

**The airport impact on employment on an
insular region: the case of Ponta Delgada
Airport, Azores**

(versão final após defesa)

Maria Leonor Cabral Patrício

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Orientador: Prof. Doutor Jorge Miguel dos Reis Silva

Coorientador: Prof. Doutora Eliane Gomes de Brito

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Declaração de Integridade

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Universidade da Beira Interior, Covilhã 4/12/2025

Dedication

Aos meus pais.

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Resumo

Nos dias de hoje, os aeroportos são infraestruturas essenciais no desenvolvimento de uma região. Além de operarem e gerirem o transporte aéreo de passageiros e carga, são também um centro de empresas, serviços e pessoas. É, pois, possível compreender os impactos diretos, indiretos e induzidos que um aeroporto pode ter na região onde está inserido, ao nível económico, ambiental e social, especialmente em áreas metropolitanas mais pequenas, como é o caso das ilhas. Neste estudo, a opção de análise centrou-se nos efeitos económicos diretos aferidos através de uma das componentes principais, a empregabilidade nas empresas atuantes no domínio do aeroporto. Para tal, escolheu-se como caso de estudo o Aeroporto de Ponta Delgada, onde se inferiu o impacto de um aeroporto numa região insular, através da análise da empregabilidade gerada diretamente. Para analisar este impacto, com recurso a um modelo quantitativo, distribuíram-se questionários pelas empresas existentes nas instalações do aeroporto, e com os dados recolhidos, estimou-se um modelo de regressão linear, de forma a perceber o impacto do tráfego aéreo na empregabilidade. Dos dados obtidos, infere-se que o número de posições de trabalho no Aeroporto João Paulo II aumenta com o aumento do número de passageiros de forma linear. Gerar empregabilidade direta implica também impulsionar todos os setores relacionados com o desenvolvimento aeroportuário e de turismo. Assim sendo, depreende-se que o Aeroporto João Paulo II tem um impacto económico positivo na ilha de São Miguel, derivado do aumento do número de postos de trabalho relacionados com o incremento da atividade aeroportuária. Estes resultados surgem alinhados com os de outros estudos, sustentando a ideia de que os aeroportos de regiões onde o transporte de passageiros é feito maioritariamente por via aérea são peças fundamentais para o seu desenvolvimento económico.

Palavras-chave

Aeroporto, Empregabilidade, Economia Insular, Impacto Económico, Desenvolvimento Aeroportuário, Âmbito Aeroportuário

Abstract

Nowadays, airports are essential infrastructures in a region's development. In addition to operating and managing passenger and cargo air transport, airports are hubs for companies, services, and people. Thus, it's possible to understand the overall economic, social, and environmental impacts of an airport on a region, especially those small metropolitan areas like islands. In the present study, the focus was on the direct economic impact of the airport, assessed by the employment rate. For this purpose, this investigation focuses on the case of Ponta Delgada Airport to examine the effect of an airport on an insular region, with a particular emphasis on the direct employment it generates. The data used was gathered through surveys conducted among companies operating in the airport facilities to determine the evolution of the number of people employed over the years. The linear regression model outcome suggests that the number of job positions at João Paulo II Airport increases linearly with the increase in passenger numbers. As found in the literature, direct employment generated by the rise in traffic contributes to the development of airport-related sectors and the tourism industry. Fundamentally, João Paulo II Airport has a positive impact on the economic growth of São Miguel Island. These outcomes reinforce the evidence found in the literature and highlight the relevance of airports in insular regions, where passenger traffic is primarily driven by air transport.

Keywords

Airport, Employment, Insular Economy, Economic Impact, Airport Development, Airport Scope.

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Acronyms and Abbreviations

GDP Gross Domestic Product

ICAO International Civil Aviation Organization

IATA International Air Transport Association

NAV Navegação Aérea de Portugal

SATA Sociedade Açoreana de Transportes Aéreos

TAP Transportes Aéreos Portugueses

SME Small and Midium-sized Enterprize

R Responded to the questionnaire

NR Did not responded to the questionnaire

INE Instituto Nacional de Estatística

SREA Serviço Regional de Estatística dos Açores

IPMA Instituto Português do Mar e da Atmosfera

BP Boarded Passengers

DP Disembarked Passengers

PiT Passengers in Transit

Chapter 1

Introduction

1.1 Motivation

Airports and aerodromes are significant landmarks that a city and region possess. Such infrastructures facilitate the transportation and transaction of cargo and passengers, contributing directly and indirectly to the local or regional economy. The contribution of an airport on its region does not need an elaborate explanation, since its relevance is notorious, the airport boosts the tourism volume and the export and import of goods to the region's community, as well as the undeniable contribution by requesting and needing services and people to maintain the infrastructure and its operations, depending on various entities, services, and small and large companies [1].

Based on various studies done in large and small cities, it is concluded that the construction of an airport is a significant step towards regional development [2], impacting the regional development in a direct, indirect, and indirect manner, not only in economic terms, but also in social and environmental terms. This development depends both on the scale of the airport and the region in which it is located [3]. Thus, it is essential to examine how a region's development unfolds, particularly in areas where an airport is under construction or undergoing expansion. One of the many aspects that the existence of an airport induces in the region where it is located is the number of job positions involved in maintaining this infrastructure and its operations. These job positions can be directly or indirectly linked to the airport's nucleus; however, they can exist to assist the airport, as explained in *The Impact of an Airport* published by the group Airports Council International [4], which addresses the different types of jobs related to a single airport. By this means, many jobs can exist as a consequence of an airport, including the jobs expected to work in the building itself, airlines, management and leadership teams, air traffic control, existing shops, security, and cleaning, among other positions. Thus, it is pertinent to go even further in this topic and explore the relationship between the airport and the job positions it requires and provides, to understand the impact of the airport on its economic development. To do so, it is helpful to know one of the most discussed topics by Kenneth Button, where the author talks about subjects such as the primary, secondary, and tertiary zones affected by an airport in a certain location, and how these zones are economically impacted [1].

Many airports and aerodromes have already conducted a study like this one, understanding the benefits and influence they have on the region where they are located,

with this topic being well-known in the research conducted by the author Kenneth Button [1]. However, the same does not happen with Ponta Delgada Airport, on the island of São Miguel, in the Azores archipelago. It is known that transport accessibility impacts regional development [5], so a remote region, such as an island, would have a significant impact with the presence of an airport. As an Azorean citizen, the author is concerned about how the airport impacts São Miguel Island, and how the region can benefit from the development of Ponta Delgada Airport. To the best of our knowledge, no public study has been conducted regarding the employment opportunities provided by João Paulo II Airport in the region, nor its impact on the island's economy. Therefore, questions arise such as: if Ponta Delgada Airport were to disappear, how would it affect the island region? How many jobs would be lost? Would the economy of this region be significantly affected? Thus, it is opportune to analyze the case study of João Paulo II Airport to study the economic impact of an insular airport.

It is also important to determine the relationship between the development of the airport and the development of the region, particularly in terms of employment opportunities. It can be interesting for stakeholders, investors, the government, and even citizens to know how an increase in the airport's area or operations relates directly to the percentage of jobs on the island. That is, to understand whether jobs would be brutally affected by a change in the airport's area, or by a change in the number of passengers (and therefore the number of flights). The author finds that it is relevant to understand whether changes in airport establishment would result in such a demand for new workers that it could reach a point where locals would no longer be able to fill these vacancies [6], or if they would be minor changes. The author considers this part of the study to be essential not only for stakeholders but also for all entities related to tourism, including hotels, restaurants, and other establishments, such as hospitals.

Together with ANA Aeroportos, it is possible to conduct work based on data analysis and the development of concepts addressed by renowned authors in the fields of economics and air transport management, such as Kenneth Button and John Kasarda. This project becomes essential to understand the benefits that an airport can bring to an insular region, in terms of employability, specifically in the case study of the island of São Miguel.

1.2 Object and Objectives

1.2.1 Object

The object that is going to be studied in this dissertation is Ponta Delgada Airport in São Miguel Island, in the Azores archipelago, Portugal.

1.2.2 Objectives

The dissertation's general objective is to study João Paulo II Airport's direct impact on the São Miguel Island's employment. In more detail, how much influence does this airport have on the island's employment, and how many employers exist because of it. These conclusions can determine if the airport has a significant direct impact on the insular region in terms of employment.

To better understand how the island can economically grow with the airport, the specific objectives are:

- Find a relationship between the number of passengers and the employment in this case study;
- How the volume of passengers influences the region's development;
- How does the development of the airport affect the development of the insular region.

This study could support new investments in the air transport field on São Miguel Island and determine whether local staff are sufficient to follow this scenario [6], for example.

1.3 Methodology

This study involves conducting a quantitative data analysis to examine the job positions that support the airport, whether directly or indirectly linked to it, to determine the airport's economic impact on the island of São Miguel.

The methodology of this dissertation consists, first and foremost, of leading an intensive search for a relevant bibliography to better guide the study, understand the variables in this scope, and filter what is most pertinent to the study. The bibliography will be selected using a method called "Bibliometric Analysis". A vast number of studies are chosen based on a selection of keywords and titles, and then filtered by criteria such as keywords, language, year of publication, and other factors that influence the relevance of the article (or other type of work). As follows, there is a smaller quantity of studies to analyze; however, their content is more relevant for the bibliographic review. This method filters all existing literature in the Web of Science database, then the information is filtered and selected using bibliometric analysis and the software *Visualization of Similarities Viewer (VOSviewer)* to facilitate both visual and quantitative analysis.

Next, it is essential to address a more practical aspect of the work, where ANA Aeroportos will be contacted to provide access to useful information, such as the companies that work directly with Ponta Delgada Airport, the number of workers employed at this specific

airport, and other relevant topics that may arise in this theme. It is intended that the companies directly linked to the airport will be contacted and asked to discuss the number of people they employ, for example. It is interesting to know whether the company could still grow in the extreme case of the airport not existing, or if the company would need to grow with the positive development of the airport, for example. This practical part would be carried out by directly filling out questionnaires with representatives from the entities and companies.

Subsequently, it is intended to analyze and study the data in a manner that reveals a relationship between the number of passengers and the number of employees within a specific time range (for example, per year, per five years, depending on the periodic constant). This relationship will provide a clearer visualization of the impact that the local economy has on the airport's existence.

To complete the specific objectives referred in Section 1.2.2, there will be done with a comparison of the number of employees of the airport (and the companies directly linked to the airport), with the number of passengers that the airport had at the moment, versus the same variables in a time where the airport was noticeable less-visited or less developed, such as times as before the Coronavirus disease (COVID-19) pandemic, or when the airport was created, depending on the data obtained, and on its relevance. This comparison provides the author with the opportunity to use linear regression as the model to analyze the collected data.

This methodology and the dissertation's structure can be consulted through the flowchart in Figure 1.1, where there is a brief input of the methodology in each chapter.

1.4 Structure

This dissertation will consist of seven chapters:

- Chapter 1, Introduction: This chapter introduces the dissertation by presenting the topic, objectives, and the subject to be studied, followed by the methodology to achieve the objective.
- Chapter 2, Bibliometric Analysis: The chapter regards the bibliometric analysis, its use, and the respective pertinent graphics and conclusions.
- Chapter 3, State-of-the-Art: This section aims to address the literature review of the topic of this dissertation, analyzing existing scientific investigations, where all concepts and theories previously studied and developed are combined to demonstrate the existing knowledge in this area in general. This chapter builds upon the knowledge acquired through the literature review and utilizes the carefully selected literature from the previous chapter's analysis.

- Chapter 4, Methodology: As the name states, the chapter describes the methodology of the investigation in detail, how the study is approached, how the data is collected and analyzed, and its limitations.
- Chapter 5, Case Study: Presents the case to be studied and the development of the main objective, disclosing the object of the study, the data collection process, and the information assembled.
- Chapter 6, Results Analyzis: In this chapter, a critical analyzis of the obtained results is presented, addressing the main objective and interpreting and commenting on the results obtained.
- Chapter 7, Conclusion: To conclude the dissertation, a brief study conclusion is presented, along with the final considerations to highlight. A list of relevant works for future investigation also accompanies this chapter.

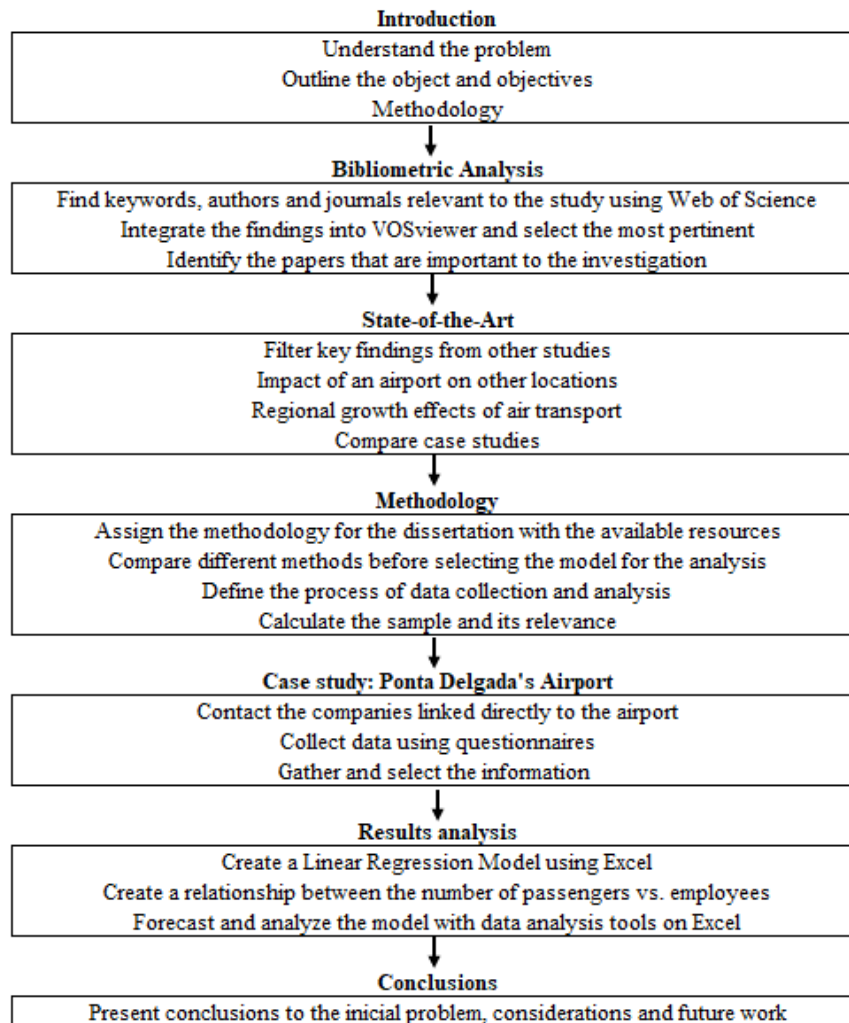


Figure 1.1: Methodology and dissertation's structure flowchart. Source: Author.

Chapter 2

Bibliometric Analyzis

2.1 Introduction

Bibliometric analyzis is a quantitative method for creating an objective selection of articles to aid in the selection of papers and studies, as it helps identify and select the more relevant ones for specific research [7]. This analyzis identifies what the scientific community has published in one particular field, evaluates trends, and aims to categorize publications based on their scope and relevance. With bibliometric analyzis, articles can be selected based on their category and scope [7]. Bibliometric analyzis is crucial for selecting and filtering articles when there is a large volume of data on a topic [8].

This dissertation's state-of-the-art research will be based on the assessment and review of articles and studies selected with the help of bibliometric analyzis. As stated earlier, this analyzis selects and filters existing scientific data, presenting a specific number of articles that align with the investigation and are relevant to the subject, rather than a high volume of articles that are less important to the study [7]. The following subsections outline the steps taken to achieve this portfolio of articles, followed by an analyzis of the chosen database, Web of Science, and the software selected, *VOSviewer*.

2.2 Research Planning

The bibliometric analyzis can be done in different ways; some authors consider that it is more relevant to filter articles considering their keywords, others the institution, the journals they are in, or even the authors [8]. There are certain steps for different approaches, but for this study, the technique chosen for selecting and filtering the studies will be the co-word analyzis, which analyzes the keyword occurrence and co-occurrence [8] between the papers.

To structure this analyzis the next steps will be followed [7]:

- State the research objectives and scope;
- Define the research's strategy;
- Elaborate a keywords tree;

- Research the database;
- Acquire an initial portfolio of articles;
- Filter the range of articles;
- Analyze the maps obtained on *VOSviewer*.

In this case, it is essential to gather a substantial volume of articles that accurately reflect the scientific data on the impact of an airport on an island. The objective is to find articles and studies whose scope aligns with this objective, whether they are general investigations or specific case studies. These articles do not necessarily have to address the insular issue, but rather the impact of an airport in general, thereby broadening the understanding of the matter

2.2.1 Keywords Tree

The keywords tree must be elaborated once the main issue has been defined. The keywords tree is a type of scheme that illustrates different levels of keywords for the research: the vertical axis defines the subjects, ensuring how wide-ranging the search can be;; the horizontal axis represents the different areas, which are split, providing the depth of the search [7], like so in Figure 2.1.

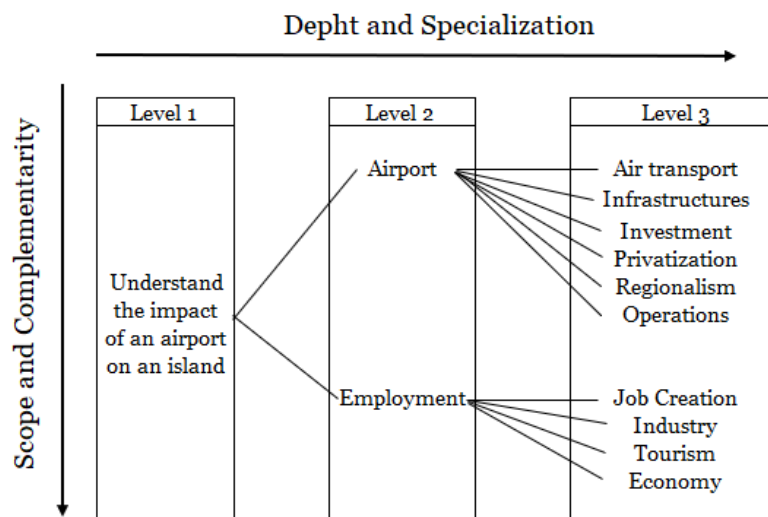


Figure 2.1: Keywords Tree. Source: Author. Based on example in [9]

This tree is aligned with the work's objectives. Level 1 contains the main purpose of the research, Level 2 corresponds to the thematic areas of the study, and Level 3 includes the thematic subareas. Airport and Employment were chosen as two main thematic areas since these words reflect the two principal matters on the main issue, which is divided into a more aviation-related part and another more socioeconomic-related topic.

Given the previous keywords tree, the next step is to enter this data on *Web of Science* database. The research for the corresponding documents shall include the desired keywords, using *AND* or *OR* commands, for example, the Level 2 theme areas *AND* one corresponding Level 3 subarea *OR* another Level 3 subarea. After searching the presented keywords, 2227 results emerged. That said, it was decided to exclude “Operations” and “Industry” from the tree, as shown in Figure 2.2, as these keywords are not essential to the study, thereby reducing the number of options to 1387 results.

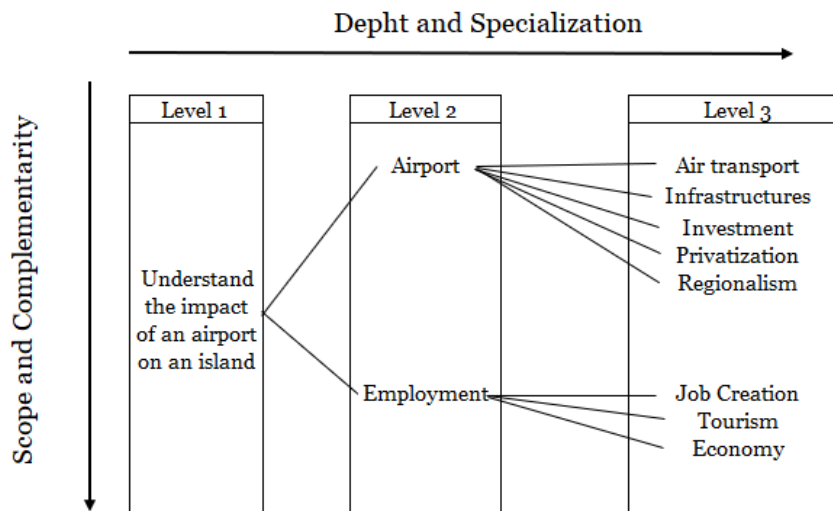


Figure 2.2: Final version of the Keywords Tree. Source: Author. Based on example in [9]

Once the results have been obtained, the next step is to analyze graphically those results in the database.

2.3 Database Analyzis

The database of choice for this study is *Web of Science*, a lot of relevant studies are available on this platform, and the search tool is very intuitive and efficient. In this step, the keyword tree 2.2.1 is the object of search in the database, as explained before. The results can be analyzed graphically directly on *Web of Science*, so the following graphics in Figures 2.3, 2.4, and 2.5 correspond to the data obtained through the database, regarding the articles gathered when considering the keywords tree. For the three graphics, the time period considered is from 1992 to 2024.

The graphic in Figure 2.3 represents the number of publications that each author considered published in the database. The presented authors are acknowledged to be the twenty most relevant of the search, so they are the ones shown in the graphic. Colin C Williams is the author of the most documents published, with a total of 15 papers under this scope.

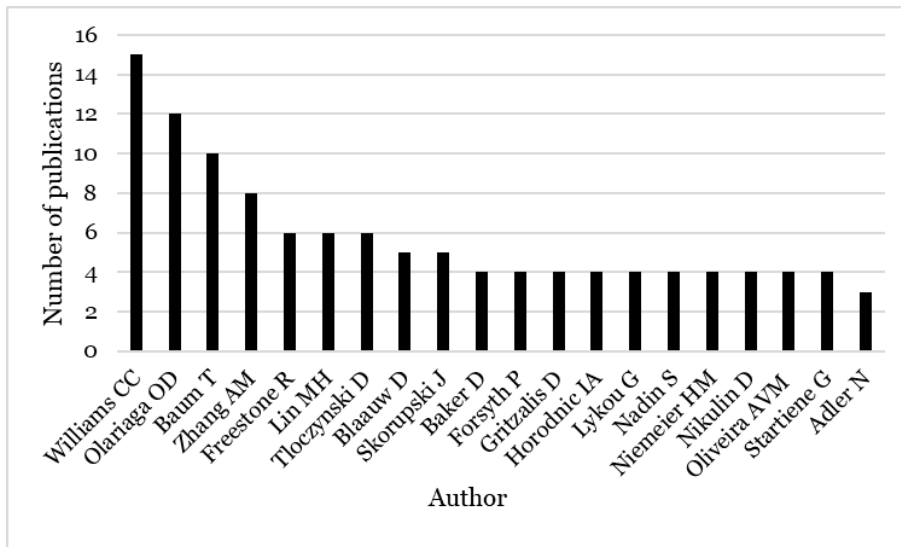


Figure 2.3: Number of publications by each author. Source: *Web of Science*. Adapted by: Author.

Regarding which publication titles are the main ones where the publications are in this scope, the graphic in Figure 2.4 shows that the *Journal of Air Transport and Management* is the journal where more documents under this search were published, so this journal is interesting to this study.

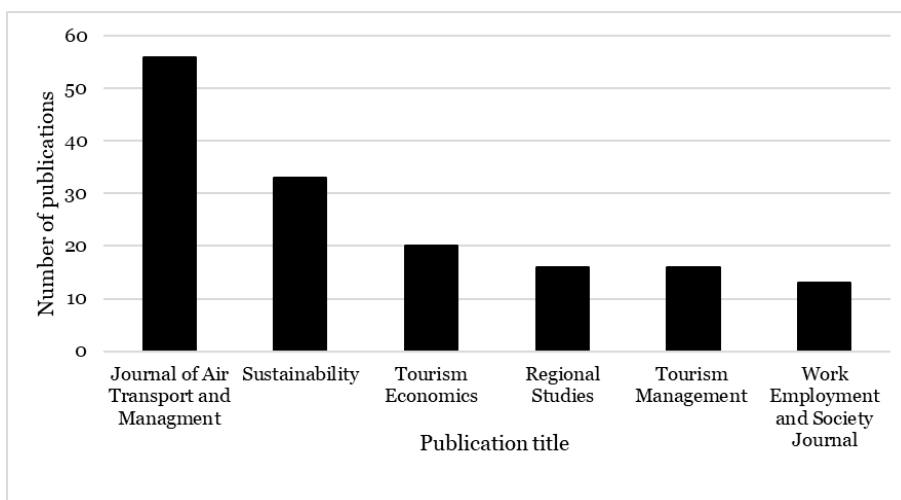


Figure 2.4: Number of publications by each publication title (journal). Data source: *Web of Science*. Adapted by: Author.

The last graphic in Figure 2.5 considers both the number of publications and the number of citations over the years.

