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Investigating the impacts of aviation subsidies on regional wellbeing in New Zealand

A thesis presented in partial fulfilment of the requirements for the degree of

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Abstract

Air transport plays an important role in maintaining regional connectivity and accessibility, which links geographically dispersed areas of New Zealand. The regional aviation subsidy policy vacuum in New Zealand highlights the need to understand the relationship between aviation subsidies and regional wellbeing outcomes. The COVID-19 pandemic has devastated economies and many sectors worldwide, including the aviation industry, which has also amplified the challenges for smaller, financially fragile regional airlines and airports in New Zealand. Therefore, this PhD thesis aims to provide a comprehensive understanding of the inter-relationships among aviation subsidies, air transport activity, and regional wellbeing by investigating the case of New Zealand. Chapter 1 systematically reviews the prior literature and publications for obtaining a better understanding of how aviation subsidies and their relationship with regional wellbeing have been researched, which provide an initial foundation for the other chapters in this thesis. The findings highlight the effects of aviation subsidies on various facets of regional wellbeing and imply that the full picture of aviation subsidies' impacts on regional wellbeing remains uncertain. Chapter 2 delineates stakeholders' perspectives and opinions about the key air transport and regional wellbeing indicators that need to be considered for designing and implementing aviation subsidies. The findings highlight the necessity of integrating economic and social wellbeing into regional subsidy policy design and implementation. Chapter 3 analyses the inter-relationships among aviation subsidies (i.e. airport subsidies), air transport activity, and regional wellbeing during the pre-COVID era. The findings indicate that the provision of airport subsidies benefited smaller and remote airports/regions and stimulated airline services, thereby promoting regional economic prosperity. Moreover, the results suggest that airport authorities in New Zealand should form stronger partnerships and coordinate with policymakers to ensure that airport subsidies are factored into their policies for regional economic development. Chapter 4 examines aviation subsidies' impacts on regional air passenger flows during the post-COVID lockdown period. It was found that airline subsidies under a trial national aviation funding scheme (i.e. the Essential Transport Connectivity (ETC) scheme) positively impacted regional air travel during the post-COVID lockdown period. Overall, the four chapters of this thesis contribute to the air transport literature on the aviation subsidy–regional wellbeing nexus, and also offer policy insights to establish a national aviation subsidy framework in the post-COVID-19 era.

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First of all, great thanks must be given to my parents, Baokang Wu and Yaqing Weng. I could not have undertaken this PhD journey without their encouragement and love. They continue to give me the strength and courage to fulfil my goals and dreams. Thank you for everything.

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Introduction

It is generally accepted that strengthening air connectivity to regions is essential to their development, particularly for facilitating the economic growth (including tourism) of peripheral regions (Alkaabi & Debbage, 2007; Brueckner, 2003). However, regional air routes are often financially unviable because of insufficient air travel demand and higher fixed and operational costs of local airports (Fageda et al., 2018, 2019). Another significant problem is that smaller communities may often face shortages of funding to attract and retain commercial air services (Baker et al., 2015). Hence, Gössling and Peeters (2007) suggested that government involvements, reflected in subsidies or support for air transport, seems to be necessary, as governments have an overall responsibility to maintain the framework for provision of the public transport system.

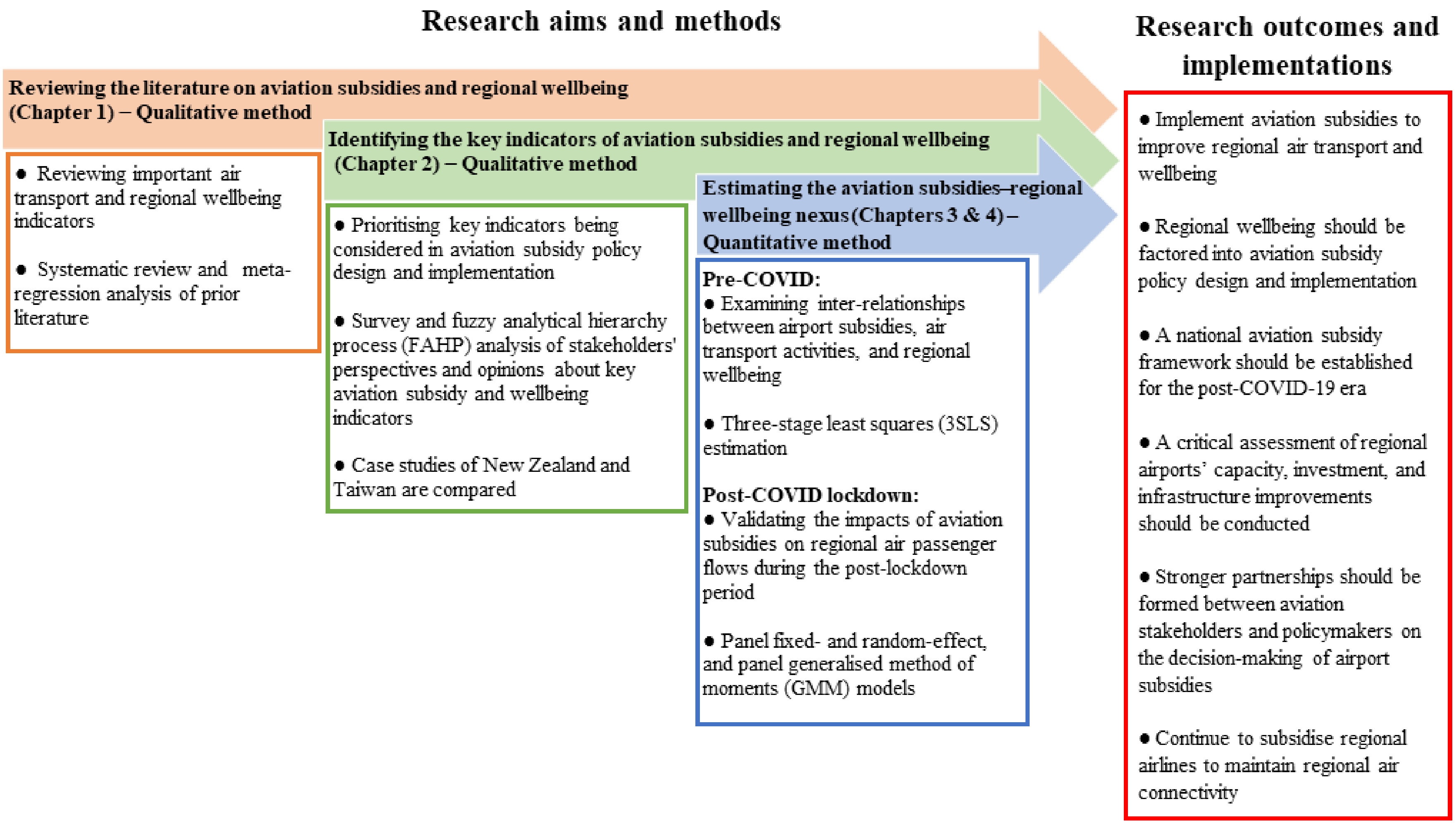
In New Zealand, remote and smaller regions (e.g. the Chatham Islands, Westport, and Hokitika) have long suffered from limited air accessibility, which has negatively impacted their economic growth and the wellbeing of local communities (New Zealand Airports Association, 2017). Unlike the land, maritime, and rail transportation sectors, which receive funding from the New Zealand government, there is no consistent national policy and funding system for the aviation sector to ensure essential air connectivity to isolated communities and smaller regions in New Zealand. The New Zealand Airports Association (2017) has publicly called for the New Zealand's central and local/regional governments to recognise the importance of well-functioning regional airports for the regions' wellbeing, and to form a national funding system for regional aviation. Moreover, the New Zealand Ministry of Transport (2019) asserted that the New Zealand government's involvement in air transport planning and investment significantly impacts not only how people travel and how products are transported, but also other outcomes, such as economic prosperity, social development, regional tourism, and the quality of the living environment. Since aviation subsidy policies involve public resources and values, policymakers should not ignore the influence of air transport on social and economic wellbeing. Accordingly, they should integrate specific wellbeing outcomes that can be achieved through policy design, implementation, and investment decisions for regional aviation subsidies (Delbosc, 2012).

Therefore, this important issue has prompted this PhD thesis to examine the interplay of aviation subsidies and regional wellbeing, as well as to offer empirical evidence to validate whether regional aviation subsidies can improve regional economic growth (including tourism) and social wellbeing, in the case of New Zealand. Importantly, though analysing the relationship between aviation subsidy policies and regional wellbeing, this thesis thus offers rich insights to the New Zealand government's present regional aviation policies and strategies, and lays the foundation for its future aviation subsidy policy design and implementation as well as those in other countries or regions without aviation subsidy policies in place.

The mixed-method approach (qualitative and quantitative methods) used in this PhD thesis and the research framework are shown in Figure 1. In order to better understand the interplay of aviation subsidies and regional wellbeing, it is necessary to first look at the cases in other countries that have implemented aviation subsidies (e.g. the Essential Air Service (EAS) scheme in the United States (US), the Public Service Obligation (PSO) in European countries, and the Regional Aviation Access Programme (RAAP) in Australia). A systematic literature review and a meta-regression analysis are conducted in Chapter 1 to achieve a synthesis and obtain a better understanding of how aviation subsidies and their relationship to regional wellbeing have been researched, which offers an initial foundation for other three chapters in this thesis. Based on the findings in Chapter 1, Chapters 2 and 3 delineate stakeholders' perspectives and opinions about the key air transport and regional wellbeing indicators that need to be considered for designing and implementing aviation subsidies, as well as empirically examining the dynamic links among airport subsidies, aviation activity, and various facets of regional wellbeing during the pre-COVID era. Because of the unprecedented devastating impacts of the COVID-19 pandemic on New Zealand's regional economies, aviation, and wellbeing, the New Zealand government first attempted to form a trial national funding system, namely the Essential Transport Connectivity (ETC) scheme to ensure essential air services to smaller and remote regions (Ministry of Transport, 2022). As the New Zealand government views essential air services as the key to recovering domestic aviation and regional economies during the COVID-19 era, Chapter 4 offers empirical evidence to validate the impacts of aviation subsidies on regional air travel during the post-COVID lockdown period.

Figure 1

Research framework of this PhD thesis



Overall, this PhD thesis aims to address gaps in the air transport literature regarding the inter-relationships between aviation subsidies and regional wellbeing, using the case of New Zealand. Not only does this thesis explore New Zealand stakeholders' perspectives and opinions about aviation subsidies, but also provides clear and empirical evidence of the impacts of aviation subsidies on New Zealand's regional air transport and wellbeing before and during the COVID-19 pandemic (i.e. the post-COVID lockdown period). More importantly, this thesis offers policy insights and recommendations to the New Zealand government and aviation stakeholders regarding the design and implementation of a formal national aviation subsidy framework, which can support New Zealand's regional aviation operations and improve regional wellbeing during the post-COVID era.

Research objectives

To recognise the significance of aviation subsidies to regional aviation activities while acknowledging how air connectivity impacts regional wellbeing, this PhD thesis sets out to fulfil the following research objectives:

1. To provide an overview of regional aviation subsidies and the impacts of aviation subsidies on regional wellbeing;
2. To identify the critical air transport and wellbeing indicators (resulting from Objective 1 above) that are considered by stakeholders in designing and implementing regional aviation subsidy policies;
3. To examine the inter-relationships among airport subsidies, air transport activity, and regional wellbeing;
4. To assess the effect of aviation subsidies on the recovery of the regional aviation markets during the post-COVID lockdown period.

Contributions and managerial implications

This PhD thesis contributes to the air transport literature on the aviation subsidies–regional wellbeing nexus. The findings offer policy insights to New Zealand's central and local/regional governments and aviation stakeholders (e.g. airlines, airports, and tourism practitioners) to establish a formal national aviation subsidy framework that supports regional aviation and benefits social and economic wellbeing.

1. This thesis is among the first research to examine the interaction between aviation subsidies and regional wellbeing. It provides the first systematic review of the impacts of aviation subsidies on regions' wellbeing. It contributes to the limited contemporary research by shedding some lights on the relationship between aviation subsidies and regional wellbeing. More importantly, it proposes a number of avenues for future research to help academics, practitioners, and policymakers better understand the aviation subsidy–regional wellbeing nexus (see Chapter 1).

2. As most prior studies have focused on aviation subsidies in the US, European countries, and Australia, this thesis investigates aviation subsidies in the New Zealand context, thus enriching the existing knowledge on the effects of aviation subsidies on regional wellbeing beyond these highly researched countries or regions (see Chapters 2, 3, and 4).

3. This thesis delineates stakeholders' perspectives and opinions in terms of regional aviation subsidies. Unlike prior studies discussing and critiquing the importance of aviation subsidies, this thesis documents and highlights the role of regional wellbeing outcomes on the formation of aviation subsidy policies which has seldom been discussed and researched previously. It contributes to the air transport literature by being the first to apply the FAHP approach to evaluate aviation subsidy issues. To survey key stakeholders, it identifies the key air transport and wellbeing indicators be considered for the design and implementation of the regional aviation subsidy policy. More importantly, it makes recommendations to the New Zealand government regarding the future aviation subsidy policy changes that will improve regional economies, tourism, and socio-environmental wellbeing (see Chapter 2).

4. This thesis is among the first research to empirically examine the interaction between aviation subsidies (i.e. airport subsidies) and regional wellbeing during the pre-COVID-19 era, with New Zealand's airports and regions as a case study. It shows strong empirical evidence of the necessity of implementing airport subsidies for New Zealand's regional airports while considering regional wellbeing, and may help policymakers to strategically consider subsidising improvements in regional airports' capacity and infrastructure. It further highlights the importance of establishing a formal national aviation subsidy framework, which ensures that smaller financially struggling airports in New Zealand can

still operate and achieve financial sustainability, as well as maintaining safe minimum standards of the facilities for providing air services. Additionally, the findings of this thesis urge policymakers in New Zealand to be more aware of the impacts of air services on the regions' economic and social growth, particularly smaller and remote regions and communities. Likewise, it offers policy insights to New Zealand's policymakers and aviation stakeholders who should factor regional air transport development and socio-economic wellbeing into aviation subsidy policies (e.g. airport subsidies) (see Chapter 3).

5. This thesis contributes to the air transport literature concerning the recovery of domestic aviation during the post-COVID lockdown period, particularly the role of regional aviation subsidies on the post-pandemic recovery of the domestic aviation market. This thesis explores the impact of the first-ever New Zealand's national aviation subsidy scheme (i.e. the ETC scheme) for supporting regional aviation activities during the post-COVID lockdown period. In addition, it demonstrates that the New Zealand government's support for essential air connectivity to smaller regions has played a vital role in the recovery of the domestic aviation markets during the post-COVID lockdown period. Importantly, the findings of this thesis are timely, providing insights into the effectiveness and feasibility of implementing a formal national aviation subsidy framework to facilitate regional aviation operations and recovery during the challenging post-COVID-19 era (see Chapter 4).

6. This thesis provides a platform for understanding New Zealand's aviation subsidies, air transport activity and regional wellbeing before and amid the COVID-19 pandemic. Chapter 1 reviews the prior literature and promotes further considerations of the relationship between aviation subsidies and regional wellbeing. Chapter 2 explores the stakeholders' perspectives and opinions about the key air transport and regional wellbeing indicators considered in forming and implementing a regional aviation subsidy policy in the early stages of the COVID-19 pandemic. Chapter 3 analyses the pre-COVID relationships between airport subsidies and regional wellbeing in New Zealand. Chapter 4 examines the effects of aviation subsidies (subsides to airlines and airports) implemented during the post-COVID lockdown period on regional air travel. Overall, this thesis keeps abreast of the New Zealand government's aviation subsidy policy before and amid the COVID-19 pandemic. The findings of this thesis offer evidence-based policy recommendations and practical insights to policymakers and industry stakeholders in New

Zealand (e.g. government officials, local/regional authorities, airlines, airports, and aviation-related sectors), which will improve regional air services, connectivity and regional wellbeing. Importantly, this thesis highlights the importance of developing a formal national aviation subsidy framework to better connect smaller and remote regions and communities across New Zealand during the post-COVID era (see Chapters 1, 2, 3, and 4).

A formatting note

All the studies presented in this PhD thesis have been reproduced as already published or submitted for publication. However, there have been some editorial changes made to all the studies in terms of formatting (e.g. tables and figures), referencing style (this thesis uses APA 7th style), spelling and the use of third person to ensure consistency throughout the thesis. All the acknowledgements have also been removed from the studies in the thesis. Accordingly, there may be superficial differences among the studies reproduced in this thesis. The versions given here have been published or are under review, but no changes have been made to the substance of the studies. It should also be noted that when the term "chapter" is used, this refers to the whole chapter, including the preamble, whereas the term "study" is used when only referring to the work that has been published or is under review for publication. There may be repetition in many places in this thesis. In accordance with the *Massey University Graduate Research School's Doctoral Thesis with Publication Guidelines*, it is noted that repetition in the thesis with publication pathway cannot be avoided.

Chapter One – Overview of aviation subsidies and regional wellbeing

Preamble

Air transport plays a vital role in fostering regional development, particularly in facilitating economic prosperity, generating trade, and creating employment opportunities. Its importance may be particularly strong in smaller and remote regions, where air connectivity and accessibility are difficult and costly. However, connecting remote regions is not always economically attractive for airlines, and thus regional airports suffer financial pressures to maintain minimum safe standards of the facilities and infrastructure. Hence, many countries worldwide have implemented aviation subsidy policies to guarantee sufficient air connectivity for smaller and remote communities. Moreover, the regional aviation subsidy policies purportedly facilitate regional development and wellbeing from the regional policymaking perspective. This chapter addresses the first research objective of the thesis (i.e. to provide an overview of regional aviation subsidies and the impacts of aviation subsidies on regional wellbeing). To do that, it undertakes a systematic review of the prior literature and publications and a meta-regression analysis (MRA) to achieve a synthesis to understand the aviation subsidy–regional wellbeing nexus. The findings of the systematic review suggest that there is still ambiguity and debate about the impacts of aviation subsidies on regional air transport activity and regional wellbeing. In addition, most of the prior literature and publications have only examined the indicators associated with air services, such as air accessibility and airfares. The MRA results additionally show that the likelihood of air transport activity, economic, and social wellbeing being investigated in prior studies is sensitive to the subsidy type, subsidy beneficiaries, study characteristics, geographic areas and research methods used in prior studies. Importantly, this chapter indicates that the impact of aviation subsidies on regional wellbeing remains a puzzle, and so further work is required when more reliable data can be accessed to develop more relevant indicators for this contemporary topic via evidence-based research. This chapter also lays the foundation for the following chapters in this thesis (Chapters 2, 3 and 4) exploring the relationship between aviation subsidies and regional wellbeing before the COVID-19 pandemic and during the post-COVID lockdown period, using New Zealand as a case study.

Study One: Impacts of aviation subsidies on regional wellbeing: Systematic review, meta-analysis and future research directions

Publication status and candidate contribution

This study was published in a *Transport Policy* in December 2020. The doctoral candidate is the first and corresponding author of the publication who contributed the most to the work, with all the doctoral supervisors being co-authors.

1.0 Abstract

More than 100 publications were systematically reviewed on the contemporary topic of aviation subsidies and their impacts on regional wellbeing. The results show that the US and European countries have received significant attention in prior research. Moreover, the majority of publications were concerned with air transport activity, whereas economic, social and environmental wellbeing were less researched. It was noted that a full picture of aviation subsidies' impacts on regional wellbeing remains uncertain, as the majority of prior studies have mostly examined indicators associated with air services. The meta-regression results further suggest that subsidy types, subsidy beneficiaries, study characteristics, geographic areas and research methods are important likely sources of variation in the likelihood of investigating various wellbeing categories. It seems that a prior publication studies aviation subsidies' impacts on environmental wellbeing over other wellbeing categories (i.e. air transport activity, economic wellbeing, and social wellbeing) is less likely to report the positive effects of aviation subsidies. This systematic review helps identifying several directions for future studies.

1.1 Introduction

In the aviation sector, subsidies have a long history since the beginning of commercial aviation, such as the Civil Aeronautics Act of 1938 in the US or state subsidies to French airlines competing with British Airline in 1919 (Barnes, 1959; Eaton, 1996). It has also been a controversy topic for several decades. A well-known example is the continuous dispute between US airlines and Gulf airlines regarding unfair competition (Bock et al., 2019; Duesterberg, 2018). Considering that subsidies are tricky to define and even more challenging to identify because of a lack of transparency (Forsyth & Guiomard, 2019; Gössling et al., 2017), there are limited reviews studies on aviation subsidy. A recent comprehensive review by Gössling et al. (2017) identified and described a wide range of subsidies relevant to aviation along its value chain, including manufacturers, infrastructure providers (airports and air traffic control) and airlines. Another study conducted by Fageda et al. (2018) critically reviewed the existing worldwide aviation subsidy policies in remote regions, including (i) route-based policies (Public Service Obligation (PSO) and Essential Air Service (EAS)), (ii) passenger-based policies (airfare discounts to residents), (iii) airline-based policies (state-owned airlines), and (iv) airport-based policies (airline incentive schemes and subsidies to airports such as Airport Improvement Program). However, these reviews did not include detailed discussions on aviation subsidy policies' impacts on regional wellbeing as this was beyond the scope of those studies. This study will fill this gap by focusing on aviation subsidies that are relevant to regional wellbeing to provide insights at regional level.

As air transport provides a timely and reliable mechanism by which to transfer individuals, goods and services from one place to another, it is widely accepted that air transport is essential to development, particularly in facilitating economic growth (including tourism) in the peripheral regions (e.g. Albalate & Fageda, 2016; Alkaabi & Debbage, 2007; Brueckner, 2003; Button et al., 2010; Debbage & Delk, 2001; Donehue & Baker, 2012; Goetz, 1992; Green, 2007; Mukkala & Tervo, 2013; Tveter, 2017; Van de Vijver et al., 2016). More importantly, the quality of air service can also be viewed as being a social right of the residents of remote communities (Fageda et al., 2018, 2019; Halpern & Brathen, 2011). For example, essential services such as hospital treatment and education are often limited in remote regions; hence, these communities have to rely on air transport to connect with larger communities. However, regional routes are often financially unviable because of insufficient air passenger demand and higher fixed costs of airline operations (e.g. Donehue & Baker, 2012; Fageda et al., 2018, 2019; Mukkala & Tervo, 2013). Another significant factor is that smaller communities may often face an unprecedented funding crisis for attracting and retaining commercial air services (Baker et al., 2015; Mills & Kalaf-Hughes, 2017). By recognising air transport's potential for fostering regional economic and social growth (e.g. Fageda et al., 2018, 2019; Jackson & Murphy, 2006; Ramos-Pérez, 2016), along with the government's responsibility for improving mobility and accessibility in rural areas (Gössling & Peeters, 2007; Merkert & O'Fee, 2013), governments in many countries have invested substantial amounts of resources into various support programmes (e.g. PSOs in European countries and EAS in the US) to support air transport development, especially in remote or small communities. Therefore, achieving a sound understanding of aviation subsidies' impacts on regional wellbeing is essential because of their considerable potential consequences, including rapidly growing regional aviation activities, strengthened regional economy, increased tourism and environmental impacts (Fageda et al., 2018; Gössling et al., 2017). Although a significant amount of research has been carried out in the US (EAS) and European countries (PSOs), most of the studies in this field have focused on assessing the design and effects of subsidy programmes with respect to defining an eligible route or the determining service levels, fares and subsidies (e.g. Fageda et al., 2016, 2017; Fageda et al., 2019; Merkert & O'Fee, 2013; Williams & Pagliari, 2004; Wittman et al., 2016), the number of passengers transported (Abreu et al., 2018; Di Francesco & Pagliari, 2012) and the efficiency of implementing the programme (Merkert & Williams, 2013; Pita et al., 2014; Santana, 2009). Although these prior studies provided useful insights into the outcomes of the regional aviation subsidies programmes, knowledge of subsidies' impacts on regional wellbeing is still fragmented and unclear.

In light of the scarcity of academic research on this issue, aviation subsidies relevant to regional wellbeing will be thoroughly and systematically reviewed in this study. Specifically, this study aims to conduct a systematic literature review and a meta-analysis to bridge the gap. The results of this study may help academics, practitioners, government agencies and others interested in this topic to achieve a synthesis and a better understanding of aviation subsidies' impacts on regional wellbeing. This study attempted to address the following research questions:

- *How have aviation subsidies relevant to regional wellbeing been researched?*
- *What are the impacts of aviation subsidies on regional wellbeing?*
- *What are the key differences in the results of previous studies regarding the impacts of aviation subsidies on regional wellbeing?*

To the best of the authors' knowledge, this study is the first systematic review of the impacts of aviation subsidies, especially at regional level; therefore, the findings will make a significant contribution to shedding some light on the relationship between aviation subsidies and regional wellbeing. Another important reason that makes this study meaningful is its managerial implications, which may help policy makers and practitioners who want to improve the interplay of aviation subsidies and regional wellbeing by deepening their knowledge about this contemporary issue.

The remainder of the paper is organised as follows: Section 1.2 presents the process of selecting the key studies for reviews purpose and describes the research methodology. In Section 1.3, the results of descriptive analysis, content and thematic analyses, and meta-regression analysis are summarised. Section 1.4 includes a discussion of the key findings and offers suggestions for future work. Finally, Section 1.5 includes a conclusion and discusses the limitations of this study.

1.2 Methodology

1.2.1 Search strategy

Systematic review papers differ from traditional narrative reviews in which the methods are explicit, rigorous and replicable (Boland et al., 2017). The advantage of this type of review is that it can include all the available studies that present both positive and negative results in a specific research field (Torgerson, 2003). To address the research question, prior review studies relevant to aviation subsidies (Bråthen & Halpern, 2012; Fageda et al., 2018; Gössling et al., 2017) were searched and their reference lists were used as a useful starting point in searching for other relevant literature. Next, a broad-scale search was conducted for studies on aviation subsidies from three electronic databases (Google Scholar, Web of Science and Scopus) up to August 2019[1] to identify the overall trend and evolution of research in aviation subsidies. The following Boolean search string was used in each of the databases: "public service obligation" or "essential air service" or "state-owned airline" or "airport incentive program" or ("aviation" or "air transport" or "airport" or "airline" or "air traffic control" or "aircraft" or "air service") and ("subsidy*" or "government subsidy*" or "bailout" or "financial support" or "state aid" or "cross-subsidisation" or "subsidy scheme" or 'financial aid" or "grants" or "tax exemption*" or "remote region" or "remote communities" or "remote area" or "peripheral region"). This literature search was fairly extensive and varied, including textbook chapters, government and industrial reports, conference papers, discussion papers, working papers and academic journal articles. Because aviation subsidies are close to government policies and the aviation industry,

[1] The literature search stage was completed by August 2019, so studies published after August 2019 were not included in this study.

research on this topic has also been performed outside of academic communities by government agencies, industry consultancies and other international and non-governmental groups. Hence, in accordance with the same Boolean search strings, the authors supplemented the three key databases by undertaking additional search for relevant government or industrial reports on Google.com. Note that a bibliographic snowballing technique was used, which involved checking the reference lists of retrieved articles manually for additional relevant studies. All of the literature searches were limited to the English language without restrictions on publication years.

1.2.2 Search results and the reviewing sample

After the searching stage, 470 studies were identified. These 470 studies were filtered to find the relevant literature and remove any duplications. At this stage, 226 duplicate publications or works were removed. The remaining 244 full-text articles were reviewed against the following primary criteria:

- First, all non-peer-reviewed papers (e.g. conference papers, discussion papers or working papers) and unpublished reports were excluded. Only peer reviewed papers, published textbooks and government or industrial reports were kept.
- Second, only studies relevant to aviation subsidies and regional air services were selected, considering the research objective of this study; other studies were excluded.

As a result, 25 articles were eliminated because they were not peer-reviewed papers. Another 109 articles were also excluded and not considered for further review and analysis because their research focus was not directly relevant to regional aviation subsidies and air services. Thus, the authors were left with 110 (out of the initial 470 articles) for further review and analysis.

1.2.3 Data extraction and analysis

A standard extraction form was used to extract the following data and information from the 110 studies above into an Excel spreadsheet:

- Study characteristics: author, year of publication, type of research, title of paper, title of journal, database source, publication types, keywords, and geographical scope stated in the studies.
- Study methodology: research approaches.

- Subsidy beneficiaries: beneficiaries relevant to the aviation sector (e.g. airports, airlines, passengers, aviation suppliers) that received subsidies.
- Subsidy categories: various types of aviation subsidies such as grant and loans, hidden subsidies, no or reduced tax, and subsidy schemes pertaining to remote regions.
- Subsidies' impacts on regional wellbeing: the impacts of aviation subsidies on air transport activity, and economic, social and environmental wellbeing.

Data and information were analysed at three different levels, including descriptive analysis, thematic and content analyses, and meta-regression analysis.

Descriptive analysis

The first level of analysis provides a descriptive analysis of all selected publications. More specifically, the overall trend of the characteristics of selected aviation subsidy studies (e.g. year of publication, publication types, database source, geographical scopes stated in the studies, research methods applied, subsidy beneficiaries and subsidy types) were analysed to understand how the extant research in aviation subsidies relevant to regional air service and wellbeing has evolved through the years.

Content and thematic analyses

Content and thematic analyses were also undertaken to identify various impacts of aviation subsidies on regional wellbeing. The first step in this analysis was to describe the predominant research focus using the text of each publication's title and abstract, and the keywords provided by authors within the selected articles or publications. All selected articles were imported into the VOS viewer software that can construct co-occurrence networks of terms (i.e. VOS maps) extracted from bibliographic data (e.g. keywords provided by authors) and text data (titles and abstracts of publications) (Modak et al., 2019). For this study, two co-occurrence maps were created based on these items reflecting the hotspots for research in aviation subsidies' impacts on regional wellbeing. Those two maps were based on the frequency of keywords and the keywords' co-occurrence. Importantly, the size of circles and keywords in the maps corresponds to the frequency of the keywords; that is, the larger the circles and the words in the maps, the more frequently those keywords were used in the publications and appear to have received more attention than their counterparts (Liao et al., 2018; van Eck & Waltman, 2014). In addition, the distance between the circles and keywords in the maps reflects the relatedness of the keywords (co-occurrence) (Li et al., 2016a; van Eck & Waltman, 2014). Furthermore, the overlay colour of the circles in the maps shows the keyword's research activities corresponding to the average publication year (Su et al., 2018).

The second step were to identify the impacts of aviation subsidies on regional wellbeing by using both inductive and deductive approaches,[2] in which the wellbeing categories and indicators were selected in line with previous studies (i.e. the deductive approach) and by using QSR NVivo version 12 software (i.e. the inductive approach), which is a specific computer-assisted qualitative data analysis tool (Bazeley & Jackson, 2013). NVivo allows us to manage and query data (Bazeley & Jackson, 2013; Sinkovics & Sinkovics, 2016). The combined results of the two yielded a meaningful set of indicators for further analysis. From a deductive approach, the initial deductive wellbeing categories and indicators were based on prior studies that revealed a correlation between air transport and regional wellbeing (e.g. Bilotkach, 2015; Florida et al., 2015; Green, 2007; Halpern & Brathen, 2011; Mukkala & Tervo, 2013; Van Beers & Van den Bergh, 2001). The inductive approach was also applied in this study to identify whether the impacts on air transport activity, and economic, social and environmental wellbeing derived via the deductive approach were examined in aviation subsidies publications, as well as identifying new wellbeing categories and indicators. Thus, all selected publications were imported into NVivo for exploration and categorisation.

Meta-regression analysis

Meta-regression analysis (MRA) is a statistical approach to review or synthesise a large collection of results on a specific subject (Elburz et al., 2017; Elvik, 2005; Gallet & Doucouliagos, 2014; Stanley & Doucouliagos, 2012). The purpose of employing MRA in this study was to explore variations in the results of prior studies regarding the impacts of aviation subsidies on different aspects of regional wellbeing as well as the direction of the effects of aviation subsidies on regional wellbeing, in which prior studies only reported if the impact is positive, negative, or null/not clear. Therefore, a probit model and an ordered probit model

[2] As stated by Thayer et al. (2007), content analysis typically involves two types of content unit: the unit of analysis and the unit of observation. The unit of analysis concerns the general idea being studied; for this study, the unit of analysis is aviation subsidies' impacts on regional wellbeing. The unit of observation concerns the specific items, namely the effects of aviation subsidies on regional wellbeing and its various indicators. Generally, there are two measurement methods for examining the unit of observation: deductive measurement and inductive measurement. The former requires a developed conceptual and theoretical structure prior to starting a content analysis, whereas the latter is concerned with the generation of new theory emerging from the data and information obtained (Castro & Lohmann, 2014; Thayer et al., 2007).

were employed to examine the differences in the results of previous studies regarding the impacts of aviation subsidies on regional wellbeing. The two models are presented in Equations (1) and (2), respectively; readers are encouraged to look for more details on those models in Elburz et al. (2017), Greene (2003), Liao (1994), Maddala (1986), Minviel and Latruffe (2017), and Wooldridge (2016), among others. Note that in ordered probit, the marginal effects, which measure the change in the dependent variable as a function of the change in a certain explanatory variable, provide more information than the estimated coefficients themselves (e.g. De Groot et al., 2009; Greene, 2003; Liao, 1994; Wooldridge, 2016). The statistical software of Stata version 16 was used to estimate the parameters of the two models.

The probit model is as follows:

$$y_i^* = x_i\beta + \varepsilon_i \tag{1}$$

$$\text{No impact was reported } y = 0 \text{ if } y^* \leq 0$$

$$\text{(Any) impact was reported } y = 1 \text{ if } y^* > 0$$

where y^* is an underlying variable[3] that is unobserved; x_i is a vector of explanatory variables such as hidden subsidies, airlines or the number of countries involved in the publications; βs represents the coefficients to be estimated and ε_i represents the error term.

The ordered probit model is established as follows:

$$y_i^* = x_i\beta + \varepsilon_i \tag{2}$$

$$\text{Negative effect } y = 0 \text{ if } y^* \leq 0$$

$$\text{Null effect } y = 1 \text{ if } 0 < y^* \leq \mu$$

$$\text{Positive effect } y = 2 \text{ if } \mu \leq y^*$$

The major difference between Equation (2) and Equation (1) is the introduction of μ as the threshold parameter (which is estimated from the data) so that Equation (2) can separate the adjacent categories to be estimated with β, thus estimating the probability associated with each observed effect.

[3] The variable does not have the traditional meaning of a latent variable. Here, y^* is unobserved and thus can be thought of as the underlying tendency of an observed phenomenon. In this model, it only allows us to model the probability of observing a positive, null or negative effect, conditional on the explanatory variables.

For the estimation purposes, all the explanatory variables identified from the selected publications from descriptive and content and thematic analyses have been divided into six groups, namely wellbeing category, subsidy types, subsidy beneficiaries, study characteristics, geographic areas and research method. The descriptive statistics for all the variables of interest in the probit and order probit models are presented in Table 1. Various issues should be noted about the 203 observations from the selected publications (see Appendix A for details). Firstly, after assessing all the selected 110 publications through content and thematic analyses, 36 publications were excluded because their research findings were not related to the four wellbeing categories of aviation subsidies' impacts being investigated (i.e. air transport activity, economic wellbeing, social wellbeing, and environmental wellbeing). Moreover, seven publications were excluded because they are review articles. Therefore, 67 publications remained for MRA. Secondly, the data used in the meta-regression analysis (i.e. 203 observations about the effects of aviation subsidies on regional wellbeing) extracted from 67 publications. Each publication was carefully examined to identify the impacts of aviation subsidies on regional wellbeing. Some selected publications involved several observations since they contained different research findings and/or analyses relating to subsidy types, subsidy beneficiaries, or wellbeing indicators. Finally, note that most of the explanatory variables in the MRA are binary (which only take the values of 0 and 1) because they reflect the characteristics of each study being examined, except for the study period of the research and the number of countries involved in the selected publications.

Table 1

Definition and descriptive statistics used in the meta-regression analysis

Variables	Description	No. of observations	Mean	St. Dev	Min	Max
Dependent variables (probit model)						
Air transport activity	= 1 if the impact on air transport activity is reported; 0 otherwise	105	0.52	0.50	0	1
Economic wellbeing	= 1 if the impact on economic wellbeing is reported; 0 otherwise	50	0.25	0.43	0	1
Social wellbeing	= 1 if the impact on social wellbeing is reported; 0 otherwise	39	0.19	0.39	0	1
Environmental wellbeing	= 1 if the impact on environmental wellbeing is reported; 0 otherwise	9	0.04	0.21	0	1
Dependent variable (ordered probit model)						
Aviation subsidies' effect	= 0 for a negative effect on regional wellbeing	17				
	= 1 for a null effect on regional wellbeing	35				
	= 2 for a positive effect on regional wellbeing	151				
Explanatory variables						
Wellbeing category (for ordered probit only)	= 1 for air transport activity, 2 for economic wellbeing, 3 for social wellbeing and 4 for environmental wellbeing	203	1.76	0.91	1	4
Subsidy types						
Grants and loans	= 1 if the type of subsidy is grants; 0 otherwise	32	0.16	0.37	0	1
Hidden subsidies	= 1 if the type of subsidy is hidden subsidies; 0 otherwise	14	0.07	0.25	0	1
Subsidy schemes pertaining to remote regions	= 1 if the type of subsidy is grants to provide air transport services to remote regions; 0 otherwise	145	0.71	0.45	0	1
Subsidy beneficiaries						
Airports	= 1 if the subsidy beneficiaries are airports; 0 otherwise	34	0.17	0.37	0	1
Airlines	= 1 if the subsidy beneficiaries are airlines; 0 otherwise	149	0.73	0.44	0	1
Local residents	= 1 if the subsidy beneficiaries are local residents; 0 otherwise	14	0.07	0.25	0	1
Research characteristics						
Journal article	= 1 for a journal article; 0 otherwise	152	0.75	0.43	0	1
Number of countries	Continuous variable, number of countries involved in the study	203			1	27
Study period	Continuous variable, timespan of the study	175			1	27
Geographic areas						
Europe	= 1 for European countries; 0 otherwise	95	0.47	0.50	0	1
North America	= 1 for North American countries; 0 otherwise	63	0.31	0.46	0	1
Research methods						
Case study	= 1 if a case study is the primary method applied in the study; 0 otherwise	24	0.12	0.32	0	1
Empirical study	= 1 if an empirical approach is the primary method applied in the study; 0 otherwise	135	0.67	0.47	0	1
Survey approach	= 1 if a survey approach is the primary method applied in the study; 0 otherwise	17	0.08	0.28	0	1

Note: Some variables are not applicable to have the mean number as they are categorical variable (i.e. *aviation subsidies' effect*) and continuous variables (i.e. *number of countries* and *study period*). The explanatory variable of *study period* was not applicable in five studies and therefore 28 observations have missing values for this variable.

1.3 Results

This section is divided into three parts. The first provides a descriptive analysis of the 110 publications selected as relevant to the topic of aviation subsidies' impacts on regional wellbeing. Content and thematic analyses are then carried out to examine the impacts of aviation subsidies on regional wellbeing (i.e. air transport activity, economic wellbeing, social wellbeing, and environmental wellbeing). Finally, the results of the MRA are presented.

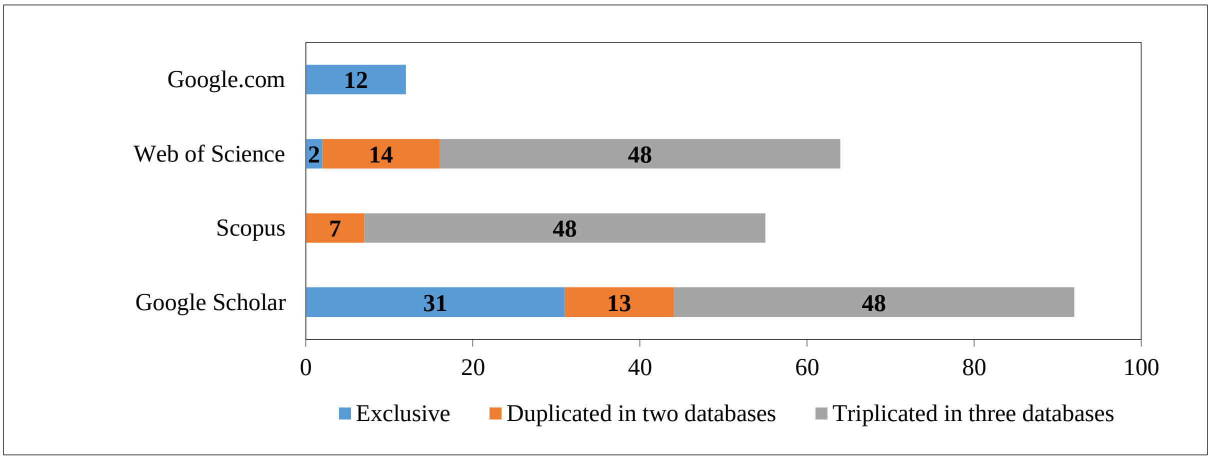
1.3.1 Descriptive analysis

Characterisation of selected publications

Considering the publications on aviation subsidies relating to regional wellbeing between January 1974 and August 2019 (see Appendix B), there is a flat trend before 2010 and a considerable increase from seven publications in 2011 to 17 publications in 2012. After 2012, there is an overall downward trend, from 12 publications in 2013 to seven publications in 2018. However, this research topic has attracted increasing attention from researchers since 2011. Regarding the distribution of related literature by publication type, journal articles represent the largest proportion, accounting for 86 (78%) publications. Next comes industrial and government reports, standing at 21 (19%) publications, whereas textbook chapters are considerably less common at three (3%) publications. Figure 2 illustrates the related literature's distribution by source: 92 (84%) studies were found in Google Scholar, followed by Web of Science (64 studies) and Scopus (55 studies). In addition to these three databases, 12 (11%) publications, mostly industrial and government reports, were retrieved from Google.com. Among the 110 publications, 48 (44%) publications were duplicated in the three academic databases (Google Scholar, Web of Science and Scopus).

