cost of importing raw materials and with the cost of exporting their final products to offshore markets either on the mainland or abroad. As a result, the reduction in transport costs is expected to improve island companies' competitiveness and create new opportunities along island supply chains, resulting in new jobs, income and development opportunities.

The effect of ITEC on the price of goods cannot be known in advance since product prices are influenced by commercial practices and depend on parameters other than transport costs. However, ITEC may contribute to maintaining existing consumer price levels.

Lower ferry costs for passengers due to ITEP will boost islanders' mobility while improving their accessibility to services and the use of infrastructure on both the mainland and islands.

Finally, the rebate mechanism does not affect ferry companies' revenues, a crucial parameter for the policy's acceptability. Instead, an increase in mobility would generate more income for island ferry companies.

Conclusions

Designing effective island policies is a complicated process due to the particularities of the island regions and the inability to apply a one-size-fits-all rule. In the case of Greece, the formulation of island policies faces specific challenges, which stem from the lack of data or outdated data and the lack of a system for monitoring policy effectiveness over time. In particular, with regard to the country's ferry system, decisions are based either on one-dimensional criteria or mainly empirical versus scientific approaches.

In this broader context, restructuring the CTN is a necessary condition in order to make the network more operational and sustainable. Reviewing the minimum island connection requirements and determining an optimal connection network is the first step for the redesign of the entire system.

Island policy formulation is a data-intense process that needs to reflect current conditions while integrating future trends. The complexity of an island ecosystem becomes higher when designing for island clusters. In this case, it is essential to use well-structured processes and intelligent tools to support decision making. The contribution of local stakeholders becomes critical for gathering practical knowledge on island conditions and bridging data gaps. Once the process is established, evaluative criteria and key performance indicators should be chosen to monitor the achievement of policy objectives and targets, and deviations or failures. The periodical evaluation of the suitability of selected criteria and their respective performance indices is one of the main conditions for the reliability and consistency of an integrated insular policy.

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Applying the Island Transport Equivalent to the Greek Islands

This report looks at the need for Greece to redesign its inter-island transport system to make it more operational and sustainable. It takes into account the challenges of designing networks for island ecosystems and island clusters, which present even greater difficulties. Specifically, it examines applying the Island Transport Equivalent policy tool to increase island accessibility and growth potential.

All resources from the Roundtable on Connecting Remote Communities are available at:
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Published: 01/2021 | Photo credit: Thomas_Kulaja/Shutterstock