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Using Gini decomposition to explore the multidimensionality of spatial dispersal for tourism promotion – the case of outgoing passengers in Queensland, Australia

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ABSTRACT

Visitor dispersal is critical in spreading tourism benefits to peripheral regions, with imbalances of visitors a problem for many tourism organisations that warrants better tools for analysis. Gini decomposition of the length of stay and expenditures was used to measure visitor dispersal based on survey data of international visitors (n = 819) departing from Brisbane International Airport. Biplot visualisation and stacked contribution bar charts revealed multiple dimensions of visitor traits influencing dispersal across eight subregions in Queensland and their complex offsetting or compounding dispersion/concentration effects. Our results suggest that including expenditure provides a more comprehensive understanding of dispersal, highlighting "high spend, short stay" visitors.

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Introduction

Tourist visitations and their associated spending are often concentrated in gateway cities or attractions, leading to issues such as overtourism. In countries such as Australia, policies have been developed to disperse tourism activity into regional areas and enhance sustainability and productivity in the industry. Various destination marketing organisations (DMOs) have implemented similar dispersal policies worldwide, using solutions such as seasonal controls, new itineraries and attractions, visitor segmentation, and marketing targeted at higher-spending visitors (Australian Trade and Investment Commission, 2022; Directorate-General for Tourism of Italy, 2017; Government of Canada, 2019; Korean Government, 2019; World Tourism Organization, 2019).

Visitor dispersal patterns are, however, different across markets; a better understanding of where and how tourists disperse and who is (or is not) dispersing is essential in devising targeted dispersal strategies or policies. Additionally, dispersing visitors and their associated benefits to regional destinations is a long-standing goal of policymakers (Tourism and Events Queensland, 2016; Tourism Research Australia, 2019) and academics (Koo et al., 2012; Oppermann, 1994; Wray et al., 2010). This applies to Australia, which is a vast "island" country, as the problem of overtourism is more a spatial than a temporal imbalance issue. However, enticing tourists to disperse to less visited destinations is challenging, as a willingness to travel further varies (Jamieson & Jamieson, 2019).

There is a need to understand better the segmentation of tourist expenditure dispersal, which is vital for designing effective visitor dispersal policies to achieve more regionally equitable tourism

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development. However, there has been a limited choice of metrics on how to measure dispersal, often due to data availability and ease of use. Visitation measures, such as length of stay, have been widely used, but they only serve as proxies for actual economic benefits such as expenditures. The complex interrelation has been a problem in highlighting which markets are more dispersive to develop more targeted and effective promotion efforts in these markets.

Based on the above, this study is motivated by the desire to understand better which kind of visitors are more (or less) likely to disperse in terms of their length of stay or spending across a set of destinations. To address the lack of useful local visitor expenditure data, we conducted a dedicated international visitor departure survey with questions about their spending, which has yet to be analysed in prior dispersal studies.

In the following section, we first outline the fundamental theoretical underpinnings and evolution of tourist dispersal studies, followed by a description of the case study area. The Gini decomposition methods are then outlined, followed by the results of the Gini decomposition analysis with multiple dimensions. After discussing the implication of the results, the research limitations and recommendations for future research are also summarised.

Literature review

Tourism represents a spatiotemporal phenomenon in which travellers traverse geographic space at a certain time during their travels. The concentration of tourist activities may cause adverse impacts, e.g. exceeding the carrying capacity of a destination and causing dissatisfaction among tourists and discontent among residents. This has consequently led to the development of policies or market strategies aimed at dispersing visitors to lesser frequented regions or arriving during off-peak periods, as well as studies about "imbalances". For temporal imbalances, the term "seasonality" has been characterised as an "imbalance between supply and demand in a given tourist destination over the course of the year" (Butler, 1994, p. 332), while a parallel concept can be applied to "spatiality" across a set of destinations within a jurisdiction. However, it is often referred to as "dispersal" in the context of tourism research. Tourist dispersal can be defined as the spatial distribution of tourist economic activity (Bohlin et al., 2020; Fujita et al., 1999). This refers to trips involving more than one destination (or multidestination travel) dispersed over a geographical space (Lew & McKercher, 2006; Lue et al., 1993; Mings & Mchugh, 1992; Santos et al., 2012; Wu & Carson, 2008). There has been greater emphasis on "seasonality" than "spatiality" (of dispersal) found in the tourism research literature (Lau et al., 2017).

Measuring imbalances of tourism distribution

Various metrics have been developed to measure the level of imbalance across space, time, or both. While it is possible to compare the figures of visits by region (Tideswell & Faulkner, 1999), analysing the extent of imbalances mathematically often yields better comparison results.

For the more advanced studies of seasonality, early work used fractional ratios (Seasonality Ratio) or difference to standard deviations (Coefficient of Seasonal Variation) (Yacoumis, 1980) was applied. Soon after, Gini was also borrowed from the field of economics to address the shortcomings of fractions/variance methods (Wanhill, 1980), and it has become a mainstay of seasonality metric (Fernández-Morales et al., 2016; Fernández-Morales & Mayorga-Toledano, 2008; Koenig-Lewis & Bischoff, 2005; Lundtorp, 2001), but research has also explored Theil/Atkinson indices (generalised entropy) (Duro & Turrión-Prats, 2019) or Herfindahl–Hirschman index was also used (Tsitouras, 2004). More recent seasonality studies have even adopted measures developed on meteorology (e.g. precipitation concentration) (Lo Magno et al., 2017) or production efficiency (e.g. data envelopment analysis (DEA)) (Pérez-Granja & Inchausti-Sintes, 2023) and complex pattern detection and clustering (Tsiotas et al., 2021), partly to address some of the shortcomings of Gini. However, metrics suitable for measuring seasonality (recurring cycles) may not be suitable for dispersal studies. Similarly, in dispersal studies, fraction-based indicators were often used as a comparative measure in earlier studies, with the pioneering Trip Index (measuring the share of the length of stay of each destination to the entire trip) being the more prominent one (Pearce & Elliott, 1983). Later, a similar Penetration Index was developed by Oppermann (1997) to measure the concentration of visitors to a particular destination to highlight the effect of gateway cities. Another Tourism Penetration Index (TPI) that concerns the carrying capacity of destinations was developed by McElroy and de

Albuquerque (1998), which measures visitor numbers or expenditures (impact values) as the numerator and local population or land area (capacity values) as the denominator.

While fractional indices are easy to calculate and operate, they can only measure proportions (e.g. share) but not their size. With information loss when aggregated, they cannot account for within-group differences. While Koo et al. (2012) extended a fractional measure by validating the underlying factors of a dispersal ratio across visitor origin groups, this approach is not "decomposable". It omits within-group differences (Lau et al., 2017). Decomposability is an essential consideration as an inequality measure. It allows researchers to break down inequality into components to help identify which groups contribute most to overall inequality and target interventions accordingly. Gini decomposition was later expanded to measure multiple dimensions at the same iteration (Lau & Koo, 2017) and later group-specific dispersal patterns in spatial and temporal aspects (Lau & Koo, 2022).

While many ways have been developed to measure tourism imbalances, be it temporal or spatial, the choice of measure should be based on the context of the study and to balance the trade-offs of advantages/disadvantages. Some fundamental principles for dispersal metric development have been developed (Lau et al., 2017), and a preferable dispersal metric should satisfy the principles of i) the principle of transfer (or Pigou-Dalton Principle); ii) scale invariance; iii) the principle of population; and iv) decomposability, and the Gini index satisfies all four criteria for spatial dispersal. Other advantages of Gini are its intuitive interpretation as a relative measure and its ease of adaptation to different datasets. However, most dispersal studies have focused on tourist numbers or visitations rather than their expenditures.

Expenditure as a tourism benefit measure

One of the primary motivations for attracting international visitors is their higher spending levels, a significant benefit to local economies. Measuring spending directly is a better measure of the benefits of tourism than visitations or length of stay. However, collecting data about how much visitors have spent on a trip is difficult due to recall issues, and many respondents also consider this sensitive. Studies examining tourist expenditures tend to ask visitors to report their total amount for the trip (Park et al., 2020). Some studies have reported varying types of expenditures (Yun et al., 2006). Research on how exact spending is distributed across destinations has been relatively rare. For those who have access to the length of stay and expenditure data, an average spending per person per night (daily) or per destination can be computed (Dwyer & Forsyth, 2008; Pearce & Wilson, 1995; Wang & Davidson, 2010) as an "intensity of spending" per time or location visited. Country of origin and travel purpose strongly influence spending patterns in studies in Amsterdam (van Loon & Rouwendal, 2017) and regional Australia (Oppermann, 1994) – long-haul holiday makers tend to spend more.