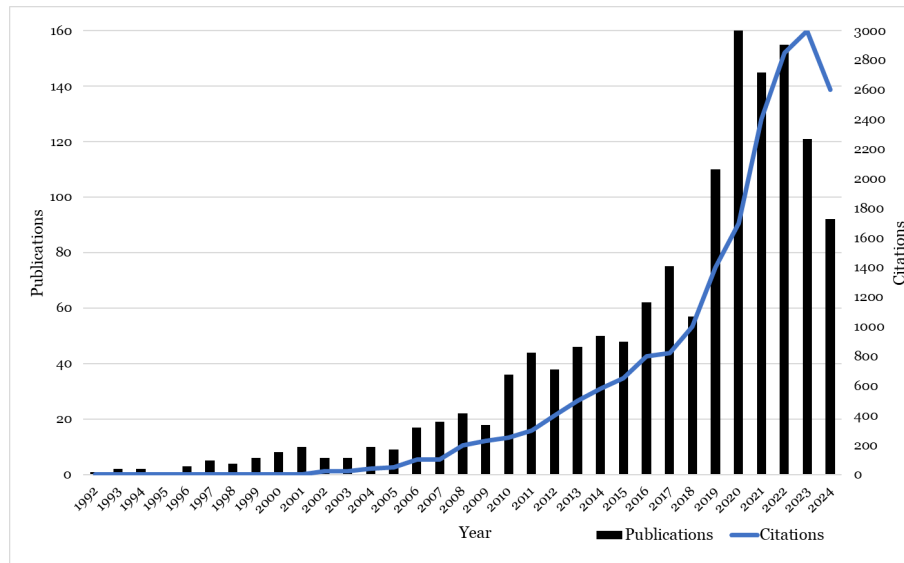


Figure 2.5: Number of publications and citations by each year. Data source: *Web of Science*. Adapted by: Author.

Since 1992, the year when this research was first conducted, 2019 was the year when 160 documents were published on the subject, although 2023 had the most citations of them. This graphic is useful for understanding that it is probably more interesting to analyze documents starting from 2010, as previous research on this subject was very limited.

2.4 VOSviewer Analysis

After understanding which authors, journals, and years are the more significant to this research, it is interesting to analyze how those documents relate to each other regarding the co-authorship and how they are connected in regard to their cited references. For that analysis, *VOSviewer* will be used as the software of choice. *VOSviewer* is defined on their website as “a software tool for constructing and visualizing bibliometric networks. These networks may, for instance, include journals, researchers, or individual publications, and they can be constructed based on citation, bibliographic coupling, co-citation, or co-authorship relations.” [10].

This step of the bibliometric analysis is done by creating different maps on *VOSviewer*, depending on the objective. The maps can be done using a co-occurrence of keywords, institutions, co-authorship, and even co-citations. For this case, it was decided that co-authorship and co-citation analysis would be the best fit for the study. The file that contains the information necessary to create those maps can be exported from the already done research on *Web of Science*, and uploaded to the designated software.

The following maps, created using the tool *VOSviewer*, show which specifications connect to each other. To start, Figure 2.6 represents which authors are linked to each other, basically, authors who worked together are connected. Each cluster means the number

of publications of that author, the bigger the cluster, the more they published on the matter. The color represents a “score system”, which varies “from blue (lowscore) to green (average score) to red (high score)” [11], giving different groups of authors different colors when those are not associated with time.

The map presented in Figure 2.6 demonstrates the connections between different authors. This co-authorship graphic considered 1000 authors, the most relevant in the field, out of 2298 authors, however, only 21 of them published together, so those are the ones that can be connected. The graphic also shows a total of five groups of authors, divided by colors.

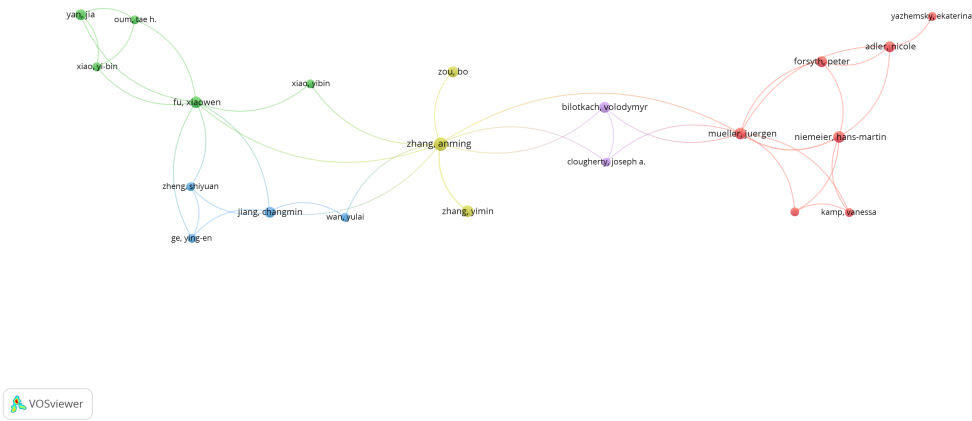


Figure 2.6: Map with the connections between authors. Data source: *Web of Science*. Prepared by: Author.

The graphic in Figure 2.7 presents the same specifications above, except for the color of the clusters and connections that vary over time, as shown in the scale - this scale varies from 2012 (blue) all the way to 2018 (yellow).

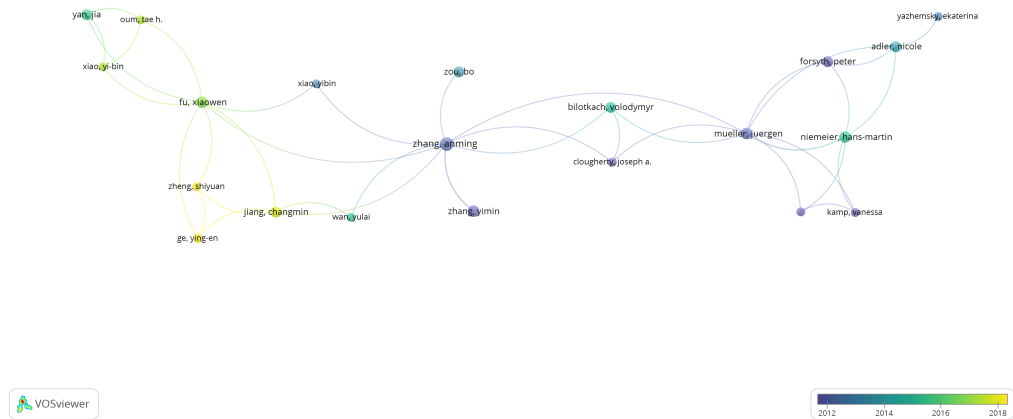


Figure 2.7: Map with the connections between authors, having time in consideration. Data source: *Web of Science*. Prepared by: Author.

Regarding the graphic in Figure 2.8, the different colors represent the density of publications for that author or group of authors, this feature gave the map its name of density map.

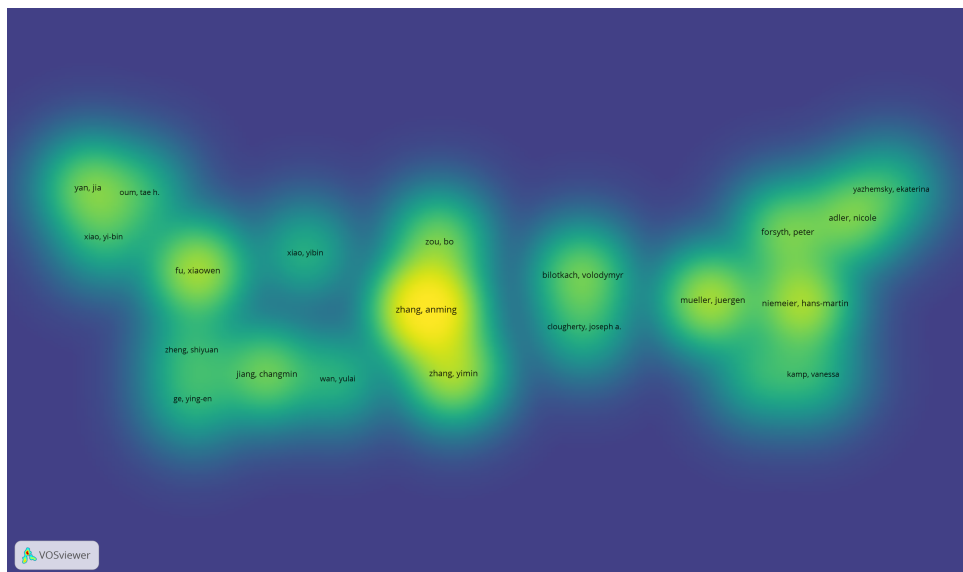


Figure 2.8: Map with the density of publications by authors. Data source: *Web of Science*. Prepared by: Author.

The following two graphics, Figures 2.9 and 2.10, show 7 groups of references that they have in common, being the connections made between publications considering their cited references. *VOSviewer* did not create a map considering the time for cited references. For these, 36 113 references could be considered, but only 1000 were counted due to the software's limit. The maps do not form an epicenter, because the search does not have a main cluster to grow from there. That way, the map shows that there are a few

papers connected to each other (regarding cited references) from different groups.

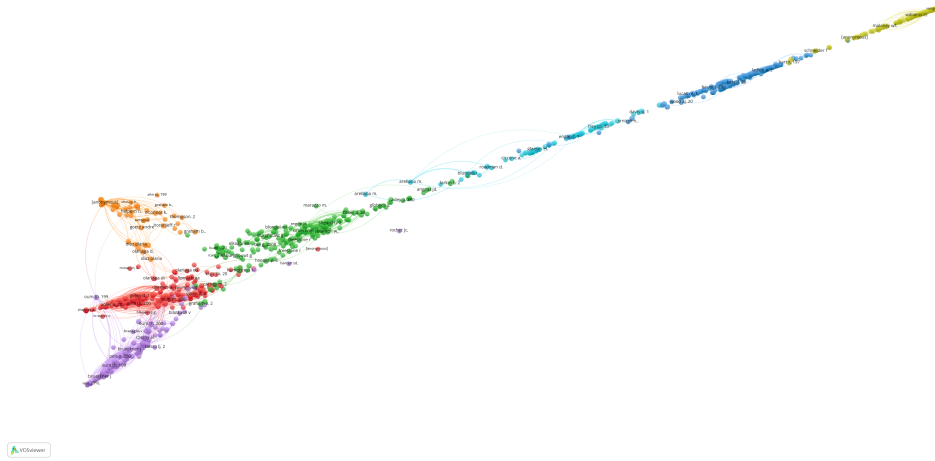


Figure 2.9: Map with the connections between publications by cited references. Data source: *Web of Science*. Prepared by: Author.

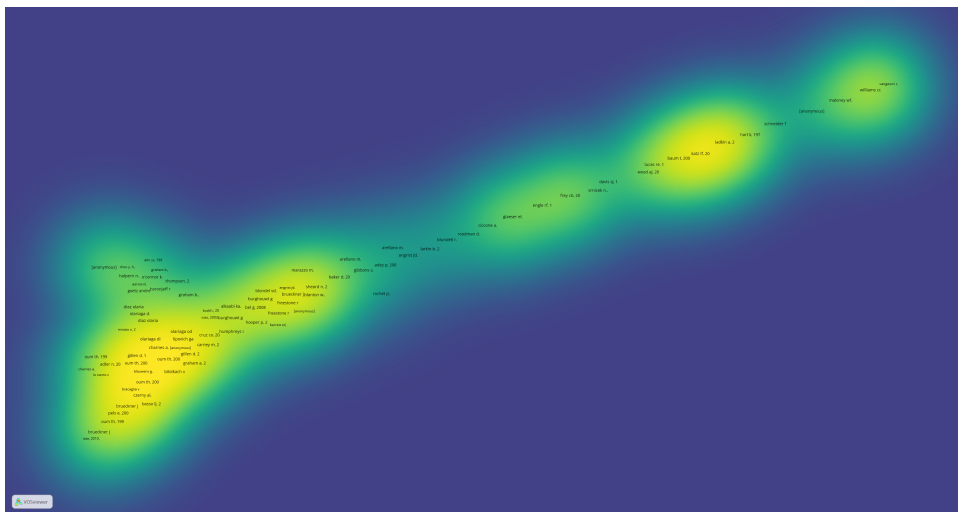


Figure 2.10: Map with the density of publications by cited references. Data source: *Web of Science*. Prepared by: Author.

In conclusion, this analysis allowed the understanding of the importance of certain authors and groups of authors, whose research is essential for this study.

Given the results obtained, it was decided to exclude every paper under 2010, and whose language is not English or Portuguese, leaving 1139 documents left to filter. This portfolio of papers was integrated by selecting papers that are included in the research areas of interest for this study, leaving 425 examples. Finally, the number of papers relevant to this study can be reduced to 54 items by only selecting those whose titles and abstracts are relevant, as demonstrated in Figure 2.11.

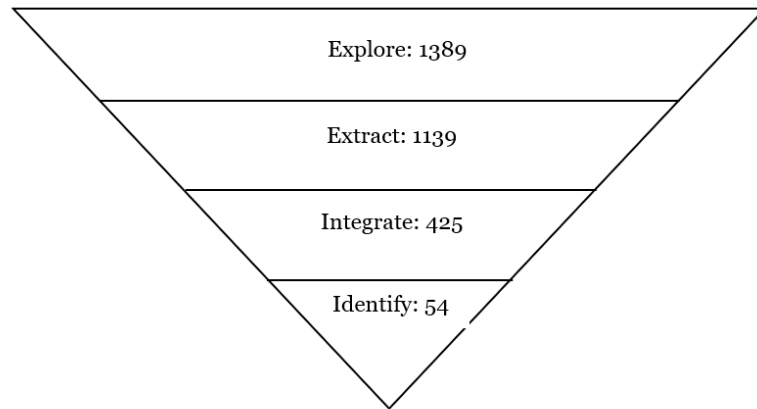


Figure 2.11: Filtering process of the bibliographic research. Data source: [12] Adapted by: Author.

2.5 Conclusion

With the papers' portfolio selected, it is easier to find useful information that contributes to the State-of-the-Art of this dissertation, Chapter 3. However, there are some documents that were found in other databases or search tools that are pertinent to mention, so the bibliometric analysis is very useful to have a significant base to start the research, but it does not limit it.

The literature concluded, in this chapter, to be the most pertinent for this dissertation's investigation, is taken into consideration for review and judgment, so the bibliography is appropriate to consider for Chapter 3 and for the present study development theoretically and in practice.

Chapter 3

State-of-the-Art

3.1 Introduction

The presence of an airport in a locality can have numerous consequences in that region, whether those consequences are economic, social, cultural, environmental, or political. It is in the interest of entities to know what impacts airports cause where they are built, so they can predict what could happen to that area once they build an airport, or expand an existing one. Those predictions are important to consider investments, to understand the economic changes, and to put sustainable issues into practice, among others.

The State-of-the-Art aims to present some conclusions about the impact of an airport on an insular region by reviewing existing literature on the topic. Although there are some public studies on the subject, there is no in-depth, detailed research into the impact of an airport on islands in general, be they countries, autonomous regions, or non-autonomous regions, compared to studies in continental countries and cities. It is therefore pertinent to find out if it is possible to infer whether an airport on an island is a necessity for the economy, by extending conclusions taken on different case studies to the island's reality, and understand the airport's influence on areas in general.

Based on the relevant bibliography, it is possible to draw conclusions and estimate which factors influence the regional economy in the airport sphere and infer what kind of importance an airport has on an island. The findings were synthesized by categorizing the different economic or social factors that can change due to the existence of an airport, such as tourism, employment, investment, and others, concluding what they have in common and how relevant they are for island cases. This chapter is essential to understand the variables and data necessary to develop a case study on a practical case and to have more knowledge on the subject.

3.2 Economic impact of airports

The existence of an airport contributes to the regional economy by creating new jobs, putting a region "on the map" by airlines and their itineraries, and attracting more tourists as well as new businesses. But how does this infrastructure really affect and impact a region? The most objective and general way that air passenger transport has proved to

impact the economy is by studying the changes in the region and relating them to air traffic using Gross Domestic Product (GDP), references [13]. There are studies which conclude that the economy is impacted by air transport because it influences the GDP; and increasing the GDP by 1% demands that the volume of passengers increases by 1.47% [14]. Air travel influences the GDP since the transport of passengers suggests that at least part of that volume of people are from outside the airport city, facilitating tourism and reflecting this relationship on the economy [14]. Recognizing that air travel affects the GDP of a region, it also impacts its economy in various ways, yet these effects can be interconnected and influence one another.

The following topics explain how some areas are affected by an airport, as well as how that impacts the local economy, based on previous studies done theoretically and practically on the issues.

3.2.1 Tourism Development

As Zeynep Elburz, Peter Nijkamp, and Eric Pels [15] state, airports are crucial in facilitating tourism and trade activities. The existence of an airport that is not only for cargo trade is immediately associated with tourism, since it contributes to the mobility for residents, promoting cultural exchange and tourism for the locality [16].

The authors Kenneth Button and Samantha Taylor [17] presented a system where the impact of a service (the airport, in this case) can be considered depending on the type of effect that it has on the region, more specifically, the region's economy: primary effects, secondary effects, tertiary effects, and perpetuity effects. The primary effects are those that have a direct effect on the local community by creating that new service or changing it, these effects immediately impact the regional economy – these are associated with companies and employment and are defined as short-term effects on the economy; the secondary effects, compared to the last case, are longer-term effects for the economy because they do not affect the economy immediately, being the more continuous flow of income and depending on the airport's operations; the tertiary effects are the result of companies, firms, and other businesses, and individuals taking advantage of international air transport, as they are mostly geographically mobile, the tertiary effects also contribute to the development of peripheral areas for example, in cases where airports are build on a peripheral area and businesses like warehouses or tech companies move next to the airport, encouraging the development of that locality; the perpetuity effects are mainly about the acceleration of economic growth and self-sustaining economy of a region, due to investment, migration of businesses to that location, and new economy activities, making this effects longer term consequences. Understanding these different types of effects that a service may have on a region is essential when analyzing the impact of an airport on its area [17].

The air transport industry is essential in a global economy, as said by Kenneth Button

and Samantha Taylor [17] in the iconic phrase “International air transport is an essential ingredient for the success of tourism in many countries and regions” [17:1]. The influx of tourists contributes to the regional economy by increasing the demand for services and stimulating job creation [18]. Under this perspective, not only is tourism a direct consequence of having an airport, especially if it is an international airport, but it is also a cause for long-term effects on the local economy [14]. For instance, it can be considered that an airport that brings tourism to a destination contributes directly to the region’s development and economy by creating a primary effect on that economy, which leads to the creation of new services needed to support and attend to tourists. Since creating new services can be associated with employing more people, these consequences of tourism are considered perpetuity effects, since there is a continuous and long-term contribution of these services to the region and its economy. Therefore, being open to tourism and having airport operations that encourage tourists to this destination is important and might make a big difference in the economy.

Jacco Hakfoort, Tom Poot, and Piet Rietveld [16] defend that tourism and the economic impacts that the airport provides to a city may also affect nearby cities, so bigger airports, with international services and more offers of services, can affect the whole country’s economy, for example. On the whole, tourism is an inevitable consequence of having an airport, being a positive influence on the economy by demanding particular services that will boost the local economy in various ways.

3.2.2 Employability

It is important to quantify the employment generated by a service or infrastructure and how that activity impacts the regional economy, to understand how significant it is for a region where that service exists. It is impossible to project, build, maintain, and operate an airport without massive job creation. Either one of these steps implies a significant creation of job positions for successful management and operations.

Airports can be considered big infrastructures where there are the most diverse businesses and companies. As long as airports exist, there are a lot of companies that only exist because of them, not only in the airport facilities but also outside the airport area. Many companies and businesses can exist without an airport, but its presence is the key to developing these businesses and expanding their operations. Therewith, air transport is a pivotal determinant of employment in a country [15].

Regarding employment, efficient air transport and better connectivity can reduce regional disparities since they provide more employment opportunities in peripheral areas (where airports are sometimes located), contributing to economic development with a more balanced traversing regions [19] - tertiary effect. In addition, some studies believe that around 30% of airport-generated jobs can be filled by citizens who were unemployed before [20], and these job positions contribute to and promote long-term employment

stability [19], lowering the percentage of a country's unemployment, which directly influences the economy positively.

Airports contribute significantly to employment in many sectors, often, these infrastructures are the largest single employer in a region [20], and being the main employer of a metropolitan area guarantees a remarkable impact on job creation. A key factor in boosting employability is the increased flow of tourism, described before, as it leads to a higher demand for particular services [19] in need of serving non-residents. The authors Matha Gadgin, Patricio Goldstein, and Jessie Lu [21] presented some pertinent points explaining different implications for job creation and how the volume of passengers would affect the distribution of employees by sector and distance from the airport. They concluded that there are urban centers next to airports that can be a cluster of employment opportunities, and those contribute to a significant part of the total country's employment, considering airports as job centers and economic hubs [21]. Other than that, the whole region benefits from the airport to increase the number of businesses and job positions.

With that information, it is simple to gather that there are different types of employment originated or promoted by the airport and can be divided into two major definitions: direct employment and indirect employment. Direct and indirect employment are very common definitions when talking about the impact of a service on the local economy, especially when issuing an airport, where there are so many strings attached to its services.

Direct employment is a job position that exists strictly because of the existence of the airport itself, meaning all jobs that would not exist at all if the airport ceased operations. Direct jobs can be found inside the building of the airport, in the terminals, retail services, food and beverages, ground handling, airlines staff, security staff, customer service, administration [15], air traffic management, jobs created when expanding the runways, for example [19], maintenance technicians, engineers, information technology support staff, financial and accounting sectors, among many others [20].

Issuing indirect employment, any job that prevails in sectors and services connected to the airport, that grows because of the airport, and is considered necessary as a consequence of the existence of the airport, but does not remain directly inside the airport's infrastructure, is considered an indirect job position. Examples of this type of job can be any position or role present in the following businesses: hospitality services, logistics companies [15], car rental, parking services, local businesses, warehousing, travel agencies, tour operators, restaurants and bars [20], producers and manufacturers, and logistics parks [21]. The referred positions are often related to tourism, since tourism exists besides air travel, and the services can be used by residents also; however, given the volume of non-residents that arrive via air transport, there is a boost and increase in the quantity and stability of the services.

In summary, when analyzing the impact of an airport on a region regarding employment,

it is important to consider that there are predominantly two types of employment, being them directly or indirectly linked to the airport's infrastructure. Direct or indirect jobs do not change the fact that the airport is a massive job center in a region, and can be considered a main employer there.

3.2.3 Attraction of investments and economic projects

There are different types of investments when it comes to breaking down the investments attracted by an airport. These investments can be in the airport itself or in other businesses that may exist or expand because of the existence of the airport. Any investment inside or outside of the airport area can count as a perpetual effect on the economy since it contributes to economic growth and goes towards expanding businesses and capital [17]. Some studies in this matter consider the attraction of investment, the Spillover Effect [15], which is positive when investment is successfully attracted.

Many investors are interested in finding businesses and areas to invest in, near an airport. There are several studies defending that when an airport is built in some area, it automatically impacts the real-estate appreciation and stimulates the development – services investment -, and other infrastructures like hotels, restaurants, leisure areas, health-care centers, and many others [22], which directly impact the regional economy. So the investment made in the airport regarding expanding an existing airport or building the infrastructure from scratch will impel the investors and businesses to create new services and boost the real-estate appreciation, so the investment in the airport reflects a positive impact on the whole region.

A visible example of the attraction of investment and economic projects is the Aerotropolis. In the definition, “an Aerotropolis is an airport-centered urban economic region that rapidly connects high-end manufacturers and business services to their global suppliers, marketplaces, and enterprise partners.” [23:1]. These airports are usually characterized by being an international hub, attracting all kinds of investment for the metropolitan area. Zhengzhou Airport in China is a perfect example of how a modest area with an airport focused primarily on domestic services could switch to a seven-terminal airport, in a region with investment from high-tech companies like smartphones and innovative vehicles, biomedicine, and aviation schools, among others [23].

A different investment approach is presented by the authors Tonny Judiantono and Wahyu Budiyo Saraswat [24], where they study how the investment directly applied on the airport's infrastructure can also influence the economy of a locality. The study proposes that when an airport's infrastructure is invested in, it leads to job creation in airport-related services because it relates more investment to more operations in the airport [24]. This research is followed up by a practical case on small islands in Indonesia to support the conclusions. As stated before, the more job positions created, the more beneficial it is for the region's economy.

On the other hand, investing in the aviation sector can be tricky for policymakers, stakeholders, and investors. Philipp Breidenbach [25] concluded that policymakers and investors must be careful when investing in airport facilities because it does not necessarily impact the economy of that area positively when we consider regional airports, as his study suggests. It is also interesting to analyze that an airport can be a cause of restructuring the economy of the metropolitan area around it, essentially because the growth in high-tech and modern industries can result in a massive shutdown or decline of traditional jobs [18].

Summarizing, the presence of an airport is something some companies seek when finding a place to start or invest in, especially in sectors like the tourism sector, logistics, and technologies that benefit connectivity and internationalization; it also can boost the development of the local structure, such as improving access roads, public transportation, and others [22].

3.2.4 Study cases: What are the variables that affect the region?

Several studies have already been published regarding the analysis and acknowledgment of the consequences of an airport in a city, county, country, or island. Some of those studies are done based on an employment impact, others count on other types of variables, such as community development, local business growth, investments, and tourism evolution. Following in this chapter, some examples of what aspects (that exist because of the existence of an airport) would impact the region regarding employment or other important socioeconomic characteristics, based on different case studies, will be presented.

Evidence from Turkey on regional development [15] states that the air passenger volume significantly impacts regional employment in the country. The significant and positive influence of air passenger volume on regional employment in Turkey shows the importance of air transportation infrastructure for stimulating economic activity and job creation across various regions in the country [15].

