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The Territorial Cohesion through Interisland Transport: An In-Depth Analysis of the Azores Autonomous Region

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Abstract: This study investigates inter-island accessibility in the Azores Islands (Portugal), a region marked by unique territorial fragmentation and significant distances between islands. Recognizing the pivotal role of sea and air transport in fostering the socioeconomic development of the archipelago by enhancing resident mobility and attracting tourism, we address the challenges posed by the region's low demographic and economic influence and the pronounced imbalances among islands. The methodological approach involves the examination of various accessibility parameters, with a specific focus on hourly operations identified as presenting the most unfavorable ratios of time availability in the destinations. We analyze inter-island sea and air schedules during the winter season, emphasizing their relevance for residents engaged in travel for business, health, administration, and related purposes. We have mainly analyzed the air schedules since it was possible to make the round trip on the same day on only two maritime routes, although these have also been considered. Regarding the study outcomes, they reveal that despite positive efforts to implement air public service obligations (PSO), which mandate specific frequencies, seat allocations, and rate caps, among other examples, the limited attention given to adapting operating hours based on demand undermines the effectiveness of these measures. Contextually, this lack of adjustment results in substantial inconvenience for travelers, particularly those engaged in round-trip operations on the same day, a common scenario in inter-island mobility. In more than 70% of the operational routes, suitable travel times at the destination are significantly compromised.

Keywords: inter-island accessibility; insularity; Azores islands; strategic planning; territorial cohesion; time availability

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1. Introduction

Situated approximately 1400 km from mainland Portugal, the Azores Archipelago exhibits a common feature across its islands—territorial fragmentation and isolation, which has significant adverse implications for its socioeconomic development [1–4]. As a paradigmatic illustration, the archipelago displays pronounced demographic and economic disparities among its islands, notably in its inter-island transport network.

In line with the islands' vulnerability, the European Union emphasized in 2010 in the so-called "European Strategy for the Economic and Social Development of Mountain Regions, islands, and Sparsely Populated Areas", while the geographical specificities

excluded them from "territorial cohesion" policies. The "European Territorial Development Perspective (ESDP)", promoted in 1999, was directed along the same lines, in addition to the "Trans-European Transport Networks" in the same decade [5]. We should remember the European Regional Development Fund (ERDF), the European Social Fund (ESF), or the Cohesion Fund (CF) as financial instruments of regional balance and with particular emphasis on the islands. Thus, this makes "territorial cohesion", in which accessibility and transport play a fundamental role, one of the main guidelines of the European Union, recognized by the Treaty of Lisbon as the third dimension of the cohesion objective, together with economic and social cohesion [6]. The concept has also given rise to various cohesion indicators, where the islands obtain a clear disadvantage compared to the continent [7].

Another distinctive aspect of these islands is their recurrent struggle with a significant scarcity of raw materials, intensifying their reliance on the mainland [8–10] and leading to a notably diminished GDP [11]. While the archipelagos are well documented for their unique characteristics, such as demography, GDP, and distances, the shared challenge of territorial fragmentation shapes them collectively. With its associated economic and temporal costs, intermodal transport emerges as the primary alternative for overcoming isolation.

As underscored in the Comprehensive Transportation Plan of the Azores, the ports and airports of the islands serve as the backbone of the transportation system. These crucial hubs are indispensable for understanding socioeconomic development, influencing factors such as "geographical reality, market size, seasonality, and operational costs." This interconnectedness is closely tied to public service obligations as a crucial instrument ensuring inter-island connections' regularity, reliability, and continuity [12].

Consequently, some scholars emphasize the pivotal role of transportation infrastructure, contending that it contributes significantly to impeding the economic growth of the Azores [4]. Along the same lines, other archipelagos, such as the Canary Islands, have agreed on the approach, demonstrating the aggravation of the problem of connectivity in the islands with less demographic and economic weight [8], an aspect that a posteriori, led to the creation of an "island dependency index" [13]. Another study, with data from 2016, raised the cost of the outermost periphery in the Canary Islands to 8% of companies' turnover [14]. In the case of the Balearic Islands, Bardolet also weighs the differential condition with the continent, indicating that "transport is vital for an acceptable development of wealth and social well-being" [15]. On the Italian islands—and despite their greater surface area and proximity to the mainland—other authors focus on transportation, the economic weakness and fragility of these territories, personifying this differential in the extra cost of the shopping basket and in the difficulties of undertaking any economic activity [16,17]. In the French Antilles, several works emphasize the transportation problem with the metropolis in a more political dimension, where the promotion of tourism or deregulation lays the foundations for this analysis [18]. From all of the above, we deduce a lack of opportunity for island environments vis à vis the continent and where the provision of solutions with instruments such as public service obligations or the promotion of more significant regional rebalancing should be the mechanisms to be implemented in order to alleviate the vulnerabilities above of the islands, as recognized by the Green Paper on Territorial Cohesion in the European Union [5,19] and one of the main demands of tourism in the Azores to reinforce inter-island tourist connectivity [12].

In recent years, there has been a growing interest in studying accessibility based on the door-door system, as it brings us closer to the actual costs and travel times [20–22]. This policy brings us closer to the evaluation of territorial cohesion that the Government of the Azores was already trying to promote with the philosophy of the "single ticket" [12]. This procedure emanates from the Trans-European Transport Network and the Transport White Papers of 2001 and 2011 [23]. Therefore, it is a methodology that we mainly collect for this study from the point of view of cost and travel times in line with what some works have previously been carried out in island areas [24–26]. Nevertheless, as we said, our main interest is focused on measuring temporal accessibility since it is considered a perception in which the human being relates to space, expressed in terms of "spatiotemporal convergence" [27],

"plasticity" [28,29] or "spatio-temporal compression" [30], among other names. Euclidean distances are now replaced by others of a functional nature, whose perception is defined in terms of frequencies, seat offerings, and, of course, travel times [31,32]. Therefore, it leads to unequal development and power relations resulting from differentiated connectivity, leading to domination and subordination of some territories over others, influencing unbalanced territorial and socio-economic patterns [33,34].

Dating back to the seventies, when the relationship between space and time began taking center stage in geography studies, the Swedish Lund school became interested in this relationship daily [35]. In fact, it promoted accessibility analyses based on transportation times between the different functional places, which would later be widely developed by other authors (see [36–41]).

However, one of the main objectives of the concept of accessibility, which Häger-strand already sensed, has been to reach destinations at reasonable costs and times, to the point that the value of time has become one of the essential pieces of accessibility [42–52]. Thus, the value of time can be considered the opportunity cost each person uses throughout their life. The time spent transporting would correspond to the provision that each person must pay for reducing their travel times or, where appropriate, the compensation they are willing to receive for losing their vital time [53]. In this way, time today is increasingly important, to the point that the adverse effects of its scarcity and its economic implications alter people's well-being, causing stress and family problems [54,55]. The result of all this is the concern to achieve the challenge of a maximum of four hours in a door-to-door system within the European Union for 90% of air travelers [56], or also the growing interest in 15 min cities [57,58], while they relate short travel times to improved quality of life, but also to other parameters such as decreased pollution, benefits for health, for the family economy.

