

Horrocks, Mitchell Lewis; Gepp, Adrian; Todd, James; Vanstone, Bruce James

Article

Pandemic borders and expenditure impact: Intervention and forecasting insights from Australia

Annals of Tourism Research Empirical Insights

Provided in Cooperation with:

Elsevier

Suggested Citation: Horrocks, Mitchell Lewis; Gepp, Adrian; Todd, James; Vanstone, Bruce James (2025) : Pandemic borders and expenditure impact: Intervention and forecasting insights from Australia, Annals of Tourism Research Empirical Insights, ISSN 2666-9579, Elsevier, Amsterdam, Vol. 6, Iss. 1, pp. 1-14,
<https://doi.org/10.1016/j.annale.2024.100163>

This Version is available at:

<https://hdl.handle.net/10419/337822>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-nc-nd/4.0/>



Pandemic borders and expenditure impact: Intervention and forecasting insights from Australia

Mitchell Lewis Horrocks^a, Adrian Gepp^{a,b,*}, James Todd^a, Bruce James Vanstone^{a,b}

^a Bond Business School, Bond University, 14 University Drive, Robina, Gold Coast 4226, Queensland, Australia

^b Bangor Business School, Bangor University, Bangor LL57 2DG, Wales, United Kingdom

ARTICLE INFO

Handling Editor: Ksenia Kirillova

Keywords:

Tourist expenditure
Coronavirus pandemic
Tourism crisis
Time series modelling
Intervention analysis
Card transaction data

ABSTRACT

The coronavirus pandemic had a devastating effect on tourism. This paper develops an integrated intervention analysis and forecasting methodology for crisis impact assessment to investigate the economic impacts of border restrictions for a popular tourist destination in Australia, the Gold Coast. Using anonymised and aggregated daily Visa expenditure data from 2018 to 2020, this paper investigates domestic and international visitors' responses to border restrictions and their subsequent easing. Responses are influenced by policy severity, proximity to destinations, and broader pandemic conditions, with international markets experiencing the greatest expenditure impact. Domestic intrastate visitors drove initial recovery, while interstate visitors faced barriers like non-reciprocal travel arrangements and frequently changing restrictions. Travel restrictions disproportionately affected tourist-oriented businesses and altered the spatial distribution of visitor spending.

1. Introduction

The coronavirus pandemic (COVID-19) caused an unprecedented crisis for the tourism sector (Škare et al., 2021), as government-led intervention and lockdown measures were used to reduce the spread of the virus. There has been a notable increase in the number of publications in the area as researchers share experiences from different geographical and industry perspectives (Sigala, 2020). These contributions have built on the extant tourism crises literature, exploring issues ranging from prevention and planning, response and recovery, as well as resolution and feedback (Ritchie & Jiang, 2019). The quantification of crisis events is crucial to the response and recovery phase, but research on the role of border restrictions, utilisation of high-resolution expenditure data and domestic tourism remains limited.

Research that quantifies the impact of crisis events on tourist demand presents methods to enable governments and organisations to analyse policy responses and evaluate tourism recovery (Wang, 2009). These studies typically employ traditional econometric analysis (McAleer et al., 2010), intervention analysis (Goh & Law, 2002) or forecast scenario analysis (Huang & Min, 2002) to investigate the effects of major events such as terrorist attacks (Bonham et al., 2006), natural disasters (Min, 2008) and health epidemics (Kuo et al., 2008). Initial empirical

evaluation of the COVID-19 pandemic has investigated methods for forecasting the evolution and recovery of visitor arrivals (Polyzos et al., 2020; Zhang et al., 2021), evaluating the macroeconomic impacts (Pham et al., 2021; Ramlall, 2024), and assessing the effects of public health interventions on mobility in the leisure industry (Fang et al., 2021). While research has quantified many aspects of crises, the effects of border restrictions have received limited attention despite their widespread use during the COVID-19 pandemic. Although research has noted the role of restrictions on aspects of tourism (Boto-García & Mayor, 2022; McCartney, 2021; Reitano et al., 2021), there has yet to be an investigation of the economic effects of implementing and relaxing border restrictions.

The quantification of the impact of crisis events is facilitated by the analysis of tourism demand, with tourism expenditure employed to understand demand through an economic lens. Studies into tourism expenditure broadly fall into two streams: an individual-level microeconomic approach and a nation- or destination-wide macroeconomic approach. Research at the microeconomic level aims to understand an individual's decisions around spending through causal characteristics (social, economic, psychological & trip related) that affect an individual's willingness to consume tourism goods and services (Disegna & Osti, 2016). Macroeconomic studies focus on modelling international

* Corresponding author. Bangor Business School, Bangor University, Bangor LL57 2DG, Wales, United Kingdom.

E-mail addresses: mhorrock@bond.edu.au (M.L. Horrocks), a.gepp@bangor.ac.uk (A. Gepp), jtodd@bond.edu.au (J. Todd), b.vanstone@bangor.ac.uk (B.J. Vanstone).

<https://doi.org/10.1016/j.annale.2024.100163>

Received 25 January 2024; Received in revised form 30 November 2024; Accepted 1 December 2024

Available online 7 December 2024

2666-9579/© 2024 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

tourist expenditures to assess demand using macroeconomic variables and time-series analysis (Rosselló-Nadal & He, 2020). The study of expenditure is a crucial aspect of economic decision-making within destinations, as it can capture both the behavioural and economic traits of visitors. This includes applications for resource allocation via demand forecasting (Song et al., 2010), targeted marketing through visitor segmentation (Rubina Nava et al., 2023) and economic impact assessment to understand the contributions and shocks of tourism to a local economy (Blake et al., 2003). Research to date has primarily depended on surveys, which limit the ability to provide detailed explanations regarding certain phenomena (Aparicio et al., 2022).

Research aiming to quantify the effects of crisis events based on tourism arrivals and expenditures has usually focused on international tourism's impact and recovery rather than domestic tourism (Wickramasinghe & Naranpanawa, 2023). The COVID-19 pandemic has underscored the importance of domestic tourism during times of crisis. The value of domestic tourism is often greater than international tourism (Li et al., 2010), serving as a viable option to compensate for the loss of international tourism due to restrictions (Duro et al., 2023) and its ability to stimulate recovery through government support (Pham et al., 2021). Early in the pandemic, Hall et al. (2020) highlighted the pivotal role that domestic tourism could play in the sector's recovery. Previous research has demonstrated the resiliency of domestic tourism during crises, where domestic tourism has displayed faster short-term recovery than international tourism (Blake et al., 2003), even increasing to reduce the impact of international shocks (Dwyer et al., 2006). Yet, research into domestic tourism's role in recovery is limited, given that international tourism data is more comprehensively captured and available (Song et al., 2019).

Overall, there is a lack of research on the economic impacts of border restrictions on tourism as well as limited attention provided to high-resolution demand measures and the analysis of domestic tourism markets. This paper addresses this shortage by investigating the economic effects of border restrictions during a pandemic on the Gold Coast, one of Australia's premier tourist destinations. To do so, we utilise aggregated daily expenditure data from a large payment provider. We contrast the economic effects between international and domestic visitor markets and further subcategorise domestic markets by visitors' state. The research questions addressed are:

1. How did domestic and international visitor markets respond to initial travel restrictions in terms of changes in expenditure?
2. What was the effect of easing restrictions on intra-state and inter-state expenditure and was this affected by asymmetries in restrictions for visitor origins and destinations?
3. How did spending behaviours change in terms of total spend and card volume across different merchant segments and areas following the implementation of initial border restrictions?

To support this investigation, we develop an integrated intervention and forecasting methodology that quantifies rapid changes in expenditure using anonymised and aggregated Visa card data. This novel data source, recorded daily, enables investigation of expenditure at a greater level of granularity with respect to region and time (Wu et al., 2017).

The first two research questions contribute by providing empirical evidence of the economic effects of border closures and openings across source markets, being the first paper to detail the extent of their impact on tourism demand, the evolution of their effects and how the broader pandemic influences them. In distinguishing international from domestic tourism and further analysing on a state level, we enhance our understanding of the role of visitor markets in crisis recovery. Research question three contributes to the literature on behavioural changes during crises by providing greater granularity to the impact on market segments of the economy and restriction impacts on tourist-centric and suburban areas of spend. We also present a methodology for evaluating the impact of tourism crises using higher-frequency data to inform

policymakers about economic impacts rapidly. Finally, aggregated card data offers a distinct perspective from the usual mobility and visitation data employed to assess tourism demand (Yang et al., 2021), providing a unique view of the economic impacts of COVID-19.

2. Background (Gold Coast)

Australia's experience in the first year of the COVID-19 pandemic contrasted with the experience of much of the world. A quick reaction resulted in most of Australia flattening the curve and eliminating community virus transmission by July 2020. The federal government was responsible for the international border, which restricted entry to only returning residents and citizens (Chang et al., 2020). In contrast, state and territory governments were responsible for their own jurisdictions, relying on activity restrictions, social distancing, and state- and location-based border restrictions. Queensland was particularly notable for its frequent use of border restrictions, often implemented with short notice, in response to COVID-19 outbreaks. Queensland is a major tourist destination, home to the Great Barrier Reef and coastal destinations such as the Gold Coast.

The Gold Coast is Australia's largest regional city and a major coastal tourism destination that provides a valuable setting for investigating COVID-19 border restrictions. In 2019, the Gold Coast was the 5th most visited destination by domestic day- and overnight trips and the 4th most-visited region by international travellers in Australia (Tourism Research Australia, 2019b). The Gold Coast primarily appeals to holiday travellers (Tourism Research Australia, 2019a). This contrasts with other major tourism destinations like Sydney, Melbourne, Brisbane, and Perth, which have a high proportion of business travellers. The city stands out from neighbouring destinations (Brisbane and the Sunshine Coast) through its combination of natural attractions, including renowned surf beaches and the World Heritage-listed Hinterland, and robust tourism infrastructure, featuring theme parks, shopping centres, and vibrant dining and entertainment precincts.

Tourism is a substantial contributor to the Gold Coast economy, directly accounting for 12.3 % of employment and \$12 billion in economic value during 2019 (EconomyId, 2021). Domestic tourism, in particular, is a major contributor with just under 80 % of all overnight visitors travelling from within Australia (Tourism Research Australia, 2019a). The impact of border restrictions on the city is evident by the impact on air traffic at Gold Coast airport, which saw a 96 % reduction in passenger numbers for September 2020 when compared with September 2019 (Gold Coast Airport, 2020). The Gold Coast's location within Australia and Queensland means that analysis will capture the impact of varying domestic and federal border policies that shifted rapidly with the changing conditions of the pandemic. As shown in Fig. 1, the destination is located on the southern border of Queensland and acts as a hub for much of Northern New South Wales and is therefore impacted by border closures.