As expenditure data are often unavailable, visitor nights remained the proxy variable of choice for tourism benefits. In Australia, the annual International Visitor Survey (IVS), conducted by Tourism Research Australia, collected categorised expenditure data for the whole reported journey but only from selected randomised locations, which required a regional expenditure model to provide an estimated aggregated spending for an area (Tourism Research Australia, 2005). Individual tourism spending data at the regional level was only available to Australian researchers if they conducted specific surveys. Instead of revealed preference based on past empirical data, stated preference surveys on expenditure were also used as an alternative way to estimate visitors' willingness to pay or visit (Koo et al., 2010a, 2010b), but these findings are hypothetical at best. Alternative ways to address tourist expenditures and their dispersal included Zoltan and McKercher's (2015) use of destination cards in estimating spatial and spending distribution. A destination card scheme is a unique way to collect spending and visit data, as it includes the user's personal details, purchased or provided by DMOs to grant free or discounted access to attractions in which the use of the card is logged. Gómez-Déniz et al. (2020) used expenditure survey data to model the determinants of the destination and origin spending of tourists visiting the Canary Islands. Alternatively, a "big data" approach was performed in more recent studies using bank card transaction data to analyse and map tourists' spatial or temporal distribution (Aparicio et al., 2021; Ramos & Sol Murta, 2022).

Geographical context

This study concerns the state of Queensland, which has diverse destination offerings to tourists.

Queensland, the third-largest state in terms of population, is the second-highest visiting state or territory in terms of international visitors (2.7 million in 2018–2019) in Australia. While there are 13 officially designated tourism regions in Queensland, to facilitate the survey, some of the smaller regions were combined into eight main tourism "subregions", as presented in Figure 1.

Queensland's international tourists primarily concentrate in the Tropical North, Great Barrier Reef and South East Queensland (SEQ) areas, including Brisbane, Gold Coast and Sunshine Coast. There are also some disparities by visitor origins and their travel purposes. Generally, younger (under 34 years old) holidaymakers, usually from Europe (light blue), are more dispersed to the north. The interior outback has not been that successful in attracting shorter-haul Asian markets. Middle-aged or older visitors tend to visit major population centres (mainly in SEQ) from New Zealand or the UK, who have extensive connections with the local population and hence more often visit friends/relatives (VFR). Figure 1 only describes a limited dimension of visitor traits at a time and is at the aggregated level.

Since Australia is an island nation, travel by air is the most common way to arrive. The role of airports in receiving international tourists is critical, and it has been evolving, especially in Queensland, which is the most decentralised in Australia. In Figure 2, Queensland's major international gateway airports are Brisbane International Airport (BNE), Gold Coast International Airport (OOL) and Cairns International Airport (CNS). In recent years, there has been a trend of increasing concentration of visitors arriving and departing from airports located towards the SEQ urban region. This was not the case in the late 1980s and early 1990s. The CNS held an approximately 30% share of international arrivals, which has taken over Townsville (TSV), as the latter dropped from approximately 5% to negligible levels. However, in the early 2000s, the CNS's secondary gateway role in Queensland was challenged by the

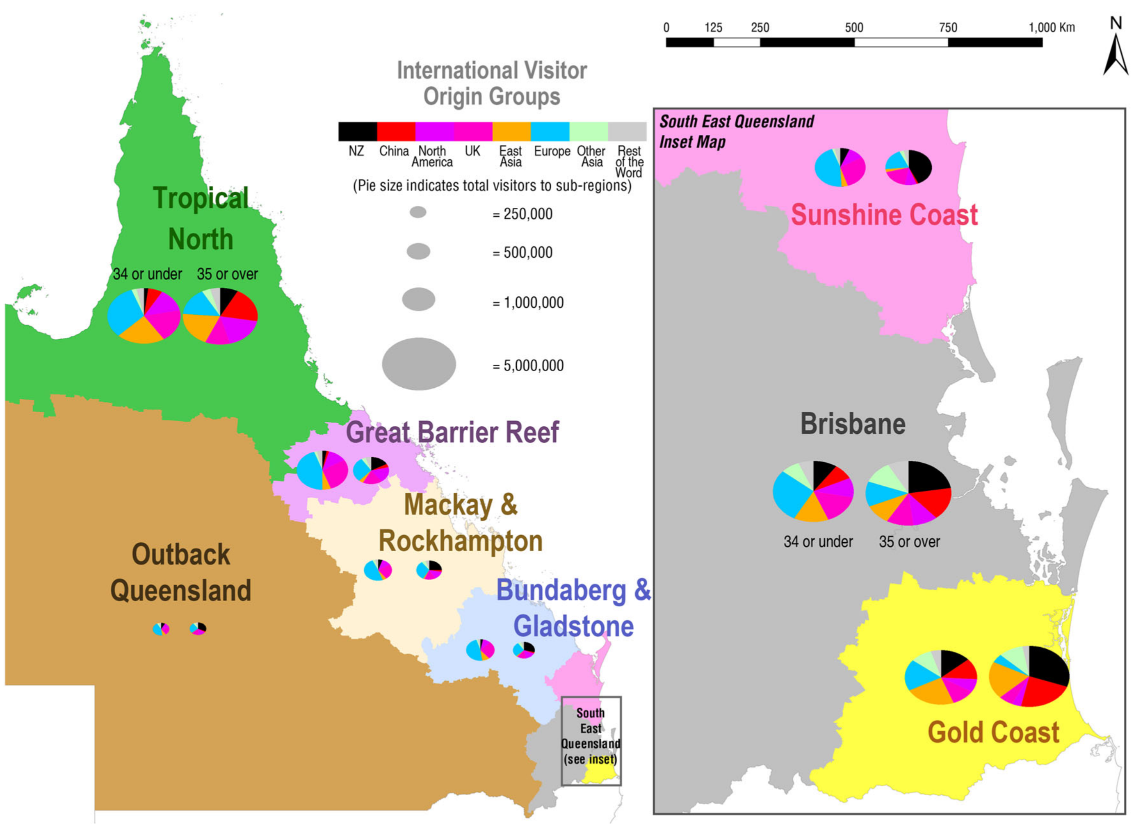

Figure 1. International visitors to Queensland subregions by origin groups. Note: Left pie indicates younger visitors (under 34 years old), and the right pie indicates middle age or older visitors (over 35 years old). Data source: International Visitor Survey, 2017.