Many works have focused on analyzing the accessibility of public transport to certain functional places, such as shops or administrations, conditioned above all by opening hours and their compatibility with public transport schedules in rural spaces. Alternatively, sparsely populated [59–62] or also at regional levels regardless of the mode of transport [63–65]. In short, the schedules of public transport systems condition the decisions to plan a trip, starting with whether the operating ranges allow mobility and, if so, when to start the trip based on the services available if it allows us a specific time in the destinations [66]. Contextually, here is why analyzing schedules as guarantors of the quality of transport networks has been gaining greater prominence [67].

In short, it is this last approach that we focus on, paying our attention to the vulnerability of the residents of the islands with lower demographic and economic potential, therefore requiring a greater need to travel to the central islands of San Miguel, although also Terceira, in the absence of specialized commercial, health or administrative services, return travel on the same day being very important here. Thus, this paper takes a relatively new approach, returning to previous works that emphasize the value of time and its cost. It translates socioeconomic vulnerability, in this case, the socioeconomic vulnerability of residents on an island compared to other islands, detecting where the problems are.

Based on the remoteness and territorial fragmentation of the Azores Islands and, generally, of an archipelago, air and maritime transport play a fundamental role in territorial cohesion. This territorial cohesion will never be better than a continental territory. However, the accessibility parameters must be analyzed, as we have studied in this paper, to minimize the territorial disadvantage of residing on the islands. Accessibility for reasons of time availability in destinations, as we delve into in this paper, is one of the fundamental points for the benefit of the territorial integration of the islands.

2. Materials and Methods

This paper studied accessibility in the Azores Islands contextually, recognizing that interpreting accessibility in its different parameters (physical, economic, and time, among others) entails a complex and sometimes deep analysis to explain traffic demand [63,68,69]. After analyzing a territorial diagnosis (economy, society, and existing demand are just a

few examples), it was studied the accessibility variables that we discussed. With this, we detected that the main problem is found in the operating schedules of the ships and planes, so this will be the one on which we will place greater emphasis and, therefore, the central reason for the methodological explanation of this section (Figure 1).

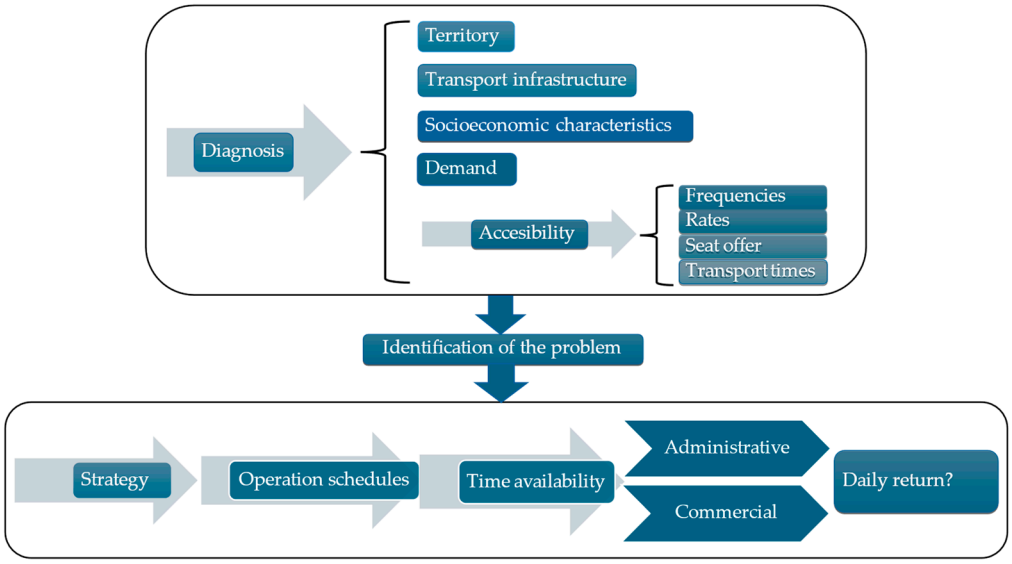

Figure 1. Summarized methodological approach.

Therefore, focusing on the main problem of accessibility in the Azores, such as the available times of passengers at the destinations, we are going to consider the winter sea and air schedule just before the COVID-19 pandemic, that is, the winter 2019–2020, since March of this last year the entire operation suffered significant downward variations, distorting the results. It is true that since the fall of 2021, a large part of operations has been recovered, but the situation is quite far from what existed before the pandemic.

We take direct winter air and sea schedules because, methodologically, they are not affected by the increase in supply and demand in the summer, and, in addition, in the latter, there is a more significant presence of trips for leisure reasons, not so closely linked to the demand for schedules that require a return on the same day. Therefore, it is logical to think—and at the expense of reliable data that indicate the reasons for travel, although we tried to obtain them, without success, through SATA and Atlânticoline, as well as the Regional Directorate of Air and Maritime Transport of the Government of the Azores—that mobility work or business between islands has a higher percentage share in winter and, therefore, it is precisely this period that interests us, as other authors have shown for other territories [52].

We would also have to argue that the schedules we cared about excluded weekends for this reason, looking only for weekdays where the presence of work, business, or healthcare travelers was more significant. Sometimes, the first departure time and the last arrival time did not coincide precisely in those five days of the week (Monday to Friday), opting for those with the highest prevalence within this period and, in the case of the same number of days with different schedules—i.e., the first frequencies of the day of the 2019–2020 winter programming—on Mondays and Fridays from 06:30 h from San Miguel to Santa María; these were selected leaving out the first ones on Tuesday and Wednesday afternoons. Therefore, we always opt for the most beneficial time accessibility for the traveler, that is, the earliest and most evening, since many commuters, faced with a certain freedom of daily choice, would surely lean toward these more beneficial alternatives. Indeed, this situation did not occur on more than twenty occasions in the twelve years analyzed.

Starting from the basis that to analyze the "availability of time" in the destinations—and on the same day that allows the round trip in the day so as not to increase the overall

costs of the trip attributable to an overnight stay—it is necessary to have two or more direct frequencies in each direction within the same route; we only have ten inter-island lines that meet this requirement of the fifteen sea and air lines operated in January 2020.

As for the calculation in percentages of the times available in administrative hours and commercial, we have methodologically set it between 08:00 and 15:00 for the first (seven hours) and between 09:00–13:00 and 16:00–20:00 for the second (eight hours). These available times are at the mercy of the variations in the SATA and Atlânticoline operating schedules. These schedules usually change twice a year, coinciding with the winter and summer seasons.