Figure 2

Literature distribution by source (n = 110)

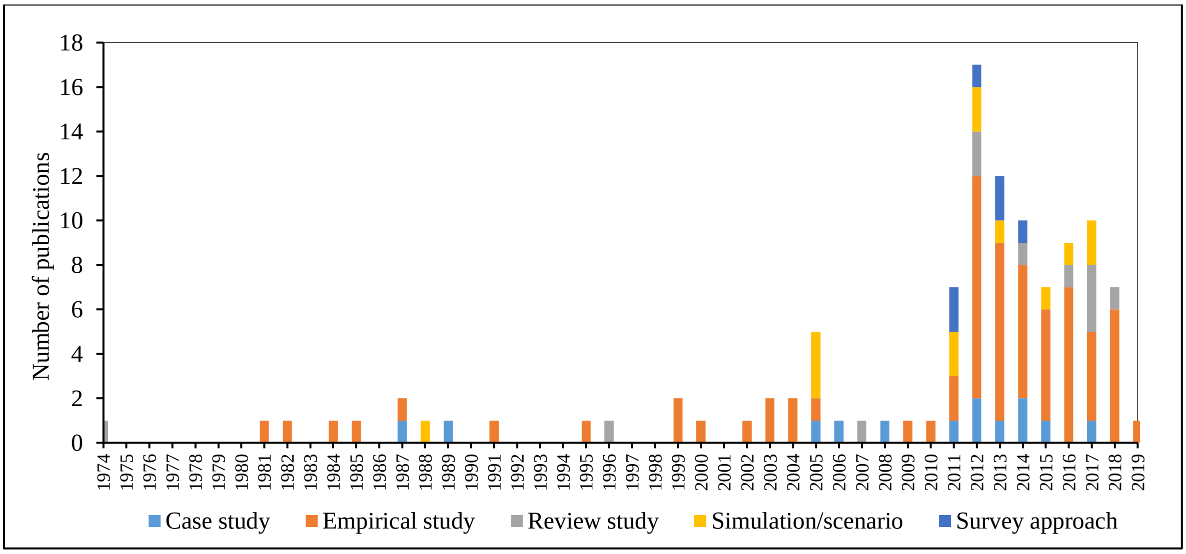


Not surprisingly, considering that EAS and PSOs have served regions and remote communities in the US and the European Union (EU) territories for decades, the US and EU countries have received significant attention in previous publications. Of the 110 publications, 47 have been conducted on air transport funding programmes in the US, followed by research on aviation subsidy programmes in the EU, including France (23 studies), Italy (22 studies), Norway (23 studies), Spain (26 studies) and the UK (30 studies). In terms of Oceania countries, Australia has been studied the most with nine studies, followed by New Zealand (2 studies) and South Pacific islands, including the Cook Islands (2 studies), the Solomon Islands (1 study), and Tonga (1 study). Moreover, only four Asian countries, India (3 studies), Indonesia (1 study), Japan (5 studies) and Malaysia (3 studies), have been studied in previous literature. It would seem that countries in Oceania and Asia have attracted less attention in this field. African and South American countries rarely received attention on this topic. It should be noted that the 29 selected publications involved cross-country analysis. A choropleth map that shows the countries studied in the selected publications is presented in Appendix C.

In addition, five different types of research design are currently being used in aviation subsidy research, namely case study, empirical study, review study, scenario simulations and survey approach. As shown in Figure 3, the empirical study (67 studies) is the most widely used method in researching regional aviation subsidies; case study and scenario simulations stand at 13 publications each, as the second-equal most popular methods, followed by review study (11 studies) and survey approach (6 studies). It is worth noting that 42 publications used two or more research methods. Here, each publication was eventually classified into one research methodology category on the basis of its most significant focus method.[4] Moreover, it seems that the empirical approach has continually been applied more often than other research methods to analyse the impacts of aviation subsidies on regional wellbeing. Since 2011, the number of publications adopting the empirical approach have increased considerably, rising to a high point of 10 publications and peaking in 2012, then falling to an average of six publications per year in the following years. Recently, the popularity of the review study has risen.

Figure 3

Trends in research methodology (January 1974–August 2019)



Number of publications involved	Case study	Empirical study	Review study	Simulation/scenario	Survey approach
	13	67	11	13	6

Research focus of aviation subsidy beneficiaries and subsidy types

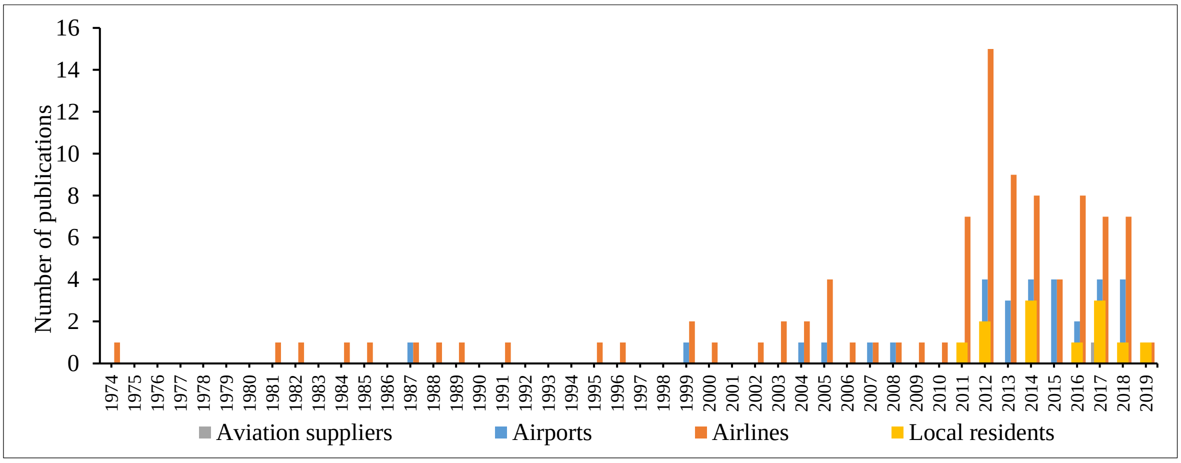
One of this study's objectives is to analyse the impacts of aviation subsidies on regional wellbeing, it appears necessary to identify the focus of previous research into aviation subsidy beneficiaries and subsidy types. Firstly, four major aviation subsidy beneficiaries were found, as shown in Figure 4. Note that more than one type of aviation subsidy beneficiary could be identified in one publication. Of the 110 publications, 92 (84%) publications were concerned with airlines. Airports accounted for 32 (29%) publications, making them the second most-

[4] This avoids the double-counting issue in the results and will not cause any confusion, as this study's objective is to describe the predominant research method applied within the selected articles, not how many times each research method has been performed.

studied beneficiaries of regional aviation subsidies. The subsidy beneficiaries featured in the fewest publications, however, were local residents (12 studies) and aviation suppliers (1 study). The majority of examined publications chose airlines as the focal point, and topic of aviation subsidies in relation to airports and local residents has gradually been brought to the attention of academics and industry practitioners since 2011.

Figure 4

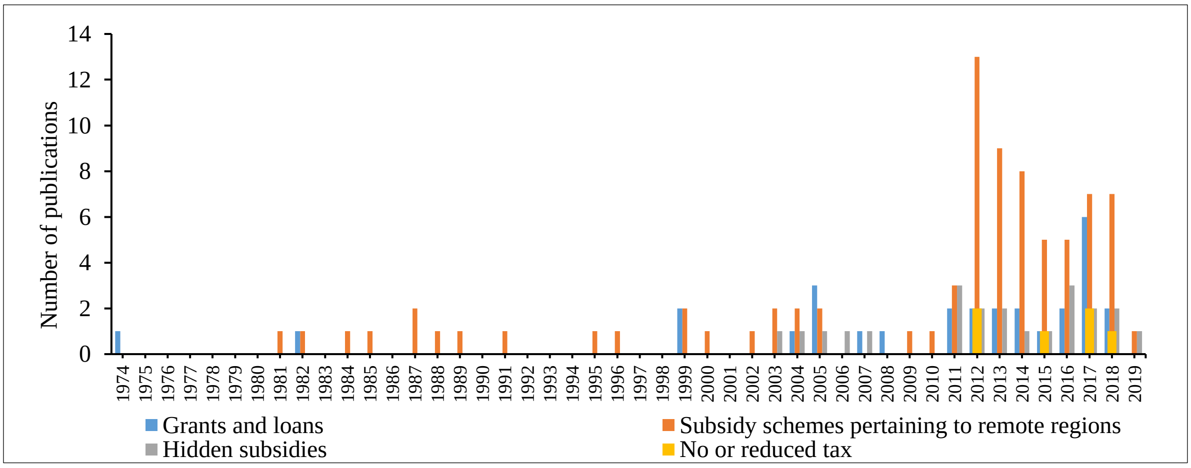
Trends in aviation subsidy beneficiaries (January 1974–August 2019)



Number of publications involved	Aviation suppliers	Airlines	Airports	Local residents
	1	92	32	12

Figure 5

Trends in aviation subsidy type (January 1974–August 2019)



Number of publications involved	Grants and loans	Subsidy schemes pertaining to remote regions	Hidden subsidies	No or reduced tax
	29	82	22	6

Table 2

Breakdown of aviation subsidy types

Breakdown of aviation subsidy types		Number of publications	Breakdown of aviation subsidy types		Number of publications
Grants and loans	R & D	1	Subsidy schemes pertaining to remote regions	Route-based	67
	Exports	1		Airport-based	22
	Investments	8		Airline-based	7
	State aid	6		Passenger-based	11
	Loss coverage	20			
	Equity infusions	1			
	Loan and loan guarantees	3			
Hidden subsidies	Reduced infrastructure fees	18	No or reduced tax	Fuel	5
	Cross-subsidisation	12		Value-added taxes	4
	Monopoly rights	5		Frequent flyer programme	1

Aviation subsidy were categorised into four different types (see Figure 5) based on the classifications of Gössling et al. (2017) and Fageda et al. (2018), which are grants and loans (29 studies), subsidy schemes pertaining to remote regions (82 studies), hidden subsidies (22 studies) and no or reduced tax (6 studies). Apparently, subsidy schemes pertaining to remote regions have, by far, received the most attention in the literature about regional aviation subsidy, probably because both EAS in the US and PSOs in the EU have been implemented for decades. A breakdown of each type of aviation subsidy is also set out in Table 2. It shows that route-based programmes (67 studies) had been studied the most, followed by airport-based programmes (22 studies), loss coverage (20 studies), reduced infrastructure fees (18 studies), cross-subsidisation (12 studies) and passenger-based programmes (11 studies). Other subsidy types were studied in fewer than 10 publications. Generally speaking, subsidy schemes pertaining to remote regions seem to have continually received the most attention during the past 50 years, whereas not much attention has been paid to other types of regional aviation subsidy. However, more research has been associated with grants and loans since 2004. In addition, few studies have been carried out on no or reduced tax subsidies after 2012. It should be noted that each publication may investigate more than one type of aviation subsidy.

1.3.2 Content and thematic analyses

Network analysis with VOS viewer

Figure 6 illustrates the co-occurrence of keywords listed in the examined publications' abstracts (see Appendix D for details). Those keywords are defined by the authors of each publication to identify its main ideas or focus. In order to increase the pool of keywords, the software was run in which the minimum number of occurrences was set at one and 148 frequent co-occurrence connections were found. It can be seen, therefore, that the keywords with greater frequency were “accessibility”, “air transport”, “airlines”, “airports”, “essential air service”, “public service obligations”, “remote regions”, “state aid” and “subsidies”. As indicated by the colour spectrum at the bottom, blue represents keywords that appeared in earlier publication (before 2005) and red represents keywords that appeared in publications after 2015 (van Eck & Waltman, 2013). In the early stage of research into aviation subsidies and regional wellbeing, “low-cost airlines”, “EU” and “international connectivity” were the main hotspots. However, during the last decade, the keywords were “airlines”, “air connectivity”, “air transport”, “airport state aid”, “public service obligations”, “remote regions” and “subsidies”.

Figure 7 shows the co-occurrence of text in titles and abstracts (see Appendix D for details). The minimum number of occurrences was set at two occurrences, and the 149 most frequently used words were included in the visualisation. Words such as “demand”, “essential air service”, “government”, “remote region”, “PSO”, “state aid” and “transport” have been most frequently used by researchers and had greater weight in previous publications. In publications before 2005, “Airline Deregulation Act”, “demand”, “European Union” and “local government” appear to be used more frequently. As times went on, more attention from researchers was paid to “air connectivity”, “essential air service”, “price”, “PSO” and “remote region”.

Figures 6 and 7 show that keywords that are relevant to the impacts of aviation subsidies on regional wellbeing seem to have been rarely seen in previous publications. There is a distinct lack of knowledge regarding regional wellbeing among previous publications, as only a handful of keywords (e.g. “accessibility or connectivity”, “economic development or growth” and “airfare”) had been used. However, the most frequent keywords used to refer to aviation subsidy programmes were “PSOs” and “EAS”, and air service providers such as “airports” and “airlines”, which confirms the results in Section 1.3.1 that academics and industry professionals have constantly chosen airlines, airports and subsidy schemes as the focal point of aviation subsidy research for the past 50 years. It should be noted that synonyms and words with identical meaning were not merged into a single term when these two co-occurrence maps were created.

Figure 6

Co-occurrence of keywords listed in abstracts

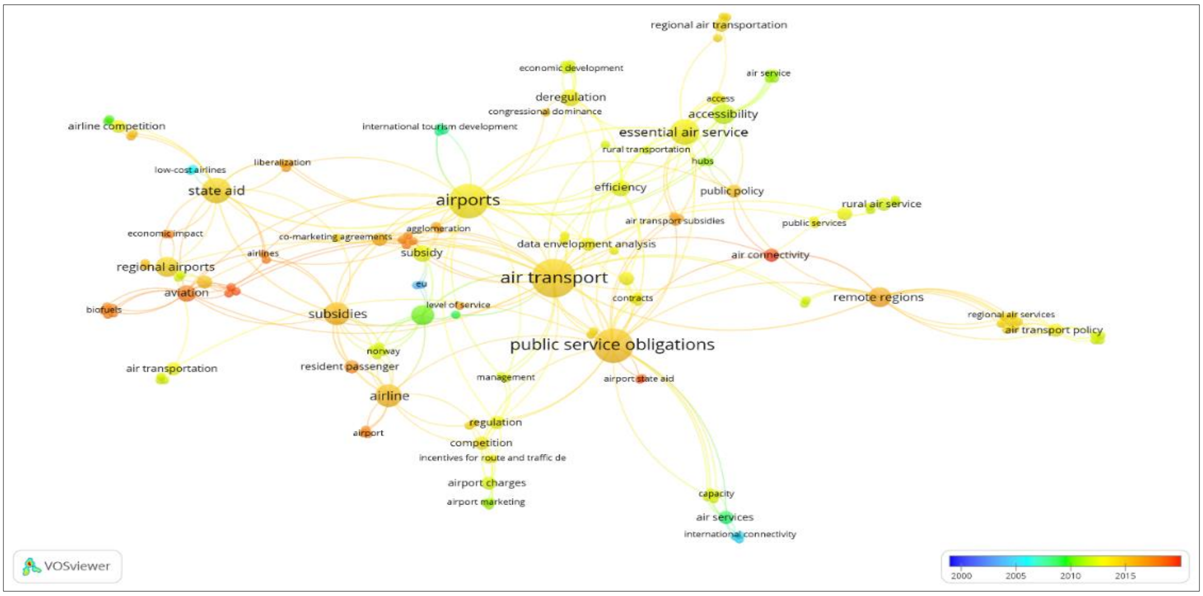
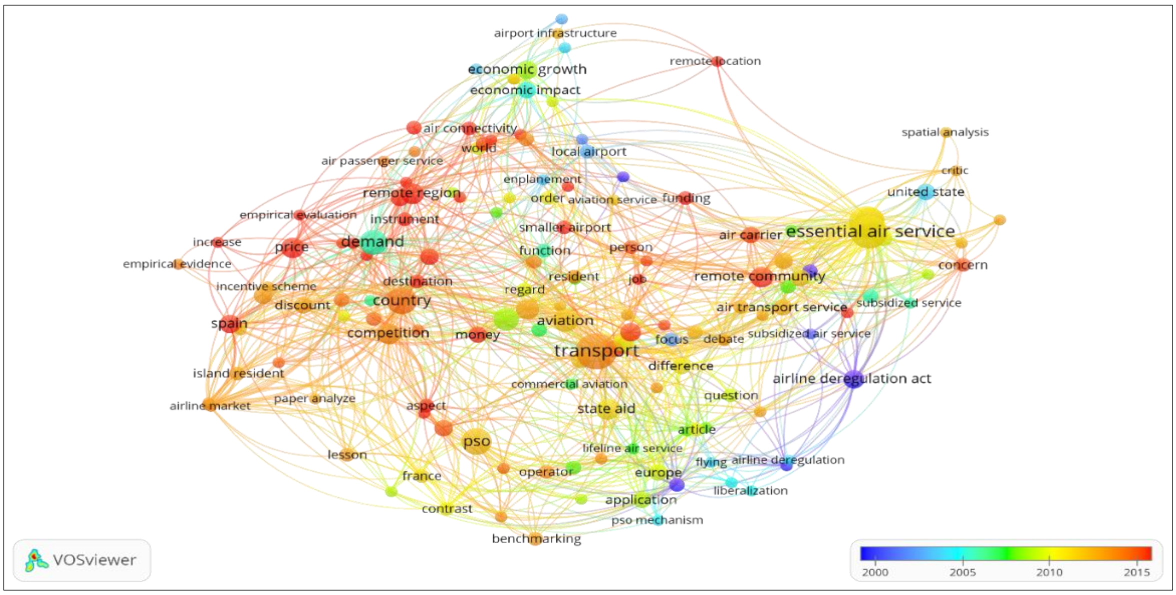


Figure 7

Co-occurrence of text listed in titles and abstracts



Word frequency queries

Word frequency queries were run by the NVivo software to identify the words and word groups (e.g. stem words) that occurred most often, as well as the relative and absolute frequency of words and word groups within the 110 publications (see Appendix E for details). Note that the text match level “words with same stem” (root or main part of a word)[5] was applied, which counted group words with the same stem together to find the most frequently occurring key terms. As shown in Figure 8, the size of the word displayed is directly correlated with its frequency of use. The most common words used in previous publications, after excluding some stop words[6] and irrelevant words[7] were “airline”, “airport”, “community”, “passengers”, “region”, “routings”, “servicing”, “subsidy” and “transports”. These most commonly used words related to aviation subsidy programmes and air service providers are also similar to the results of Figures 6 and 7 (keywords listed in abstracts, and text listed in titles and abstracts). However, among all the top 100 most frequently used words, there was still a scattering of keywords in the word cloud that stood out as showing the impacts of aviation subsidies on regional wellbeing, including “connects”, “economics”, “fare”, “pricing” and “seats”.

Figure 8

Word cloud showing the top 100 most frequently used words

[5] The word frequency queries were also conducted to count group words with synonyms together as a robust check (see Appendix F). The result is similar to that counting group words with stemmed words together.

[6] A stop word is a commonly used word (such as "the"), which is deemed to be irrelevant for search purposes in this study because it is used frequently in the English language (Banks et al., 2018; Edhlund & McDougall, 2019). In this study, stop words such as “may”, “also”, “however”, etc. were also filtered out and removed when running the word frequency queries.

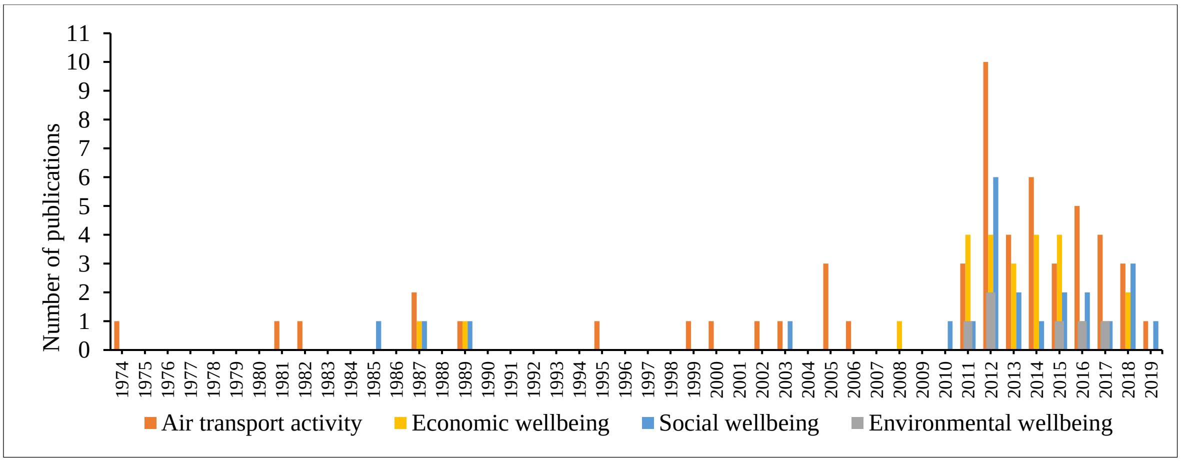
[7] Irrelevant words refer to words that were not relevant for search purposes in this study (Banks et al., 2018; Edhlund & McDougall, 2019). The search purposes in this study is to generate an overview of aviation subsidies’ impacts on air transport activity, as well as identifying the impacts of aviation subsidies on regional wellbeing (economic, social and environmental). Hence, words such as “using”, “providing”, “results”, “including”, “data”, “table”, etc. were considered as irrelevant words and were filtered out when running the word frequency queries.

Content and thematic analyses

The second research question stated in Introduction was to identify the impacts of aviation subsidies on regional wellbeing, as well as looking at the indicators showing the impacts of aviation subsidies on regional wellbeing in the selected publications. There was a scattering of keywords, such as “accessibility”, “fare”, “price”, and “seats” showing in Figures 6, 7 and 8 that can be associated with some indicators of the aviation subsidies’ impacts on regional wellbeing (e.g. air accessibility, airfares, and seat capacity). To explore the impacts of aviation subsidies on regional wellbeing in more detail, this study took the initial deductive wellbeing categories (as mentioned in Section 1.2.3) combined with the three indicators mentioned above as a starting point and went deeper into all the 110 publications. Although the publications relating to regional aviation subsidies are generally assumed to include indicators of the aviation subsidies’ impacts on regional wellbeing, 36 publications did not discuss aviation subsidies’ impacts on regional wellbeing, focusing instead on subsidy programme efficiency, criteria of the subsidy programme and subsidy programme contracts (e.g. Adler et al., 2013; Grubesic et al., 2016; Merkert & Hensher, 2013; Merkert & Williams, 2013). Consequently, content and thematic analyses of the other 74 publications identified 20 indicators regarding aviation subsidies’ impacts on regional wellbeing. All the identified indicators were grouped under the four main wellbeing categories: air transport activity, and economic, social and environmental wellbeing (see Figure 9 and Table 3).

Figure 9

Trends in aviation subsidies’ impacts (January 1974–August 2019)



Number of publications involved	Air transport activity	Economic wellbeing	Social wellbeing	Environmental wellbeing
	54	26	24	6

Note: The total number of publications regarding aviation subsidies’ impacts on regional wellbeing is 74 publications, as some publications may cite more than one wellbeing category and 36 publications did not mention any wellbeing categories.

Table 3

Wellbeing categories and indicators identified in aviation subsidies' publications

Wellbeing categories	Indicators	Publications with the indicators (%)	Number of publications
Air transport activity		**73%**	**54**
	Air accessibility	61%	45
	Flight frequency	15%	11
	Flight movements or traffic	7%	5
	Seat capacity	7%	5
	Number of passengers	16%	12
Economic wellbeing		**35%**	**26**
	Employment growth	11%	8
	Gross domestic product (GDP) or gross regional product (GRP)	4%	3
	Gross value added (GVA)	1%	1
	Local business	8%	6
	Per capita income	1%	1
	Population	4%	3
	Real aggregate taxable income	3%	2
	Tourism	15%	11
	Air cargo	51%	4
Social wellbeing		**32%**	**24**
	Airfare	24%	18
	Education	8%	6
	Medical treatment	10%	7
	Social inclusion	51%	4
	Work-related mobility	1%	1
Environmental wellbeing		**8%**	**6**
	Carbon emissions	8%	6

Note: Percentage refers to the percentage of publications citing each indicator. The total number of publications regarding aviation subsidies' impacts on regional wellbeing is 74 publications, which has been used as the denominator to calculate the percentage of publications citing each indicator. As some publications may mention more than one indicator, the percentage column does not add up to 100%.

Among the four wellbeing categories, air transport activities (73%) accounted for most of the publications. The next two most important wellbeing categories were economic wellbeing (35%) and social wellbeing (32%). Environmental wellbeing was given significantly less attention by previous publications, at only 8% of overall publications. It is likely that academics and industry professionals have been principally concerned with air transport activity, economic wellbeing and social wellbeing since 2011; importantly, these three key areas have gained increasing attention. Before that, the majority of research focused on the impacts on air transport activities. Surprisingly, not much attention has been paid to the impacts of aviation subsidies on environmental wellbeing during the past five decades. When looking at the percentage of publications with the indicators, 45 (61%) publications were concerned with air accessibility. Airfares accounted for 18 (24%) publications, making them the second most-studied indicator, followed by number of passengers at 12 (16%) publications. Indicators such as GDP, GRP, GVA, per capita income, population, real aggregate taxable income, social inclusion, cargo and work-related mobility were not frequently studied, as the total number of publications studying these indicators was less than five. The following review is divided into four parts on the basis of the four categories' impacts on regional wellbeing: air transport activity, economic wellbeing, social wellbeing and environmental wellbeing.

- *The air transport activity category*

The air transport activity category included five indicators that can be used as metrics for the impacts of aviation subsidies on regional wellbeing. The most widely examined indicators were air accessibility at 45 (61%) publications, followed by number of passengers at 12 (16%) publications and flight frequency at 11 (15%) publications. The indicators with the fewest publications were flight movements or traffic (7%) and seat capacity (7%). As one of the important objectives of aviation subsidy programmes is to improve domestic connectivity levels and prevent lapses in small communities' air services, it is not surprising that a significant amount of research and attention have been given to air accessibility (e.g. Brathen & Eriksen, 2016; International Transport Forum, 2018; Merkert & O'Fee, 2013; Wittman, 2014a). Most of these studies indicated the positive impact of regional aviation subsidies, as they successfully helped local airports or communities to attract and retain air services (e.g. Airport Cooperative Research Program, 2015; Di Francesco & Pagliari, 2012; Wittman, 2014a, 2014b); however, Laurino and Beria (2014) expressed concerns about whether air service is stable when the subsidisation of routes comes to an end. In addition, the majority of academics and industry professionals agreed that various regional aviation subsidies may produce welfare gains, reflected by increasing flight frequencies, seat supply and more enplanements (e.g. Di Francesco & Pagliari, 2012; German Airport Performance, 2012; Miller et al., 2016; Ramos-Pérez, 2016). However, some authors found exceptions in Spain and the US (e.g. Calzada & Fageda, 2014; Valido et al., 2014; Wittman & Swelbar, 2013).

- *The economic wellbeing category*

The category of economic wellbeing included nine indicators, including employment growth, GDP or GRP, GVA, local business, per capita income, population, real aggregate taxable income, tourism and air cargo. The most widely mentioned indicator was tourism at 11 publications. Within this specific category's impact, the majority of previous publications confirmed the positive effects of regional aviation subsidies on the development of the local tourism sector, which resulted in boosting local economy (e.g. Amoroso et al., 2012; Castillo-Manzano et al., 2011; Minato & Morimoto, 2011; Özcan, 2014b; Smyth et al., 2012). Besides tourism, employment growth, local business and population were also mentioned in some publications as indicators reflecting the effects of aviation subsidies on a region's economic wellbeing. Some studies believed that regional employment appears to have a close connection to the wider regional economy, which is influenced by aviation subsidies that contributed to regional air connectivity and air passenger flows (Faber & Nelissen, 2015; Özcan, 2014b; Smyth et al., 2012). However, in a study in Finland, Halpern (2008) found that subsidies granted for air transport projects did not contribute to the creation of any new jobs. Regarding indicators such as local business and population, several publications stated that there is a strong possibility that regional aviation subsidies seem to be an effective way to guarantee the support of business communities (i.e. attracting new business) and keeping a population stable (i.e. reducing the outflow of local people) (e.g. Craig, 2011; Hromádka, 2017; Leinbach, 1989; Özcan, 2014b; Rymanov & Fomin, 2014). As for air cargo, it is expected to improve local economy when air freight transportation is supported by subsidised air services. However, little evidence showed the relationship between aviation subsidies and air cargo (Merkert & O'Fee, 2013). Surprisingly, indicators such as GDP or GRP, GVA, per capita income and real aggregate taxable income were rarely studied in previous publications as indicators of how a region's economic wellbeing is affected by aviation subsidies.

- *The social wellbeing category*

The social wellbeing category included five indicators, including airfare, education, medical treatment, social inclusion and work-related mobility. Airfare were frequently used at 18 (24%) publications to measure the effects of aviation subsidies on social wellbeing in the regions. Some studies argued that local residents could take advantage of the subsidy to purchase airfares at a discount (e.g. Brathen & Eriksen, 2016; Bråthen & Halpern, 2012; Fageda et al., 2016; Fageda et al., 2019), whereas some publications suggested that no difference in ticket price was found in some countries' regional routes that received an aviation subsidy (Calzada & Fageda, 2012; Fageda et al., 2017; Pita et al., 2013). Moreover, education, medical treatment and social inclusion can be regarded as the availability of social services, which are often used as indicators in a situation where communities are in isolated areas. Although not many prior publications focused on these indicators (e.g. education (6 publications), medical treatment (7 publications), and social inclusion (4 publications)), regional aviation subsidies still provided a vital tool for generating social benefits in remote and isolated communities (e.g. Brathen & Eriksen, 2016; Department of State Growth, 2018; Fageda et al., 2018; Merkert & O'Fee, 2013;

Smyth et al., 2012). Although a few publications questioned the effects of aviation subsidies on reduced airfares, a number of prior publications (Bråthen & Halpern, 2012; Merkert & O'Fee, 2013; New Zealand Airports Association, 2017) have generally acknowledged subsidised air services to be integral to remote communities' identity, which is perceived as crucial to the development and wellbeing of remote and smaller regions.

- *The environmental wellbeing category*

The environmental wellbeing category only included one indicator: carbon emissions. Prior publications concerning the carbon emissions indicator mostly in discussing whether a detrimental environmental impact could be caused by increased regional air transport activity that was facilitated by implementing aviation subsidy programmes (Craig, 2011; Ryerson, 2016a; Smyth et al., 2012). This indicator was also cited by Reimer and Zheng (2017), who proposed potentially workable subsidy policies that would promote the development of the aviation biofuel supply chain and thus increase the use of biofuel in the aviation sector. Another way to manage and reduce carbon emissions is to implement energy and carbon taxes or a value-added tax on airfares (Faber & Nelissen, 2015; Lockley & Dresner, 2012). In general, there were only a few publications, in comparison with those on other three wellbeing categories, which indicates that environmental wellbeing and the carbon emissions indicator were not mentioned frequently in prior publications related to aviation subsidies and regional wellbeing.

1.3.3 Meta-regression analysis (MRA)

After assessing all the selected 110 publications through content and thematic analyses, 36 publications were excluded because their research findings were not related to the four wellbeing categories of aviation subsidies being investigated (i.e. air transport activity, economic wellbeing, social wellbeing and environmental wellbeing). Moreover, seven publications were excluded because they are review articles. Therefore, the remaining 67 publications were used to perform the MRA and contained a total of 203 observations regarding the impacts of aviation subsidies on regional wellbeing.

Probit model

The estimation results of the probit models for the determinants of aviation subsidies' impacts on air transport activity (Model 1), economic wellbeing (Model 2), social wellbeing (Model 3) and environmental wellbeing (Model 4) are presented in Table 4. Recall that the dependent variables in the probit model are the binary variables that take a value of 1 when a study reported that aviation subsidies impacted on the corresponding aspect of regional wellbeing (i.e. air transport activity, economic wellbeing, social wellbeing or environmental wellbeing) and 0 otherwise. Each of the dependent variables was regressed against the established explanatory variables in the corresponding probit model. A significant positive coefficient estimate of the explanatory variable indicates that there is a higher probability or likelihood that a study will find an impact of aviation subsidies on the corresponding dependent variable with a set of identified explanatory variables. A statistically significant and negative coefficient estimate indicates that the explanatory variables tend to decrease the probability of a study finding any impact of aviation subsidies on the corresponding dependent variable.

Regarding the group of subsidy types, there is a clear difference in reporting the different types of wellbeing categories among prior publications that studied different types of aviation subsidies (i.e. *grants and loans*, *hidden subsidies*, *subsidy schemes pertaining to remote regions*, and *no or reduced tax* (the omitted base model)). For the estimation purpose, this study used "*no or reduced tax"* as the base model. Compared with the base model, prior publications that studied *grants and loans* and *hidden subsidies* were characterised by a relatively high probability of finding aviation subsidies' impacts on economic wellbeing. On the other hand, *subsidy schemes pertaining to remote regions* seems to have impact on obtaining results related to environmental wellbeing. More specifically, prior publications that studied *schemes pertaining to remote regions* decreased the likelihood of finding aviation subsidies' impacts on environmental wellbeing, compared with the base model.

One of the most important results of the probit models is the effects of various subsidy beneficiaries on wellbeing categories. Prior publications that studied *airports*, *airlines* and *local residents* had more statistically significant coefficient estimates than publications that studied *aviation suppliers* (the omitted base model). The findings indicated that studying the effect of aviation subsidies on *airports*, *airlines* and *local residents* are more likely to find the impacts of aviation subsidies on air transport activity and social wellbeing, compared with the base model studying aviation suppliers. In contrast, *airlines* is reported to have a statistically significant and negative coefficient estimate, suggesting that the probability of finding that aviation subsidies that have an impact on economic wellbeing is decreased compared with the base model.

Considering the group of study characteristics, it appears that findings on economic wellbeing are usually more sensitive to the study characteristics than other wellbeing categories. One of the noteworthy points is that the impacts of aviation subsidies on economic wellbeing were less likely to be found in *journal articles*, with a significant negative coefficient estimate, than in other types of publications (the omitted base model). Similarly, *number of countries* was also reported to have the significant negative coefficient estimates. This finding indicated that prior studies that included more countries decreased the chance of finding the impacts of aviation subsidies on economic wellbeing. On the contrary, publications using longer study periods tended to obtain or report results that showed the impacts of aviation subsidies on economic wellbeing, but were less likely to find that aviation subsidies had an impact on social wellbeing.

Table 4

Estimation results of the probit model

Dependent variables	**Wellbeing categories**			
	Air transport activity – Model 1	**Economic wellbeing – Model 2**	**Social wellbeing – Model 3**	**Environmental wellbeing – Model 4**
Explanatory variables				
Subsidy types				
Grants and loans	0.983 (0.670)	1.348* (0.753)	/	-0.734 (0.924)
Hidden subsidies	1.117 (0.818)	2.188** (0.975)	/	-1.341 (1.021)
Subsidy schemes pertaining to remote regions	0.953 (0.708)	1.180 (0.843)	-1.376 (0.940)	-2.094** (0.834)
Subsidy beneficiaries				
Airports	6.042*** (0.514)	-0.790 (0.846)	3.061** (0.985)	/
Airlines	6.188*** (0.480)	-1.652** (0.780)	3.862*** (0.827)	-0.817 (0.914)
Local residents	5.615*** (0.655)	/	4.879*** (0.959)	/
Study characteristics				
Journal articles	0.268 (0.303)	-1.147** (0.393)	0.412 (0.443)	-0.417 (0.589)
Number of countries	0.013 (0.025)	-0.155** (0.070)	0.023 (0.031)	/
Study periods	-0.010 (0.022)	0.084** (0.028)	-0.054* (0.030)	-0.055 (0.050)
Geographic areas				
Europe	0.428 (0.326)	-0.356 (0.443)	-0.291 (0.405)	5.072*** (1.073)
North America	1.100*** (0.332)	-1.195** (0.405)	-0.713* (0.421)	5.627*** (1.046)
Research methods				
Case study	-0.586 (0.608)	-1.208* (0.668)	2.121** (0.848)	1.615 (1.082)
Empirical study	-0.149 (0.518)	-1.729** (0.582)	1.711** (0.756)	0.394 (0.935)
Survey approach	-1.819** (0.664)	1.465** (0.709)	1.877** (0.861)	/
Observations	175	162	141	93
Log-likelihood	-98.653	-58.138	-64.502	-18.036

Notes: *, ** and *** indicate that the explanatory variable is significant at the 10%, 5% and 1% significance levels, respectively. Robust standard errors are presented in parentheses. Twenty-eight observations were omitted because of collinearity. A solidus (/) indicates that the explanatory variable was automatically dropped because it predicted the outcome perfectly during the estimation.

Another interesting result was found for the geographic areas in the models. In a nutshell, *Europe* and *North America* were substantial areas for obtaining significant results. Compared with those studies on *countries outside Europe and North America* (the base model), studies on *European* and *North American* countries were more likely to find the impacts of aviation subsidies on environmental wellbeing, with the significant positive coefficient estimates. Prior studies about *North America* also had a higher chance of reporting aviation subsidies' impacts on air transport activity, and a decreased likelihood of reporting the impacts of aviation subsidies on economic and social wellbeing.

Turning to the group of research methods, there is a clear difference in reporting different types of wellbeing categories among studies that used a *case study*, the *empirical study*, a *survey approach* or a *scenario simulation* (the omitted base model). The significant negative coefficient estimate of *survey approach* indicates that previous studies using this particular research method were less likely to find the impacts of aviation subsidies on air transport activity, compared with the base research method (i.e. scenario simulations). Meanwhile, compared with the base model, those studies adopting a *case study* or the *empirical study* were also less likely to find aviation subsidies' impacts on economic wellbeing, but those studies taking a *survey approach* had the opposite effect. However, all methods were likely to find a positive link between aviation subsidies and social wellbeing compared with the base model of scenario stimulation.

Taken together, the likelihood that air transport activity, economic and social wellbeing were investigated in prior publications was quite sensitive to the subsidy type, the subsidy beneficiaries, study characteristics, geographic areas and research methods used in prior studies. In particular, the likelihood of obtaining results that are relevant to aviation subsidies' impacts on air transport activity can be affected by: (1) publications that studied airports, airlines and local residents as subsidy beneficiaries; (2) conducting studies in North America; and (3) studies applied survey approach. This holds true for the probability of reporting the effect of aviation subsidies on social wellbeing, whereas social wellbeing category is also sensitive to more explanatory variables: (1) the study period for analysis; and (2) studies applied different types of research methods such as case study and empirical study. With regards to the effects of aviation subsidies on economic wellbeing, the likelihood of finding such impacts can be affected by the aforementioned explanatory variables, except for publications that studied airports and local residents. Moreover, publications that studied grants and loans as well as hidden subsidies also have impact on the probability of finding aviation subsidies' impacts on such wellbeing category. Generally speaking, the probability of finding aviation subsidies' impacts on economic wellbeing and social wellbeing are more affected by those significant explanatory variables incorporated in the prior studies.

Ordered probit model

The estimation results of the ordered probit model and the marginal effects for each of the aviation subsidy impact categories (i.e. negative, null or positive impacts) are presented in Table 5. It is noted that for a probit model, a statistically significant and positive coefficient estimate suggests a positive relationship between the explanatory variable and the probability of finding a positive result, and vice versa. However, the interpretation of the estimated coefficients of the ordered probit model is not that simple because the coefficient estimates cannot reveal the magnitude of changes in the probability of observing each effect of aviation subsidies (negative, null and positive effects) in answer to changes in the explanatory variables (De Groot et al., 2009; Greene, 2003; Liao, 1994; Wooldridge, 2016). To this end, the corresponding marginal effects, which measure the change in the dependent variable as a function of the change in a certain explanatory variable, was calculated (Wooldridge, 2016).

It should be noted that the coefficient estimates of the ordered probit model highlighted two main findings regarding previous publications on aviation subsidies' impacts on regional wellbeing. First, the statistically significant and negative coefficient estimate was reported for the variable of *wellbeing category*, which indicates that the probability of finding a positive effect was reduced by higher values of the *wellbeing category* (e.g. if a study examines aviation subsidies' impacts on economic wellbeing, social wellbeing and environmental wellbeing). Recall that there are four major regional wellbeing categories, and the variable of *wellbeing category* is a categorical variable with four possible values, namely air transport activity (a value of 1), economic wellbeing (a value of 2), social wellbeing (a value of 3) and environmental wellbeing (a value of 4) in Table 1. Therefore, it seems that a prior publication studies aviation subsidies' impacts on environmental wellbeing over other wellbeing categories (i.e. air transport activity, economic wellbeing, and social wellbeing) is less likely to report the positive effects of aviation subsidies. This holds true for the results of marginal effects.

It should be borne in mind that the inclusion of different study characteristics is another primary source of variation in the estimation of aviation subsidies' impacts. This is confirmed by both the significance and sign of the coefficient estimates and the marginal effects. Compared with prior studies published as *textbook chapters* and *reports* (the omitted base model), the results showed that prior studies published as *journal articles* decreased the probability of obtaining a positive effect and increased the likelihood of obtaining a negative or insignificant effect of aviation subsidies on regional wellbeing. This finding is somewhat surprising, since one might have expected prior studies that reported the significant positive results of overall aviation subsides' impacts on regional wellbeing would be more likely to be published, because there is a tendency to publish a certain type of significant and interesting results in peer reviewed journals. It should be noted that due to the data limitation issue, this study only examines the overall impacts of aviation subsidies on regional wellbeing rather than on each wellbeing category separately.

Table 5

Estimation results of the ordered probit model

	Coefficients	**Marginal effects**		
		Negative impact	**Null impact**	**Positive impact**
Explanatory variables				
Wellbeing category	-0.278** (0.116)	0.043** (0.018)	0.041** (0.017)	-0.084** (0.033)
Subsidy types				
Grants and loans	0.796 (0.690)	-0.123 (0.106)	-0.118 (0.101)	0.241 (0.204)
Hidden subsidies	0.299 (0.784)	-0.046 (0.122)	-0.044 (0.115)	0.090 (0.236)
Subsidy schemes pertaining to remote regions	0.549 (0.751)	-0.085 (0.115)	-0.081 (0.110)	0.166 (0.225)
Subsidy beneficiaries				
Airports	-0.566 (1.034)	0.088 (0.156)	0.084 (0.154)	-0.171 (0.309)
Airlines	-0.790 (0.973)	0.122 (0.146)	0.117 (0.145)	-0.239 (0.290)
Local residents	-0.986 (1.083)	0.153 (0.163)	0.146 (0.161)	-0.298 (0.322)
Study characteristics				
Journal articles	-0.958** (0.426)	0.148** (0.062)	0.141* (0.066)	-0.290** (0.122)
Number of countries	-0.017 (0.023)	0.003 (0.004)	0.003 (0.003)	-0.005 (0.007)
Study periods	0.001 (0.021)	0.0002 (0.003)	0.0002 (0.003)	0.0003 (0.006)
Geographic areas				
Europe	-0.405 (0.291)	0.063 (0.049)	0.060 (0.041)	-0.123 (0.089)
North America	-0.356 (0.308)	0.055 (0.050)	0.053 (0.046)	-0.108 (0.094)
Research methods				
Case study	0.126 (0.561)	-0.019 (0.087)	-0.019 (0.083)	0.038 (0.170)
Empirical study	0.051 (0.483)	-0.008 (0.075)	-0.008 (0.071)	0.015 (0.146)
Survey approach	0.819 (0.660)	-0.127 (0.102)	-0.121 (0.099)	0.248 (0.198)
Observations	175			
Log-likelihood	-125.659			

Notes: *, ** and *** indicate that the explanatory variable is significant at the 10%, 5% and 1% significance levels, respectively. Robust standard errors are presented in parentheses. Twenty-eight observations were omitted because of collinearity thereby constraining the number of observations to 175 for analysis.