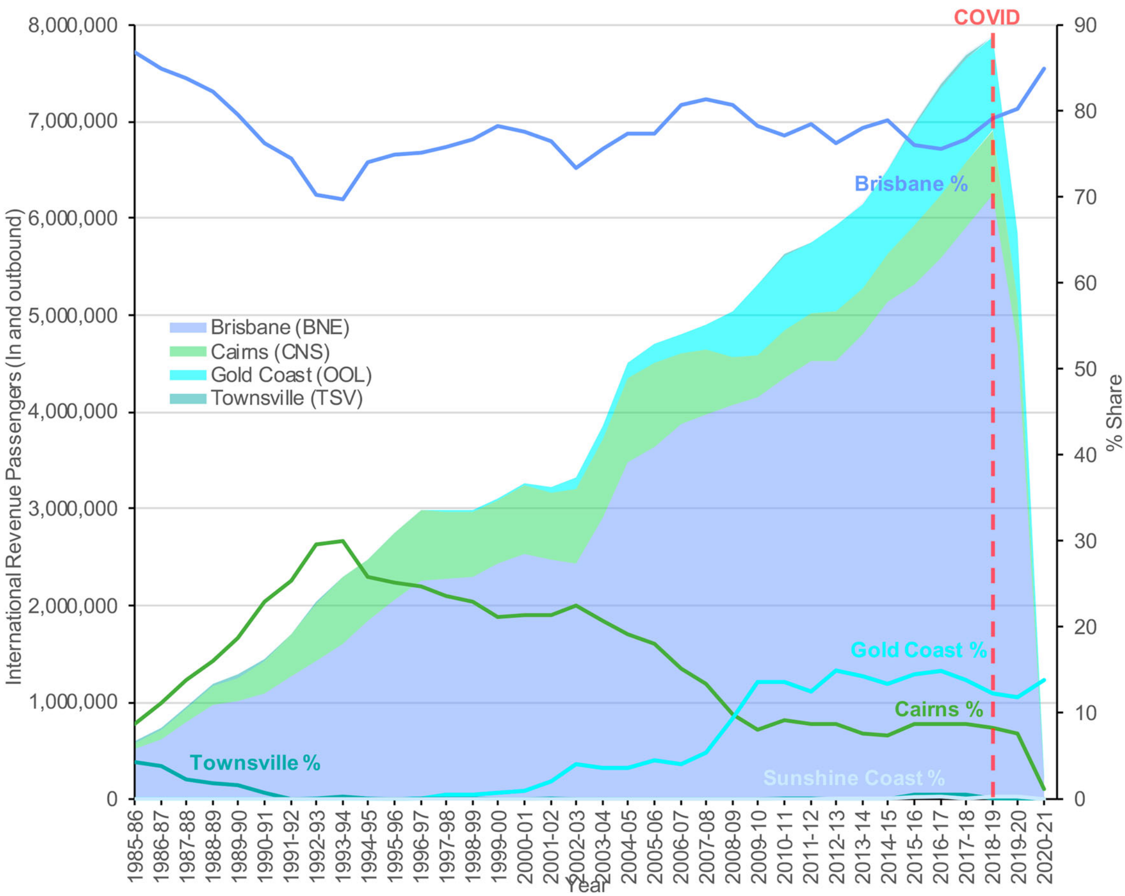

Figure 2. Changes in passenger share for the five major airports in Queensland (financial years from 1985–86–2020–21). Data source: Bureau of Infrastructure and Transport Research Economics.

rapid rise of OOL, partly due to the emergence of low-cost carriers. In 2020, the COVID pandemic effectively closed Australia's international border, resulting in very low traffic levels only through BNE and OOL. The impact on visitor dispersal is uncertain, but this will be a matter of future research.

Methodology

Gini decomposition and relative marginal effect (RME)

The Gini coefficient has traditionally been used to measure income inequality (the concentration of wealth or incomes) across a population. As outlined in the review in Section 2, tourism researchers have adapted this to understand the concentration or dispersal in tourism better, avoiding the pitfalls of using fractional metrics, especially being insensitive to volume. By adopting the Gini (initially an income inequity measure) to tourism dispersal, "population" is adapted as a set of tourism destinations or time-frames available (in our case, we measure the spatial spread of eight subregions as the possible destinations in Queensland), and "income" can be replaced by a metric that is considered tourism gains (e.g. duration of stay or expenditure).

Inequality, originally an economic concept, does not refer to a concentration of tourism activities – a higher Gini, with one being the maximum, means more concentrated. In the case of spatial dispersal, this can measure whether tourists are visiting fewer destinations. Conversely, a lower Gini value, with zero being the minimum, refers to a more dispersed pattern as tourists visit more destinations.

In addition to measuring the concentration or dispersal of tourist activity using Gini, we can decompose the "contribution of inequality" of specific subgroups.

Initially, in income inequality studies, this concept was used to identify which sociodemographic groups cause inequality (Mookherjee & Shorrocks, 1982) to devise more targeted welfare policies. Gini decomposition has also been applied recently in tourism research to identify the "contribution" of visitor traits to the concentration or dispersal of tourists, either spatially (Lau & Koo, 2017) or temporally (Fernández-Morales et al., 2016). One of the prevailing methods of Gini decomposition was developed by Lerman and Yitzhaki (1985), which expresses the Gini index in terms of covariances and has been widely regarded as an attractive approach in tourism imbalance studies (Duro & Turrión-Prats, 2022; Giorgi & Gigliarano, 2017).

This decomposition method can be represented in equation (1), where:

- k identifies a specific segment of the overall tourism market;
- G_k is the Gini coefficient for segment k;
- S_k is the share of segment k in the overall tourism market; and
- R_k is the Gini correlation between segment k and the entire market.

1)

The additive nature of this decomposition method allows the relative increment or decrement for each segment (k) of the tourist market to be measured by the relative marginal effect (RME_k, as in Equation 2) of the Gini coefficient (G). The RME quantifies in relative terms how the overall Gini changes in relation to an increase in the market size of a given source where all other factors are unchanged (ceteris paribus). The relative marginal effect of market k (RME_k) can be expressed as follows:

$$RME_k = \frac{S_k R_k G_k}{G} - S_k \tag{2}$$

Using RME as a dispersal metric is valuable because it can "decompose" the contribution to the total Gini by each respective market. It should be noted that the RME measures the relationship between a market segment's size and the Gini (dispersal), not the effect on visitor behaviour. RME, as a derived measure, allows for visualising dispersal with multiple dimensions (Lau & Koo, 2017). The resultant RME values are analysed using the multivariate graphical representation method of biplot developed by Fernández-Morales et al. (2016) and stacked bar charts as in Lau and Koo (2017). Biplot can show the Gini results of the sample size count, S_k and RME (contribution of a tourism market variable to Gini) effectively, which allows for easy identification of market segments by their direction of dispersal (low RME) or concentration (high RME) and their relative size (S_k). Stacked bar charts help visualise the extent of RME per market for each bi-level pair in relation to the overall uni-level RME.

Multidimensional decomposition

In its basic form, RME is measured unidimensionally: only one dimension (e.g. the country of origin) is decomposed at a time. Lau and Koo (2017) extended the original Gini decomposition method of Lerman and Yitzhaki (1985) to consider two dimensions simultaneously, utilising the additive nature of RME calculation as represented in Equations (3) and (4), where.

- source I refers to dimension X (e.g. visitor origin) and
- source J refers to dimension Y (e.g. travel purpose)

$$G = \sum_{1}^{I} \sum_{1}^{J} S_i S_{ij,i} R_i R_{ij,i} G_{ij} \tag{3}$$

$$RME_i = \sum_{1}^{j} RME_{ij} = \sum_{1}^{j} \frac{S_{ij} R_{ij} G_{ij}}{G} - S_{ij} = \sum_{1}^{j} \frac{S_i S_{ij,i} R_i R_{ij,i} G_{ij}}{G} - S_{ij} = \frac{S_i R_i G_i}{G} - S_i \tag{4}$$

The source can be decomposed by visitors' demographic information (e.g. visitor origin, travel purpose). By creating a subcomponent of the overall Gini, the RME can be decomposed into "sub-RMEs" (e.g. European tourists (origin) who are on holiday (purpose)). Since the RME is calculated additively, the sum of these sub-RMEs will equal the total origin RME of the European market in the overall Gini. The multidimensional decomposition of the Gini coefficient allows better analysis of the interrelationships of tourist sources, which was not possible in unidimensional fractional measures (e.g. trip index).

Quasi-subpopulation decomposition

Most tourism market traits (e.g. origin or purpose) are single-choice questions. However, in some cases, there are multiple choices for the variables. For example, the question "Which states/territories have you visited outside Queensland?" can be answered by multiple choices simultaneously (the other seven states/territories in Australia).

To overcome this problem of overlapping data in Gini decomposition, Lau (2020) developed a quasi-subpopulation decomposition technique, which also took advantage of the additive nature of the RME. The options not chosen in the question can be filled with zeros and then added. This approach allows the calculation of the RME with multiple-choice variables and provides additional variables for analysis. Lau and Koo (2017) demonstrated the use of RME in the length of stay to measure what variables impact dispersal in Australian tourism regions. Our study aims to test whether expenditure can be a useful indicator of dispersal. Some additional variables were also included for a state (subnational entity) setting – such as the mode of travel into a region.

The survey

In August 2019, an outbound international passenger survey was conducted at the closed departure area of Brisbane Airport (BNE) with security clearance. This survey was conducted in collaboration with the Brisbane Airport Corporation. BNE is Queensland's main gateway airport that accounts for 70% of the passenger traffic of the state. The survey team used hand-held tablet devices to survey passengers in the restricted area of the international departure terminal. Three screening questions were used to determine whether a passenger was eligible for the survey:

1. spent at least one night of their trip in a Queensland region;
2. did not live in Australia; and
3. was over the age of 18.