By having only seven weekly frequencies or fewer in each direction, we know that the remaining routes make it impossible to return to the origin on the same day or restrict it even more in time and cost if stopovers must be made to return on the same day.

Contextually, time accessibility or "time availability" at the destination, conditioned above all by air and sea schedules, is crucial because it will determine the probability of spending the night on the island visited with the consequent costs of accommodation, food allowances, and the loss of working hours at the origin of the next day; thus, ultimately, the time translates into a powerful economic value that could even be integrated into the global travel rate.

Thus, in Table 1, we present the different theoretical blocks of time that a traveler has to assume at the destination when traveling by plane or ship between islands, and that has been supervised and endorsed by the commercial department of SATA and Atlânticoline, as well as by the technical staff of the Regional Directorate of Air and Maritime Transport of the Government of the Azores, all of them in Ponta Delgada. The deduction of these blocks of time at destinations is essential for effectively calculating "time availability".

Table 1. Land transportation times to and from the island capitals, and check-in times on return, in the inter-island destinations of the Azores (in minutes) *. (Source: Authors).

Lines	Land Access to the Island Capital (One Way) **	Land Access to the Airport/Port (Return) **	Check-In, Security, and Boarding (Return)
São Miguel–Terceira	25 (25)	25 (25)	40 (30)
Terceira–São Miguel	15 (5)	15 (5)	40 (30)
São Miguel–Santa María	10 (5)	10 (5)	40 (30)
Santa María–São Miguel	15 (5)	15 (5)	40 (30)
São Miguel–Faial	20	20	40
Faial–São Miguel	15	15	40
São Miguel–Pico	15	15	40
Pico–São Miguel	15	15	40
São Miguel–São Jorge	10	10	40
São Jorge–São Miguel	15	15	40
São Miguel–Flores	5	5	40
Flores–São Miguel	15	15	40
Terceira–Graciosa	10 (5)	10 (5)	40 (30)
Graciosa–Terceira	25 (25)	25 (25)	40 (30)
Graciosa–São Jorge	(5)	(5)	(30)
São Jorge–Graciosa	(5)	(5)	(30)
Pico–São Jorge	(5)	(5)	(30)
São Jorge–Pico	(20)	(20)	(30)
Pico–Faial	(5)	(5)	(30)
Faial–Pico	(5)	(5)	(30)

Table 1. *Cont.*

Lines	Land Access to the Island Capital (One Way) **	Land Access to the Airport/Port (Return) **	Check-In, Security, and Boarding (Return)
Terceira–Faial	20	20	40
Faial–Terceira	25	25	40
Terceira–Pico	15	15	40
Pico–Terceira	25	25	40
Terceira–São Jorge	10 (20)	10 (20)	40 (30)
São Jorge–Terceira	25 (25)	25 (25)	40 (30)
Faial–Flores	5 (25)	5 (25)	40 (30)
Flores–Faial	20 (5)	20 (5)	40 (30)
Flores–Corvo	5 (5)	5 (5)	40 (30)
Corvo–Flores	5 (5)	5 (5)	40 (30)

* Data in parentheses corresponds to sea transport. ** By taxi or rental vehicle.

As an example of all the above and given the complexity of the calculation, in Figure 2, we simplify the time available in Ponta Delgada (São Miguel) for travelers from the island of Faial, taking the first and last frequency of the day according to the schedules. SATA regulations were in force in January 2020 and only in the direction of Faial–San Miguel, since in the opposite direction, the availability of time changes in favor of the eastern island since the main base of operations of the Archipelago is in São Miguel. Thus, from the following Figure, it can be deduced that the time available in Ponta Delgada is reduced to less than an hour for travelers for administrative reasons coming from Faial and to less than an hour and a half for commercial reasons.

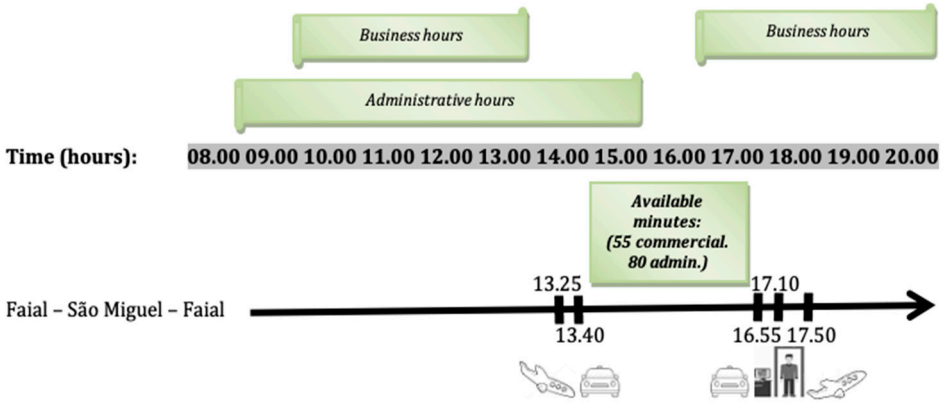

Figure 2. The time it takes for a resident of Faial Island traveling by plane to reach Ponta Delgada (São Miguel) is available (January 2020) (Source: Authors).

3. Framework of the Study Area and Its Connection to Interisland Transportation

The Autonomous Region of the Azores has a complex transportation system. It features nine airports managed by different entities, three class A ports, six class B ports, five class C ports, and small ports exclusively dedicated to supporting fisheries. Maritime and air transport between islands and connections with the outside of the Azores currently exhibit a dynamic achieved mainly through sector development policies.

SATA Air Açores provides passenger and cargo air transport between islands. Regarding passenger air transport between the Azores and the outside, with the implementation of the new air link model between the mainland and the Azores and between the Azores and Madeira in 2015, access between the Portuguese mainland and the islands of São Miguel and Terceira was easy. So, it led to the immediate emergence of low-cost airlines, resulting in increased passenger flow, including many tourists, with ripple effects on other economic

activities. The potential of this measure benefits from the fact that air connections with the outside are the only regular means of entry and exit for people.

Despite maritime routes being the primary means for importing and exporting cargo in the Azores, the local population has demanded strengthening territorial connections for air cargo transport. They seek regular and efficient transport for perishable products to external markets that cannot be transported by sea. Azores Airlines and TAP provide connections between the Azores and the mainland.

As for maritime passenger transport, the seasonal operation between different groups has been interrupted since the COVID-19 pandemic. Only the operation between the islands of the Central Group and the islands of the Western Group remains. A new transport model for this operation and the acquisition of new vessels are under consideration due to the chartering costs of the ships that previously carried out this operation. Currently, the maritime passenger transport operation is ensured by the company Atlânticoline, SA.