It is interesting to acknowledge that the existence of an airport in a certain region also impacts the population. A study done on regional accessibility and social development in Norway [26] proves that there is a strong connection between the presence of an airport with the decision of residents to continue living in that region, as 70% of the participants of that study said they agree that they are more likely to continue living in the region as a result of having a local airport [26]. The main reasons are accessibility and opportunities; however, the employment opportunities that the airport offers residents can also influence their decisions. Therefore, it is pertinent to relate the two previous study cases and state that social and economic consequences are closely tied to the impact of an airport.

Another study from the Czech Republic suggests that the regional economy development

is stable or not, depending on the services and conditions of the airport, since the airport's infrastructure is relevant enough to provide certain services and businesses, increase tourism and trade, which leads to a better and stable economy [27]. The study found out that in the Czech Republic, any disruptions in the airport and its services can lead to consequences not only economic but also on national security and public health [27]. The authors conclude that security is a key factor in the efficiency of airport operations, which in turn are considered responsible for impacting the region and its economic activities, since the quality of well-performed operations attracts more passengers, airlines, and investment, thrusting the local economy [27].

An article that studies the development of an aviation network strategy in Queensland, where the airport plays a main role in the state's economy [28], professes that strategies and connections implemented at Queensland airport, in Australia, can impact the state, and the community, as well as the economy are beneficiaries of those consequences [28]. The airport can impact the region by facilitating tourism, creating new jobs, promoting local businesses, and improving connectivity [28].

Other factors directly impact the local economy, creating a more objective and equitable relationship between itself and employment: a study done by [29] reveals that passenger traffic volume can be a variable for the economy. This study shows that passenger traffic volume affects employment and the average wage, but does not affect the number of establishments that exist in that location [29]. This author also concludes that the number of destinations served by non-stop flights impacts the economy, as it increases the number of job positions, businesses, and the average wage. Like that, the regional economy is predictable by the number of non-stop destinations offered by the local airport. In conclusion, the study of [29] shows that attracting services to new destinations can have a larger impact on the local economy than expanding services to existing destinations.

Unfortunately, as stated before, there is a lack of studies on insular regions regarding the impact that aviation has on them, so there is not much relevant information on the topic. Therefore, since there are not many case studies specifically on islands, it is very hard to define the variables contributing to this research.

3.3 Conclusion

Islands are regions where the importance of air transportation is very straightforward. As maritime transport and air transport are the options for exchanging cargo and people, air transport quickly becomes the preferred mode for people exchange, as it is faster and sometimes the only option. That way, air transport automatically turns out to be a very significant portion of an island's economy.

After understanding the factors that may impact the economy of certain areas in general, it is possible to deduce what factors can be considered in cases when that area is specifically

an island.

Attracting private investment is a very important factor for the island's growth, so there is investment in the development of new and better services to attract more tourism and help residents settle in the islands. Attracting public investment in airports' infrastructure and related businesses is also important for meeting the needs of the population and helping to fix the population in the insular region. Not only would residents experience a better quality of life, by taking advantage of new and different services, but also by having more opportunities for job positions across many different sectors, and higher average wages [29].

Investment in the aeronautical sector is also an incentive to promote the island's self-sustainability, a self-sustainability that results from a robust local economy, which can be positively enhanced by the development of tourism and increased employability. Investing in the airport's infrastructure guarantees that there are more employment opportunities for citizens, as stated before, directly in the airport, leading to even more job creation in indirect employment [24]. It is pertinent to understand that in some cases, there is a likelihood that the demand for services and job positions will be so high that the airport will become the main employer on an island (directly or indirectly), and it may be necessary to obtain foreign labor to meet the demand, since islands can have limited resources in one way or another.

Considering and stipulating that airports on islands are usually regional and smaller than international airports in capital cities, for example, small airports definitely do not have the same level of impact as large hubs, when taking into consideration absolute data; but they play a crucial role in the development and support of a local economy [30]. International hubs also exist most of the time in large metropolitan areas, where airports do contribute to urban growth, but their influence on that area is very variable and can be considered weak [31]. Stephen J. Appold [31] claims that the more populous a metropolitan area is, the weaker the impact that an airport there has on the employment of that area. That way, the conclusions obtained from general studies and even case studies can be easily reflected, to a certain extent, on an island reality, since its metropolitan area is smaller in most cases.

Using the analysis carried out in other case studies is a good way of characterizing what type of airport investment should be made for each case, using the causes and consequences addressed by different studies as a basis for what might happen in the desired practical case. For example, increasing the supply of non-stop flights to different destinations might increase the number of job positions, but if the aim is to increase the number of businesses established, increasing passenger volume may not be the best choice [29].

Realizing that an island may depend more exclusively on tourism and the investment that comes with it, compared to a mainland town, it is crucial to the development of the insular

region, as it lacks the means and conditions to support itself and its population without air transport. The employment generated by airports on an island is so significant that if it were to cease operations, the island could face an immediate shutdown in its economy. Although airports play a huge part in the development of an insular region, it is up to the political and urbanist sectors to guarantee a development plan that positively affects the sustainable development of an island, ensuring a balance between environmental regulations and economic growth.

Chapter 4

Methodology

4.1 Introduction

This chapter is essential to outline what steps need to be taken to conduct the study successfully, minimizing the errors that may be encountered during the investigation, and what needs to be taken into consideration for a reliable conclusion. The methodology not only covers the choices made to collect and analyze the data, but also the theoretical structure and the justification behind it.

The methodology used for the theoretical aspects of this dissertation, specifically regarding the state of the art, focused on identifying and analyzing relevant documents and studies within the scope of this investigation. Using the database *Web of Science*, papers were searched using the key topics obtained by *VOSviewer*, and selected by title and abstract relevance. The chapter concluded some variables and data that were common to find in studies regarding the impact of an airport in general, which can be inferred to be variables in cases of islands as well.

The following sections in this chapter will overall specify the research type and strategy, the data collection method and analysis, and the limitations of this study.

4.2 Research Problem

This dissertation's problem is to, as mentioned before, relate the airport in Ponta Delgada with the development of São Miguel island. The State-of-the-Art, Chapter 3, concluded that, although there are studies that investigate the impact of an airport, it is difficult to find studies done on islands or remote regions. It is important to research this case study and to develop a study on the insular region issue because there are no studies in this case scenario, and few studies in general. Scientific studies like this are essential to understand limitations, what improvements can be applied, and how certain changes that are made can affect other variables, which are also important for stakeholders to analyze, among others. To better understand the conclusions and considerations in the study, it is important to have knowledge of the variables in this subject's regard and the changes that may arise. There is a range of changes that have been made in aviation that are pertinent to include when investigating the panorama of the impact of an airport on a region, such

as the increase of low-cost flights, the cheaper alternatives and packages in non-low-cost companies, the trending travel destinations, and excessive tourism, for example.

For this dissertation, the field of inquiry is the relationship between the airport and employment, as seen in Chapter 3. The influence of this relationship may fluctuate depending on the metropolitan area of the region being studied. The insular region in question being São Miguel Island, the relationship between airport repercussion and the region's employment is much influential, on account of the metropolitan area in question being relatively small when compared to others like Lisbon, Oporto, Faro, and Madrid, for example, the insular region is much more easily affected, so this case study is indeed prominent.

The bibliographic research is concluded, so the problem stretches to what impact an airport has on an insular region, such as São Miguel. For this problem, the following questions are asked:

- What is the relationship between the number of passengers and the employment in São Miguel?
- What is the relationship between the number of flights and the employment in São Miguel?
- How does the development of the airport affect the development of the island?

4.3 Research Philosophy

The research philosophy lies mainly in providing a description of the principles underlying the study, what the beliefs and values are behind the investigation, and how it is going to be approached.

This probe aims to assess the impact of an airport on the island of São Miguel, recognizing that it has indeed had some economic and social effects on the insular region. The author seeks to obtain knowledge on the issue with an approach based on Positivism Methodology [32]. This ideology describes the insight that the author gains from the investigation can be obtained from an objective data collection and observation, data that can be measured, numerical data, among other objective information that can be defined as a variable affected by another variable [33].

In the present case, the objectives of this study can be answered based on an investigation done by collecting numerical and objective data from companies that work at the airport, and the airport itself, so the conclusions can be gathered by controlling the environment and manipulating variables carefully.

4.4 Research Type

Scientific research can be categorized as quantitative or qualitative, considering the chosen methods, the issue in question, and what the objectives are. Qualitative research methods usually seek answers that are more like an abstract concept or even philosophical conclusions that answer to “why” and “how” subjectively; qualitative research works with data that is based on concepts, and information that is not numerical, subjective data, also known as exploratory [34]. The quantitative research methods are conclusions taken with exact data, like measurements or other factual and precise information, where the data collection is done on a controlled population in order to have objective conclusions; quantitative research is an objective research, focused on measurements and numerical data, also known as statistical [34].

Given the research philosophy of methodology, it is not questionable that this type of research is quantitative. This study aims to obtain objective information regarding the variables and their relationships, the procedures, and the data taken into account throughout this dissertation are more evident in quantitative research than in qualitative studies. To conclude, the relationships outlined in the dissertation’s objectives are between numerical data, numbers, and can be defined as dependent variables and independent variables, like the number of passengers and the number of job positions.

4.5 Research Strategy: Case Study

The strategy chosen to elaborate on this investigation is the case study. A case study is defined as an “assessment of a specific situation in the real world created for the purpose of deriving generalizations” [35:1]. A case study is a direct observation that allows the researcher to deal with a range of variables [35] and shed light on a situation in which the researcher has no control over [36]. Some authors define the questions “how” and “why” as the types of questions that a case study can answer regarding the investigation [36], which also reflects being a great option for quantitative research methods.

The research strategy chosen for this dissertation is the case study, since the intention is to study the impact of an airport on an insular region, it is suitable to apply a case study on an island. Studying a specific island allows for concluding the investigation and finding answers to the objectives of this research, which can be generalized afterward. Robert Yin [36] states that a case study is a frequent model for a thesis or dissertation analysis. For this dissertation, a case study offers more credibility and relevance on the subject.

The case study is João Paulo II Airport, in Ponta Delgada, São Miguel Island, which is part of the Azores archipelago in Portugal. Studying a specific island allows for concluding the investigation and finding answers to the objectives of this research, which can be

generalized afterward.

4.6 Data Collection Method

As the name suggests, data collection involves gathering information and facts from a sample of the population being investigated. The data in question refers to any relevant information that can be acquired and subsequently analyzed to achieve results and conclusions that support the explicit objectives of an investigation.

For this context, defined data is going to be collected to have reliable information regarding the employment of the companies and entities that work in the airport's infrastructure, to infer their impact on the insular region, and to understand their role in the scenery.

The designated data collection method for this dissertation is the use of questionnaires. For quantitative research, one of the most commonly used methods of data collection is the questionnaire, as it can collect numerical data while organizing it by sections/questions effectively and straightforwardly. This method was chosen because the data collection aims mainly at numerical information on the companies and entities that work at the airport, which is relevant for the study of the impact of the airport on the island. The questionnaire has the advantages of targeting only the audience to which it was sent/requested and collecting quantitative data [37], as well as making time comparisons of the data and comparisons of the different answers to the same question. Conducting questionnaires to collect the desired information also has some disadvantages, including misunderstandings about certain questions, where the person answering will reply based on their understanding and knowledge, and the possibility of receiving false responses or non-responders [37].

4.7 Sampling Strategy

To collect the desired data for any investigation, the method chosen to collect the data must be specified, in other words, the sampling method. Samples are outstanding parts of a larger group, the population. In the research field, "the population is the complete set of individuals, events, or objects that exhibit the behaviors and/or possess the characteristics of interest to the researcher" [38:1]. Inferring from the previous definition, a sample would be a portion of the population, decided by the researcher.

There are many types of sampling methods, and they can be separated into two categories: probability and non-probability sampling methods. As the name suggests, probability sampling is a method where the selection of the sample guarantees that every part of the population has the same probability of being selected, and non-probability sampling does

not ensure that the sampling is chosen objectively; a characteristic in common selects the sample, or the selection is done to achieve a specific distribution of data [38]. According to João Maroco [39], the probability sampling method, or random sampling, is like a lottery system, where, even though the population can be divided into groups or sections, the sample is completely random, the author defends that the random sampling method is the preferred one, since it is aligned with the following basic principles of probability. Although it is the preferred method in theory, sometimes it is not possible to coordinate this method with the investigation due to time or cost limitations [39]. Regarding the non-random sampling, it does not mean that the sample is picked out one by one and chosen meticulously to support the desired conclusions; however, it can be done by accident, convenience, by diversity, or by objective [39].

The present investigation considered the defined population to be all companies and entities working and present at the João Paulo II Airport. However, after some steps into the investigation, it was noticed that to consider the population to be every company and entity would lead to some problems when calculating the representativeness of the sample. This topic will be addressed later on Chapter 5.

For the analysis of this dissertation, the sample is selected using a non-probability sampling method. The relevant data to be analyzed resides in the information provided by the companies and entities that were able to respond and attend to data collection, which is addressed in the previous subsection. Since the study deals with data collected through questionnaires and the population is the companies and entities that work at the airport, the sample in this dissertation is the companies that responded to the questionnaires. This method is a non-random method, because the companies present on the airport's landside have more probability of answering, since the author can reach out to them in person, and the companies present on the air-side have less probability to be part of the sample, since they are being reached out via e-mail or by a point of contact, excluding the option of being approached directly. International companies or governmental entities are also less likely to deliver the demanded data, since their administration centers are not based in São Miguel, and the employees do not have the permission or knowledge to answer the questions.

To this extent, the sampling method employed in this investigation is non-probability sampling, and the sample comprises the group of subjects that provided useful data.

4.7.1 Sample Representativeness

The sample considered in this study is simply the number of companies in the population that responded to the distributed questionnaire.

To assess the representativeness of an investigation, it is necessary to calculate the sample size required to achieve the desired confidence level. It is important to estimate if the

sample is representative, the target audience for this study can consider the confidence of this study, how it can be reliable at the time of the publication, what to consider for next studies, and its importance for the scientific community.

The calculation of the sample size of a finite population is obtained using Equation 4.1. This formula takes into account parameters such as the confidence level, the margin of error, and the proportion of the population that is expected to be part of the sample. This equation already considers the finite population correction that is usually applied to the formula that defines the infinite-population sample size.

The confidence level represents an indication of the sample’s probability of corresponding to the measured characteristics [40], in other words, it corresponds to how likely the sample is to have the characteristics estimated. The most common level of confidence values is 90%, 95%, and 99%, which means that, for example, in the last case, 99 out of 100 subjects from the sample match the population’s parameter [40]. The level of confidence is then translated to *Z*, which is “the inverse of the standard normal cumulative distribution that correspond to the level of confidence” [40:5]. The values that *Z* embodies are specifically determined numbers that can be observed in Figure 4.1.

| Level of confidence (%) | <i>Z</i> | <i>Z</i> ² |
|-------------------------|----------|-----------------------|
| 90 | 1.645 | 2.706 |
| 95 | 1.960 | 3.841 |
| 99 | 2.576 | 6.635 |

Z - the inverse of the standard normal cumulative distribution that correspond to the level of confidence

Figure 4.1: *Z* values that correspond to the most used levels of confidence. Source: [40]

The degree of variability, or expected proportion, is a percentage that indicates the variability of the population, representing the proportion of an attribute or characteristic within that population [40]. This value is usually previously known to the investigator, if there have been studies on the subject that have concluded the proportion, or if that attribute is known by analyzing the population before calculating the sample. Because this research is a pioneer in this specific case study and employs this methodology, and there is no previous information stating the interest ratio, the expected proportion can be considered 50% of the total population [41]. Although significant efforts were made in data gathering, the present sample is somewhat shorter (23.8%), which may be justified by the fact that the entrepreneurial ecosystem is mainly composed of firms with fewer than 5 employees.

The error, margin of error, or level of precision are different names that represent the “range of accuracy of estimating the true value of the parameter” [40:2]. Many studies present a range of values that are treated as the preferred values of the error for investigations. Usually, the range varies between 5% and 10% of error for scientific studies, defended by many authors, for example, Marina Marconi and Eva Lakatos [42]; however, Marilyn Agranonik and Vania Hirkata defend that the value of the error must depend on the investigation, and the expected proportion, or prevalence [41]. The error in a study can occur through various strands, especially when subjectivity or the human factor is involved.

The data for this dissertation were obtained through a questionnaire, which introduces some limitations, errors, and subjective points that should be considered, as mentioned earlier. Some questions can be misinterpreted, some answers can be false due to a lack of information or misunderstanding, or the questionnaire can not be filled out at all [42]. All these variables and issues interfere with the error.

Since the population is known and it is a finite number, the following equation 4.1 will be used for calculating the sample [41], considering n the size of the sample, N the size of the population, p the expected proportion, Z the value considered through the confidence level, and ε the error.

$$n = \frac{p(1-p)Z^2N}{\varepsilon^2(N-1) + Z^2p(1-p)} \quad (4.1)$$

Although a significant portion of scientific studies determines the sample size based on the assigned error and level of confidence chosen by the authors for each case, this study’s sample is determined by the number of companies that provided the necessary data for the study. With that, the sample is already defined by the number of companies that responded, so there is no need to estimate the sample size. In the next chapter, the representativeness of the sample is introduced for the available sample.

4.8 Data Analyzis Method

Data analyzis is the process of transforming and interpreting the information collected systematically [35]. In any investigation that requires collecting data, that data needs to be analyzed and processed so it can be phased into pertinent conclusions. To have reliable and accurate scientific findings for research, it is important to implement the correct data analyzis method, which can change depending on the data in question, or the desired conclusions. These methods are crucial for analyzing trends, tendencies, and distributions, considering whether it is possible to make certain changes, and planning future decisions [35].

The data analysis of this dissertation aims to identify a relationship between existing variables that are relevant for the conclusion regarding the impact of the airport on the island. Various methods can be used to estimate the impact of a sector on a locality, and some studies have already had similar investigations using different methodologies.

This dissertation's main objective is to find a relationship between the volume of passengers and employment, so the impact of the airport in the insular region of the case study can be estimated. This estimation process involves quantitative data, which means that the data analysis is also a quantitative analysis. This section follows with a brief description of some data analysis models that could be considered for this dissertation and the reason why they were not chosen, along with a description of the selected model.

The method selected for this analysis is linear regression. This method was chosen because it is a simple yet effective way of identifying relationships between two or more variables, taking into account the residual error. This method also guarantees that there is a proper relationship capable of forecasting the increasing rate and a linear prediction for the future.

After the data is successfully collected, it is time to prepare the data on an *Excel* datasheet and select the trustworthy information, as there is the possibility of having mistakes, duplicates, human error, and missing information.

When this information is confirmed and selected, it is time to transfer the selected data into the software *Excel*, where the Linear Regression Method will be executed using a premeditated code to find answers to the described objectives. The analysis itself will consist of interpreting the graphics and the values of the independent terms of the analogy and finding final equations that represent the relations that answer the objectives.

4.8.1 Linear Regression Model

This section of the chapter introduces the linear regression model and describes how it can be used in this case to better understand its outline, importance, and relevance to this study.

The linear regression model is a statistical method for modeling the relationship between two or more variables [43], where one variable is independent and the other depends on it. This regression is a technique that predicts the behavior of the dependent variable with fluctuations in the independent variable. It is possible to state that the linear regression analysis estimates a causal relationship, in other words, estimates that changes in one variable are caused by another one. This method is also important for predicting and projecting how variables can behave under other conditions or in the future [43].

This relationship can be simply translated as the following equation (Equation 4.2).

$$y = mx + b \quad (4.2)$$

where m is the slope, also known as the regression coefficient [44], and b the intercept (both m and b are constants), y is the dependent variable, and x is the independent variable [43].

Even though linear regression is represented as a straight line on a graphic, that is the portrayal of different values of y for variations of x that do not necessarily correspond to that straight line [43]. So, the straight line being a mere representation of the relationship between those two variables, there is an error that comes from this depiction that needs to be considered, that error is represented as ε in the following equation (Equation 4.3) [43].

$$y = mx + b + \varepsilon \quad (4.3)$$

Equation 4.3 is the definition of simple linear regression. When the variable y can change based on k factors, the regression model begins to be treated as multiple linear regression, as seen in Equation 4.4 [43].

$$y = m_1x_1 + m_2x_2 + \dots + m_kx_k + b + \varepsilon \quad (4.4)$$

It is important to consider a linear regression model when investigating a subject where the objective is to understand the relationship between variables and predict a specific behavior. The linear regression model is a descriptive technique that quantifies the strength between factors and helps quantify future or new scenarios for a specific case or relationship [45].

Since the principal objective of this model is to predict unknown parameters [43], and find an objective relationship between variables, this method is appropriate to apply in this study, where the author aims to find a relationship between the number of passengers and the number of job positions, and can predict an estimation for the future. To achieve this goal, simple linear regression is sufficient to analyze the available data.

4.8.1.1 Justification for using this method

Linear Regression Analyzis was selected as the data analyzis model for this dissertation in detriment to other methods, considering relevance, appropriateness, and data compatibility. This method is the most commonly used in research, as it helps visualize

the relationships between variables and the behavior of the variables [46]. This analysis can establish the causality between variables, and it helps the investigator understand how one variable changes with the other.

This methodology is appropriate for this study because it can integrate the data available for this analysis. The sample size of 19 entities is small, yet sufficient to successfully apply this method, unlike most data analysis methods that require larger sample sizes. The data collected for this study includes time comparisons of the number of employees and the number of passengers, and the linear regression model is well known for its ability to analyze the dependence of two variables using time comparisons.

This model is chosen over others because it utilizes only available data and does not require additional specifications, unlike many other methods, such as input-output analysis, which relies on statistical tables, as discussed in Section 4.8.2.

Knowing directly how employment is affected by the volume of passengers without complex or qualitative estimates is another advantage of this method. It is possible to project and quantify the relationship between the variables and understand how to possibly get to the desired goal by manipulating the dependent variable.

In summary, this data analysis method is a good choice for this dissertation because it can analyze data from a small sample size, it allows the development of a relationship between two variables using time comparisons, and it only uses available quantitative data.

4.8.2 Alternative Methods

Numerous methods can be considered when searching for the appropriate methodological approach to understand how employment in an insular region can be affected by the airport passenger volume throughout the years. This section presents and explains the methods that could potentially be the methodology approach chosen for this analysis.

4.8.2.1 Input-Output Model

Input-output analysis is a well-established and widely used framework within the scientific community for analyzing the economic impacts on regional economies. This method involves developing a mathematical representation of the independence of variables, which are defined as distinct sectors of an economy [47]. This method was developed by Wassily Leontief, who had the objective of analyzing the economy based on assumed numerical data by observing already existing statistical information [47]. This method is developed using multiplier matrices that reflect the sectoral developments around the economy [48].

In the context of air transport, this method is frequently used for a single region and applied when studying the impact of transportation, since this method recognizes the

direct effects that an industry causes, as well as the indirect and induced effects on the region's economy [49]. Many studies use this method to understand the impact of tourism on a region or the impact of an airport on a regional economy [50], assuming that the sectors of the economy and industry are stable. This method is often chosen for airport-related studies, as it can estimate the impact of an airport by considering employment multipliers that conclude how direct employment of the airport affects indirect employment and how it can be generated [51].

The application of the input-output model has many requirements and challenges. This model requires using matrices that are statistical tables, or input-output tables, that have information regarding the areas of interest of the region's economy [49]. Usually, these tables are available on national or regional statistics platforms, or the investigator can create the tables by collecting the necessary data, if available, regarding the economic sectors [49]. The tables mentioned have to integrate the data that is fundamental for the specific study, and have to be available for the investigator.

Although this method seems to be the perfect fit to calculate the impact of the João Paulo II Airport in São Miguel, the author concluded that statistical tables referring to the direct employment of the airport on the island do not exist in the national and regional statistical services, Serviço Regional de Estatística dos Açores (SREA) and Instituto Nacional de Estatística (INE). Such detailed information is not available, at the moment, to complete this study using the input-output method; the input-output tables for a larger range of economic sectors are more common in larger regions with a well-developed economy. To create these tables, the investigator must have access to all information about employment in the region's economy, such as wages, productivity levels, employment coefficients, and other variables that the author does not have access to. This model is not going to be used in this dissertation, since the primary goal is to find a relationship between direct employment and volume of passengers, and the input-output method estimates the indirect and induced employment as well; the input-output tables are not available for this region for these specific parameters; and there are no resources available for the author to create the needed tables.

4.8.2.2 Difference-in-Differences Model

The difference-in-differences model estimates causal relationships by comparing the differences in outcomes before and after an intervention in a group and comparing the results with a control group, monitoring for unobserved variables that could interfere with the analysis [52].

This model is appealing for studying impacts, since it can estimate how the airport causes an effect on the employment, by comparing it with a group that is not affected by the airport [52]. This method is used in some studies related to airport impacts because it can measure employment fluctuations in airport-related businesses, comparing the results

with those of businesses not related to the airport. It considers external factors and changes at the airport, such as new routes, new businesses in the infrastructure, increased area, and others. This method estimates the influence that the airport would have on employment by considering the same period of time for both groups, and addressing consequences that might be caused by other variables that were not considered [53].

This method is not the ideal one for this specific dissertation, because the impact of the airport is studied in a small, insular region, which indicates that there would be a big difficulty in selecting a considerable group of businesses and companies that do not have any interference from the airport at all. This method is most reliable when the sample size is larger, allowing for broader unobserved variables and control groups, which is not the case here. Additionally, using the method results in better outcomes when the time period considered is the longest, which is another issue.