A total of 992 survey responses were recorded and entered into the dataset. The unit of study was a travel group to avoid duplication of individuals who belonged to the same group. A total of 819 (82.9%) responses were considered usable for further analysis. Responses with missing values or inconsistent answers were included. Some of the questions were identical to those in Australia's official International Visitor Survey (IVS) to allow for cross-comparison. Table 1 compares the surveyed sample with the IVS datasets in raw and interpolated forms. The interpolated form is weighted with Australia-wide arrival and departure statistics. Our survey's passenger profile was reassembled reasonably with the IVS (Table 1). We did not attempt to weight our responses to the IVS, as we are interested in the individual data patterns, not the aggregated form, to represent state-wide trends.

Descriptive and trip index analyses of the survey and IVS data have been conducted earlier *(citation redacted in this paper during review)*. This paper is an extension of prior work to explore the application of

Table 1. Comparison of descriptive statistics of the common variables between the BNE survey and International Visitor Survey (2017) with departures at Brisbane airport only).

Variable	BNE survey	IVS2017 (raw)	IVS2017 (interpolated)
Sample size (n)	819	5,210	1,089,068
Age (% share)			
15–24	21.98%	29.64%	15.93%
25–34	21.37%	25.22%	19.05%
35–44	17.46%	12.09%	15.52%
45–54	16.00%	11.06%	18.32%
55–64	13.43%	11.50%	17.89%
65+	9.04%	10.50%	13.28%
Age (mean)	40.54	38.00	44.07
Origin			
China (Mainland)	8.06%	12.48%	17.16%
East Asia	14.41%	14.28%	14.07%
Europe (excl. UK)	18.80%	13.78%	10.43%
New Zealand	14.77%	21.55%	23.87%
North America	14.04%	8.71%	9.70%
Other Asia	11.97%	10.94%	9.20%
UK	10.38%	9.04%	8.06%
Rest of the World	7.57%	9.21%	7.51%
Main purpose			
Holiday/Leisure	44.44%	39.92%	52.00%
Visiting Friends and Relatives (VFR)	28.08%	30.44%	25.71%
Business/Conference/ Events	16.97%	9.37%	8.89%
Education	8.06%	15.91%	7.04%
Other	2.44%	4.36%	6.35%
Regions nights stayed (mean)			
Brisbane (BRI)	16.16	28.14	18.23
Gold Coast (GC)	4.53	6.44	4.46
Sunshine Coast (SC)	2.73	2.72	2.17
Bundaberg and Gladstone (BG)	0.60	0.99	1.07
Mackay and Rockhampton (MR)	0.51	0.70	0.66
Great Barrier Reef (GBR)	0.68	0.52	0.42
Tropical North (TN)	1.89	2.06	1.48
Outback Queensland (OUT)	0.34	0.40	0.39
Total (in Queensland)	39.10	48.04	33.71
Airport of arrival in Australia			
Sydney (SYD)	13.31%	14.28%	16.26%
Melbourne (MEL)	6.96%	6.49%	8.08%
Brisbane (BNE)	73.14%	72.57%	68.49%
Gold Coast (OOL)	1.95%	2.80%	3.59%
Perth (PER)	1.34%	1.27%	1.04%
Other	3.30%	2.59%	2.54%

Gini decomposition in visitor dispersal measurement and analysis. The variables considered in this study, some modelled on the IVS, are listed in Table 2. We tested various options and found that visitor origin groups and travel purposes were the two most useful base pairs for decomposing with the other five visitor variables. The expenditure question in the survey specifically referred to expenses incurred while visiting a region, such as local accommodations, meals, or attractions. Tourist spending before visiting the region during the trip planning stage (e.g. airfare, accommodations or packaged tour bookings made before arrival) was not considered. This is a limitation, but there are difficulties in ascertaining whether such prearrival spending will flow through the region. For instance, airfares are not paid directly to local tourism businesses.

In this paper, we sought to measure the contribution of tourists in visiting a region, and how dispersed they were using the Gini decomposition with the following metrics:

1) visitor nights stayed in a region (N);
2) expenditure spent in a region (E); and
3) expenditure per visitor nights stayed in a region (hereafter referred to as DE - daily expenditure) computed per sample. This should be seen as a composite measure of i) and ii).

In some cases of overtourism, the external effects of visitation may incur some disbenefits (e.g. crowding, infrastructure strain). DE is a relative measure that captures tourists who spend only a few nights but spend a large amount at businesses in a certain location. In a usual sense, DE should not be aggregated, but by doing so, a measure of "tourist spending intensity" can be made.

Results

Uni-level Gini decomposition and RME calculation

The working proof showing how Gini and RME are decomposed with visitor origin and travel purpose is provided in Appendix (Table A1 and Table A2, respectively). The six variables used for decomposition in uni-level Gini decomposition are shown in Figure 3 as a series of biplots. The red arrows show the direction of the metrics. Count refers to the sample size of each variable. The "Share" here refers to the share of the nights stayed (N), expenditure (E), and expenditure per night stayed (DE) dispersed across the set of Queensland regions, with their corresponding RMEs. RME is a valuable measure to indicate the contribution of a source to the Gini coefficient. Figure 3 shows a 100% increase for a certain market source while *ceteris paribus* (provided all other variables remain the same).

Since a higher RME indicates high inequality of the measured value, the level of dispersal (or concentration) is clearly seen here. Short-haul Asian

Table 2. Key variables considered in the multilevel decomposition.

Visitor Origin Group	Travel Purpose	Length of Stay (in Queensland)	Port of Entry	Other States Visited	Queensland Regions Visited	Mode Used to Travel in Queensland
- China, Mainland (CN) - East Asia (other than Mainland China) (EAsia) - Europe (EU, other than the UK) (Eur) - North America (NA) - New Zealand (NZ) - Other Asia (OtAsia) - United Kingdom (UK) - Rest of the World (RotW)	- Business (Biz) - Education (Edu) - Holiday - Visiting Friends & Relatives (VFR) - Other	- 1–7 nights (1 week or less) - 8–14 nights (1-2 weeks) - 15–28 nights (2–4 weeks) - 29–60 nights (1–2 months) - Over 60 nights (more than 2 months)	- Adelaide (ADL) - Cairns (CNS) - Darwin (DRW) - Sunshine Coast (MCY) - Melbourne (MEL) - Gold Coast (OOL) - Perth (PER) - Sydney (SYD) - Townsville (TSV) - Other	- New South Wales (NSW) - Victoria (Vic) - Western Australia (WA) - Southern Australia (SA) - North Territory (NT) - Tasmania (Tas) - Australian Capital Territory (ACT)	- Brisbane (BRI) - Gold Coast (GC) - Sunshine Coast (SC) - Bundaberg and Gladstone (BG) - Mackay and Rockhampton (MR) - Great Barrier Reef (GBR) - Tropical North (TN) - Outback Queensland (OUT)	- Plane - Private car - Rental car - Bus/Coach - Train

Figure 3. Biplots showing the RME and share by the three-dispersal metrics.

markets (e.g. China, East Asia, and Other Asia) have a higher RME than longer-haul markets (e.g. Europe, the UK, and North America). In contrast, New Zealand is the closest to Australia, straddling in between. When expenditure is used as a metric, it tends to have a lower RME, meaning spending is more dispersed across Queensland, particularly for Chinese, New Zealand and other Asian visitors. There are exceptions to these results – North American visitors have more concentrated spending in fewer regions and are located away from the RME. (E arrow). The daily expenditure measure tends to be moderated (when N and E are in contradicting directions) or compounded (when N and E are both at high or low levels).

The first seven biplots are for uni-level Gini decomposition. For this purpose, it is unsurprising that holidaymakers are the most dispersive with RME. N and RME. arrows pointing against it, but educational visitors are the most concentrative regarding the length of stay with the RME. N arrow pointing towards its direction, but their level of spending was more dispersed across regions and with opposite RME. DE that is even more "dispersive" than holidaymakers. This is plausible, as students were not asked to report living expenses while studying, but they had spread some (possibly higher amounts) of tourism expenditures while on vacation breaks.