While the passenger transport model is economically deficient and subsidized by the government of the Azores, the freight transport model generally meets demand requirements without any financial support. Naturally, due to the geographic reality of the region, maritime transport is the primary means of goods circulation in the Azores, both in external connections, namely to Madeira and the Portuguese mainland, and inter-island connections. The archipelago's specificity configures the entire system with substantial logistical complexity, not only due to the islands' fragmentation, dispersion, and heterogeneity but also due to the natural sea conditions and weather variations. Nevertheless, a relatively robust and effective system has been in place for several years, ensuring the regular supply of all islands and mitigating, in various cases, the effects of distance and isolation.

The operation of freight transport in the Azores unfolds generically and practically, where the connection with the outside usually occurs through the Port of Ponta Delgada, one of the two main TEN-T ports in the Region, and the Port of Praia da Vitória. Three shipping companies mainly ensure freight transport in insular cabotage (transportation between mainland ports and Azorean ports and between these). These three shipping companies usually navigate on the same days, using ships with onboard cranes that allow loading and unloading operations on almost all islands.

The Azores are characterized by presenting a tremendous socioeconomic disparity, a fact that conditions maritime and air connectivity. As shown in Table 2, the island of São Miguel accounts for almost 60% of the population and GDP, quite distant from Terceira, which slightly exceeds 20%. This means that the other seven islands hold the remaining 20% of the population and economy, influencing the disparate demand for air mobility mentioned. The consequence is the fragile connectivity of several of these island groups, although a minimum air demand must be provided to guarantee the basic principle of territorial cohesion.

Table 2. Main macromagnitudes of the Azores Islands, 2019. (Source: Authors).

Islands	Population	GDP *	PIB (%) *
São Miguel	137.307	18.059	58.12
Terceira	55.124	16.935	21.95
Faial	14.521	18.414	6.28
Pico	13.651	15.160	4.85
São Jorge	8.277	15.753	3.08
Santa María	5.616	21.592	2.85
Graciosa	4.208	14.514	1.44
Flores	3.628	14.364	1.22
Corvo	464	19.523	0.21

* Data referring to 2018.

Another fact to highlight is that the archipelago only has a population of 250 thousand. At the same time, the GDP per inhabitant only represents 58 and 89%, respectively, of the average of the European Union and Portugal [70]. These figures represent a scarce

hinterland for the potential demand for inter-island air transport since the small population is combined with a low income with less mobility for leisure, work, business, and others, which is expected for all islands [71].

Thus, the socioeconomic disparity of the archipelago, its small population, and its economic activity constitute the main characteristics. However, it is worth highlighting the growing weight of tourism, which in 2019 reached 970 thousand visitors, with very notable growth since the arrival of low-cost operators such as Ryanair and Easyjet to the Islands in March 2015, managing to increase tourist demand in the period 2014–2019 by 145% [70,72].

As shown in Figure 3, the movement of inter-island passengers, despite starting from shallow figures—only 800 thousand travelers per year at the beginning of the 21st century—takes almost 20 years to double for the air case and a 35% increase in maritime. Nevertheless, it will not be the primary case until 2014 when air mobility increased rapidly with the new air fleet of greater capacity and public service obligations approved in 2009 and by which time the deep economic crisis had been overcome. In this way, this movement of travelers grew by 60% in just five years (2014–2019). Maritime transport, incorporating larger and more modern ships, also increased passengers, although at a lower percentage compared to air transport. All this is carried out without forgetting the economy's improvement and its effect on the increase in inter-island mobility.

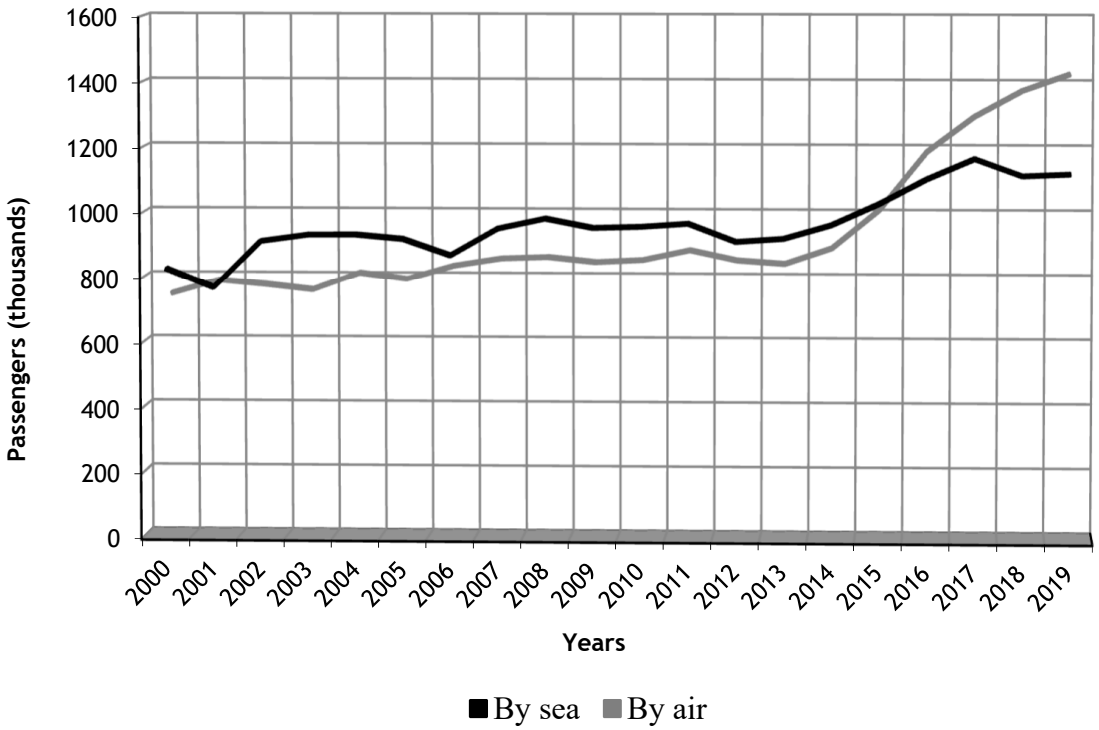

Figure 3. Traffic of inter-island passengers in Azores (2000–2019). (Source: Authors).

Inter-island air travelers predominate in the Azores (56%). However, their distribution is very uneven, to the point that almost a third of inter-island air and sea passengers are concentrated on a single line and by sea, as it is the journey between the islands of Faial and Pico, without the plane taking center stage in this case. However, on the second route with the highest volume of traffic (São Miguel–Terceira), the plane moves 95% of the traffic, exceeding 180 thousand travelers in 2019. So, saving the prominence of the ship in the three central islands (the so-called triangle), the rest is at the expense of air transport (Table 3).