4.8.2.3 Panel Data Analyzis

This method studies relationships between variables using an econometric approach that is cross-sectional and time-series, evaluating multiple observations over time of the individuals in the sample [54]. This model aims to control for unobserved components that remain constant over time and treat them as such. The panel data analyzis is used when there are reasons that support that the differences between the individuals of the sample are random and are not related to each other [54].

In theory, this model of data analyzis has a lot of advantages; this method can support more data and can work with more degrees of freedom, and the model generates reliable predictions for the outcomes of the individuals in question [54]. However, this method also has some disadvantages, such as the complexity of developing it for data analyzis [54].

For this study, this method of analyzis is not considered, as the data available on direct employment is from several non-consecutive years, which is insufficient to apply this method, given its complexity and robustness. Moreover, the sample size is smaller than what is advisable for a panel data model, which requires more degrees of freedom, more time series, and more individuals in the sample to have a reliable analyzis.

4.8.2.4 Time Series Model

Time series stands for a series of observations sequentially in time [55]. Observing a sequence of data during a time series is a method of data analyzis called, redundantly, time series analyzis. This method used in data analyzis aims to investigate the dependence between adjacent observations [55]. For this model, it is necessary to have data collected during a continuous, long interval of time of adjacent events, to obtain as much information as possible [56]

Many authors defend that this method is effective, reliable, and its application is methodical and systematic, which makes it easier to apply if used correctly [55]. This model gives an optimal statistical relationship between variables, since it processes the data from different time observations and provides patterns in the object being studied, while identifying breaks in the dependent relationship, which can be later interpreted by the researcher [55].

Along with advantages, some investigators do not choose this model due to some disadvantages. For example, the subjectivity with which the model is presented in the scientific community, having the possibility of having multiple results and models while using the method [57]; the need for an extended period to collect information from multiple observations [56]; this method needs to have a considerable sample size to provide enough data that this model requires, as some authors introduced, between fifty to one hundred individuals in the sample [55].

This method would not be considered at this time for this dissertation, as it requires multiple observations over an extended period, which is not feasible for this work. The sample size of this study is too small to justify applying this method, since the airport does not have a large number of companies and entities. There are no resources or information to have observations from the variables over a long, continuous period.

4.8.2.5 Qualitative Analyzis: Case Study

This methodology is a qualitative research method that is focused on interpreting an individual case, the case study. This method is often chosen when the author faces a complex situation that requires knowing the context of the case study, which quantitative methods are not capable of doing with just quantitative data [58].

Qualitative data analyzis can be done by collecting qualitative data, observing, and interviewing, among other data collection methods [59]. This is an advantage of this model, creating and testing various theories and hypotheses in a real case scenario. However, this model has the disadvantage of being always susceptible to subjectivity, complexity [59], and contextual issues.

This dissertation methodology is based on a case study; however, it does not employ a traditional qualitative approach, as quantitative data were collected regarding a specific airport ecosystem, without considering the remaining airports available in the region. The airport of Ponta Delgada was chosen because it is the largest airport in the archipelago in terms of passenger numbers, and it has a private management system, due to the ANA Airport concession agreement with the Azores Government. Thus, the main difference lies in the data typology, which is mainly quantitative, and the objective of this study is to find a quantitative relationship between two variables. Thus, the qualitative data analyzis model cannot be applied to this case, despite its classification as a case study.

4.8.2.6 Correlation analysis

This data analysis model is a statistical technique that estimates the correlation between variables, identifying coefficients that measure the strength of relationships between two or more variables [60].

This method has the advantage of simplifying the data analysis, since it rates the variables by their “strength” in the relationship, and it is very accessible for researchers. With that, there are some limitations to this approach, since its estimation does not count causality, meaning that the model does not take into account that changing one variable causes a change in the other variable [61].

For this dissertation data analysis, using correlation as a method would not be the best choice, because the goal of this study is to understand how the number of passengers directly influences employment, which is the definition of causality in this case. Another reason for not using this method is that the number of passengers is a variable that changes based on season, trends, and other conditions, and some authors believe that this method is not reliable when other factors influence the behavior of the variables [61].

4.9 Methodological Limitations

In every scientific research study, a range of limitations to the methods used and potential errors should be considered. For a methodology to be as legitimate as possible, all limitations and possible errors of the methodology must be clearly outlined.

Some limitations to this methodology are as follows.

- Sampling errors, variation from the actual population [38], although the goal is to have the sample as close to the population for data collection, in this dissertation, it cannot always be the case.
- Missing data, although the companies and entities are contacted for data collection, a response is not always delivered.
- Human error, since data collection is going to be done via questionnaires from people, there is always the possibility of having human error in the data collection process and the analysis process.
- Estimation or approximation, the numerical data received during the data collection process can be an estimation/approximation, as well as the information, like the number of passengers, that will be used to conclude the data analysis.

Despite these limitations being acknowledged, the investigations still provide value to the scientific community and to the entities and companies involved in them. In this context,

the conclusions of this study are not compromised by the limitations described above, since there are still a lot of reliable findings and conclusions that can be placed and add new and correct information to this subject.

Whereas limitations potentially influence conclusions, these limitations can be mitigated and have the minimal impact possible by being loyal to the described methodology, using reliable and pertinent bibliographic references, gathering as much data as possible, and being alert for possible errors that might be easily solved.

4.10 Conclusion

To summarize the dissertation's methodology, the essential ideas and characteristics can be laid out as:

- Research philosophy: positive methodology;
- Research type: quantitative;
- Research strategy: case study;
- Sampling strategy: probability sampling;
- Data collection: questionnaire;
- Data analysis: simple linear regression model.

Chapter 5

Case Study: Ponta Delgada Airport

5.1 Introduction

This chapter will start by describing this dissertation's case study and its relevance for the scientific community, led by a collection of factual data from the field, using questionnaires. This chapter also includes a layout of the relevant information gathered from the survey and the number of passengers that the airport counted throughout the stipulated time frame.

The methodology used to understand the impact of an airport on an insular region is the case study, as previously asserted in Chapter 4. This method “is an in-depth study of one person, group, or event” [62:1] to support an investigation done on a subject that requires more of a practical part, ensuring that the results are realistic and can be applied to specific scenarios. Case studies have the advantage of taking a particular case and generalizing it to similar scenarios, often with characteristics in common with the case studied [62].

Since the objective of this study is to find a relationship between employment and the number of passengers on an island, to infer the impact that it has on the region, it is pertinent to elaborate on this relationship based on a case study.

For the matter, the case study for this dissertation is the João Paulo II Airport, the airport of São Miguel Island, in the archipelago of the Azores, in Portugal. This airport in particular is relevant for the study of the impact of an airport, since ANA Ponta Delgada, the company responsible for the management of this airport [63], noticed a gap in the information on the impact of this airport on the island, specifically on the employment it generates there. Therefore, this study will help fill this gap in the airport's file and contribute to the understanding of development variables in the region.

The present case study done at Ponta Delgada Airport is valuable both for the scientific community, because there are few studies on the impact of airports on insular regions, and also specifically on airports on the Azores. It is essential for the airport's administration, stakeholders, investors, citizens, and the government to learn and understand how the development of the airport and the development of the island are related, how one of the variables can be manipulated and predicted. The predictions that come with finding a relationship between these variables are crucial to understanding the consequences of changes in this service, as well as essential for investments in the airport and in the region, in order to achieve an established goal.

5.2 João Paulo II Airport

The airport of Ponta Delgada, João Paulo II Airport, is in Ponta Delgada city. It is the only airport on the island of São Miguel, in the Portuguese archipelago of the Azores. The first aviation-related infrastructure on this island was a small aerodrome in Santana, inaugurated in 1942, Figure 5.1, which first operated as a military support airport, and later was used for both civil and military operations [64]. However, Santana Airport did not even have a paved runway, and had a lot of poor conditions that caused delays and cancellations frequently [64]. Some years later, post-World War II living encouraged a large percentage of the population to emigrate, especially to North America. The soon-to-be emigrants had to stop in Santa Maria or Terceira, other islands in the Azores that had International Airports, to go to North America or even to the mainland of Portugal [64], since Santana Aerodrome was only adapted to offer flights between islands. Even though those flights from Santana were to the neighboring islands, the population started to complain about the poor conditions, the cancellations, layovers, and endless delays; so around that time, the government decided to project and build a “real” airport: Nordela Airport [64]. Nordela Airport, now known as João Paulo II Airport, was inaugurated in 1969 in Ponta Delgada and acquired its name as we know it now thanks to a visit from the holy father, Pope John Paul II - João Paulo II, in 1991 [64].



Figure 5.1: Santana aerodrome. Source: Aeroportos dos Açores [65].

At the time of Nordela Airport’s opening, the only runway was 1800 meters long. In 1989, it was extended to 2353 meters, and the airport welcomed a new control tower [66]. Step by step, this airport improved its infrastructure, investing in better conditions for passengers and companies, and has become an airport of choice for international destinations.

João Paulo II Airport, with a latitude of 37.74205 and longitude of -25.69775, is now considered a large airport [67] and the aeronautical community knows this airport as LPPD, its International Civil Aviation Organization (ICAO) code, and PDL, its

International Air Transport Association (IATA) code [67]. This airport has only one small terminal with twelve gates, which can hold domestic and international flights; two runways, designated as 12 and 30, six taxiways (A, B, C, D, E, and F), and three aprons, named as N, S, and W [68]. This airport's runway 12/30 is 2443 meters long and has a width of 150 meters [68]. Annex A can cover all airport layout details, and it corresponds to the official aerodrome chart of LPPD, as provided by Navegação Aérea de Portugal (NAV) and based on the ICAO standards.

NAV also provides information about this airport that can be useful to have more insight regarding the dimension and its relevance in the aviation field, for example, LPPD is equipped with Category 7 fire-fighting and serves 180 meals per hour [68]. These parameters can be another way to describe the airport's user flow without looking for the number of passengers or the number of flights.

To contextualize a little bit more, in this case study, it is important to understand not only the airport itself but the island in question. As quoted before, this airport is located in the city of Ponta Delgada, the capital of the Azores archipelago, in Portugal. Ponta Delgada is a small city in the island of São Miguel, which is in the middle of the Atlantic Ocean; this island is around $744.58km^2$ [69] and has 133 390 residents (in 2021) [70], 4.1% less than in 2011, representing around 56.4% of the total population of the Azores. The insularity of this place is quite noticeable when one realizes that the shortest distance via air transport between São Miguel island and Portugal mainland (in this case, Lisbon) is $1445.78km$ [71], and $2851.38km$ from São Miguel to Boston in the United States of America [72]. There is no other way that passengers can travel from São Miguel to the mainland, because air transport is the only option.

Given the insularity and the factor of being geographically the “heart of the Atlantic”, São Miguel has the peculiarity of connecting North America to Europe and being a stopover for air transport and ships. Since Santana aerodrome, the Azores have been a strategic point for both military and civil aviation, and that did not change with the development of João Paulo II Airport; on the contrary, there were even more conditions and capacity to operate for both directions [64]. The establishment of a local airline in 1941, Sociedade Açoreana de Transportes Aéreos (SATA), assured that Azorean citizens had the opportunity to travel between islands and the mainland, to later initiate regular operations to Canada and the United States of America [64]. Now, this airline is divided into SATA Air Açores, which guarantees the transport between all islands of the Azores archipelago, and Azores Airlines, also known as SATA International, responsible for all international flights and domestic flights that require that fleet (from the Azores to Portugal mainland, and sometimes from the Azores to Madeira island) [73]. Transportes Aéreos Portugueses (TAP), the Portuguese airline, began operating to Ponta Delgada, and the two airlines maintained this duopoly until 2015, when airspace liberalization occurred [74]. Even though there was already existing tourism from the Portuguese citizens, American tourists, and residents from other islands, the liberalization of the

airspace opened a whole other perspective on tourism in the island; now any airline could fly to LPPD, and any destination could land on Ponta Delgada's runway [74]. Ryanair and Easyjet, two low-cost, well-known airlines, started to land on São Miguel, which brought a lot of new travel opportunities to the residents, as well as more tourism, which instantly boosted the region's economy and development [74].

Tourism, defined by Cambridge University [75] as “the business of providing services such as transport, places to stay, or entertainment for people who are on holiday” [75:1], has always been an important part of this Portuguese region. Studies on this subject suggest that insular regions and small, isolated localities face numerous limitations and issues with accessibility and various resources, resulting in social and economic difficulties in those areas, which in turn encourages investment and development in the tourism sector [76]. As addressed in Chapter 3, the smaller the metropolitan area is, the greater the impact those events have on that region [31]; therefore, tourism plays a significant role in these regions, as this sector is known for crossing several areas. São Miguel is a fitting example of the necessity of tourism on an island: insularity, poor accessibility, a small area, and limited resources.

For several years, tourism was restricted for the residents of the islands adjacent to it, Portuguese citizens, and North Americans [64]. Now, tourism in the island region of São Miguel is taken for granted with the liberalization of airspace and the constant development of the airport and related businesses. This locality is a chosen tourist place for different types of tourism, and it has also been selected as the ideal place to stopover when passengers are traveling from one side of the Atlantic to the other.

Tourism in the Azores is considered one of the heaviest sectors in the regional economy, either through employability, or on the archipelago's GDP [74]. Chapter 3 introduces the impact of tourism on a locality, including its effects on islands. This subject is particularly noticeable in Ponta Delgada, where there is a significant investment in hospitality, restaurants, transportation, and numerous businesses and services that cater to tourists. All of these services are part of the indirect jobs that the airport generates, and they play an essential role in the island's economy and social development.

With the development of tourism, the airport has also been pushed to develop its infrastructure and services [77] to accommodate the increasing volume of passengers and meet the growing expectations, as there are now more airlines and destinations from Ponta Delgada than ever. If the airport did not correspond to these demands for new operations and better services, the much-acclaimed tourism sector would face a brake that would certainly affect negatively the regional economy. Accordingly, the airport's development needs to meet the demand of the tourism and hospitality sector, so the island and the city can develop and grow their activity and economy. Since João Paulo II Airport is the only “gate” for passengers, the airport's investment and development are even more valuable.

To meet the expectations of having more people traveling to Ponta Delgada, and after the 2015 liberalization, the airport seeks to benefit from that need for tourism and embraces new companies and travel destinations. What once was only a SATA - as SATA Air Açores and Azores Airlines - and TAP duopoly, now is shared by multiple airlines, such as Binter Canárias, British Airways, Brussels Airlines, Edelweiss Air, Iberia, Lufthansa, Ryanair, Smartwings A.S., Transavia, TUI Belgium, TUI Nederland, and United Airlines [78]. The destinations that the traveler can get to from LPPD besides the other Azores islands, Portugal mainland and Madeira are Amsterdam, Barcelona, Bilbao, Bermuda, Boston, Brussels, Frankfurt, Gran Canaria, London (Gatwick, Heathrow, Stansted), Madrid, Milan, Montreal, Newark, New York, Paris, Prague, Praia, Toronto, and Zurich [78].

To compare, in 2019 there were only seven airlines operating in Ponta Delgada to fifteen destinations [79], now, up to this date in 2025, fifteen airlines are operating to thirty-three destinations [78].

Currently, João Paulo II Airport (Figure 5.2) is expanding its area to accommodate the increasing number of passengers and routes. This expansion is projected to increase 30% of the total area, meaning that $4000m^2$ will be added by the year 2027 [80]. The project will impact not only the infrastructure's design and its usefulness, but also provide a new opportunity for more airlines, services, retail, and passengers at the airport.



Figure 5.2: João Paulo II Airport, 2015. Photographer: Ingo Warnecke. Source: [81].

5.3 Data Collection

The employment referred to in this case study is direct employment, defined in Chapter 3. Since São Miguel offers a diverse range of services and establishments that could be considered indirect employers, it is challenging to obtain useful and accurate information regarding all sectors of the airport's indirect services. Indirect jobs related to the airport can be very unsteady because they have a lot of external factors that contribute to the increase or decrease of the number of jobs. However, indirect employment of the airport is just as necessary as direct jobs, since they contribute to the region and to the airport's development. Those indirect employers can be, for example, hospitality services, which include car rentals, hotels, guest houses (or similar), hostels, tourism centers, and even restaurants. Ponta Delgada city itself has 1102 services that are hospitality, restaurant, and similar, which means that those would be included in indirect employment [82]. For this study, investigating the development of indirect jobs in São Miguel is not an objective, since it serves a lot of residents and has many variables to consider. For the mentioned reasons, this investigation only considers the jobs that exist in the airport.

To understand the impact of LPPD on São Miguel, in terms of the employment it generates for the region, it is more interesting and reliable only to consider direct job positions. Direct job positions are directly impacted by the airport, as mentioned in Chapter 5, meaning that the changes the airport faces are reflected in the employment. Direct jobs related to João Paulo II Airport include any positions within the airport infrastructure, such as handlers, maintenance, administration, rent-a-car services, post offices, caterers, and others that operate on both the landside and airside, as described in Appendix B.

The objective of this stage is to gather pertinent information about the job positions of the services and entities that work at the airport. The primary goal is to determine an association between these numbers and the number of passengers that the airport records. This relationship is a measure of what impact the airport can have on the island, including the direct employees. If the indirect positions were to be counted, the impact would be much higher, but the results would not be so reasonable since they have other influences.

5.4 Questionnaire

To illustrate the direct employment of the airport in São Miguel, a questionnaire was developed and distributed to companies and entities operating at João Paulo II Airport. Chapter 4 explains the target of this investigation, as well as the population defined for this questionnaire.

The objective of doing a questionnaire for this dissertation's part is to have specific information and direct answers from the companies that work at João Paulo II Airport.

The questionnaire intends to have concise data that represents the employment that this airport generates through the companies it houses, in other words, the direct employment. A questionnaire allows the investigator to gather only the desired information, and the participants are restricted to answering the same questions, so there is no possibility of having random or useless information. Organizing information raised by a questionnaire is also an advantage for this type of study.

In order to have the desired data, twenty questions were asked of the companies through a *Google Forms*, and the questions only regard issues related to the employment of those companies, and their indispensability to the airport. This set of questions essentially proposes numerical or short direct answers to make the survey as objective as possible. Regarding the employees' quantity or relevance, three questions concerning a time comparison were made: how many employees companies had at the moment, how many they had during the COVID-19 pandemic, and how many were counted when the companies were inaugurated. Time contrasts are necessary to later infer a relationship between the employment and the number of passengers that the airport welcomes, and to understand how the company grows with time.

Another important element in this questionnaire was a set of questions that allowed for understanding the impact of the company on the airport, as well as the impact that the airport has on the company.

The questions elaborated can be consulted in Appendix C, which has the original version of this survey. The English translation of the questionnaire is available in Appendix D.

The companies/entities contacted to answer the survey were disclosed by ANA Ponta Delgada in the last trimester of 2024, which means that this study's section and results only apply to the companies that exist at this time at this airport, and that can change at any time in the future.

The companies meant to participate in this part of the study were contacted via e-mail or were approached in person by the author at the PDL Airport. However, the in-person approach was limited because the airside of the airport was not accessible to engage these contacts. Besides this limitation, some companies on the landside, specifically some coffee shops and the post office, did not facilitate the exchange of information. Another problem faced during the distribution of the data was that some companies' representatives did not answer or view emails, making it even more challenging to gather the needed information. A lot of companies and entities do not have their headquarters on the island due to them being international or national companies, so there was another limitation; the points of contact for those companies could either be general e-mails, which usually do not collaborate in disclosing the company's information, or people who worked in the field, who do not have the needed information for the questionnaire, or were not allowed to answer by superiors.

To try to mitigate these problems, some contacts were done via *LinkedIn*, the author

went to the airport multiple times to distribute questionnaires and collect information, and the companies that were known beforehand to be the ones with the most impact on the airport were contacted through different points of contact, for example, specific people who worked on the administration of the company or people known for being the company’s representatives on São Miguel.

The majority of the listed entities can be classified as micro or small-sized companies, as defined by the European Commission [83]. The former president of the European Commission, Jean-Claude Juncker, affirms that SME are an essential economic pillar that creates around 85% of new job positions [83]. Defining the SMEs, these businesses represent 99% of the services in Europe, and are identified by the number of staff they employ, turnover (business volume), or total balance [83]. Following the definition, Table 5.1 represents the classification of SME, where *M€* means “million euros”.

Table 5.1: Definition of SME by European Commission.

| Category | Employees | Turnover |
|--------------------------|-------------------|-----------------|
| Micro enterprises | $0 < x < 10$ | $x \leq 2M€$ |
| Small enterprises | $10 \leq x < 50$ | $x \leq 10M€$ |
| Medium-sized enterprises | $50 \leq x < 450$ | $x \leq 50M€$ |

Data source: [83]. Prepared by: Author.

Some of the entities that replied are not considered SME, being large businesses, or even international. Although they are considered large enterprises, the division of those companies present in São Miguel is considered a micro, small, or medium-sized branch of the larger company, if treated as an individual company.

Because SMEs focus on efficiency and creating new and better services, these businesses are important for balancing the economy and growing in a healthy progress [83]. The majority of the study’s subjects are SMEs, meaning that the airport likely has a significant impact on their businesses, which in turn reflects a direct influence on the economy. In conclusion, having the airport associated with multiple SME can imply a direct influence on the development of the region and its economy.

5.4.1 Questionnaire Results

In total, there were nineteen responses to the questionnaire. These responses were not the desired number, since that is only 23.8% of the population. However, considering that most of the services contacted were international companies or service providers for the airport, it is not easy to contact those entities, and when the contact is made, the chance of success is not the greatest.

This sample is smaller than ideal and expected, as a significant portion of the company population is international or multinational, operating on the airside of the airport or lacking points of contact capable of delivering the requested data. Also, some companies

did not respond to the surveys, either because the representatives were not able to provide the information, or did not wanted to take part in this study.

Regarding data selection, there were no problems in coding the data obtained through the questionnaire. All responses were completed correctly and with the necessary information, except for two cases: one response was done by a company that does not work at or with the airport, and one company answered the same questionnaire four times. The first exception occurred probably by mistake of someone who was contacted to answer, and they sent it to someone else, and it was not considered in the analyzis; the second event was that ANA Portugal responded four times, and the author considered the answers that were more common among the four replies.

All the answers to the questionnaire are separately disclosed in the following tables (Tables 5.2 to 5.4) and figures (Figures 5.3 to 5.10). All figures and captions in this subsection that refer to “Airport” mean “João Paulo II Airport”. It is important to note that not all questions in the questionnaire are presented, since some of the questions were made so that the author could better understand the context of those questioned. Those questions were not considered for the data analyzis.

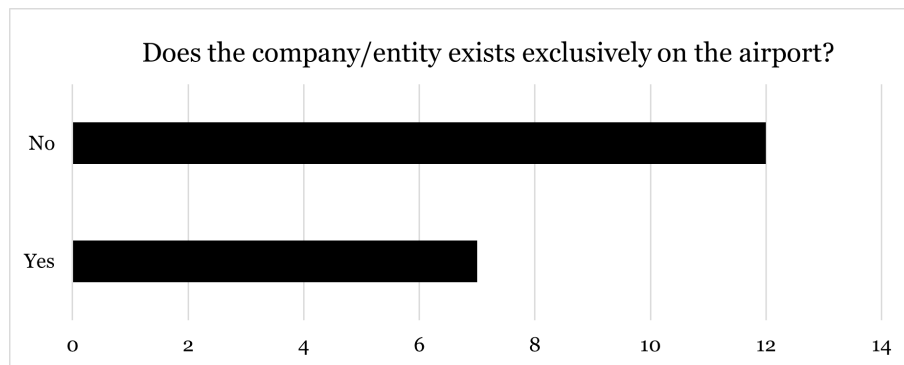


Figure 5.3: Number of companies and entities that have services exclusively on the airport. Data source: Questionnaire responses. Prepared by: Author.



Figure 5.4: Number of companies and entities that have services essential to the proper function of the airport. Data source: Questionnaire responses. Prepared by: Author.

Although few companies exist only to assist the airport in this case study, the majority of

the companies questioned are a key element to ensure that the airport operates properly, as shown in Figures 5.3 and 5.4. Question 1, which asks about the exclusivity of the company at the airport, can be interpreted as referring to the administration of the company being located outside the airport facility, which is a very common case, or if the business has other establishments open outside the airport.

Table 5.2 shows that the years that companies started working in the airport are evenly distributed, with sporadic openings throughout the years. 2017 was the year that saw the inauguration of three new services at the airport. Upon consulting the answers, it was found that these three companies were car rentals. All cells in the following Tables that show “N/A” mean “Non-Applicable”, so the representatives that responded to the questionnaire chose to answer “N/A” to questions that they did not think were suitable for the company they represent.

Table 5.2: Year that the companies and entities started working at the airport.

| | |
|------|---|
| N/A | 2 |
| 1977 | 1 |
| 1980 | 1 |
| 1990 | 1 |
| 1998 | 1 |
| 2000 | 1 |
| 2001 | 1 |
| 2004 | 1 |
| 2005 | 2 |
| 2007 | 1 |
| 2008 | 1 |
| 2014 | 1 |
| 2015 | 1 |
| 2017 | 3 |
| 2023 | 1 |

Data source: Questionnaire responses. Prepared by: Author.