1.4 Discussion and future research directions

Since 2011, the growing interest among academics and industry professionals in the topic of regional aviation subsidies has been demonstrated by the increase in publications and reports. This study sets out with the aim of providing an overview of regional aviation subsidy research and summarising the key findings on aviation subsidies' impacts on regional wellbeing in previous literature and publications. A systematic review of 110 publications (journal articles, industrial and government reports and textbook chapters) between January 1974 and August 2019 on this contemporary topic has been conducted. In addition to the systematic review (descriptive analysis, and content and thematic analyses), the MRA of 203 observations from 67 studies with respect to the impacts of aviation subsidies on regional wellbeing was also conducted to summarise the evidence from these studies. Based on the results of the systematic literature review and MRA, there are several essential findings to be highlighted and discussed.

1.4.1 Geographic scope of aviation subsidy research

With the intention of providing regional communities with lifeline air transport services, a varied set of aviation subsidies have been initially implemented in the European countries and the US. According to the review of worldwide regional aviation subsidy programmes, more and more Asian and Latin American countries (e.g. Brazil, Chile, India, Malaysia and Peru) in recent years have also implemented similar funding systems, providing air connections to isolated communities where commercial airline operations are not financially viable (Fageda et al., 2018, 2019). Some countries have a combination of different types of subsidies addressing air connectivity issues in remote areas, such as Australia and the US. Although the effects of EAS and PSOs in the European and US markets have been assessed by many studies (e.g. Brathen & Eriksen, 2016; Fageda et al., 2018; Grubesic et al., 2016; Wittman et al., 2016), evidence-based research on regional aviation subsidies' impacts remains scarce in Asian and Latin American countries. Furthermore, it is somewhat surprising that there was no prior literature focussing on China, which has a large and fast-growing regional aviation markets and is projected to be the world's largest aviation market by around 2024 (International Air Transport Association, 2016). This could be attributed to the fact that the selected publications included in this study are all in English. Another important finding of this study was that aviation subsidy studies on developing countries, particularly landlocked developing countries, are still lacking, despite the importance of regional air connectivity to those countries in terms of trade and economic development, flows of goods and people, and tourism (Borchert et al., 2012; Grosso, 2012).

1.4.2 The impact of aviation subsidies

In reviewing prior publications, aviation subsidies' impacts were categorised in this study into air transport activity, economic wellbeing, social wellbeing and environmental wellbeing. In most cases, the evidence of a strong link between aviation subsidies and regional air transport activity has been well examined. This may be explained by the fact that the initial purposes of implementing aviation subsidies by governments are to guarantee air connectivity in remote and smaller regions (e.g. Abreu et al., 2018; Bråthen & Halpern, 2012; Fageda et al., 2018; Gössling et al., 2017; Hromádka, 2017).

In terms of other regional wellbeing categories, the evidence presented in the content and thematic analyses is worth mentioning. The recent literature has documented the strong link between air services (e.g. airports) and economic growth (e.g. Albalate & Fageda, 2016; Alderighi & Gaggero, 2017; Baker et al., 2015; Bilotkach, 2015; Blonigen & Cristea, 2015; Fageda et al., 2019; Florida et al., 2015). Furthermore, the evidence that air services could undoubtedly strengthen air connectivity in regions has been generally assumed to produce social welfare gain for local communities (e.g. connecting smaller communities to the main centres, improving living standards and social inclusion) (e.g. Halpern & Brathen, 2011; Smyth et al., 2012; Solvoll & Hanssen, 2018; Williams, 2005). In addition, continual growth in air travel and increasing concerns about its sustainability present a considerable challenge to the aviation industry (Daley et al., 2016). However, there appears to be no clear and empirical evidence from prior literature to validate whether aviation subsidies could improve regional economic and social wellbeing via aviation. As mentioned above, prior studies focussed more on aviation subsidy program itself. Furthermore, far too little attention has been paid to environmental wellbeing. There are two possible explanations for this interesting finding.

Firstly, this could be attributed to the fact that aviation subsidy programmes such as EAS and PSOs in Europe and the US have been serving remote and smaller communities for decades, aiming to maintain a minimal level of scheduled air services to people living in those communities. Hence, prior studies of European countries and the US focused more on the appropriate execution of their respective aviation subsidy programmes and air transport performance, rather than on the potentially broader or catalytic impacts of aviation subsidy programmes. This also accords with the earlier content and thematic analyses in Section 1.3.2, which showed that indicators such as air accessibility, airfare and number of passengers were mostly considered by prior studies. Undoubtedly, from the policymaking perspective, it is necessary to regularly monitor the execution and costs of the subsidy programmes, as this process could help to increase their efficiency. However, it is also essential to be aware of the fact that, from governments' perspective, neither efficiency nor costs should be considered as top priorities beyond the consideration of the wellbeing of people living in remote regions who will be affected by or benefit from aviation subsidies. Therefore, regional aviation subsidies can hardly be fully or systematically understood unless the subsidies' impacts on regional wellbeing are included.

Another possible explanation might be the limitations in accessing relevant and reliable data. As a consequence, prior studies providing empirical evidence of the relationship between aviation subsidies and improved regional wellbeing are lacking. Therefore, there is still uncertainty about whether the impacts of aviation subsidies on regional air transport links can impact regional wellbeing in turn. It could be questioned if aviation subsidies or the coexistence of varied types of aviation subsidies can be viewed as appropriate approaches or schemes to improve regional economic, social and environmental wellbeing by promoting improved air connectivity.

1.4.3 Aviation subsidies and regional tourism

It was found that there is little research on the interaction between aviation subsidies and regional tourism despite the importance of air transport connectivity on regional tourism development (e.g. Castillo-Manzano et al., 2011; Lowden & Bentley, 2012; Özcan, 2014a; Rymanov & Fomin, 2014; Smyth et al., 2012; Williams, 2005). This is particularly true in poorly connected regions, as tourism in remote regions and rural areas may require substantial air transport development (Carson & Harwood, 2007). In the case of these peripheral areas, remote regions may contain valuable natural resources and display life and nature that has not been affected by modern society, which could be an attractive feature for certain tourists seeking a periphery experience. Therefore, there is no question as to the importance of improved air connectivity via aviation subsidies to eliminate the limitations of accessing remote areas, resulting in success in attracting more tourists, which presumably could bring various benefits to the regions (e.g. facilitating regional economy, bringing jobs and businesses, creating vibrant places to live, contributing to community sustainability, etc.) (Li et al., 2016b; Muresan et al., 2016; Shariff & Abidin, 2013). More importantly, it is possible that more passengers and travellers may travel on routes benefiting from aviation subsidies, thereby establishing and sustaining those regional air routes and achieving commercial viability. Hence, a sound understanding of the relationship between aviation subsidies and regional tourism development seems to be needed via more empirical studies or case studies.

1.4.4 Aviation subsidies and social wellbeing

To date, the impact of aviation subsidies on regional air connectivity and social wellbeing has gradually received increasing attention in the air transport and social science literature. Although it is now well established and researched by prior studies that regional airports and air services undoubtedly provide significant social benefits to smaller communities (e.g. connecting smaller communities to main centres, enabling mobility to sustain health and education, and improving the living standards and social inclusion of smaller regions), and also they play a very important social role for local communities (e.g. Adler et al., 2013; Baker et al., 2015; International Transport Forum, 2018). However, research in the field of regional aviation subsidies have not explored and developed the social wellbeing indicators in much detail. For example, most studies in aviation subsidies to date have tended to focus on airfare rather than other social impacts such as education, medical treatment and social inclusion. Hence, future research will be needed to examine and provide quantified evidence to assess and validate whether aviation subsidies could improve regional social wellbeing in terms of different social wellbeing indicators. Moreover, different stakeholders engaged process of developing aviation subsidy policies could help reflect the values of the community they serve, so as to align polices and practice recommendations with the social needs and expectations of local communities. In order to develop more social wellbeing indicators for a better understanding of the impacts of aviation subsidy programmes on social wellbeing, it might be possible to use qualitative methods (e.g. surveys and questionnaires) in addition to evidence from empirical studies, which could provide reliable measurements of the impacts of aviation subsidies on social wellbeing.

1.4.5 Aviation subsidies and environmental wellbeing

Environmental concerns are rising rapidly around the world, but lack of attention has been paid to the relationship between aviation subsidies and environmental wellbeing in prior literature. Hence, much uncertainty still exists about this contemporary issue. Some researchers believe that additional air traffic volume brought about by implementing aviation subsidies is accompanied by additional air travel-related emissions (e.g. Forsyth & Guiomard, 2019; Lockley & Dresner, 2012; Ryerson, 2016a). However, others argued that no detrimental environmental impacts have been or would be caused by additional essential air services (Craig, 2011; Smyth et al., 2012), because some travellers would still travel via alternative modes (i.e. land and sea transport) in the absence of air services. Another issue that causes uncertainty about aviation subsidies' impacts on regional environmental wellbeing could be attributed to having insufficient indicators being developed. It was found that prior studies relevant to aviation subsidies' impacts on environmental wellbeing lack adequate indicators to measure the impacts, as the content and thematic analyses (see Section 1.3.2) could only identify one indicator (i.e. carbon emissions) that was used in the selected publications under the environmental wellbeing category. It appears that further research is required to develop more relevant environmental wellbeing indicators (e.g. air quality, noise level, wildlife, heritage and landscape) to create a new understanding of aviation subsidies' impacts on environmental wellbeing.

It is worth mentioning that air transport is still perceived as a lower-emission mode of transportation, which produces around 2% of all human-induced carbon dioxide emissions and is responsible for 12% of emissions from all modes of transportation (Air Transport Action Group, 2019). Therefore, it is presumed that the environmental impact of providing subsidies to bring more flights into remote and smaller regions might be negligible, especially considering the flying distance and flight frequency on those regional routes. Along with improving regional air transport activity, aviation subsidies can also be allocated to promote the use of advanced aviation technology that may mitigate the problem of carbon emissions from flight activity and operations, for example, by promoting the aviation biofuel supply chain and using electric or hybrid-electric aircraft. For example, aviation subsidies may prompt an increase in biofuel development and use (Reimer & Zheng, 2017), which could help the aviation sector manage and reduce its growing carbon footprint while serving smaller regions. This could also be achieved by allocating grants and loans from the governments to help regional airlines replace the current regional fleet with new, advanced fuel-efficient aircraft or electric and hybrid-electric aircraft with cleaner power to serve short- and medium-haul regional routes.

1.4.6 The data availability issue

It is important to note that the topic of the aviation subsidies' impacts on regional wellbeing is a complex research topic. As can be seen in the descriptive analysis (see Section 1.3.1), the majority of prior publications have examined aviation subsidy schemes pertaining to remote regions, but there is still very little knowledge of other types of aviation subsidies such as grants and loans, hidden subsidies, and no or reduced tax. There are two likely causes for this circumstance. One possible explanation is that subsidy schemes pertaining to remote regions (i.e. EAS and PSOs) have been the most important national funding system for supporting small communities and have been widely implemented across Europe and the US for decades, not to mention that the quality of information and databases on these aviation subsidy schemes is generally reliable and they are regularly updated. Therefore, these subsidy schemes have attracted considerable attention from aviation practitioners, policymakers, academics and even the general public (e.g. Fageda et al., 2018; Özcan, 2014b; Park & O'Kelly, 2017). Another possible explanation is that the majority of selected publications in this study are journal articles but only a few are government or industrial reports. It seems that aviation researchers and academics face the problem of data limitations when conducting research into aviation subsidies. It is worth noting that the definition of aviation subsidies is a spectrum and that these subsides can take a number of forms (Forsyth & Guiomard, 2019; Gössling et al., 2017; Wittman et al., 2016). Hence, aviation subsidies are quite difficult to define and some of them, such as hidden subsidies and no or reduced tax, may not be conventionally thought of as subsidies from regional governments' perspectives. The nebulous definition of aviation subsidies may also pose a problem for academics and industrial practitioners when gathering appropriate and precise data.

Another important finding of this study is that most of the prior studies on aviation subsidies focus on airlines, airports and local residents. Among the selected publications, there has rarely been a discussion about local communities as the beneficiaries of subsidies. It is worth noting that there is an important difference between local residents and local communities in aviation subsidy research. Research looking into local residents mainly focuses on airfare discount policies for residents living in remote and smaller communities who can enjoy domestic air travel, whereas research looking into local communities is concerned with how communities can form partnerships with airports and airlines to facilitate air services in the region, thereby producing benefits to a broad local sector (e.g. local businesses, retailing and tourism); this may be called a symbiotic impact. It seems that local communities are gaining more attention and importance in the field of regional aviation subsidy research. Air service subsidy programmes, which usually offer incentives in the form of discounts on airport fees, bonus payments to airlines for a limited period in exchange for new routes, guaranteed growth in the number of passengers transported, and joint marketing activities between regional authorities and/or airport operators and airlines are commonly seen in European countries and the US. However, more air carriers nowadays view local communities rather than local airports as their partners, who must share the risks of any new air services (Fageda et al., 2018; Mills & Kalaf-Hughes, 2017; Wittman, 2014b). A recent study by Mills and Kalaf-Hughes (2017) showed the crucial role of community participation in applying for the Small Community Air Service Development Grant Program in the US. They claimed that a strong level of community support (i.e. gaining the support of not only local businesses but also local elected officials (e.g. congressional delegation)) is critical for successfully securing EAS. Hence, there is abundant room for further research in determining what kind of aviation subsidies and policies (e.g. community air service development programmes, or airport or airline incentive programmes) may be more appropriate for local communities and how local communities can contribute more to facilitating air connectivity, thus making a positive contribution to and improving regional wellbeing.

1.4.7 Future research

This study does not aim to provide a complete list but an overview of previous studies about aviation subsidies' impacts on regional wellbeing, and to propose a number of avenues for future research to help us better understand the above topic. First, all aviation subsidies that mentioned in prior literature showed the contributions and impacts of aviation subsidies on the wellbeing of people living in remote regions or smaller communities, but the specific impacts on economic, social and environmental wellbeing remain unclear. In this regard, further studies need to be carried out to validate the impacts of aviation subsidies on these three key areas of regional wellbeing via promoting regional air connectivity.

As indicated in this study, the majority of prior studies have examined indicators associated with air services, including air accessibility and airfare. Thus, a full picture of aviation subsidies' impacts on regional wellbeing remains unclear and more research will also be needed for understanding this particular issue. Therefore, further works is required to access more relevant and reliable data (e.g. socio-economic variables) or develop more indicators to measure social and environmental wellbeing for this contemporary topic via evidence-based research. In addition to regional wellbeing and its respective indicators (see Table 3), there could be many other indicators reflecting regional wellbeing that are worthy of study, such as air and water quality, feelings of safety, foreign direct investment, housing affordability, imports and exports, inbound and outbound tourism, leisure and recreation, noise levels, waste disposal, etc. It is suggested that future studies regarding the impacts of aviation subsidies on regional wellbeing that take these indicators into account would help in successfully shaping the aviation subsidy policy landscape, thereby enhancing the delivery of improved air services to smaller regions and improving regional wellbeing. Moreover, ensuring that appropriate data become available and indicators are developed are prerequisites for future research that provides a comprehensive investigation of aviation subsidies' impacts on wellbeing across regions.

In addition to achieve a better understanding of aviation subsidies' impacts on regional wellbeing in different aspects, countries that have not yet implemented or want to develop aviation subsidy programmes could also benefit from using more relevant indicators in future work, which could justify support for their initiatives. By the same token, future studies also need to expand to different countries (e.g. Brazil, Chile, China, India and New Zealand), as most of the prior studies have focused on aviation subsidies in European countries and the US.

Furthermore, five major research methods (see Figure 3) have been used in prior studies to research the impact of aviation subsidies on regional wellbeing. According to the estimation results of the MRA via the probit model (see Table 4), the likelihood that certain types of wellbeing, particularly economic and social wellbeing are quite sensitive to the application of the research methods used. Where the quality data might not be available, it is suggested that the survey approach could be a good alternate method to obtain a better understanding of the impacts of aviation subsidies on a region's economic and social wellbeing. Clearly, further works is required to apply different research methods to gain a comprehensive and conclusive knowledge of the impacts of aviation subsidies on regional wellbeing. Depending on the research questions and the areas being studied, a study might even use a mixed-method approach.

1.5 Conclusion

This study aims to provide an overview of published studies from January 1974 to August 2019 regarding the aviation subsidies' impacts on regional wellbeing (air transport activity, economic wellbeing, social wellbeing and environmental wellbeing), and identify the primary wellbeing and indicators being studied, as well as synthesising the results of previous studies regarding this contemporary topic. The key results of this study are summarised as follows. First, 110 selected publications (journal articles, industrial and government reports and textbook chapters) meeting the requirements of this research were included in a descriptive analysis. In these studies, the aviation subsidy programmes in the US and European countries have received significant attention and have been widely researched, but not those in other countries. This highlights that future studies need to expand to include different countries. Second, the majority of prior publications were concerned with air transport activity, whereas economic, social and environmental wellbeing were less researched. In particular, there is still uncertainty about whether the impacts of aviation subsidies on regional air transport activity can also impact regional wellbeing. Third, the majority of prior studies have only examined indicators associated with air services, including air accessibility and airfare. Likewise, a full picture of aviation subsidies' impacts on regional wellbeing remains a puzzle, and thus further works is required to access more relevant and reliable data and to develop more relevant indicators for this contemporary topic via evidence-based research. Finally, the MRA was conducted via the probit and ordered probit models. The likelihood that air transport activity, economic and social wellbeing were investigated in prior publications was quite sensitive to the subsidy type, the subsidy beneficiaries, study characteristics, geographic areas and research methods used in prior studies. In fact, the probability of finding aviation subsidies' impacts on economic wellbeing and social wellbeing seem to be more affected by those significant explanatory variables applied in this study. Furthermore, it seems that a prior publication studies aviation subsidies' impacts on environmental wellbeing over other wellbeing categories (i.e. air transport activity, economic wellbeing, and social wellbeing) is less likely to report the positive effects of aviation subsidies.

Importantly, this study is a systematic understanding of how aviation subsidies impact a region’s wellbeing and that could be used to gain knowledge and provide insights to policymakers, assisting them to devise better aviation subsidy-related policies for remote regions and smaller communities in the future.

This study has limitations that must be recognised. First, this study only reviewed studies published in English. It did not include studies published in languages other than English (e.g. Chinese, Indian, Japanese or Spanish). Future research might expand the article review scope by exploring other literature from different languages, which might provide more insights and present a broader and more in-depth understanding of aviation subsidies’ impacts on regional wellbeing in different countries. Second, a note of caution is due here, since the majority of selected publications are related to European countries and the US. Hence, aviation subsidies’ impacts on countries outside Europe and the US are still unclear and have not been properly reviewed. Third, aviation subsidies’ impacts on regional wellbeing is a complex research topic and the majority of prior studies have just examined indicators associated with air services, including air accessibility and airfare. Thus, a full picture of aviation subsidies’ impacts on other wellbeing categories remains unknown and relevant information concerning the impacts of aviation subsidies on regional wellbeing is also difficult to discover in prior publications. If more observations on the impacts of aviation subsidies on various regional wellbeing types can be identified, it would be worth running the ordered probit model separately for each wellbeing category.

1.6 References

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Chapter Two – Key indicators for aviation subsidy policy design and implementation

Preamble

Having reviewed air transport subsidies relevant to regional wellbeing in the prior literature and publications in Chapter 1, this chapter evaluates stakeholders' perspectives and opinions about the key air transport and regional wellbeing indicators (e.g. economic, social, environmental, and tourism) for aviation subsidy design and implementation in the early stages of the COVID-19 pandemic. The aviation subsidy policy aims to achieve the accessibility and increased availability of air transport options, thus contributing to and improving communities' wellbeing. Hence, the roles of regional wellbeing indicators in informing regional transport policies (including aviation subsidy policies) should not be neglected. Moreover, the formation and implementation of aviation subsidies should consider the interests and perspectives of various stakeholders. Failure to adequately reconcile their interests and opinions may increase the probability of a failed subsidy request and a lost regional opportunity. As such, this chapter meets the second research objective of this thesis (i.e. to identify the critical air transport and wellbeing indicators that are considered by stakeholders in designing and implementing regional aviation subsidy policies). Because New Zealand had not formed a national aviation subsidy policy before the COVID-19 pandemic, this chapter also investigates the case of Taiwan, which has implemented its aviation subsidy scheme since 2006, but still faces similar challenges in offering seamless regional air services as those in New Zealand, as a comparison. Identifying the differences and similarities of the key indicators considered for regional aviation subsidy policies in New Zealand and Taiwan, allows this thesis to generalise the findings to other countries or regions and to offer policy insights to their governments regarding aviation subsidy policy changes or initiatives. This chapter uses a qualitative approach (survey) to identify and prioritise the key air transport and wellbeing indicators from stakeholders' perspectives and opinions regarding the design and implementation of regional aviation subsidies. This chapter's findings present important insights and policy implications; for example, the destinations served and flight frequency are the key factors when designing or implementing aviation subsidies. It also reveals that integrating economic and social wellbeing into the design and implementation of aviation subsidy policies is very necessary. In terms of academic contributions, this chapter is the first study to demonstrate the FAHP approach's usefulness and robustness in reflecting stakeholders' judgements in responding to the decision-making process of aviation subsidy policies. More importantly, the key factors derived from the stakeholders' perspectives and opinions in this chapter, along with those indicators discussed and identified in Chapter 1, provide a research framework for empirically examining the inter-relationships among aviation subsidies, air transport activity, and regional wellbeing in Chapter 3.

Study Two: Aviation subsidy policy and regional wellbeing: Important indicators from key stakeholders' perspectives in the early stages of COVID-19

Publication status and candidate contribution

This study has been submitted to a highly ranked transport journal and is currently under review. The doctoral candidate is the first author of the publication, with the doctoral supervisors being co-authors. The doctoral supervisors provided minor contributions towards the methods, analysis and review of the study, however, the work is primarily that of the doctoral candidate.

2.0 Abstract

A failure to adequately reconcile stakeholder interests and opinions can increase the probability of a failed aviation subsidy request or a lost of regional opportunity. This study, instead of arguing the importance and offering critiques of aviation subsidies, conducts a survey of stakeholders in New Zealand and Taiwan and uses fuzzy analytic hierarchy process to evaluate and prioritise key air transport activities and regional wellbeing indicators regarding the design and implement of aviation subsidy policies in the early stages of the COVID-19 pandemic. The findings show that destination served, flight frequency, local business activities, medical treatment, and rapid hazard response were considered the key factors of aviation subsidies. Integrating economic and social wellbeing into subsidy policy design and implementation is highly necessary. The results provide useful insights for the development of aviation subsidy policies aimed at improving regional wellbeing in New Zealand and Taiwan during the post-COVID-19 era.

2.1 Introduction

According to contemporary evidence, transport has played a significant role in facilitating wellbeing (Delbosc, 2012). Air transport is a small, but critical, component of transportation, increasing wellbeing by allowing a larger range of vacation destinations, facilitating connections among far-flung families and friends, and expanding the market and supply catchment areas of business, thereby allowing deeper specialisation of function and efficiency.

It is generally accepted that air services to peripheral regions are not always commercially viable, leading to a demand for subsidy from governments (e.g. Donehue & Baker, 2012; Fageda et al., 2018, 2019; Merkert & O'Fee, 2013). Integrating specific wellbeing outcomes help governments to design and implement their aviation subsidy programmes efficiently. While there has been a good deal of recent debate about the efficacy, efficiency, and equity of such subsidy (e.g. Calzada & Fageda, 2014; Fageda et al., 2018, 2019), some research gaps are still to be filled. First, the aviation subsidy programmes in Australia, the European countries and the US have been widely researched (e.g. Baker et al., 2015; Fageda et al., 2018; Wittman et al., 2016) but not those in other countries. Secondly, there has been little discussion about aviation subsidies and regional wellbeing (Wu et al., 2020). Recent research has surveyed the perceived importance of aviation subsidies to the regions and the contribution of aviation subsidies to smaller communities. They also endeavoured to address the perspectives of various stakeholders (e.g. airlines, air transport authorities, city council officials, regional airports and residents) and their motivations in procuring subsidised regional air services to inform better policy decisions (Donehue & Baker, 2012; Halpern & Bråthen, 2011; Özcan, 2014). These studies resulted in range of opinions about aviation subsidies but little discussion about the role of wellbeing outcomes play in aviation subsidy policy formation and their potential to inform subsidy policy changes.

Often a loose-knit group of interested stakeholders – those who believe their interests would be served by expanded (subsidised) air service – form a ‘growth coalition’ by commissioning aviation consultant or academics to generate a study arguing for increased air service. Some of these coalitions tend to consist of a disparate set of stakeholders from regional airports and airline managers to members of regional/local governments to leaders of the local business communities and staff from tourism groups. Academics and environmentalists also get involved. A failure to adequately reconcile stakeholder interests and opinions can increase the probability of a failed subsidy request and a lost regional opportunity.

Generally, government backed stakeholders who promote regional air travel and aviation activities are unlikely to speak against aviation subsidy policies (Özcan, 2014). However, their perspectives regarding the indicators considered in subsidy policy are still worth exploring. Therefore, this study, instead of arguing the importance and offering critiques of aviation subsidies, focuses on exploring key indicators being considered during the regional aviation subsidy policy forming and implementing processes. Previously, the most common approach to explore stakeholders' and policymakers' perspectives in terms of aviation subsidy is to ask them to offer preference judgements using rating scales (i.e. Likert scale). Examples can be found in the European countries and the US (Merkert & O'Fee, 2013, Özcan, 2014). Since humans and preference judgements are often vague, the Likert scores may be difficult to represent the respondents' preferences (Li et al., 2017). Therefore, it is important to apply a good alternative to the Likert scale (i.e. pairwise comparison method) for evaluating aviation subsidy policy in this study. On the other hand, the analytical hierarchy process (AHP) is a widely used method which may provide a theoretical underpinning and advancement to reflect the policymakers' judgement instincts to respond to complex decision-making processes in real-world applications, including air transport policy (Dožić, 2019). Since aviation subsidy policy involves public resources and values, policymakers need to be aware of stakeholders' opinions (e.g. aviation experts, industry professionals and practitioners) before implementing aviaiton subsidy policy design and changes that meets the multiple demands of relevant stakeholders (Arslan, 2009). In addition, when it comes to making decisions for aviation subsidy, there is growing concern about the participants' uncertainty and lack of knowledge of the subject that may lead to their judgemental statements becoming imprecise. Adopting fuzzy logic into the AHP has been suggested by many scholars to capture vague information and deal with uncertainty (Arslan, 2009, Li et al., 2017).

This study sets out to explore aviation subsidies and regional wellbeing outside aforementioned well-researched countries or regions by investigating the cases of New Zealand and Taiwan, where both are facing the challenges of offering better regional air connectivity between major cities and smaller regions. Tourism is important to both New Zealand and Taiwan's economy, with generating a direct contribution to gross domestic product (GDP) of USD11.8 billion (5.9% of GDP) and USD 10.7 billion (1.8% of GDP) in 2018, respectively (World Travel and Tourism Council, 2019). On the other hand, two cases are considered meaningful because they represent different stages of adopting aviation subsidies: New Zealand has not yet formed the national aviation subsidy policies except for a trial program named Essential Transport Connectivity (ETC) scheme introduced during the post-COVID-19 lockdown period, but Taiwan has continuously implemented aviation subsidy programs since 2006. In this study, a fuzzy analytical hierarchy process (FAHP) was applied to evaluate New Zealand and Taiwan stakeholders' perspectives of key indicators considered in adopting aviation subsidy policy.

The technique of FAHP has been used in other contexts but, to the best of the authors' knowledge, not for the air transport subsidy issues. In this study, usefulness and robustness of this technique was demonstrated using two proof of concept applications, the cases of New Zealand and Taiwan. Identifying the differences and similarities of key indicators considered in regional aviation subsidy policies in New Zealand and Taiwan, which allow making recommendations to both governments regarding their aviation subsidy policy changes or initiatives, thus improving their regional economies, tourism, and socio-environmental wellbeing in the post-COVID-19 era.

This study therefore focuses on 25 indicators/factors of air transport activities and wellbeing categories, and identifies which ones should be considered as key factors in designing and implementing (regional) aviation subsidies. The remainder of this paper is organised as follows. Section 2.2 provides a review of the extant literature on the indicators of air transport activities, and the key regional wellbeing categories and indicators. Section 2.3 provides background on the research context in relation to regional aviation subsidies in New Zealand and Taiwan. Section 2.4 describes the methodology. Section 2.5 presents the results. Section 2.6 discusses the findings and policy implications. Section 2.7 presents the conclusion and discusses the contributions, implications as well as limitations of this study.

2.2 Literature review

2.2.1 Aviation subsidies and regional air transport activity

Gössling and Peeters (2007), and Merkert and O'Fee (2013) argued that governments have the overall responsibility of maintaining the framework of public transport systems by providing subsidies. Indeed, governments in many countries have invested substantial amounts of capital and resources (e.g. grants or cross-subsidisation, and loans and loan guarantees) or various support programmes (e.g. provision of air services on specific routes and airfare discounts for residents living in remote communities) for airlines and airports serving regional markets. More details can be found in Gössling et al. (2017) and Fageda et al. (2018). Undoubtedly, many of these subsidy policies have received criticism in terms of market distortion, policy transparency (e.g. definition of service levels, fares and time period), and subsidies' validity and efficiency (e.g. flight operaitons with low load factors and redundancy of subsidised community areas) (Fageda et al., 2018; Grubesic & Wei, 2012).

Regional air transport has been recognised as being essential for facilitating the mobility of travellers (e.g. highly skilled human capital and tourists) and goods and services within peripheral regions (Bråthen & Halpern, 2012; Tveter, 2017). A number of air transport activity indicators are used by researchers to examine regional air services. The number of available seats, flight frequency and destinations served are commonly used as indicators to measure air service accessibility and the airline capacity of a region (Fageda et al., 2018; Ramos-Pérez, 2016). In addition, regional airports represent important points of access to remote locations of a country that have limited or lengthy ground access. It has been suggested that the provision of well-functioning regional airport infrastructure and efficient airport operations are vital to regional economic and social welfare gains (Baker et al., 2015; Tveter, 2017). Furthermore, Nõmmik and Antov (2017) claimed that affordable and efficient airport infrastructure and effective operations are essential for ensuring regional airports' existence and a sustainable future.

2.2.2 Regional wellbeing

Prior studies have attempted to measure wellbeing with different levels and with different constructs or indicators, such as measurements of wellbeing at both the national and personal levels, and wellbeing with various indicators across economic, social and environmental accounts (Allin & Hand, 2014; Diener et al., 2013). This study thus applies some common indicators from the economic, social and environmental aspects to the measurement, as well as incorporating tourism indicators as the supplement because of their important contributions to New Zealand and Taiwan's regional development and economies. Transport policy provides the accessibility and availability of transport options, contributing, in turn, to the wellbeing of communities (Delbosc, 2012; Reardon & Abdallah, 2013). In rural and regional communities, air transport services can play a pivotal role in promptly transferring individuals, goods and services from one place to another, which largely contributes to the various wellbeing of those communities (Albalate & Fageda, 2016; Tveter, 2017).

Economic wellbeing indicators

A well-functioning air transport system enhances trade and enables people, businesses, cities and regions to be well connected, and it is essential for facilitating regional economic activities (Donehue & Baker, 2012). For instance, the growth of regional air connectivity and air passenger flows help reduce regional unemployment levels (Florida et al., 2015) and promote a greater region's per capita income (Diener et al., 2013), thus bringing economic and social benefits to the region. It should be noted that two key indicators (regional unemployment and a region's per capita income) are always considered to be important for analysing regional economic wellbeing (Layard, 2010). Moreover, regional air services provide substantial benefits for the regional import and export trade, as air services are vital for reducing some barriers to the movement of goods and services (Merkert & O'Fee, 2013). Furthermore, there is a strong possibility that regional aviation subsidies may support business communities, including attracting new local businesses and inward investments (Bråthen & Halpern, 2012), not to mention the significant impacts of investments to improve regional air transport by foreign direct investors (Bannò & Redondi, 2014).

Social wellbeing indicators

Improved air connectivity to and from regions can play an important role in many aspects of people's lives. Since air travel demand for regional routes tends to be low, airlines may provide less frequent and more expensive flight services, or may not offer any flight services at all (Bitzan & Chi, 2006). Therefore, airfares on regional routes are frequently used as the main indicator in the air transport literature to measure regional social wellbeing (Bråthen & Halpern, 2012; Fageda et al., 2016, 2017). It is widely known that regional air services help residents living in remote or isolated communities to overcome the geographical difficulties of being isolated or having limited surface transport, thus delivering lifeline services to ensure necessary access to medical treatment, visiting friends and relatives, education and social cohesion, etc. (Bråthen & Halpern, 2012; Merkert & O'Fee, 2013). Particularly for elderly people, increased air mobility may lead to more frequent air travel for enjoying leisure activities, pursuing interests, meeting with relatives and friends, or even accessing medical services (Bråthen & Halpern, 2012; Svenson et al., 2006). Furthermore, many prior studies have found that mobility also plays an essential role in affecting residents' social wellbeing in terms of their enjoyment of leisure time (Spinney et al., 2009; Stanley et al., 2010). Another indicator of social wellbeing that might be relevant to regional air transport is housing affordability. Since an airport has long been considered to be a crucial driver of economic activity in a region (Appold, 2015), a few prior studies have empirically investigated the relationship between air transport activity and housing prices in both major and smaller regions (Biagi et al., 2015; Tsui et al., 2017). Finally, some research has highlighted the importance and use of regional airports during and after catastrophes, such as for rapid hazard response (e.g. search and rescue services) (Minato & Morimoto, 2012; Smith, 2010). This enhances a regional airport's responsiveness to catastrophes or natural disasters and provides a new rationale for establishing and maintaining regional air transport, a topic that has otherwise been discussed primarily from the connectivity and economic perspectives.

Environment wellbeing indicators

Environmental concerns are rising rapidly around the world. The aviation sector, like all other industries, is also facing increasing environmental pressure from the public. Graham (2013) suggested using five primary indicators to measure the environmental impacts at the regional level, namely air quality (emissions), noise, wildlife, heritage and landscape, waste management, and water use and pollution. Increasing air traffic volumes to and from the region are generally accompanied by additional air travel emissions (Ryerson, 2016). In addition to emissions from aircraft, airports have large numbers of ground support vehicles that contribute to the worsening of local air quality (Daley et al., 2008; Hooper & Greenall, 2005). Another important environmental impact indicator of aviation is aircraft noise, which has been used as an environmental wellbeing indicator in prior studies (Chang et al., 2015; Mak et al., 2007). Moreover, airports require large land areas that are hostile to wildlife because of a loss or disruption of wildlife habitats, vegetation damage or removal, and the development of airport surroundings. Finally, water use and pollution, as well as waste management, are also problematic because of airlines and airport operations (Tofalli et al., 2018).

Tourism indicators

Regional tourism and air transport are explicitly linked (Spasojevic et al., 2018). In the tourism and air transport literature, researchers have generally achieved a consensus that air transport and tourism are mutually dependent, with airlines often involved in the planning and development of tourist destinations, whereas tourism destinations may benefit from local airports' activities or the development of new airline routes, ultimately facilitating inbound tourism growth (Castillo-Manzano et al., 2011; Forsyth, 2016; Tsui, 2017). Moreover, better and more convenient air services provide benefits to local residents in terms of providing them with opportunities to travel outside the regions (Baker et al., 2015; Forsyth, 2016). Accommodation occupancy has also been considered as an important indicator, as it may reflect a region's tourism demand and patterns (De Cantis et al., 2011). Furthermore, an increase in visitor expenditure in the region, for example, retail, car rentals, food and beverages, have positive effects on the region's economy (Forsyth, 2016). Consequently, while tourism can be treated as an independent industry, it is reasonable to examine those tourism-related indicators as wellbeing factors that can stimulus other economic and socio-environmental wellbeing of the regions.

2.3 Regional aviation subsidies in New Zealand and Taiwan

2.3.1 New Zealand

Road and rail transportation in New Zealand seem to be time-consuming to get to small communities in isolated and remote areas. The state highway networks are the principal road infrastructure connecting New Zealand's major urban centres. The national rail services are largely focused primarily on freight transportation, with limited tourism focussed services on some routes. According to Environmental Health Intelligence New Zealand (2018), 16.3% of New Zealanders lived in rural areas. Consequently, air transport plays an important role in maintaining regional connectivity, which links geographically dispersed parts of New Zealand.

There are 29 certificated aerodromes operating in New Zealand (Civil Aviation Authority of New Zealand, 2020), but only 26 commercial airports offer scheduled flight services (see Appendix G). Auckland, Christchurch and Wellington airports serve as key domestic aviation hubs that connect to each other and to smaller regional airports, whereas small regional airports function as nodes that connect to the three domestic hub airports. New Zealand's airport system, in which there is only one commercial airport per city or region (Fu et al., 2020). However, New Zealand's airport industry is facing a range of financial pressures, such as the combination of the high costs of maintaining airport infrastructure and complex operations (e.g. operational and safety regulatory requirements), the commercial sustainability of air services and financial sustainability (New Zealand Airports Association, 2017). Over time, these financial pressures may influence small regional airports' future viability and ability to serve their communities.

Furthermore, smaller airlines (e.g. Jetstar and Sounds Air) may also be forced to cease operations due to a lack of patronage, high operating costs per seat, small market demand or a combination of all these factors. Aviation in New Zealand has no national funding system. Often, the local governments stepped in to underwrite air services and fund airport infrastructure to ensure essential air connectivity to their regions (e.g. Sounds Air operating a

Westport–Wellington service and Air Chatham operating a Whakatane–Auckland service) (New Zealand Airports Association, 2017). Regional air transport also received financial support from various government projects. The New Zealand government has allocated three billion dollars (NZD) from the Provincial Growth Fund to invest in regional economic development including regional connectivity and wellbeing. For example, Invercargill Airport received NZD$500,000 from the Provincial Growth Fund in 2019 for upgrading terminal facilities to accommodate the newly launched Auckland to Invercargill service. In 2020, given the immense impacts of the COVID-19 pandemic that has had upon the New Zealand's regional aviation industry, the trial aviation subsidy program (i.e. the ETC scheme) was introduced by the Ministry of Transport to provide support for air transport providers (e.g. airports, airlines, and aviation support services) over the short term in the post-COVID-19 lockdown period. The objective of this scheme is to ensure capacity, regional connectivity, and essential services are maintained in the wake of COVID-19 (Ministry of Transport, 2020). For example, Sounds Air (a small regional airline based at Picton) received NZD$30 million to keep flying to remote communities (e.g. Blenheim and Westport airports). The combination of the importance of a fit-for-purpose air transport network to regional economic growth and enhanced social connection and the devastating impact of COVID-19 highlights the urgency of understanding stakeholders' and policymakers' perspectives concerning the link between aviation subsidies and regional wellbeing outcomes.

2.3.2 Taiwan

Taiwan's most important urban transportation system is concentrated in three metropolitan areas on the west coast: Taipei, Taichung and Kaohsiung, where the majority of economic, population and tourism activities are located. Intercity transportation between major cities relies mainly on highways and the Taiwan High Speed Rail (THSR). Unlike the west coast's well-developed highway networks and THSR, many cities or counties on the east coast (e.g. Hualien and Taitung) and communities on offshore islands (e.g. Kinmen, Matsu and Penghu) still have limited surface transport. According to the Ministry of the Interior (2020), 21.5% of the population of Taiwan is rural population. Air transport still plays a vital role in providing connections linking cities or counties, offshore islands and metropolises, thus delivering considerable economic and social benefits to offshore island residents (Dai et al., 2004).

Currently, 17 civil airports in Taiwan are operated by the Taiwan Civil Aeronautics Administration and 15 of them provide scheduled domestic air services (Taiwan Civil Aeronautics Administration, 2020) (see Appendix H).To improve connections among offshore islands and remote communities, the Taiwanese government provides financial support to airlines operating scheduled services through three primary forms of subsidy: (1) airfare discounts for offshore island residents, (2) annual premiums for airlines accomplishing required air services, and (3) a subsidy scheme for airlines to cover their losses when operating air routes to remote offshore islands. Table 6 shows a considerable increase in Taiwanese government's expenditures on airfare discounts for offshore island residents and subsidies for air routes of remote offshore islands. Between 2012 and 2017, the Taiwanese government's spending for airfare discounts for offshore island residents increased by 251%, and subsidy scheme expenditures have tripled. As of March 2020, the Ministry of Transportation and Communication (MOTC) announced a package of financial aid for the Taiwan's aviation industry, in the form of subsidies and loans, to cope with the impact of the COVID-19 pandemic. The relief package covers airlines, airports, airport terminal retailers, and catering services (Ministry of Transportation and Communications, 2020a). Aviation subsidies in the relief package also include funding each flight costs, landing fees, land and warehouse use fees, and maintenance hangar use fees, etc. Importantly, the Taiwanese Government also offered loans to help regional airlines keep operating offshore island routes during the Covid-19 period. In April 2020, the MOTC unveiled a second round of relief measures to the aviation industry, with NT$50 billion credit guarantees from the Taiwanese Government (Ministry of Transportation and Communications, 2020b). The primary challenge for Taiwan's aviation sector is a considerable increase in government expenditure on airfare discounts for offshore island residents and subsidies for air routes to remote offshore islands in recent years. Funding from the Taiwanese government still appears insufficient to encourage regional airlines to continue providing adequate flight services to remote offshore islands, consequently affecting offshore island residents' wellbeing (Ministry of Transportation and Communications, 2020c). As such, there is a need to gather the perspectives of stakeholders and policymakers to deepen the knowledge of the interplay between aviation subsidies and regional wellbeing outcomes, which could be a useful supplement to aviation subsidy regulation changes aimed at improving the offshore islands' air services.