3. Data and analytical approach

3.1. Data

This study uses anonymised daily aggregate visitor Visa card expenditure data for the Tourism Research Australia (TRA) tourism region of the Gold Coast from January 2018 to December 2020. Visa, through its VisaNet Payment network, is the source of the data for this study. VisaNet operates in more than 200 countries with 4.1 billion cards worldwide (Visa, 2022) and accounts for 63.5 % of card processing within Australia, according to IBISWorld Pty Ltd (2021). The data provided is supplemented by market share statistics and census data based on visitor origin to reflect population-level insights. Although the dataset offers improvements over survey methods in terms of timeliness, granularity, and frequency, it is sourced from a single provider and does not capture cash transactions. While we expect that the current data



Fig. 1. Data Setting - Gold Coast. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.) Note: Map generated using Mapbox (2023) (<https://www.mapbox.com/about/maps/>), OpenStreetMap contributors (2023) (<https://www.openstreetmap.org/copyright>) tiles and Australian Bureau of Statistics (2021a) shapefiles.

forms a sufficiently representative sample for estimating the impact of border restriction on card expenditure due to the large processing share, the findings will not extend to cash expenditure, which we expect faced larger reactions to restrictions and were slower to recover.

This study's advantages lie in analysing daily, destination-level data, offering granular insights compared to the less frequent country-level data common in the tourism crisis literature. Fig. 2 compares indexed card expenditure against TRA's indexed expenditure and trips for domestic and international visitors to the Gold Coast. Crises involve multiple compound effects occurring simultaneously (Prideaux et al., 2003), as seen during COVID-19 with rapidly changing border restrictions and policies. While data from official sources, such as TRA, provide essential data for tourism planning, the publication of these metrics is often delayed and reported at quarterly frequencies. Such data is unsuitable for identifying, quantifying and responding to changes that occur in the short-term (Emili et al., 2020). This limitation is evident in Fig. 2, where destination expenditure is reported as a quarterly rolling annual figure, delaying the full assessment of crisis impacts by 12 months. Further, card expenditure allows policymakers to evaluate the economic impact of restrictions based on real economic activity, whereas official statistics typically employ self-reported surveys that are prone to recall bias (Song et al., 2010) and attribute total trip spend to a region based on the length of stay, not actual activity (Tourism Research Australia, 2023a).

Due to the commercial sensitivity of the data, each expenditure series has been rescaled to mask the absolute dollar values, a step that would not be conducted in practical applications. As this research employs linear models (Section 3.2.1), the linear rescaling will not affect statistical significance but will affect coefficient size by the same scaling factor. That is, if a series was multiplied by 100 then the new coefficients would also be 100 times larger than the original coefficients, reflecting

the fact that the series is now measured in cents instead of dollars. We choose the pre-pandemic average expenditure as the scaling factor for each series so that changes in expenditure can be interpreted as percentage changes from the pre-pandemic average. Eq. (1) shows the precise transformation:

$$Y_{t,i} = \frac{S_{t,i}}{\mu_i} \times 100 \quad (1)$$

where $Y_{t,i}$ is rescaled daily tourist expenditure at time t for visitor series i , $S_{t,i}$ is daily expenditure at time t for visitor series i and μ_i is the pre-pandemic¹ average of daily expenditure for visitor series i .

Fig. 2 illustrates the contrasting reactions of different visitor markets due to the varying application of restrictions. In this research, we analyse the initial impact of restrictions by distinguishing international and domestic visitors based on the country of issue for cards. As the pandemic developed, border restrictions were modified to target areas with community transmission. To capture this, analysis is refined to segment domestic visitors at a state level, where origins are inferred from a card's regular spatial spending activity, which is mapped at a statistic area (SA) 4 level from the Australian Statistical Geography Standard and then aggregated by state. Our study considers the four largest pre-pandemic domestic visitor markets: Queensland, New South Wales, Victoria, and Western Australia. By disaggregating domestic visitors, we can better analyse the response and recovery of the domestic market as visitors have origin-dependent responses to crisis events (Park & Reisinger, 2010; Wang, 2009).

3.1.1. Analysed events

Table 1 provides a timeline of the major Queensland border closures and openings that affected the Gold Coast's international and domestic

Tourism Research Australia Metric Comparison Gold Coast Tourism Region

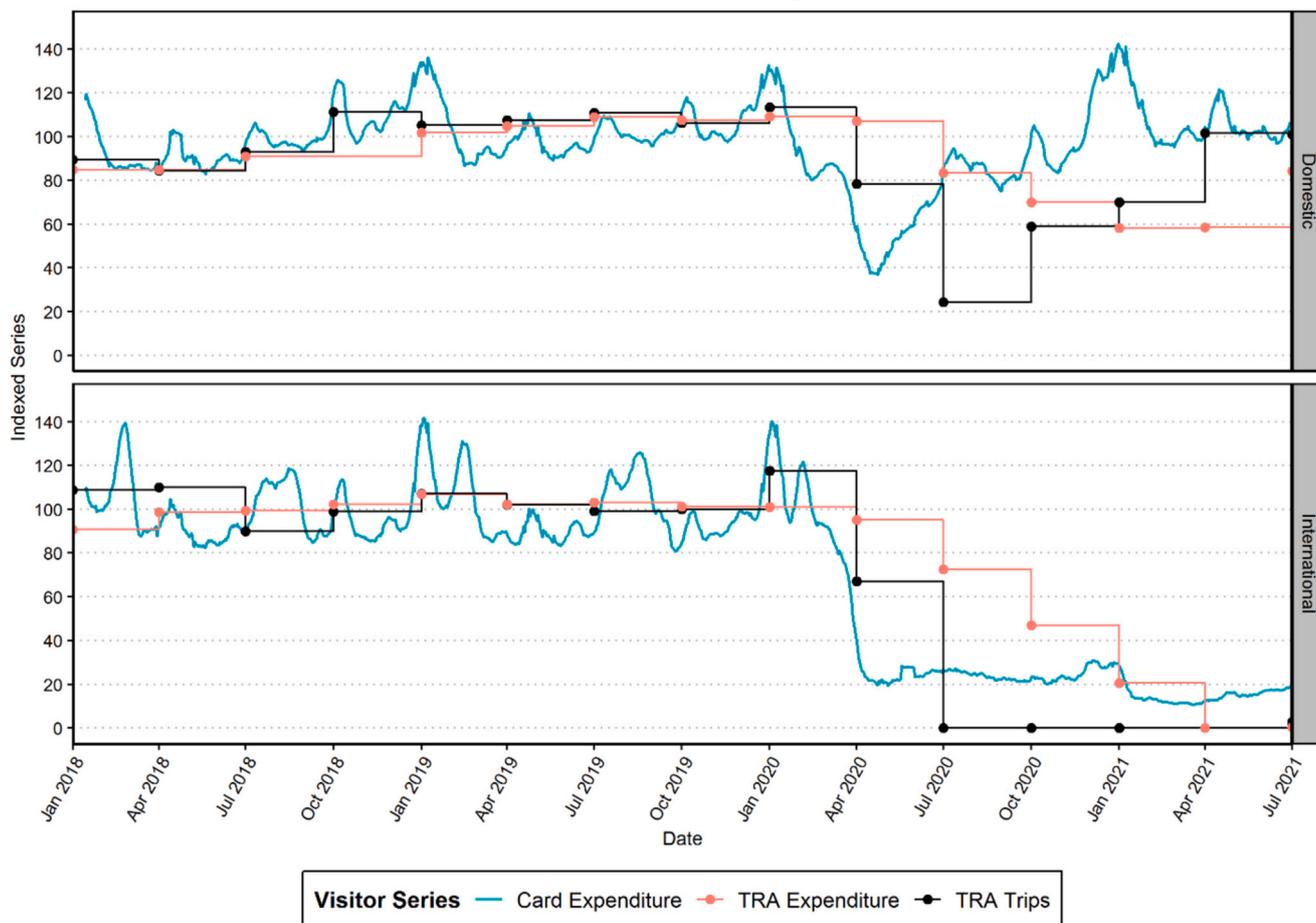


Fig. 2. TRA Data Comparison.

Note: Each series was indexed by its pre-pandemic average. Card expenditure is presented as a rolling 14-day average. Domestic TRA Trips measure overnight trips. Supplementary 2 of the supplementary materials contain TRA index values and card expenditure comparison with holiday periods. TRA source: (Tourism Research Australia, 2023b).

Pre-Intervention/Pandemic period refers to data beginning on the 1st of January 2018 and spanning until the 1st of February 2020 for the international series, 25th of March 2020 for all domestic series.

visitor markets during 2020. Each event has unique dynamics, such as scope and forewarning, that are expected to change how visitors respond to the travel restrictions.

3.1.2. Levels of analysis

Given the various facets involved in the analysis, it is important to distinguish the different levels of analysis conducted throughout the study. In all analyses, expenditure for the analysis area of the Gold Coast will be considered. However, in parts of the research, this will be disaggregated to examine expenditure by spend segment and geographic region within the Gold Coast for more detailed analysis. Additionally, visitor markets are initially analysed at a domestic and international level, with further analysis conducted at the state level. We avoid further disaggregation of markets within these analysis stages for consistency and to avoid analyses becoming increasingly complex as specific subsegments are defined. For example, the subsegments of China in the international, and Sydney in the New South Wales series. Although there is potential for more granular analysis, the application of restrictions was not uniform across the subsegments, making it difficult to establish a clear level of distinction. While subsegments were not considered as distinct visitor markets, subsegment-specific events are noted where relevant, such as the application of targeted restrictions.

3.2. Analytical approach

A time series modelling approach is used with impact forecasting and intervention analysis methodologies to evaluate the effect of border changes on visitor spending. The combination of these methodologies enables real-time crisis quantification. Comparison of observed values with baseline forecasts assesses the immediate impact of policy changes or crisis events (Huang & Min, 2002; Lim, and To, W. M, 2021), and intervention analysis assesses their long-term effects (Goh & Law, 2002; Su et al., 2012). When evaluating multiple events during an ongoing crisis, models with intervention variables can become representative of baseline conditions. This allows for further evaluation through impact forecasting assessment once subsequent events occur. These approaches are thus considered in concert with one another to provide a flexible methodology for quantifying long-term level changes in expenditure and daily impacts of travel restrictions.

Regression models with Autoregressive Integrated Moving Average (ARIMA) errors are used to capture the typical pre-pandemic expenditure dynamics and then forecast what would have happened without the pandemic. This approach provides increased model interpretability compared to an ARIMA with exogenous variables (ARIMAX), as exogenous coefficients are not confounded with the AR and MA coefficients

Table 1
Timeline of Relevant Major Border Changes.