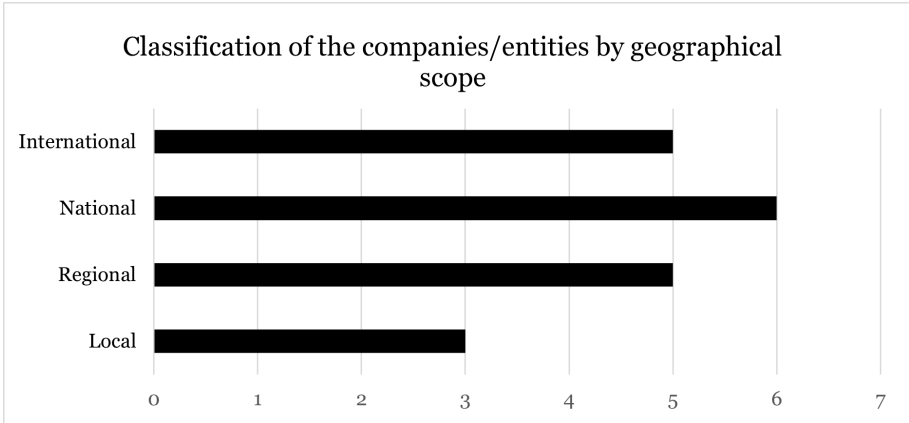


Figure 5.5: Classification of the companies and entities by their geographical area of operation. Data source: Questionnaire responses. Prepared by: Author.

As seen in Figure 5.6, the recruitment of the entities present at LPPD is not linear. Most companies claim that recruitment depends on various factors and does not have a defined

frequency. Others recruit once a year, once every five years, or have never recruited more employees.

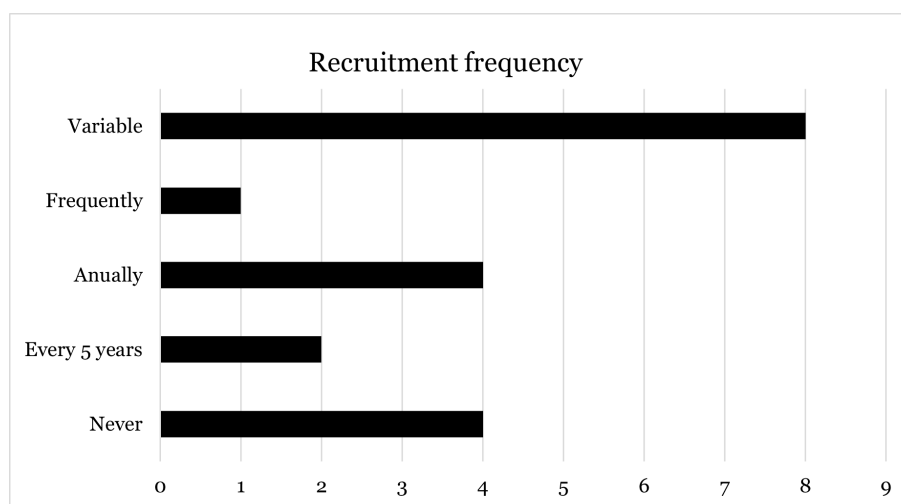


Figure 5.6: Recruitment frequency of the companies and entities that work at the airport. Prepared by: Author. Source: Questionnaire responses.

When questioned about the recruitment procedures in high season, question 9 of the questionnaire present in Appendix B and Appendix C, six out of the nineteen companies claim that recruitment is seasonal.

Table 5.3 presents the number of employees at companies, the number of airport staff members, and the number of job positions in 2020. Table 5.4 represents the total number of employees in each section. There are two cases where the numbers are higher than the average; those cases are 500 and 7000, with only 8 and 9 employees working at João Paulo II Airport, respectively. These numbers are eye-catching, since the discrepancy between the number of employees in total, and the number of employees of that company in the airport is large. Those companies are, respectively, Instituto Português do Mar e da Atmosfera (IPMA), which is the Portuguese institute responsible for the sea and atmosphere, indispensable for the airport, and Petrogal, a company owned by Galp, responsible for the fuel supply at the airport. These services are necessary for the airport; however, the numbers of employees described in the answers, as 500 and 7000, are the number of employees of that company in general, not only in São Miguel Island. Both websites of IPMA and Galp disclose the total number of employees as being more than 500 [84], and more than 7000 [85]. For this reason, the numbers will be considered as the number of employees nationally or even internationally, not the number of employees in São Miguel. The other companies and entities presented reasonable data for the number of employees to be considered in São Miguel.

In total, according to the answers given to this questionnaire, there are 249 employees working actively at the airport's infrastructure, as shown in Table 5.4. Because IPMA and Petrogal responses lead to an inflation of the percentage of employees of the studied companies who work at the airport. For the interest of having a relationship that can be

truthful in how many workers out of the total workers of the companies that work at the airport of PDL, the numbers handed by IPMA and Petrogal will not be considered to have 500 and 7000 employees working at the airport in 2020.

As can be observed in Table 5.3, some companies misunderstood when questioned about how many employees they had working at the airport facilities in 2020. A fraction of the companies responded with a number close to the total employees they had in 2020, and the number is not very realistic when compared to the number of people working in the airport facilities in 2024. For example, in the first line of Table 5.3, the number of employees of the company is 46, the number of those who work directly at the airport is 2, and the ones working there in 2020 is 39. It is very likely that this company’s representative misunderstood or was mistaken when responding to the last question, since it is more likely to have many workers close to 2 than to 46. Chapter 6 will introduce another values collected later to complete Table 5.3, and to present more realistic numbers.

Table 5.3: Number of employees of each company and entity that work at the airport.

| Employees in 2024 | Working in the airport in 2024 | Employees in 2020 |
|-------------------|--------------------------------|-------------------|
| 46 | 2 | 39 |
| 49 | 47 | 36 |
| 20 | 7 | 2 |
| 17 | 5 | 15 |
| 4 | 4 | 5 |
| 4 | 4 | 3 |
| 9 | 9 | 10 |
| 13 | 13 | 11 |
| 7 | 7 | 7 |
| 2 | 2 | 0 |
| 8 | 4 | 8 |
| 3 | 2 | 3 |
| 8 | 3 | 10 |
| 98 | 78 | 51 |
| 2 | 2 | 2 |
| 500 | 8 | 500 |
| 6 | 3 | 5 |
| 40 | 40 | 40 |
| 7000 | 9 | 0 |

Data source: Questionnaire responses. Prepared by: Author.

Table 5.4: Total number of employees of companies and entities that work at the airport.

| Total in 2024 | Working in the airport in 2024 | Total in 2020 |
|---------------|--------------------------------|---------------|
| 7836 | 249 | 747 |

Data source: Questionnaire responses. Prepared by: Author.

Figures 5.7, 5.8, and 5.9 illustrate the rate of impact each company would face in the scenario of the airport doubling its operations, infrastructure, or even ceasing operations. These rates help to understand how necessary the airport is for these companies and whether they are dependent on the airport’s well-functioning.

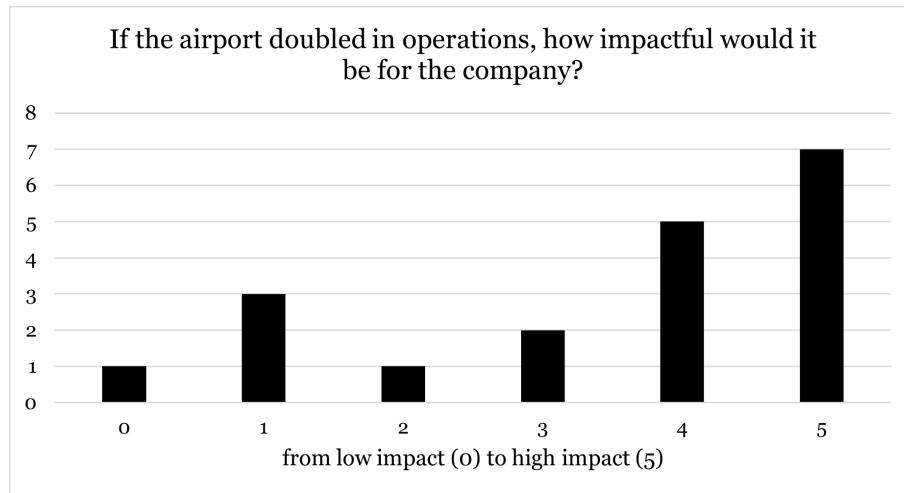


Figure 5.7: The companies and entities rated the impact they would have on the business if the airport doubled its operations. Data source: Questionnaire responses. Prepared by: Author.

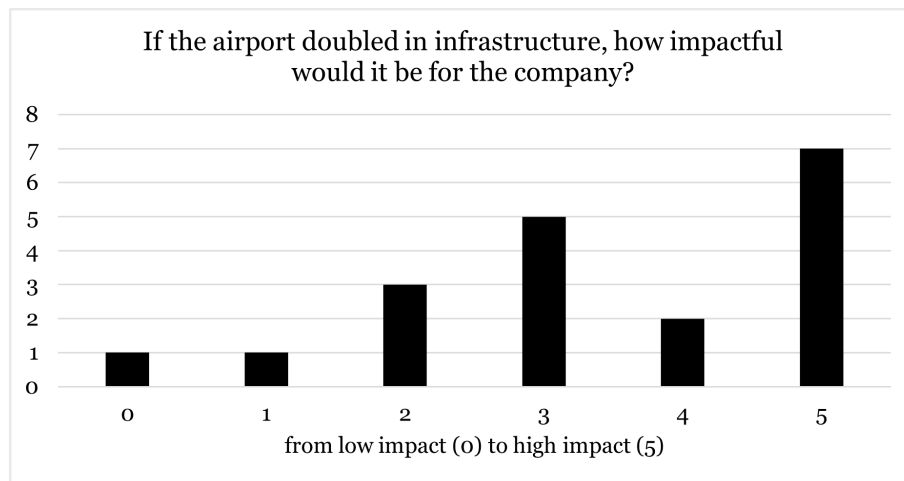


Figure 5.8: The companies and entities rated the impact they would have on the business if the airport doubled its infrastructure. Data source: Questionnaire responses. Prepared by: Author.

Most of the respondents registered a high impact, with ratings grouped at 4 and especially 5, and only a few selected low scores (0-2).

Some companies even state that they would close if the airport ceased its operations, as seen in Figure 5.10.

Responses were more common at 5, with a secondary cluster at 3, some responses at 2 and 4, and very few companies responded 0 or 1. Thus, it is apparent that the airport has a great impact on the companies and entities questioned.

Not only are the listed companies essential to the airport's operation, but the airport is also an important element to the companies. Especially when addressing the shutdown of the airport, the most of companies believe it would have a profoundly negative impact on their operations.

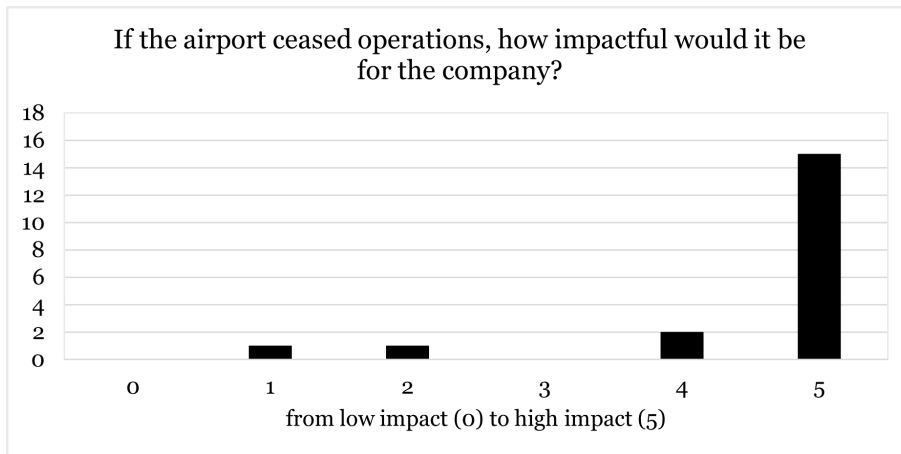


Figure 5.9: The companies/entities rated the impact they would have on the business if the airport ceased its operations. Data source: Questionnaire responses. Prepared by: Author.

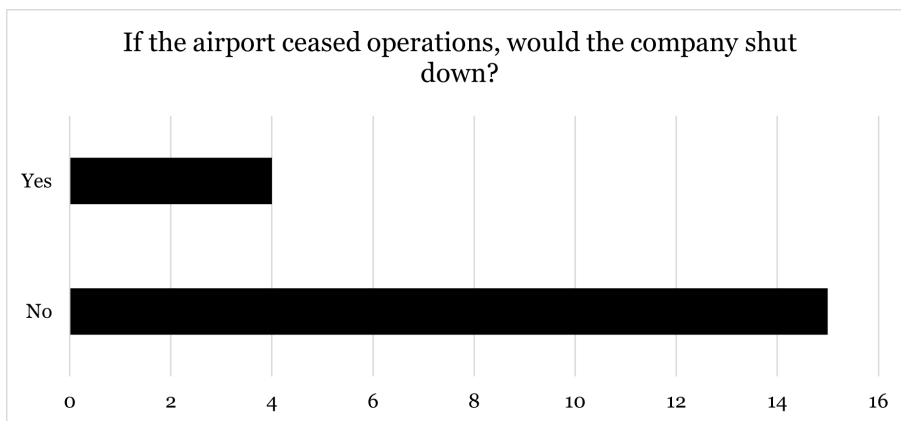


Figure 5.10: Number of companies and entities that would shut down if the airport ceased operations. Data source: Questionnaire responses. Prepared by: Author.

5.4.2 Sample Representativeness

The companies that participated in this information exchange motion are considered a sample of the population targeted for this study. The number of companies and entities totals fifty-eight different objects, which include entities, companies, and unipersonal entities. All companies are listed in Appendix A.

Appendix A is a table that states which type of service and the name of the companies, along with the abbreviation regarding whether the company responded to the questionnaire or not, with Responded to the questionnaire (R) for the ones that responded, and Did not responded to the questionnaire (NR) for the ones that did not respond. The sample is considered to be all companies in Appendix A that are signed with R.

Although the sample is already known by the number of companies that responded, its representativeness is intended to confirm whether the number of responses is sufficient to consider the sample as representative and trustworthy in the case study.

As quoted, the error considered for investigations that use a questionnaire as a data collection method is between 5% and 10% [41]. The smaller the error is, the more precise the study can be. In this step of the study, two estimations will be presented errors of 5% and 10%.

As a reminder, the percentage considered in this study to be expected as part of the sample is 50% of the population, as there are no previous studies on this issue at João Paulo II Airport to draw upon.

The confidence level for this study is calculated using Equation 4.1, and an error of 5% with the following constants:

- $N = 58$;
- $n = 19$;
- $p = 58 \times 0.50 = 29$;
- $\varepsilon = 5\%$.

$$19 = \frac{29 \times (100 - 29) \times Z^2 \times 58}{5^2 \times (58 - 1) + Z^2 \times 29 \times (100 - 29)}$$

$$Z = -0.5804 \wedge Z = 0.5804$$

Knowing the value of Z , also known as Z-score, the confidence level translates to Equation 5.1:

$$\text{Confidence Level} = \Phi(Z) - \Phi(-Z) \quad (5.1)$$

where $\Phi(Z)$ is the area of the distribution to the left of Z and $\Phi(-Z)$ is the area of the distribution to the right of $-Z$.

For this study, the distribution of the probability considered is a normal distribution, although the sample is small. The probability of data collection is considered continuous, and the association with a normal distribution allows the central limit theorem to be applied, as it “the central limit theorem will apply for sample sizes much smaller than 30” [86:155]. Therefore, the confidence level can be obtained by considering this case as a normal distribution [86]. Keeping this factor in mind, the previous Equation 5.1 can be updated to Equation 5.2, due to the areas to the left of Z and to the right of $-Z$ being the same.

$$\text{Confidence Level} = \Phi(Z) - (1 - \Phi(Z)) = 2\Phi(Z) - 1 \quad (5.2)$$

With Equation 5.2, the absolute value of Z is used, so $Z = 0.5804$.

To obtain $\Phi(Z)$, the table in Annex B must be consulted, where the value of Z considered is $Z = 0.58$, since it is the closest value of $Z = 0.5804$. According to the table that defines values obtained by observation, the value of $\Phi(Z)$ is 0.71904. Applying Equation 5.2, the Level of Confidence of this study is 43.8%. To increase the confidence level, the sample size should be larger.

Seeing that the level of confidence is very low, another estimation was done, this time with an error of 10%, since it is the only variable that can be changed to estimate an increase in the level of confidence in this study.

- $N = 58$;
- $n = 19$;
- $p = 58 \times 0.50 = 29$;
- $\varepsilon = 10\%$.

$$19 = \frac{29 \times (100 - 29) \times Z^2 \times 58}{10^2 \times (58 - 1) + Z^2 \times 29 \times (100 - 29)}$$

$$Z = -1.1613 \wedge Z = 1.1613$$

With Equation 5.2, the absolute value of Z is used, so $Z = 1.1613$.

To obtain $\Phi(Z)$, the table in Annex B must be consulted, where the value of Z considered is $Z = 1.16$, since it is the closest value of $Z = 1.1613$. When consulting the table, the value of $\Phi(Z)$ is 0.87698. Applying Equation 5.2, the Level of Confidence of this study is 75,4%.

Chapter 4 referred to 99%, 95%, and 90% as the most frequently accepted values of the confidence level of scientific studies. Both 43.8% and 75,4% are not the desired confidence level of a scientific study. However, this study's sample is limited by the number of companies and entities that have responded to the questionnaire to date. It is not possible to increase the level of confidence to the desired percentage because the author has no control over how many or which companies and entities respond to the questionnaire. Despite numerous attempts to increase the sample size, it remains at 19.

When facing this problem, the author noticed that the majority of the companies that responded were companies present at the landside of the airport. This circumstance led the author to experiment with another way of visualizing the problem to try to increase the confidence level of this dissertation. Instead of having the population as all the companies that work directly at the airport, the population of the investigation would be all the companies that exist on the landside of the airport. That way, the population of the study would decrease, as would the sample size needed to achieve a well-accepted confidence level. Although in theory this would work, after calculating the sample size that was necessary to meet the most accepted confidence levels and the most frequently used errors, the necessary sample size continued to be too large for the real sample size that we already had. Not only was the sample size too large for the available sample, but some responses would not be considered, as they came from companies that operate on the airside.

To conclude this section, it was decided to consider the sample as it is, with the initially considered population. However, due to the difficulty of having an acceptable level of confidence and the norms not being 100% complied with, it is not possible to calculate the representativeness of the sample. The sample is lower than the ideal, as explained in the previous section, Section 5.4.1.

5.5 Number of passengers

One of the most common characteristics used to define an airport is the number of passengers. The number of passengers is directly related to the size or importance of an airport. On the other hand, the number of passengers can be deeply affected by the economy [87]. The number of passengers refers to the number of passengers handled in an airport, and does not consider the number of flights, or separate the number of boardings, Boarded Passengers (BP), or Passengers in Transit (PiT). It can be confusing to have a solid, unanimous interpretation, since some statistics consider the number of passengers in transit, for example, and others do not. For this investigation, statistics will be gathered regarding the number of passengers from official sources, including the INE and SREA, the statistical services of Portugal, and the Azores. Using the data and statistics present in INE means that the number of passengers handled is the sum of BP, Disembarked Passengers (DP), and PiT [88]. SREA presents the data separately, so the number of passengers represents the total information that the service provides.

Studies show that in 2019, there was a peak in aviation, which was the year that registered the most passenger traffic, domestic flights, and revenue in air transport than any previous year [87]. Unexpectedly, COVID-19 spread throughout the world in 2020, forcing countries to shut down, restricting air transport [89]; leaving 2019 as the year of the peak of aviation. Later on, after the shutdown, 2023 finally suppressed the numbers reached

in 2019, and from 2023 on, there has been a yearly increase in aviation statistics [87]. In Portugal, in 2023, the airports handled 67.5 million passengers, 18.9% more than 2022 and more than 12.3% than in 2019 [90].

According to the Portuguese Institute of Statistics, INE, the volume of passengers handled in Portuguese airports and aerodromes was 60114×10^3 passengers in 2019, 18393×10^3 in 2020, 25599×10^3 in 2021, 56762×10^3 in 2022, and 67505×10^3 in 2023 [90], being that 2024 was the year with the most handled passengers registered, 70416×10^3 passengers [88].

Regarding this case study, João Paulo II Airport, the years meaningful to consider the number of passengers are: the first year with known data on SREA, 1986, the year the liberalization of the airspace in Ponta Delgada was celebrated, 2015, the peak of aviation before the pandemic, 2019, the year most affected by the pandemic, 2020, and last full year, 2024. All data regarding the number of passengers handled by LPPD is information disclosed by the Azores Regional Statistic Service, SREA [91], and can be consulted in Table 5.5.

Table 5.5: Number of passengers handled in Ponta Delgada throughout the years.

| | BP | DP | PiT | Total |
|-------------|-----------|-----------|------------|--------------|
| 1986 | 150 935 | 148 124 | 4 048 | 303 107 |
| 2015 | 620 972 | 618 829 | 25 991 | 1 265 792 |
| 2019 | 1 004 974 | 994 638 | 27 542 | 2 027 154 |
| 2020 | 346 423 | 343 454 | 11 007 | 700 884 |
| 2024 | 1 353 223 | 1 353 358 | 26 532 | 2 733 113 |

Data source: SREA [91]. Prepared by: Author.

According to SREA data, the rate of increase in the number of passengers in the last five years, in Ponta Delgada, was an increase of 80.6% from 2020 to 2021, an increase of 64.1% from 2021 to 2022, and an increase of 18.9% from 2022 to 2023 and an increase of 10.6% from 2023 to 2024 [91]. There has been a noticeable increase in the number of passengers every year in the last five years. Although the numbers continue to grow, the velocity with which those numbers are growing is eye-catching because the growth is slowing down. The number of passengers is still thriving at João Paulo II airport. Still, the momentum has been reduced, which can happen due to some causes, for example, tourists following trends and going to destinations that are trending in those years, by the influence of prices or conditions given by the hospitality services that do not attract masses, or just the fact that the airport is not receiving new and more airlines or routes. Either way, the airport on this island is still increasing its number of handled passengers over the years. It is important to consider the number of passengers annually, since this number is dependent on high season and meteorological interference, for example.

João Paulo II Airport counts a reasonable number of passengers in transit, since it is a key airport for stopovers in flights between Europe and North America, and between the mainland of Portugal and the other Azorean islands.

5.6 Conclusion

This chapter provides some context about the airport of Ponta Delgada, including its local conditions, history, and characteristics. This chapter examines the specific case of Ponta Delgada, so that it can be generalized to all insular regions later on.

To collect information about the employment generated by the airport, a questionnaire was sent to all companies working at the airport. This questionnaire includes questions about the number of job positions filled by the company or entity, as well as a time comparison. It has some questions that help us understand how necessary the company is for the airport, and vice versa.

The results show that the majority of companies are categorized as SME, and the branches of international or national companies located in São Miguel can be considered SME if viewed individually, and the branches of international or national companies that are located in São Miguel can be considered SME if looked at as individuals. The answers indicate that the majority of companies that participated in the survey are essential for the airport's operation to be successful. The recruitment is very variable and does not follow a pattern. For the nineteen businesses that responded, there are 249 employees in 2024 of those entities that work in the airport facilities, corresponding to almost 70% of the total employees of those entities, considering Table 5.4. The questionnaire concluded that not only does the airport need these enterprises to function, but the businesses also need the airport to provide its services and develop.

For the case study, an estimate for the confidence level was not concluded due to the sample size being too small for the population, when using all the norms and values accepted by the scientific community to calculate the level of confidence. Although the sample size is small, the possibility of human error factors in the responses is present, as well as mistakes made when completing the questionnaire. To mitigate these problems, different contacts through different points of contact were made, but the attempts were not successful.

The number of passengers considered for this study is the sum of passengers boarded, disembarked, and in transit at João Paulo II Airport. In 2024, 2 733 113 passengers were handled, increasing 10.6% more than the previous year, and increasing 289.9% more than in 2020.

There were some limitations to this part of the investigation, such as the lack of responses to the questionnaire, the difficulty in contacting the companies, and once contact was made, the lack of participation was evident. Another limitation is the misinterpretation of the number of employees that the companies had in 2020 working at the airport, which led to an issue when calculating the number of direct employees in 2020.

In conclusion, the airport is undoubtedly a necessity for the population of São Miguel,

since it is the only way that residents can travel, and it is an employment center. João Paulo II Airport creates new and more jobs, either demanding new companies to provide those services, or creating more job positions at companies that already exist outside the airport. This interdependence relationship becomes a necessity for both the airport and the companies and is an engine for the local economy.

Chapter 6

Results Analyzis

6.1 Introduction

This chapter intends to conclude how the direct employment of the airport is affected by the volume of passengers at João Paulo II Airport. The objective is to identify a relationship between employment and the number of passengers, thereby opening the possibility of estimating and projecting the region's future employment based on traffic changes.

To achieve this goal, this chapter addresses how the data is analyzed and interpreted, applying the simple linear regression method to estimate this relationship, and using *Microsoft Excel* as the data analyzis tool.

This chapter begins with a descriptive analyzis of airport activity and the trends found in direct employment. A descriptive analysis helps organize the information obtained when studying the variables and how they change in relation to one another, or whether their changes are linear. This description is followed by the application of a linear regression model, including its specifications, the development of the model using *Microsoft Excel* software, the rates of growth of the variables, and the residual error.