Table 6

Offshore islands' air transport services subsidies (2012−2017)

Years	Airfare discounts for offshore island residents (million NT$)	Annual premiums (million NT$)	Subsidies for air routes of offshore islands (million NT$)
2012	386.3	12.5	145.0
2013	609.4	12.5	183.7
2014	731.3	15.0	190.3
2015	844.0	15.0	190.3
2016	928.3	15.0	444.4
2017	968.1	15.0	455.3

Source: Civil Aviation Authority (2019).

2.4 Methodology

This study presents a method for aggregating preferences, opinions, and views of various stakeholders that allows all their viewpoints to be represented, but also yields a clear hierarchy structure among them so that a united front could be presented in stakeholder requests. It focuses on 25 indicators/factors of air transport activities and wellbeing categories, and identifies which ones are considered as key factors in designing and implementing (regional) aviation subsidies. The AHP is a multi-criteria decision-making process that estimates the relative magnitude of criteria or factors through pairwise comparisons (Saaty, 2008). The major advantage of the AHP is that it does not require a large sample size to achieve sound and statistically robust results, and this approach can focus on a specific issue (Doloi, 2008; Saaty, 2008). Although AHP is an effective tool for multi-criteria decision-making, the application of AHP may suffer a few drawbacks, such as the uncertainty and subjectivity of the factor comparisons, as participants may not precisely express their preferences (e.g. Li et al., 2017; Mahtani & Garg, 2018; Pehlivan et al., 2017); however, these shortcomings can be reduced by applying a fuzzy approach to the conventional AHP (FAHP). This study follows the same procedure as these previous studies that applied FAHP. For the sake of brevity, more details about the FAHP applied in this study can be seen in Appendix I. Figure 10 presents the research framework of this study.

Figure 10

Research framework

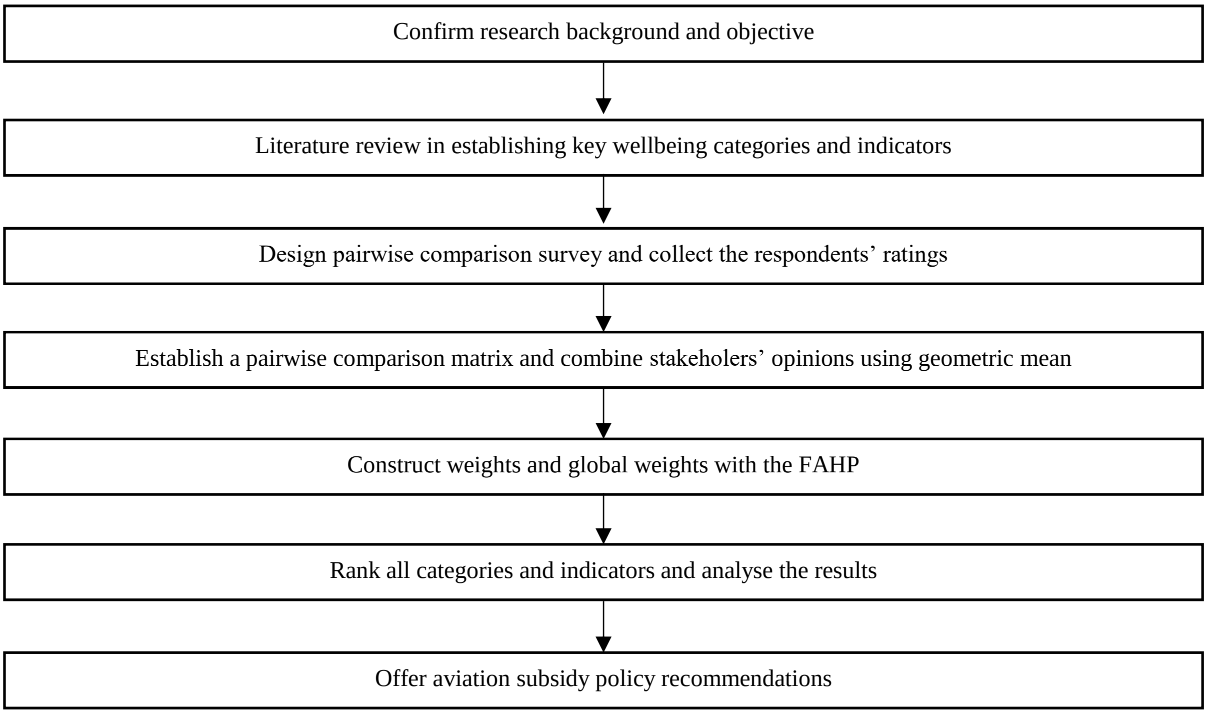
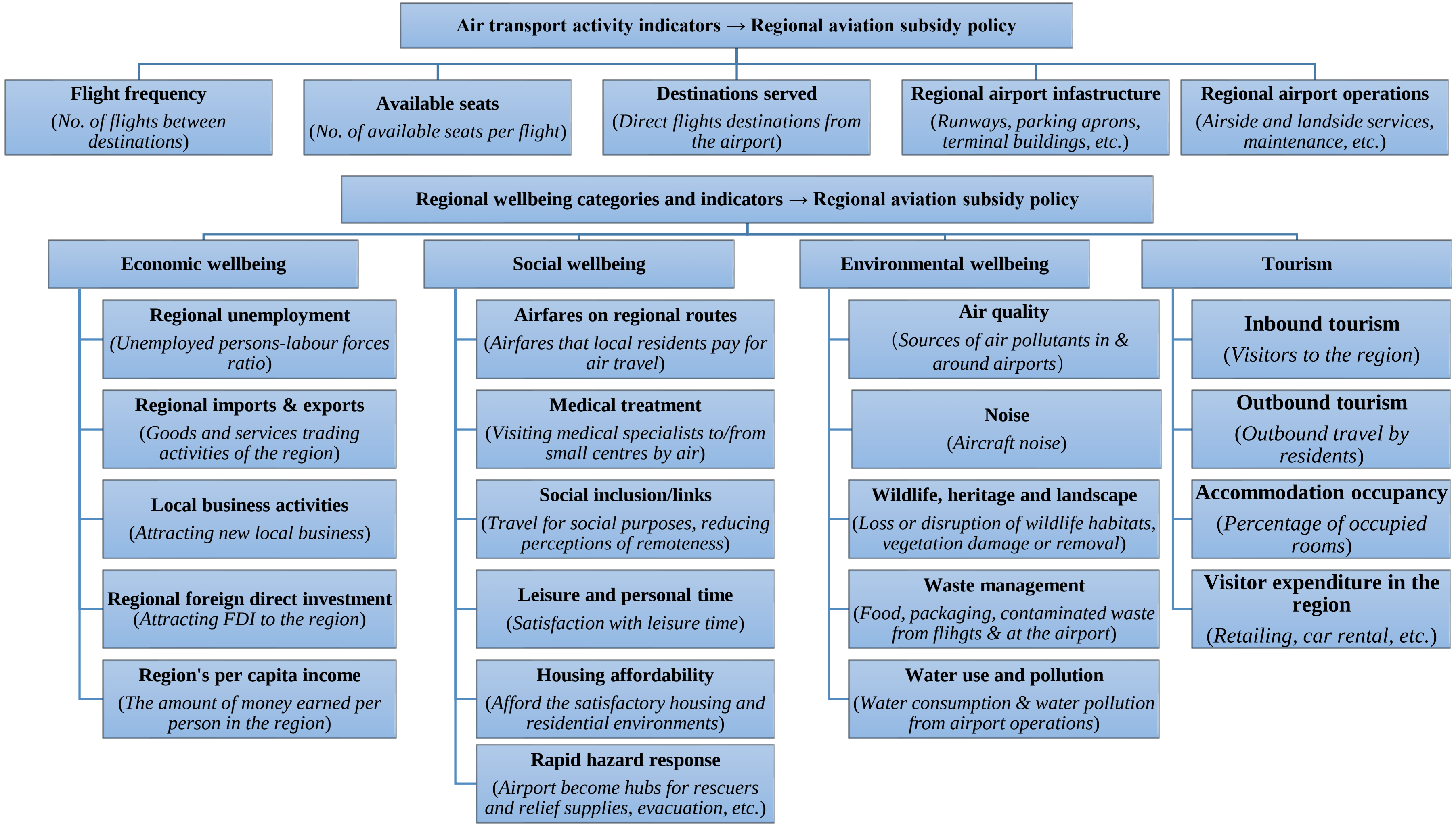


Figure 11 demonstrates the hierarchy structure of the FAHP model for this study, and an online questionnaire (see Appendix J) was structured. Following the approach of Saaty (2008), the questions were asked to rate on a nine-point scale for the comparison of the wellbeing categories and indicators. Target stakeholders residing in New Zealand and Taiwan were contacted and surveyed: (1) industry practitioners, including regional airport and airline managers; (2) aviation researchers, including academic scholars from universities and research institutions; (3) government agencies, including officials from the Civil Aviation Authority of New Zealand and Taiwan's Civil Aeronautics Administration, the Ministry of Transport and other transport-related agencies; (4) regional and local governments, including councillors who are responsible for regional transportation policies; and (5) others, including experts and staff from tourism and environmental groups. All the potential participants who must understand and work in the aviation or related sectors, reflecting their diverse backgrounds, expertise and knowledge of aviation subsidy. Particularly, aviation researchers' responses were sought in reinforcing the aviation experts, industry professional and practitioners' point of view. The surveys were carried out in New Zealand and Taiwan simultaneously after the occurrence of COVID-19 crisis from March to June 2020. In total, 51 (New Zealand) and 45 (Taiwan) responses were received. Participants were mainly recruited via email and social media, and aviation or transport-relevant associations or organisations (e.g. Transport Knowledge Hub of the Ministry of Transport of New Zealand) were contacted to mail out the survey invitations to their members. It is unknown the total number of aviation experts and stakeholders who received the questionnaire, and therefore the response rate is not available in this case. After eliminating incomplete responses with unanswered questions in the questionnaire, 36 (New Zealand) and 43 (Taiwan) responses are used for further analyses.

In the AHP analysis, pairwise comparisons may lead to some inconsistencies because individual judgments could be affected by a lack of rationality and violate the consistency condition of the matrix (Saaty, 2008). Hence, it is necessary to obtain the consistency ratio (CR) of a survey for checking the reliability of participants' responses. Generally, a CR value of a response lower than 0.2 should be acceptable (Lee & Walsh, 2011; Saaty, 2008). For the sake of brevity, more details on this method can be seen in previous AHP studies such as Brunelli (2014) and Saaty (1987). According to the results of the pairwise CR analysis, 25 New Zealand participants and 22 Taiwanese participants provided reliable answers with a CR of 0.2 or less for all comparison matrices. Detailed demographical information of the New Zealand and Taiwanese participants is shown in the Appendix K.

Figure 11

Hierarchy of the FAHP model for forming or designing regional aviation subsidy policy



In the FAHP, triangular fuzzy numbers are computed to represent the relative importance in the comparison matrices (Pehlivan et al., 2017; Zhu et al., 1999). In this study, the geometric mean of each participant's responses was computed for aggregating group responses (Davies, 1994; Kar, 2014). Next, the geometric mean method of FAHP[8] developed by Buckley (1985) was used to maintain consistency with the aggregation of group responses. According to Pehlivan et al. (2017), a major advantage of the geometric mean method is that it is easy to extend to the fuzzy case without complex computations. This method has been used in this study to obtain the fuzzy weights of air transport activity indicators, and regional wellbeing categories and indicators, followed by adopting two ranking systems, namely ranking (within the air transport activity and a specific regional wellbeing category) and overall ranking (within the four regional wellbeing categories).

2.5 Results

Results of the FAHP technique are shown in Tables 7 and 8. In addition to applying the AHP technique under fuzzy conditions, the standardized AHP was also conducted and presented for comparison purposes. As a group of target stakeholders were contacted and surveyed, the weights of regional wellbeing categories and indicators are determined by combining the questionnaire results, taking the geometric average of pairwise assessments by the target stakeholders. The results of the AHP method (see Appendix M) are similar to those of the FAHP technique (see Appendix L), except for a minor difference in the ranking of regional wellbeing categories and indicators was noted. Therefore, the results of FAHP method were reported with confidence.

2.5.1 Air transport activities

The ranking of the air transport activity indicators for New Zealand and Taiwan are shown in Table 7. For both New Zealand and Taiwan, *destinations served* had the highest fuzzy weight; consequently, it is the most important indicator to be considered by participants when designing and implementing aviation subsidies. The next important indicators are *flight frequency*,

[8] For the sake of brevity, more details regarding the geometric mean method of FAHP can be found in the previous AHP literature (Chen & Chen, 2010; Pehlivan et al., 2017). Another popular FAHP method (the extent analysis method) was also performed as a robustness check (Chang, 1996). However, it suffers from the shortcoming that it may assign zero weights during computation. Therefore, the weights obtained from the geometric mean method were reported.

available seats and *regional airport infrastructure*. The least important indicator is *regional airport operations*.

Table 7

Rankings of air transport activity indicators using FAHP and AHP

Indicators	New Zealand		Taiwan	
	Rank (FAHP)	Rank (AHP)	Rank (FAHP)	Rank (AHP)
Flight frequency	2	2	2	2
Available seats	3	3	3	3
Destinations served	1	1	1	1
Regional airport infrastructure	4	4	4	4
Regional airport operations	5	5	5	5

2.5.2 Regional wellbeing categories and indicators

Ranking of regional wellbeing categories

The ranking of the regional wellbeing categories for New Zealand and Taiwan is shown in Table 8. For New Zealand, *economic wellbeing* has the highest rank as the primary wellbeing outcome to be considered by participants when designing regional aviation subsidies. The next highest ranked regional wellbeing categories are *social wellbeing*, *environmental wellbeing* and, lastly, *tourism*. Regarding Taiwan, *social wellbeing* as a result of implementing aviation subsidies stands out as the top-ranked category, followed by *economic wellbeing*, *tourism*, and lastly *environmental wellbeing*.

Ranking and overall ranking of each indicator

Table 8 also shows the overall rankings of all regional wellbeing indicators. New Zealand's top four regional wellbeing indicators are *local business activities*, *wildlife, heritage and landscape*, *medical treatment* and *visitor expenditure in the region*. In Taiwan's context, the top four regional wellbeing indicators are *visitor expenditure in the region, medical treatment, rapid hazard response*, and *inbound tourism*.

Table 8

Rankings of regional wellbeing categories and indicators using FAHP and AHP

Regional wellbeing categories	New Zealand		Taiwan		Regional wellbeing indicators	New Zealand				Taiwan			
	Rank (FAHP)	Rank (AHP)	Rank (FAHP)	Rank (AHP)		Overall rank (FAHP)	Overall rank (AHP)	Rank (FAHP)	Rank (AHP)	Overall rank (FAHP)	Overall rank (AHP)	Rank (FAHP)	Rank (AHP)
Economic wellbeing	1	1	2	2	*Regional unemployment*	8	7	3	2	7	5	2	1
					Regional imports & exports	7	8	2	3	17	17	5	5
					Local business activities	1	1	1	1	6	7	1	2
					Regional foreign direct investment	16	16	5	5	13	13	4	4
					Region's per capita income	9	9	4	4	10	10	3	3
Social wellbeing	2	2	1	1	*Airfares*	17	17	5	5	9	9	3	3
					Medical treatment	3	3	1	1	2	2	1	1
					Social inclusion and links	14	14	4	4	11	11	4	4
					Leisure and personal time	19	20	6	6	19	19	6	6
					Housing affordability	13	13	3	3	18	18	5	5
					Rapid hazard response	5	5	2	2	3	3	2	2
Environmental wellbeing	3	3	4	4	*Air quality*	15	15	5	5	14	14	3	3
					Noise	11	11	3	3	8	8	1	1
					Wildlife, heritage and landscape	2	2	1	1	15	15	4	4
					Waste management	12	12	4	4	16	16	5	5
					Water use and pollution	6	6	2	2	12	12	2	2
Tourism	4	4	3	3	*Inbound tourism*	10	10	2	2	4	4	2	2
					Outbound tourism	18	18	3	3	20	20	4	4
					Accommodation occupancy	20	19	4	4	5	6	3	3
					Visitor expenditure in the region	4	4	1	1	1	1	1	1

Amongst New Zealand's stakeholders, *local business activities* takes the top rank in the *economic wellbeing* category, followed by *regional imports and exports*, *regional unemployment* and *region's per capita income*. It is noted that the results obtained from the AHP method show that *regional unemployment* is slightly more important than *regional imports and exports*.[9] The least important indicator is *regional foreign direct investment,* suggesting that it is the least important outcome to be considered when implementing aviation subsidies. With respect to the *social wellbeing* category, *medical treatment* has the highest importance, followed by *rapid hazard response* and *housing affordability*. Other indicators with lower importance are *social inclusion and links*, *airfares*, and *leisure and personal time*. For the *environmental wellbeing* category, *wildlife, heritage and landscape* received the highest rank, followed by *water use and pollution*, *noise*, *waste management*, and *air quality*. In addition, '*visitor expenditure in the region'* has the highest importance in the *tourism* category, followed by *inbound tourism, outbound tourism*, and *accommodation occupancy*.

For Taiwan's stakeholders, *local business activities* and *regional unemployment* are the most important indicators in the *economic wellbeing* category, in terms of the decision-making process of aviation subsidies which presented in both FAHP and AHP methods, although the AHP results have different rankings compared to the FAHP results in which *regional unemployment* occupies the top rank.[10] For the *social wellbeing* category, *medical treatment* is the most important indicator, followed by *rapid hazard response*, *airfares*, and *social inclusion and links*. Other indicators that are lower in importance are *housing affordability* and *leisure and personal time*. With regard to the *environmental wellbeing* category, *noise* occupied the top rank and is the issue of greatest concern for the participants, followed by *water use and pollution*, *air quality, wildlife, heritage and landscape*, and *waste management*. *Visitor expenditure in the region* is considered as the most important indicator under the *tourism* category, followed by *inbound tourism* and *accommodation occupancy*. *Outbound tourism* was the least important indicator.

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[9] As shown in Appendices L and M, it is observed that regional unemployment and regional imports and exports for the New Zealand case share the similar weights. The fuzzy theory as FAHP has ability to process such information because it allows uncertainty and fuzziness in decision-making as suggested by many scholars (e.g. Arslan, 2009; Li et al., 2017; Mahtani & Garg, 2018).
[10] Same explanation as Footnote 9.

2.6 Discussions and implications of key findings

Several key findings are worth highlighting and discussing. These findings provide policy implications for stakeholders and policymakers in New Zealand and Taiwan while forming and implementing regional aviation subsidies.

2.6.1 The importance of destinations served

It is necessary to consider the effect of aviation subsidies on existing regional air connections. Both New Zealand and Taiwanese participants achieved a consensus about the ranking of *destinations served* as the most important factor of air transport activity when forming or implementing regional aviation subsidies. This finding supports prior research, which indicated the positive impact of aviation subsidies on domestic connectivity levels, preventing lapses in small communities' air services (Merkert & O'Fee, 2013).

For New Zealand, it is important to recall that Air New Zealand and Jetstar, the two leading domestic carriers, pulled out flight services connecting three major domestic hub airports (i.e. Auckland, Christchurch and Wellington) to several regional destinations in the past few years. Hence, this study suggests that aviation subsidies could be used to help New Zealand's regional and small airports host more destinations and resume connections from hub airports. On the other hand, aviation subsidies can be used as a mechanism to support and improve the essential air services between smaller underserved regions provided by small regional carriers (e.g. Sounds Air). Indeed, the newly introduced ETC scheme exactly has supported small regional carriers to retain their services to small and remote regions. In the case of Taiwan, the finding indicates that *destinations served* should always be viewed as a key factor for future subsidy policy changes. It is worth noting that this finding supports the currently implemented aviation subsidy schemes (i.e. subsidy schemes for air routes to remote offshore islands and annual airline premiums), which have specifically included requirements related to destinations served (i.e. service to a certain number of offshore islands) as one of the primary conditions for aviation subsidy applications from airlines.

2.6.2 Flight frequency is another key factor of aviation subsidy

In addition to *destinations served*, *flight frequency* is another important aspect to be considered when forming and implementing aviation subsidies by New Zealand and Taiwanese participants. This also accords with prior studies, which showed that regional aviation subsidies produce welfare gains, reflected by increasing flight frequencies to the regions (Di Francesco & Pagliari, 2012; Ramos-Pérez, 2016).

In New Zealand, the majority of regional routes are operated by Air New Zealand, and a few routes are offered by small airlines, both with less than five daily flights. Hence, if the New Zealand government wants to support the regional aviation sector, aviation subsidies to regional carriers by increasing the *flight frequency* between major cities and smaller regions should be one of the main strategic options considered. This is in line with most subsidy programmes in the US and European countries (e.g. Essential Air Service (EAS) and Public Service Obligation (PSO)), which specify the flight frequency requirements in the subsidy contracts (Fageda et al., 2018; Özcan, 2014). In Taiwan's case, the existing aviation subsidy programmes (i.e. a subsidy scheme for air routes to remote offshore islands and annual airline premiums) have explicitly required a minimum number of daily flights to fly to each offshore island. As Taiwanese participants believed *flight frequency* to be the key factor, the existing subsidy programmes regarding the requirements of *flight frequency* need to be carefully monitored and regularly tracked by policymakers.

Practically, airlines have two main options to accommodate growing demand for a route: increase flight frequency or use larger aircraft with more seat capacity (Wang et al., 2014). However, in New Zealand and Taiwan, while improving air transport-related activities to smaller regions or remote areas is the main objective of aviation subsidies, thus preference should be given to an increase in *flight frequency* instead of increasing *seat capacity* because most regional airports in New Zealand and Taiwan are relatively small and can only accommodate smaller aircraft (e.g. ATR72, Cessna 208 Caravan, Pilatus PC-12, Embraer ERJ-190, Bombardier Q400).

2.6.3 Integrating economic and social wellbeing into aviation subsidy policy design

In this study, New Zealand participants indicated that *economic* and *social wellbeing* are equally important considerations in regional aviation subsidy policy formation, whereas Taiwanese participants significantly prioritised *social wellbeing* outcomes over *economic wellbeing*. Notably, such findings offer fresh insights into the interplay of regional aviation subsidies, air transport activity and regional wellbeing from the perspectives of various stakeholders, as there is still a lack of evidence on aviation subsidies' effects on regional economic and social wellbeing through improved regional air transport links. The different results among New Zealand and Taiwan might be attributed to their different approaches/policies towards aviation subsidy as mentioned in Sections 2.1 and 2.3. It is worth noting that roads or highways can connect most remote communities in New Zealand despite being time-consuming, and rural communities with comparatively poor access to air transport already struggled with social and economic sustainability (Fu et al., 2021). Thus, subsidised regional air services seem to be equally critical to facilitate regional economic growth and offer significant social benefits to smaller communities in New Zealand. Whilst aviation subsidies in Taiwan primarily aim to provide better air connections between offshore islands and the main island of Taiwan, island residents' social welfare attracted great attention as the Taiwanese government subsidised airlines to operate a minimum number of daily flights and offered airfare discounts to island residents to fly.

Among the economic wellbeing indicators included in this study, *local business activities* was found to be a key factor by New Zealand and Taiwanese participants. Consistent with the literature, regions that are connected and equipped with a modern and resilient transport infrastructure could help small businesses to grow their businesses domestically and internationally, which, in turn, helps to shape a strong and vibrant economy in the region (Ramos-Pérez, 2016). In New Zealand, 97% of all enterprises are small businesses with less than 20 employees, playing a vital role in sustaining regional and rural communities (Ministry of Business, Innovation & Employment, 2020). In Taiwan, this finding further supports the idea of continually developing local businesses (e.g. Kinmen Kaoliang Liquor) through improved offshore air transport and tourism activity (National Development Council, 2016). In addition, *regional unemployment* is another economic wellbeing indicator that has received attention from Taiwanese participants. It is believed that improved offshore air services can facilitate local businesses and tourism development, thus creating more job vacancies for offshore island residents (National Development Council, 2016).

Of all the social wellbeing indicators, *medical treatment* and *rapid hazard response* are the greatest concerns of both New Zealand and Taiwanese participants. Although air ambulance flights are mostly performed by helicopters in New Zealand, two-engine turbine aircraft (e.g. King Air 200) are also used when they are able to operate from aerodromes (Ministry of Health, 2020). In continuously improving local residents' *medical treatment*, the New Zealand government needs to devote their efforts and maintain regional air services. This pinpoints the critical role of regional flight services and well-functioning small regional airports, as a reduction in regional flight services or the closure of smaller aerodromes may affect urgent medical transfer flight services in New Zealand. Similarly, a timely and cost-effectively air services seem to be essential for offshore island residents in Taiwan to access health services in the metropolises. The Taiwanese government showed a strong interest in advancing the offshore islands' air transport to improve the performance of health services, for instance, stationing aircraft at three offshore islands (i.e. Kinmen, Matsu islands and Penghu) for the use of emergency medical transfers (National Development Council, 2016).

Moreover, New Zealand and Taiwan are susceptible to natural disasters (e.g. earthquakes and typhoons). Previous studies have shown the important role of regional airports in the case of a catastrophe (Minato & Morimoto, 2012; Smith, 2010). Aerodromes are regarded as national lifeline utilities by the Civil Aviation Authority of New Zealand in their advisory circular (AC139-14), as airstrips and aerodromes are an essential part of disaster response, particularly when roads or land transport are cut off (New Zealand Airports Association, 2017). The recent case of the 2016 Kaikōura earthquake in New Zealand clearly supports the view that disaster response and recovery and air services are closely linked. In a similar vein, it is also important for the Taiwanese government to integrate offshore islands' air services with an improved emergency management system to reduce the negative consequences of disasters and for search and rescue purposes.

There is a nexus between aviation subsidy policies and regional wellbeing (e.g. economic and social wellbeing). From the discussions above, continued efforts to effectively and strategically form and implement aviation subsidy are needed by both the New Zealand and Taiwanese governments. Despite the differences in aviation subsidy policies' maturity, economic and physical geography between New Zealand and Taiwan, New Zealand's policymakers could learn from Taiwan's experience by forming a national aviation funding system that will not only incorporate the objective of regional development but also directly benefit residents living in smaller and remote communities and improving their social wellbeing. As for Taiwan's policymakers, the regional aviation subsidy policy needs to be continuously monitored and amended to better cope with the social benefits increase and potential demand growth in offshore island residents' medical treatments.

2.6.4 Calling attention to environmental externalities associated with aviation subsidies

The environmental concern was a relatively low priority for New Zealand and Taiwanese participants when considering the issue of regional aviation subsidies, but *water use and pollution* was voiced for both cases. A possible explanation for this might be that increasing regional air traffic volumes may increase environmental concerns regarding water usage and disposal.

In addition, the indicator of *wildlife, heritage and landscape* is likely to be of great importance for future aviation subsidy policy formation by New Zealand participants. It is believed that building additional facilities and infrastructure at regional airports may potentially be hostile to wildlife (e.g. disrupting, displacing or damaging their habitat) and that airports' surroundings will be developed into a more urbanised setting (Higham et al., 2019). There is little information in any previous New Zealand government's policy document about mitigating the effects of air transport development on *wildlife, heritage and landscape*, thus this finding suggests that greater attention should be given to this environmental factor in New Zealand's future aviation subsidy policy design.

In the context of Taiwan, the participants predominantly focused their attention on the indicator of *noise*. It is known that the Taiwanese government has introduced multiple regulations for noise monitoring and control schemes at airports, and has provided subsidies to residents who have been living in specified areas around airports since 2000 (e.g. the Airport Compensation Fund Allocation and Use Regulations) (Environmental Protection Administration, 2020). Therefore, this finding corroborates the importance of implementing noise control at airports in offshore islands by the Taiwanese government. However, with a small sample size, caution must be applied when discussing these results and making further policy recommendations. A note of caution is due here since the survey participants are mainly male and dominated by air transport expertise in New Zealand and Taiwan. Therefore, the relatively low ranking of environmental wellbeing may be explained by the fact that males are less supportive of environmental practices in general, and those women board members with interlinks to other firms are strongly and significantly associated with stronger environmental practices (Glass et al., 2016).

It is also noteworthy that New Zealand and Taiwan are now at the forefront of concerns regarding the growing pressures of tourism management (Ministry of Business, Innovation & Employment, 2019; Ministry of Transportation and Communications, 2017). This means that the concerns about wildlife interactions, noise, water usage and pollution associated with aviation activities (e.g. flight services and airport operations) might be swamped by increased pressure on the entire region's environmental impacts.

2.6.5 More attentions needed for aviation subsidies benefiting regional tourism

It seems that spurring the regional tourism sector is not the main factor to be considered by either government for forming or implementing aviation subsidies. Even in prior studies, little is known about the interaction between aviation subsidies and regional tourism, although tourism's close relationship with regional air transport and local economy has been identified (Castillo-Manzano et al., 2011; Spasojevic et al., 2018). As the poorly connected peripheral regions may have valuable natural resources and display life and nature that are not affected by modern society (e.g. New Zealand's indigenous tourism and Taiwan's forest recreation tourism), these could be attractive features for tourists seeking a periphery experience (Lee et al., 2010; Riddle & Thompso-Fawcett, 2019). Therefore, tourism in remote regions and rural areas may require substantial air transport development, which will transport more tourists and bring various benefits to the remote regions (Carson & Harwood, 2007). This study shows that two important tourism factors, *visitor expenditure in the region* and *inbound tourism*, need to be emphasised by New Zealand and Taiwanese participants.

The New Zealand government has worked closely with local councils, businesses and communities to promote regional accessibility (e.g. improved regional transportation, including air services) and high-quality and authentic visitor experiences (e.g. building more quality tourism infrastructure, and incorporating the unique Māori culture into the destination brand), which ensure that regional tourism destinations are more attractive (Ministry of Business, Innovation & Employment, 2019). Note that the growth or recovery of regional tourism in New Zealand will continue to be led by domestic tourists because of the COVID-19 pandemic (Deloitte New Zealand, 2020). If the New Zealand government can design a mechanism to support better air services to smaller or remote communities, more weekend trips and holidaymakers will be encouraged to enjoy the local nature, culture and history, which may lead to significant boosts in tourist arrivals and visitor spending in smaller regions. It should be noted that the purpose of this funding is to help local communities facilitate their tourism development through subsidised air services. To maintain the efficiency and validity of the subsidy program, the funding mechanism should be more resilient and regularly monitored to remove routes that become financially self-supporting during the subsidy period.

In Taiwan, the government's interest is to continually make the offshore islands' culture, kaoliang liquor, and nature more accessible to domestic and international tourists (National Development Council, 2016). However, providing sufficient airline seat capacity to transport tourists and holidaymakers between the main island and offshore islands during peak seasons appear to be a serious challenge (Ministry of Transportation and Communications, 2020). To this point, subsidised routes may provide opportunities for airlines to continue optimising their route capacity, eventually, helping increase tourist numbers and developing more tourism activities in offshore islands. This could be demonstrated by the high load factor of offshore island during the COVID-19 pandemic (ET today, 2021). As none of the Taiwanese participants are associated with the tourism sector and as their major expertise, therefore the results relating to be the tourism factors should be discussed cautiously.

2.7 Conclusion

With the development of regional air transport, regional aviation subsidies have been widely discussed. Unlike previous studies, however, this study focused on obtaining preferences, opinions and views from various interested stakeholders that identify the most important wellbeing categories and factors to be considered when forming or improving aviation subsidy policies. The findings of this study, using New Zealand and Taiwan as two case studies, show that *destination served* and *flight frequency* are the key factors when designing or implementing aviation subsidies. It also reveals that integrating *economic wellbeing* and *social wellbeing* into aviation subsidy policy design and implementation is highly necessary. More specifically, *local business activities*, *medical treatment*, and *rapid hazard response* are the top-ranked factors, which need to be prioritised when designing or making changes to their respective regional aviation subsidy policies. In addition, spurring the regional tourism sector does not seem to be the main concern in forming or implementing aviation subsidies. Lastly, environmental concerns have a relatively low priority when considering the issue of regional aviation subsidies.

One reason making this study meaningful is because it provides insights and policy implications for the governments and, regarding the importance of regional wellbeing indicators to aviation subsidy policy formation and implementation. For example, if the New Zealand government wants to provide subsidies to support the regional aviation sector, the government's main strategic option would be to improve the destinations served by regional airports and increase flight frequency to the regions. For the Taiwanese government, minimum daily flights to offshore islands should remain an important requirement for future aviation subsidy policies. Besides the air transport-related indicators, the regional wellbeing indicators (i.e. economic and social wellbeing indicators, as previously mentioned) are also important, no matter how long the COVID-19 pandemic will persist. Both New Zealand and Taiwanese governments should formulate aviation subsidy policy that could benefit local business activities, medical treatment, rapid hazard response, and visitor expenditure in the region. These key indicators are believed to affect the formation and implementation of their respective future aviation subsidy policies in the post-COVID-19 recovery phase. Therefore, both governments should closely consider their regional air connectivity objectives and determine how aviation subsidies can support air services to remote regions and smaller communities, as well as impacting the intended economic, social and environmental wellbeing and stimulating regional tourism development. More importantly, regional aviation subsidy policies should be evaluated periodically against predetermined objectives.

The study contributes to the air transport literature by being the first to evaluate the key regional air transport activity and wellbeing indicators to be considered when forming or implementing aviation subsidies. Despite using the FAHP technique, it is important to bear in mind the possible bias in participants' responses, as they are an outcome of the understanding and judgment of the participants being surveyed. Although surveying aviation stakeholders and policymakers can be justified for small samples, such as in this study, it would be even better to extend the sample sizes for more insightful results. For example, it is unfortunate that this study did not include Taiwanese participants with background and expertise in environmental impacts and tourism, as those from New Zealand – this mis-match issue could be remedied in future studies with larger samples. It can also simplify the survey questions (as it is difficult and time-consuming to construct the comparison pairwise matrix) to incorporate mass public opinions into the consideration of regional aviation subsidy policy to be more understanding of this contemporary issue. Further research to empirically quantify the impact of aviation subsidies and regional wellbeing are also important. Moreover, also it is interesting to extend this study to investigate the relationship between aviation subsidies and regional wellbeing in countries that will continuously improve and strengthen their regional air transport development as a national policy.

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Chapter Three – Inter-relationships between airport subsidies and regional wellbeing

Preamble

Regional airports are important for facilitating regional wellbeing, as they play a critical role in maintaining regional air connectivity and transporting individuals, goods, and services. New Zealand had no national aviation subsidy scheme or funding system before the COVID-19 pandemic, so local/regional governments often stepped in to underwrite flight services and fund airport infrastructure to ensure essential air connectivity to their regions. Therefore, this chapter examines airport subsidies in New Zealand and addresses the third research objective (i.e. to examine the inter-relationships among airport subsidies, air transport activity, and regional wellbeing). As the first two chapters of this thesis provide a solid foundation for understanding the aviation subsidy–regional wellbeing nexus, and the key air transport and regional wellbeing indicators for designing and implementing aviation subsidy policies through qualitative analyses, this chapter presents empirical research (quantitative method) investigating the inter-relationships among airport subsidies, air transport activity, and regional wellbeing in New Zealand during the pre-COVID-19 era using a three-stage least squares (3SLS) model. The findings show that airport subsidies helped unprofitable regional airports significantly and promoted their regions' air transport activity. The impact of airport subsidies on a region's economic growth (i.e. regional GDP per capita as an economic wellbeing indicator) and employment (i.e. a reduced unemployment rate as a social wellbeing indicator) were observed. These findings imply that the continued provision of airport subsidies benefited smaller and remote regions and made them more attractive to airline services, thereby promoting the region's economic prosperity. Another important finding is that scheduled airline seat capacity, economic development and environmental sustainability are important for determining airport subsidies. In this light, a regional aviation subsidy policy should consider regional economic, social wellbeing and environmental wellbeing, consistent with the policy implications suggested in Chapter 2 exploring the stakeholders' perspectives and opinions about the key regional wellbeing indicators for designing and implementing an aviation subsidy policy. Importantly, this chapter recommends that airport authorities in New Zealand should form stronger partnerships and coordinate with the central and local/regional governments to ensure that airport subsidies are factored into their decisions on regional economic development.

Study 3: Airport subsidies impact on wellbeing of smaller regions: A systemic examination in New Zealand

Publication status and candidate contribution

This study was published in a Transport Policy in October 2022. The doctoral candidate is the first author of the publication, with the doctoral supervisors being co-authors. The doctoral supervisors provided minor contributions towards the methods, analysis and review of the study, however, the work is primarily that of the doctoral candidate.

3.0 Abstract

This study investigated the inter-relationships among airport subsidies, air transport activity, and regional wellbeing by applying a three-stage least squares structural model using a panel dataset of New Zealand's regions from 2010 to 2019. By investigating these inter-relationships, the study provides empirical evidence of the necessity of implementing regional airport subsidies in New Zealand, and contributes to the regional aviation literature. The empirical findings reveal that implementing airport subsidies significantly increased scheduled flight seat capacity and helped unprofitable regional airports to increase their regional air transport activity. This study also shows that increases in airport subsidies can facilitate economic growth and employment in the region in which the airport is located. More importantly, this study empirically finds that regional air transport activity, economic growth, and environmental sustainability should be critical considerations when determining airport subsidies. These findings have profound implications for regional policymakers and airport stakeholders.

3.1 Introduction

Although many studies have investigated the relationships between air transport activities and regional development, there has been little discussion about the inter-relationships among airport subsidies, aviation activities, and regional wellbeing (e.g. Baker et al., 2015; Fageda et al., 2018; Wu et al., 2020). It is important to empirically identify their inter-relationships correctly so that the most effective airport subsidy policies can be implemented. Regional airports are likely to be of great importance for facilitating regional wellbeing as airports play a critical role in maintaining regional connectivity and transporting individuals, goods, and services (e.g. Baker et al., 2015; Brueckner, 2003; Florida et al., 2015). Hence, regional airports are often seen as regions' strategic assets for benefiting the local economy and social welfare (Fu et al., 2020). Considering that airport infrastructure is a huge investment, as well as the fact that smaller airports may often face insufficient funding when it comes to attracting and retaining commercial air services, the construction, operation, and maintenance of an airport is more likely to require government funding (Baker et al., 2015; Wu & Qi, 2021). Some researchers also believe that the government has an overall responsibility to provide subsidies or support for public transport systems such as air transport (Gössling & Peeters, 2007). Previously, Fageda et al. (2018) comprehensively reviewed existing airport subsidies worldwide that promoted improvements by airports located in remote regions in terms of attracting air services, safety, and capacity. On the other hand, it has been suggested that the role of wellbeing in informing transport policies should not be neglected (Delbosc, 2012). This is because some of the effects of the transport policy may be absent or inconsistent when objective measures only focus on transport-related indicators (Delbosc, 2012). Hence, the public transport policy decisions, such as airport subsidies, should incorporate the central governments' or local communities' or councils' demands and integrate the outcomes (e.g., broader economies, social growth, and environmental sustainability) into the efficient formation of airport subsidy policies.

Airport subsidies in New Zealand have long faced a contradiction between central and local governments. The central government has paid great attention to regional development, offering financial support to regions through the Provincial Growth Fund (PGF) project, a funding scheme that has invested in various regional projects helping drive economic development and community wellbeing (Regional Economic Development & Investment Unit, 2017). Unlike the land, maritime, and rail transportation systems in New Zealand, which all receive the government funding, airports have no national funding system (New Zealand Airports Association, 2017). Although New Zealand's local governments generally believe that their airports have great potential to facilitate their region's economic and social growth, many regions have more important projects that identify regional priorities and opportunities for growth. The burden of subsidising local airports is also becoming too great. Hence, achieving a sound understanding of the effect of airport subsidies and how airport subsidies contribute to regional air transport activities and wellbeing appears to be critical.

The study examines the inter-relationships among airport subsidies, air transport activities, and regional wellbeing by using a panel three-stage least squares (3SLS) methodology and annual data from 13 regions[11] and airports in New Zealand from 2010 to 2019. Scheduled available seat kilometres (ASKs) were used to explain regional air transport activities, whereas regional gross domestic product (GDP) per capita, regional unemployment rate, and regional carbon dioxide equivalent emissions (RCE) were used to measure regional wellbeing. The findings from this study make two key contributions to the current literature on regional aviation studies: (i) it complements the literature by examining the interaction of airport subsidies and regional wellbeing by incorporating of the role of regional aviation activities, and (ii) to the authors' knowledge, this is one of the first empirical studies in New Zealand to assess this relationship. The study also provides empirical evidence of the necessity of implementing regional airport subsidies in New Zealand. In addition, it provides policy recommendation and management advice to New Zealand regional policymakers and airport stakeholders in terms of airport subsidies, air services, and regional wellbeing in remote and smaller communities.

The remaining part of the study proceeds as follows: Section 3.2 provides an overview of the New Zealand regional airport subsidies. Section 3.3 presents the research model and a brief review of the relevant literature, and proposes hypotheses regarding the linkages among airport subsidies, regional aviation activities, and regional wellbeing. Section 3.4 deals with the methods used and the variables of interest. Section 3.5 presents the findings of the research. Section 3.6 discusses and summarises the main findings and policy implications. Section 3.7 presents the conclusion and indicates the limitations and directions for future research.

3.2 Overview of New Zealand's regional airport subsidies

New Zealand is geographically remote, with limited land transport links between regions. Thus, transportation across regions is heavily relying on domestic air transport. (Fu et al., 2020; Lyon & Francis, 2006). Despite its small population, New Zealand has a well-developed network of

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[11] This study adopts Statistics New Zealand's definition of administrative regions. There are 15 regions in New Zealand: Northland, Auckland, Waikato, Bay of Plenty, Gisborne, Hawke's Bay, Taranaki, Manawatu–Whanganui, Wellington, West Coast, Canterbury, Otago, Southland, Marlborough, and Tasman/Nelson. As the West Coast, Marlborough, and Tasman/Nelson are adjacent regions with a relatively small economic and social status, data on some variables for these three regions were merged. Therefore, to make it easier to obtain regional data and consistency, this study combined these three regions into one.

regional airports, with 30 airports[12] operating scheduled commercial air services prior to the COVID-19 pandemic. Three key domestic aviation hub airports (i.e. Auckland, Christchurch, and Wellington) connect to each other and smaller regional airports, reflecting the hub-and-spoke network system used by Air New Zealand's domestic operations (the dominant player in New Zealand's domestic aviation market) (Fu et al., 2020). While airlines of all sizes are free to operate domestically without government restrictions on route or capacity deployment, relatively low market demand, high operating costs per seat, and other commercial imperatives have resulted in airlines pulling out of some smaller communities, including Jetstar and Sounds Air (New Zealand Airports Association, 2017). Even though regional airports set their aeronautical charges (e.g. landing fees) and seek to increase revenues from non-aeronautical activities (e.g. property management and retailing facilities), smaller airports are still facing a range of financial pressures to maintain and increase regional air services (Fu et al., 2020; Lyon & Francis, 2006). A notable problem is that smaller airports are financially unviable to meet capital, safety standards, and maintenance requirements, thus influencing their ability to serve their communities and achieve the regional economic and social objectives (New Zealand Airports Association, 2017).