Date in 2020	Event	Description
Feb 1	Chinese Border Closure	The Australian border closed to foreign nationals that have transited through China, Australia's top international visitor market pre-pandemic.
Mar 20	International Border Closure	All foreign arrivals are barred from entering Australia. Flight capacity for Citizens and Residents is substantially reduced.
Mar 25	Domestic Border Closure	Travellers who do not reside or work within the state cannot enter without quarantining. Stay-at-home orders issued for residents in early April.
Jun 1	Intrastate Travel Resumes	Queensland residents are allowed to travel freely throughout the state.
Jul 10	Queensland Domestic Border Reopens	Queensland allows unrestricted travel into the state from all domestic states and territories except Victoria. The Western Australia border remains closed to Queensland.
Aug 8	Borders Close to New South Wales	Outbreak within New South Wales resulted in the closure of the border. A border bubble was established for border communities in northern New South Wales, such as Tweed Heads.
Nov 3	Queensland Border Reopens to Regional New South Wales	The border to New South Wales reopens to all regional areas. Sydney residents are unable to enter Queensland.
Nov 14	Western Australia Border Reopens to Queensland	Western Australia relaxes restrictions on travellers from Queensland.
Dec 1	Queensland Border Reopens to Sydney and Victoria	Queensland allows travellers from Sydney and Victoria to enter the state. It is the first time that Victoria visitors have been able to enter Queensland since the pandemic started (251 days).

Note: Restrictions that only applied to Local Government Areas were not included given their small size. Travel restrictions that were applied to Sydney on the 21st of December 2020 were not included as there was a lack of data to accurately quantify the impact of this restriction during the Christmas period. As such, the New South Wales series is only analysed until the 20th of December 2020.

(Hyndman & Athanasopoulos, 2021). Exogenous dummy variables were required within the models to capture seasonal and calendar effects, which have a noticeable effect on the level of the series (de Livera et al., 2011). Seasonal effects consisted of month and day-of-the-week variables. Calendar variables corresponded to events such as public and school holidays,¹ the Easter and Christmas period, and the Lunar New Year. These events were identified through analysis of the pre-pandemic period.

3.2.1. Intervention analysis

Intervention analysis (Box & Tiao, 1975) models how an economic time series responds to an exogenous event, such as how travel flows are affected by policy changes (Su et al., 2012), natural disasters (Jorge-González et al., 2020), epidemics (Chen et al., 2007), financial crises (Haque & Haque, 2018) and terrorism (Coshall, 2003). This method estimates the long-term structural changes in visitor expenditure caused by travel restrictions and constructs baseline models to capture the short-term impacts of subsequent border changes through impact

¹ School holidays dummies varied with each state. School holidays corresponded with Queensland dates for the domestic and international series. It was unclear whether Queensland school holidays impact the international series. While directly relevant to Queensland residents, international visitors may either align their visits with visiting relatives on holidays or avoid these periods. We tested their inclusion in the model, ultimately excluding them based on statistical significance.

forecasting. Including intervention dynamics within the model's specification ensures that the models are robust (Goh & Law, 2002) and representative of conditions at the time of estimation. Eq. (2) shows the functional form of the intervention models used within our analysis:

$$Y_t = I_t + \beta X_t + \eta_t \quad (2)$$

where Y_t is rescaled daily tourist expenditure, I_t is the intervention variable, X_t is a set of calendar dummy variables at time t with coefficients β , and η_t is a daily seasonal ARIMA error process.

Separate intervention models were created for each visitor series, where intervention variables were determined using the events in Table 1 that directly affected each series. The intervention periods identified in Table 1 have an immediate and prolonged effect on a visitor's ability to travel and are thus modelled through an instant level-changing effect that takes the value one throughout the entire restriction period. Interaction effects with calendar events will be included to study how expenditure during holiday periods changed due to travel restrictions. Each fitted intervention's start and end dates are presented in Supplement 1.

3.2.2. Forecasting impact

As part of the evaluation process, intervention models are iteratively constructed prior to changes in travel restrictions to generate forecasts. As these models are constructed before a structural change occurs, the generated forecasts represent what would be expected without the event (Jin et al., 2019). The forecasted values of these models are compared against realised values to estimate the effect of the intervention events (Joo et al., 2019) and allow analysis of their evolution (Ito & Lee, 2005). This process provides an effective way of evaluating and assessing impacts on visitors to inform government resource allocation in times of crisis (Huang & Min, 2002). The use of daily data in impact forecasting allows for near real-time tracking of the evolution and recovery of tourism expenditure after the event.

Estimates of each restriction's effects are based on forecasting daily expenditure for eight weeks (56 days) after the event or until another restriction is implemented, whichever is shorter. The total of actual expenditure in this period is subtracted from the total forecasted expenditure to compute the restriction's effect. The eight-week period allows for the initial shock of policy changes to influence travel plans, allowing these effects to stabilise and capture dynamics that may not immediately manifest following a change in restrictions. We generate 10,000 sets of forecasts from the forecasting model to quantify the uncertainty associated with these estimated effects. These are used to determine 95 % prediction intervals for the effect of each restriction event.

3.2.3. Model construction

The construction of intervention models was based on Enders (2015). Augmented Dickey-Fuller (ADF) tests were conducted on pre-intervention data to identify unit roots and determine which series required differencing to achieve stationarity (Coshall, 2003; Goh & Law, 2002; Min, 2008). Each series was then iteratively modelled using data prior to the analysed restriction events. To ensure that the estimated intervention effects were appropriate, models were then evaluated using a variety of procedures and diagnostic checks. Variable suitability was based on parsimonious model construction, using a backward stepwise approach, starting with a full model of all explanatory variables and sequentially eliminating variables based on p -values. Further, Wald and Likelihood Ratio hypothesis tests were employed to evaluate differences in the effects of intervention variables and their effect on model complexity. Residuals were assessed using Ljung-Box tests for white noise. To adhere to the principle of parsimony, the Bayesian Information Criterion (BIC) (Lim & McAleer, 2001) was used to select among ARIMA specifications that satisfied all other model criteria. All hypothesis tests were conducted with a significance level of 5 % for consistency.

3.2.4. Merchant segment and area analysis

Investigation of research question three involved analysis of percentage change in spend and card volume across spatial areas and merchant segments. Analysis of spatial area occurred at an SA3 level for regions on the Gold Coast, while merchant segments were classified via their aggregated Merchant Category Code, defined by the International Standards Organisation. Additional information on these classifications, and reference points for the analyses, are presented in Supplement 17.

4. Results and discussion

For conciseness, the results presented are limited to the model effects relevant to the discussion. The supplementary materials contain all diagnostic tests outlined in the model construction, intermediate models used to generate forecasts prior to changes in travel restrictions, fully specified intervention models, event forecast summaries, and date ranges associated with restriction periods for each series. All results presented here pertain to expenditure on the Gold Coast. To contextualise presented results, Table 2 shows the relative contribution of visitor source markets to pre-pandemic expenditure¹.

4.1. Pre-pandemic calendar effects

Pre-intervention models were created to establish the regular dynamics of each series prior to the pandemic, which are later used to forecast and quantify the initial impact of COVID-19 travel restrictions. Table 3² provides model estimates for each series prior to the first border restriction events, which have been provided to illustrate the spending patterns of each market and contextualise later results. Evident in the model estimates are the significant effects of seasonal calendar variables on visitor expenditure. Seasonal spending patterns differ between domestic and international visitors; while domestic spending aligns with monthly and school holiday trends, international spending is more influenced by holiday periods like Easter, Christmas, and Lunar New Year. Public holidays have a significant negative impact across all models, attributable to the closure of most businesses on these dates. This finding stands in contrast to previous studies (Liu et al., 2018), which have generally observed a positive effect of public holidays on visitor arrivals. The gap between visitor numbers and spending on public holidays highlights an opportunity to enhance visitor experiences. By encouraging businesses to stay open with incentives and actively promoting them, destinations can capture existing demand, ensuring they remain appealing to visitors even during holidays.

4.2. Initial impact

In February 2020, the closure of the international border to visitors

Table 2
Pre-Pandemic and Mid-Pandemic Expenditure Shares by Visitor Market.

Source Market	Relative Contribution 2018–2019	Relative Contribution 2020
International	21.56 %	11.61 %
Domestic	78.44 %	88.39 %
Queensland	36.29 %	50.63 %
New South Wales	25.18 %	24.61 %
Victoria	9.89 %	6.49 %
Western Australia	2.27 %	2.16 %
Other States	4.81 %	4.50 %

² An extended version of Table 3 that includes all the coefficient estimates can be found in Supplement 4 of the Supplementary Materials.

from China represented the first travel restrictions implemented in response to COVID-19. This was followed by a full international and domestic border closure in March 2020. Results in the following sections utilise Table 4 to discuss the effects of border restrictions and the evolution of spend. These intervention variables should be interpreted as the percentage change in the average level of expenditure prior to the pandemic. It should be noted that the international border closure variable has an additive effect on the Chinese border closure, meaning the total impact of the international border closure is a – 63.67 % (–24.28 % - 39.38 %) drop in expenditure.

4.2.1. Impact on visitor markets

Initial COVID-19 border restrictions caused an immediate reduction in expenditure that greatly affected both international and domestic visitors. From Table 4, international expenditure had a staggered initial impact with the Chinese border closure resulting in a 24.28 % reduction in daily expenditure, followed by a further drop of 39.38 % from the international closure. In comparison, the impact of initial restrictions was less severe for domestic visitors, with a 27.89 % drop in average expenditure. However, in April 2020, stay-at-home restrictions came into effect for Queensland, which substantially impacted businesses and mobility, with spend reducing a further 18.40 % from the pre-pandemic average, leading to an overall decline of 46.29 %. While international and domestic policies were restrictive, the severity of international closures had a more pronounced impact than domestic restrictions, where shared borders permitted essential travel by car.

Evaluating the effects of restrictions on domestic markets, visitors from each state exhibited varying responses as displayed by the intervention effects in Table 4. Border restrictions had the largest intervention effect on Victoria visitors of 60.52 %, who sustained restrictions until December due to ongoing COVID-19 transmission. Other states that had relative control over transmission were less affected. New South Wales and Western Australia were impacted to a similar degree, between 34 and 36 %, whereas Queensland was least affected, with internal restrictions only reducing visitors' spending by 20.39 %. The impact of stay-at-home orders in April was influenced by proximity to the destination, with only Queensland and bordering New South Wales having significant interaction effects during April, resulting in an additive reduction of 20.63 % and 22.09 %, respectively. This was a substantial decline, as these markets represented 61.5 % of the pre-pandemic visitor expenditure (Table 2).

4.2.2. Impact on merchant segments

The effects of initial restrictions on expenditure were unevenly distributed across local businesses in different merchant segments. Fig. 3 displays the quarter-on-quarter change in total expenditure and businesses that accepted transactions (merchant counts) for the second quarter of 2020. Visitor-oriented merchant segments such as travel services, lodging and vehicle rental all had merchant counts decrease by over 20 % and expenditure dropped more than 60 % as their primary customer base could not visit the destination. Consumer discretionary sectors like entertainment, restaurants, and retail experienced varied impacts based on their ability to operate or adapt. Retailers continued to operate under mild restrictions, while many restaurants shifted to takeaway models, whereas entertainment businesses were under strict restrictions. Residential-oriented businesses were the least affected: home improvement and automotive experienced strong spending growth of 9 % and 25 %, respectively. This likely attributable to increases in Australian disposable income (Australian Bureau of Statistics, 2021b) and reduced consumption across consumer discretionary segments. The disproportionate impact of initial restrictions across merchants emphasises the need for policymakers to implement targeted support measures. Stimulus packages, tax or rental relief can reduce the burden on heavily impacted businesses. These findings also suggest businesses can explore options to adapt operations during times of crises to reduce their impact. Additionally, policymakers and businesses can

Table 3
Pre-Intervention Model Estimates.