Table 3. Scheduled passenger traffic between islands in Azores. 2019 (round trip). (Source: Authors).

Lines	Air		Sea		Total
	Passengers	Quote (%)	Passengers	Quote (%)	
Faial–Pico	----	0.00	412.723	100.00	412.723
São Miguel–Terceira	181.803	94.46	10.663	5.54	192.466
São Miguel–Santa María	77.426	79.81	19.589	20.19	97.015
São Miguel–Faial	79.401	99.00	804	1.00	80.205
São Miguel–Pico	71.878	96.76	2.403	3.24	74.281
Terceira–São Jorge	47.346	88.83	5.951	11.17	53.297
Terceira–Graciosa	45.475	89.32	5.435	10.68	50.910
São Jorge–Pico	----	0.00	46.821	100.00	46.821
Terceira–Faial	42.578	95.25	2.124	4.75	44.702
Terceira–Pico	35.980	85.95	5.881	14.05	41.861
São Miguel–Flores	40.378	99.10	365	0.90	40.743
São Jorge–Faial	----	0.00	33.897	100.00	33.897
São Miguel–São Jorge	32.585	96.88	1.051	3.12	33.636
Faial–Flores	21.955	97.73	511	2.27	22.466
Terceira–Flores	14.661	97.28	410	2.72	15.071
São Miguel–Graciosa	11.331	94.93	605	5.07	11.936
Flores–Corvo	1.626	27.92	4.197	72.08	5.823
Pico–Pico	----	0.00	4.495	100.00	4.495
Faial–Corvo	3.846	100.00	----	0.00	3.846
São Miguel–Corvo	3.249	100.00	----	0.00	3.249
Graciosa–São Jorge	----	0.00	1.825	100.00	1.825
Graciosa–Pico	----	0.00	1.195	100.00	1.195
Graciosa–Faial	----	0.00	752	100.00	752
TOTAL	***711.518***	***55.88***	***561.697***	***44.12***	***1273.215***

The limited physical distances between the three islands of the triangle and, more specifically, between their island capitals, as shown in Table 4, favor maritime mobility, exempt from land transportation to airports and the time spent in billing and processing procedures. Boarding primarily affects plane transport. Thus, air transport is no longer viable on these routes; hence, it does not have a presence. However, the maritime mode is negligible compared to the air mode at greater distances, especially on routes whose nodes have a significant economic and demographic weight within the network—i.e., São Miguel–Terceira or São Miguel–Faial.

Table 4. Physical distances of the Azores inter-island lines currently operating between "island capitals" (kilometers). (Source: Authors).

Lines	Airplane	Boat	Difference % Airplane–Boat
Faial–Pico	41	12	242
São Miguel–Terceira	211	207	2
São Miguel–Santa María	121	115	12
São Miguel–Faial	291	286	2
São Miguel–Pico	268	283	−5
Terceira–São Jorge	120	141	−15
Terceira–Graciosa	115	123	−6
São Jorge–Pico	38	37	3
Terceira–Faial	179	175	2
Terceira–Pico	146	164	−11
São Miguel–Flores	515	516	0
São Jorge–Faial	60	44	36
São Miguel–São Jorge	249	248	0
Faial–Flores	246	249	−1
Terceira–Flores	379	390	.3

Table 4. *Cont.*

Lines	Airplane	Boat	Difference % Airplane–Boat
São Miguel–Graciosa	256	259	−1
Flores–Corvo	25	25	0
Faial–Corvo	254	258	−2
São Miguel–Corvo	522	528	−1
Graciosa–São Jorge	54	72	−25
Graciosa–Pico	77	86	−10
Graciosa–Faial	108	90	20

Another peculiarity of the Azores interisland network is that in 2019, almost 50% of interisland air traffic occurred in just the four summer months (between June and September inclusive). This fact denotes the strong tourist movement in the summer, corroborating the fact that our analysis, focused on the problem of time connectivity, makes more sense in winter, when the most demanding trips with schedules take place, that is, those focused on reasons of labor, health, or other displacements (Figure 4).

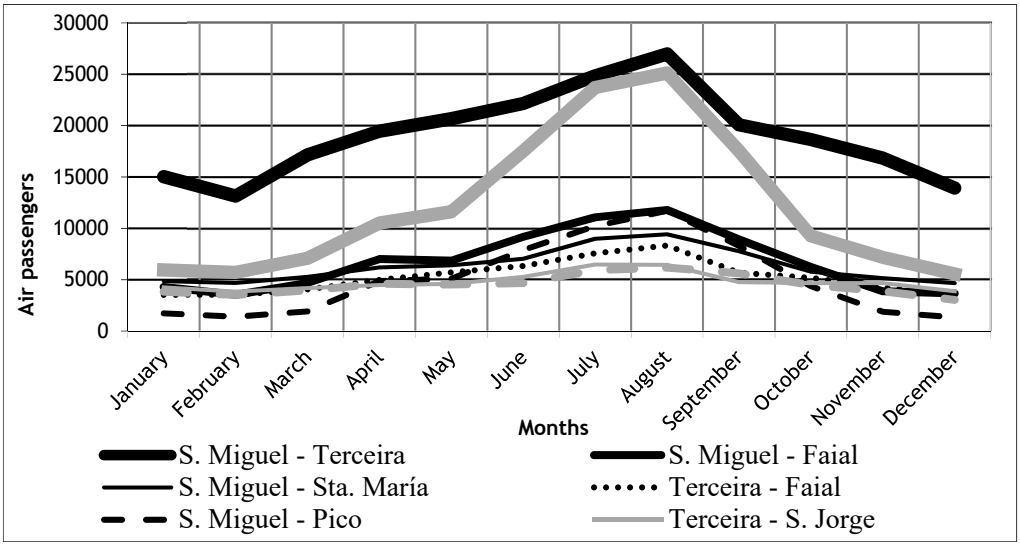

Figure 4. Monthly traffic of inter-insular air passengers in Azores by routes (the thick gray line and thick gray dashed line represent highest values). 2019. (Source: Authors).

In the maritime case, the concentration of mobility is greater, since 60% tends to concentrate in the four summer months (June–September). And many maritime lines only operate during these months. The most important maritime lines are those of the so-called triangle, that is, those that operate between the islands of Faial, Pico, and San Jorge, which otherwise operate throughout the year (Figure 5).

In short, the Azores' socioeconomic framework is very meager, although interisland air mobility has increased considerably in recent years. Furthermore, the imbalance in seasonal demand is notable, detecting a certain complementarity between maritime and air modes rather than competitiveness on some routes.