For the port of entry, Brisbane (BNE) is the most concentrated and has the highest share, while Sydney (SYD) is the most dispersed with a high share, followed by Melbourne (MEL) and other airports. For other states/territories visited, those who visited Northern Territories (NT) are the most dispersed in Queensland, followed by New South Wales (NSW), which has the largest count and share. For Queensland regions visited, Brisbane visitors are the least dispersed. However, here, the RME axes are pointed in different directions: Gold Coast visitors are the most concentrative in terms of NE but less concentrative for N and E; Tropical North visitors exhibit dispersive effects in terms of N and E but not DE, whereas Outback visitors are less dispersive in terms of N and E but more dispersive in terms of DE. For the mode used in Queensland, flying has the highest share and RME; hence, it has a concentrating effect. Buses and rental cars are considered dispersive modes. The train is limited by the location where it is available and hence has higher concentrating effects. In the uni-level analysis, we demonstrated that adding expenditure metrics to the Gini decomposition analysis, in addition to the length of stay as used in prior work, can provide a better picture of what is being dispersed. However, uni-level Gini decomposition can only show one variable at a time, but tourists can be identified not only by their origin but also by their purpose. The next section combines two variables at once, using bi-level Gini decomposition, and the remaining biplots will be explained there. We also offer a more detailed explanation of the uni-level analyses there.

Bi-level origin-purpose decomposition

Visitor origin versus travel purpose

Visitor origin was the base dimension, and travel purpose was decomposed (Figure 4). The top rows of Figures 4 and 5 stacked bar charts show the cross-decomposition of these two variables. The total RME in a subgroup is indicated by the black line, with a dot representing the value, which is also the result of uni-level decomposition (Table 3). This visualisation clearly shows the offsetting influences, with positive values being concentrative (to the right of the centreline) and negative values dispersive (to the left).

Our survey data's visitor night dispersal patterns are broadly consistent with the IVS data analysis conducted by Lau and Koo (2017). In Figure 3 (biplot), the points are colour-coded by purpose. We found that European holiday tourists are the most dispersive. However, Asian tourists are generally concentrated, with a very high share of decomposed travel purposes originating from education purposes. Conversely, the concentrative effects of European-education tourists slightly offset the dispersive effects of European tourists with other purposes.

In addition to visitor nights, we extended the bi-level decomposition to expenditure variables for comparison. Our findings are wide-ranging. One example is Chinese tourists, a key market before the COVID pandemic. The overall level of expenditure dispersal is more spread out when compared with visitor nights. The bi-level decomposition shows that Chinese holidaymakers are more dispersive in terms of geographical expenditure spread (i.e. their reported expenditures are more dispersed over regions), which can be explained by the stacked bar chart with the offset effects. First, the concentrative effects of nights of stay were contributed largely by those with education purposes, who did not report travel-related spending. Second, the actual spending of noneducational Chinese visitors was spread out as they visited more

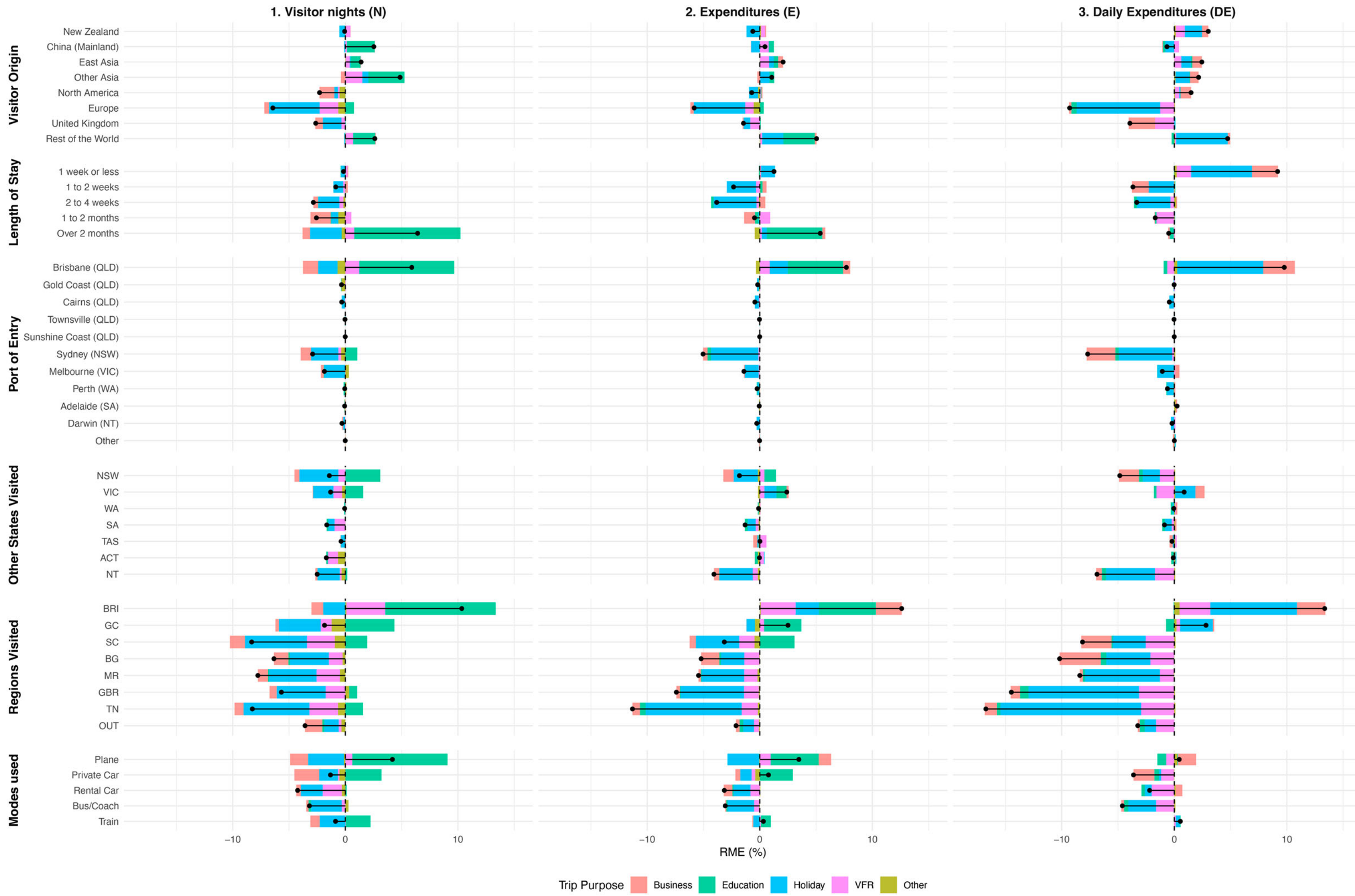

Figure 4. Bi-level Gini decomposition by travel purpose.