Variable	International	Domestic	Queensland	New South Wales	Victoria	Western Australia
Jan		10.341** (3.996)	3.302 (3.64)	13.104** (4.421)	-0.726 (7.367)	13.05** (4.531)
Feb		-3.049 (3.61)	-4.418 (3.04)	-1.052 (3.697)	-15.099* (7.073)	-3.253 (4.536)
Mar		-6.663 (3.556)	-5.51 (3.034)	-5.71 (3.649)	-18.046* (7.038)	-0.796 (4.373)
Apr		10.466** (3.654)	9.08** (3.353)	6.586 (4.428)	2.185 (6.779)	7.821 (4.372)
May		1.269 (3.286)	1.87 (3.165)	-0.761 (3.595)	-5.608 (5.665)	-1.748 (3.981)
Jul		9.14** (3.269)	4.857 (3.128)	2.123 (3.81)	15.242** (5.598)	5.694 (3.987)
Aug		3.936 (3.623)	2.021 (3.255)	-0.512 (3.862)	8.392 (6.831)	4.95 (4.331)
Sep		17.864*** (3.858)	12.498*** (3.508)	12.328** (3.999)	29.928*** (7.32)	7.801 (4.649)
Oct		9.66* (3.841)	4.351 (3.372)	8.063 (4.146)	-6.625 (7.782)	9.908* (4.884)
Nov		5.476 (4.122)	5.13 (3.684)	11.1** (4.138)	-2.581 (7.918)	3.054 (4.822)
Dec		20.387*** (4.071)	25.269*** (3.624)	21.992*** (4.266)	-0.521 (7.934)	14.352** (4.834)
Public Holidays	-44.603*** (2.321)	-54.317*** (1.882)	-49.937*** (2.172)	-59.395*** (2.255)	-45.958*** (2.649)	-54.02*** (4.589)
Lunar NY	14.662*** (3.855)					
Christmas	25.874*** (4.604)	16.27*** (3.464)	14.141*** (3.608)	19.715*** (3.976)	13.917** (4.842)	
Christmas Day	-108.41*** (6.419)	-121.6*** (4.86)	-130.539*** (5.311)	-131.356*** (6.293)	-113.579*** (7.104)	-98.938*** (12.258)
Boxing Day	50.865*** (6.366)			-25.349*** (6.311)	-16.154* (7.062)	
Easter	17.931*** (4.716)	21.114*** (3.867)	21.381*** (4.102)	24.555*** (4.121)	21.655*** (4.761)	
Easter Holidays				11.249** (4.03)		
Winter Holidays				7.815* (3.684)		
Oct Holidays		6.364* (3.177)	9.65** (3.459)	19.335*** (3.66)	12.735** (4.638)	10.487* (4.309)
Summer Holidays		14.31*** (2.699)	13.599*** (2.817)	18.858*** (3.331)	13.319** (4.224)	
σ^2	95.458	66.055	76.945	85.566	116.902	318.118
BIC	5726.568	5899.575	6040.304	6109.411	6358.448	7144.796

Note: Standard error of estimate in parentheses; *** p < 0.001, ** p < 0.01, * p < 0.05.

Table 4
Initial Impact Intervention Effects.

Visitor Series	Variable	Coefficient
International	Chinese Border Closure (1/02/2020–31/05/2020)	-24.284*** (6.404)
	International Border Closure (20/03/2020–31/05/2020)	-39.383*** (7.492)
	Domestic Border Closure (25/03/2020–31/05/2020)	-27.891*** (4.905)
Domestic	Apr × Domestic Border Closure	-18.402*** (5.015)
	Domestic Border Closure (25/03/2020–31/05/2020)	-20.386*** (3.345)
Queensland	Apr × Domestic Border Closure	-20.625*** (5.174)
	Queensland Border Closure (25/03/2020–9/07/2020)	-34.572*** (2.466)
New South Wales	Apr × Domestic Border Closure	-22.091*** (5.461)
	Domestic Border Closure (25/03/2020–30/11/2020)	-60.521*** (8.641)
Victoria	Western Australia Border Closure (25/03/2020–13/11/2020)	-36.156*** (4.807)
Western Australia		

collaborate to incentivise consumers to redirect their increased disposable income towards local tourism after the removal of restrictions.

4.2.3. Evolution of restriction effects

Fig. 4 illustrates the evolution of initial border closures over time and their total impact in the weeks following implementation. It shows the percentage reduction in spend between pre-intervention forecasts and realised values, along with a summary and prediction interval of the total impact over the eight-week period. The evolution of the expenditure effects varies across visitor markets and time, with the impact of restriction events likely influenced by restriction severity and the broader pandemic. The initial impact of the Chinese border closure was stable and low because restrictions were geographically targeted. However, as the restrictions continued, the impact grew larger, likely due to greater hesitation from international visitors as the global situation deteriorated. In comparison, the initial impact of the international and domestic border closures was rapid and substantial because restrictions were widely applied across each visitor segment. For domestic visitors, as stay-at-home restrictions tightened in April (second week), it significantly increased the impact on visitor expenditure. However, the effect is less pronounced than the international impact due to the proximity and shared borders that permit essential travel by car. When the severity of the restrictions was reduced with the removal of stay-at-home restrictions (sixth week), partial recoveries were observed in

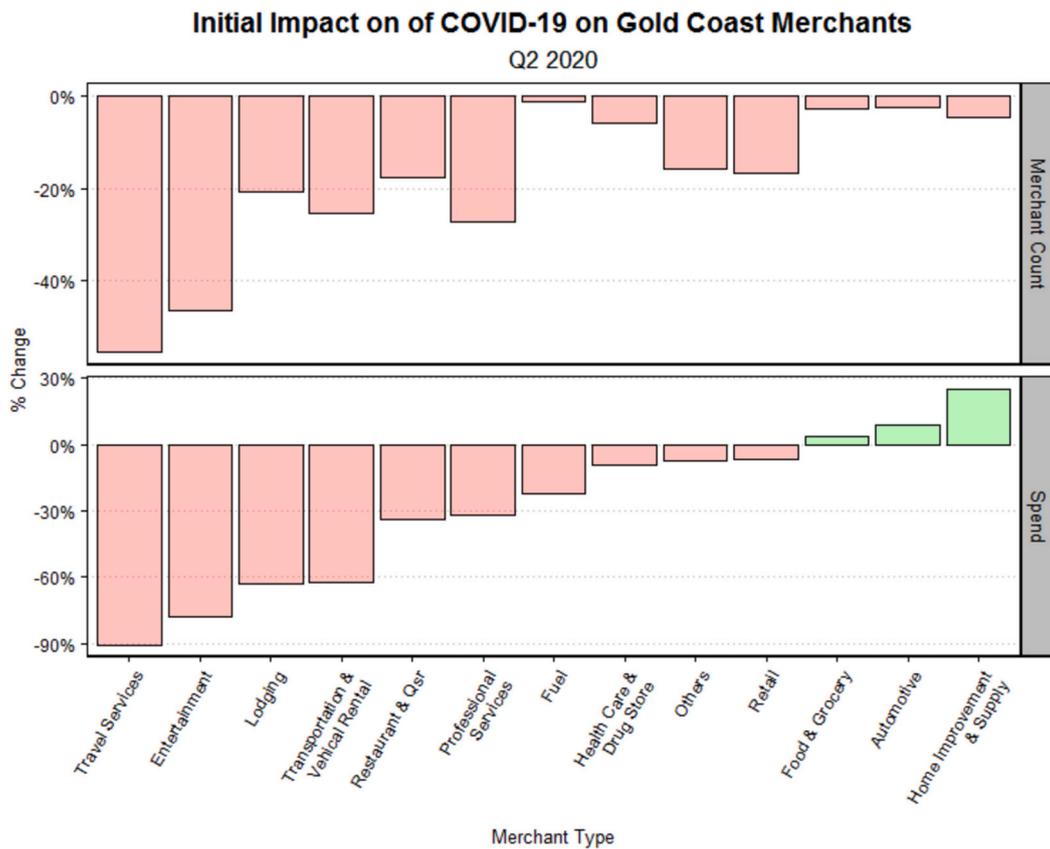


Fig. 3. Initial Impact of COVID-19 on Merchant Segments (Quarterly Change).

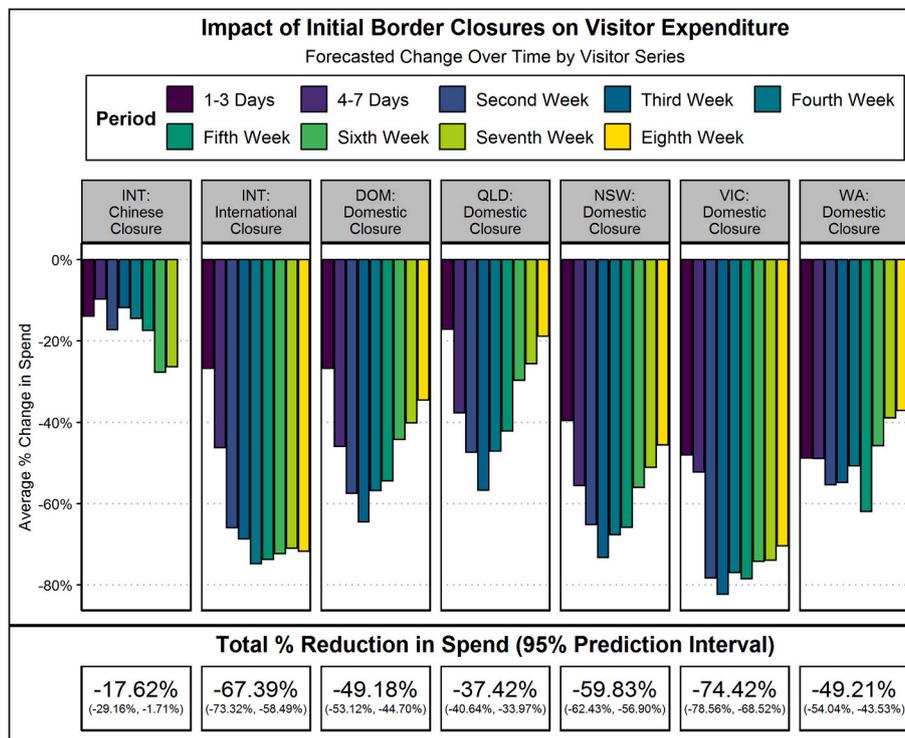


Fig. 4. Forecasted Changes in Expenditure by Visitor Series and Border Closure Event.

domestic markets. In comparison, the persistent reduction in spending observed in Victoria and international markets reflects volatile pandemic conditions where COVID-19 transmission was still prevalent. For policymakers, it highlights the importance of proportionate health responses. While restrictions are necessary, they require careful application as severe restrictions can substantially impact key markets and may require targeted applications to reduce the economic impact.