Since the commercialisation policy was initiated in the late 1980s, Auckland airport (a publicly listed company), Christchurch airport (75% of shares owned by the local council and 25% owned by the government), and Wellington airport (34% of shares owned by the local council and 66% of shares owned by the publicly listed infrastructure company Infratil) were the first three airports to become companies. The remaining airports in New Zealand exhibit a variety of ownership structures, such as local government ownership (e.g. Palmerston North Airport), fully owned by the central government (e.g. Milford Sound Airport), and joint venture airports[13] (e.g. Whanganui Airport) (Fu et al., 2020; Lyon & Francis, 2006). As aviation in New Zealand has no national funding system, local governments often step in to underwrite air services and subsidise the airport infrastructure to ensure essential air connectivity to their regions (e.g. Sounds Air operating a Westport–Wellington service and Air Chatham operating a Whakatane–Auckland service) (New Zealand Airports Association, 2017). It is worth noting

[12] Among 30 New Zealand's domestic airports offering commercial flights, four airports (i.e. Kaikoura, Kaitaia, Masterton, and Wanaka) ceased commercial operations during the research period.

[13] A joint venture airport is where the Crown (the central government agency) and the local authority operate and manage an airport in partnership.

that the burden on local governments of subsidising airports is becoming too great, as they have many competing priorities for taxpayers' money. Apart from that, only some local airport authorities and governments have successfully sought funding from the central government's PGF project, because the PGF project will only offer financial support to airports where they will lead to an increase in the economic and social potential growth of regions (Ministry of Business, Innovation & Employment, 2019). An example is Invercargill Airport, which received NZ$500,000 from the Provincial Growth Fund in 2019 for upgrading its terminal facilities to accommodate the newly launched Auckland − Invercargill service. In practice, the regional airport funding crisis and the limited airport subsidies have received criticism from various stakeholders and local authorities. The current lack of a national airport subsidy scheme and the scarcity of airport subsidy research in New Zealand highlight the need to gain a better understanding of the inter-relationships among airport subsidies, air transport activity, and regional wellbeing outcomes.

3.3 Literature review and hypotheses

3.3.1 Airport subsidies and regional air transport activities

Given that air transport offers a timely and reliable way to move people, goods, and services between regions, in some cases, air transport can be a real option for "lifeline services" in rural and remote communities (Fageda et al., 2018). Governments and local authorities around the world have subsidised various programmes to support the development of regional air transport, especially in remote or small communities (e.g. de Rus & Socorro, 2022; Fageda et al., 2018; Merkert & O'Fee, 2013). A significant body of literature on air transport subsidies have paid particular attention to route subsidies, such as the Essential Air Service in the US and the Public Service Obligation in Europe (e.g. Calzada & Fageda, 2014; Mueller, 2021; Wittman et al., 2016). However, only a relatively small body of literature concerns airport subsidies.

Generally, airport subsidies have been granted to small or remote communities where local residents have limited mobility and air connectivity. The positive impacts of implementing airport subsidies on attracting and retaining airline operations and increasing regional air traffic have been documented in prior studies (Malina et al., 2012; Smyth et al., 2012). In Europe, these airport subsidies mainly include airport incentive programs and help airlines reduce their operation costs at secondary airports, significantly affecting low-cost carriers' choice of airports (Forsyth & Campus, 2006; Papatheodorou, 2003). Iyer and Thomas (2021) also provided evidence favouring airport-based subsidy policies, suggesting that airport subsidies can help upgrade the infrastructural capacity and facilities of existing regional airports, thus making it possible for airlines to adopt new routes to regional airports. In the US, the federal government provides funds to airports under the Small Community Air Service Development Grant Program. However, the effectiveness of airport subsidies was questioned by Wittman (2014), who recommended more restrictive criteria for eligible airports.

Although small regional airports in New Zealand provide the necessary infrastructure to enable essential air transport in small and remote communities, they need financial support from their local councils to cope with limited traffic and insufficient revenues (New Zealand Airports Association, 2017). Despite the importance of airport subsidies, there remains a paucity of evidence on the causal relationship between airport subsidies and air transport activity. Hence, in light of this above discourse, the following hypotheses are established:

> **H_1:** *Airport subsidies help regional airports to attract more air traffic, thus promoting regional air transport activity.*
>
> **H_2:** *A region's air transport activity affects the government's decision to provide airport subsidies.*

3.3.2 Airport subsidies, air transport activity, and regional wellbeing

For small and remote regions, air transport connectivity and the introduction of airport subsidies can be crucial from the perspective of regional policymaking for regional development and growth (Forsyth & Campus, 2006; Malina et al., 2012). It thus seems relevant to discuss the importance of subsidised air transport services on aspects of regional wellbeing, such as economic growth, job generation, and carbon emissions.

It has been established by various studies that the provision of air connectivity facilitates economic growth and development on the regional level (e.g. Bilotkach, 2015; Brueckner, 2003; Smyth et al., 2012). Although the positive effects of airports on economic growth might be overstated (Cidell, 2015), the improved transportation infrastructure (e.g. airports) reduces the overall transportation costs for people and products, thereby encouraging regional economic development (Doerr et al., 2020; Percoco, 2010). Moreover, air transport could be the most realistic means for residents living in the peripheral regions to travel, thus undoubtedly providing significant social benefits and improving wellbeing, such as increased local employment. Evidence from European countries and the US have confirmed the positive effects of air transport activity on job creation in a region (e.g. Brueckner, 2003; Green, 2007; Percoco, 2010). On the other hand, existing evidence from Australia and European countries has suggested that the real GDP and employment rate are higher when a region is more accessible. Thus, the regional economy has also been found to be associated with regional air transport activity (Baker et al., 2015; Mukkala & Tervo, 2013). This bi-directional relationship between regional air transport and regional wellbeing (e.g. regional GDP per capita and unemployment rate) is also expected in the New Zealand context (Fu et al., 2020; Tsui et al., 2019). It is also worth noting that the aviation industry is identified as one of the most energy-consuming and pollution-intensive sectors (Brasseur & Gupta, 2010). The environmental concerns in New Zealand are growing as its gross emissions have increased by 21 per cent from 1990 to 2020 (Ministry of Environment, 2020). The authors therefore propose the following hypotheses:

H_3: *A region's air transport activity has a positive impact on regional GDP per capita.*

H_4: *A region's GDP per capita impacts regional air transport activity.*

H_5: *A region's air transport activity has a positive impact on reducing regional unemployment.*

H_6: *A region's unemployment impacts regional air transport activity.*

H_7: *A region's air transport activity has a negative impact on regional environment.*

Smyth et al. (2012) argued that policymakers inevitably face conflicting pressures to address the needs of remote and smaller regions in terms of providing air travel opportunities. Subsidising smaller local airports to stimulate economic activities and improve wellbeing has been given a growing amount of attention by some local/regional governments (Forsyth & Campus, 2006). One of the important reasons behind this regional strategy is that airport subsidies help local smaller airports to serve more passengers and flights, tourists, and other aviation-related activities, thus increasing the competitiveness of the region and supporting its economic development (Bråthen & Halpern, 2012; Papatheodorou, 2021). Moreover, subsidised regional airports may successfully improve air services for business and leisure passengers, resulting in an increase in the competitiveness of local businesses and the wider regional economy, which eventually lead to economic growth and higher employment within the region (e.g. Allroggen et al., 2013; Malina et al., 2012; Smyth et al., 2012). However, environmental externalities are significant in aviation because of its energy-intense, and the issue of airport (aviation) subsidies has long been tackled by environmental agencies and non-governmental organizations (Dwyer et al., 2010; Pearce, 2003).

In the New Zealand context, the majority of regional airports are still under local government ownership. As local authorities have often subsidised their airport's operations and expenditure, subsidised local airports possibly attract more air traffic and improve air accessibility to the region, promoting the region's economic growth and job creation. In the context of ongoing debates on the regional aviation development and its environmental impacts, it would thus seem relevant to discuss environmental externalities in relation to regional airport subsidies (Gössling et al., 2017). Hence, regional economic, social, and environmental wellbeing should be taken into consideration when local/regional governments decide to financially support their local airports. It makes sense that the bi-directional relationship between airport subsidies and the regional wellbeing need to be examined in the New Zealand context. The authors therefore propose the following hypotheses:

H_8: *The provision of airport subsidies has a positive impact on regional GDP per capita.*

H_9: *A region's GDP per capita prompts the government's decisions to provide airport subsidies.*

H_{10}: *The provision of airport subsidies has a positive impact on reducing regional unemployment*

H_{11}: *The region's unemployment impacts government's decisions to provide airport subsidies*

H_{12}: *The provision of airport subsidies has a negative impact on regional environment.*

H_{13}: *The concerns of regional environment affect government's decisions to provide airport subsidies*

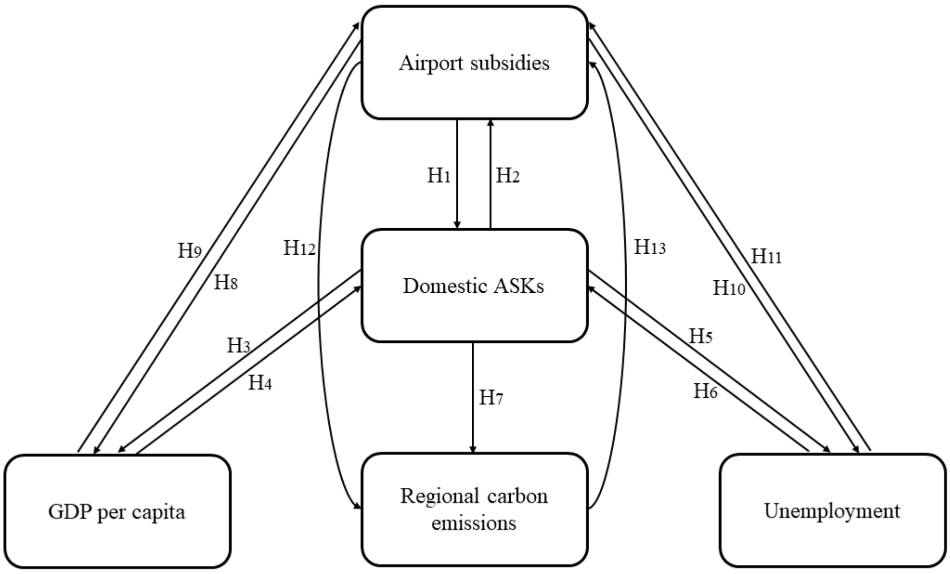
3.4 Data definitions and empirical models

3.4.1 Research framework

The proposed research framework in this study was developed through a review of the extant literature on airport subsidies, air transport activities, and regional wellbeing. The proposed research framework (see Figure 12) concerns the inter-relationships of airport subsidies, regional economic growth, unemployment, and regional greenhouse gas emissions (i.e., a region's GDP per capita, unemployment rate, and regional carbon dioxide equivalent emissions) by incorporating the role of regional air transport activity.

Figure 12

Research framework of the study



3.4.2 Data

This study used a panel dataset of 13 administrative regions in New Zealand from 2010 to 2019 (see Table 9). There are five key variables of interest (airport subsidies, ASKs, region's GDP per capita, unemployment rate, and regional carbon dioxide equivalent emissions) in this study. New Zealand's airport subsidy data were sourced from various governments and airports' annual reports[14]. This variable contains zero-valued observations, and this study added the value of 1 to the zero-valued observations prior to logarithmic transformation (MaCurdy & Pencavel, 1986; O'Hara & Kotze, 2010). As the value of airport subsidies are in New Zealand dollars (NZD), the addition of 1 to the zero-valued observations does not affect the results. Air transport activity is proxied by the total domestic ASKs of a sampled airport (Tsui et al., 2019). Region's GDP per capita, unemployment rate, and regional carbon dioxide equivalent

[14] Some data have been interpolated to accommodate calendar-year based annual frequency, as the fiscal year is more commonly used in the governments' and airport organisations' financial statements in New Zealand.

emissions were collected to capture New Zealand's regional economic, social and environmental wellbeing, respectively (Fu et al., 2020; Tsui et al., 2019).

Table 9

Definitions and sources of the variables (2010−2019)

Variables	Definition	Source
$\ln(SUBs)_{it}$	The natural logarithm of the total airport subsidies provided by the government deflated by the regional consumer price index (CPI) in region i at time t.	Airports' annual reports; councils' annual reports; authors' own calculations
$\ln(ASKs)_{it}$	Domestic ASKs in region i at time t.	Official Airline Guide (OAG)
$\ln(GDPPC)_{it}$	The natural logarithm of GDP per capita deflated by the regional CPI of region i at time t.	Statistics New Zealand
$\ln(Unemploy)_{it}$	The natural logarithm of unemployment rate in region i at time t.	Statistics New Zealand
$\ln(RCE)_{it}$	The natural logarithm of regional carbon dioxide equivalent emissions in region i at time t.	Statistics New Zealand
$\ln(Guest)_{it}$	The natural logarithm of guest arrivals to region i at time t.	Statistics New Zealand; Ministry of Business, Innovation & Employment
$\ln(Popul)_{it}$	The natural logarithm of the population size of region i at time t.	Statistics New Zealand
$\ln(Petrol)_{t}$	The natural logarithm of the petrol price per litre at time t in New Zealand.	Ministry of Business, Innovation & Employment
$\ln(Inflation)_{it}$	The natural logarithm of changing inflation (the changes in the CPI of the current period and the last period) in region i at time t.	Statistics New Zealand
$\ln(Edu)_{it}$	The natural logarithm of the number of school leavers with NCEA Level 3 of region i at time t.	Ministry of Education
$Num\_airport_{it}$	The number of airports operating in the region at time t.	Authors' own calculations
$Govt\_party_{t}$	The dummy variable that takes 1 for the Labour party being in power and 0 for the National party.	Authors' own calculations
$Inter\_flights_{it}$	The dummy variable that takes 1 if the region's airport had international flights and 0 otherwise.	Official Airline Guide (OAG)
$Airport\_profit_{it}$	The dummy variable that takes 1 if the region's airport's operating revenue is positive and 0 otherwise.	Airports' and governments' annual reports; authors' own calculations
$Metro_{t}$	The dummy variable that takes 1 for the three largest regions of Auckland, Canterbury and Wellington, and 0 otherwise.	Authors' own calculations
Yearly dummies	The dummy variable for each year of the study	Authors' own calculations

A number of relevant socioeconomic factors (e.g. guest arrivals, $\ln(Guest)_{it}$; the size of the population, $\ln(Popul)_{it}$; petrol prices, $\ln(Petrol)_{t}$; changes in inflation, $\ln(Inflation)_{it}$; and education level, $\ln(Edu)_{it}$) were also collected for the estimation process (see Table 9). As mentioned above, 30 commercial airports offered scheduled domestic air services during the research period. Hence, to account for the effect of having multiple airports in the same administrative regions (e.g. Northland, Waikato, etc.), the variable of $Num\_airport_{it}$ was used in this study. Noted that this study used the annual data of all New Zealand regions, including three well-developed regions with large international airports: Auckland (Auckland airport), Canterbury (Christchurch airport), and Wellington (Wellington airport). Some airports located in areas with tourist attractions also had international flight services during the research period (e.g. Hamilton Airport in Waikato, Rotorua Airport in the Bay of Plenty, and Dunedin Airport and Queenstown Airport in Otago). Therefore, it is necessary to take the availability of international flight services ($Inter\_flights_{it}$) into consideration when investigating the inter-relationships among regional airport subsidies, air transport activity, and regional wellbeing. Moreover, this study used additional two dummy variables (governing political party, $Govt\_party_t$; and the profitability of the airport in the region, $Airport\_profit_{it}$) to capture the amount of airport subsidies received, $\ln(SUBs)_{it}$; domestic ASKs, $\ln(ASKs)_{it}$; GDP per capita, $\ln(GDPPC)_{it}$; unemployment rate, $\ln(Unemploy)_{it}$; and regional carbon dioxide equivalent emissions, $\ln(RCE)_{it}$ of the regions. The variables $Metro_t$ and $Yearly\ dummies$ were included to capture regional heterogeneity and yearly effect on the sampled regions.

Table 10 presents the descriptive statistics for the variables of interest. For estimating the panel data 3SLS model, it is necessary to test for stationarity to avoid spurious regression results (Balli et al., 2016; Gujarati, 2021). The panel unit root tests (Levin, Lin, and Chu (LLC), Im, Pesaran, and Shin (IPS), augmented Dickey−Fuller (ADF)−Fisher, and Phillips−Perron (PP)−Fisher) performed on the data are shown in Appendix N (Im et al., 2003; Levin et al., 2002). First-order differencing was applied to the non-stationary variables, namely $\ln(SUBs)_{it}$, $\ln(GDPPC)_{it}$, $\ln(Unemploy)_{it}$, $\ln(Guest)_{it}$, $\ln(Popul)_{it}$, $\ln(petrol)_t$, $\ln(Inflation)_{it}$, and $\ln(Edu)_{it}$), to render them stationary.

Table 10

Descriptive statistics of the variables (2010−2019)

Variables	Unit	Observations	Mean	Standard deviation	Minimum	Maximum
$SUBs_{it}$	NZD	130	873,023	1,903,830	1	11.3
$ASKs_{it}$	Kilometres (billion)	130	1.13	1.58	0.44	6.65
$GDPPC_{it}$	NZD	130	48,388.79	11,625.74	29,803.19	79,773.41
$Unemploy_{it}$	%	130	5.61	1.55	2.80	9.90
RCE_{it}	Kilotonnes	130	6,117.45	3,824.35	1,286	16,198
$Guest_{it}$	Number	130	1,475,548	1,012,960	116,876	3,836,408
$Popul_{it}$	Number	130	344,430	387,327	44,600	1,680,500
$Petrol_t$	NZD	130	206.78	14.08	179.02	225.88
$Inflation_{it}$	Index	130	15.24	9.28	0.20	40.10
Edu_{it}	Number	130	2346	2934	221	12989
$Num\_airport_{it}$	Number	130	2.09	1.00	1	4
$Govt\_party_t$	Dummy	130	0.20	0.40	0	1
$Inter\_flights_{it}$	Dummy	130	0.39	0.49	0	1
$Airport\_profit_{it}$	Dummy	130	0.73	0.45	0	1
$Metro_t$	Dummy	130	0.23	0.42	0	1

Note: See Table 9 for definitions of the variables.

3.4.3 Empirical models

The purpose of this study was to examine the dynamic linkages among airport subsidies, regional air transport activity, and regional wellbeing. Airport subsidies are believed to have an impact on regional air transport activity, as the main purpose of implementing airport subsidies is expected to improve smaller communities' air connectivity (Baker et al., 2015; Wittman et al., 2016). On the other hand, airport subsidies facilitate air transport activity, but the amounts received (the subsidy amount) partly depend on the current air transport capacity (Fageda et al., 2018; Smyth et al., 2012). According to the air transport and regional wellbeing literature, regional air transport activity, income, and employment are inextricably linked (Baker et al., 2015; Zhang & Graham, 2020). Particularly in remote and small communities, subsidised air transport activity has played an essential role in the social and economic life of local residents (e.g. Fageda et al., 2018; Özcan, 2014; Wu et al., 2020). In addition, the government's involvement in transport planning and investment significantly impact not only how people travel and how goods are transported, but also other wellbeing outcomes, such as economic prosperity, social development, and local environment (Delbosc, 2012). However, regional wellbeing can also be viewed as an incentive to implement airport subsidies, indicating that airport subsidies could impact wellbeing outcomes.

Given the possible presence of endogeneity when estimating the four key variables (airport subsidies, air transport activity, GDP per capita, unemployment rate, and regional carbon dioxide equivalent emissions), and to test the hypotheses established in Section 3.3, this study simultaneously formulated a system of equations, which is a 3SLS model. The 3SLS is one of the most common system estimations used in simultaneous equation modelling, and it has been successfully applied in aviation studies to address endogeneity (e.g. Tsui et al., 2019; Wang et al., 2014; Zaefarian et al., 2017). In the 3SLS model, each of the equations contains a lagged dependent variable to indicate the possible dependence on previous period. Simultaneous estimation of the system of equations addresses not only any endogeneity and simultaneity problems, but also correctly accounts for any cross-correlation in the error terms that may be shown across each equation (Zaefarian et al., 2017; Zellner & Theil, 1962). Hence, the 3SLS method is an appropriate estimator for testing systems of equations, and the estimations are more consistent and asymptotic, which is more efficient than estimating each equation individually (Wooldridge, 2016).

The panel 3SLS model with a simultaneous system of equations (Equations (1)−(5)) was as follows:

$$\begin{aligned}\ln(SUBs)_{it} = {} & \alpha_0 + \alpha_1 \ln(SUBs)_{it-1} + \alpha_2 \ln(ASKs)_{it} + \alpha_3 \ln(GDPPC)_{it} \\ & + \alpha_4 \ln(Unemploy) + \alpha_5 Inter\_flights_{it} \\ & + \alpha_6 Govt\_party_t + \alpha_7 Metro_t + \alpha_8 Year\ dummies_t + \varepsilon_{1it}\end{aligned} \tag{1}$$

$$\begin{aligned}\ln(ASKs)_{it} = {} & \beta_0 + \beta_1 \ln(ASKs)_{it-1} + \beta_2 \ln(SUBs)_{it} + \beta_3 \ln(SUBs)_{it-1} \\ & + \beta_4 \ln(GDPPC)_{it} + \beta_5 \ln(Guest)_{it} \\ & + \beta_6 \ln(Popul)_{it} + \beta_7 \ln(Petrol)_t + \beta_8 \ln(Unemploy)_{it} \\ & + \beta_9 Airport\_profit_{it} + \beta_{10} Inter\_flights_{it} \\ & + \beta_{11} Metro_t + \beta_{12} Year\ dummies_t + \varepsilon_{2it}\end{aligned} \tag{2}$$

$$\begin{aligned}\ln(GDPPC)_{it} = {} & \gamma_0 + \gamma_1 \ln(GDPPC)_{it-1} + \gamma_2 \ln(SUBs)_{it} + \gamma_3 \ln(ASKs)_{it} \\ & + \gamma_4 \ln(Guest)_{it} + \gamma_5 \ln(Unemploy)_{it} + \gamma_6 Inter\_flights_{it} \\ & + \gamma_7 Metro_t + \gamma_8 Year\ dummies_t + \varepsilon_{3it}\end{aligned} \tag{3}$$

$$\begin{aligned}& \ln(Unemploy)_{it} \\ & = \delta_0 + \delta_1 \ln(Unemploy)_{it-1} + \delta_2 \ln(SUBs)_{it} + \delta_3 \ln(ASKs)_{it} \\ & + \delta_4 \ln(GDPPC)_{it} + \delta_5 \ln(Guest)_{it} + \delta_6 \ln(Inflation)_{it} \\ & + \delta_7 \ln(Edu)_{it} + \delta_8 Num\_airport_{it} + \delta_9 Inter\_flights_t \\ & + \delta_{10} Metro_t + \delta_{11} Year\ dummies_t + \varepsilon_{4it}\end{aligned} \tag{4}$$

$$\begin{aligned}\ln(RCE)_{it} = {} & \theta_0 + \theta_1 \ln(RCE)_{it-1} + \theta_2 \ln(SUBs)_{it} + \theta_3 \ln(ASKs)_{it} \\ & + \theta_4 \ln(GDPPC)_{it} + \theta_5 Metro_t + \theta_6 Year\ dummies_t + \varepsilon_{5it}\end{aligned} \tag{5}$$

where i and t denote the region and time, respectively; α_s, β_s, γ_s, δ_s, and θ_s are the coefficients to be estimated; ε_{1it}, ε_{2it}, ε_{3it}, ε_{4it}, and ε_{5it} are the error terms; and lndenotes the natural logarithm. The coefficients can be interpreted as elasticities. The statistical program Stata 16 was used for estimation.

3.5 Empirical findings

The panel 3SLS model aimed to examine the inter-relationships among airport subsidies, regional air transport activity, and regional wellbeing (region's GDP per capita, unemployment rate, and regional carbon dioxide equivalent emissions) of New Zealand regions. Table 11 reports the results obtained from the panel 3SLS model estimation (Equations (1)–(5)). This study also applied the dynamic panel generalised method of moments (GMM) method as a robustness check, which estimates each of the equations individually (see Equations (6)–(10) in Table 11). The dynamic panel GMM model has been widely used to address endogeneity issues by incorporating the lag of the dependent variable, along with other explanatory variables[15] (Arellano & Bond, 1991). The results of the hypothesis tests established in Section 3.3 are reported in Figure 13.

3.5.1 Empirical results of the panel 3SLS model

In Equation (1), the dependent variable, $\ln(SUBs)_{it}$, represents the total airport subsidies received for the sampled New Zealand regions. The one-period lagged value (the previous year), labelled $\ln(SUBs)_{it-1}$, is reported with a significant negative coefficient estimate. This implies that the current year's total airport subsidies are inversely related to the last year's subsidy amounts. This finding is expected, considering that New Zealand has no national funding system and local/regional governments often step in irregularly to fund smaller airports facing unprecedented funding crises (New Zealand Airports Association, 2017). In addition, $\ln(ASKs)_{it}$ is reported with a statistically significant and negative coefficient estimate, suggesting that well-functioning airports with increased scheduled airline seat capacity are less likely to require and receive government support (Donehue & Baker, 2012). A 1% increase in scheduled flight seats reduced airport subsidies from the governments by 1.186%. Thus, Hypothesis H_2 is supported. Moreover, $\ln(GDPPC)_{it}$ is reported to have a significant positive coefficient estimate, indicating that the growth in the income level of a region is positively related to the total airport subsidies for a region. This finding corroborates the idea that regional economic growth increases air travel demand, which leads to an increase in investments and expansion of airport infrastructure construction (e.g. Chow et al., 2021; Song et al., 2020; Tsui et al., 2019). Hence, Hypothesis H_9 is accepted. In addition, $\ln(RCE)_{it}$ is reported to have a significant negative coefficient estimate, suggesting that the growing concern of regional carbon dioxide equivalent emissions is negatively related to the total airport subsidies for a region. Thus, Hypothesis H_{13} is accepted. The dummy variable, $Govt\_party_t$, is reported with a statistically significant and positive coefficient estimate, showing that when the New Zealand government changed from the National Party to the Labour Party, this positively affected local/regional authorities' decisions to subsidise or fund their regional airport operations.

In Equation (2), the dependent variable, $\ln(ASKs)_{it}$, represents the total domestic ASKs of the sampled New Zealand regions. The one-period lagged value of total domestic ASKs,

[15] The GMM model removes endogeneity by subtracting a variable's past value from its present value, resulting in a reduction in the number of observations (Roodman, 2009). Since GMM requires a large amount of panel data, it may not be efficient for relatively small sample and thus is only used for the robustness test.

$\ln(ASKs)_{it-1}$, is reported to have a significant positive coefficient estimate. This finding is consistent with the findings of Tsui et al. (2019) that the current year's scheduled airline seat capacity in New Zealand regions is related to the previous scheduling year's planning. In terms of the key variable of interest, $\ln(SUBs)_{it}$, it is reported to have a significant positive coefficient estimate, thus suggesting that if more airport subsidies were provided by local/regional governments to their airports, this would positively increase the airline seat capacity for the regions. More specifically, a 1% increase in region's airport subsidies increased scheduled flight seats by 0.033% within a region. Moreover, the coefficient of the one-period lagged value of airport subsidies, labelled $\ln(SUBs)_{it-1}$, was also found to have a statistically and positive coefficient estimate. This implies that a region's scheduled airline seats are positively related to the airport subsidies provided by local/regional governments (Chow et al., 2021). Thus, Hypothesis H_1 is accepted. In addition to the key variables of interest, the result shows that the coefficient of $\ln(Petrol)_{it}$ was found to be statistically significant and positive, which suggests that an increase in New Zealand's petrol prices (for land transport) stimulated regional scheduled airline seat capacity, as visitors or travellers may choose air travel instead of land transport (self-driving) to travel to their destination when they need to spend more on petrol. This finding is consistent with Tsui (2017). Interestingly, the significant negative coefficient of $Inter\_flights_{it}$ is reported. This finding indicates that when an airport has international flight services, the airport's scheduled domestic flight capacity might be negatively impacted.

In Equation (3), the dependent variable of $\ln(GDPPC)_{it}$ is the sampled region's GDP per capita. The last period's GDP per capita of the sampled regions was found to have significant positive coefficient, suggesting that a region's current year's GDP per capita is positively related with last year's GDP per capita, as expected (Prayag et al., 2019). Regarding $\ln(ASKs)_{it}$, it is reported to have a statistically significant positive coefficient, indicating that it has a significant positive influence on a region's GDP per capita. The increase in scheduled flight seats by 1% tends to increase the region's GDP per capita by 0.008%. This finding is somewhat in line with the prior literature (e.g. Baker et al., 2015; Fu et al., 2020; Kazda et al., 2017). Thus, Hypothesis H_3 is accepted.

In Equation (4), the dependent variable of $\ln(Unemploy)_{it}$ is the sampled region's unemployment rate. The significant negative coefficient of the one-period lagged value of unemployment rate, $\ln(Unemploy)_{it-1}$, suggests that it has a negative correlation with its current period's unemployment in the region, as expected (Nymoen & Sparrman, 2015). The significant negative coefficient of $\ln(GDPPC)_{it}$ suggests that an increase in the income level of the sampled regions is negatively related to the region's unemployment rate, as expected (AboElsoud et al., 2020). Furthermore, the significant negative coefficient of $\ln(Edu)_{it}$ suggests that the unemployment rate can be reduced by improving the education level of the population in the region (e.g. more residents achieving NCEA Level 3 or higher certification). This finding is in agreement with previous literature (La Grow, 2004).

In Equation (5), the dependent variable of $\ln(RCE)_{it}$ is the sampled region's carbon dioxide equivalent emissions. The significant positive coefficient of the one-period lagged value of regional carbon dioxide equivalent emissions, $\ln(RCE)_{it-1}$, indicates that it has a strong correlation with its current period's carbon dioxide equivalent emissions in the region. The significant positive coefficient of $\ln(ASKs)_{it}$ suggests that an increase in scheduled flight seats for the sampled regions is positively related to the region's carbon dioxide equivalent emissions, as expected. Most regional airports in New Zealand are relatively small and can only accommodate smaller aircraft (e.g. ATR72). Hence, increased scheduled flight seats will lead to more flights from and to the sampled regions, ultimately producing more carbon emissions (Choi & Ritchie, 2014). Hence, Hypothesis H_7 is accepted.

3.5.2 Robustness check

Equations (6)–(10) of Table 11 show the estimation results of the dynamic panel GMM models as a robustness check for the five key variables of interest. Overall, there was no clear evidence of inconsistency in the five key variables of interest, with the exception of a few changes. In Equation (6), $\ln(SUBs)_{it-1}$ is reported have a significant negative coefficient estimate. Moreover, a significant negative coefficient of $\ln(ASKs)_{it}$ is also reported. The variable of $\ln(GDPPC)_{it}$ also have a significant positive coefficient estimate. These findings are consistent with those of the panel 3SLS model.

For Equation (7), $\ln(ASKs)_{it-1}$ and $\ln(SUBs)_{it}$ were also found to have a significant positive effect on $\ln(ASKs)_{it-1}$. These findings are consistent with the estimation results of the panel 3SLS model. However, the dynamic GMM model reported a significant positive coefficient for $\ln(GDPPC)_{it}$, which indicated that a region's scheduled airline seats is strongly related to the region's GDP per capita (Profillidis & Botzoris, 2015). Thus, Hypothesis H_4 is supported by the dynamic panel GMM specifications.

Regarding Equation (8), the significant positive coefficient of $\ln(ASKs)_{it}$ is consistent with that of the panel 3SLS model. However, the coefficient of $\ln(SUBs)_{it}$ becomes statistically significant and positive in the GMM model but not in the panel 3SLS model. This finding suggests that if more airport subsidies are provided by the local/regional governments for their airports, it will positively impact the regional economy. The important finding may justify the notion that introducing airport subsidies is important for improving economic activities from the perspective of regional policymaking (Forsyth & Campus, 2006; Lohmann et al., 2009). Hence, Hypothesis H_8 is accepted by the dynamic panel GMM model.

With respect to Equation (9), a significant negative coefficient of $\ln(Unemploy)_{it-1}$ is reported, which agrees with the results of the panel 3SLS model. It should be noted that the variable of $\ln(SUBs)_{it}$ was found to have a significant negative coefficient in the panel dynamic GMM specifications. Although there is little evidence as to why airport subsidies and the unemployment rate are negatively related, it is likely that increased air transport-related activities and businesses could be promoted by improved airport infrastructure and services via subsidisation. This empirical finding is consistent with the findings of previous literature regarding the positive impact of air transport on boosting local employment (Fageda et al., 2018; Halpern & Brathen, 2011). Thus, Hypothesis H_{10} is accepted by the dynamic panel GMM model. Furthermore, the significant negative coefficient of $\ln(Tour)_{it}$ shown in the GMM estimation is consistent with Gnoth and Anwar (2000), as a growth in a region's guest arrivals creates more jobs in the tourism and hospitality sectors, which helps to reduce the unemployment rate.

In terms of Equation (10), $\ln(RCE)_{it-1}$ is reported to have a significant positive coefficient estimate. Moreover, a significant positive coefficient of $\ln(ASKs)_{it}$ is also reported. These findings are consistent with the estimation results of the panel 3SLS model.

Figure 13

Visualisation of the estimation results of the panel 3SLS and dynamic panel GMM models

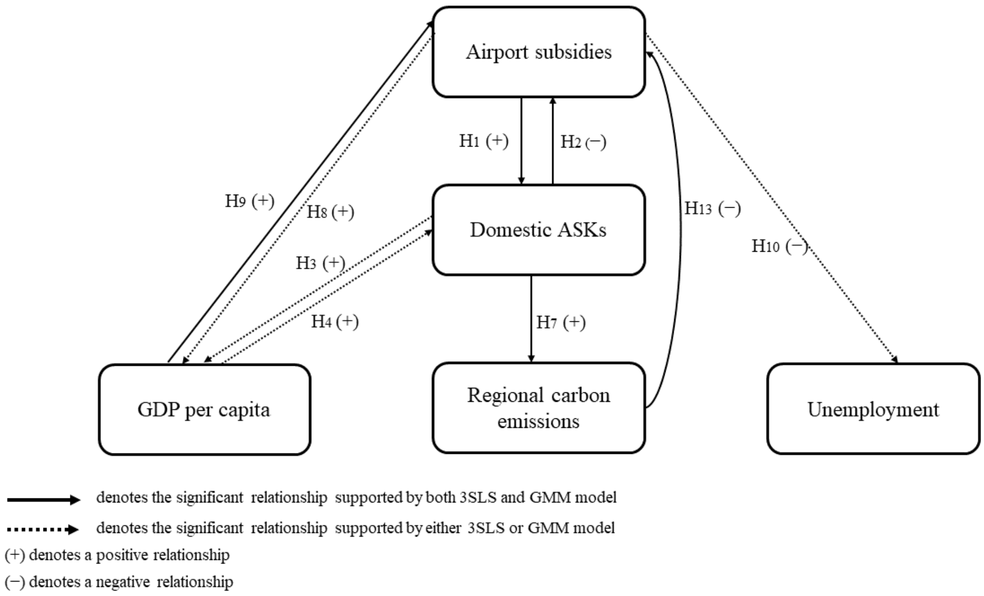


Table 11

Estimation results of the panel 3SLS model and dynamic panel GMM models

Variables	**Panel 3SLS (balanced)**				
	Equation (1) $\ln(SUBs)_{it}$	**Equation (2)** $\ln(ASKs)_{it}$	**Equation (3)** $\ln(GDPPC)_{it}$	**Equation (4)** $\ln(Unemploy)_{it}$	**Equation (5)** $\ln(RCE)_{it}$
$\ln(SUBs)_{it-1}$	−0.367*** (0.11)	0.013** (0.01)			
$\ln(ASKs)_{it-1}$		1.055*** (0.03)			
$\ln(GDPPC)_{it-1}$			0.234** (0.11)		
$\ln(Unemploy)_{it-1}$				−0.441*** (0.14)	
$\ln(RCE)_{it-1}$					1.006*** (0.01)
$\ln(SUBs)_{it}$		0.033** (0.01)	0.002 (0.001)	−0.0002 (0.01)	0.002 (0.002))
$\ln(ASKs)_{it}$	−1.186* (0.69)		0.008* (0.01)	0.044 (0.03)	0.008* (0.01)
$\ln(GDPPC)_{it}$	83.998** (37.18)	−0.781 (1.63)		−4.409** (2.15)	–0.285 (0.31)
$\ln(Guest)_{it}$		0.364 (0.30)	−0.040 (0.09)	−0.526 (0.59)	
$\ln(Popul)_{it}$		2.200 (1.77)			
$\ln(Petrol)_{t}$		2.264** (1.32)			
$\ln(Unemploy)_{it}$	5.567 (1.63)	−0.066 (0.17)	0.047 (0.05)		
$\ln(RCE)_{it}$	−1.208* (0.63)		0.002 (0.01)		
$\text{In}(Inflation)_{it}$				0.043 (0.04)	
$\ln(Edu)_{it}$				−0.883** (0.38)	
$Govt\_party_{t}$	5.302*** (1.61)				
$Inter\_flights_{it}$	1.662 (1.47)	−0.096* (0.06)	−0.008 (0.01)	−0.038 (0.06)	
$Airport\_\ profit_{t}$		0.030 (0.03)			
$Num\_airport_{t}$				−0.001 (0.02)	
$Metro_{t}$	0.755 (1.62)	−0.068 (0.05)	−0.006 (0.01)	−0.062 (0.07)	–0.017 (0.01)
Year 2011					
Year 2012	−2.932 (2.11)	0.333** (0.12)	0.044** (0.02)	0.401*** (0.13)	0.009 (0.02)
Year 2013	4.395** (1.96)	0.155** (0.07)	−0.029** (0.01)	0.097 (0.08)	–0.033** (0.02)
Year 2014	1.611 (1.84)	0.170* (0.09)	0.041*** (0.01)	0.190** (0.09)	0.009 (0.02)
Year 2015	5.670** (1.86)	0.346** (0.16)	−0.023* (0.01)	0.166 (0.11)	–0.026* (0.01)
Year 2016	5.639** (1.95)	0.255** (0.11)	−0.016 (0.01)	−0.022 (0.09)	–0.052*** (0.02)
Year 2017		0.128** (0.05)	0.024 (0.02)	0.142 (0.09)	0.008 (0.02)
Year 2018	−4.765** (1.87)		0.032** (0.01)	0.183** (0.09)	–0.012 (0.02)
Year 2019					
Constant	29.111 (14.54)	−1.222** (0.56)	−0.154 (0.10)	−0.868 (0.57)	82.208** (37.25)
R^2	0.013**	0.990***	0.437***	−0.537**	0.997***
Observations	90	90	90	90	90

Note: *, **, and *** indicate that the coefficient is significant at the 10%, 5%, and 1% significance level, respectively. Standard errors are reported in parentheses. Forty observations were omitted by Stata because of collinearity in the estimation of the panel 3SLS model.

Variables	Dynamic panel GMM (unbalanced robustness check)				
	Equation (6) $\ln(\boldsymbol{SUBs})_{it}$	**Equation (7)** $\ln(\boldsymbol{ASKs})_{it}$	**Equation (8)** $\ln(\boldsymbol{GDPPC})_{it}$	**Equation (9)** $\ln(\boldsymbol{Unemploy})_{it}$	**Equation (10)** $\ln(\boldsymbol{RCE})_{it}$
$\ln(SUBs)_{it-1}$	−0.459*** (0.07)	0.007 (0.01)			
$\ln(ASKs)_{it-1}$		1.065*** (0.07)			
$\ln(GDPPC)_{it-1}$			0.171 (0.15)		
$\ln(Unemploy)_{it-1}$				−1.227*** (0.24)	
$\ln(RCE)_{it-1}$					1.006*** (0.01)
$\ln(SUBs)_{it}$		0.015** (0.01)	0.001* (0.001)	−0.008* (0.01)	0.002 (0.001)
$\ln(ASKs)_{it}$	−2.144*** (0.56)		0.008 (0.01)	−0.005 (0.03)	0.014** (0.004)
$\ln(GDPPC)_{it}$	31.989** (13.56)	1.863* (1.03)		1.214 (1.55)	−0.142 (0.12)
$\ln(Guest)_{it}$		0.036 (0.57)	−0.052 (0.05)	−2.015** (0.87)	
$\ln(Popul)_{it}$		−0.695 (3.27)			
$\ln(Petrol)_{t}$		−0.692 (0.48)			
$\ln(Unemploy)_{it}$	2.169 (3.63)	−0.131 (0.10)	0.051 (0.05)		
$\ln(RCE)_{it}$	−2.155** (0.56)		−0.006 (0.01)		
$\mathrm{In}(Inflation)_{it}$				0.025 (0.04)	
$\ln(Edu)_{it}$				−1.489** (0.70)	
$Govt\_party_{t}$	−1.114 (1.95)				
$Inter\_flights_{it}$	4.590** (1.98)	−0.071 (0.10)	−0.004 (0.02)	0.101 (0.07)	
$Airport\_profit_{t}$		0.363** (0.16)			
$Num\_airport_{t}$				−0.019 (0.02)	
$Metro_{t}$	−1.126 (2.11)	−0.235** (0.08)	−0.007 (0.02)	−0.103 (0.07)	−0.026 (0.15)
Year 2011					−0.020* (0.01)
Year 2012	−5.692** (2.50)	0.104 (0.08)	0.018 (0.01)	−0.057 (0.13)	
Year 2013		0.082 (0.07)	−0.050*** (0.02)		−0.033* (0.02)
Year 2014	0.219 (1.25)	0.014 (0.05)	0.018** (0.01)	−0.174 (0.12)	−0.005 (0.01)
Year 2015	2.034 (1.46)		−0.036** (0.01)	0.115 (0.11)	−0.031 (0.02)
Year 2016	1.962* (1.20)	0.061 (0.05)	−0.034** (0.02)	0.017 (0.11)	−0.051*** (0.02)
Year 2017	−2.765* (1.44)	0.133** (0.06)		−0.035 (0.12)	−0.007 (0.01)
Year 2018			0.013** (0.01)	−0.192* (0.11)	−0.021* (0.01)
Year 2019	4.543** (2.24)	−0.067 (0.06)	−0.015* (0.01)	−0.248** (0.08)	−0.012 (0.01)
Constant	59.732*** (16.21)	−1.550 (1.23)	−0.059 (0.11)	0.153 (0.47)	−0.292** (0.10)
Observations	104	90	104	104	117
Sargan statistic (*p*-value)	0.001	0.268	0.001	0.027	0.001
AB(1) test *p*-value	0.046	0.501	0.031	0.113	0.013
AB(2) test *p*-value	0.091	0.065	0.088	0.013	0.030

Note: *, **, and *** indicate that the coefficient is significant at the 10%, 5%, and 1% significance level, respectively. Standard errors are reported in parentheses. Some observations were omitted by Stata because of collinearity in the estimation of the dynamic GMM models.