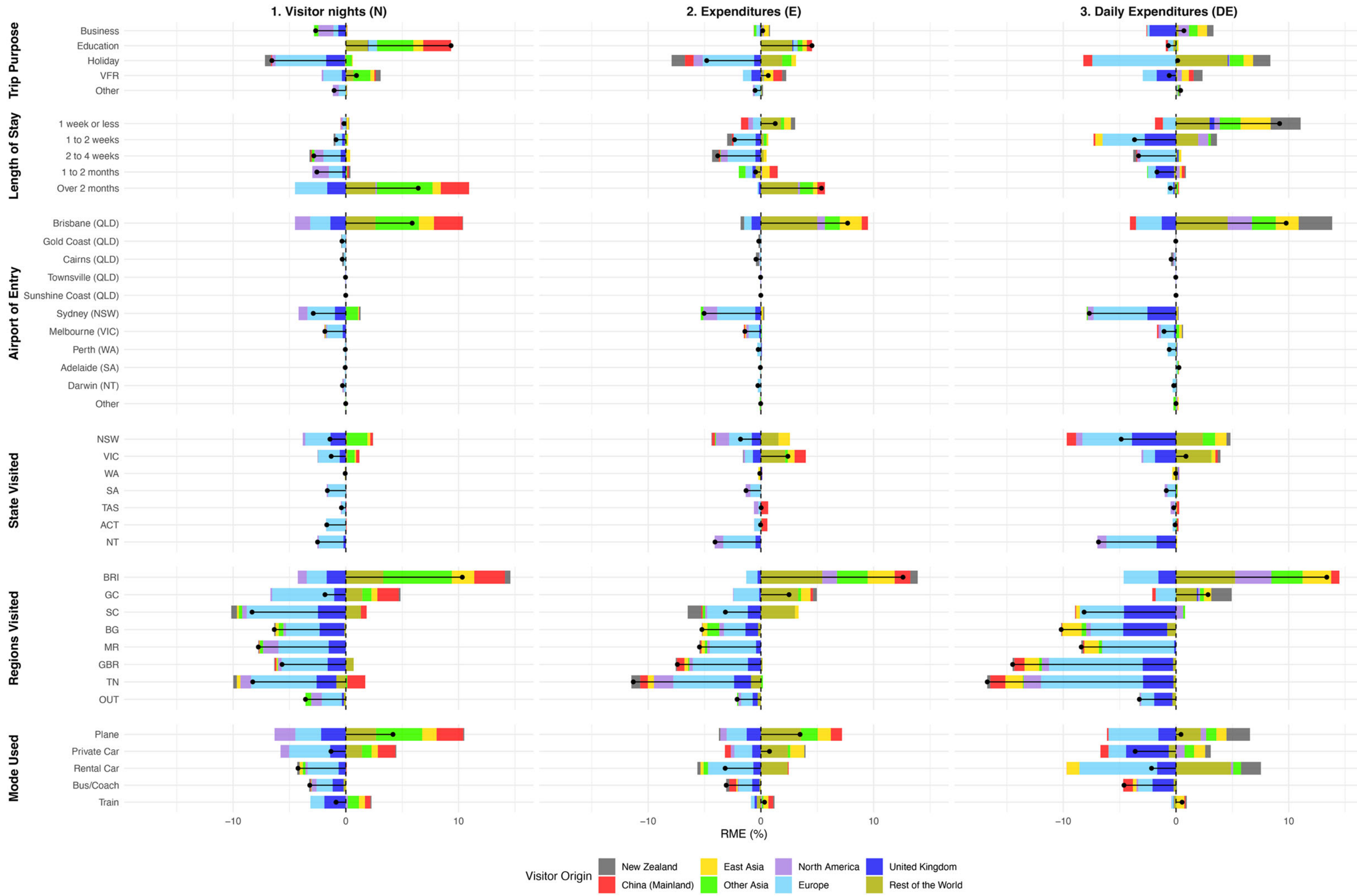

Figure 5. Bi-level Gini decomposition by visitor origin.

regions. This value disparity prompts a rethink of whether visitors' nights alone are an apt measure of tourism dispersal, especially the benefits. Conversely, European tourists exhibit the highest level of dispersion among all markets, regardless of visitor nights or expenditures. To understand the combined effect of visitations and expenditure, we also tested an intensity measure of expenditure, i.e. daily expenditure (DE). For the case of European holiday markets, their length of stay and expenditure are spreading in many regions across Queensland. This creates the opposite of the offset effect seen in Chinese visitors – a compounding effect was exerted on DE. This implies that European holiday visitors are high in spending and in the length of stay and are prime visitors to attract if dispersal of benefits is the key policy intention. Various patterns are also revealed for other origin-purpose pairs, generally differentiated by short-haul (Asian) versus long-haul (European and North American) markets. For this purpose, educational visitors are dominated by Asian markets, concentrated (in SEQ) and stay for more extended periods, distorting the length of stay dispersal metric. However, in terms of expenditure, those who stay approximately one to four weeks are more dispersive than those who stay for shorter or longer periods. As educational visitors tend to prebook their trips or plan lower impulse spending, their DE values are much lower. Conversely, those who stay less than a week have limited time to disperse across different regions, and their DE is highly concentrated.

Additional bi-level decompositions

We then extended the cross-decomposition of Gini by origin and purposes against the other variable pairs (see Table 2). These are also visualised as stacked bar charts in Figure 4 (visitor origin groups decomposed by travel purposes) and Figure 5 (travel purposes decomposed by visitor origin groups). We rely on the stacked bar charts to show their bi-level decomposition for brevity.

Airport of entry

The airport of entry refers to the first airport where international travellers entered Australia, as the respondents were surveyed while departing at BNE. Those travellers who entered Australia at BNE (same as departure) were less likely to disperse across the Queensland subregions. They were also more likely to be travelling for education purposes. Conversely, holidaymakers are more dispersive and tend to enter Australia via Sydney or Melbourne. This is possibly explained by the greater availability of international long-haul flights to these two cities. These visitors in our survey are leaving Australia via Brisbane, as they are not returning to their original port of entry as the port of departure. This pattern is also identified in New Zealand (Lohmann & Zahra, 2010). Other Queensland airports have small uptake, as they only offer flights from low-cost carriers or shorter haul flights (the furthest flight from OOL was to East Asia). Hence, the RMEs of those from airports in other Queensland airports were lower, with a higher proportion of the market share from UK and New Zealand visitors.

Other states visited (external dispersal)

We also collected data about which state or territories outside Queensland were visited. The "other states" visited variable is a multiple-choice question; the quasi-subpopulation decomposition technique must be used. An interesting observation is that visitors who visit the Northern Territory, a more remote and sparsely populated part of Australia, are highly dispersive in terms of length of stay and expenditure. Possibly, due to Sydney being Australia's largest primary gateway with the most international connections available, visitors who have visited NSW also exhibited a more significant dispersive effect in Queensland.

Regions visited in Queensland (internal dispersal)

In addition to external dispersal outside Queensland, we also examined the internal dispersal patterns within Queensland. This variable produces the strongest RME among all the variables. As the largest city and capital of Queensland, "visiting Brisbane" produces a very strong concentration effect, mainly from Asian tourists. However, those who ventured further to visit less "touristy" destinations became more dispersive as they visited more destinations along the way by chaining itineraries (Lau & McKercher, 2006). This effect was even stronger for DE. The visitors in our sample who travelled beyond the Sunshine Coast to the north, even those subpopulations with overall "concentrative" tendencies (e.g. short-haul Asian markets), were more dispersive. Surprisingly, the "visited Sunshine Coast" factor produced an even stronger dispersive RME than Tropical North for the nights stayed metric. Still, those who visited the Tropical North had a greater dispersion of expenditure across subregions. This is possible because the Sunshine Coast is a less