Across all markets, the full impact of these restrictions was not realised until weeks after restrictions took effect. For international visitors, this is likely a lag effect from visitors in the destination waiting for their return flight. However, for domestic and state visitor markets, this is because border restrictions disrupt the regular dynamics of seasonal calendar effects. The forecasted impact peaks in the third week after restrictions, corresponding to the usually high expenditure Easter period. The supplementary materials also display significant interactions between initial restrictions and easter dummy variables that had an offsetting effect compared to the original dummy variable. These results indicate that the full economic impacts of border restrictions are often delayed and amplified during seasonal periods, highlighting the dynamic nature of interventions and, thus, the importance of regular monitoring during crises.

Given asymmetries in responses of different markets, it highlights the need for policymakers and destination managers to tailor preventative and recovery responses. State visitor results enhance the findings on the severity of restrictions, suggesting that proximity and unstable pandemic conditions increase the impact on spending. The Victoria and international markets experienced a large and sustained effect, whereas internal and neighbouring markets, such as Queensland and New South Wales, recovered faster with a more rapid relaxing of border restrictions. The results reaffirm the importance of domestic markets for recovery (Hall et al., 2020), indicating that domestic sub-markets are disparate with respect to proximity and pandemic conditions. This can facilitate more targeted recovery initiatives based on market proximity, such as pre-emptive marketing before changing restrictions.

4.3. Domestic recovery

The experience of domestic visitor markets varied across the remainder of 2020 due to differing pandemic conditions around the country. As a result, domestic recovery is analysed by state to capture context-specific recovery patterns. During the pandemic, Australian residents required travel exemptions to leave the country, with no guarantee of return, limiting them largely to domestic travel destinations. This section utilises intervention estimates in Table 5 to discuss the factors that both contributed to and hindered recovery in the latter half of 2020. Additionally, the forecasting results in Fig. 5 illustrate the changes in spend and the total forecasted uplift in visitor expenditure in the weeks after border restrictions eased.

4.3.1. Intrastate recovery

The first major restriction easing was the removal of intrastate travel restrictions in Queensland in June. This was immediately followed by

Table 5
Border Reopening Intervention Effects.

Visitor Series	Variable	Coefficient
Queensland	Intrastate Travel Resumes (1/06/2020–31/12/2020)	14.228*** (1.842)
	Queensland Border Opening (10/07/2020–7/08/2020) & (3/11/2020–30/11/2020)	–13.557*** (3.399)
New South Wales	Queensland Border Reopens to Sydney and Victoria	–7.92 (12.46)
Victoria	(1/12/2020–31/12/2020)	–20.384** (6.781)
Western Australia	Western Australia Border Reopens (14/11/2020–31/12/2020)	

recovery for the Gold Coast's largest visitor market, with Fig. 5 showing the removal of restrictions projected a 45.8 % increase in expenditure compared to the initial restriction period. The intervention results, Table 5, show that not only did expenditure recover from initial restrictions, but it surpassed the pre-pandemic average with an increase of 14.23 %. The relaxing of restrictions saw intrastate visitors become the largest visitor market to the Gold Coast, contributing over 50 % (Table 2) to total visitor expenditure in 2020. The substantial growth in intrastate visitor expenditure following restrictions highlights the importance of local tourism and its potential to promote recovery.

Hall et al. (2020) report that removing domestic travel restrictions is the catalyst for tourism recovery. For the Gold Coast, recovery was influenced by the intrastate market, as Australia's domestic borders resembled international borders throughout the pandemic. With outbreaks occurring in other states and restrictions still in place for other destinations, this may have been a decision on behalf of travellers to reduce their potential exposure to risk; a similar suggestion was made by Bonham et al. (2006) regarding United States domestic travel post 9–11. This may also be explained by tourism ethnocentrism at a state level, where residents are more willing to engage in domestic tourism, support tourism development and contribute to the local economy (Kock et al., 2019). This finding could guide destination managers in the creation of targeted campaigns that encourage residents to explore their own state and emphasise the role of internal markets when regional restrictions inhibit travel within a country.

4.3.2. Reciprocal travel arrangements

The first easing of restrictions for interstate markets occurred in early July when Queensland reopened its domestic borders to every state except Victoria. Despite restrictions to Western Australia easing, this action was not reciprocal, as the Western Australia border remained closed to interstate travellers until November 2020. The intervention model fitted on this event provided a level-changing estimate of –36.20 % for the period of eased restrictions, a minor change from the initial restriction estimate of –40.31 % (Supplement 13). While both estimates were significant, the intervention variables were not significantly different from one another (Wald test,³ $p = 0.483$). This is further supported by the prediction interval range for the total effect in Western Australia (Fig. 5), which presents inconclusive results on whether this event had a strictly positive increase in expenditure. These findings suggest that the ability to return home may be a key factor in recovery after easing restrictions. A similar phenomenon can be seen in the emergence of Korean outbound tourism once restrictions were lifted in the late 1980s (Prideaux, 1997). This result highlights the potential role of bilateral travel agreements in facilitating tourism recovery. Policymakers should consider negotiating reciprocal border-opening agreements to ensure mutual benefits and a smoother recovery process.

Towards the end of 2020, COVID-19 was widely considered under control within Australia, and states began to relax domestic border restrictions. In November, Western Australia reopened its borders to Queensland, with forecast spend by Western Australia visitors (Fig. 5) increasing by 29.09 % compared to the previous restriction period. Despite this, intervention analysis (Table 5) indicates that spending was down by 20.38 % compared to the pre-pandemic average spend. This was likely a product of Western Australia's strict border policy throughout the pandemic, meaning people were more unlikely to travel given an increased likelihood of being unable to return. Perceived risk has a large impact on one's intention to travel (Li et al., 2021). However, this is often a perceived risk of the destination and not the risk that one may be unable to return home. Additionally, the distance between Western Australia and Queensland presents another potential barrier, as tourists might seek out shorter holidays after a crisis event (Li et al., 2021).

³ See Supplements 12–14 for details

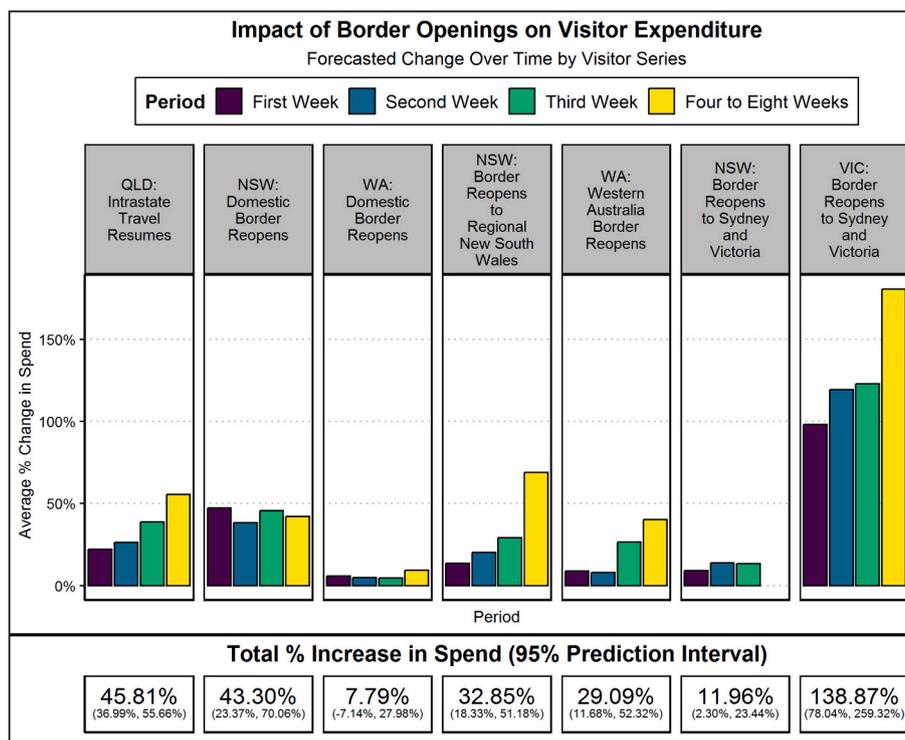


Fig. 5. Forecasted Changes in Expenditure by Visitor Series and Border Opening Event.

4.3.3. Interstate barriers to recovery

The road to recovery for New South Wales visitors was unsteady in the second half of 2020 due to frequent changes in border restrictions. New South Wales experienced four border events, two opening and two closing, that were applied with consistency to target certain regions. The initial border closure mirrored the subsequent closure, with exceptions to restrictions for bordering communities in northern New South Wales via a travel bubble arrangement. While these events were captured independently because they occurred at different points in time, the two opening effects were not significantly different (Wald Test⁴, $p = 0.528$) and were captured by a single coefficient in intervention analysis. The estimates of two closing effects were similarly combined (Wald Test⁴, $p = 0.989$). In this instance, Queensland borders reopened to New South Wales but restricted access to visitors from Greater Sydney. Table 5 illustrates how the targeted reopening reduced the impact of the border closure on pre-pandemic spending from -34.57 % (from Table 4) to -13.56 %. These findings highlight the importance of targeted controls and their ability to reduce the impact of restrictions while balancing public safety. Additionally, it indicates that when restrictions are applied consistently, their effect can be captured accurately through a single variable, meaning that policymakers may be able to accurately forecast the effects of restrictions before their implementation.

In December, Queensland lifted prolonged restrictions to visitors from Sydney and Victoria. However, the modelling process showed that the intervention coefficients for this change were not statistically significant for New South Wales and Victoria visitors, indicating that spending returned to pre-pandemic levels. Likelihood-ratio tests⁴ indicated the intervention variable significantly improved recovery explanation for Victoria visitors ($p = 0.005$), but not for New South Wales ($p = 0.647$), suggesting variable impacts of border reopenings on different states. The improved specification in the Victoria visitor series is due to significant amplified interaction with the Christmas period after the removal of border restrictions. This result is not observed in the New South Wales series, as restrictions were reintroduced for Sydney before Christmas. These results suggest that domestic visitor markets can bolster recovery in times of crisis. This effect may be attributable to

Queensland’s relatively limited restrictions during 2020, which likely strengthened consumer confidence, as the destination was perceived as safe and prepared to welcome visitors, even amid a pandemic.