Finally, when the final relationship is established, it is possible to analyze the graphics obtained and the results. When the intended results are achieved, an estimate of the future impact of the airport on direct employment can be made, along with pertinent observations regarding the causal relationship between the variables. These estimations are important to interpret how direct employment can be changed with the volume of passengers expected in the future, and to prepare companies and businesses beforehand. The forecast is also important to stakeholders, the airport's administration and management, and the government, which could use it to manipulate the variables, predict how certain changes in operations would affect employment, the economy, and services at the airport and in the region.

Time contrasts are necessary to infer a relationship between employment and the number of passengers that the airport welcomes, and to understand how the company grows with time. For the descriptive analyzis and to apply the linear regression model, the points considered were the value of employees when there were x numbers of passengers. The number of passengers considered is the respective volume for the years 2010, 2015, 2019, 2020, 2023, and 2024. To complete the analyzis and obtain specific data on employment

for the mentioned years, another questionnaire was sent to the companies. The needed information about the number of employees and passengers is specified for the years indicated as 2010, as reference, 2015, as the year where the airspace liberalization occurred in the Azores, 2019, which was the peak of aviation, as explained before, 2020, which is relevant because it was the year affected by COVID-19, 2023, for reference after the pandemic, and 2024, being the most recent data reference.

6.2 Descriptive Analyzis

6.2.1 João Paulo II Activity

The previous chapter, Chapter 5, covered all the important details regarding this airport and its importance to the insular region, São Miguel. This section aims to introduce specific data that is needed to apply the linear regression model.

The airport’s activity is measured by the number of passengers, in this case, the total number of passengers handled in João Paulo II Airport. The selected information can be consulted in Table 6.1.

Table 6.1: Number of passengers handled in Ponta Delgada airport throughout the years.

| Year | Number of passengers |
|------|----------------------|
| 2010 | 929 682 |
| 2015 | 1 265 692 |
| 2019 | 2 027 154 |
| 2020 | 700 884 |
| 2023 | 2 470 723 |
| 2024 | 2 733 113 |

Data source: SREA [91]. Prepared by: Author.

If we exclude 2020 from Table 6.1, an increase in the number of passengers over time is noticeable and clear. 2020 was an atypical year, especially in the aviation sector, as it was the year significantly impacted by the COVID-19 pandemic. At that time, many airports stopped operating, and others were available only for emergency or restricted operations. For that, the year 2020 appears with a very low volume of passengers compared to the other years presented.

When analyzing the other years, there is an increase in passenger volume each year, and, as seen in Table 5.5, this increase is observed since the airport was inaugurated, so the prediction is that passenger volume increases every year.

Although an absolute increase is noticeable, the number of passengers escalates between April and October, especially post-pandemic. In 2020, due to the lockdown and the general restrictions imposed because of COVID-19, the pattern does not apply, as seen in Figure 7.7 of Annex C. Annex C presents all available tables from SREA for the years

of interest for this study. The tables show the number of passengers that boarded, disembarked, and were in transit at João Paulo II Airport every month for the intended years for this analysis.

Observing Annex C and Table 6.1, the number of passengers increases every year, however, it also increases seasonally. For this data analysis, the annual increase will be the time range in consideration, as only six out of the nineteen companies treated declared to conduct seasonal recruitment, which is not a sufficiently large sample to analyze the impact of passenger traffic seasonally.

6.2.2 Employment Scenario

The number of employees directly created by the airport's operation presented in this dissertation is merely an approximation, since there is no available data regarding the number of jobs created by the demand of the airport over the years. This data, as mentioned, was obtained via a questionnaire, so it is an estimation.

When observing that the analysis only had two values of the number of employees per year, and some answers regarding the number of employees working at the airport in 2020 were not very realistic, it was decided that the best way to complement this study was to integrate another questionnaire. This questionnaire can be found in Appendix D for the original version and in Appendix E for the English translation. It was sent to the same companies and the same points of contact, and the author personally went to the airport to introduce and distribute the questionnaires. It includes questions that complement the previous questionnaire, so it is possible to determine the number of employees for years that are important for the data analysis, adding four more observations in time. can be performed using the data from the previous questionnaire, which has only two observations in time: 2024 and 2020. Nevertheless, collecting data corresponding to six different years helps sustain the final equation, providing a more realistic and reliable estimation.

For the reasons mentioned, Table 5.3 will no longer be considered for this dissertation. Table 6.2 presents the total number of employees working at the airport facilities for each year, which serves as at the airport facilities for each year, and is the referenced data for this dissertation. This time, there were no atypical answers. ANA Portugal was made an exception in Chapter 5, since there were four different answers from this entity, however, this time, a representative of the company responded with the final and exact answers to the questionnaire. The sample is the same as before, since the companies that responded are the same.

Table 6.2: Number of employees in João Paulo II Airport throughout the years.

| Year | Number of employees |
|-------------|----------------------------|
| 2010 | 143 |
| 2015 | 174 |
| 2019 | 237 |
| 2020 | 213 |
| 2023 | 253 |
| 2024 | 267 |

Data source: Questionnaire responses. Prepared by: Author.

Although do an estimate for the number of employees exists, only a small percentage of the companies at the airport responded, making it impossible to conduct a complete descriptive analyzis. SATA did not respond to the questionnaires, which influences the results since the company is likely the one that creates the most job positions in the field (it includes an airline, operations, maintenance, airworthiness, and ground handling).

It is possible to observe that the rate of increase in new job positions from previous years to 2024 is not very drastic, which could be justified by technology development and automation, or strategies that cut unnecessary costs and positions. The airport has more routes and companies than ever, which means that the number of flights or routes on their own does not directly influence the number of job positions.

A simple descriptive analyzis regarding the job positions can be made by stating that the number of employees of the companies working at the airport does increase with time, but smoothly and organically. Although there is a general increase in the number of job positions at the airport facilities, 2020 is once again an exception due to the COVID-19 pandemic, and some people were let go or laid off.

It is possible to note that out of 19 companies, some maintained the same number of employees during the years, others increased the positions, and some of the entities even decreased the number of employees in 2024, when comparing to 2019, for example. Although the number of passengers, flights, and airport area increased from 2019 to 2024, some of the companies did not increase their job openings, in fact, they were cut. This observation could be justified as, when facing the pandemic in 2020 and those jobs were lost, with the adoption of more automated systems, companies might find it difficult to justify hiring more workers to complete their objectives.

In Table 6.3 there are some examples of real answers given by some of the companies to the last questionnaire, where the number of job positions decreased during the years, even tho the number of passengers increased. The names of the companies will be referred to as A, B, and C to ensure that any company-specific terms and regulations are not violated.

Table 6.2 shows an increase in the number of passengers despite what is observed in Table 6.3, as some companies only started operating at the airport in 2017 or 2023, and others that indeed increased the number of workers. This data was obtained with the questionnaire.

Table 6.3: Number of employees by year for companies A, B, and C

| Company | Year | Number of employees |
|---------|------|---------------------|
| A | 2010 | 63 |
| | 2015 | 55 |
| | 2019 | 54 |
| | 2020 | 52 |
| | 2023 | 50 |
| | 2024 | 53 |
| B | 2010 | 8 |
| | 2015 | 8 |
| | 2019 | 8 |
| | 2020 | 12 |
| | 2023 | 5 |
| | 2024 | 6 |
| C | 2010 | 3 |
| | 2015 | 4 |
| | 2019 | 12 |
| | 2020 | 6 |
| | 2023 | 7 |
| | 2024 | 7 |

Data source: Questionnaire responses. Prepared by: Author.

6.3 Linear Regression Analyzis

The objective of applying the linear regression model in this data analyzis is to quantify the relationship between the number of passengers handled in João Paulo II Airport and direct employment at the airport. As shown in the descriptive analyzis above, a positive relationship exists between the two variables. The research hypothesis is that there is a positive and linear relationship between passenger traffic and direct employment.

This data analyzis model is suitable for the dissertation's conclusion, as the primary objective is to establish a relationship between the two variables, with an absolute value, including determining the slope coefficient and the associated error. The linear regression model is sufficient to meet the objectives with the available data.

Given that, in general, airport operations naturally lead to the positive development of a specific region or metropolitan area, where an increase in passengers handled demands more services across different sectors, it can be anticipated that the relationship between passenger traffic and direct employment is positive, meaning that when one variable increases, the other also does.

6.3.1 Specifications

As specified in Chapter 4, the linear regression analyzis is done using Equation 4.2.

Direct employment at João Paulo II represents the dependent variable, and the number of passengers at the present airport represents the independent variable.

There are a total of six observations, meaning that data is available for both variables at six different times. These observations are specifically for the years 2010, 2015, 2019, 2020, 2023, and 2024.

6.3.2 Linear Regression Model Development

Table 6.4 portrays a visual representation of the data from this dissertation.

Table 6.4: Number of passengers and number of employees in João Paulo II Airport throughout the years.

| Year | Number of passengers, x | Number of employees, y |
|------|---------------------------|--------------------------|
| 2010 | 929 682 | 143 |
| 2015 | 1 265 692 | 174 |
| 2019 | 2 027 154 | 237 |
| 2020 | 700 884 | 213 |
| 2023 | 2 470 723 | 253 |
| 2024 | 2 733 113 | 267 |

Data source: Questionnaire responses and SREA [91]. Prepared by: Author.

Just by doing a simple analysis of Table 6.4, it is possible to state that the passenger traffic grew by around 194% from 2010 to 2024, and the employment grew approximately 87% over the same time range. The number of passengers from 2023 to 2024 increased by 11% and from 2019 to 2023, by 22%, not considering the atypical year 2020. The number of employees increased by around 6% from 2023 to 2024 and by around 7% from 2019 to 2023.

To improve the interpretation of the coefficient, the number of passengers is converted from units to millions, as observed in Table 6.5. This approach will be used in the next calculations and analysis.

Table 6.5: Number of passengers in millions and number of employees in João Paulo II Airport throughout the years.

| Year | Number of passengers, x | Number of employees, y |
|------|---------------------------|--------------------------|
| 2010 | 0.930 | 143 |
| 2015 | 1.266 | 174 |
| 2019 | 2.027 | 237 |
| 2020 | 0.701 | 213 |
| 2023 | 2.471 | 253 |
| 2024 | 2.733 | 267 |

Data source: Questionnaire responses and SREA [91]. Prepared by: Author.

It is essential to note that the employment data adhere to the same criteria, specifically focusing on direct employees. The referenced positions may or may not include part-time workers, and seasonal changes are not considered.

To analyze the data obtained, Equation 4.2 is the model used, as stated previously in this dissertation. The parameters can be interpreted as b representing the intercept, in other words, it is the number of employees, theoretically, when there are zero passengers

handled [92]; m represents the slope coefficient, meaning that it quantifies the impact that the number of passengers has on direct employment [92].

To achieve satisfying results from the linear regression analysis, some assumptions about the regression must be made [93]:

- Independence, every observation made is independent, which means that each one represents a different time period than the others. With that, an error that may occur in one observation is not related to other observations' errors.
- Linearity, it is very visual and clear that the number of employees grows with the number of years, illustrating a straight line. This assumption is crucial to defining a linear regression analysis.
- Homocedasticity, the residual variance is considered constant throughout the values of the independent variable [94].

Assuming that the previous definitions can be applied in this case, it is possible to proceed with the linear regression model.

6.3.3 Expected Results and Hypothesis

Previous sections of this dissertation have already covered that the visual and general relationship between the number of passengers and the number of direct employees is positive.

When data analysis is performed by applying the linear regression model, the R-squared, R^2 , is determined as the coefficient of determination [95], and "indicated how large the portion of variance that can be explained by independent variables" [94:1]. Many authors define this coefficient as the "proportion or percentage of the variation in the dependent variable that is explained or predicted by the independent variables" [95:1].

The R-squared calculation was performed using an already defined function in *Excel's* Data Analysis. With this analysis, *Excel* has determined $R^2 = 0.67$, which means that 67% of the variance in the number of direct job positions can be attributed to fluctuations in passenger traffic. Knowing that $R^2 = 0$ translates to the regression model not explaining the variability [95], and $R^2 = 1$ means that it explains 100% of the variability [95], the value obtained of 67% can be interpreted as the linear regression model being a satisfactory choice to explain the variability of this study and its coefficients. The results can be consulted in Appendix F, Figure 7.1.

As with any dissertation development, it is important to establish a hypothesis that will guide and support our analysis. Our hypothesis leads to the conclusion that the slope coefficient, m , is positive and significant, which means that the number of employees, in fact, increases with the increase in the number of passengers at the airport.

$$H_1 : m > 0$$

The previously made *Excel* analysis for the obtained data can be consulted in Appendix F, and it has been concluded that the p-value corresponding to the independent variable is 0.046, which means that the independent variable of this study is statistically meaningful to the dependent variable, since it is lower than 0.05 [96]. In other words, the p-value being lower than the reference number confirms that the relationship between the variables is not random, and the number of passengers does have an influence on the number of employees.

With confirmation that the number of employees is statistically influenced by the number of passengers at João Paulo II Airport, it is possible to reject the null hypothesis, $H_0 : m = 0$.

6.4 Linear Regression Analyzis Results and Analyzis

This section presents the methodology used for data analyzis, along with the results and their interpretation.

The data used to develop this model is the data observed in Table 6.5, which presents the number of passengers in millions, x , the number of employees, y , and the corresponding year.

The summary output presented by the *Excel* data analyzis can be consulted in Appendix F. This analyzis concludes that the R-squared is 0.67, as mentioned previously, and the adjusted R-squared is 0.59.

With six observations, *Excel* calculated that the value of the coefficient b , named as “Intercept” in Appendix F, is $b = 135.78$ and the coefficient m , named as “X Variable 1” in Appendix F, is $m = 46.63$.

Taking into account the calculated coefficients, it is possible to complete Equation 4.2, achieving the final equation that represents how the number of employees depends on the number of passengers (in millions), Equation 6.1.

$$y = 46.63x + 135.78 \quad (6.1)$$

Equation 6.1 describes exactly what was predicted at the beginning: the employment depends on the number of passengers at this airport.

It is possible to confirm our hypothesis, $H_1 : m > 0$, since 46.63 is a positive number.

Concluding that the variables have a positive relationship, 46 job positions are added to the airport for handling one million passengers. While confirming that this relationship is positive, the intercept coefficient is valued as 135.78, which means that even when there are no passengers at all, the number of employees is counted as 135. This number reflects that the number of passengers is not the only reason why the airport exists and, therefore, its employees. João Paulo II Airport is an airport that also receives and handles all cargo sent by air transport, which also needs handling, operations, and a lot of airport services to complete its procedures. This airport is targeted for scales and stops, due to its location being in the middle of the Atlantic Ocean, connecting the American Continent to Europe, which also requires people and services to act on these situations.

6.4.1 Standard Error

Although the error is a theoretical part of this equation, it is not presented or estimated when using the formula obtained to predict or calculate the number of employees with the number of passengers [97]. Nevertheless, the standard error is an important component of this regression and of the model. Usually, the standard error is, in some way, a value that reflects the quality of the regression and its estimation for the variables' relationship [97].

The data analysis, concluded using *Excel*, presented a standard error of 30.77, which can be consulted in Appendix F.

An error of 30.77 essentially means that there is an estimated standard margin of error of 30.77 job positions. This is the average deviation of the number of employees from the regression. For example, if it is predicted that the number of employees for a specific number of passengers is 300, there is the possibility that the real value can vary from 269 to 331, given the error being, in practice, 31 positions. For each example, it is possible to calculate the relative error, which is lower when the number of direct employees is the highest.

Therefore, the higher the number of passengers, the higher the number of direct jobs, which leads to a smaller error. This error is considered to be relatively low when its interpretation is combined with the obtained R^2 .

6.4.2 Graphical Representation and Analysis

Now that Equation 6.1 reflects how the number of job positions at João Paulo II Airport changes based on the number of passengers handled in this airport, and knowing that the standard error is 30.77, it is possible to illustrate how the variables behave when they are manipulated.

This subsection presents a visual illustration of the behavior of the designated

equation that represents the relationship between the number of passengers and direct employment, and how the residuals are distributed. The data used to develop the plots can be consulted in Figure 7.2 from Appendix G.

The first graphic presented in Figure 6.1 illustrates the number of employees per number of passengers in millions in the six observations done during data collection. This plot is called the scatter plot, and it is one of the most important charts in data analysis development, since, with this plot, it is possible to visualize how the data is distributed, the values that each variable assumes in different observations, and even the regression line delineated [Linear (Observations)]. The observed regression confirms that the relationship between the two variables is linear, and it is a positive relationship. With the increase in passenger traffic, there is undoubtedly an increase in the number of direct employees of this airport. The observation bullets on this chart are close to the regression line, meaning that this regression is pertinent and adequate for this case study. This analysis confirms the predictions made by the R-squared and p-value values, providing confidence that the model and the prediction, Equation 6.1, are well-suited for this study. This graphic also shows that the higher the volume of passengers, the closer the real number of employees is to the linear regression.

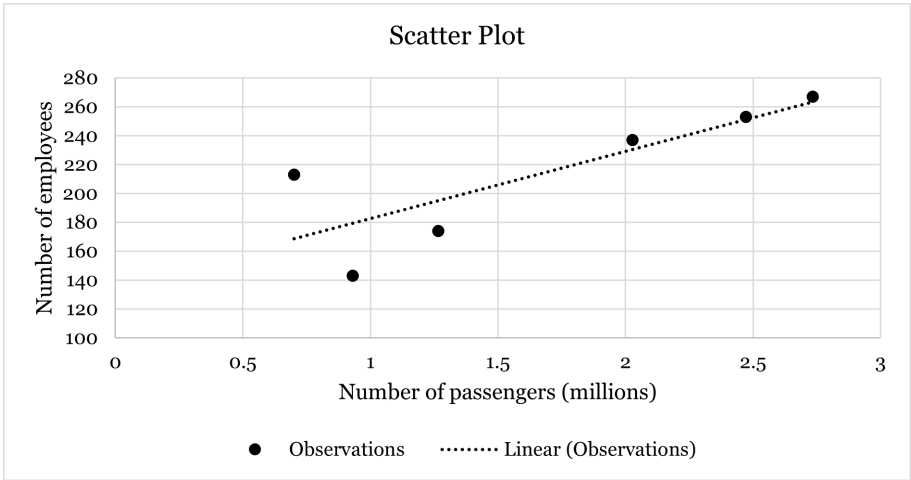


Figure 6.1: Scatter plot and regression. Prepared by: Author. Data analysis tool: *Excel*.

Figure 6.2 presents a graphic that illustrates the distribution of the residuals for the six different observations. The observations considered for this plot were the predicted values, or fitted values, which are the values of the number of employees in the airport obtained for the number of passengers already considered, but using Equation 6.1, rather than the number concluded when collecting the data. The residuals were obtained by subtracting the fitted values from the actual number of employees. In other words, residuals are the errors of the linear regression model for each observation. As observed, the values of the residuals are random and do not follow a pattern, as they differ in each observation. The random dispersion of the residuals confirms that the linear regression model can represent this relationship, and confirms the assumptions made

before applying the linear regression model (independence) [93].

It is possible to visualize that, in Figure 6.2, the residual that corresponds to the fitted value of 168 is around 44. This discrepancy from the other residuals can be explained by checking that the corresponding year of that observation is 2020. This abnormality appears as a result of the year affected by the COVID-19 quarantine and protocols. The number of passengers decreased drastically, while the number of employees was maintained at approximately the same level. As in other services and situations, many employees were not actively working and were sent home to quarantine, while job positions were maintained, despite a decrease in passenger traffic.

Another pertinent observation that confirms the previous statement that the higher the number of passengers is, the smaller the error becomes, is when observing the Residuals versus Predicted values graphic, the residuals are objectively lower when the predicted values for the number of employees are higher.

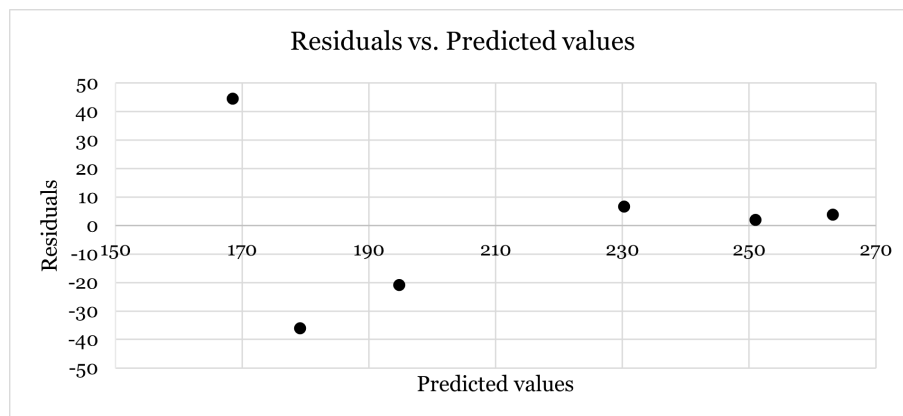


Figure 6.2: Fitted values and each residuals distribution. Data analyzis tool: *Excel*. Prepared by: Author.

The histogram in Figure 6.3 confirms that the most of the residuals are around zero, as also observed in Figure 6.2.

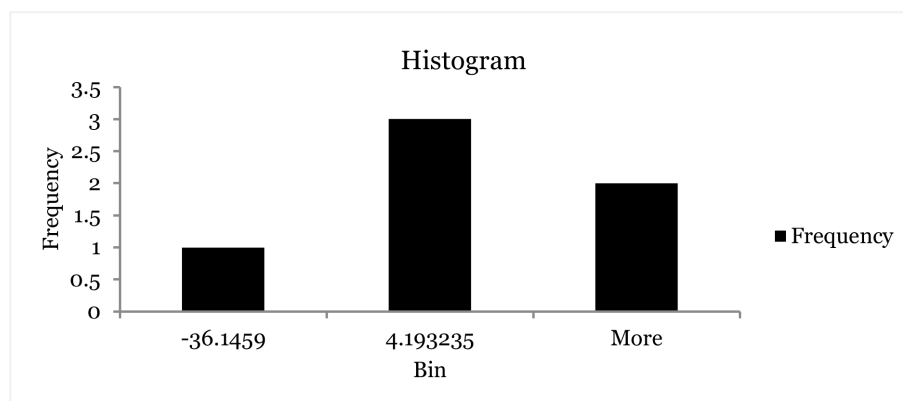


Figure 6.3: Histogram of residuals' distribution. Prepared by: Author. Data analyzis tool: *Excel*.

To complete this data analyzis, it is interesting to understand how Equation 6.1 could

predict and estimate hypothetical future values for the region's employment in the airport. To achieve this objective, a forecasting plot needs to be developed.

Figure 6.3 presents a histogram of residuals. This graphic is essential for visualizing that the residuals of this relationship follow a normal distribution, allowing the linear regression model to be reliable and statistically supported [93]. The histogram presented has the limitation of considering only six observations, which can be a small sample for *Excel* data analysis histogram tool.

To elaborate on this graphic, the data analysis tool used is the "Forecast Sheet" on *Excel*. However, to complete this analysis, the investigator needs to estimate a hypothetical new value for the independent variable, for future observation.

For this case, the observation is 2025, and the value of the number of passengers can be estimated by inference of how many passengers could be handled in João Paulo II Airport, considering the number of passengers it has until this date (September of 2025) and its increase rates to forecast the next months' growth. This estimation is based on SREA data for São Miguel Airport [91]. The estimated values for 2025 and the corresponding rates can be found in Appendix H.

The values described in Figure 7.3 in Appendix H were obtained considering the growth rate as the average growth rate. The average growth rate was calculated by averaging the known growth rates from January to July.

The prediction for the total number of passengers handled by João Paulo II Airport in 2025 is 2 837 645, that is 2.838 million passengers. With this value, the fitted value for the number of job positions predicted for 2025 using Equation 6.1 is 268 jobs.

It was decided to add another observation on the following graphic, which corresponds to the number of jobs that exist when the number of passengers reaches 3 million. There is no specific year or date prediction for this observation.

Now, it is possible to forecast and analyze the forecasting plot present in Figure 6.4.

The graphic in Figure 6.4 displays eight observations; the first six represent the real observed values obtained through data collection, and the last two represent hypothetical or potential future values. Since the tendency is to increase the number of passengers, the model can be used to estimate the number of job positions at the airport in the future.

It was already covered before that the error of this model decreases when the independent variable increases, so it can be inferred that the more passenger traffic in Ponta Delgada Airport, the more employees it can directly host, the better this approximation.

In the future, it may be possible that, if the number of passengers continues to increase, the prediction of the number of employees given by Equation 6.1 will correspond to reality.

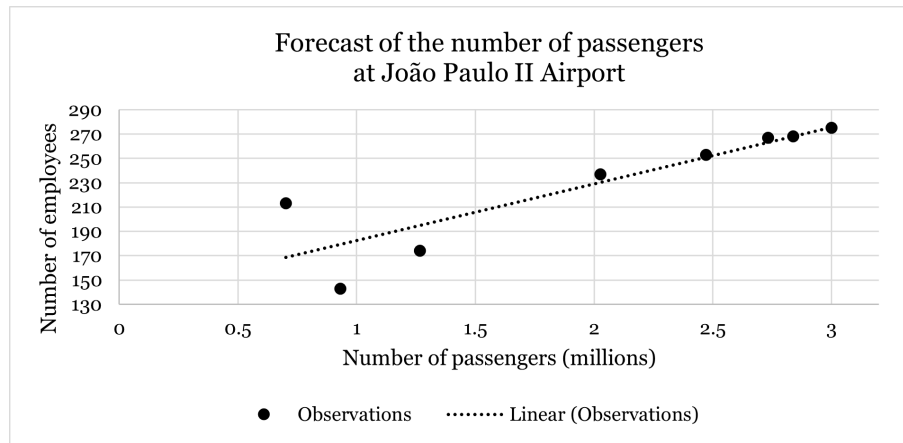


Figure 6.4: Forecast of the number of employees predicted for 2025, and for when Ponta Delgada Airport handles 3 million passengers in the future. Data analysis tool: *Excel*. Prepared by: Author.