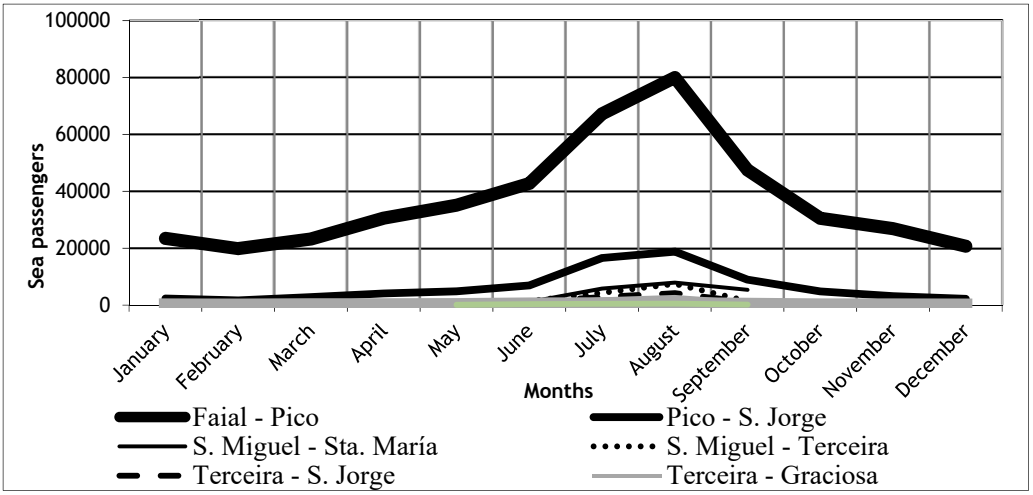

Figure 5. Monthly traffic of inter-insular sea passengers in Azores by routes (the green line represents the summer months—high season). 2019. (Source: Authors).

4. Results and Discussion

The frequencies in the winter season of 2020 (January of that year) showed a significant predominance of the air mode, accounting for two-thirds of the total frequencies, and only maritime transport acquires some significance in the corridor between Horta (Faial) and the port of Madalena (Pico). The programming of air frequencies is weak in winter since they are reduced by approximately 40% compared to summer. The exception would have to be made for the São Miguel–Terceira corridor since the rest of the routes do not reach four per day in winter, which meant that on one or several days of the week, there was only a frequency of two, i.e., a return trip to the original destination on the same day. However, on twelve air routes, it is possible to return on the same day (Table 5).

Table 5. Average direct sea and air frequencies and per day of travel on a regular basis between the Azores Islands in January 2020 (round trip). * (Source: Authors).

Lines	Air		Sea		Total
	Frequencies	Quotes %	Frequencies	Quotes %	
Faial–Pico–Faial	0.00 (0.00)	0.00	10.86 (14.00)	100.00	10.86 (14.0)
S. Miguel–Terceira–S. Miguel	8.58 (13.14)	100.0	0.00 (0.00)	0.00	8.58 (13.14)
S. Miguel–Sta. María–S. Miguel	2.57 (5.14)	100.0	0.00 (0.00)	0.00	2.57 (5.14)
S. Miguel–Faial–S. Miguel	2.57 (4.86)	100.0	0.00 (0.00)	0.00	2.57 (4.86)
S. Miguel–Pico–S. Miguel	2.14 (4.00)	100.0	0.00 (0.00)	0.00	2.14 (4.00)
Terceira–S. Jorge–Terceira	2.57 (1.86)	100.0	0.00 (0.00)	0.00	2.57 (1.86)
Terceira–Graciosa–Terceira	3.43 (3.43)	100.0	0.00 (0.52)	0.00	3.43 (4.00)
S. Jorge–Pico–S. Jorge	0.00 (0.00)	0.00	2.86 (4.00)	100.0	2.86 (4.00)
Terceira–Faial–Terceira	2.86 (4.00)	100.0	0.00 (0.00)	0.00	2.86 (4.00)
Terceira–Pico–Terceira	2.00 (3.42)	100.0	0.00 (0.0)	0.00	2.00 (3.42)
S. Miguel–Flores–S. Miguel	0.00 (2.00)	100.0	0.00 (0.0)	0.00	0.00 (2.00)
S. Miguel–S. Jorge–S. Miguel	0.00 (2.58)	100.0	0.00 (0.0)	0.00	0.00 (2.58)
Faial–Flores–Faial	1.43 (2.00)	100.0	0.00 (0.0)	0.00	1.43 (2.00)
Terceira–Flores–Terceira	0.57 (1.14)	100.0	0.00 (0.0)	0.00	0.57 (1.14)
S. Miguel–Graciosa–S. Miguel	0.00 (0.58)	100.0	0.00 (0.00)	0.00	0.00 (0.58)
Flores–Corvo–Flores	0.86 (0.86)	43.00	1.14 (3.43)	57.00	2.00 (4.29)
Faial–Corvo–Faial	0.86 (1.42)	100.0	0.00 (0.0)	0.00	0.86 (1.42)
S. Miguel–Corvo–S. Miguel	0.00 (0.28)	100.0	0.00 (0.0)	0.00	0.00 (0.28)
Graciosa–S. Jorge–Graciosa	0.00 (0.00)	0.00	0.00 (0.58)	100.00	0.00 (0.58)
TOTAL	**30.44 (50.70)**	**67.20**	**14.86 (22.59)**	**32.80**	**45.30 (73.29)**

* Data in parentheses corresponds to that of the 2019 summer season.

Regarding door-to-door travel times, that is, between island capitals, these are generally between 100 and 120 min one way, with an acceptable first arrival time in the morning between the main islands and between São Miguel and Santa María. The rest of the routes exceeded, even widely, the 9:00 a.m. reference time for arrival at the destination capital, which was not ideal for this improvement in connectivity. For its part, maritime transport was only genuinely accessible on a round trip in the day in the Pico–Faial corridor since the long time on the other routes made it challenging to compete with the air mode (Table 6).

Table 6. Real travel times and the first time slot for arrival to destination on working days (January 2020). (Source: Authors).

Lines	*Door-to-Door* Times (Minutes)		First Arrival Time at the *"Island Capital"* of Destination *	
	Airplane	Boat	Airplane	Boat
San Miguel–Terceira	125	----	08:20	----
Terceira–San Miguel	125	----	07:55	----
San Miguel–Santa María	95	----	07:10	----
Santa María–San Miguel	95	----	08:10	----
San Miguel–Faial	130	----	09:55	----
Faial–San Miguel	130	----	13:40	----
San Miguel–Pico	130	----	09:15	----
Pico–San Miguel	130	----	10:35	----
San Miguel–San Jorge	120	----	15:30	----
San Jorge–San Miguel	120	----	16:55	----
Terceira–Graciosa	105	----	09:05	----
Graciosa–Terceira	105	----	10:15	----
Terceira–Faial	120	----	09:35	----
Faial–Terceira	120	----	10:40	----
Terceira–Pico	115	----	11:05	----
Pico–Terceira	115	----	12:10	----
Terceira–San Jorge	105	----	09:10	----
San Jorge–Terceira	105	----	10:20	----
Faial–Pico	----	80	----	07:35
Pico–Faial	----	80	----	08:50
Pico–San Jorge	----	105	----	11:20
San Jorge–Pico	----	105	----	12:40
Faial–San Jorge	----	170	----	10:45
San Jorge–Faial	----	170	----	13:15

* Travel times between "island capitals", including average land transportation times, billing, security measures and air and maritime operations times. Only routes that allow at least one round trip on the same day, whether by boat or plane, are considered.