While previous results suggest a damping effect of border closures on seasonal variation, there is evidence of an amplifying effect after the removal of restrictions. Fig. 5 displays the significant increase in visitor expenditure in the Victoria visitor series during the third week after restrictions, which corresponds with the Christmas period. Similar amplifying effects were observed in the Queensland visitor series, where visitor expenditure greatly increased during the October Holidays and Christmas period (see Supplement 7). These findings highlight the importance of designing strategies addressing the challenges and opportunities of seasonal tourism during crisis periods. Policymakers might consider contingency plans that include support mechanisms for businesses during off-peak seasons, while businesses might utilise promotions, dynamic pricing, and specialised marketing campaigns tailored to the unique context of the crisis period.

4.4. Changes in visitor spending behaviours on the Gold Coast

An advantage of card expenditure data is that it enables spatial analysis that allows us to identify the areas and merchants most affected by border restrictions and the pandemic. Fig. 6 compares spatial expenditure since initial COVID-19 restrictions to average pre-pandemic spend.⁴ During periods of travel restrictions, overall visitor spending was considerably reduced across the Gold Coast regardless of the visitor’s origin. However, coastal, tourist-centric destinations within the Gold Coast, such as Surfers Paradise, Broadbeach-Burleigh and Coolangatta, are most heavily affected by travel restrictions, where intrastate spending was reduced by 60 %, 47 % and 62 %, respectively. Conversely, when restrictions were removed, these locations experienced the largest increases in spending compared to pre-pandemic

⁴ Supplement 17 includes specifications of merchant segments, spatial areas and time reference points for the comparative analysis.

Change in Visitor Expenditure by Area on Gold Coast
 Compared to Pre-Pandemic Average Daily Expenditure

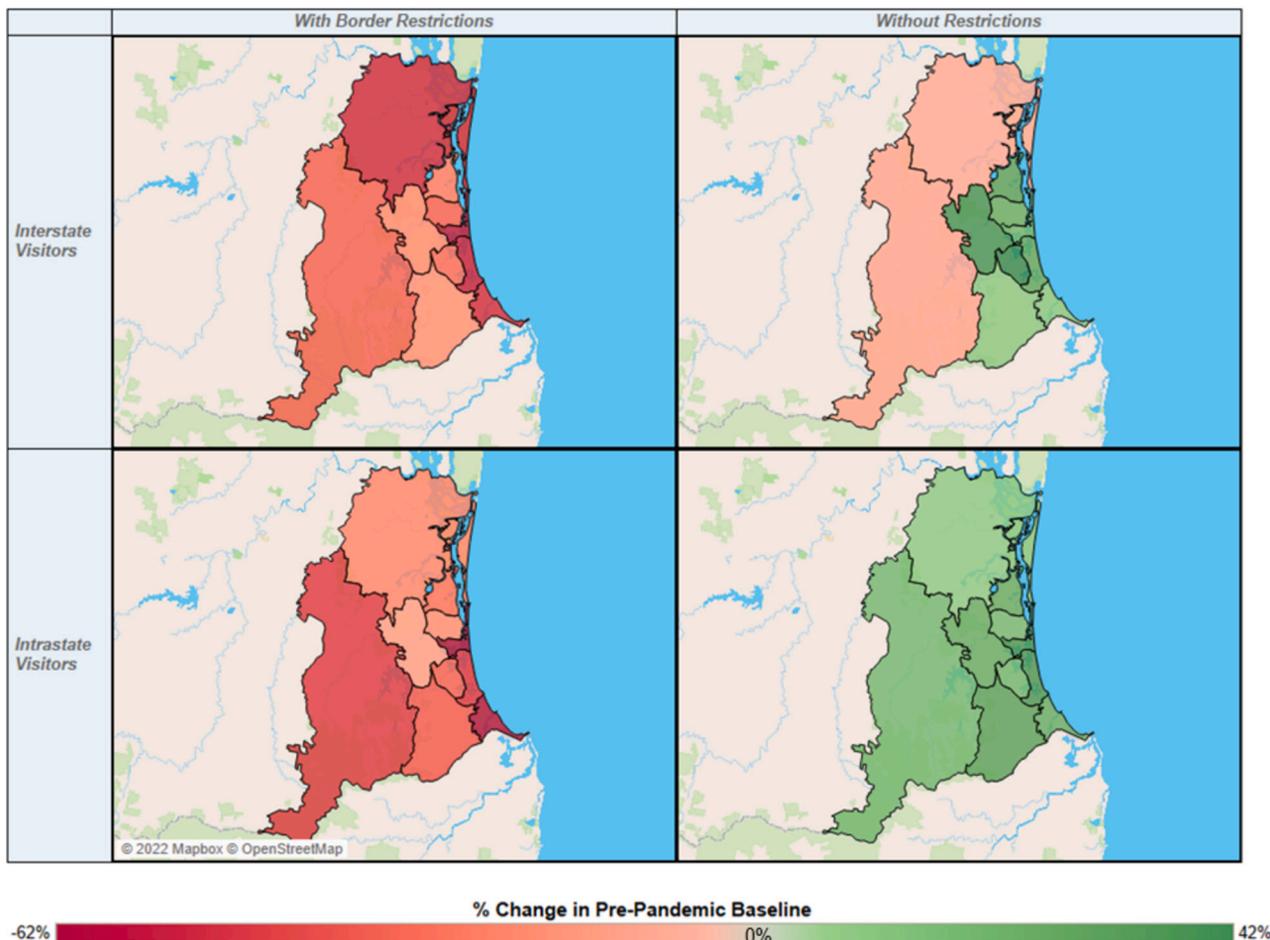


Fig. 6. Changes to Spatial Distribution of Spend on the Gold Coast for Domestic Visitors. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Note: Map generated using Mapbox (2023) (<https://www.mapbox.com/about/maps/>), OpenStreetMap contributors (2023) (<https://www.openstreetmap.org/copyright>) tiles and Australian Bureau of Statistics (2021a) shapefiles.

levels. Consistent with section 4.2.2, this indicates that tourism-oriented merchants and areas are those most adversely affected by border restrictions. Such analysis can assist policymakers in providing targeted economic support to the most affected areas while also monitoring the effectiveness of the support.

Spatial analysis further provided evidence of spending behaviours shifting away from tourist-centric areas, with suburban merchants increasing their visitor share, as seen in Fig. 7. Within the figure, suburban areas are defined as areas outside of the three tourist-centric areas, with card volume included as a proxy for visitation. Since the pandemic, total suburban visitor expenditure has increased by 4.9 %, while card volume increased by 5.5 %. Spending and card volume have increased across almost all travel- and leisure-oriented merchant categories. Visitor share in suburban lodging did not increase during the pandemic, likely due to the large existing infrastructure throughout the tourist areas⁵ and a reduction in demand from international visitors. Such a large change in the distribution of spending may align with travellers’ preferences to avoid crowded areas during a pandemic (Hall et al., 2020); thus, they seek out more varied destinations. This provides

⁵ 75 % of lodging merchants within the expenditure data were in tourist-centric areas. This was the only category with such a tourist-centric concentration.

evidence that the spatial distribution of spending has changed substantially since the initial introduction of restrictions, indicating that not only do tourist-oriented merchants require support during crises, but there is an ability to target those in need spatially.

5. Conclusion

Using an integrated intervention and forecasting methodology, this paper investigated the economic effect of border restrictions during a pandemic on a key tourism economy in Australia, the Gold Coast. This is the first paper to our knowledge that studies the longitudinal effects, magnitude, and nature of travel restrictions across different source markets, extending our knowledge on the impacts and the role of travel restrictions in response to COVID-19 (Sigala, 2020). Additionally, this paper is one of the few papers to utilise card expenditure data within a tourism context (Aparicio et al., 2022; Ren et al., 2024) and demonstrates its potential benefit within tourism research. We summarise the findings of each research question before presenting overall contributions.

- 1 How did domestic and international visitor markets respond to initial travel restrictions in terms of changes in expenditure?

International visitors displayed larger reductions in expenditure

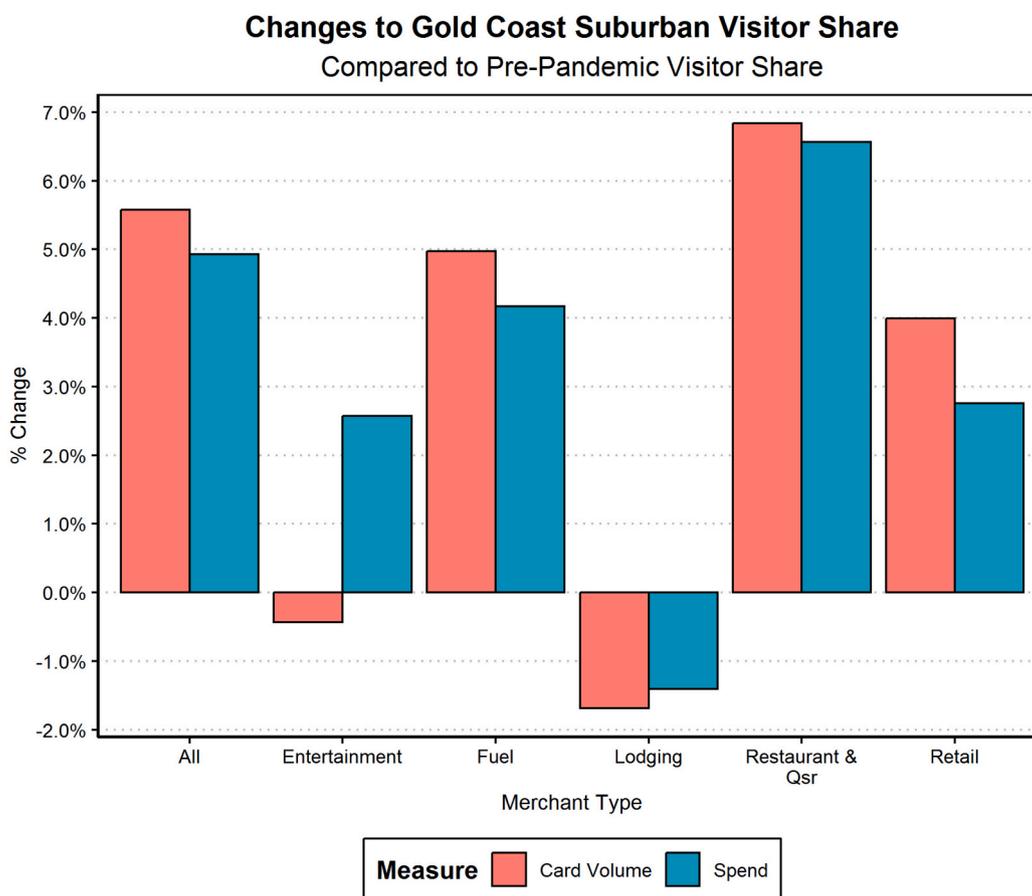


Fig. 7. Changes in Gold Coast Suburban Visitor Share by Expenditure Measure and Merchant Segment. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

after initial travel restrictions when compared to domestic visitors. Greater severity of restrictions, increased distance from the Gold Coast, and unstable pandemic conditions in visitor origins likely led to this greater impact, causing a persistent reduction in spend that delayed recovery.