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3.6 Discussion and policy implications

Air transport, coupled with land and maritime transport, plays a vital role in supporting regional prosperity and wellbeing in New Zealand (Ministry of Transport, 2019). Regional air services and most airports in New Zealand focus on the domestic movement of people and supplies. This means that the operations of the local/regional airports have economic, social and environmental impacts, but the demand for air services is relatively low in New Zealand because of its small population. As most New Zealand airports are partially or wholly government-owned by local or regional governments, this leads to a desire to consider regional economic and social growth while considering the impact of airport investments and operations. However, it is difficult for many regional airports to be financially sustainable because of the relatively small population and market size. Thus, most smaller airports have been struggling to make commercial returns and investment decisions (Lyon & Francis, 2006). As airport subsidies are fast becoming a heavy burden to regional/local governments, airport stakeholders and regional/local governments are calling on the central government to subsidise regional airports to underwrite air services. Thus, achieving a comprehensive understanding of the inter-relationships among airport subsidies, air transport activity, and wellbeing (e.g., region's GDP per capita, unemployment rate, and carbon dioxide equivalent emissions) of New Zealand's regions is essential. This study empirically investigated these unique inter-relationships and the main findings of this study are worth discussing further.

3.6.1 Inter-relationships among airport subsidies, air transport activity, and regional wellbeing

Very little research has been published that examines the effect of subsidising airports on improving regional wellbeing (Wu et al., 2020). This study's findings revealed the linkage between airport subsidies and regional wellbeing (see Figure 13). The positive effects of well-functioning airports and air services on facilitating region's economic growth have been demonstrated in prior studies (e.g. Bilotkach, 2015; Fageda et al., 2018; Tsui et al., 2019). These positive effects of regional air services have also been confirmed in this study in the New Zealand context.

In addition, the finding that airport subsidisation by central and local/regional governments plays an important role in enhancing the region's air transport activity is consistent with what has been found in previous research in China, European countries, and the US, etc. (e.g. Chow et al., 2021; Fageda et al., 2018; Malina et al., 2012). For smaller and remote regions in New Zealand with smaller market demand, it is not surprising to see that subsidisation may help these smaller airports improve their operations, capacity, and infrastructure, thus promoting and yielding increased regional air services (e.g. Hawke's Bay airport expansion upgrade) (Hawke's Bay Airport, 2017).

More importantly, the impact of airport subsidies on facilitating a region's economic growth (regional GDP per capita) and employment (reducing the unemployment rate) has also been found in this study. These findings complement the literature by investigating the interplay of airport subsidies, region's GDP per capita and unemployment rate by incorporating the role of regional air transport activities. This important finding indicates the critical effect of subsidised airports on New Zealand's regional development. As New Zealand has a unique airport system and a highly concentrated airline industry (a duopolistic domestic aviation market), Air New Zealand and Jetstar are the dominant and low-cost players largely severing most of the regional airports (Tsui et al., 2019). The limited number of flights serving the smaller and more remote regions generally constrains their ability to grow. In the past few years, Air New Zealand has been cutting some commercially unviable routes to smaller regions (e.g. Northland and Whakatane), exacerbating the constraint on visitor arrivals and regional growth. Taken together, the empirical results of this study are believed to be valuable for helping New Zealand's regional policymakers and airport authorities to strategically consider subsidising and improving regional airport capacity and infrastructure. A clear policy recommendation is that continued provision of airport subsidies may make the country's smaller and remote regions more attractive to airlines and business activities.

On the other hand, a further finding is that scheduled airline seat capacity, economic development (i.e., regional GDP per capita), and environmental concerns (i.e., regional carbon dioxide equivalent emissions) are of great importance for determining airport subsidies. In this light, policymakers in New Zealand are expected to have a better understanding of the regions' air services and to distribute appropriate funds to maintain a seamless regional air transport network. This is consistent with much of the literature, which has discussed the criteria for providing air transport/airport subsidies, most of which are related to the impact on scheduled airline seat capacity and operating routes (e.g. Fageda et al., 2018; Merkert & Hensher, 2013; Wittman et al., 2016). In addition, the transport policy should not be considered separately from the economic, social and environmental of the regions. It needs to be well integrated with other policies (e.g., regional economic, social development, and decarbonisation) for sustainable growth (Delbosc, 2012; Hart, 1993). In fact, the New Zealand government has long considered sustainable development as the core of all government policy (DPMC, 2003). The New Zealand Ministry of Transport (2019) also pointed out that the decision-making process across the transport sector (including air transport) needs to facilitate the best outcomes for New Zealand's sustained regional economies. Sustained regional economic growth, therefore, could be an essential part of expanding optimal investment and support for regional transportation, including air transport. In light of the discussion above, it is recommended that airport operators in New Zealand should form stronger partnerships and coordinate with the central and local/regional governments to ensure that regional economic development and environmental sustainability is better factored into the decision-making process regarding airport subsidies.

3.6.2 The importance of forming a consistent airport subsidy framework

Understanding the effects of regional air services, particularly flight services serving smaller and remote airports, on a region's economic growth can help New Zealand's policymakers to recognise its contribution at the regional level. Hence, the New Zealand government should focus not only on developing large international airports (Auckland, Christchurch, and Wellington airports) but also other regions' smaller airports. This is consistent with a recent study conducted by Fu et al. (2020), which recommended that the New Zealand government should conduct a critical assessment of regional airports' capacity, investment, and infrastructure improvements.

Unlike land, maritime, and rail transportation, the New Zealand central government have not formed any national funding scheme to subsidise regional aviation development, and local/regional governments often step in to subsidise airports using taxpayers' money (New Zealand Airports Association, 2017). This highlights a clear inconsistency between various transport modes in New Zealand. Moreover, it is necessary for well-functioning regional airports to regularly upgrade and maintain their airport infrastructure to meet minimum service and operation standards. Considering that local/regional governments have many competing priorities for regional development (e.g. local land transportation, and water and waste), the New Zealand government should consider the cases of other developed nations (e.g. Australia, the USA, and Europe) and establish a national funding system to support financially struggling regional airports. A significant body of literature has already proved the effectiveness of implementing a continuous airport subsidy scheme for regional air transport activity in the abovementioned countries (e.g. Fageda et al., 2018; Lohmann et al., 2009; Malina et al., 2012).

Green (2007, p.111) asserted that “should air traffic (airport development) be a large determinant of economic success, it is entirely possible that the benefits of new or expanded airports excess costs”. Likewise, not only is air travel in New Zealand important for realising an increase in the number of travellers and economic growth, but it is also an important economic and social component for the smaller regions (New Zealand Airports Association, 2017). In 2019, the New Zealand government announced its plan to support regions to respond to challenges and opportunities, aligned with assisting in the development of regional prosperity, connectivity, and wellbeing (Ministry of Business, Innovation & Emplyoment, 2020). With a consistent airport subsidy policy, in effect, scheduled flight services to smaller and remote regions can be expected to remain and be sustained. More importantly, the region’s economic and social growth can benefit from supporting airport capacity.

New Zealand’s regional growth is critical for national economic and social prosperity. Regional airports are strategic assets that enable businesses, regions, and cities to be well connected and productive, as well as improving access to employment and other social opportunities. Because of the limited population and market size, smaller regional airports are underserved and connected, and this has stopped them from making sustainable economic returns. Smaller airports’ operations were even worse during the COVID-19 pandemic because a sharp fall in domestic air travel resulted in a sudden drop in airport revenue. Hence, there is a need for central and local/regional governments to establish a formal airport subsidy system that ensures smaller airports to maintain sustainable and safe minimum standards of facilities for providing air services.

3.7 Conclusion

Airport subsidies have become an important contemporary issue and have received much attention from airport stakeholders, policymakers, and academics. This study used the panel 3SLS model to simultaneously analyse the inter-relationships among airport subsidies, air transport activity, and the wellbeing of New Zealand regions during the 2010−2019 period.

This study contributes to the air transport literature by being the first to empirically model the inter-relationships among airport subsidies, air transport activity, and regional wellbeing. The empirical findings of this study revealed that implementing airport subsidies may help unprofitable regional airports to significantly promote their regional air transport activity. It also showed that airport subsidies can facilitate a region's economic growth and reduce the unemployment rate. Importantly, the findings confirmed the bi-directional relationship between regional air transport activity and economic development. Moreover, the importance of both regional air transport activity and economic growth factors identified in this study for assessing the impact of airport subsidies has profound implications for policymakers and airport stakeholders.

The key findings of this study imply that the governments, policymakers, and airport authorities in New Zealand should have a greater awareness of the value of air services to the regions' economic and social growth, particularly small and remote regions and airports. In addition, a number of important suggestions and policies can be adopted for future practice in light of the findings of this study. First, the New Zealand government's main focus should be the development of both large international airports and other smaller airports across New Zealand regions. Second, a consistent airport subsidy policy should be planned and establishing for assisting long-term regional growth and development. Third, regional air transport, economic development, and environmental sustainability are recommended to be better factored into the airport subsidy decision process.

The study was conducted in New Zealand, an island country that has a developed economy but is comparatively small in the global marketplace. Moreover, it is worth noting that no national funding system to support regional airports in New Zealand, which is quite distinct from other developed nations (e.g. Australia, Europe and the USA). Therefore, it must be noted that the findings of this study may not generalise to countries with well-implemented government funding systems for assisting airport infrastructure improvement and underwriting essential air links. Having said that, this study provides the opportunity for further study to explore the inter-relationships among airport subsidies, air transport activity, and regional wellbeing in other parts of the world. Several limitations are observed in this study. As most regional airports in New Zealand are partially or fully owned by local/regional governments, it was not possible to assess information other than what has been published (e.g. local councils and airports' annual reports). It is possible that regional airports may receive other forms of support or aid from local/regional governments, such as destination marketing activities and cross-subsidisation, which may not be listed in the published reports. Moreover, it is plausible that using the domestic ASKs data as a proxy of regional air transport activity to measure the scheduled flight seat capacity of the airports, instead of using the actual air passenger numbers of the region's airports, may have influenced the results. Future studies may use data on the exact number of passenger numbers and guest arrivals by air to a region (if available) to understand the inter-relationships among airport subsidies, air transport activity, and regional wellbeing for a more robust result. In addition, it is almost certain that COVID-19 has had a negative impact on regional air transport/airport development. Hence, additional studies will be needed to understand the importance of airport subsidies and their relationship with regional air transport activity and wellbeing in New Zealand during the post-COVID-19 period. Such findings can be used by regional authorities, aviation stakeholders, and policymakers in New Zealand to develop regional policies and targeted interventions aimed at supporting the delivery of air transport outcomes and improving the regions' wellbeing.

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Chapter Four – Analysing aviation subsidies during the post-COVID lockdown period

Preamble

The COVID-19 pandemic has devastated economies and many sectors worldwide, and the aviation industry has been one of the most affected sectors. Whereas Chapter 3 in this thesis examines the issues related to the inter-relationships between aviation subsidies and regional wellbeing before the COVID-19 pandemic, Chapter 4 focuses more on the impact of aviation subsidies on New Zealand's domestic aviation markets during the post-COVID lockdown period. Because of data availability, this chapter only analyses the relationship between aviation subsidies (subsidies to smaller airlines and regional airports) and air passenger traffic in New Zealand's domestic aviation markets for the period of June 2020–December 2020, using the fixed-effect (FE), random-effect (RE), and panel two-step GMM models. It should be noted that the airline subsidies in this chapter refer to the newly introduced ETC scheme, the first-ever national aviation subsidy scheme launched by the New Zealand government. This chapter contributes to the air transport literature as one of the first studies to empirically analyse the role of aviation subsidies (i.e. airline and airport subsidies) in New Zealand's regional aviation market's recovery during the post-COVID lockdown period. Thus, the fourth research objective of this thesis is addressed (i.e. to assess the effect of aviation subsidies on the recovery of the regional aviation market during the post-COVID lockdown period). The findings of this chapter reveal that airline subsidies positively impacted regional air passenger flows during the post-COVID lockdown period, whereas airport subsidies had a limited effect on regional air passenger traffic probably because of the lack of a specific subsidy program that covers a broader range of airports' operational expenses arising from the COVID-19 pandemic. The chapter's findings allow the New Zealand central and local/regional governments and aviation-related sectors (e.g. airlines, airports and tourism authorities) to better understand the positive impacts of aviation subsidies on regional recovery during the post-COVID lockdown period. Particularly, some policy insights presented in this chapter expand on those discussed in Chapters 2 and 3. For example, New Zealand's central government should establish a formal national aviation subsidy framework that ensures essential air connectivity to serve smaller and remote regions. Additionally, local/regional governments should also cautiously and continuously assess their regional airports' capacities, investments and infrastructure improvements, and devise their strategic plans to consistently support the operations and the recovery of small struggling regional airports during and after the difficult operating situation.

Study Four: Investigating aviation subsidy scheme's impact on domestic aviation during the post-lockdown period: a case study of New Zealand

Publication status and candidate contribution

This study was submitted in a highly ranked transport policy journal and is currently under review. The doctoral candidate is the first author of the publication, with the doctoral supervisors being co-authors. The doctoral supervisors provided minor contributions towards the methods, analysis and review of the study, however, the work is primarily that of the doctoral candidate.

4.0 Abstract

The effect of regional aviation subsidies on domestic aviation market in the post-lockdown period is less empirically explored. This study uses panel data regression models to investigate and validate the impact of the first-ever Essential Transport Connectivity scheme on New Zealand's regional air passenger flows. It shows clear evidence that the provision of airline subsidies positively impacted regional air passenger flows, whereas airport subsidies had a limited effect. Importantly, this study provides policy recommendations to policymakers in designing future aviation subsidy policies that facilitates regional aviation market growth in the post-COVID-19 era.

4.1 Introduction

A considerable amount of literature has been published on the significant challenges to the global air travel industry as well as airlines' and airports' resilience capability in response to the damaging impact of the COVID-19 and travel restrictions (Dube et al., 2021; Liu et al., 2021). Similar to international air travel, domestic aviation has also suffered sharp declines in flight capacity, passenger volumes and the operation revenues of airlines and airports (Bauranov et al., 2021; Czerny et al., 2021). Although the unprecedented commercial catastrophic impact of COVID-19 on the domestic aviation markets has drawn attention from academics and professionals, there remains a paucity of evidence about the damaging effects of the pandemic on regional air connectivity (Abate et al., 2020; Hotle & Mumbower, 2021).

Governments' interventions have undoubtedly affected the aviation sector since early 2020 because of the financial devastation of the sector wreaked by the pandemic (Liu et al., 2021; Zhang & Zhang, 2021). Governments worldwide have introduced different types of aviation subsidy (e.g., Regional Airports Program in Australia, and Airline Relief Programs and Airport Rescue Grants in the US) to help airlines and airports maintain their operations and survive throughout the COVID-19 pandemic. However, the effect of regional aviation subsidies on domestic aviation market in the post-lockdown period is less empirically explored in smaller economies. Note that aviation subsidies in smaller economies are normally distributed on an ad-hoc basis and without a formal funding system.

In the case of New Zealand, New Zealand's strategy for combating COVID-19 proved relatively effective (McDougall, 2021). For almost two months (April and May) in 2020, the New Zealand government implemented the highest level of restrictions [16] (i.e., national lockdown) to stop the virus spreading and eliminate it within the community (McDougall, 2021). As of 8 June 2022, there were no more active COVID-19 cases within the community, and the New Zealand government shifted their focus to the economic and social recovery (McDougall, 2021). The relatively good response to the COVID-19 and the efficient national lockdown made New Zealand a unique case in comparison with other developed countries such as Australia, the United States (US) and European countries. Another important reason for choosing New Zealand as the case study is that New Zealand's domestic aviation market was ready for take-off after the national lockdown, with airlines and airports restoring operations and steadily increasing domestic passengers and tourist numbers. For example, Air New Zealand, the national carrier, operated more than 58,000 domestic flights during the post-lockdown period from June to December 2020 (Air New Zealand, 2021). Moreover, Jetstar, a low-cost carrier (LCC), resumed its scheduled flights on five domestic routes as travel restrictions eased within New Zealand (Jetstar, 2020). More importantly, the New Zealand government introduced the Essential Transport Connectivity (ETC) scheme to ensure that small regional carriers, such as Air Chatham and Sounds Air, continued to operate essential flight routes between small and rural regions (Ministry of Transport, 2022). It is worth noting that

[16] The New Zealand government introduced a four-tier alert level system to manage the outbreak within New Zealand. From 26 March to 27 May 2020, the whole nation entered into lockdown, with all non-essential businesses closing, as well as schools and educational institutions. The Auckland region entered lockdown again in August−September 2020.

before the COVID-19, New Zealand did not have a national funding system to support regional air transport activity (NZ Airports Association, 2017). The ETC scheme is New Zealand's first-ever aviation subsidy funding program dedicated to its aviation sector in response to the COVID-19 pandemic, therefore the ETC scheme is a practical case to explore the impact of aviation subsidies on facilitating domestic aviation during the post-lockdown period (June 2020– December 2020).[17]

The study contributes to the literature concerning COVID-19 related aviation subsidies, particularly the effect of aviation subsidies on regional aviation markets. Moreover, the importance and originality of this study are that it investigates and validates the impact of New Zealand's first-ever ETC scheme in supporting its domestic aviation activities during the post-lockdown period. This study also provides recommendations and management advice to New Zealand governments and aviation stakeholders in designing future aviation subsidy policies that facilitate regional aviation market growth in the post-COVID-19 era, as well as responding to any future pandemics. Importantly, the findings will be of interest to policymakers and aviation stakeholders in other countries, as it provides insights into the effectiveness and feasibility of implementing a subsidy scheme to support the aviation sector's operations in such difficult operating environments.

The structure of this study is as follows: Section 4.2 presents a brief review of the relevant literature and proposes hypotheses regarding the linkages between aviation subsidies and both regional air travel and passenger flows. Section 4.3 describes the data and methodology used, and the variables of interest. Section 4.4 presents the estimation results. Section 4.5 discusses and summarises the key findings and policy implications. Section 4.6 presents the conclusion and indicates the limitations and directions for future research.

4.2 Literature review and hypotheses

As air transport services play a vital role in a region's economic growth and development, a considerable amount of literature has been published to determine the factors that drive regional

[17] New Zealand went for almost one year without any nationwide lockdown after June 2020 (from June 2020 to August 2021). In this sense, the sample period in this study refers to the post-lockdown period. Although New Zealand entered nationwide lockdown again in August 2021 because of a case of the Delta variant in Auckland, this falls outside this study's research period.

air passenger traffic (e.g. Button & Yuan, 2013; Zhang & Graham, 2020; Zhang et al., 2018). However, Dobruszkes and Vandermotten (2022) argued that research into the factors impacting domestic and regional air passenger flows remains relatively sparse. In addition, most previous efforts to explore air passenger flows have been mostly focused on the country level (e.g. developed countries such as the US and European countries, and emerging economies including China and southeastern Asian countries) (Dobruszkes & Vandermotten, 2022; Wang et al., 2019). Furthermore, the impact of the COVID-19 pandemic on the aviation sector might last for a long time (Liu et al., 2021). Even with the generally loosened travel restrictions implemented by governments worldwide, many air service providers (e.g. airlines and airports) still face financial pressure from having insignificant air traffic volumes before full market recovery, particularly small regional carriers and secondary airports (Bauranov et al., 2021; Czerny et al., 2021). Governments worldwide have resorted to introducing different forms of support and aid to help financially struggling airlines and airports to survive or maintain their operations during the COVID-19 era (Oum & Wang, 2020). Nevertheless, the effect of government support and aid (i.e. aviation subsidies) on domestic air traffic flows during the COVID-19 era remains unclear. In the following sections, the literature on domestic aviation subsidies in terms of COVID-19 will be reviewed first, followed by a review of the literature on the determinants of domestic air passenger flows.

4.2.1 Domestic aviation subsidies during the COVID-19 pandemic

Many scholars and industry professionals tend to believe that the COVID-19 pandemic may have a long-term impact on economies and the aviation sector (Cifuentes-Faura & Faura-Martínez, 2021; Hotle & Mumbower, 2021). Considering that the substantial drop in air traffic volume has put airlines and airports under significant financial pressure, most governments have provided financial support to the aviation sector for survival and to maintain air transport connectivity (e.g. Czerny et al., 2021; Fu et al., 2020; Scheelhaase et al., 2022). It is evident that governments worldwide have also widely used financial support or a form of subsidy to help air service providers to cope with the massive drop in domestic air transport flows (Abate et al., 2020; Ng et al., 2022). For example, all 10 of the largest US domestic passenger carriers have received financial assistance to maintain a minimum level of air services to domestic cities that had been served during pre-COVID-19 period (Hotle & Mumbower, 2021). More importantly, the financial support provided by the US government has shielded smaller and remote airports from losing air services through the implementation of minimum flight service restrictions. In China, the Chinese government has introduced financial support schemes to subsidise regional airlines and small airports to help them reduce their operation costs during the COVID-19 pandemic (Czerny et al., 2021). In Europe, the state aid (e.g. grants and loans) provided to smaller and charter airlines (e.g. Blue Air, Corsair and Condor) seems to have eased airlines' financial pressures (Martín-Domingo & Martín, 2022; Scheelhaase et al., 2022).

As mentioned in Section 4.1, the New Zealand government first attempted to institute the ETC scheme to support and subsidise air service providers (airlines and airports), which had been severely affected by the COVID-19 pandemic. Under the ETC scheme, the New Zealand government has provided funding of up to a total of NZ$1.7 million to smaller regional airlines (e.g. Air Chatham and Barrier Air) in maintaining vital air links to offshore islands (e.g. the Chatham Islands) (New Zealand Parliament, 2020). For example, Air Chatham maintained their air links to rural and remote destinations such as the Chatham Islands, Paraparaumu, Whakatane and Wanganui with a total of 3,185 scheduled flights and 99,267 scheduled seats after the national lockdown from June to December 2020. The scheduled flights and seats accounted for −19.45% and −20.46% respectively, compared with the same period in the year (June to December 2019) before the COVID-19 pandemic. In addition, Sounds Air received NZ$30 million to maintain its services to small and remote regions (e.g. Blenheim, Paraparaumu, Taupo and Westport), with a total of 10,785 scheduled flights and 119,013 scheduled seats from June to December 2020. The scheduled flights and seats accounted for a change of 14.54% and 15.55%, respectively, compared with the same period in the year (June to December 2019) before the COVID-19 pandemic. Apparently, the ETC funding to Sounds Air recognised the importance of Sounds Air operating lifeline services and keeping small and remote communities connected. In terms of Air New Zealand and Jetstar, neither airline received funding support under the ETC scheme, suffering a massive reduction in scheduled flights and seats, with a total of 53,957 scheduled flights and 4,739,349 scheduled seats (−41.94% and −41.06% compared with the same period in 2019), and 2850 scheduled flights and 530,100 scheduled seats (−76.57% and −66.59% compared with the same period in 2019), respectively. With regard to airports, no airport subsidies have been granted to them under the ETC scheme. Only wage subsidies were provided by the New Zealand government to assist these airports, which suffered significant losses in air traffic volume. Therefore, the following hypotheses were established to test the impact of aviation subsidies on regional air passenger flows during the post-lockdown period:

H$_1$: *The provision of airline subsidies has a positive impact on increasing regional air passenger flows during the post-lockdown period.*

H$_2$: *The provision of airport subsidies has a positive impact on promoting regional air passenger flows during the post-lockdown period.*

4.2.2 Determinants of domestic air passenger flows

Many published studies have identified numerous determinants of air passenger flows, which can be categorised into two groups: (i) geo-economic (e.g. gross domestic product (GDP) per capita and tourism); and (ii) aviation-related factors (e.g. airfares, flight frequency and LCC) (e.g. Calzada & Fageda, 2019; Hakim & Merkert, 2019; Zhang & Zhang, 2016). Generally, both the geo-economic and aviation-related factors have already been demonstrated as being important determinants supporting higher air passenger flows (e.g. Grosche et al., 2007; Wang et al., 2018; Yue & Byrne, 2021; Zhang et al., 2018).

The aforementioned factors have also been identified in prior studies investigating domestic and regional aviation markets within specific countries. For example, Bhadra and Wells (2005) found that regional GDP significantly affected the air passenger traffic in the US. Similar results have also been confirmed in other countries' domestic aviation markets (e.g. China and Turkey) (Albayrak et al., 2020; Li et al., 2022). Furthermore, several studies related to European countries and China have demonstrated the positive relationship between tourism activities and domestic air passenger flows (Jankiewicz & Huderek-Glapska, 2016; Li et al., 2022). Moreover, many studies in the US and European markets have highlighted several factors closely associated with air passenger traffic, including airfares, flight frequency, seasonality, LCCs and seat availability (e.g. Boonekamp et al., 2018; Pitfield et al., 2012; Wadud, 2015). Likewise, regions' GDP per capita and LCC services have been critical in growing New Zealand's regional air traffic and tourism flows (Tsui, 2017; Tsui et al., 2019).

4.3 Data definitions and empirical models

4.3.1 Data collection and sample

The research period was from June to December 2020 (i.e. the post-lockdown period). Consequently, data from 7 months were assembled for a panel of 26 airports covering domestic air passenger flows on 104 flight routes, yielding a total of 728 route-month observations. The variables of interest were derived from various sources (see Table 12). This study had four key variables of interest: air passenger numbers, available seat-kilometres (ASKs) of subsidised carriers, origin airport subsidy and destination airport subsidy ($\ln(PAX)_{ijt}$, $\ln(SC\_ASK)_{ijt}$, $\ln(Subs\_Airport\_O)_{it}$ and $\ln(Subs\_Airport\_D)_{jt}$, respectively). New Zealand's domestic air passenger numbers were sourced from the International Air Transport Association. Data on the ASKs of subsidised carriers[18] were sourced from the New Zealand Ministry of Transport and the Official Airline Guide. Data on New Zealand's airport subsidies were sourced from various governments and airports' annual reports.[19] Here, $\ln(SC\_ASK)_{ijt}$ represents airline subsidies as mentioned in H_1, whereas $\ln(Subs\_Airport\_O)_{it}$ and $\ln(Subs\_Airport\_D)_{jt}$ represent airport subsidies, as explored in H_2.

Several air transport-related determinants of domestic air passenger flows were collected for this estimation, such as airfares ($\ln(Fare)_{ijt}$), total domestic ASKs ($\ln(Total\_ASK)_{ijt}$), and the percentage of LCCs within the total ASKs ($\%\ of\ LCC\_ASK_{ijt}$). Airfares have long been considered an important indicator of air travel demand, particularly for leisure travellers who are price-sensitive (Boonekamp et al., 2018; Fu & Kim, 2016), and therefore, airfares are included for determining New Zealand's domestic air passenger flows. The total domestic ASKs were used as an indicator of the scheduled seat capacity of New Zealand's domestic air travel market (Tsui et al., 2019; Yue & Byrne, 2021). The presence of LCCs was also included to analyse New Zealand's domestic air passenger flows because their impact on air passenger and tourist flows has often been studied in recent literature (e.g. Boonekamp et al., 2018; Tsui, 2017; Yue & Byrne, 2021).

In addition to air transport-related determinants, several control variables were included in this study, including the regional GDP per capita of the origin airport ($\ln(GDPPC_{O_{it}})$), the regional tourism electronic card transactions (TECTs) of the destination airport ($\ln(TECT_{D_{jt}})$) and the Auckland lockdown for combating COVID-19 ($Lockdown_t$). Data on the regional GDP per

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[18] The New Zealand government only subsidised small regional carriers under the ETC scheme. Only two regional subsidised carriers (Air Chatham and Sounds Air) were included in this study because the Official Airline Guide and the International Air Transport Association did not publish the air passenger numbers and scheduled seats of other smaller subsidised carriers. Note that the New Zealand Ministry of Transport and the two regional subsidised carriers (Air Chatham and Sounds Air) did not disclose a breakdown of the subsidy amount for each route.

[19] Some annual data were interpolated to obtain the monthly frequency.

capita were collected to reflect the income level of a region, as prior evidence has suggested that higher income is associated with more regional air traffic (Albayrak et al., 2020; Tsui et al., 2019). Generally, the inter-relationship between tourism and air passenger flows is relatively straightforward and has been confirmed by numerous studies (e.g. Bieger & Wittmer, 2006; Jankiewicz & Huderek-Glapska, 2016; Spasojevic et al., 2018). In this study, data on the regional TECTs were collected to represent and capture regional tourism activity because data on other key tourism indicators (e.g. regional tourist arrivals, tourism expenditure and accommodation costs) are not available for the research period. A second COVID-19 lockdown was imposed from August to September 2020 in the Auckland region[20]; therefore the dummy variable $Lockdown_t$ was added to capture the effect of this COVID-19 lockdown on New Zealand's domestic air passenger traffic (Cifuentes-Faura & Faura-Martínez, 2021). Table 13 presents the descriptive statistics for the variables of interest.

[20] The entire Auckland region went into lockdown because of community transmission of the disease from August to September 2020.

Table 12

Definitions and sources of the variables (June−December 2020)

Variables	Definition	Source
$\ln(PAX)_{ijt}$	The natural logarithm of the total air passenger numbers from the origin airport of region i to the destination airport of region j at time t	International Air Transport Association
$\ln(SC\_ASK)_{ijt}$	The natural logarithm of total ASKs scheduled by subsidised regional carriers from the origin airport of region i to the destination airport of region j at time t	OAG; New Zealand Ministry of Transport
$\ln(Subs\_Airport\_O)_{it}$	The natural logarithm of the subsidy amount for the airport of region i at time t	Airports' annual reports; councils' annual reports; authors' own calculations
$\ln(Subs\_Airport\_D)_{jt}$	The natural logarithm of the subsidy amount for the airport of region j at time t	Airports' annual reports; councils' annual reports; authors' own calculations
$\ln(Fare)_{ijt}$	The natural logarithm of average airfares from the origin airport of region i to the destination airport of region j at time t	International Air Transport Association
$\ln(Total\_ASK)_{ijt}$	The natural logarithm of domestic ASKs scheduled by all carriers from the origin airport of region i to the destination airport of region j at time t	Official Airline Guide
$\%\ of\ LCC\_ASK_{ijt}$	Percentage of LCCs' ASK from the origin airport of region i to the destination airport region j at time t	Official Airline Guide; authors' own calculations
$\ln(GDPPC\_O)_{it}$	The natural logarithm of GDP per capita of region i where the origin airport is located at time t	Statistics New Zealand
$\ln(TECT\_D)_{jt}$	The natural logarithm of TECTs of region j where the destination airport is located at time t	Ministry of Business, Innovation and Employment
$Lockdown_t$	A binary variable that takes 1 for the COVID-19 lockdown in the Auckland region, and 0 otherwise	Authors' own calculations
Route dummies	The dummy variable for each air route	Authors' own calculations
Monthly dummies	The dummy variable for each month of the study	Authors' own calculations

Note: $ln(SC\_ASK)_{ijt}$, $ln(Subs\_Airport\_O)_{it}$ and $ln(Subs\_Airport\_D)_{jt}$ contains zero-valued observations, and this study added the value of 1 to the zero-valued observations before logarithmic transformation (MaCurdy & Pencavel, 1986; O'Hara & Kotze, 2010).

Table 13

Descriptive statistics of the variables (June−December 2020)

Variables	Unit	Observations	Mean	Standard deviation	Minimum	Maximum
PAX_{ijt}	Number	718	5,791	10,154.66	16	61,375
SC_ASK_{ijt}	Kilometres	718	81,181	201,131.00	1	1,091,160
$Subs\_Airport\_O_{it}$	NZD	728	45,774	115,139.90	1	550,333
$Subs\_Airport\_D_{jt}$	NZD	728	45,774	115,139.90	1	550,333
$Fare_{ijt}$	NZD	718	142	22.42	86	204
$Total\_ASK_{ijt}$	Kilometres	718	4,059,890	9,798,025.00	2,556	6.39e+07
$\%\ of\ LCC\_ASK_{ijt}$	%	718	1.86	6.20	0	31.24
$GDPPC\_O_{it}$	NZD	728	6,225.87	2,126.00	2,088.71	10,640.46
$TECT\_D_{jt}$	NZD (million)	728	68.65	56.32	5.54	227.27
$Lockdown_t$	Dummy	728	0.06	0.23	0	1

Note: All numbers in this table are the level numbers. The variables of PAX_{ijt}, SC_ASK_{ijt}, $Fare_{ijt}$, $Total\_ASK_{ijt}$, and $\%\ of\ LCC\_ASK_{ijt}$ have missing values in 10 observations. See Table 12 for definitions of the variables.

4.3.2 Methodology

The impact of aviation subsidies (i.e. airline subsidies under the ETC scheme and airport subsidies provided through the New Zealand government's COVID-19 wage subsidy scheme) on the recovery of domestic air passenger flows during the post-lockdown period from June to December 2020 in New Zealand was estimated by Equation (1):

$$\ln(PAX)_{ijt} = \beta_0 + \beta_1 \ln(SC\_ASK)_{ijt} + \beta_2 \ln(Subs\_Airport\_O)_{it} + \beta_3 \ln(Subs\_Airport\_D)_{jt} + \sum_{k=1}^{k} \beta_{k+3} X_{k,i,j,t} + \varepsilon_{ijt} \quad (1)$$

where $\ln(PAX)_{ijt}$ is air passenger numbers from the airport of region i to airport j at time t, β_0 is the intercept term, β_1 is the coefficient for $\ln(SC\_ASK)_{ijt}$, β_2 is the coefficient for $\ln(Subs\_Airport\_O)_{it}$, β_3 is the coefficient for $\ln(Subs\_Airport\_D)_{it}$, $X_{k,i,j,t}$ is the kth explanatory variable for the airports of regions i and j at time t (i.e. $\ln(Fare)_{ijt}$, $\ln(Total\_ASK)_{ijt}$, $\%\ of\ LCC\_ASK_{ijt}$, $\ln(GDPPC\_O)_{it}$, $\ln(TECT\_D)_{jt}$ and $Lockdown_t$), β_{k+3} is the coefficient for the kth explanatory variable and ε_{ijt} is the error term. The statistical program Stata 16 was used for this estimation.

Prior to estimating of Equation (1), the pairwise correlation between all the explanatory variables varied in the range from -0.45 to 0.47 (see Appendix O), suggesting that the possibility of multicollinearity is limited (Shrestha, 2020). Moreover, panel unit root tests (the augmented Dickey−Fuller test and the Phillips−Perron test were performed (see Appendix P), and non-stationary variables were first-differenced to make them stationary. Fixed effect (FE) and random effect (RE) panel regression analyses were applied to Equation (1) to form the baseline models. The Hausman test indicated that a FE panel model was more efficient, as the null hypothesis (the RE model) was rejected (p = 0.0001). Wooldridge (2016) stated that a FE and RE panel regression is unbiased when the explanatory variables are under the assumption of strict exogeneity. There could be some possible variables in the models that do not meet the strict exogeneity requirements. For example, the relationship between $\ln(PAX)_{ijt}$ and $\ln(Fare)_{ijt}$ is determined endogenously (Lurkin et al., 2017; Perera & Tan, 2019). Similarly, $\ln(PAX)_{ijt}$ and other explanatory variables including $\ln(SC\_ASK)_{ijt}$, $\ln(Subs\_Airport\_O)_{it}$, $\ln(Subs\_Airport\_D)_{it}$, $\ln(Total\_ASK)_{ijt}$ and $\ln(TECT\_D)_{jt}$ are likely to be determined as endogenous variables (e.g. Fageda et al., 2019; Spasojevic et al., 2018; Tsui et al., 2019). Endogeneity bias can therefore cause inconsistent estimates, which potentially leads to incorrect inferences, misleading conclusions and incorrect theoretical interpretations (Ullah et al., 2018).

Given the possible presence of endogeneity when estimating the four key variables, and to test the hypotheses established in Section 4.2, the panel system generalised method of moments (GMM) model with robust standard errors was applied to estimate Equation (1). The panel system GMM model has been widely used to address endogeneity issues by incorporating the lags of the endogenous variables as instrument variables[21], and it has been successfully applied in air transport and tourism studies (Arellano & Bover, 1995; Gasmi & Sassi, 2015). To verify the estimation results, it is important to apply two post-estimation tests (the Hansen test and the Arellano–Bond test)[22] to determine a proper panel system GMM model estimation. In addition, the static model estimations in Equation (1) may suffer from a loss of dynamic information of $\ln(PAX)_{ijt}$, which may lead to model misspecification (Balli et al., 2016). Therefore, this dynamic issue has been taken into consideration in the panel system GMM estimation by incorporating a one-period lagged dependent variable, $\ln(PAX)_{ijt-1}$, as one of the explanatory variables. The dynamic panel system GMM model for domestic air passenger flows is represented Equation (2):

$$\ln(PAX)_{ijt} = \beta_0 + \beta_1 \ln(PAX)_{ijt-1} + \beta_2 \ln(SC\_ASK)_{ijt} + \beta_3 \ln(Subs\_Airport\_O)_{it} + \beta_4 \ln(Subs\_Airport\_D)_{jt} + \sum_{k=1}^{k} \beta_{k+4} X_{k,i,j,t} + \varepsilon_{ijt} \quad (2)$$

4.4 Empirical findings

Table 14 shows the estimation results of the panel FE and RE models (Models 1 and 2), and the panel system GMM model (Models 3 and 4). For the panel FE and RE estimations (Models 1 and 2), the key variable, $\ln(SC\_ASK)_{ijt}$, was reported to have a statistically significant and positive coefficient, which shows its positive influence on regional air passenger numbers during the post-lockdown period in the panel FE estimation. Regarding air transport-related determinants, the variable $\ln(Total\_ASK)_{ijt}$ was statistically significant in both the FE and RE estimations (Models 1 and 2). These empirical findings accord with prior studies, which

[21] For the sake of brevity, more details regarding the panel system GMM model, as well as the appropriate lag selection of instrument variables, can be found in previous literature (Roodman, 2009; Ullah et al., 2018).

[22] The Hansen test for the validity of an instrument was used because this study involved two steps with robust standard errors. The null hypothesis (H_0) for the Hansen test is that the instruments as a group are exogenous (Roodman, 2009). The Arellano–Bond test for no serial correlation is used under the null hypothesis (H_0) that the error terms of two different time periods are uncorrelated (Ullah et al., 2018). In other words, it means that the lagged variables are not correlated with the error term in Equation (1).

showed that increased scheduled airline services could significantly contribute to a region's air passenger volumes (Hsiao & Hansen, 2011; Tsui et al., 2019). Moreover, the panel RE estimation (Model 1) showed that the coefficient of $\%\, of\ LCC\_ASK_{ijt}$ was statistically significant and positive, which is partially line with the previous finding of Tsui (2017) regarding the importance of an LCC (Jetstar) on New Zealand's regional air passenger traffic. More importantly, this finding is in accord with a recent study in the US indicating that LCCs could play an important role in speeding up and supporting the recovery of aviation (Kaffash & Khezrimotlagh, 2022). Regarding the other explanatory variables, $Lockdown_t$ was found to have a significant negative effect on New Zealand's domestic air passenger traffic in both the FE and RE estimations (Models 1 and 2), as expected. In addition, significant positive coefficients of $\ln(GDPPC\_O)_{it}$ and $\ln(TECT\_D)_{jt}$ were only reported in the RE estimation (Model 2). These findings are likely to be related to the inextricable connections between air travel demand and regional economic prosperity, as well as regional air transport's close relationship with tourism (Papatheodorou, 2021; Zhang & Graham, 2020).

Because Equation (1) could have the potential problem of endogeneity, Models 3 and 4 report the estimation results of the static and dynamic panel system GMM models, respectively. Importantly, the Hansen test for Models 3 and 4 was statistically insignificant at the 5% significant level, which confirms the validity of the GMM instrument[23] and also shows that the instruments applied in Models 3 and 4 are exogenous. The Arellano–Bond test statistic for serial correlation of order 2 in the errors in the dynamic system GMM (Model 4) is statistically insignificant which indicates the non-existence of second-order autocorrelation after a dependent variable lagged by one-period was introduced. It also validates that the lags of the endogenous variables as suitable instruments.

The similarity in the outcomes of the static and dynamic system GMM estimations is reported in Models 3 and 4. In the dynamic system difference GMM model (Model 4), the estimation result shows that the one-lagged value of the dependent variable, $\ln(PAX_{ijt-1})$, is statistically significant and positive. This finding is consistent with prior literature and implies that the current period's air passenger traffic of the sampled airport of a region is related to its previous

[23] The validity of panel system GMM instruments have only mildly significant Hansen test statistics, with p-values of 0.068 and 0.065, which can be accepted (Bouayad-Agha & Vedrine, 2010; Hansen & Lee, 2021)

period's air passenger traffic (Higgoda & Madurapperuma, 2020; Tsui et al., 2021). This finding is also expected, and McDougall (2021) mentioned that airlines gradually transported more and more air passengers or tourists on their domestic/regional routes when the country started economic recovery during the post-lockdown period. In addition, the estimation results of Models 3 and 4 show that $\ln(SC\_ASK)_{ijt}$ and $\ln(Total\_ASK)_{ijt}$ have statistically significant and positive coefficients, which support the results of the FE model (Model 1). Another key variable, $\%\ of\ LCC\_ASK_{ijt}$, was also found to have a positive impact on regional air passenger traffic in Model 3, with statistically significant and positive coefficients. However, it is reported to have a positive but statistically insignificant coefficient in Model 4. The underlying explanation of these empirical findings is that more LCC's seat capacities have been scheduled to serve regional aviation markets, which has had a positive impact on New Zealand's regional air passenger traffic during the post-lockdown period. Likewise, the contribution of subsidised regional airlines to improving regional air passenger traffic should be acknowledged (Hotle & Mumbower, 2021; Kaffash & Khezrimotlagh, 2022). Similar to the estimation results of the FE and RE models (Models 1 and 2), as expected, the COVID-19 lockdown in the Auckland region, $Lockdown_t$, had a significant adverse effect on New Zealand's regional air passenger traffic (Becken & Hughey, 2021).