From the point of view of the cost of the one-way trip for a resident of the Azores, this was around EUR 30, and almost double if we add the door-to-door land trips at the origin and destination, both by air and sea, except for the Faial–Pico route, which was noticeably more affordable by boat. Based on the average income of a resident, it does not seem that a round trip means an excessive financial effort on their part, which is why we once again point out the schedules and subsequent availability of time in the destinations as the main accessibility problem in the Azores (Table 7).

Table 7. Cost of maritime and air transport for one-way passengers on a regular basis and on direct routes between the island capitals of the Azores in January 2020 (EUR). * (Source: Authors).

Lines	Airplane **	Boat **
São Miguel–Terceira	33.26/51.26	----
São Miguel–Santa María	33.26/46.26	----
São Miguel–São Jorge	33.26/51.26	----
São Miguel–Pico	33.26/53.26	----
São Miguel–Graciosa	33.26/44.26	----
São Miguel–Faial	33.26/51.26	----
São Miguel–Flores	33.26/44.26	----
São Miguel–Corvo	33.26/44.26	----
Terceira–Graciosa	33.86/56.86	27.50/47.50
Terceira–São Jorge	33.86/63.86	32.00/55.00
Terceira–Pico	33.86/65.86	32.00/55.00
Terceira–Faial	33.86/63.86	32.00/55.00
Terceira–Flores	33.86/56.86	----
Pico–São Jorge	----	9.90/44.90
Faial–Pico	----	3.60/9.60
Flores–Corvo	33.26/39.26	----

* Rates applying the discount for residents of Azores. The most requested rate is always taken according to the operators ("Azores fare" rates for SATA; and "tourist" rates for Atlânticoline). ** The first rate corresponds to the basic rate called "tourist" and the second also includes the cost of ground travel by taxi to and from the airports of origin and destination. The airfare is 14% cheaper each way if a round-trip ticket is purchased.

On the other hand, analyzing the availability of seats at certain vital times that would allow the round trip on the same day again indicates a significant deficit, especially in the evening. Except for the São Miguel–Terceira and São Miguel–Santa María routes, the latter with only thirty seats, the rest operated beyond 8:30 a.m., with expected arrival at the destination capitals even exceeding 10:00 a.m., a factor that, as we indicated, works totally against greater territorial cohesion of the Archipelago (Table 8). The operating hours of airport infrastructures, notably restricted on some islands, have also had something to do with this. All the routes considered in January 2020 were by air, except for the sea routes from Faial (Horta) to Pico (Madalena) and from Pico (São Roque) to São Jorge (Velas), which allowed return on the same day.

Table 8. Availability of inter-island seats in Azores per working day in the hours of greatest demand (winter schedule 2019–2020). * (Source: Authors).

Lines	07.00–08.30 h. **	20.00 h. and after *
São Miguel–Terceira	80 (160)	0 (80)
Terceira–São Miguel	80 (80)	0 (31)
São Miguel–Santa María	32 (80)	0 (0)
Santa María–São Miguel	32 (80)	0 (0)
São Miguel–Pico	16 (80)	0 (0)
Pico–São Miguel	0 (0)	0 (0)
Terceira–Graciosa	0 (48)	0 (0)
Graciosa–Terceira	0 (0)	0 (0)
Terceira–São Jorge	0 (32)	0 (0)
São Jorge–Terceira	0 (0)	0 (0)
Terceira–Faial	0 (16)	0 (0)
Faial–Terceira	0 (0)	0 (0)
Terceira–Pico	0 (0)	0 (0)
Pico–Terceira	0 (0)	0 (0)

Table 8. *Cont.*

Lines	07.00–08.30 h. **	20.00 h. and after *
São Miguel–Faial	0 (0)	0 (0)
Faial–São Miguel	0 (0)	0 (0)
Pico–São Jorge (by sea)	0 (0)	0 (191)
São Jorge–Pico (by sea)	0 (0)	0 (191)
Faial–Pico (by sea)	287 (287)	0 (287)
Pico–Faial (by sea)	287 (287)	0 (287)

* Only routes that allow return to the island of origin on the same day are considered. ** The data in parentheses refers to the summer 2019 programming.

Finally, we focus on time accessibility, which some authors have developed within the concept of "time or time availability" in destinations, all in a door-to-door system and a round trip on the same day. The primary condition for this is at least two daily connections in each direction. About eight routes within the Azores inter-island air network met this requirement in January 2020, which we reflect in Table 9.

Table 9. Hourly accessibility to the "capitals" of other islands of the Azores by air and sea travel by a commuter on a working day (January 2020). * (Source: Authors).

	One-Way Time Blocks		Time Blocks in the Lap			Time Available in Open Functional Places (%)	
Routes	Airplane/Boat Arrival	*Arrival to the Capital*	*Leaving the Capital*	Arrival to the Boarding	Leaving by Airplane/Boat	Administration	Commercial
S. Miguel–Terceira	08:35	***09:00***	***17:30***	17:55	18:35	86	69
Terceira–S. Miguel	07:40	***07:55***	***19:20***	17:35	18:15	100	92
S. Miguel–Sta. María	07:00	***07:10***	***18:45***	18:55	19:35	100	84
Sta. María–S. Miguel	07:55	***08:10***	***17:45***	18:00	18:40	98	72
S. Miguel–Faial	11:50	***12:10***	***16:35***	16:55	17:35	40	18
Faial–S. Miguel	12:30	***12:45***	***11:05***	11:20	12:00	0	0
S. Miguel–Pico	09:00	***09:15***	***17:35***	17:50	18:30	82	67
Pico–S. Miguel	10:00	***10:15***	***15:05***	15:20	16:00	67	33
Terceira–Pico	10:50	***11:05***	***16:50***	17:05	17:45	56	34
Pico–Terceira	11:50	***12:15***	***16:05***	16:30	17:10	39	9
Terceira–Graciosa	10:20	***10:30***	***14:40***	14:50	15:30	60	19
Graciosa–Terceira	11:15	***11:40***	***13:30***	13:55	14:35	40	17
Terceira–Faial	09:25	***09:35***	***15:05***	15:25	16:05	77	43
Faial–Terceira	10:30	***10:55***	***14:00***	14:25	15:05	44	26
Terceira–S. Jorge	10:05	***10:15***	***15:10***	15:20	16:00	68	34
S. Jorge–Terceira	10:35	***11:00***	***13:55***	14:20	15:00	42	25
Faial–Pico **	07:30	***07:05***	***17:25***	17:30	18:00	100	68
Pico–Faia l **	08:45	***08:50***	***16:40***	16:45	17:15	88	58
Pico–S. Jorge **	11:15	***11:20***	***20:40***	20:45	21:15	52	71
S. Jorge–Pico **	12:20	***12:40***	***19:30***	19:50	20:10	38	48

* Only routes with two or more daily frequencies in each direction are considered. ** Only operational routes by sea in winter, allowing round trips on the same day.