- 2 What was the effect of easing restrictions on intra-state and inter-state expenditure and was this affected by asymmetries in restrictions for visitor origins and destinations?

Our results suggest that the removal of domestic border restrictions catalysed recovery in visitor expenditure, specifically through intrastate visitors. Expenditure within this market increased beyond pre-pandemic levels, suggesting that easing intra-state restrictions early can mitigate the economic impact of inter-state and international restrictions to support local businesses. While interstate expenditure can return to pre-pandemic levels, recovery was likely hindered by non-reciprocal travel arrangements, changing restrictions, and unstable conditions in visitor origins. The results imply that restrictions disrupted high-spend seasonal spending patterns, decreasing expenditure when in effect but boosting spend once lifted. Together, findings from research questions one and two provide empirical evidence of the economic effects of border closures and openings across visitor markets, particularly highlighting the importance of domestic tourism, which is underexplored in the literature.

- 3 How did spending behaviours change for different merchant segments and areas?

Travel restrictions disproportionately affect tourist-oriented businesses and areas. Merchant segments require differing levels of support during and after the pandemic, with associated policies to reflect these differentials. This may be with targeted stimulus or through proactive restrictions designed to reduce the risk of restrictions during high-value periods for these segments. Further, visitors have displayed more diverse spatial spending behaviours suggesting that visitors may be avoiding crowded areas during the pandemic.

While the previous findings pertain to the COVID-19 pandemic, this study has broader implications for tourism in the post-pandemic era and with respect to future crisis events:

- **Adaptable Methodology:** The time-series methodology applied within this study allows for dynamic events to be evaluated in higher resolution than has been previously studied in tourism. This approach can be applied to other economic analyses, such as natural disasters, terrorism impacts, major events, and long-term tourism infrastructure investments. By enabling near-real-time evaluation, this supports ongoing analysis of impacts and recovery across spatial regions, visitor markets, and expenditure segments.
- **Drivers of Impact and Recovery:** The study has identified several factors associated with increased costs of preventative measures and barriers to recovery, such as the severity of restrictions, proximity to the destination, non-reciprocal travel arrangements and pandemic conditions in visitor origins. This may lead policymakers to consider balancing health and economic outcomes, the need for coordination or bilateral agreements when easing restrictions, clear communication, and early, proactive measures to mitigate extended interventions during high-spend periods. Given that crises present an

ongoing risk to tourism, these findings contribute to future preparedness and planning strategies to stimulate recovery in future crisis events.

- **Differential Effects on Segments:** The results have highlighted that visitor markets, merchant segments and areas within a destination respond differently to external shocks. This demonstrates the need within tourism to improve our understanding of these differential impacts through more granular data collection and analysis. Through this analysis, stakeholders can develop more effective intervention, stimulus and resilience strategies that target the most vulnerable segments of the economy to enhance the stability and sustainability of the tourism sector.

This paper offers a platform for future research to address its limitations. Further studies could employ more sophisticated modelling techniques to enhance long-term forecasting and capture restriction effects simultaneously across multiple series. Incorporating transfer functions into the intervention analysis may clarify how quickly restrictions take full effect. Future research should also assess policy effectiveness and the role of bilateral agreements in building resilience across prolonged crises. The prolonged recovery of international markets and shifts in visitor behaviours highlight the need for long-term studies on economic impacts, persistent effects, and changes in traveller confidence. This study provides a background section to guide interpretation and identify the types of destinations where findings are most likely to generalise, and destinations where further research is needed. Further, the methodology can be adapted to other locations with different pandemic experiences to facilitate comparative insights. The aggregated card data cannot capture lengths of stay and distances from residences, making distinguishing tourism from other visitation types challenging. Access to the reason for travel data could allow further exploration of restriction impacts by tourist type.

CRediT authorship contribution statement

Mitchell Lewis Horrocks: Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Adrian Gepp:** Writing – review & editing, Supervision, Funding acquisition. **James Todd:** Writing – review & editing, Supervision. **Bruce James Vanstone:** Writing – review & editing, Supervision, Funding acquisition.

Declaration of competing interest

Financial support for this project is provided via a collaborative research agreement with the City of Gold Coast and an Australian Government Research Training Program (RTP) Scholarship. Ethical approval for this project has been granted from the Bond University Research Ethics Committee under ethics application MH02410.

As per the Declaration of interest, financial support and data for this project was provided by City of Gold Coast. Financial support was also provided by an Australian Government Research Training Program (RTP) Scholarship to Mitchell Horrocks. One of the authors (Horrocks) has also worked on a casual basis for City of Gold Coast in a data analyst role for some of the period when this research was being conducted. No other conflicts to report.

Ethical approval for this project has been granted from the Bond University Research Ethics Committee under ethics application MH02410.

Acknowledgements

The authors extend their gratitude to the City of Gold Coast for their support and assistance in providing access to the necessary data for this research. We would also like to thank Visa Consulting and Analytics for granting permission to utilise their data for research purposes. The authors would like to express their appreciation to Dr. Linda Osti for her

valuable insights and feedback on the initial draft of this study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.annale.2024.100163>.

References

- Aparicio, D., Hernández Martín-Caro, M. S., García-Palomares, J. C., & Gutiérrez, J. (2022). Exploring the spatial patterns of visitor expenditure in cities using bank card transactions data [article]. *Current Issues in Tourism*, 25(17), 2770–2788. <https://doi.org/10.1080/13683500.2021.1991898>
- Australian Bureau of Statistics. (2021a). Digital boundary files, Australian statistical geography standard (ASGS) edition 3. <https://www.abs.gov.au/statistics/standards/australian-statistical-geography-standard-asgs-edition-3/jul2021-jun2026/access-and-downloads/digital-boundary-files>.
- Australian Bureau of Statistics. (2021b). Household Impacts of COVID-19 Survey. Retrieved 01/03/2022 from <https://www.abs.gov.au/statistics/people/people-and-communities/household-impacts-covid-19-survey/latest-release#spending>.
- Blake, A., Sinclair, M. T., & Sugiyarto, G. (2003). Quantifying the impact of foot and mouth disease on tourism and the UK economy [article]. *Tourism Economics*, 9(4), 449–465. <https://doi.org/10.5367/00000003322663221>
- Bonham, C., Edmonds, C., & Mak, J. (2006). The impact of 9/11 and other terrible global events on tourism in the United States and Hawaii [review]. *Journal of Travel Research*, 45(1), 99–110. <https://doi.org/10.1177/0047287506288812>
- Boto-García, D., & Mayor, M. (2022). Domestic tourism and the resilience of hotel demand [article]. *Annals of Tourism Research*, 93, Article 103352. <https://doi.org/10.1016/j.annals.2022.103352>
- Box, G. E. P., & Tiao, G. C. (1975). Intervention analysis with applications to economic and environmental problems [article]. *Journal of the American Statistical Association*, 70(349), 70–79. <https://doi.org/10.1080/01621459.1975.10480264>
- Chang, S. L., Harding, N., Zachreson, C., Cliff, O. M., & Prokopenko, M. (2020). Modelling transmission and control of the COVID-19 pandemic in Australia [article]. *Nature Communications*, 11(1), Article 5710. <https://doi.org/10.1038/s41467-020-19393-6>
- Chen, Y. C., Kang, H. H., & Yang, T. C. (2007). A study on the impact of SARS on the forecast of visitor arrivals to China [article]. *Journal of Asia-Pacific Business*, 8(1), 31–50. https://doi.org/10.1300/J098v08n01_04
- Coshall, J. T. (2003). The threat of terrorism as an intervention on international travel flows [article]. *Journal of Travel Research*, 42(1), 4–12. <https://doi.org/10.1177/0047287503253901>
- Disegna, M., & Osti, L. (2016). Tourists' expenditure behaviour: The influence of satisfaction and the dependence of spending categories [review]. *Tourism Economics*, 22(1), 5–30. <https://doi.org/10.5367/te.2014.0410>
- Duro, J. A., Osório, A., & Perez-Laborda, A. (2023). Competition for domestic tourism in the COVID-19 pandemic: A characterization using a contest model [article]. *Tourism Economics*, 29(2), 378–391. <https://doi.org/10.1177/13548166211049870>
- Dwyer, L., Forsyth, P., Spurr, R., & VanHo, T. (2006). Economic effects of the world tourism crisis on Australia [article]. *Tourism Economics*, 12(2), 171–186. <https://doi.org/10.5367/000000006777637467>
- Economyid. (2021). Gold Coast City - Tourism and hospitality value. Retrieved 23/01/2021 from <https://economy.id.com.au/gold-coast/tourism-value>.
- Emili, S., Figini, P., & Guizzardi, A. (2020). Modelling international monthly tourism demand at the micro destination level with climate indicators and web-traffic data [article]. *Tourism Economics*, 26(7), 1129–1151. <https://doi.org/10.1177/1354816619867804>
- Enders, W. (2015). *Applied econometric time series* (Fourth edition. ed.). Wiley.
- Fang, Y., Zhu, L., Jiang, Y., & Wu, B. (2021). The immediate and subsequent effects of public health interventions for COVID-19 on the leisure and recreation industry [article]. *Tourism Management*, 87, Article 104393. <https://doi.org/10.1016/j.tourman.2021.104393>
- Goh, C., & Law, R. (2002). Modeling and forecasting tourism demand for arrivals with stochastic nonstationary seasonality and intervention [article]. *Tourism Management*, 23(5), 499–510. [https://doi.org/10.1016/S0261-5177\(02\)00009-2](https://doi.org/10.1016/S0261-5177(02)00009-2)
- Gold Coast Airport. (2020). Gold Coast Passenger Numbers Fall Significantly In September. Retrieved 11/12/2021 from <https://www.goldcoastairport.com.au/latest-news/gold-coast-passenger-numbers-fall-significantly-in-september>.
- Hall, C. M., Scott, D., & Gössling, S. (2020). Pandemics, transformations and tourism: Be careful what you wish for. *Tourism Geographies*, 22(3), 577–598. <https://doi.org/10.1080/14616688.2020.1759131>
- Haque, T. H., & Haque, M. O. (2018). Evaluating the impacts of the global financial crisis on tourism in Brunei [note]. *Tourism Analysis*, 23(3), 409–414. <https://doi.org/10.3727/108354218X15305418667011>
- Huang, J. H., & Min, J. C. H. (2002). Earthquake devastation and recovery in tourism: The Taiwan case [article]. *Tourism Management*, 23(2), 145–154. [https://doi.org/10.1016/S0261-5177\(01\)00051-6](https://doi.org/10.1016/S0261-5177(01)00051-6)
- Hyndman, R. J., & Athanasopoulos, G. (2021). *Forecasting: Principles and Practices*. 3. OTexts.
- IBISWorld Pty Ltd. (2021). *Credit card processing in Australia (AU industry (specialized) report Od5533)*. IBISWorld. <https://my.ibisworld.com/au/en/industry-specialized/od5533/major-companies>.