Overall, the panel FE and RE models and the two-step system GMM models provided fairly consistent estimation results. Importantly, $\ln(SC\_ASK)_{ijt}$ was reported to have a positive and statistically significant coefficient in Models 1, 3 and 4. Thus, Hypothesis 1 is accepted, which suggests that airline subsidies had a positive impact on increasing regional air passenger flows during the post-lockdown period. A 1% increase in total ASKs scheduled by regional subsidised carriers led to 0.060−0.088% growth in New Zealand's domestic air passenger traffic during the post-lockdown period. Regarding the airport subsidies offered by the New Zealand government, both $\ln(Subs\_Airport\_O)_{it}$ and $\ln(Subs\_Airport\_D)_{jt}$ were statistically insignificant in all models. Therefore, Hypothesis 2 fails to be accepted, which implies that airport subsidies had no positive impact on promoting New Zealand's regional air passenger flows during the post-lockdown period.

Table 14

Estimation results of the aviation subsidy effect (June−December 2020)

Dependent variable = $\ln(PAX)_{ijt}$				
Explanatory variables	**(1) FE**	**(2) RE**	**(3) Static GMM**	**(4) Dynamic GMM**
$\ln(PAX)_{ijt-1}$				0.168** (0.078)
$\ln(SC\_ASK)_{ijt}$	0.088*** (0.240)	0.019 (0.020)	0.060** (0.026)	0.062** (0.025)
$\ln(Subs\_Airport\_O)_{it}$	0.002 (0.003)	0.001 (0.003)	0.005 (0.007)	−0.058 (0.045)
$\ln(Subs\_Airport\_D)_{jt}$	0.001 (0.003)	−0.002 (0.003)	0.001 (0.008)	0.032 (0.029)
$\ln(Fare)_{ijt}$	−0.025 (0.418)	0.354 (0.345)	−1.530 (1.001)	0.037 (0.845)
$\ln(Total\_ASK)_{ijt}$	0.302*** (0.090)	0.370*** (0.066)	0.277** (0.077)	0.357*** (0.091)
$\%\ of\ LCC\_ASK_{ijt}$	0.036 (0.287)	0.959** (0.339)	0.727* (0.377)	0.142 (0.369)
$\ln(GDPPC\_O)_{it}$	3.437 (4.022)	1.262*** (0.324)	5.098 (4.794)	15.972 (28.230)
$\ln(TECT\_D)_{jt}$	−0.092 (0.143)	0.362*** (0.109)	0.048 (0.203)	−0.440 (0.287)
$Lockdown_t$	−0.225*** (0.051)	−0.123** (0.051)	−0.209** (0.093)	−0.255** (0.108)
$July$				0.374** (0.130)
$August$	−0.327*** (0.068)	−0.216*** (0.060)	−0.142 (0.091)	
$September$	−0.303*** (0.062)	−0.212*** (0.052)	−0.084 (0.102)	0.077 (0.116)
$October$	−0.301*** (0.079)	−0.324*** (0.073)	−0.072 (0.120)	0.002 (0.216)
$November$	−0.240** (0.080)	−0.214*** (0.064)	0.065 (0.151)	−0.051 (0.275)
$December$	0.948** (0.323)	0.982*** (0.263)	1.129** (0.355)	1.292** (0.429)
Constant	−26.222 (34.762)	−9.920*** (2.818)		
Observations	622	622	518	518
R^2	0.27/0.07/0.07	0.17/0.63/0.60		
Hansen test			0.068	0.065
Arellano–Bond AR(2)			0.001	0.207

Note: *, **, and *** indicate the explanatory variable is significant at the 0.10, 0.05 and 0.01 significant level, respectively. Robust standard errors are reported in the parentheses.

4.5 Discussion and policy implications

4.5.1 Importance of airline subsidies in maintaining regional connectivity

Air services to rural and small communities provided by small and regional carriers have been generally deemed to be essential air services, and can ensure these peripheral regions' air connectivity (Fageda et al., 2018). The COVID-19 pandemic affected airline operations, especially for small and regional financially vulnerable airlines serving regional markets with limited passenger demand (Czerny et al., 2021). The New Zealand government provided different forms of financial support to help small airlines and airports deal with this critical situation. The findings of this study suggest that the provision of subsidies to small and regional airlines under the New Zealand government's ETC scheme not only has achieved its objective of maintaining essential regional air connectivity during the post-lockdown period, but it could also facilitate air passenger flows in the regional aviation sector.

Although the airline subsidies were provided under the ETC scheme for only seven months after the national lockdown, this study offers insights into the development of New Zealand's regional aviation sector during the post-COVID-19 era and, more importantly, it can further the understanding of the purposes of airline subsidies implemented in other small economies. First, providing airline subsidies to support essential regional connectivity is feasible. Subsidies are beneficial to small and regional airlines for mitigating their economic damage caused by the COVID-19 pandemic, as well as maintaining a minimum level of flight services to remote cities and rural areas (Hotle & Mumbower, 2021). In the case of New Zealand, except for Air New Zealand and Jetstar, all other carriers are small regional carriers that mainly operate low-demand regional routes during the post-COVID-19 era. Hence, policymakers and aviation stakeholders should also pay attention to the fragility and survivability of regional routes. Second, the airline subsidies implemented under the newly launched ETC scheme reveal that the New Zealand government has recognised small and regional airlines' essential role in connecting smaller and remote communities and promoting regional development. The successful outcome of this airline subsidy trial may strengthen the government's confidence in further exploring an effective and continuous airline subsidy scheme similar to those of other developed nations (e.g. the Essential Air Service program in the US, the remote air services subsidy scheme in Australia and the Public Service Obligation in European countries) (Fageda et al., 2018). As discussed earlier, the lower traffic demand of regional routes and airline financial stress may be exacerbated during post-COVID-19 period; therefore, the New Zealand government is recommended to establish a continuous airline subsidy scheme that ensures essential air connectivity for smaller and remote regions.

4.5.2 Rethinking the purpose of airport subsidies during the post-COVID era

Regional air services and most airports across New Zealand are responsible for transporting peoples and goods domestically. During the post-lockdown period (June to December 2020), regional airports only received wage subsidies from the New Zealand government to subsidise their employees' wages from June 2020 to September 2020. However, the findings of this study show that the wage subsidies available to regional airports had a limited effect on regional air passenger traffic during the post-lockdown period, because its purpose was to support affected employees and business organisations during the COVID-19 pandemic, rather than helping New Zealand airports to operate from an operational perspective (McDougall, 2021).

Prior to the COVID-19 pandemic, the absence of a national funding system prompted New Zealand's local and regional governments to use their own funding sources (e.g. grants, subsidies and loans) to maintain and improve their local airports' operations and infrastructure (New Zealand Airports Association, 2017). Since 2020, the devastating impact of the COVID-19 pandemic has brought challenges to the regional aviation sector in New Zealand, such as reduced air traffic demand and rising safety concerns, particularly for smaller and financially struggling regional airports, as they may not be able to return to their old financial orthodoxies (i.e. reliance on intermittent subsidies from local authorities). More importantly, the decline in regional air passenger traffic may affect ongoing and planned airport capacity expansions, making airport investments lumpy (Ng et al., 2022; Xiao et al., 2017). From the regional development perspective, this study raises an important question of forming effective and rational policies on airport investments, suggesting that the New Zealand government (including local/regional governments) should rethink the necessity of an airport funding system during the post-COVID-19 era. Similar to the airline subsidies offered to small regional carriers, New Zealand's airport subsidy policy should draw lessons from the cases of other nations. For example, the US airport subsidy programmes (e.g. the Airport Improvement Program and the Small Community Air Service Development Program) have been implemented to help small communities to address issues regarding the planning and development of their local airports from the pre-COVID-19 period to the present day (Fageda et al., 2018; Oum & Wang, 2020). Additionally, another dedicated program, namely Airport Rescue Grants, was introduced in the US in 2021 to help eligible airports to prevent, prepare for and respond to the COVID-19 pandemic (Federal Aviation Administration, 2021). In light of the US experience, a key policy priority for New Zealand or other countries should be to plan and implement a feasible means of supporting the operations and recovery of smaller, financially struggling airports during the post-COVID-19 era. It should be noted that eligible US airports can use Airport Rescue Grant funding for any operational expenses arising from the COVID-19 pandemic, covering a broader range of expenses than merely wage subsidies. During the post-COVID period, airport subsidies should focus on keeping small and remote airports that have suffered financial difficulty running. This could improve regional air passenger traffic and keep peripheral regions connected. To support the regional airport sector further, particularly small airports facing financial pressures in the post-COVID period, continued efforts by the New Zealand government are needed via a critical assessment of regional airports' capacity, investment, and infrastructure improvements, as well as through forming a long-term support plan for regional airports' development (Fu et al., 2020).

4.5.3 Importance of aviation in boosting recovery during the post-COVID era

As air transport activity forms a significant part of New Zealand's economy and prosperity (New Zealand Airports Association, 2017), a steadily invigorated aviation sector is a vital enabler of New Zealand's regional tourism markets, as well as impacting regional economic wellbeing and achieving sustainable, prosperous regional development during the post-COVID-19 era. This has been seen in many New Zealand's tourist destinations (e.g. Rotorua and Queenstown), which rely heavily on flight services to bring tourists and travellers to local businesses that employ many locals (Ministry of Business, Innovation and Employment, 2021). On the other hand, accessible air services should be available for all people in New Zealand, whether they live in large urban centres or small and remote communities, as seamless air connectivity will facilitate the movement of people and goods, which benefits economic development and social wellbeing (Gössling & Peeters, 2007). However, it is expected that several of New Zealand's regional commercial air transport services could be compromised or even disappear because of the massive drop in domestic air travel demand and unprofitable operations (Abate et al., 2020). Hence, the New Zealand government's responsibility to support the regional aviation sector and operators will be crucial for keeping all communities connected and boosting regional development during the post-COVID-19 era. Once again, this study has proved the effectiveness of an aviation subsidy program (i.e. airline subsidies under the ETC scheme) for helping smaller regional airlines deal with the effects of the COVID-19 pandemic and maintain their services to smaller and remote communities. A rapid rebound in regional air passenger traffic will be an essential part of creating regional economic growth during the recovery phase following the COVID-19 pandemic (Abate et al., 2020).

4.6 Conclusion

Air transport contributes to regional economies and plays an essential role in transferring individuals, goods and services (Baker et al., 2015). Thus, sustained recovery of the regional aviation sector is critical during the COVID-19 era. This study analyses aviation subsidies' impact on New Zealand's domestic air passenger flows during the post-lockdown period. Importantly, this study contributes to the air transport literature by being one of the first to empirically investigate and validate the effect of aviation subsidies (i.e., airline and airport subsidies) on the regional aviation market during the post-lockdown period. The empirical findings of this study reveal that the provision of airline subsidies positively impacted regional air passenger flows during the post-lockdown period. It also shows that increased scheduled airline services could significantly contribute to New Zealand's regional air passenger traffic.

The New Zealand government's support for essential air connectivity has played a vital part in boosting its domestic aviation market during the post-lockdown period. More importantly, several important suggestions and policies related to the design and planning of aviation subsidies are recommend for future practice. First, the New Zealand government and other countries facing similar situations are recommended to establish a continuous airline subsidy scheme that ensures essential air connectivity to serve smaller and remote regions. Second, it is necessary for governments to cautiously assess their regional airports' capacity, investment and infrastructure improvements, along with a strategic plan for the consistent support of the recovery of small and financially struggling airports after difficult operating periods. This study will assist policymakers and aviation stakeholders obtain better knowledge regarding the impact of aviation subsidies on regional development and social benefit, thus enabling them to develop suitable regional aviation subsidy schemes/policies and targeted interventions to reconnect smaller and remote regions, as well as to support the delivery of better air transport outcomes during the post-COVID era.

A number of limitations need to be noted regarding the present study. As the New Zealand Ministry of Transport and the subsidised airlines did not disclose a breakdown of the airline subsidy amount for each route, this means that the precise impact of airline subsidies remains to be elucidated in a further study if the data are accessible. Another important limitation of this study is that the research period contains information only from June 2020 to December 2020 because of data availability. It is noted that the volatile spread of COVID-19 virus also made New Zealand enter another national lockdown in August 2021 after the research period, which might also have disrupted the recovery process of the domestic aviation market somewhat. As the COVID-19 pandemic is likely to have lasting effects on New Zealand’s domestic aviation market for a long time, the current research period (only 7 months) is relatively short. Thus, the current picture of the aviation subsidies’ impact on New Zealand’s regional air passenger traffic needs to be cautiously assessed, and caution should be taken when generalising the findings of this study to other countries. Therefore, future research should be carried out to investigate and quantify the relationship between the damaging impact of COVID-19 on aviation subsidies and regional air passenger flows with a longer research period and a number of countries.

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General Discussion

Linking back to the research objectives

Collectively, all four chapters in this PhD thesis address the research objectives outlined in the Introduction. Chapter 1 systematically reviews the prior literature on aviation subsidies and regional wellbeing, suggesting that the impacts of aviation subsidies on regional wellbeing remains uncertain, and more wellbeing indicators associated with regional aviation subsidies should be examined and developed in future studies. Chapter 2 identifies the critical air transport and wellbeing indicators to be considered for regional aviation subsidy policy design and implementation from stakeholders' perspectives, highlighting the necessity of integrating economic and social wellbeing into regional aviation subsidy policies. Chapter 3 analyses the inter-relationships among airport subsidies, air transport activity, and regional wellbeing in the pre-COVID-19 era. This indicates that the continued provision of airport subsidies benefited smaller and remote regions and stimulated airline services, thereby promoting regional economic prosperity. Moreover, it suggests that airport authorities in New Zealand should form stronger partnerships and coordinate with policymakers to ensure that airport subsidies are factored into the decisions on regional economic development. Chapter 4 examines the impacts of aviation subsidies on regional air travel during the post-COVID lockdown period. It suggests that New Zealand government should establish a formal national aviation subsidy framework that ensures essential air connectivity to serve smaller and remote regions and communities, and enables quick recovery of the regional aviation markets and economies. In addition, the mixed approach (qualitative and quantitative methods) used in this thesis contributes to the air transport literature on understanding the aviation subsidy–regional wellbeing nexus, and the findings of the thesis offer policy insights for designing and implementing regional aviation subsidies by examining the case of New Zealand.

Policy implications

Table 15 lists six key policy implications that have been discussed in this PhD thesis. Noted that only Chapters 2, 3 and 4 offer policy insights and implications related to New Zealand's regional aviation subsidy policy, whereas Chapter 1 systematically reviews the prior literature and publications and proposes a number of avenues for future research relating to the relationship between aviation subsidies and regional wellbeing.

Table 15

Summary of policy insights and implications in this PhD thesis

• Implement aviation subsidies to improve regional air transport and wellbeing.
• Regional wellbeing should be factored into aviation subsidy policy design and implementation.
• A national aviation subsidy framework should be established for the post-COVID-19 era.
• A critical assessment of regional airports' capacity, investment, and infrastructure improvements should be conducted.
• Stronger partnerships should be formed between aviation stakeholders and policymakers on the decision-making of airport subsidies.
• Continue to subsidise regional airlines to maintain regional air connectivity.

Among all the policy insights implications listed above, the following three key policy insights and implications are worth highlighting and discussing, as they are obvious, and appear repeatedly across the chapters of this thesis.

Implement aviation subsidies to improve regional air transport and wellbeing

As indicated in Chapter 1, most prior studies regarding regional aviation subsidies have confirmed their contributions to and impacts on the wellbeing of people living in remote regions or smaller communities (e.g. Donehue & Baker, 2012; Fageda et al., 2018; Gössling et al., 2017). The findings of Chapters 3 and 4 also support the notion that aviation subsidies play an essential role in improving regional air transport activities, as well as economic and social wellbeing. In New Zealand, before the COVID-19 pandemic, airport subsidies were mostly funded by local/regional governments and were considered the main enabler of regional aviation activities, such as increasing the number of scheduled airline seats available to smaller regions across New Zealand. These finding prove the effectiveness of airport subsidies, which also accords with previous research on other countries where airport subsidies have been implemented, such as the US, European countries, and Australia (Chow et al., 2021; Fageda et al., 2018). On the other hand, Chapter 3 specifically highlights the importance of airport subsidies in facilitating a region's economic growth (i.e. regional GDP per capita) and reducing the unemployment rate during the pre-COVID-19 era. These empirical findings echo the statements of the New Zealand Ministry of Transport (2019), which indicates that decision-makers from the transport sectors (including air transport) need to facilitate the best outcomes for New Zealand's regional economies and social welfare. Chapter 4 indicates that during the post-COVID lockdown period, airline subsidies under the newly introduced ETC scheme were purposely offered to smaller regional airlines to subsidise and mitigate their economic damage from the unprecedented COVID-19 pandemic, as well as maintaining a minimum level of flight services to remote regions and communities (Hotle & Mumbower, 2021). Collectively, Chapters 3 and 4 support the importance of aviation subsidies in maintaining essential air connectivity, facilitating economic growth, and offering social benefits to smaller and remote regions and communities before and amid the COVID-19 pandemic. Importantly, Chapters 3 and 4 also urge the New Zealand's central government to further explore effective ways to offer aviation subsidies to aviation operators, thus positively contributing to regional air connectivity and wellbeing for recovery from the COVID-19 pandemic.

Regional wellbeing should be factored into aviation subsidy policy design and implementation

Chapters 2 and 3 use both qualitative and quantitative methods to illustrate the importance of regional air transport and regional wellbeing indicators for aviation subsidies before and amid the COVID-19 pandemic. Specifically, Chapter 2 describes the stakeholders' perspectives on and opinions about the air transport and regional wellbeing indicators in the early stage of the COVID-19 pandemic, and calls for more attention to and consideration of the economic, social and environmental wellbeing indicators (e.g. local business activities, medical treatment, rapid hazard response, and water use and pollution) when designing and implementing regional aviation subsidies. Chapter 3 empirically validates the relationship between airport subsidies and regional economic development in the pre-COVID-19 setting. It shows that scheduled airline seat capacity and economic development (i.e. regional GDP per capita) are of great importance in determining airport subsidies. This is consistent with the prior literature on the criteria for providing air transport/airport subsidies, particularly those related to the impacts of scheduled airline seat capacity and operating routes on regional development (e.g. Fageda et al., 2018; Merkert & Hensher, 2013; Wittman et al., 2016). Such findings also agree with Delbosc's (2012) views that transport policy should not be considered separately from the economic and social wellbeing of the regions. This thesis also suggests that, during the post-COVID-19 era, a regional aviation subsidy policy needs to be well-integrated with other regional policies for achieving sustainable growth (e.g. regional economic and social development). Hence, this thesis calls for strong relationships and closer coordination among aviation operators, stakeholders and policymakers, which will ensure that regional economic and social development can be factored into future regional aviation subsidy policy design and implementation.

A national aviation subsidy framework should be established for the post-COVID-19 era

As indicated in Chapters 2, 3, and 4, the New Zealand government should establish a formal national funding framework to support the regional aviation sector and regional air connectivity. This critical policy recommendation is first discussed in Chapter 2 (i.e. in the early stage of the COVID-19 pandemic), as New Zealand's aviation stakeholders and local/regional governments were eager to have a national aviation subsidy framework in place. Specifically, the national aviation subsidy framework needs to be continuously monitored and amended to better cope with regional economic development, and to improve social wellbeing for residents living in smaller and remote communities across New Zealand. It is also necessary for policymakers in New Zealand to regularly monitor the execution and costs of the future aviation subsidy schemes, for example, to remove the financially self-sustainable flight routes which are currently subsided. This assessment process will help to improve the effectiveness of the national aviation subsidy framework. Chapter 3 investigates airport subsidies during the pre-COVID-19 era and highlights the importance of forming a national aviation subsidy framework to support New Zealand's smaller regional airports, assisting small financially fragile regional airports to maintain their operations and upgrade their airport infrastructure. Consistent with the evidence from many developed countries with the national airport subsidy schemes (e.g. Australia, Europe, and the US), a significant body of literature has shown the effectiveness of implementing a formal airport subsidy scheme for supporting financially struggling regional airports, thus maintaining and improving regional air transport activities (e.g. Fageda et al., 2018; Lohmann et al., 2009; Malina et al., 2012).

The devastating impact of the COVID-19 pandemic has amplified challenges to the development of New Zealand's regional aviation sector, such as a significant decline in air travel and rising flight safety concerns, particularly for smaller, financially struggling regional airlines and airports (Bauranov et al., 2021; Czerny et al., 2021). Therefore, the notion of establishing a formal national aviation subsidy framework in New Zealand is again reinforced in Chapter 4 (i.e. in the post-COVID lockdown period). The empirical evidence of Chapter 4 suggests that a steadily invigorated aviation sector will be a vital enabler of New Zealand's regional economy and wellbeing during the post-COVID-19 era. The New Zealand government's financial support and aids for the regional aviation sector will play a vital role in the recovery of the domestic aviation markets, facilitating a faster rebound of regional air travel, as well as improving regional economic and social wellbeing during the post-COVID recovery phase (Abate et al., 2020). Therefore, New Zealand's national aviation subsidy framework to support the post-COVID regional aviation industry should be carefully designed and implemented.

Conclusion

Despite the importance of regional aviation subsidy policies, a systematic understanding of the linkage between aviation subsidy and regional wellbeing is lacking in the air transport literature. This PhD thesis contributes to the limited contemporary research by shedding some lights on the relationships between aviation subsidies and regional wellbeing in the case of New Zealand. Road and rail transport in New Zealand are time-consuming for reaching smaller and remote regions and communities (New Zealand Airports Association, 2017). Therefore, air transport plays an important role in maintaining regional connectivity and accessibility by linking the geographically dispersed areas of New Zealand. However, smaller and remote regions in New Zealand have long suffered from limited air connectivity and accessibility, which has negatively impacted their economic growth and the wellbeing of local communities (New Zealand Airports Association, 2017). As New Zealand had no consistent national aviation subsidy policy and funding system to ensure essential air connectivity to connect isolated communities and smaller airports before the COVID-19 pandemic, local/regional governments often stepped in to underwrite air services and fund and upgrade airport infrastructure to ensure essential air connectivity to their regions. This regional connectivity problems presents a contradiction between New Zealand’s central and local/regional governments, because the burden of subsidising the regional aviation sector (airlines and airports) became too large for local/regional governments. The New Zealand government has introduced a trial national aviation subsidy scheme (i.e. the ETC scheme) to ensure and maintain essential regional air connectivity during the post-COVID lockdown period. Hence, achieving a clear understanding of the effect of this national scheme on regional aviation subsidies and how aviation subsidies contribute to regional aviation activities and wellbeing is important in the context of New Zealand.

This PhD thesis uses mixed approaches (qualitative and quantitative methods) to understand aviation subsidies and regional wellbeing. It begins by achieving a synthesis and obtaining a better understanding of how aviation subsidies and their relationship to regional wellbeing have been researched, which provides an initial foundation for the other chapters in this thesis. The thesis then examines the interplay of three key components (i.e. aviation subsidies, air transport activities, and regional wellbeing) to offer timely and constructive insights and implications into aviation subsidy policy design and implementation. Overall, the thesis has been structured as four chapters addressing four research objectives: (i) providing an overview of regional aviation subsidies and the impacts of aviation subsidies on regional wellbeing; (ii) identifying the critical air transport and wellbeing indicators that are considered by stakeholders in designing and implementing regional aviation subsidy policies; (iii) examining the inter-relationships among airport subsidies, air transport activity, and regional wellbeing; and (iv) assessing the effect of aviation subsidies on the recovery of the regional aviation markets during the post-COVID lockdown period.

This thesis also makes some important contributions to the air transport literature. Firstly, it contributes to the limited research by shedding some light on the relationship between aviation subsidies and regional wellbeing. Secondly, it advances the use of the qualitative method (i.e. FAHP analysis) to examine stakeholders' perspectives and opinions about the key air transport and regional wellbeing indicators which need to be considered in forming and implementing regional aviation subsidy policies. Thirdly, it empirically investigates the interaction between aviation subsidies (i.e. airport subsidies) and regional wellbeing in New Zealand in the pre-COVID-19 era. Finally, it contributes to the air transport literature by investigating the recovery of New Zealand's domestic aviation market during the post-COVID lockdown period. Although each chapter in this thesis provides its own individual contributions, the collective findings significantly contribute to the air transport literature on aviation subsidies and regional wellbeing. In addition, this thesis provides a platform for better understanding New Zealand's aviation subsidies, air transport activity, and regional wellbeing before and amid the COVID-19 pandemic, as well as offering timely insights into the effectiveness and feasibility of implementing a national aviation subsidy framework to facilitate regional aviation operations and economies during the post-COVID recovery period.

Limitations and future research

Along with the individual limitations presented in each chapter, a number of limitations regarding this PhD thesis should be noted. The main limitation is that because of data constraints, it was only possible to investigate the effect of aviation subsidies on regional air passenger flows during the post-COVID lockdown period. Therefore, empirical evidence of the effect of aviation subsidies on regional economic and social wellbeing cannot be provided. When reliable and updated data related to other key regional economic and social wellbeing indicators (e.g. tourism expenditure and unemployment rate) are available, future research can better quantify and examine the inter-relationships among aviation subsidies, air transport activity, and regional socio-economic wellbeing in New Zealand during the post-COVID-19 era.

This thesis may also be limited by the fact that the environmental wellbeing indicators were not incorporated into the empirical estimations in Chapters 3 and 4. Not surprisingly, increasing air transport activity could be accompanied by environmental concerns (e.g. carbon emissions and aircraft noise) (e.g. Forsyth & Guiomard, 2019; Lockley & Dresner, 2012; Ryerson, 2016). However, data on the environmental wellbeing indicators are still lacking at the regional level in New Zealand. Since the growing level of public and political pressure is likely to further urge New Zealand's aviation sector (at the national and regional levels) to reduce the climate impact of aviation emissions, further research should be undertaken to investigate how aviation subsidies impact the environment and environmental wellbeing of the regions. Despite the data availability issue, there is potential for future research to adopt the mixed-method approach to empirically examine how aviation subsidies impact social, economic and environment wellbeing, whereas the environmental wellbeing indicators can be identified qualitatively.

Finally, future research could also be conducted to offer an updated investigation of the impact of aviation subsidies if a formal national aviation subsidy framework is successfully established and implemented by New Zealand government. This will certainly offer a more in-depth understanding of the interplay between aviation subsidies, air transport activities, and regional wellbeing outcomes during the post-COVID-19 era. On the other hand, further research could also be conducted in countries that have already introduced the specific aviation subsidy framework in response to the COVID-19 pandemic. More importantly, the findings of this future research avenue would be of great help in deepening policymakers' and aviation stakeholders' knowledge of how aviation subsidies support the regional aviation sector's recovery and thus accelerate social and economic recovery in the post-COVID-19 era.

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Appendices

Appendix A – The selected publications included in this study

Authors and year	Study type	Geographic scope	Primary research method	Subsidy category	Subsidy beneficiaries	Wellbeing category	Effect of aviation subsidies	Observation
Fageda et al. (2019)	Journal article	France, Portugal, Sweden, the UK, the US, Norway, Greece, Italy, India, Colombia, Malaysia	Empirical study	Subsidy schemes pertaining to remote regions; hidden subsidies	Airlines, airports, local residents	Air transport activity, social wellbeing	-/0/+	18
Abreu, Fageda and Jimenez (2018)	Journal article	Spain	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity	0/+	2
Congressional Research Service (2018)	Report	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0
Department of State Growth (2018)	Report	Australia	Empirical study	Subsidy schemes pertaining to remote regions	Airlines, airports, local residents	Air transport activity, economic wellbeing, social wellbeing	+	12
Fageda et al. (2018)	Journal article	Norway, Greece, Spain, Italy, Portugal, the United States, Sweden, France, Scotland, Australia, Malaysia, Peru, Chile, India, Ecuador, Colombia, Bolivia, Canada, Brazil	Review study	Subsidy schemes pertaining to remote regions, hidden subsidies	Airlines, airports, local residents	Economic wellbeing, social wellbeing,		0
Grimme, Maertens and Schröpfer (2018)	Journal article	EU	Empirical study	Subsidy schemes pertaining to remote regions	Airports, airlines			0
International Transport Forum (2018)	Report	Australia, Canada, Japan, Norway, Sweden, the US	Empirical study	Subsidy schemes pertaining to remote regions, grants and loans, hidden	Airlines	Air transport activity	+	10

				subsidies, no or reduced tax				
Solvoll and Hanssen (2018)	Journal article	Norway	Empirical study	Subsidy schemes pertaining to remote regions	Airports, airlines	Social wellbeing	+	2
Fageda, Jiménez and Valido (2017)	Journal article	Italy, France, Greece, Spain, Portugal	Empirical study	Subsidy schemes pertaining to remote regions	Airlines, local residents	Social wellbeing	-	2
Gössling, Fichert and Forsyth (2017)	Journal article	US, Germany, UK, France, Norway, Spain, Malaysia, New Zealand, Australia	Review study	Subsidy schemes pertaining to remote regions, grants and loans, hidden subsidies, no or reduced tax	Airports, airlines			0
Hromádka (2017)	Journal article	EU	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0
Ivanova (2017)	Textbook	Ireland, the US, India, UK, Italy, Iceland, Spain, Lithuania, Bulgaria	Review study	Hidden subsidies	Airlines, airports	Air transport activity		0
Kazda, Hromádka and Mrekaj (2017)	Journal article	Slovak	Case study	Grants and loans	Airports			0
Mills and Kalaf-Hughes (2017)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airports			0
Minato and Morimoto (2017)	Journal article	Japan	Scenario simulation	Subsidy schemes pertaining to remote regions	Airlines, local residents	Air transport activity	+	2
New Zealand Airports Association (2017)	Report	New Zealand	Review study	Subsidy schemes pertaining to remote regions, grants and loans	Airlines, airports	Air transport activity		0
Park and O'Kelly (2017)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity	+	1
Reimer and Zheng (2017)	Journal article	The US	Scenario simulation	Grants and loans, no or reduced tax	Aviation suppliers	Economic wellbeing, environmental wellbeing	-/+	6
Brathen and Eriksen (2016)	Journal article	Norway	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity, social wellbeing	+	3

Elliott (2016)	Textbook	Belgium	Review study	Grants and loans, hidden subsidies	Airlines	Economic wellbeing		0
Fageda, Jiménez and Valido (2016)	Journal article	Spain	Empirical study	Subsidy schemes pertaining to remote regions	Airlines, local residents	Social wellbeing	+	1
Grubesic et al. (2016)	Journal article	The US	Scenario simulation	Subsidy schemes pertaining to remote regions	Airlines			0
Miller et al. (2016)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airports	Air transport activity	+	3
Ramos-Pérez (2016)	Journal article	Spain	Empirical study	Grants and loans	Airlines	Air transport activity	+	4
Ryerson (2016a)	Journal article	The US	Empirical study	Hidden subsidies	Airlines	Air transport activity, environmental wellbeing	-/+	2
Ryerson (2016b)	Journal article	The US	Empirical study	Hidden subsidies	Airlines	Air transport activity	0/+	2
Wittman, Allroggen and Malina (2016)	Journal article	The US, EU (Finland, France, Germany, Greece, Ireland, Italy, Norway, Portugal, Sweden, UK)	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0
Airport Cooperative Research Program (2015)	Report	The US	Empirical study	Grants and loans, subsidy schemes pertaining to remote regions	Airports	Air transport activity, economic wellbeing	+	3
Baker, Merkert and Kamruzzaman (2015)	Journal article	Australia	Empirical study	Subsidy schemes pertaining to remote regions	Airports	Economic wellbeing	0/+	2
Beifert (2015)	Journal article	Sweden, Belarus	Case study		Airports			0
Faber and Nelissen (2015)	Report	France	Scenario simulation	No or reduced tax	Airlines	Air transport activity, economic wellbeing, social wellbeing, environmental wellbeing	-/+	7

Hall, Ross, and Yencha (2015)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0
Núñez-Sánchez (2015)	Journal article	Spain	Empirical study	Hidden subsidies	Airlines	Air transport activity, economic wellbeing	0/+	2
RP Erickson & Associates Aviation Consultants (2015)	Report	The US, Norway, Sweden, Finland, Denmark, Australia, Russia, Canada	Empirical study	Subsidy schemes pertaining to remote regions	Airports, airlines, local residents	Social wellbeing	+	1
Calzada and Fageda (2014)	Journal article	Spain, France, Italy, UK	Empirical study	Subsidy schemes pertaining to remote regions	Airlines, local residents	Air transport activity	-/+	5
Knieps (2014)	Journal article		Review study	Grants and loans	Airports			0
Laurino and Beria (2014)	Journal article	The US	Case study	Hidden subsidies	Airlines	Air transport activity, economic wellbeing	+	3
Özcan (2014a)	Journal article	The US	Survey approach	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity, economic wellbeing, social wellbeing	0/+	5
Özcan (2014b)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Economic wellbeing	+	1
Pita, Adler and Antunes (2014)	Journal article	Norway	Case study	Grants and loans, subsidy schemes pertaining to remote regions	Airlines			0
Rymanov and Fomin (2014)	Journal article	Russia	Empirical study	Grants and loans, subsidy schemes pertaining to remote regions	Airports, airlines, local residents	Economic wellbeing	+	9
Valido et al. (2014)	Journal article	Spain	Empirical study	Subsidy schemes pertaining to remote regions	Local residents	Air transport activity	-	1
Wittman (2014a)	Report	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airports, airlines	Air transport activity	+	1

Wittman (2014b)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airports	Air transport activity	0/+	4
Adler, Ülkü and Yazhemsky (2013)	Journal article	Scotland, Norway, UK, Austria, France, Germany, Italy	Empirical study	Subsidy schemes pertaining to remote regions, hidden subsidies	Airports			0
Airports Council International (2013)	Report	EU	Empirical study	Grants and loans	Airports	Economic wellbeing	+	2
Allroggen, Malina and Lenz (2013)	Journal article	EU	Empirical study	Hidden subsidies	Airlines			0
Angelopoulos et al. (2013)	Journal article	Greece	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0
Grubesic, Murray and Matisziw (2013)	Journal article	The US	Scenario simulation	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity	0	1
Desel and Schikorr (2013)	Report	Norway, Denmark, Germany, the Netherlands, Belgium, UK	Empirical study	Grants and loans	Airports	Economic wellbeing	+	2
Grubesic and Wei (2013)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity	+	1
Merkert and Hensher (2013)	Journal article	Australia, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Norway, Portugal, Spain, Sweden, UK	Survey approach	Subsidy schemes pertaining to remote regions	Airlines			0
Merkert and O'Fee (2013)	Journal article	EU (Finland, France, Germany, Iceland, Ireland, Italy, Norway, Portugal, Scotland, Sweden, Wales)	Survey approach	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity, economic wellbeing, social wellbeing	-/+	5
Merkert and Williams (2013)	Journal article	Ireland, France, Spain, Italy, Germany, UK, Greece, Portugal, Slovakia, Sweden	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0

Pita et al. (2013)	Journal article	Portugal	Case study	Subsidy schemes pertaining to remote regions	Airlines	Social wellbeing	-	1
Wittman and Swelbar (2013)	Report	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity	-/+	3
Amoroso et al. (2012)	Journal article	Italy	Scenario simulation	Grants and loans	Airlines	Air transport activity, economic wellbeing	+	2
Bråthen and Halpern (2012)	Journal article	EU/the US/Canada	Review study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity, economic wellbeing, social wellbeing		0
Bubalo (2012)	Journal article	Norway	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0
Calzada and Fageda (2012)	Journal article	Spain	Empirical study	Subsidy schemes pertaining to remote regions	Local residents	Air transport activity, social wellbeing	0	2
Di Francesco and Pagliari (2012)	Journal article	Italy	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity, social wellbeing	+	3
Donehue and Baker (2012)	Journal article	Australia	Survey approach	Subsidy schemes pertaining to remote regions	Airlines, airports			0
Fageda, Jimenez and Diaz (2012)	Journal article	Spain	Empirical study	Subsidy schemes pertaining to remote regions	Local residents	Social wellbeing	+	1
German Airport Performance (2012)	Report	Norway, Scotland, Sweden, Finland, Denmark, Iceland, France, UK, Germany, Italy	Empirical study	Grants and loans, subsidy schemes pertaining to remote regions, hidden subsidies, no or reduced tax	Airports	Air transport activity	+	1
Grubesic, Matisziw and Murray (2012)	Journal article	The US	Scenario simulation	Subsidy schemes pertaining to remote regions	Airlines			0
Grubesic and Wei (2012)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity	0/+	2

Kotler (2012)	Report	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines, airports	Air transport activity	+	1
Lockley and Dresner (2012)	Report	The UK	Empirical study	No or reduced tax	Airlines	Social wellbeing, environmental wellbeing	-/+	2
Lowden and Bentley (2012)	Textbook	UK, Australia, EU, the US, Egypt, Caribbean region, Tunisia, Morocco, Solomon Islands, Wales, Scotland	Review study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity, economic wellbeing		0
Malina, Albers and Kroll (2012)	Journal article	EU, Germany	Empirical study	Subsidy schemes pertaining to remote regions, hidden subsidies	Airlines	Air transport activity	+	2
Mathisen and Solvoll (2012)	Journal article	Norway	Case study	Subsidy schemes pertaining to remote regions	Airlines			0
Matisziw, Lee and Grubesic (2012)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0
Smyth et al. (2012)	Journal article	Scotland	Case study	Subsidy schemes pertaining to remote regions	Airlines, airports	Air transport activity, economic wellbeing, social wellbeing, environmental wellbeing	0/+	7
Grubesic and Matisziw (2011)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0
Castillo-Manzano, Lopez-Valpuesta and Gonzalez-Laxe (2011)	Journal article	Spain	Survey approach	Hidden subsidies	Airlines	Economic wellbeing	+	1
Craig (2011)	Journal article	Scotland	Survey approach	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity, economic wellbeing, social	0/+	6

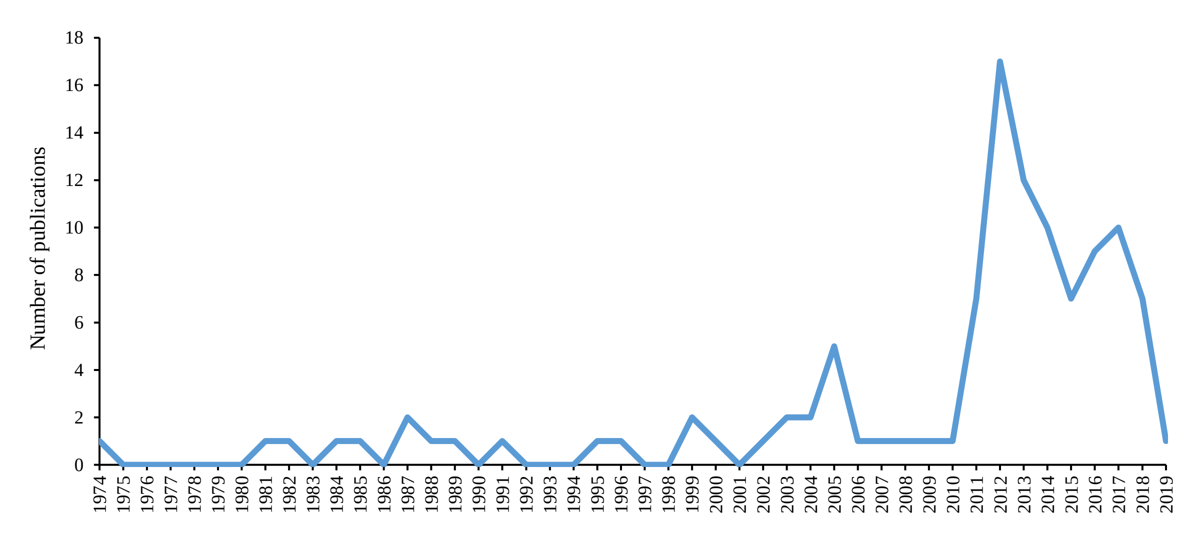
						wellbeing, environmental wellbeing		
Duval and Winchester (2011)	Journal article	Cook Islands	Case study	Grants and loans	Airlines	Air transport activity	+	1
Fichert and Klophaus (2011)	Journal article	Germany	Empirical study	Hidden subsidies	Airlines			0
Hazledine and Collins (2011)	Journal article	Tonga, Cook Islands	Scenario simulation	Grants and loans	Airlines	Air transport activity, economic wellbeing	0/+	6
Lian (2010)	Journal article	Norway	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Social wellbeing	0	1
Minato and Morimoto (2011)	Journal article	Japan	Scenario simulation	Grants and loans, subsidy schemes pertaining to remote regions, hidden subsidies	Airlines	Economic wellbeing	+	1
Santana (2009)	Journal article	Spain, UK, Norway, Portugal, France, the US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0
Halpern (2008)	Journal article	Finland	Case study	Grants and loans	Airports, airlines	Economic wellbeing	0	1
Forsyth (2007)	Journal article		Review study	Grants and loans, hidden subsidies	Airports, airlines			0
Barbot (2006)	Journal article	EU	Case study	Hidden subsidies	Airlines	Air transport activity	+	1
Ida, Tamura and Arimura (2005)	Journal article	Japan	Scenario simulation	Grants and loans	Airports	Air transport activity	+	1
Kita, Koike and Tanimoto (2005)	Journal article	Japan	Scenario simulation	Grants and loans	Airlines	Air transport activity	+	1
Nolan, Ritchie and Rowcroft (2005)	Journal article		Scenario simulation	Grants and loans	Airlines			0
Pagliari (2005)	Journal article	Scotland	Empirical study	Grants and loans, subsidy schemes pertaining to remote regions, hidden subsidies	Airlines	Air transport activity	0	1
Williams (2005)	Journal article	Ireland, Norway, UK	Case study	Subsidy schemes pertaining to remote regions	Airlines			0

Organisation for Economic Co-operation and Development (2004)	Report	France	Empirical study	Grants and loans, subsidy schemes pertaining to remote regions, hidden subsidies	Airports, airlines			0
Williams and Pagliari (2004)	Journal article	France, Germany, Iceland, Ireland, Italy, Norway, Portugal, Scotland, Spain, Sweden	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0
Department of Transportation (2003)	Report	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0
General Accounting Office (2003)	Report	The US	Empirical study	Subsidy schemes pertaining to remote regions, hidden subsidies	Airlines	Air transport activity, social wellbeing	+	3
General Accounting Office (2002)	Report	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity	+	2
General Accounting Office (2000)	Report	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity	+	1
Fischer and Kirk (1999)	Report	The US	Empirical study	Subsidy schemes pertaining to remote regions, grants and loans	Airlines, airports			0
Vowles (1999)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity	+	1
Eaton (1996)	Report	Spain, Ireland, France, Greece, Belgium	Review study	Subsidy schemes pertaining to remote regions	Airlines			0
Reynolds-Feighan (1995)	Journal article	Ireland, UK, the US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity	+	2
Kaemmerle (1991)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines			0
Leinbach (1989)	Journal article	Indonesia	Case study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity, economic	0/+	7

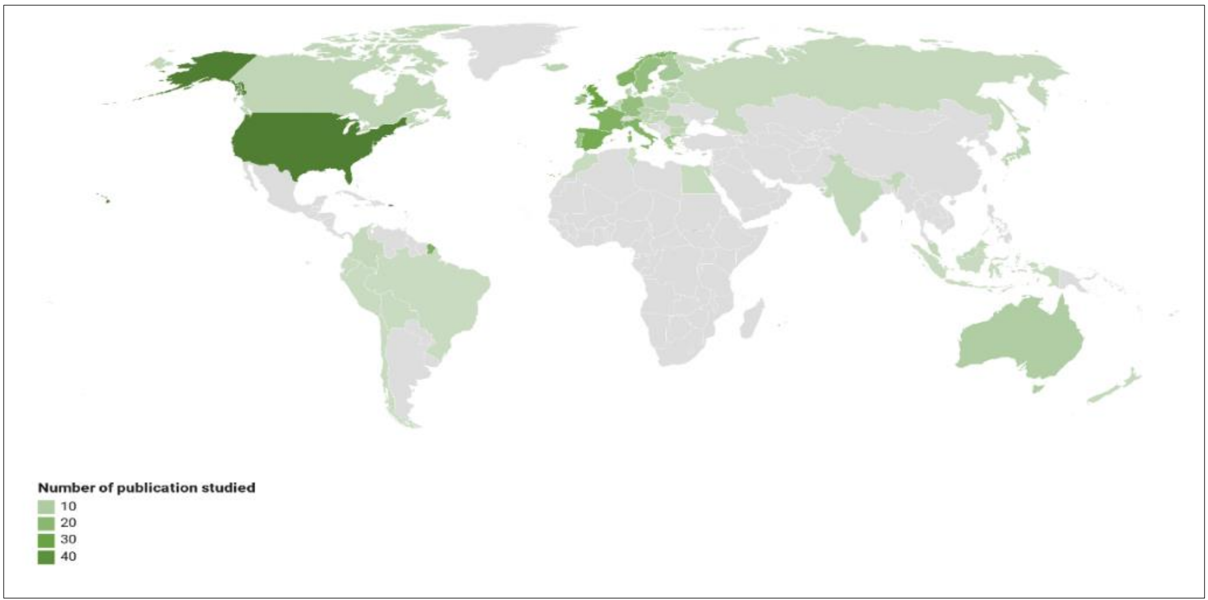
						wellbeing, social wellbeing		
Flynn and Ratick (1988)	Journal article	The US	Scenario simulation	Subsidy schemes pertaining to remote regions	Airlines			0
Cunningham and Eckard (1987)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity, social wellbeing	0/+	5
Kanafani and Abbas (1987)	Journal article	The US	Case study	Subsidy schemes pertaining to remote regions	Airports	Air transport activity, economic wellbeing	0/+	3
Addus (1985)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Social wellbeing	0	1
Addus (1984)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions, grants and loans	Airlines			0
Williamson, Cunningham and Singer (1982)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions, grants and loans	Airlines	Air transport activity	+	2
Havens and Heymsfeld (1981)	Journal article	The US	Empirical study	Subsidy schemes pertaining to remote regions	Airlines	Air transport activity	+/-	3
Scott and Farris (1974)	Journal article	The US	Review study	Grants and loans	Airlines	Air transport activity		0
Total selected pulications			**110**					
Total observations for meta-regression analysis			**203**					

Note: "+", "-" and "0" indicate the aviation subsidies impacts on regional wellbeing is positive, negative, and null/not clear, respectively.