Although, indeed, the connectivity between São Miguel and the islands of Terceira and Santa María can be classified as relatively close to the ideal situation in terms of schedules, in addition to the sea route between Faial and Pico, the remaining routes are barely accessible, with time availability due to administrative or commercial situations that they do not even reach 30% in destinations. The exception would only have to be made between São Miguel and Pico. However, it also suffers from the time availability of the citizens of Pico in San Miguel for commercial reasons. Likewise, the routes between Terceira Faial and São Jorge show time availability—only for reasons of administrative schedules—close to 80 and 70%, respectively. Nevertheless, in the opposite direction, from these last two islands to Terceira, time availability falls drastically, and no maritime alternative can solve these barely accessible schedules.

Therefore, the indicators show us the need to improve the interisland air market of the Azores, especially in terms of schedules. Of the ten routes considered, since they met the requirement of being able to return to the origin on the same day, only three—and another two partially—had a time availability at the destinations greater than 70%, either for commercial or administrative reasons. These data highlight the high risk of forced overnight stays and the economic implications that this entails.

Suppose we translate the cost that an overnight stay in the destinations entails for travelers. In that case, we can deduce that the air operator's rate, in this case, SATA, which is influenced by both the air PSOs [12], even though it is not residual, does represent a significantly lower weight about the costs attributable to the aforementioned overnight stay, as we demonstrate in Table 10 with a real case for residents in Faial, in such a way that the overnight stay ends up implying a cost of 110% of the initial air and taxi fare.

Table 10. Estimated expenses attributable to an air departure and departure of a resident between Horta (Faial) and Ponta Delgada (San Miguel) in a situation with and without overnight stay in January 2020 (EUR). (Source: Authors).

	Taxi Horta	Air Fare	Taxi Ponta Delgada	Hotel	Extra Support *	Working Hours *	Total
Return on the day	10.00	57.52	8.00	----	----	----	75.52
One-day overnight stay	10.00	57.52	8.00	50.00	12.00	21.31	158.83

* Extra food refers to a basic dinner, since breakfast is included in the accommodation rate; and working hours to the loss of time on the second day until the traveler arrives in Horta on the first air frequency from São Miguel (09:55 h), estimating in this case 01:55 h of work. For this, the salary of a civil engineer in January 2020 has been taken, which, according to the INE of Portugal, amounted to EUR 11.12/working hour.

For all this, the PSOs of the Azores must collect specific operating time slots, for example, considered in the homonymous case of the Canary Islands, in such a way that the hourly availability of passengers at the destinations is increased so important, avoiding the high costs indicated in the previous table. Thereby, coinciding with other works, it is demonstrated that acting on the operating schedules of transport companies is much more effective than subsidizing air passengers [52,65] without undermining the importance of this last policy to promote the territorial cohesion of the islands.

In turn, various policies such as the convenient use of a diverse fleet, flexibility in the availability of seats, and, therefore, adapted to demand, would promote this operation subject to specific key time slots for increasing the available times at destinations, especially in the early morning and late afternoon hours. At the same time, the other lines with only one daily frequency can have at least two to facilitate the round trip on the same day.

Nevertheless, as noted in the paper, the main accessibility problem in the Azores islands is due to the time spent planning ships and aircraft. This planning does not allow for acceptable time availability at the destinations, so the risk of overnight stays increases, significantly increasing the overall costs of travel. From this point of view, only the air routes between San Miguel and Terceira and San Miguel–Santa María, and the sea route between Faial and Pico are acceptable.

5. Conclusions

Inter-island sea and air accessibility in the Azores have significantly improved, mainly since implementing the 2015 air public service obligations (PSOs), which replaced the 2009 regulations. In fact, it has spurred inter-island mobility, contributing to economic prosperity and a substantial rise in tourism.

However, the enforcement of this regulation has yet to be accompanied by a timely intervention to promote the cohesion of the archipelago. The PSOs did not mandate adherence to specific time slots for air operations. Nonetheless, they allowed inter-island flights between 6 a.m. and 24 a.m. with varying minimum frequencies depending on the routes. Moreover, the analysis needs more reliable data on the percentage of travelers

returning to their island of residence on the same day. Experiences in other island systems, such as the Canary Islands, suggest high rates of same-day returns due to the flexibility provided by the time system.

After examining various accessibility parameters, including connectivity, travel times, frequencies, rates, and seat offerings, we identified the primary challenge in time availability at destinations. Many travelers are compelled to spend the night away from their homes, leading to accessibility issues. Our calculations show that, for a resident worker in the islands, this overnight stay represents more than 100% of the total cost of the air ticket and the round-trip taxi. Consequently, fundamental accessibility problems, typically analyzed in the classical literature and considered in this study, persist without adequate resolution.

The 2014 Azores Integrated Transport Plan (PIT) recognized the necessity of achieving "operational excellence" between islands through unified transport tickets. The plan emphasized intermodality based on a door-to-door approach, integrating land, sea, and air transport. This integration aims to optimize overall rates resulting from the use of multiple means of transport and enhance intermodal time coordination. The plan highlighted the example of the five central islands (Faial, São Jorge, Terceira, Pico, and Graciosa), where maritime transport played a significant role, and its synchronization with air transport schedules was crucial for connections within this group and, particularly, from this group to São Miguel.

Regardless, the absence of inter-island schedules facilitating same-day return to the island of residence undermines the fundamental principle of the door-to-door policy. This policy, encouraged by the European Union through its Transport White Papers, loses its prominence and fails to promote the territorial cohesion of the Azores without addressing this critical aspect.

For all this and based on the discussion and results of this paper, it is essential that air and maritime operations between islands concentrate mainly on the first and last hours of the day, expanding the times available for passengers at the destinations on a round trip on the same day. The improvement of maritime and air operating schedules would have notable benefits for inter-island travelers, as it would avoid high expenses due to an extra stay on the visited island.

Contextually, this analysis methodology—especially regarding time availability at destinations when public transport is used and therefore depends on its operating schedules—can have wide applications in other territories, especially islands where sensitivity to temporal accessibility is very high.

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