In the event of a case similar to COVID-19, this model may be limited in estimating the number of employees based on the number of passengers, as it resembles a linear regression. When analyzing the observation regarding the year 2020, the residual is the highest among the other observations, and it is not well represented through the linear regression. It does not mean that, if João Paulo II Airport faced a natural decrease in passenger traffic, the prediction would not be accurate, because this model can also estimate the value of y for any $x > 0$.

6.5 Conclusion

To summarize this section, the equation that reflects how the number of direct employees (y) depends on the number of passengers (x) at João Paulo II Airport, as shown in Equation 6.1:

$$y = 46.63x + 135.78$$

The initial hypothesis $H_1 : m > 0$ is confirmed, indicating a positive relationship between the number of employees and the number of passengers.

The existence of an interceptive coefficient such as 135.78 can be interpreted as the airport also handles cargo on its services, not only passengers, and that cargo also needs its own operations and handling. Therefore, more elements and variables could potentially influence the number of direct employees at this airport, or any airport that offers services beyond passenger traffic.

With an R-squared of 0.67, this model can effectively characterize the situation in this case study, where 67% of the variation in employment is explained by variance in the number of passengers, reinforcing that this relationship is positive and meaningful. The p-value

being lower than the referenced number of 0.05 states that this study's conclusion is not random, and is statistically meaningful.

As proposed at the beginning of this dissertation, this chapter presents a final equation that predicts and projects how the employment generated by João Paulo II Airport can behave and vary depending on the passenger traffic. This equation does not limit the possibility of the number of employees being different in practice than it is in theory when forecasting with this linear regression model. In other words, this model is an estimation and can be used to predict the variables' magnitude because of their relationship and nature.

The findings from this work confirm that a region's economy, especially in an insular region, can be impacted by an airport. Insular regions are limited by maritime and air transport. The great majority of passenger traffic nowadays is conducted by air, which underscores the significant impact that an airport can have on an island. Direct employment is just the "tip of the iceberg" when it comes to the impact that an airport has on a locality: the generated tourism, facilitating goods and services exchange, indirect employment development, creating new demanded services, and developing what already exists in the region are some of the immediate consequences that a region faces when an airport is created or expanded. As a result of this study, the following regression model is proposed:

$$y = 46.63x + 135.78$$

Where x represents the independent variable, the number of passengers in millions, and y represents the dependent variable, the number of employees. The intercept of 135.78 can be translated into all other variables that influence the number of jobs available at the airport, especially because, in this case, the airport also handles cargo exchanges. The slope of 46.63 indicates the impact of the number of passengers on the number of jobs.

However, some limitations can be identified when using this regression, for example:

- When the number of passengers is relatively low, the residuals and errors are considerably higher than when the number of passengers is high. This problem can be explained because the two observations with a lower number of passengers have higher residuals. This includes the year 2020, when the number of passengers decreased due to the pandemic, and the number of job positions did not change drastically. However, the employees were not actively working. This atypical ratio can affect the model.
- The sample of observations being only six leads to the linear regression model, which makes the model weaker if there is an atypical value.
- Although this analysis is based on a case study, and it was already expected that

the predictability by the independent variable, R-squared, is not 100%, in this case, $R^2 = 0.67$, this value translates to a variation of 33% of our dependent variable. This variance suggests that other factors besides the number of passengers determine the number of job positions.

- This model is a linear regression, which means that the relationship between the studied variables is constant and linear. The limitation regarding this model is that, in the future, this relationship can change, and Equation 6.1 would no longer represent it.

In general, this case study defined that there is, in fact, a positive relationship between the number of passengers at the airport and the number of direct jobs created at the airport. Although it cannot be considered a generalized finding, since the model reflects the reality of the Ponta Delgada case, it can be applied to other similar cases, such as other insular regions with comparable traffic or operational characteristics.

Chapter 7

Conclusion

7.1 Dissertation Synthesis

This dissertation's main objective was to investigate how an airport can contribute to the economic development of a region, assessing its impact through employment in the first tier of the airport ecosystem. For this work, João Paulo II Airport was chosen as a case study. João Paulo II Airport affects employment on the island of São Miguel, as a gap in information regarding the relationship between this airport and employment was identified in this case. The employment generated by the existence of an airport can be induced through various vectors, categorized into indirect and direct employment. To quantify this employment in the most objective manner, this study focuses solely on direct employment at Ponta Delgada airport. To quantify the airport activity on the island, after some literature research that addresses similar issues, it was decided that the appropriate way to estimate this activity is through the number of passengers handled in the airport per year.

To find a quantitative relationship between the number of passengers and the number of direct airport employees, this research uses the case study of Ponta Delgada as its case study for a quantitative investigation. The data was collected with questionnaires delivered to the companies that work in the airport facilities in order to have information regarding their job positions, the direct employment. The data obtained by the questionnaires distributed and the number of passengers available on SREA's website were analyzed using the linear regression model in *Excel*.

This investigation's data analysis reported that there is a positive linear relationship between the passenger traffic and the direct employment at João Paulo II Airport. This analysis is statistically significant and holds a considerable good prediction, since the resulting values on *Excel* for p-value and R^2 justify that the linear regression model is well-fitted to forecast and predict the number of employees working at the airport depending on the number of passengers.

This work explains how the variables of this relationship are related and can predict the dependent variable behavior in the future. However, it is essential to note that this conclusion is an estimate based on the available data provided by a sample of companies and entities operating at the airport. This means that the values obtained using this model should be treated as an estimation, only considering the number of entities that provided

the information, not the final general number of all employees that would work at the airport at a specific time.

7.2 Final Consideration

The outcome of this work confirms the main evidence of the works of Florida, Mellander, and Holgersson, being its most valuable contribution, inferring that the airports play a significant role in a region's economy [3], its application to small-scale regions, particularly those in the outermost areas, such as São Miguel Island.

This study fills an information gap regarding the impact of João Paulo II Airport on the Ponta Delgada region, specifically in terms of its employment effects. The investigation reveals that the number of passengers has a positive and linear relationship with the number of direct job positions available at the airport.

This work can be utilized by João Paulo II Airport's management team to forecast the future demand for employees that the airport may encounter. It can also be helpful to justify the addition of new routes, operations, and more, knowing that a demand for new employees will lead to the actions.

Beyond the immediate managerial implications, these findings have clear policy relevance, particularly because the airport is owned by the Regional Government, providing evidence for the Secretary of Mobility and Tourism. Specifically, the analysis reveals a robust, positive, approximately linear relationship between passenger volumes and direct airport employment, a pattern that is likely to generalize beyond the specific case.

Although the statistical results from *Excel's* data analysis show that this model is a great representation of the relationship between these variables, there are limitations to this study that need to be considered:

- Small sample of companies. Nineteen out of fifty-eight companies and entities working at the airport provided the necessary data. If the sample were larger, the final equation, relationship, and forecast would be more accurate.
- Small sample of observations. Six observations were conducted to determine the relationship between the variables. Those observations were from 2010, 2015, 2019, 2020, 2023, and 2024. If the observations were from the year the airport opened or were taken annually, the model would be statistically more accurate. Since the majority of the companies that responded to the questionnaires were not open from the time the airport started operating, and some of them did not have annual data to provide, this was not possible.
- Human factor/error. Since the questionnaires were answered by employees,

representatives, or managers of the designated companies, there is the possibility of making mistakes, misinterpretations, or even answering with approximations and not the exact values when asking for the number of employees.

- Limitations of the linear regression model. Although this model is a great representation of the case study, and it represents the relationship in the present, it is not guaranteed that, in the future, the number of direct employees will change linearly and continuously with the number of passengers.

These limitations could be managed if there were more time and resources to develop this dissertation, such as reliable points of contact of the companies, and representatives who could provide yearly, steady data.

In conclusion, this study confirms that the number of employees who work at the airport of São Miguel Island depends on the number of passengers that this airport handles, which is relevant and valuable for understanding what to expect for the future and how these variables can behave. Consequently, the airport impacts the insular region, boosting employment and, therefore, the regional economy. The linear regression model determined reflects this relationship objectively and statistically, contributing to the literature on the impact of an airport, establishing that passenger traffic influences human resources and economic elements.

7.3 Perspectives of Future Work

This investigation can be a valuable foundation for other studies and developments regarding the impact of an airport in general, and the impact of the case study of João Paulo II Airport in particular. The methodology of this study can be useful to implement similar investigations in other case studies, and the conclusions made are a great starting point for different investigations.

The following topics represent relevant future investigations with both academic and practical significance.

- Incorporate a dataset with a wider sample of companies and observations into this model in order to develop a more complex, robust, and reliable version;
- Incorporation of multiple variables to estimate the number of passengers at the airport. Such as the cargo traffic, the number of destinations, the number of flights, and the variety of airlines, for example;
- Analysis and investigation on how the number of passengers influences the indirect employment, and therefore, the economy on a more complex level;

- Compare different case studies to conclude what could be the main influences between the number of passengers and the employment or economy, identifying a relationship between the variables for a general case.

These ideas could be developed in the case study of João Paulo II Airport, as well as in other scenarios.

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Appendices

Appendix A - Table of the population considered for the questionnaire

| Service | Name |
|---------------------------------|--|
| Airport management | ANA Aeroportos - ANA Ponta Delgada, R |
| Handlers, Market Access Permits | BP Portugal, S.A., NR Iberlim, S.A., NR Groundlink III, Lda., NR ICTS Portugal, S.A., NR LAS, S.A., R PETROGAL, L.A., R Ryanair, Lda., NR SATA Air Açores, S.A., NR Servicater, Lda., R Sky Valet, Lda., NR WXJ Aviation, Lda., NR JC Aircraft Maintenance, Lda., NR Omni Handling, NR Varela e Companhia, Lda., NR |
| Terminal Services | CTT Portugal, NR Unicâmbio, R Santander Totta, NR Euronet, NR |
| Shops | Vodafone, R Azorean Gift Shop, R Loja dos Açores, R My Azores Collection, NR Gateleven, R Parfois, NR Portugal Duty Free, NR Liderexpress, NR |
| Car rentals | Ilha Verde, NR 296 / Hertz, NR SIXT / JAP, R Europcar, R |

| Service | Name |
|-------------------|---|
| | Guerin, R Autatlantis, R Wayzor, R |
| Restaurant | Ibersol, NR |
| Advertisement | JCDecaux, NR |
| Cargo and Transit | Abreu Cargas e Trânsitos, Lda., NR Luís Resendes, S. Unipessoal, R |
| Public Entities | Autoridade Tributária Aduaneira, NR Polícia de Segurança Pública, R NAV Portugal, NR Instituto Português do Mar e da Atmosfera, R Direção Regional de Agricultura, Veterinária e Alimentação, NR Delegação de Turismo, R |
| Service Providers | SAMSIC, NR Reis e Filhos, NR Siemens, NR Aerociências, NR SEGMA, Lda., NR Petskill, Lda., NR dBwave.i, S.A., NR Medidaçor, R Agroleico, NR Associação Humanitária de Bombeiros Voluntários de Ponta Delgada, NR Mário Rui Caetano Martins (EDA), NR FÁCIL, R Sousa & Garcês, NR Rui Miguel Barata Teixeira (occupational health and safety service provider), NR |

Appendix B - Original version of the questionnaire sent to the companies

Impacto do Aeroporto João Paulo II na região.

Este questionário foi elaborado no âmbito de uma dissertação de Mestrado em Engenharia Aeronáutica na Universidade da Beira Interior, com o tema "**O Impacto de um Aeroporto numa Região Insular: O Caso de Estudo do Aeroporto de Ponta Delgada**", em conjunto com a ANA Aeroportos Açores.

O questionário tem como finalidade recolher as respostas fornecidas pelas empresas que trabalham diretamente com o Aeroporto João Paulo II, em Ponta Delgada, de modo a ser possível analisar de que forma este aeroporto influencia toda a ilha em termos de empregabilidade e de contexto económico.

Observação: Este questionário não recolhe dados pessoais ou informações de indivíduos ou funcionários, todas as perguntas dizem respeito a dados quantitativos gerais sobre as empresas. O anonimato dos dados será garantido através da codificação dos dados. Ao avançar para o preenchimento do questionário, aceito participar neste estudo e permito a utilização dos dados que de forma voluntária forneço, confiando em que apenas serão utilizados para esta investigação e nas garantias de confidencialidade e anonimato que me são dadas pela investigadora.

Agradecemos a sua colaboração e contribuição neste estudo.

** Indica uma pergunta obrigatória*

1. 1. Indique o nome da empresa/entidade que representa: *

2. 2. A empresa/entidade trabalha nas instalações do aeroporto (lado terra e/ou lado ar)? *

Marcar apenas uma oval.

Sim

Não

3. 3. A empresa/entidade existe exclusivamente nas instalações do aeroporto? *

Marcar apenas uma oval.

- Sim
- Não
- Outra: _____

4. 4. O serviço que oferece é indispensável ao bom funcionamento do aeroporto? *

Marcar apenas uma oval.

- Sim
- Não
- Outra: _____

5. 5. No caso de ser uma empresa, em que ano foi inaugurada? (Caso esta pergunta não se aplique, responda com N/A). *

6. 6. Em que ano a empresa/entidade começou a trabalhar no/para o aeroporto? (Caso esta pergunta não se aplique, responda com N/A). *

7. 7. A empresa/entidade existe a nível: *

Marcar apenas uma oval.

- Local
- Regional
- Nacional
- Internacional

8. 8. Com que frequência é feito o recrutamento? *

9. 9. Recrutam mais trabalhadores em época alta? *

Marcar apenas uma oval.

Sim

Não

Outra: _____

10. 10. Quantas pessoas a empresa emprega neste momento (todo o tipo de funcionários)? Por favor, responda de forma quantitativa. *

11. 11. Quantos desses trabalhadores exercem funções diretamente no aeroporto? Por favor, responda de forma quantitativa ou em percentagem. *

12. 12. Quantos trabalhadores a empresa/entidade tinha quando esta foi inaugurada? Por favor, responda de forma quantitativa. (Caso esta pergunta não se aplique, responda com N/A). *

13. 13. Quantos trabalhadores a empresa/entidade contava aproximadamente nos anos 2020/2021 (para referência, anos afetados pelos planos de contingência referidos à COVID-19). Por favor, responda de forma quantitativa. (Caso esta pergunta não se aplique, responda com N/A). *

14. 14. De 0 a 5, sendo 0 pouco impacto e 5 muito impacto, selecione quão impactante seria para a empresa/entidade o aeroporto duplicar as suas operações. *

Marcar apenas uma oval.

0 1 2 3 4 5

pouco muito impactante

15. 15. De 0 a 5, sendo 0 pouco impacto e 5 muito impacto, selecione quão impactante seria para a empresa/entidade o aeroporto duplicar a sua área em infraestrutura. *

Marcar apenas uma oval.

0 1 2 3 4 5

pouco muito impactante

16. 16. De 0 a 5, sendo 0 pouco impacto e 5 muito impacto, selecione quão impactante seria para a empresa/entidade o aeroporto cessar operações. *

Marcar apenas uma oval.

0 1 2 3 4 5

pouco muito impactante

17. 17. No caso de o aeroporto cessar operações, a empresa/entidade deixaria de existir? *

Marcar apenas uma oval.

Sim

Não

Outra: _____

18. 18. No caso de o aeroporto restringir operações a metade, a empresa/entidade teria de proceder a um despedimento em massa ou encerrar? *

Marcar apenas uma oval.

- Sim
- Não
- Outra: _____

19. 19. Até à data, a empresa/entidade conseguiu acompanhar o crescimento do aeroporto sem dificuldades? *

Marcar apenas uma oval.

- Sim
- Não
- Outra: _____

20. 20. Se o aeroporto aumentar significativamente as suas operações e/ou a sua área, a empresa/entidade terá possibilidades de acompanhar esse crescimento? *

Marcar apenas uma oval.

- Sim
- Não
- Outra: _____

Este conteúdo não foi criado nem aprovado pela Google.

Google Formulários

Appendix C - Questionnaire sent to the companies (in English)

The Impact of João Paulo II Airport on the region.

This questionnaire was drawn up as part of a Master's dissertation in Aeronautical Engineering at the University of Beira Interior, on the subject of "**The Impact of an Airport on an Isular Region: The Case Study of Ponta Delgada Airport**", in collaboration with ANA Aeroportos Açores.

The purpose of the questionnaire is to collect data from companies that work directly with João Paulo II Airport in Ponta Delgada, so that it is possible to analyze how this airport influences the entire island in terms of employability and the economic sector.

Observation: This questionnaire does not collect personal data or information from individuals or employees, all the questions are gathering general quantitative data about the companies. Data anonymity will be guaranteed by coding the data. By completing the questionnaire, I agree to take part in this study and allow the use of the data I voluntarily provide, trusting that it will only be used for this research and the guarantees of confidentiality and anonymity given to me by the researcher.

Thank you for your cooperation and contribution to this study.

* Indicates required question

1. 1. Enter the name of the company/entity that you represent: *

2. 2. Does the company/entity works in the airport building (landside and/or airside)? *

Mark only one oval.

Yes

No

3. 3. Does the company/entity exists exclusively in the airport building? *

Mark only one oval.

- Yes
- No
- Other: _____

4. 4. Is the service the company offers essential to the smooth running of the airport? *

Mark only one oval.

- Yes
- No
- Other: _____

5. 5. If it is a company, in what year was it inaugurated? (If this question does not apply, answer with N/A). *

6. 6. In what year did the company/entity start working at/for the airport? (If this question does not apply, answer with N/A). *

7. 7. The company/entity is: *

Mark only one oval.

- Local
- Regional
- National
- International

8. 8. How often do you recruit? *

9. 9. Do you recruit more employees during the high season? *

Mark only one oval.

Yes

No

Other: _____

10. 10. How many people does the company currently employs (all types of employees)? Please answer quantitatively. *

11. 11. How many of these workers work directly at the airport? Please answer quantitatively or as a percentage. *

12. 12. How many employees did the company/entity had when it was inaugurated? Please answer quantitatively. (If this question does not apply, answer with N/A). *

13. 13. Approximately, how many employees did the company/entity had in the years 2020/2021 (for reference, years affected by the contingency plans referred to COVID-19). Please answer quantitatively. (If this question does not apply, answer with N/A). *

14. 14. From 0 to 5, with 0 being low impact and 5 being a lot of impact, select how ^{*} impactful it would be for the company/entity if the airport to double its operations.

Mark only one oval.

0 1 2 3 4 5

low a lot of impact

15. 15. From 0 to 5, with 0 being low impact and 5 being a lot of impact, select how ^{*} impactful it would be for the company/entity if the airport doubled its infrastructure area.

Mark only one oval.

0 1 2 3 4 5

low a lot of impact

16. 16. From 0 to 5, with 0 being low impact and 5 being a lot of impact, select how ^{*} impactful it would be for the company/entity if the airport ceased operations.

Mark only one oval.

0 1 2 3 4 5

low a lot of impact

17. 17. If the airport ceased operations, would the company/entity cease to exist? ^{*}

Mark only one oval.

Yes

No

Other: _____

18. 18. If the airport restricted operations to half, would the company/entity have to make mass lay offs or close? *

Mark only one oval.

- Yes
- No
- Other: _____

19. 19. To this date, has the company/entity been able to keep up with the airport's growth without difficulty? *

Mark only one oval.

- Yes
- No
- Other: _____

20. 20. If the airport significantly increased its operations and/or its area, will the company/entity be able to keep up with this growth? *

Mark only one oval.

- Yes
- No
- Other: _____

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Google Forms

**Appendix D - Original version of the second questionnaire
sent to the companies**

Impacto do Aeroporto João Paulo II na região.

Este questionário foi elaborado no âmbito de uma dissertação de Mestrado em Engenharia Aeronáutica na Universidade da Beira Interior, com o tema "**O Impacto de um Aeroporto numa Região Insular: O Caso de Estudo do Aeroporto de Ponta Delgada**", em conjunto com a ANA Aeroportos Açores.

O questionário tem como finalidade recolher as respostas fornecidas pelas empresas que trabalham diretamente com o Aeroporto João Paulo II, em Ponta Delgada, de modo a ser possível analisar de que forma este aeroporto influencia toda a ilha em termos de empregabilidade e de contexto económico.

Observação: Este questionário não recolhe dados pessoais ou informações de indivíduos ou funcionários, todas as perguntas dizem respeito a dados quantitativos gerais sobre as empresas. O anonimato dos dados será garantido através da codificação dos dados. Ao avançar para o preenchimento do questionário, aceito participar neste estudo e permito a utilização dos dados que de forma voluntária forneço, confiando em que apenas serão utilizados para esta investigação e nas garantias de confidencialidade e anonimato que me são dadas pela investigadora.

Agradecemos a sua colaboração e contribuição neste estudo.

1. Indique o nome da empresa/entidade que representa.

2. Em que ano a empresa começou a trabalhar no Aeroporto João Paulo II?

3. Quantas pessoas trabalham no aeroporto por parte da sua empresa?
(2024/2025)

4. Quantos funcionários da empresa trabalhavam no aeroporto no ano **2023**?

5. Quantos funcionários da empresa trabalhavam no aeroporto no ano **2020** (período afetado pelos constrangimentos referentes à **COVID-19**)?

6. Quantos funcionários da empresa trabalhavam no aeroporto no ano **2019**?

7. Quantos funcionários da empresa trabalhavam no aeroporto no ano **2015**?

8. Quantos funcionários da empresa trabalhavam no aeroporto no ano **2010**?

9. Pensa aumentar, manter ou diminuir o seu nível de atividades (em **número de trabalhadores** no aeroporto) nos **próximos 5 anos**?

Mark only one oval.

Aumentar

Manter

Diminuir

10. Pensa aumentar, manter ou diminuir o seu nível de atividades (em **volume de receitas** no aeroporto) nos **próximos 5 anos**?

Mark only one oval.

Aumentar

Manter

Diminuir

N/A

Appendix E - Second questionnaire sent to the companies (in English)

The Impact of João Paulo II Airport on the region.

This questionnaire was drawn up as part of a Master's dissertation in Aeronautical Engineering at the University of Beira Interior, on the subject of "**The Impact of an Airport on an Isular Region: The Case Study of Ponta Delgada Airport**", in collaboration with ANA Aeroportos Açores.

The purpose of the questionnaire is to collect data from companies that work directly with João Paulo II Airport in Ponta Delgada, so that it is possible to analyze how this airport influences the entire island in terms of employability and the economic sector.

Observation: This questionnaire does not collect personal data or information from individuals or employees, all the questions are gathering general quantitative data about the companies. Data anonymity will be guaranteed by coding the data. By completing the questionnaire, I agree to take part in this study and allow the use of the data I voluntarily provide, trusting that it will only be used for this research and the guarantees of confidentiality and anonymity given to me by the researcher.

Thank you for your cooperation and contribution to this study.

1. Please indicate the name of the company/entity you represent.

2. In what year did the company start working at João Paulo II Airport?

3. How many people work at the airport on behalf of your company? **(2024/2025)**

4. How many company employees worked at the airport in **2023**?

5. How many company employees worked at the airport in **2020** (a period affected by COVID-19 restrictions)?

6. How many company employees worked at the airport in **2019**?

7. How many company employees worked at the airport in **2015**?

8. How many company employees worked at the airport in **2010**?

9. Do you plan to increase, maintain, or decrease your level of activity (in terms of the **number of workers** at the airport) over the **next 5 years**?

Mark only one oval.

Increase

Maintain

Decrease

10. Do you plan to increase, maintain, or decrease your level of activity (in terms of **revenue** at the airport) over the **next 5 years**?

Mark only one oval.

Increase

Maintain

Decrease

N/A

Appendix F - *Excel's* data analysis summary results

| SUMMARY OUTPUT | | | | | | | | |
|------------------------------|---------------------|-----------------------|---------------|----------------|-----------------------|------------------|--------------------|--------------------|
| <i>Regression Statistics</i> | | | | | | | | |
| Multiple R | 0.819002063 | | | | | | | |
| R Square | 0.670764379 | | | | | | | |
| Adjusted R Square | 0.588455474 | | | | | | | |
| Standard Error | 30.76542305 | | | | | | | |
| Observations | 6 | | | | | | | |
| ANOVA | | | | | | | | |
| | <i>df</i> | <i>SS</i> | <i>MS</i> | <i>F</i> | <i>Significance F</i> | | | |
| Regression | 1 | 7713.454978 | 7713.455 | 8.149354 | 0.046175611 | | | |
| Residual | 4 | 3786.045022 | 946.5113 | | | | | |
| Total | 5 | 11499.5 | | | | | | |
| | <i>Coefficients</i> | <i>Standard Error</i> | <i>t Stat</i> | <i>P-value</i> | <i>Lower 95%</i> | <i>Upper 95%</i> | <i>Lower 95,0%</i> | <i>Upper 95,0%</i> |
| Intercept | 135.7817586 | 30.30060189 | 4.481157 | 0.01098 | 51.65380079 | 219.90972 | 51.65380079 | 219.909716 |
| X Variable 1 | 46.63402927 | 16.33583574 | 2.854707 | 0.046176 | 1.278478091 | 91.98958 | 1.278478091 | 91.9895805 |

Figure 7.1: Results' summary of the *Excel's* data analysis. Data analysis tool: *Excel*.