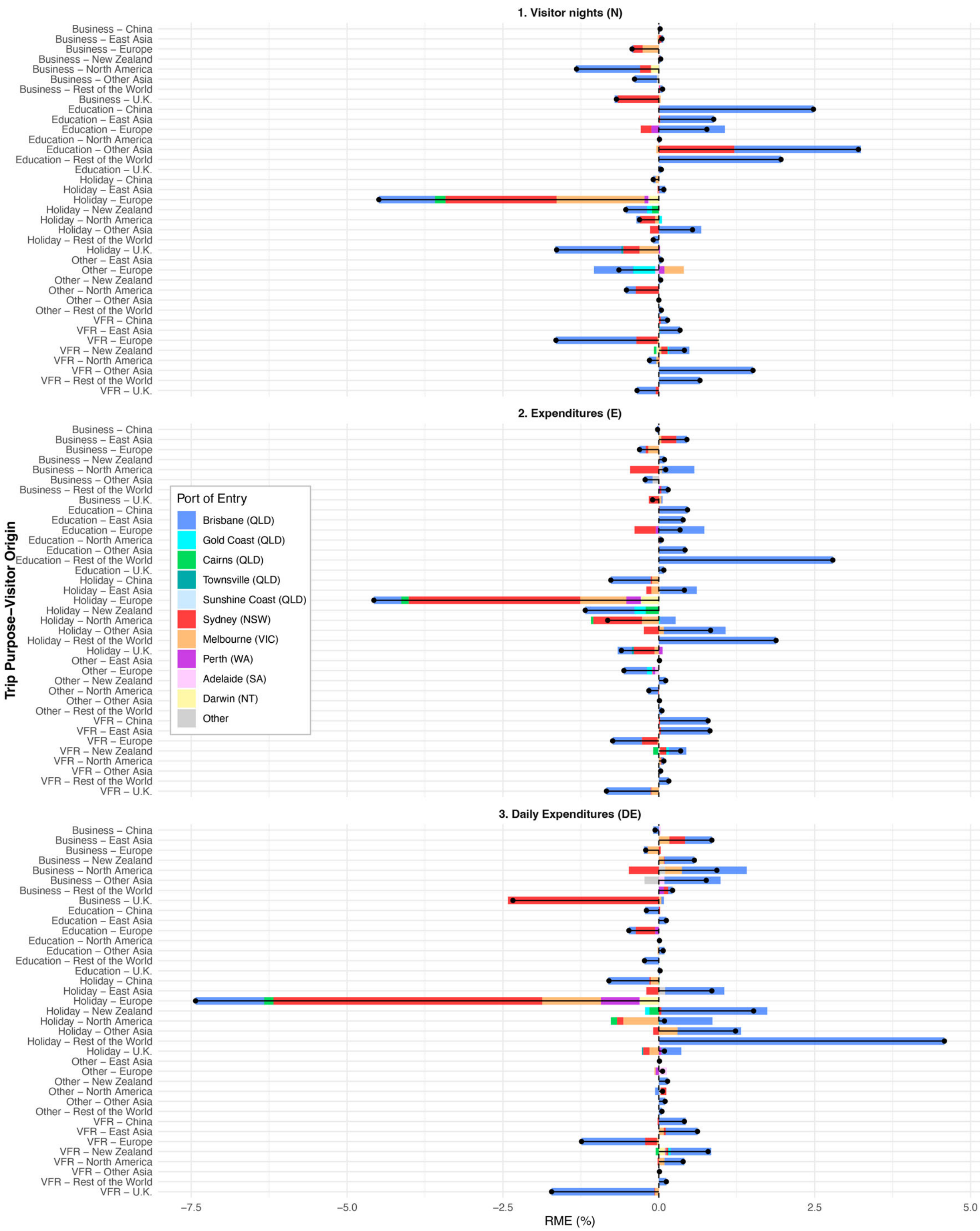

Figure 6. Tri-level Gini decomposition by port of entry versus purpose-origin.

common destination than the Tropical North, despite being adjacent to Brisbane.

By examining the dispersal impact of which internal regions are visited, we suggest that DMOs in Queensland should invest more in attracting tourists to venture into remote regions, as visiting these areas itself is more likely to promote longer stays and higher expenditure in more regions visited. This

Table 3. Bi-level Gini decomposition by visitor origin and travel purpose.

		RME (Visitor origin by travel purpose)					
Dispersal Metrics	Visitor Origin	Business	Education	Holiday	VFR	Other	Total RME of All Purposes
Visitor nights (N)	China (Mainland)	0.02%	2.47%	−0.10%	0.14%	0.00%	2.53%
	East Asia	0.05%	0.88%	0.08%	0.35%	0.04%	1.40%
	Europe	−0.43%	0.76%	−4.49%	−1.65%	−0.63%	−6.44%
	North America	−1.33%	0.01%	−0.31%	−0.14%	−0.52%	−2.29%
	New Zealand	0.02%	0.00%	−0.53%	0.42%	0.03%	−0.06%
	Other Asia	−0.39%	3.21%	0.53%	1.51%	0.00%	4.86%
	Rest of the World	0.05%	1.96%	−0.09%	0.66%	0.04%	2.62%
	United Kingdom	−0.67%	0.04%	−1.65%	−0.35%	0.00%	−2.63%
	Total RME of all groups	−2.68%	9.33%	−6.56%	0.94%	−1.04%	0
Expenditure (E)	China (Mainland)	−0.02%	0.46%	−0.77%	0.79%	0.00%	0.46%
	East Asia	0.44%	0.39%	0.41%	0.82%	0.01%	2.07%
	Europe	−0.31%	0.34%	−4.56%	−0.75%	−0.55%	−5.83%
	North America	0.11%	0.05%	−0.81%	0.08%	−0.15%	−0.72%
	New Zealand	0.09%	0.00%	−1.18%	0.36%	0.11%	−0.62%
	Other Asia	−0.22%	0.42%	0.82%	0.03%	0.01%	1.06%
	Rest of the World	0.16%	2.79%	1.88%	0.16%	0.05%	5.04%
	United Kingdom	−0.09%	0.08%	−0.60%	−0.84%	0.00%	−1.45%
	Total RME of all groups	0.16%	4.53%	−4.81%	0.65%	−0.52%	0
Daily expenditure (DE)	China (Mainland)	−0.07%	−0.20%	−0.80%	0.42%	0.00%	−0.65%
	East Asia	0.85%	0.12%	0.85%	0.62%	0.01%	2.45%
	Europe	−0.21%	−0.47%	−7.42%	−1.24%	0.05%	−9.29%
	North America	0.93%	0.02%	0.09%	0.39%	0.06%	1.49%
	New Zealand	0.56%	0.00%	1.53%	0.79%	0.14%	3.02%
	Other Asia	0.76%	0.06%	1.23%	0.01%	0.10%	2.16%
	Rest of the World	0.22%	−0.23%	4.58%	0.12%	0.05%	4.74%
	United Kingdom	−2.34%	0.02%	0.09%	−1.71%	0.00%	−3.94%
	Total RME of all groups	0.70%	−0.68%	0.15%	−0.60%	0.41%	0

is similar to the "Northern Territory effect" in the Other States Visited (external dispersal) variable.

Transport mode

The survey also collected data on how respondents entered the Queensland subregions during their visit. As a mode of transport, air travel exhibits a concentrative influence, as it is more costly to take short-haul flights or "airport hopping". In contrast, land-based modes allow visitors to explore along their route as a road trip with more stopovers, facilitating dispersal with more subregions being visited. Rental cars and buses/coaches are the most dispersive mode of transport. The uptake of these transport choices is more likely to be taken by European holidaymakers (possibly backpackers). We also observed that students and business travellers tend to fly or use privately owned vehicles to cross into other regions. In contrast, train users are slightly dispersive in their length of stay, but their expenses are slightly concentrated due to limited coverage by the Queensland Rail network. The Spirit of Queensland coastal main line offers a more reliable and comfortable service, whereas the various inland railways towards the interior attract fewer passengers.

Tri-level dimension decomposition of the port of entry with travel purpose and visitor origin

Combining travel purpose and visitor origin as "sources" of the length of stay and expenditures into a single dimension (purpose-origin) and then performing bi-level decomposition can lead to a "tri-level" decomposition. This could be useful for understanding the dispersion effects of airports used for entry, as outlined in Section 5.3.1.

In Figure 6, some "super dispersive" tourist market subsegments (having long bars towards the left) are highlighted, in particular, "European holiday travellers" decomposed by the airport of entry. This is also visible in the Figure 3 biplot. Again, the overall pattern shows that those who entered and exited via Brisbane during their stay in Australia tend to be concentrative – they do not venture too far from Brisbane, usually visiting Gold Coast only. Those who came to airports other than Brisbane are using different airports for entering and departing (as our survey is only conducted in Brisbane; hence, all passengers are departing at Brisbane). Having separate flights, not "returning" from the airport of entry, exhibits stronger dispersive tendencies. The overall dispersal effect is particularly significant for Sydney and, to a lesser extent, Melbourne – both are important international gateways that offer more long-haul flights than other airports. Marketing Queensland's attractions to tourists arriving on the interstate (particularly those landing in Sydney) might be a good option, as these tourists are likely dispersive, as indicated in our tri-level decomposition analysis of entry ports.

Student travellers are also found to be very concentrative in the tri-level analysis, regardless of which airport they choose to enter Australia. Business travellers, particularly those from the UK, "splashed" their spending much more often than other segments when measured daily. Although the refined two-level subsegments (origin-purpose) are being used as a source market in the tri-level decomposition, it should be emphasised that the sample size in such decomposition is smaller and may be subject to greater outlier effects.

Discussion, limitations and future research

Tourism is essential for Queensland, with visits concentrated in coastal areas and larger cities. In this study, we offered cross-variable multidimensional analysis. For the first time, we included expenditure as a metric in dispersal research as we know of and have advanced earlier Queensland-focused dispersal research to look beyond stopover numbers (Tideswell & Faulkner, 1999). The Gini decomposition presented in this paper reveals the otherwise masked multidimensional offsetting effects in a unidimensional analysis. This study compared the length of stay and regional visitor expenditure. This is a step further from prior Gini decomposition analysis concerning visitor dispersal (Lau & Koo, 2017).