Appendix B – Number of aviation subsidy publications relating to regional wellbeing



Appendix C – The countries studied in the publications



Appendix D – Top 20 co-occurrence of keywords, text in titles and abstracts

Keywords		*Text in titles and abstracts*	
Keyword	Occurrences	Term	Occurrences
Air transport	12	Transport	15
Airports	10	Essential air service	13
Public service obligations	10	EAS	12
Essential air service	6	Country	9
State aid	6	PSO	9
Subsidies	5	Essential air service program	8
Airline	5	Demand	8
Accessibility	4	Aviation	7
Remote regions	4	Government	7
Public service obligations	4	State aid	6
Regional airports	4	Remote region	6
Aviation	3	Competition	6
Efficiency	3	Remote community	6
Subsidy	3	Price	6
Deregulation	3	Airline deregulation act	5
Air transport policy	2	Economic growth	5
Low-cost carriers	2	Challenge	5
Fleet assignment	2	Economic impact	4
Flight scheduling	2	Air traffic	4
Regional development	2	Air travel	4

Appendix E – Results of word frequency queries

Word	Count	Weighted percentage (%)	Word	Count	Weighted percentage (%)	Word	Count	Weighted percentage (%)
Airport	14724	2.17	2012	1497	0.22	Populous	899	0.13
Servicing	10143	1.50	Travels	1492	0.22	Nations	898	0.13
Air	9156	1.35	Supports	1476	0.22	Regulators	897	0.13
Transports	4956	0.73	Internationally	1464	0.22	Imports	886	0.13
Community	4882	0.72	Aircrafts	1455	0.21	Seats	876	0.13
Airline	4844	0.71	Managing	1447	0.21	Country	870	0.13
Region	4808	0.71	Revenues	1436	0.21	Grants	869	0.13
Routings	4704	0.69	Changing	1408	0.21	Periods	857	0.13
Passengers	3969	0.59	Incentives	1395	0.21	Capacity	836	0.12
Subsidy	3838	0.57	European	1379	0.20	Scheduling	832	0.12
Costs	3784	0.56	Competitive	1372	0.20	Destinations	807	0.12
Operators	3160	0.47	Funds	1370	0.20	Aid	755	0.11
Carriers	3147	0.46	Flights	1356	0.20	Norway	752	0.11
Markets	2812	0.41	Areas	1347	0.20	Subsidizing	745	0.11
Economics	2648	0.39	Network	1297	0.19	Traffic	742	0.11
Small	2396	0.35	Busy	1265	0.19	Tourisme	731	0.11
Eas	2388	0.35	Serving	1238	0.18	Locations	727	0.11
Hubs	2235	0.33	Fare	1198	0.18	Distance	725	0.11
Programs	2161	0.32	Relatives	1188	0.18	Contracts	702	0.10
Develops	2112	0.31	Basing	1165	0.17	Higher	701	0.10
Increasingly	2041	0.30	Impacts	1146	0.17	Improving	698	0.10
Governments	1996	0.29	Domestic	1142	0.17	Existing	693	0.10
Pso	1954	0.29	flights	1114	0.16	Orders	684	0.10
Levels	1941	0.29	Islands	1110	0.16	Attracts	682	0.10
Publicly	1909	0.28	System	1108	0.16	Francs	682	0.10
Pricing	1843	0.27	Requirements	1087	0.16	Lower	682	0.10
Local	1775	0.26	Remoter	1083	0.16	Federative	681	0.10
Aviation	1693	0.25	Differs	1052	0.16	Frequency	679	0.10
Demands	1684	0.25	Directs	1051	0.15	Less	678	0.10
Connects	1665	0.25	Factors	1046	0.15	Making	678	0.10
Effect	1639	0.24	City	1025	0.15	Types	678	0.10
Policy	1634	0.24	Commercially	1014	0.15	Residents	667	0.10
Accessing	1528	0.23	Industry	907	0.13	Taxing	666	0.10
						Smaller	659	0.10

Note: There are five text match levels for running the word frequency queries: exact matches, with stemmed words, with synonyms, with specializations, and with generalizations. In this study, the word frequency queries were conducted to count group words with the same stem together (i.e. with stemmed words).

Appendix F – Results of word frequency queries (adjusted text match level)

Word	Count	Weighted percentage (%)	Word	Count	Weighted percentag e (%)	Word	Count	Weighted percentage (%)
Airports	14771	2.27	Norway	765	0.12	Europe	504	0.08
Service	11675	0.83	Demand	3263	0.12	Significant	500	0.08
Airlines	5133	0.76	Revenue	1592	0.12	Competition	1967	0.08
Passenger	3969	0.61	Traffic	742	0.11	Industry	1014	0.08
Subsidy	3838	0.59	Tourism	731	0.11	Specific	490	0.08
Carriers	3147	0.48	Incentive	1454	0.11	Flights	1607	0.07
Regional	6178	0.41	France	682	0.10	Business	2585	0.07
Eas	2388	0.37	Economic	2845	0.10	Psos	485	0.07
Hub	2235	0.34	Frequency	679	0.10	Travel	2244	0.07
Air	13074	0.31	Based	3079	0.10	Public	3482	0.07
Pso	1954	0.30	Smaller	659	0.10	Served	2753	0.07
Communities	5899	0.27	Support	5312	0.10	Analyzed	481	0.07
International	2833	0.26	2005	639	0.10	Although	466	0.07
Program	3932	0.26	Slots	636	0.10	Deregulation	462	0.07
Access	2168	0.25	2004	608	0.09	Possible	1098	0.07
Policy	1634	0.25	Financial	605	0.09	Different	1764	0.07
2012	1497	0.23	2001	604	0.09	Related	2950	0.07
Government	5021	0.22	2003	602	0.09	Areas	2503	0.07
Aircraft	1455	0.22	Aviation	2398	0.09	Enplanements	435	0.07
European	1379	0.21	Geographic	572	0.09	Compared	1175	0.07
Network	1486	0.21	Traffic	568	0.09	Minimum	528	0.07
Market	3903	0.20	Size	551	0.08	Factors	1318	0.07
Costs	5637	0.19	Population	1490	0.08	Benefit	425	0.07
Fights	1114	0.17	Social	537	0.08	Maximum	485	0.07
Islands	1110	0.17	Statistics	532	0.08	Made	422	0.06
Effects	3701	0.16	Connectivity	4358	0.08	Seats	1818	0.06
Operating	5387	0.15	2015	522	0.08	Commission	849	0.06
Transport	7325	0.14	Fuel	538	0.08	Day	413	0.06
Routes	5020	0.14	Percent	651	0.08	2000	411	0.06
Positive	3777	0.14	Medium	618	0.08	Commercial	1160	0.06
Capacity	1076	0.13	Required	2025	0.08	Efficiency	410	0.06
Local	3392	0.13	Recent	552	0.08	Presented	2990	0.06
Regulation	1934	0.13	Eligible	508	0.08	Impact	1527	0.06
						Funding	1601	0.06

Note: There are five text match levels for running the word frequency queries: exact matches, with stemmed words, with synonyms, with specializations, and with generalizations. In this study, the word frequency queries were conducted to count group words with synonyms together.

Appendix G – List of certified aerodromes with scheduled domestic services in New Zealand (2020)

Aerodromes	Scheduled domestic services	Air operators (airlines)	Number of domestic destinations
Auckland	√	Air Chathams; Air New Zealand; Jetstar	20
Blenheim	√	Air New Zealand; Sounds Air	5
Chatham Islands	√	Air Chathams	3
Christchurch	√	Air Chathams; Air New Zealand; Jetstar; Sounds Air	15
Dunedin	√	Air New Zealand; Jetstar	3
Gisborne	√	Air New Zealand	2
Hamilton	√	Air New Zealand	3
Hokitika	√	Air New Zealand	1
Invercargill	√	Air New Zealand	3
Kerikeri	√	Air New Zealand	1
Napier	√	Air New Zealand	4
Nelson	√	Air New Zealand; Sounds Air	4
New Plymouth	√	Air New Zealand	3
Palmerston North	√	Air New Zealand	4
Paraparaumu	√	Air Chathams; Sounds Air	3
Picton	√	Sounds Air	1
Queenstown	√	Air New Zealand; Jetstar	3
Rotorua	√	Air New Zealand	3
Taupo	√	Air New Zealand; Sounds Air	2
Tauranga	√	Air New Zealand	3
Timaru	√	Air New Zealand	1
Whanganui	√	Air Chathams	1
Wellington	√	Air Chathams; Air New Zealand; Jetstar; Sounds Air	19
Westport	√	Sounds Air	1
Whakatane	√	Air Chathams	1
Whangarei	√	Air New Zealand	1
Total	**26**		

Notes: List of Part 139 certified operators, retrieved from the New Zealand Civil Aviation Authority website; scheduled flight services and domestic destinations served data are retrieved from the Official Airline Guide (OAG), and there is no difference in terms of scheduled flight services and destinations served between 2019 and 2020.

Appendix H – List of certified aerodromes with scheduled domestic services in Taiwan (2020)

Aerodromes	Scheduled domestic services	Air operators (airlines)	Number of domestic destinations
Chiayi	√	Uni Air	2
Hualien	√	Mandarin Airlines; Uni Air	3
Kaohsiung	√	Mandarin Airlines; Daily Air; Uni Air	5
Kinmen	√	Mandarin Airlines; Uni Air	6
Lanyu	√	Daily Air	1
Lyudao	√	Daily Air	1
Matsu Beigan	√	Uni Air	1
Matsu Nangan	√	Uni Air	2
Penghu	√	Uni Air; Mandarin Airlines	6
Qimei	√	Daily Air	2
Taichung	√	Mandarin Airlines; Uni Air	4
Tainan	√	Uni Air	2
Taipei Songshan	√	Mandarin Airlines; Uni Air	6
Taitung	√	Mandarin Airlines; Uni Air	3
Wangan	√	Daily Air	1
Total	**15**		

Source: Taiwan Civil Aeronautics Administration (2020).

Appendix I – The FAHP procedure applied for this study

Step 1. *Defining air transport activity indicators and the regional wellbeing categories and indicators*

All the indicators of air transport activity and regional wellbeing in the FAHP were identified on the basis of prior literature and validated by four independent aviation researchers and industry experts through a pilot study. Figure 11 demonstrates the hierarchy structure of the FAHP model for this study.

Step 2. *Conducting an online questionnaire to obtaining stakeholders' perspectives*

An online questionnaire was structured with the online survey software '*Qualtrics*' to generate a link, which could be attached in the survey invitation emails sent to the prospective participants. Following the approach of Saaty (2008), the questions were asked to rate on a nine-point scale for the comparison of the wellbeing categories and indicators (see Appendix J). The standardised 1–9 AHP scale is provided in Table 16. Target stakeholders residing in New Zealand and Taiwan were contacted and surveyed: (1) industry practitioners, including regional airport and airline managers; (2) aviation researchers, including academic scholars from universities and research institutions; (3) government agencies, including officials from the Civil Aviation Authority of New Zealand and Taiwan's Civil Aeronautics Administration, the Ministry of Transport and other transport-related agencies; (4) regional and local governments, including councillors who are responsible for regional transportation policies; and (5) others, including experts and staff from tourism and environmental groups. All the potential participants who must understand and work in the aviation or related sectors, reflecting their diverse backgrounds, expertise and knowledge of aviation subsidy. Particularly, aviation researchers' responses were sought in reinforcing the aviation experts, industry professional and practitioners' point of view. The surveys were carried out in New Zealand and Taiwan simultaneously from March to June 2020. In total, 51 (New Zealand) and 45 (Taiwan) responses were received. After eliminating incomplete responses with unanswered questions in the questionnaire, 36 (New Zealand) and 43 (Taiwan) responses are used for further analyses.

In the AHP analysis, pairwise comparisons may lead to some inconsistencies because individual judgments could be affected by a lack of rationality and violate the consistency condition of the matrix (Karaman & Akman, 2018; Le Pira et al., 2016; Saaty, 2008). Hence, it is necessary to obtain the consistency ratio (CR) of a survey for checking the reliability of participants' responses. First, the pairwise comparison matrices are established according to each participant's responses. Next, the matrices are normalised, and the eigenvectors (relative weights) and the consistency index for each indicator are computed. Generally, a CR value of a response lower than 0.2 should be acceptable (e.g. Lee & Walsh, 2011; Saaty, 2008). For the sake of brevity, more details on this method can be seen in previous AHP studies such as Brunelli (2014) and Saaty (1987). According to the results of the pairwise CR analysis, 25 New Zealand participants and 22 Taiwanese participants provided reliable answers with a CR of 0.2 or less for all comparison matrices. Detailed demographical information of the New Zealand and Taiwanese participants is shown in the Appendix K.

Table 16

Scale for pairwise comparisons of participants' responses

Relative importance	Definitions
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values between the two adjacent judgements
Reciprocals	If activity i has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i. In this study, activities i and j refer to an air transport activity indicator, or regional wellbeing category or indicator.

Step 3. *Transforming crisp numbers to fuzzy numbers*

In the FAHP, triangular fuzzy numbers are computed to represent the relative importance in the comparison matrices (Pehlivan et al., 2017; Zhu et al., 1999). A triangular fuzzy number is fully characterised by a triple of real numbers (l, m, u), where l represents the minimum possible value, m represents the optimum value and u represents the maximum possible value (e.g. Anagnostopoulos et al., 2007; Pehlivan et al., 2017). In this study, scale numbers were transformed to fuzzy numbers with the 1–9 fuzzy conversion scale (see Table 17).

Table 17

The 1−9 fuzzy conversion scale

Scale value	Triangular Fuzzy Scale	Reciprocal Scale	Triangular Fuzzy Reciprocal Scale
1	(1, 1, 1)	1	(1, 1, 1)
2	(1, 2, 3)	1/2	(1/3, 1/2, 1)
3	(2, 3, 4)	1/3	(1/4, 1/3, 1/2)
4	(3, 4, 5)	1/4	(1/5, 1/4, 1/3)
5	(4, 5, 6)	1/5	(1/6, 1/5, 1/4)
6	(5, 6, 7)	1/6	(1/7, 1/6, 1/5)
7	(6, 7, 8)	1/7	(1/8, 1/7, 1/6)
8	(7, 8, 9)	1/8	(1/9, 1/8, 1/7)
9	(8, 9, 9)	1/9	(1/9, 1/9, 1/8)

Sources: Anagnostopoulos et al. (2007), Zhu et al. (1999).

Step 4. *Aggregation of group responses*

As 47 participants (25 New Zealand participants and 22 Taiwanese participants) were left for the FAHP analysis, aggregation of diverse individual preferences to obtain a single collective preference was performed. In this study, the geometric mean of each participant's responses was computed for aggregating group responses (e.g. Davies, 1994; Kar, 2014; Sivrikaya et al., 2015), which was done by means of the following equation:

$$l_{ij} = \left(\prod_{k=1}^{k} l_{ijk}\right)^{1/k}, m_{ij} = \left(\prod_{k=1}^{k} m_{ijk}\right)^{1/k}, u_{ij} = \left(\prod_{k=1}^{k} u_{ijk}\right)^{1/k}$$

where k represents the number of participants. Thus, the aggregated fuzzy pairwise comparisons were obtained. For example, the processes were applied to obtain the fuzzy comparison matrix for air transport activity indicators, and the regional wellbeing categories and indicators, respectively.

Step 5. *Applying the FAHP method (the geometric mean method) to calculate the fuzzy weights*

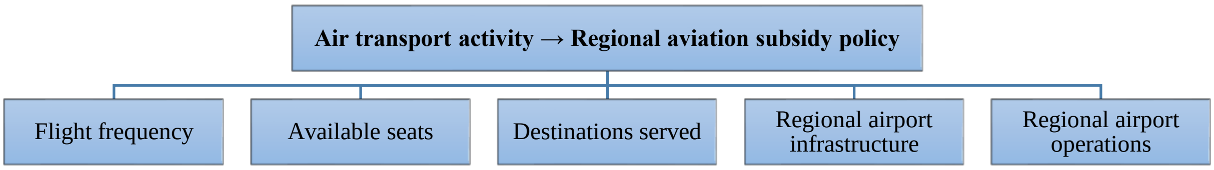
In this study, the geometric mean method of FAHP developed by Buckley (1985) was used to maintain consistency with the aggregation of group responses (Step 4). According to Pehlivan et al. (2017), a major advantage of the geometric mean method is that it is easy to extend to the fuzzy case without complex computations. This method has been used to obtain the fuzzy weights of air transport activity indicators, and regional wellbeing categories and indicators from a fuzzy comparison matrix. The sum of the fuzzy weights of indicators and categories was 1.00; the fuzzy weights of indicators and categories indicate their respective rankings. The same processes were applied for each of the comparison matrices.

Step 6. *Ranking air transport activity indicators, and regional wellbeing categories and indicators with the fuzzy weights*

Two ranking systems have been adopted in this FAHP research, namely ranking (within the air transport activity and specific wellbeing category) and overall ranking (within the four regional wellbeing categories). The method discussed above was applied to determine the fuzzy weighs of each comparison matrix (i.e. air transport activity indicators, and regional wellbeing categories and indicators), and the rankings were arranged according to the value of the fuzzy weights. For the regional wellbeing indicators, the overall rankings were determined by the overall weights, which were calculated by multiplying the respective fuzzy weight of each wellbeing indicator with the fuzzy weight of the corresponding wellbeing category.

Appendix J – Online questionnaire

Section A: Prioritising aviation subsidies' impacts on regional air transport activity

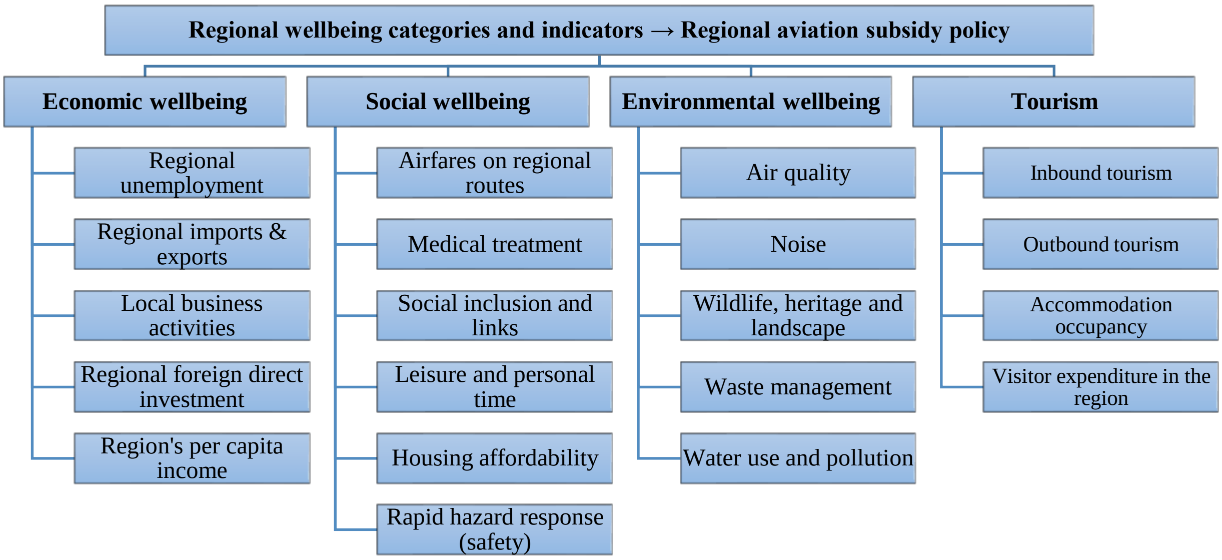


Wellbeing category	Indicators	Definition
Air transport activity	Flight frequency	Number of flights between destinations
	Available seats	Number of available seats per flight
	Destinations served	Direct flights destinations from the regional airport
	Regional airport infrastructure	Airside infrastructure (e.g. navigation, taxiways, runways, aircraft parking aprons) and landside infrastructure (e.g. terminal buildings, parking lots, access roads)
	Regional airport operations	Airside and landside services, maintenance, safety and security

Which of the following *indicators*, compared with each other, is relatively <u>more important</u> to be considered when forming or implementing aviation subsidies? (please √ to indicate your answer)

Indicator A	Extremely		Very strong		Strongly		Slightly		Equal	Slightly		Strongly		Very strong		Extremely		Indicator B
Scale	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Scale
Flight frequency																		Available seats
																		Destinations served
																		Regional airport infrastructure
																		Regional airport operations
Available seats																		Destinations served
																		Regional airport infrastructure
																		Regional airport operations
Destinations served																		Regional airport infrastructure
																		Regional airport operations
Regional airport infrastructure																		Regional airport operations

Section B: Prioritising aviation subsidies' impacts on regional wellbeing



Regional wellbeing category	Indicators	Definition
Economic wellbeing	Regional unemployment	The ratio between unemployed persons and the labour force
	Regional imports & exports	Goods and services trading activities of the region
	Local business activities	Attracting new local businesses
	Regional foreign direct investment	Attracting foreign direct investment (FDI) to the region; growing opportunities for FDI in the region
	Region’s per capita income	Average income per person in the region
Social wellbeing	Airfares on regional routes	Airfares that local residents pay for air travel
	Medical treatment	Hospital visits and visiting medical specialists to and from small centres by air
	Social inclusion and links	Local residents’ travel for social purposes (e.g. access to education, visits to relatives and friends); reducing perceptions of the remoteness of parts of the country
	Leisure and personal time	Leisure and personal time, satisfaction with leisure time
	Housing affordability	Residents can afford satisfactory housing and residential environments
	Rapid hazard response (safety)	Airports become central hubs for rescuers and relief supplies, cargo deliveries and refugee transfers; airlines assist with the evacuation of those stranded by disasters or conflict
Environmental wellbeing	Air quality	Sources of air pollutants in and around airports (e.g. aircraft engine emissions, airport operations)
	Noise	Aircraft noise
	Wildlife, heritage and landscape	When land is taken for airport and development, there may be a loss or disruption of wildlife habitats, vegetation damage or removal, and a change in airports’ surroundings to a more urbanised setting
	Waste management	Waste (e.g. food, packaging, contaminated waste) from flights and at the airport
	Water use and pollution	Water consumption and water pollution from airport operations
Tourism	Inbound tourism	Visitors to the region
	Outbound tourism	Outbound travel by residents of the region
	Accommodation occupancy	The percentage of a hotel that is occupied
	Visitor expenditure in the region	Visitor expenditure (e.g. retailing, car rental, food and beverages)

Which of the following *dimensions of wellbeing*, compared with each other, is relatively more important to be considered when forming or implementing aviation subsidies? (please √ to indicate your answer)

Dimension A	Extremely		Very strong		Strongly		Slightly		Equal	Slightly		Strongly		Very strong		Extremely		Dimension B
Scale	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Scale
Economic wellbeing																		Social wellbeing
																		Environmental wellbeing
																		Tourism
Social wellbeing																		Environmental wellbeing
																		Tourism
Environmental wellbeing																		Tourism

With respect to *economic wellbeing*, which of the following indicators, compared with each other, is relatively more important to be considered when forming or implementing aviation subsidies? (please √ to indicate your answer)

Indicator A	Extremely		Very strong		Strongly		Slightly		Equal	Slightly		Strongly		Very strong		Extremely		Indicator B
Scale	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Scale
Regional unemployment																		Regional imports & exports
																		Local business activities
																		Regional foreign direct investment
																		Region's per capita income
Regional imports & exports																		Local business activities
																		Regional foreign direct investment
																		Region's per capita income
Local business activities																		Regional foreign direct investment
																		Region's per capita income
Regional foreign direct investment																		Region's per capita income

With respect to *social wellbeing*, which of the following indicators, compared with each other, is relatively more important to be considered when forming or implementing aviation subsidies? (use √ to indicate your answer)

Indicator A	Extremely		Very strong		Strongly		Slightly		Equal	Slightly		Strongly		Very strong		Extremely		Indicator B
Scale	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Scale
Airfares on regional routes																		Medical treatment
																		Social inclusion and links
																		Leisure and personal time
																		Housing affordability

																		Rapid hazard response (safety)
Medical treatment																		Social inclusion and links
																		Leisure and personal time
																		Housing affordability
																		Rapid hazard response (safety)
Social inclusion and links																		Leisure and personal time
																		Housing affordability
																		Rapid hazard response (safety)
Leisure and personal time																		Housing affordability
																		Rapid hazard response (safety)
Housing affordability																		Rapid hazard response (safety)

With respect to *__environmental wellbeing__*, which of the following indicators, compared with each other, is relatively __more important__ to be when forming or implementing aviation subsidies? (use √ to indicate your answer)

Indicator A	Extremely		Very strong		Strongly		Slightly		Equal	Slightly		Strongly		Very strong		Extremely		Indicator B
Scale	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Scale
Air quality																		Noise
																		Wildlife, heritage and landscape
																		Waste management
																		Water use and pollution
Noise																		Wildlife, heritage and landscape
																		Waste management
																		Water use and pollution
Wildlife, heritage and landscape																		Waste management
																		Water use and pollution
Waste management																		Water use and pollution

With respect to *regional tourism*, which of the following indicators, compared with each other, is relatively more important to be considered when forming or implementing aviation subsidies? (please √ to indicate your answer)

Indicator A	Extremely		Very strong		Strongly		Slightly		Equal	Slightly		Strongly		Very strong		Extremely		Indicator B
Scale	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Scale
Inbound tourism																		Outbound tourism
																		Accommodation occupancy
																		Visitor expenditure in the region
Outbound tourism																		Accommodation occupancy
																		Visitor expenditure in the region
Accommodation occupancy																		Visitor expenditure in the region

Section C: Demographic information

What is your gender?

☐ Male ☐ Female ☐ Don't want to reveal

What is your age?

☐ Under 18 ☐ 18–24 years old ☐ 25–34 years old ☐ 35–44 years old ☐ 45–54 years old ☐ 55–64 years old ☐ 65 or older

Where are you currently residing?

☐ New Zealand ☐ Taiwan ☐ Other

What is the highest level of education you have completed?

☐ High school degree or equivalent ☐ Bachelor's degree ☐ Master's degree ☐ Doctorate ☐ Other (please specify) ________

What organisation do you work for currently?

☐ Airport ☐ Airline ☐ Consulting agency ☐ Research institute or university ☐ Government agency ☐ Regional, District or City council ☐ Other (please specify) ____

What is your current position in your organisation?

____

What is your major area of expertise?

☐ Air transportation ☐ Environmental impact ☐ Governance ☐ Health and safety ☐ Infrastructure investments ☐ Public policy and planning ☐ Public transport planning ☐ Transport and logistics ☐ Transport economics ☐ Transport funding ☐ Tourism ☐ Urban planning ☐ Other (please specify) ______________________________

What is your second major area of expertise?

☐ Air transportation ☐ Environmental impact ☐ Governance ☐ Health and safety ☐ Infrastructure investments ☐ Public policy and planning ☐ Public transport planning ☐ Transport and logistics ☐ Transport economics ☐ Transport funding ☐ Tourism ☐ Urban planning ☐ Other (please specify) ______________________________

How long have you been working in your area of expertise?

☐ less than 3 years ☐ 3–5 years ☐ 5—7 years ☐ 7—10 years ☐ more than 10 years

Appendix K – Profile of survey participants

Profile of the participants	New Zealand (n = 25)		Taiwan (n = 22)	
	Frequency	Percentage	Frequency	Percentage
Gender				
Male	21	84%	18	82%
Female	4	16%	4	18%
Age (years)				
18−24	3	12%	0	0%
25−34	4	16%	3	14%
35−44	4	16%	3	14%
45−54	7	28%	9	41%
55−64	2	8%	4	18%
65 or older	5	20%	3	14%
Education level				
Bachelor	12	48%	4	18%
Master	6	24%	7	32%
Doctorate	4	16%	11	50%
Other (e.g. no degree or diploma)	3	12%	0	0%
Organisation				
Airport	5	20%	2	9%
Airline	4	16%	2	9%
Research institute or university	6	24%	7	32%
Government agency	4	16%	8	36%
Regional, District or City council	4	16%	2	9%
Other (e.g. tourism or environmental group)	2	8%	1	5%
Area of expertise				
Air transportation	12	48%	5	23%
Public transport planning	3	12%	3	14%
Transport economics and logistics	6	24%	8	36%
Governance	8	32%	19	86%
Public policy, urban planning and infrastructure investments	7	28%	7	32%
Health and safety	3	12%	1	5%
Environmental impact	5	20%	0	0%
Tourism	5	20%	0	0%
Other	1	4%	0	0%
Working experience in the area of expertise (years)				
Less than 3 years	5	20%	1	5%
3−5 years	3	12%	1	5%
5−7 years	4	16%	0	0%
7−10 years	3	12%	1	5%
More than 10 years	10	40%	19	86%

Appendix L – Ranking details using FAHP

Table 18

Ranking of air transport activity indicators (FAHP)

New Zealand		Indicators	Taiwan	
Rank	Weight		Weight	Rank
2	0.220	Flight frequency	0.328	2
3	0.171	Available seats	0.118	3
1	0.321	Destinations served	0.346	1
4	0.159	Regional airport infrastructure	0.112	4
5	0.129	Regional airport operations	0.096	5

Table 19

Rankings of regional wellbeing categories and indicators (FAHP)

Regional wellbeing categories	New Zealand		Taiwan		Regional wellbeing indicators	New Zealand				Taiwan			
	Rank	Weight	Rank	Weight		Overall rank	Overall weight	Rank	Weight	Overall rank	Overall weight	Rank	Weight
Economic wellbeing	1	0.298	2	0.251	*Regional unemployment*	8	0.061	3	0.204	7	0.061	2	0.243
					Regional imports & exports	7	0.061	2	0.206	17	0.034	5	0.135
					Local business activities	1	0.084	1	0.283	6	0.061	1	0.243
					Regional foreign direct investment	16	0.035	5	0.116	13	0.041	4	0.163
					Region's per capita income	9	0.056	4	0.190	10	0.054	3	0.215
Social wellbeing	2	0.273	1	0.312	*Airfares*	17	0.028	5	0.104	9	0.057	3	0.183
					Medical treatment	3	0.066	1	0.242	2	0.077	1	0.247
					Social inclusion and links	14	0.043	4	0.158	11	0.051	4	0.164
					Leisure and personal time	19	0.026	6	0.095	19	0.024	6	0.078
					Housing affordability	13	0.046	3	0.168	18	0.030	5	0.095
					Rapid hazard response	5	0.064	2	0.234	3	0.072	2	0.232
Environmental wellbeing	3	0.265	4	0.213	*Air quality*	15	0.039	5	0.146	14	0.040	3	0.190
					Noise	11	0.047	3	0.179	8	0.057	1	0.270
					Wildlife, heritage and landscape	2	0.071	1	0.267	15	0.036	4	0.170
					Waste management	12	0.046	4	0.174	16	0.036	5	0.169
					Water use and pollution	6	0.062	2	0.235	12	0.043	2	0.201
Tourism	4	0.165	3	0.224	*Inbound tourism*	10	0.048	2	0.292	4	0.064	2	0.286
					Outbound tourism	18	0.026	3	0.161	20	0.019	4	0.084
					Accommodation occupancy	20	0.025	4	0.155	5	0.062	3	0.277
					Visitor expenditure in the region	4	0.065	1	0.393	1	0.079	1	0.353

Note: The weight is based on the participants' responses within a specific regional wellbeing category. The overall weight is based on the participants' responses within all four regional wellbeing categories (20 regional wellbeing indicators in total).

Appendix M – Ranking details using AHP

Table 20

Ranking of air transport activity indicators (AHP)

New Zealand		Indicators	Taiwan	
Rank	Weight		Weight	Rank
2	0.221	Flight frequency	0.326	2
3	0.171	Available seats	0.120	3
1	0.318	Destinations served	0.341	1
4	0.161	Regional airport infrastructure	0.115	4
5	0.128	Regional airport operations	0.098	5

Table 21

Rankings of regional wellbeing categories and indicators (AHP)

Regional wellbeing categories	New Zealand		Taiwan		Regional wellbeing indicators	New Zealand				Taiwan			
	Rank	Weight	Rank	Weight		Overall rank	Overall weight	Rank	Weight	Overall rank	Overall weight	Rank	Weight
Economic wellbeing	1	0.297	2	0.251	*Regional unemployment*	7	0.061	2	0.207	5	0.061	1	0.245
					Regional imports & exports	8	0.061	3	0.204	17	0.034	5	0.135
					Local business activities	1	0.083	1	0.281	7	0.061	2	0.242
					Regional foreign direct investment	16	0.035	5	0.117	13	0.041	4	0.165
					Region's per capita income	9	0.057	4	0.191	10	0.054	3	0.213
Social wellbeing	2	0.269	1	0.312	*Airfares*	17	0.028	5	0.104	9	0.057	3	0.183
					Medical treatment	3	0.065	1	0.242	2	0.076	1	0.244
					Social inclusion and links	14	0.042	4	0.156	11	0.051	4	0.165
					Leisure and personal time	20	0.026	6	0.097	19	0.024	6	0.078
					Housing affordability	13	0.045	3	0.167	18	0.030	5	0.096
					Rapid hazard response	5	0.063	2	0.234	3	0.073	2	0.236
Environmental wellbeing	3	0.266	4	0.213	*Air quality*	15	0.039	5	0.148	14	0.041	3	0.193
					Noise	11	0.047	3	0.178	8	0.057	1	0.268
					Wildlife, heritage and landscape	2	0.072	1	0.269	15	0.036	4	0.169
					Waste management	12	0.046	4	0.172	16	0.036	5	0.169
					Water use and pollution	6	0.062	2	0.234	12	0.043	2	0.201
Tourism	4	0.168	3	0.224	*Inbound tourism*	10	0.050	2	0.295	4	0.065	2	0.291
					Outbound tourism	18	0.027	3	0.163	20	0.019	4	0.083
					Accommodation occupancy	19	0.026	4	0.155	6	0.061	3	0.273
					Visitor expenditure in the region	4	0.065	1	0.387	1	0.079	1	0.354

Appendix N – Summary of panel unit root test for the variables

Variable	Level (constant only)				First-order differencing			
	LLC	IPS	ADF	PP	LLC	IPS	ADF	PP
$\ln(SUBs)_{it}$	0.3618	−	0.9084	0.9084	0.0000	−	0.0000	0.0000
$\ln(ASKs)_{it}$	0.0002	0.9985	0.9913	0.9913	0.0000	0.2210	0.1773	0.1773
$\ln(GDPPC)_{it}$	0.4257	1.0000	1.0000	1.0000	0.0000	0.0002	0.0000	0.0000
$\ln(Unemploy)_{it}$	0.9165	0.8935	0.6704	0.6704	0.0000	0.0000	0.0000	0.0000
$\ln(RCE)_{it}$	0.0000	0.0168	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
$\ln(Tour)_{it}$	0.0501	0.9997	0.5305	0.5305	0.0000	0.0043	0.0000	0.0000
$\ln(Popul)_{it}$	0.9128	1.0000	1.0000	1.0000	0.0000	0.4230	0.9117	0.9117
$\ln(Petrol)_{t}$	0.0000	0.0008	0.0020	0.0020	0.0000	0.0004	0.0001	0.0001
$\text{In}(Inflation)_{it}$	0.0000	0.0135	0.1410	0.1410	0.0000	0.0000	0.0000	0.0000
$\ln(Edu)_{it}$	0.0003	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: P-values are presented for each test. LLC: Levin et al. (2002); IPS: Im et al. (2003); ADF: ADF-Fisher chi-square; PP: PP-Fisher chi-square.

Appendix O – A Correlation matrix of the variables of interest

	$\ln(SC\_ASK)_{ijt}$	$\ln(Subs\_Airport\_O)_{it}$	$\ln(Subs\_Airport\_D)_{jt}$	$\ln(Fare)_{ijt}$	$\ln(Total\_ASK)_{ijt}$	% of LCC_ASK_{ijt}	$\ln(GDPPC\_O)_{it}$	$\ln(TECT\_D)_{jt}$	Lockdown
$\ln(SC\_ASK)_{ijt}$	1.000								
$\ln(Subs\_Airport\_O)_{it}$	−0.153	1.000							
$\ln(Subs\_Airport\_D)_{jt}$	−0.153	0.137	1.000						
$\ln(Fare)_{ijt}$	−0.452	0.045	0.050	1.000					
$\ln(Total\_ASK)_{ijt}$	−0.431	0.160	0.160	0.287	1.000				
% of LCC_ASK_{ijt}	−0.177	−0.036	−0.036	0.131	0.474	1.000			
$\ln(GDPPC\_O)_{it}$	−0.090	−0.128	0.092	0.083	0.144	0.107	1.000		
$\ln(TECT\_D)_{jt}$	−0.211	0.073	−0.213	0.179	0.187	0.200	−0.359	1.000	
Lockdown	−0.022	−0.027	−0.027	−0.039	0.112	0.129	−0.072	−0.020	1.000

Appendix P – Summary of panel unit root tests for the variables

	Level (constant only)		First-order differencing	
	ADF	PP	ADF	PP
$\ln(PAX)_{ijt}$	0.0000	0.0000	0.0000	0.0000
$\ln(SC\_ASK)_{ijt}$	0.0000	0.0000	0.0000	0.0000
$\ln(Subs\_Airport\_O)_{it}$	0.6560	0.6560	0.0000	0.0000
$\ln(Subs\_Airport\_D)_{jt}$	0.6560	0.6560	0.0000	0.0000
$\ln(Fare)_{ijt}$	0.9870	0.9870	0.0000	0.0000
$\ln(Total\_ASK)_{ijt}$	0.0000	0.0000	0.0000	0.0000
$\%\ of\ LCC\_ASK_{ijt}$	0.0000	0.0000	0.0000	0.0000
$\ln(GDPPC\_O)_{it}$	0.0000	0.0000	0.0000	0.0000
$\ln(TECT\_D)_{jt}$	0.0000	0.0000	0.0000	0.0000

Note: *P*-values are presented for each test. ADF: augmented Dickey−Fuller, Fisher's chi-square; PP: Phillips−Perron, Fisher's chi-square.

Appendix Q – Statements of contribution

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- Please provide the full reference of the Research Output:

Wu, H., Tsui, K. W. H., Ngo, T., & Lin, Y. H. (2020). Impacts of aviation subsidies on regional wellbeing: Systematic review, meta-analysis and future research directions. Transport Policy, 99, 215–239.

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