- Ito, H., & Lee, D. (2005). Assessing the impact of the September 11 terrorist attacks on U. S. airline demand [article]. *Journal of Economics and Business*, 57(1), 75–95. <https://doi.org/10.1016/j.jeconbus.2004.06.003>
- Jin, X. C., Qu, M., & Bao, J. (2019). Impact of crisis events on Chinese outbound tourist flow: A framework for post-events growth [article]. *Tourism Management*, 74, 334–344. <https://doi.org/10.1016/j.tourman.2019.04.011>
- Joo, H., Maskery, B. A., Berro, A. D., Rotz, L. D., Lee, Y. K., & Brown, C. M. (2019). Economic impact of the 2015 MERS outbreak on the Republic of Korea's tourism-related industries [article]. *Health Security*, 17(2), 100–108. <https://doi.org/10.1089/hs.2018.0115>
- Jorge-González, E., González-Dávila, E., Martín-Rivero, R., & Lorenzo-Díaz, D. (2020). Univariate and multivariate forecasting of tourism demand using state-space models [article]. *Tourism Economics*, 26(4), 598–621. <https://doi.org/10.1177/1354816619857641>
- Kock, F., Josiassen, A., Assaf, A. G., Karpen, I., & Farrelly, F. (2019). Tourism ethnocentrism and its effects on tourist and resident behavior [article]. *Journal of Travel Research*, 58(3), 427–439. <https://doi.org/10.1177/0047287518755504>
- Kuo, H. I., Chen, C. C., Tseng, W. C., Ju, L. F., & Huang, B. W. (2008). Assessing impacts of SARS and avian flu on international tourism demand to Asia [article]. *Tourism Management*, 29(5), 917–928. <https://doi.org/10.1016/j.tourman.2007.10.006>
- Li, J., Nguyen, T. H. H., & Coca-Stefaniak, J. A. (2021). Coronavirus impacts on post-pandemic planned travel behaviours [article]. *Annals of Tourism Research*, 86, Article 102964. <https://doi.org/10.1016/j.annals.2020.102964>
- Li, S., Blake, A., & Cooper, C. (2010). China's tourism in a global financial crisis: A computable general equilibrium approach [article]. *Current Issues in Tourism*, 13(5), 435–453. <https://doi.org/10.1080/13683500.2010.491899>
- Lim, C., & McAleer, M. (2001). Monthly seasonal variations: Asian tourism to Australia. *Annals of Tourism Research*, 28(1), 68–82. [https://doi.org/10.1016/s0160-7383\(00\)00002-5](https://doi.org/10.1016/s0160-7383(00)00002-5)
- Lim, W. M., & To, W. M. (2021). The economic impact of a global pandemic on the tourism economy: The case of COVID-19 and Macao's destination- and gambling-dependent economy [article]. *Current Issues in Tourism*, 25(8), 1258–1269. <https://doi.org/10.1080/13683500.2021.1910218>
- Liu, Y. Y., Tseng, F. M., & Tseng, Y. H. (2018). Big data analytics for forecasting tourism destination arrivals with the applied vector autoregression model [article]. *Technological Forecasting and Social Change*, 130, 123–134. <https://doi.org/10.1016/j.techfore.2018.01.018>
- de Livera, A. M., Hyndman, R. J., & Snyder, R. D. (2011). Forecasting time series with complex seasonal patterns using exponential smoothing [article]. *Journal of the American Statistical Association*, 106(496), 1513–1527. <https://doi.org/10.1198/jasa.2011.tm09771>
- Mapbox. (2023). *Mapbox mapping platform*. Mapbox. <https://www.mapbox.com/maps>.
- McAleer, M., Huang, B. W., Kuo, H. I., Chen, C. C., & Chang, C. L. (2010). An econometric analysis of SARS and avian flu on international tourist arrivals to Asia [article]. *Environmental Modelling and Software*, 25(1), 100–106. <https://doi.org/10.1016/j.envsoft.2009.07.015>
- McCartney, G. (2021). The impact of the coronavirus outbreak on Macao. From tourism lockdown to tourism recovery [letter]. *Current Issues in Tourism*, 24(19), 2683–2692. <https://doi.org/10.1080/13683500.2020.1762549>
- Min, J. C. H. (2008). Forecasting Japanese tourism demand in Taiwan using an intervention analysis [article]. *International Journal of Culture, Tourism and Hospitality Research*, 2(3), 197–216. <https://doi.org/10.1108/17506180810891582>
- OpenStreetMap contributors. (2023). OpenStreetMap. <https://www.openstreetmap.org/>.
- Park, K., & Reisinger, Y. (2010). Differences in the perceived influence of natural disasters and travel risk on international travel [article]. *Tourism Geographies*, 12(1), 1–24. <https://doi.org/10.1080/14616680903493621>
- Pham, T. D., Dwyer, L., Su, J. J., & Ngo, T. (2021). COVID-19 impacts of inbound tourism on Australian economy [article]. *Annals of Tourism Research*, 88, Article 103179. <https://doi.org/10.1016/j.annals.2021.103179>
- Polyzos, S., Samitas, A., & Spyridou, A. E. (2020). Tourism demand and the COVID-19 pandemic: An LSTM approach [article]. *Tourism Recreation Research*, 46(2), 175–187. <https://doi.org/10.1080/02508281.2020.1777053>
- Prideaux, B. R. (1997). Korean outbound tourism: Australia's response [article]. *Journal of Travel & Tourism Marketing*, 7(1), 93–102. https://doi.org/10.1300/J073v07n01_07
- Prideaux, B. R., Laws, E., & Faulkner, B. (2003). Events in Indonesia: Exploring the limits to formal tourism trends forecasting methods in complex crisis situations [article]. *Tourism Management*, 24(4), 475–487. [https://doi.org/10.1016/S0261-5177\(02\)00115-2](https://doi.org/10.1016/S0261-5177(02)00115-2)
- Ramlall, I. (2024). Modeling the impact of COVID-19 on the tourism sector in Mauritius: A dynamic stochastic general equilibrium analysis [article]. *Annals of Tourism Research Empirical Insights*, 5(2), Article 100130. <https://doi.org/10.1016/j.annale.2024.100130>
- Reitano, A., Fazio, M., Schirripa Spagnolo, F., & Karanasios, N. (2021). The Covid-19 impact on the tourism industry: Short holidays within National Borders. *Symphonya. Emerging Issues in Management*, (2), 85–98. <https://doi.org/10.4468/2021.2.08reitano.fazio.schirripa.karanasios>
- Ren, M., Xu, Y., Park, S., Huang, X., Sun, M., Xia, J., & Koh, S. Y. (2024). Consumer spending during COVID-19 in a tourism city [article]. *Annals of Tourism Research*, 109, Article 103830. <https://doi.org/10.1016/j.annals.2024.103830>
- Ritchie, B. W., & Jiang, Y. (2019). A review of research on tourism risk, crisis and disaster management: Launching the annals of tourism research curated collection on tourism risk, crisis and disaster management [article]. *Annals of Tourism Research*, 79, Article 102812. <https://doi.org/10.1016/j.annals.2019.102812>
- Rosselló-Nadal, J., & He, J. (2020). Tourist arrivals versus tourist expenditures in modelling tourism demand [article]. *Tourism Economics*, 26(8), 1311–1326. <https://doi.org/10.1177/1354816619867810>
- Rubina Nava, C., Osti, L., & Zoia, M. G. (2023). From quantity to quality: Capturing higher spending markets through a segmentation of Travelers' expenditure [article]. *Journal of Travel Research*, 62(1), 75–90. <https://doi.org/10.1177/00472875211054568>
- Sigala, M. (2020). Tourism and COVID-19: Impacts and implications for advancing and resetting industry and research [article]. *Journal of Business Research*, 117, 312–321. <https://doi.org/10.1016/j.jbusres.2020.06.015>
- Škare, M., Soriano, D. R., & Porada-Rochoń, M. (2021). Impact of COVID-19 on the travel and tourism industry [article]. *Technological Forecasting and Social Change*, 163, Article 120469. <https://doi.org/10.1016/j.techfore.2020.120469>
- Song, H., Li, G., Witt, S. F., & Fei, B. (2010). Tourism demand modelling and forecasting: How should demand be measured? [article]. *Tourism Economics*, 16(1), 63–81. <https://doi.org/10.5367/000000010790872213>
- Song, H., Qiu, R. T. R., & Park, J. (2019). A review of research on tourism demand forecasting [article]. *Annals of Tourism Research*, 75, 338–362. <https://doi.org/10.1016/j.annals.2018.12.001>
- Su, Y. W., Lin, H. L., & Liu, L. M. (2012). Chinese tourists in Taiwan: Crowding out effects, opening policy and its implications [article]. *Tourism Management Perspectives*, 4, 45–55. <https://doi.org/10.1016/j.tmp.2012.04.003>
- Tourism Research Australia. (2019a). Local Government Area Profiles 2019. Retrieved 12/12/2021 from <https://www.tra.gov.au/Regional/local-government-area-profiles>.
- Tourism Research Australia. (2019b). National Visitor Survey. <https://www.tra.gov.au/Data-and-Research/publications>.
- Tourism Research Australia. (2023a). Regional expenditure methodology. Retrieved 20/03/2023 from <https://www.tra.gov.au/About-us/Methodology/regional-expenditure>.
- Tourism Research Australia. (2023b). TRA online [unpublished data]. <https://traonline.tra.gov.au/webapi/jsf>.
- Visa. (2022). Visa Fact Sheet: A global payments technology company at a glance. Retrieved 25/03/2023 from <https://www.visa.com.au/content/dam/VCOM/global/about-visa/documents/aboutvisafactsheet.pdf>.
- Wang, Y. S. (2009). The impact of crisis events and macroeconomic activity on Taiwan's international inbound tourism demand [article]. *Tourism Management*, 30(1), 75–82. <https://doi.org/10.1016/j.tourman.2008.04.010>
- Wickramasinghe, K., & Naranpanawa, A. (2023). Tourism and COVID-19: An economy-wide assessment [article]. *Journal of Hospitality and Tourism Management*, 55, 131–138. <https://doi.org/10.1016/j.jhtm.2023.03.013>
- Wu, D. C., Song, H., & Shen, S. (2017). New developments in tourism and hotel demand modeling and forecasting [article]. *International Journal of Contemporary Hospitality Management*, 29(1), 507–529. <https://doi.org/10.1108/IJCHM-05-2015-0249>
- Yang, M., Han, C., Cui, Y., & Zhao, Y. (2021). COVID-19 and mobility in tourism cities: A statistical change-point detection approach [article]. *Journal of Hospitality and Tourism Management*, 47, 256–261. <https://doi.org/10.1016/j.jhtm.2021.03.014>
- Zhang, H., Song, H., Wen, L., & Liu, C. (2021). Forecasting tourism recovery amid COVID-19 [article]. *Annals of Tourism Research*, 87, Article 103149. <https://doi.org/10.1016/j.annals.2021.103149>