Appendix G - Excel data table used to elaborate graphics present on Figures 6.1, 6.2, and 6.3, and specific values obtained for the fitted values and residuals

| YEAR | JOBS | PAX (million) | Fitted values (jobs) | Residuals | EQUATION |
|------|------|---------------|----------------------|-----------|-----------------------|
| 2024 | 267 | 2.733 | 263.21979 | 3.78021 | $y = 46.63x + 135.78$ |
| 2023 | 253 | 2.471 | 251.00273 | 1.99727 | |
| 2020 | 213 | 0.701 | 168.46763 | 44.53237 | |
| 2019 | 237 | 2.027 | 230.29901 | 6.70099 | |
| 2015 | 174 | 1.266 | 194.81358 | -20.8136 | |
| 2010 | 143 | 0.93 | 179.1459 | -36.1459 | |

Figure 7.2: Excel data table used to elaborate graphics present on Figures 6.1, 6.2, and 6.3. Prepared by: Author.

Appendix H - Data table used to predict the number of passengers of 2025, using data from SREA [91]

| MONTH | 2024 | 2025 | RATES | PREDICTION |
|-----------|---------------------|--------|---------------|-------------|
| JANUARY | 128918 | 141621 | 9.853550319 | 141621 |
| FEBRUARY | 133174 | 132680 | -0.370943277 | 132680 |
| MARCH | 170318 | 174068 | 2.20176376 | 174068 |
| APRIL | 222506 | 248734 | 11.7875473 | 248734 |
| MAY | 251406 | 259312 | 3.144714128 | 259312 |
| JUNE | 296877 | 300069 | 1.075192757 | 300069 |
| JULY | 339738 | 342545 | 0.826224914 | 342545 |
| AUGUST | 354796 | | AVERAGE RATE: | 369236.1972 |
| SEPTEMBER | 304052 | | 4.074007129 | 316426.9164 |
| OCTOBER | 230085 | | | 239449.4595 |
| NOVEMBER | 155629 | | | 161963.1003 |
| DECEMBER | 145614 | | TOTAL RATE | 151540.4898 |
| TOTAL | 2733113 | | 3.824655739 | 2837645.163 |
| | | | | |
| | calculated rates | | | |
| | variable X obtained | | | |

Figure 7.3: Data table of the monthly number of passengers of 2024 at João Paulo II Airport, and the predicted values for 2025. Prepared by: Author. Tool: *Excel*. Data source: SREA [91].

Appendix I – Articles Submitted to Conference and Journal.

Appendix I.1 - Paper presented at ICEUBI 2024 and Article Published in the Proceedings Book.

The Economic Impact of an Airport on an Insular Region

Maria Patrício¹, Jorge Silva^{1,2}, Eliane Brito^{1,2}

¹ Universidade da Beira Interior, Faculty of Engineering / Department of Aerospace Sciences

² CiTUA, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001, Lisboa, Portugal

Abstract

Airports and aerodromes are essential infrastructures that significantly contribute to the regional economy. These contributions manifest through increased tourism, enhanced import and export activities, and the creation of job opportunities directly and indirectly linked to airport operations. This study explores an airport's economic and employment implications in insular regions, addressing critical questions about job loss and economic downturns if an airport were to cease operations. Insights from this research are vital for stakeholders, investors, government agencies, and local businesses to comprehend the broader economic impacts of airports and make informed decisions regarding infrastructure development and investment. There is a lack of information about the socioeconomic effects of an airport on islands, however, a literature review of studies related to the economic impact and employability in remote regions will be done in this article, so this effect on islands can be better understood. This study concludes that an airport does indeed have a positive influence on the economy and employment of an island. Because this region cannot have transactions of goods and people by land, all jobs that exist in relation to the airport, and all the tourism companies, for example, are a large part of the number of jobs on an island, and one of the most necessary to keep the economic status.

Appendix I.2 - Article Submitted in the Journal of Airline and Airport Management (JAIRM).

The impact of an airport on an insular region: the case study of João Paulo II Airport

Maria Patrício¹, Jorge Silva^{1,2}, Eliane Brito^{1,2}

¹ Universidade da Beira Interior, Faculty of Engineering / Department of Aerospace Sciences

² CiTUA, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001, Lisboa, Portugal

Purpose: This study aims to analyze the impact that an airport may have on an insular region, so it is possible to understand how the development of an airport can influence an island. In this case, Ponta Delgada Airport will be the object of study to infer its direct impacts on São Miguel Island's economy, through the analysis of the airport's direct employment. This impact can be evaluated by finding a relationship between the number of passengers and the number of direct job positions at the airport.

Design/methodology/approach: To this end, a quantitative approach was chosen, collecting employment data from companies operating at the airport via questionnaires. To intercept this data with the passenger traffic volume, a linear regression analysis was implemented to quantify and determine the relationship between these variables.

Findings: The linear regression model showed that there is a positive linear relationship between direct employment and passenger traffic volume in this airport. The results show that the increase in the number of passengers handled at this airport linearly increases direct employment, boosting the direct economy of the island.

Originality/value: This paper fills an information gap on the direct impact of airports on islands, specifically at João Paulo II Airport. This airport has never been a case study in this subject, and the direct effect it has on the employment of the region is not known. The importance of airports in the employment of insular regions in general is not often an object of study.

Annexes

Annex A - ICAO Aerodrome Chart of LPPD from AIP Portugal. Source: NAV Portugal [68]

AERODROME CHART - ICAO

37°44'31"N
025°41'52"W

ELEV 79m

TWR 118.300

PONTA DELGADA
João Paulo II (LPPD)

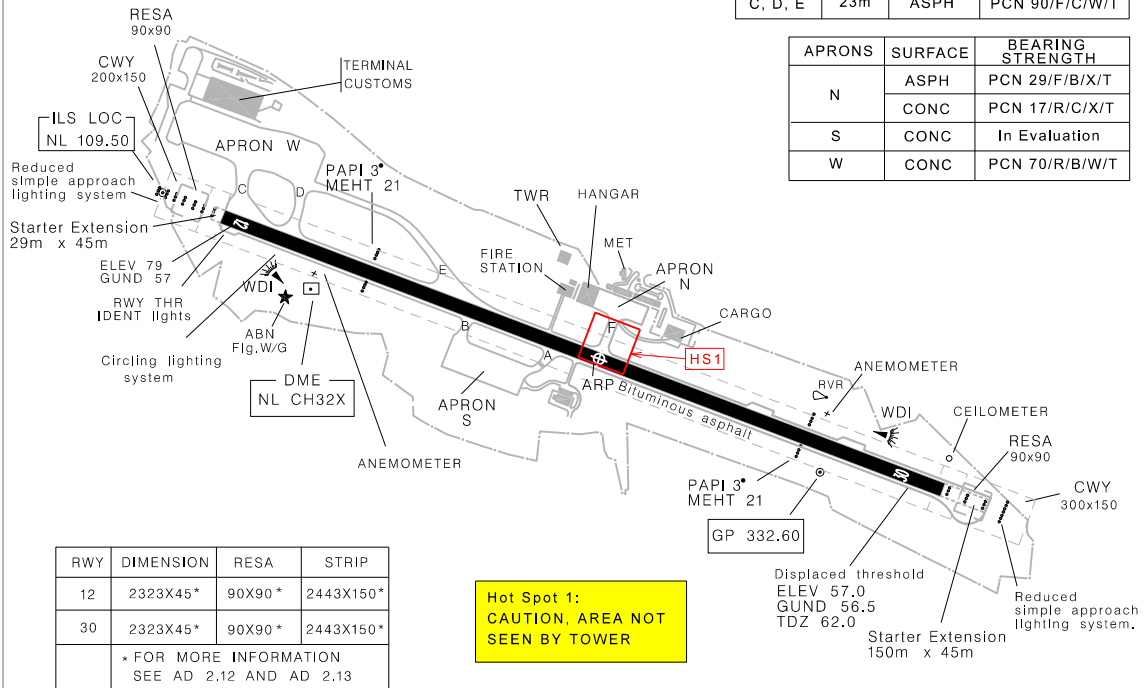
ELEVATIONS AND DIMENSIONS IN METRES
BEARINGS ARE MAGNETIC

VAR 07°M 2020
ANNUAL CHANGE 10"E

| RWY | DIRECTION | THR | BEARING STRENGTH |
|-----|-----------|---------------------------|--|
| 12 | 118° | 37°44'46"N 025°42'38"W | First 1800m PCN 62/F/B/W/T After 1800m PCN 70/F/B/W/T |
| 30 | 298° | 37°44'19"N 025°41'13"W | First 626m PCN 70/F/B/W/T After 626m PCN 62/F/B/W/T |

| TWY | WIDTH | SURFACE | BEARING STRENGTH |
|---------|-------|---------|------------------|
| A, B, F | 23m | ASPH | In Evaluation |
| C, D, E | 23m | ASPH | PCN 90/F/C/W/T |

| APRONS | SURFACE | BEARING STRENGTH |
|--------|---------|------------------|
| N | ASPH | PCN 29/F/B/X/T |
| | CONC | PCN 17/R/C/X/T |
| S | CONC | In Evaluation |
| W | CONC | PCN 70/R/B/W/T |

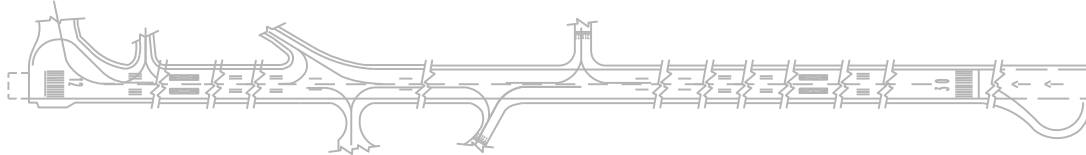


| RWY | DIMENSION | RESA | STRIP |
|-----|-----------|--------|-----------|
| 12 | 2323X45* | 90X90* | 2443X150* |
| 30 | 2323X45* | 90X90* | 2443X150* |

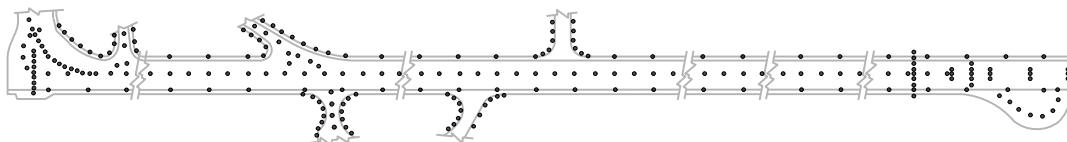
* FOR MORE INFORMATION
SEE AD 2.12 AND AD 2.13



MARKING AIDS RWY 12/30 AND EXIT TWY



LIGHTING AIDS RWY 12/30 AND EXIT TWY



ARO removed.

Annex B - Values of the area to the left of the Z score for standard normal distribution

STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.

| Z | .00 | .01 | .02 | .03 | .04 | .05 | .06 | .07 | .08 | .09 |
|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 0.0 | .50000 | .50399 | .50798 | .51197 | .51595 | .51994 | .52392 | .52790 | .53188 | .53586 |
| 0.1 | .53983 | .54380 | .54776 | .55172 | .55567 | .55962 | .56356 | .56749 | .57142 | .57535 |
| 0.2 | .57926 | .58317 | .58706 | .59095 | .59483 | .59871 | .60257 | .60642 | .61026 | .61409 |
| 0.3 | .61791 | .62172 | .62552 | .62930 | .63307 | .63683 | .64058 | .64431 | .64803 | .65173 |
| 0.4 | .65542 | .65910 | .66276 | .66640 | .67003 | .67364 | .67724 | .68082 | .68439 | .68793 |
| 0.5 | .69146 | .69497 | .69847 | .70194 | .70540 | .70884 | .71226 | .71566 | .71904 | .72240 |
| 0.6 | .72575 | .72907 | .73237 | .73565 | .73891 | .74215 | .74537 | .74857 | .75175 | .75490 |
| 0.7 | .75804 | .76115 | .76424 | .76730 | .77035 | .77337 | .77637 | .77935 | .78230 | .78524 |
| 0.8 | .78814 | .79103 | .79389 | .79673 | .79955 | .80234 | .80511 | .80785 | .81057 | .81327 |
| 0.9 | .81594 | .81859 | .82121 | .82381 | .82639 | .82894 | .83147 | .83398 | .83646 | .83891 |
| 1.0 | .84134 | .84375 | .84614 | .84849 | .85083 | .85314 | .85543 | .85769 | .85993 | .86214 |
| 1.1 | .86433 | .86650 | .86864 | .87076 | .87286 | .87493 | .87698 | .87900 | .88100 | .88298 |
| 1.2 | .88493 | .88686 | .88877 | .89065 | .89251 | .89435 | .89617 | .89796 | .89973 | .90147 |
| 1.3 | .90320 | .90490 | .90658 | .90824 | .90988 | .91149 | .91309 | .91466 | .91621 | .91774 |
| 1.4 | .91924 | .92073 | .92220 | .92364 | .92507 | .92647 | .92785 | .92922 | .93056 | .93189 |
| 1.5 | .93319 | .93448 | .93574 | .93699 | .93822 | .93943 | .94062 | .94179 | .94295 | .94408 |
| 1.6 | .94520 | .94630 | .94738 | .94845 | .94950 | .95053 | .95154 | .95254 | .95352 | .95449 |
| 1.7 | .95543 | .95637 | .95728 | .95818 | .95907 | .95994 | .96080 | .96164 | .96246 | .96327 |
| 1.8 | .96407 | .96485 | .96562 | .96638 | .96712 | .96784 | .96856 | .96926 | .96995 | .97062 |
| 1.9 | .97128 | .97193 | .97257 | .97320 | .97381 | .97441 | .97500 | .97558 | .97615 | .97670 |
| 2.0 | .97725 | .97778 | .97831 | .97882 | .97932 | .97982 | .98030 | .98077 | .98124 | .98169 |
| 2.1 | .98214 | .98257 | .98300 | .98341 | .98382 | .98422 | .98461 | .98500 | .98537 | .98574 |
| 2.2 | .98610 | .98645 | .98679 | .98713 | .98745 | .98778 | .98809 | .98840 | .98870 | .98899 |
| 2.3 | .98928 | .98956 | .98983 | .99010 | .99036 | .99061 | .99086 | .99111 | .99134 | .99158 |
| 2.4 | .99180 | .99202 | .99224 | .99245 | .99266 | .99286 | .99305 | .99324 | .99343 | .99361 |
| 2.5 | .99379 | .99396 | .99413 | .99430 | .99446 | .99461 | .99477 | .99492 | .99506 | .99520 |
| 2.6 | .99534 | .99547 | .99560 | .99573 | .99585 | .99598 | .99609 | .99621 | .99632 | .99643 |
| 2.7 | .99653 | .99664 | .99674 | .99683 | .99693 | .99702 | .99711 | .99720 | .99728 | .99736 |
| 2.8 | .99744 | .99752 | .99760 | .99767 | .99774 | .99781 | .99788 | .99795 | .99801 | .99807 |
| 2.9 | .99813 | .99819 | .99825 | .99831 | .99836 | .99841 | .99846 | .99851 | .99856 | .99861 |
| 3.0 | .99865 | .99869 | .99874 | .99878 | .99882 | .99886 | .99889 | .99893 | .99896 | .99900 |
| 3.1 | .99903 | .99906 | .99910 | .99913 | .99916 | .99918 | .99921 | .99924 | .99926 | .99929 |
| 3.2 | .99931 | .99934 | .99936 | .99938 | .99940 | .99942 | .99944 | .99946 | .99948 | .99950 |
| 3.3 | .99952 | .99953 | .99955 | .99957 | .99958 | .99960 | .99961 | .99962 | .99964 | .99965 |
| 3.4 | .99966 | .99968 | .99969 | .99970 | .99971 | .99972 | .99973 | .99974 | .99975 | .99976 |
| 3.5 | .99977 | .99978 | .99978 | .99979 | .99980 | .99981 | .99981 | .99982 | .99983 | .99983 |
| 3.6 | .99984 | .99985 | .99985 | .99986 | .99986 | .99987 | .99987 | .99988 | .99988 | .99989 |
| 3.7 | .99989 | .99990 | .99990 | .99990 | .99991 | .99991 | .99992 | .99992 | .99992 | .99992 |
| 3.8 | .99993 | .99993 | .99993 | .99994 | .99994 | .99994 | .99994 | .99995 | .99995 | .99995 |
| 3.9 | .99995 | .99995 | .99996 | .99996 | .99996 | .99996 | .99996 | .99996 | .99997 | .99997 |

Annex C - SREA Report: "Passageiros Embarcados, Desembarcados, em Transito, por Ilha, Tipo de Voo, Ano e Mês", translated as "Passengers Boarded, Disembarked, in Transit, by Island, Flight Type, Year, and Month". Source: SREA [91]

TipoVoo: InterIlhas; Internacionais; Territorial | Ano: 2010; 2015; 2019; 2020; 2023; 20 |
 Mes: Janeiro; Fevereiro; Março; Abril; Ma | Ilha: São Miguel

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SREA Serviço Regional de Estatística dos Açores

Passageiros Embarcados, Desembarcados, em Transito, por Ilha, Tipo de Voo, Ano e Mês

| Transportes Aéreos | | Ano | | | | | | | | | | | |
|--------------------|---------------------------|---------|-----------|--------|--------|--------|--------|--------|--------|----------|---------|----------|----------|
| | | 2010 | | | | | | | | | | | |
| | | Janeiro | Fevereiro | Março | Abril | Maio | Junho | Julho | Agosto | Setembro | Outubro | Novembro | Dezembro |
| São Miguel | Passageiros Embarcados | 24 252 | 21 930 | 30 706 | 35 931 | 39 047 | 42 117 | 54 211 | 67 050 | 49 098 | 35 710 | 25 462 | 25 297 |
| | Passageiros Desembarcados | 23 131 | 22 128 | 29 072 | 36 649 | 39 743 | 42 632 | 57 591 | 66 982 | 44 778 | 33 138 | 24 831 | 25 450 |
| | Passageiros em trânsito | 2 434 | 1 916 | 2 763 | 2 681 | 2 013 | 2 595 | 4 448 | 4 131 | 3 166 | 2 457 | 1 997 | 2 145 |

Figure 7.4: Number of passengers boarded, disembarked, and in transit per month in 2010 in João Paulo II Airport.

TipoVoo: InterIlhas; Internacionais; Territorial | Ano: 2010; 2015; 2019; 2020; 2023; 20 |
 Mes: Janeiro; Fevereiro; Março; Abril; Ma | Ilha: São Miguel

1 de 1

SREA Serviço Regional de Estatística dos Açores

Passageiros Embarcados, Desembarcados, em Transito, por Ilha, Tipo de Voo, Ano e Mês

| Transportes Aéreos | | Ano | | | | | | | | | | | |
|--------------------|---------------------------|---------|-----------|--------|--------|--------|--------|--------|--------|----------|---------|----------|----------|
| | | 2015 | | | | | | | | | | | |
| | | Janeiro | Fevereiro | Março | Abril | Maio | Junho | Julho | Agosto | Setembro | Outubro | Novembro | Dezembro |
| São Miguel | Passageiros Embarcados | 27 402 | 25 075 | 31 832 | 49 523 | 55 528 | 62 990 | 75 683 | 83 301 | 68 748 | 52 963 | 45 060 | 42 867 |
| | Passageiros Desembarcados | 26 005 | 25 253 | 31 971 | 51 518 | 56 454 | 64 490 | 78 984 | 82 199 | 63 344 | 49 804 | 43 515 | 45 292 |
| | Passageiros em trânsito | 1 901 | 1 475 | 1 922 | 1 817 | 1 636 | 2 686 | 3 025 | 2 387 | 2 495 | 2 223 | 2 078 | 2 346 |

Figure 7.5: Number of passengers boarded, disembarked, and in transit per month in 2015 in João Paulo II Airport.

TipoVoo: InterIlhas; Internacionais; Territorial | Ano: 2010; 2015; 2019; 2020; 2023; 20 |
 Mes: Janeiro; Fevereiro; Março; Abril; Ma | Ilha: São Miguel

1 de 1

SREA Serviço Regional de Estatística dos Açores

Passageiros Embarcados, Desembarcados, em Transito, por Ilha, Tipo de Voo, Ano e Mês

| Transportes Aéreos | | Ano | | | | | | | | | | | |
|--------------------|---------------------------|---------|-----------|--------|--------|--------|---------|---------|---------|----------|---------|----------|----------|
| | | 2019 | | | | | | | | | | | |
| | | Janeiro | Fevereiro | Março | Abril | Maio | Junho | Julho | Agosto | Setembro | Outubro | Novembro | Dezembro |
| São Miguel | Passageiros Embarcados | 56 271 | 48 675 | 63 651 | 85 856 | 86 765 | 104 477 | 120 750 | 130 180 | 107 035 | 83 317 | 63 837 | 54 160 |
| | Passageiros Desembarcados | 51 847 | 49 326 | 65 270 | 87 357 | 88 217 | 104 512 | 124 650 | 127 085 | 98 414 | 78 589 | 60 980 | 58 391 |
| | Passageiros em trânsito | 1 197 | 1 182 | 2 261 | 2 571 | 3 180 | 2 563 | 3 371 | 2 833 | 3 086 | 1 977 | 1 856 | 1 465 |

Figure 7.6: Number of passengers boarded, disembarked, and in transit per month in 2019 in João Paulo II Airport.

TipoVoo: Interilhas; Internacionais; Territorial Ano: 2010; 2015; 2019; 2020; 2023; 20; Mes: Janeiro; Fevereiro; Março; Abril; Ma Ilha: São Miguel

| Transportes Aéreos | | 2020 | | | | | | | | | | | |
|--------------------|---------------------------|---------|-----------|--------|-------|-------|-------|--------|--------|----------|---------|----------|----------|
| | | Janeiro | Fevereiro | Março | Abril | Mai | Junho | Julho | Agosto | Setembro | Outubro | Novembro | Dezembro |
| São Miguel | Passageiros Embarcados | 56 789 | 55 325 | 30 805 | 663 | 1 442 | 8 738 | 28 361 | 51 340 | 43 020 | 34 135 | 18 739 | 17 066 |
| | Passageiros Desembarcados | 53 188 | 56 146 | 29 000 | 633 | 1 265 | 8 760 | 30 882 | 52 215 | 40 106 | 33 322 | 18 220 | 19 717 |
| | Passageiros em trânsito | 1 806 | 1 751 | 1 712 | 2 | 0 | 9 | 541 | 1 898 | 1 667 | 321 | 499 | 801 |

Figure 7.7: Number of passengers boarded, disembarked, and in transit per month in 2020 in João Paulo II Airport.

TipoVoo: Interilhas; Internacionais; Territorial Ano: 2010; 2015; 2019; 2020; 2023; 20; Mes: Janeiro; Fevereiro; Março; Abril; Ma Ilha: São Miguel

| Transportes Aéreos | | 2023 | | | | | | | | | | | |
|--------------------|---------------------------|---------|-----------|--------|---------|---------|---------|---------|---------|----------|---------|----------|----------|
| | | Janeiro | Fevereiro | Março | Abril | Mai | Junho | Julho | Agosto | Setembro | Outubro | Novembro | Dezembro |
| São Miguel | Passageiros Embarcados | 62 793 | 59 662 | 75 434 | 104 736 | 108 027 | 122 978 | 145 452 | 158 946 | 136 935 | 105 856 | 72 276 | 68 085 |
| | Passageiros Desembarcados | 58 949 | 60 098 | 79 125 | 105 808 | 108 947 | 126 516 | 151 766 | 156 831 | 129 880 | 102 048 | 67 666 | 72 312 |
| | Passageiros em trânsito | 2 855 | 2 019 | 2 562 | 2 547 | 2 503 | 2 469 | 2 832 | 2 158 | 1 815 | 1 801 | 2 502 | 3 534 |

Figure 7.8: Number of passengers boarded, disembarked, and in transit per month in 2023 in João Paulo II Airport.

TipoVoo: Interilhas; Internacionais; Territorial Ano: 2010; 2015; 2019; 2020; 2023; 20; Mes: Janeiro; Fevereiro; Março; Abril; Mai Ilha: São Miguel

| Transportes Aéreos | | 2024 | | | | | | | | | | | |
|--------------------|---------------------------|---------|-----------|--------|---------|---------|---------|---------|---------|----------|---------|----------|----------|
| | | Janeiro | Fevereiro | Março | Abril | Mai | Junho | Julho | Agosto | Setembro | Outubro | Novembro | Dezembro |
| São Miguel | Passageiros Embarcados | 64 170 | 65 077 | 82 872 | 107 287 | 125 266 | 145 728 | 165 449 | 178 005 | 154 911 | 116 633 | 79 040 | 68 785 |
| | Passageiros Desembarcados | 61 655 | 65 593 | 85 646 | 112 349 | 124 800 | 148 730 | 172 181 | 174 206 | 147 572 | 111 588 | 74 632 | 74 406 |
| | Passageiros em trânsito | 3 093 | 2 504 | 1 800 | 2 870 | 1 340 | 2 419 | 2 108 | 2 585 | 1 569 | 1 864 | 1 957 | 2 423 |

Figure 7.9: Number of passengers boarded, disembarked, and in transit per month in 2024 in João Paulo II Airport.