Prior visitor dispersal research has focused on visitor night metrics, which is understandable, as they are more available to researchers. However, certain groups, such as education visitors, are likely to report longer stays, distorting this measure. Using our airport departure survey data, we included subregion visits and their associated expenditure questions, allowing this variable to be analysed in Gini decomposition analysis. Since the actual benefit of tourism to local areas could be in actual visitor money spent, this should interest tourism stakeholders, destination management organisations (DMOs) and local and regional governments. Combining length of day and expenditure using DE also provides a useful "spending intensity" measure – those spending more with shorter length of stay are identified. Gini decomposition again proves to be a formidable tool in supplementing the traditional fraction-based methods (Lohmann & Pearce, 2010; Tourism Research Australia, 2019) with deeper insights added in this study. Using travel purpose and visitor origin as "base pairs", these were cross-decomposed with five other variables: iii) length of stay, iv) port of entry, v) states outside Queensland visited, vi) transport mode used, and vii) Queensland regions visited. Gini decomposition can handle complex multi-dimensionalities better than fraction-based methods. This method could also be extended to analyse outgoing domestic travellers to international destinations, enriching a recent geodemographic study conducted at Gold Coast (Leung et al., 2017).

The analysis also revealed a series of unique dispersal patterns, demonstrating the need for researchers and tourism policymakers to consider the multidimensionality of visitor dispersal better. Prior research has been overly focused on visitor origin and nights, often stereotyping a certain nationality; for instance, Chinese tourists are concentrators in gateway cities and large spenders in those areas. This observation is only partly accurate, and our work challenges this preconception, revealing that the dispersal of Chinese visitors' expenditures is more widespread than their nights spent. Hence, multilevel decomposition shows more nuances, with visitor expenditures being dispersed more than the length of stay. Chinese (and other Asian) markets have a higher ratio of student travellers than other countries; the longer length of stay skews the impression of these markets being concentrators. As an alternative metric, expenditure changes this preconception.

Furthermore, the composite DE measure considers the length of stay and expenditures simultaneously, which can identify "high-yield" markets. The region visited dimension decomposed with origin and purpose also helps reveal those who visit more remote locations. If dispersal is the policy aim, future marketing should focus on these subgroups and travellers moving between states. Additionally, since interstate travellers visiting Queensland tend to be dispersed, marketing campaigns within Australia could be more cost-effective than overseas campaigns. Our work using Gini decomposition, biplots and stacked bar charts provided a relatively easy-to-use method for tourism policymakers and practitioners to visualise and identify the level of dispersiveness of each market. It could be expanded to different locations and types of metrics (e.g. supply-side factors such as hotel availability).

This paper makes the following methodological contributions: i) it lends further support to the use of Gini decomposition as a dispersal measure; ii) it demonstrates that expenditure should be included as a measure of "actual benefit" in addition to visitor nights as a proxy measure; and iii) DE could consider visitor nights and expenditures simultaneously. Gini decomposition can measure the market share contribution to the dispersal (Gini) of one or two variables in a multidimensional manner. This is an advancement on fraction-based dispersal measures that merely measure the share of values across regions. Furthermore, it should be noted that this work examines dispersal at a state (Queensland, Australia) level. Using the length of stay dispersal metric is similar to prior work examining the nationwide (Sydney-Australia) travel (Lau, 2020; Lau & Koo, 2017). The primary concentration effect of the most significant gateway airport for a particular region (Brisbane-Queensland) is also evident.

As for contribution to theory, our work opens up the avenue to explore dispersal using more metrics and explore the subnational entity and local dynamics for third-tier or "gamma cities" (Brisbane) or jurisdictions (Insch & Bowden, 2016). Our work focusing on intra-region travel in Queensland and an airport survey that extracted data otherwise unavailable in IVS (a national survey) can show which kind of interstate visitors were more dispersive. The primacy effect of airports is also significant, with visitors landing first from the airports of alpha/beta cities in Australia of, Sydney and Melbourne, found to be more dispersive. Brisbane (the third largest airport) and Queensland (the third largest state) have fewer airport connections to draw more dispersive holiday-making and long-haul tourists. Our work indicates that dispersal policies need to consider the effects of destinations as drawcards and travel nodes by their location, attractiveness, and transport availability.

Due to data limitations, we looked only at demand-side factors. We hope that future work will also explore supply-side factors (such as the number of tourist businesses, accommodations, and size of gross regional tourism product), as done by Wen and Sinha's Gini analysis (2009) – it is possible to use supply factor variables as the subject of interrogation. For brevity, to aid the survey flow, only the total expenditure within a region was gauged in the survey, without the types of expenditure. Better decomposition estimations are possible if spending categories are included. Some previous fractional studies could use such measures but with a more limited analysis of the visitor dispersal (Yun et al., 2006). Alternatively, tourist tracking with a digitalised diary or self-reported online travel journals/reviews could offer a reliable location (Su et al., 2020) or spending data (Ramos & Sol Murta, 2022; Shoval & Ahas, 2016).

It should be noted that the survey in this paper was cross-sectional; hence, examining long-term temporal dispersal or seasonality was not possible. Future dispersal work should consider spatial and temporal dimensions (Lau & Koo, 2022) should data be available. As dispersal metrics continue to develop, complex combined patterns may need better tools, with the transportation problem approach using supply-side metrics being quite promising in this regard (Ferrante et al., 2018, 2020; Lo Magno et al., 2017).

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Appendix

Table A1. Uni-level Gini decomposition by visitor origin with three dispersal metrics (N, E, DE).

Visitor source by Origin	Visitor source Gini (G_k)			Gini Correlation with total visitor contribution rankings (R_k)			Market Share (S_k)			G_k x R_k x S_k (workings to compute total Gini (G))			RME (% change in Gini from a 100% change in visitor source)		
	N	E	DE	N	E	DE	N	E	DE	N	E	DE	N	E	DE
China	0.78	0.67	0.54	1.00	0.96	0.90	0.11	0.08	0.08	0.09	0.05	0.04	2.53	0.46	-0.65
East Asia	0.75	0.74	0.64	0.99	0.99	0.99	0.08	0.10	0.13	0.06	0.08	0.08	1.40	2.06	2.45
Europe	0.47	0.43	0.35	0.99	0.98	0.80	0.24	0.19	0.19	0.11	0.08	0.05	-6.44	-5.83	-9.28
North America	0.49	0.60	0.64	0.89	0.95	0.93	0.07	0.10	0.12	0.03	0.06	0.07	-2.29	-0.72	1.49
New Zealand	0.63	0.58	0.65	0.99	1.00	1.00	0.06	0.12	0.14	0.04	0.07	0.09	-0.06	-0.62	3.02
Other Asia	0.79	0.71	0.67	0.98	0.95	1.00	0.21	0.10	0.08	0.16	0.07	0.05	4.86	1.06	2.17
United Kingdom	0.54	0.56	0.47	0.84	0.93	0.80	0.09	0.09	0.13	0.04	0.05	0.05	-2.63	-1.44	-3.94
Rest of the World	0.77	0.78	0.73	0.97	0.98	0.99	0.14	0.21	0.13	0.10	0.16	0.10	2.63	5.04	4.74
Sum							1.00	1.00	1.00	0.63	0.61	0.53	0.00	0.00	0.00

Table A2. Uni-level Gini decomposition by travel purpose with three dispersal metrics (N, E, DE).

Visitor source by Purpose	Visitor source Gini (G_k)			Gini Correlation with total visitor contribution rankings (R_k)			Market Share (S_k)			G_k x R_k x S_k (workings to compute total Gini (G))			RME (% change in Gini from a 100% change in visitor source)		
	N	E	DE	N	E	DE	N	E	DE	N	E	DE	N	E	DE
Business/ Conference/ Events	0.48	0.64	0.59	0.90	0.97	0.93	0.09	0.14	0.19	0.04	0.09	0.11	-2.68	0.16	0.70
Education	0.80	0.76	0.44	1.00	0.99	0.98	0.35	0.19	0.04	0.28	0.14	0.02	9.33	4.53	-0.68
Holiday/Leisure	0.46	0.55	0.54	1.00	0.99	0.98	0.24	0.45	0.58	0.11	0.25	0.31	-6.56	-4.81	0.15
VFR	0.58	0.64	0.52	0.99	0.99	0.99	0.27	0.20	0.17	0.18	0.12	0.09	-1.04	-0.52	0.41
Other	0.66	0.59	0.72	0.87	0.80	0.96	0.05	0.02	0.01	0.03	0.01	0.01	0.94	0.65	-0.60
Total							1.00	1.00	1.00	0.63	0.61	0.53	0.00	0.01	0.00