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Monetising crowding effect of cruise passengers in Sydney CBD

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Abstract

While the economic and environmental impacts of cruise ship visits are well researched, their social impacts have been mainly studied through a qualitative lens. Cruise ships unload large numbers of people within a relatively short time into typically already crowded tourist sites (Higgins-Desbiolles, 2019). Anecdotes around the world suggest that the crowding generated can be significant (Sanz-Blas, et al., 2019), indicating potentially high societal costs. Having increased people's awareness of crowds, the COVID-19 pandemic has most likely amplified these costs. Further, until it is eradicated, at least a degree of social distancing and other risk mitigation measures are likely to be a part of daily life. This increases the importance of better understanding the crowding impacts of cruise ships.

This paper develops a model to quantify the costs of crowding to the local community by cruise ship passengers. This is illustrated using the Sydney Central Business District (CBD) as a case study. It simulates cruise passenger dispersion in the Sydney CBD under two types of movement scenarios: (a) free roaming in micro groups on their own illustrating a pattern before the COVID-19 outbreak, and (b) controlled movement following a strategy developed by cruise operators considering COVID-19 measures. The cost estimation accounts for cruise passenger characteristics such as their demographics and walking speeds.

The paper finds that crowding can be significant under both movement scenarios, especially at already busy intersections with traffic lights. Under Scenario (a) where passengers roam freely, this effect is likely to be confined to the area close to the terminal as they disperse quickly and effectively blend into the crowds already present. Under Scenario (b) where they move in groups, the effect propagates throughout the entire inner city leading to substantially higher crowding cost. These results suggest that while movement under Scenario (b) can make tracing, relative to (a) it is likely increase crowding and thus possibly the chances of infection as social distancing will be more difficult.

1. Introduction

In the years leading up to COVID-19, the Australian cruise ship industry has seen strong growth at nearly 10 per cent a year since the early 2000s (Douglas, et al., 2018). Tourism from cruise ships may bring positive economic stimulus to the destinations (Cruise Lines International Association (CLIA), 2016-17), but it can also have negative social implications such as crowding perceived by the local community (Higgins-Desbiolles, 2019).

The economic and environmental impacts of cruise ships have been well researched, focusing on passenger, crew and cruise line expenditure, and vessel emissions. However, research on social impacts of cruise tourism is scarce. Social impacts range from changes in the perception of destinations' reputation, noise generated by visitors, and crowding. Out of these social impacts, crowding is attracting increasing attention in recent years (Sanz-Blas, et al., 2019).

When more than 3,500 passengers from a megaship (Silverstein, 2020) disembark at once, it can result in significant crowding indicated by excessive queuing in stores and restaurants, overuse of public facilities and infrastructure (Jet, 2018), as well as sidewalk congestion (McKinsey & Company, 2017). Overcrowding not only impacts the experience of visitors for the area (Sanz-Blas, et al., 2019) but more importantly decreases the quality of life for the local community (Zemla, 2020).

Crowding in major cruise tourist destinations prior to COVID-19 has often be regarded as an issue. As COVID-19 has led communities to become more aware of social distancing, the effects of crowding are becoming increasingly pronounced as it limits one's ability to socially distance. In Australia, these social distancing measures during outdoor activities require a physical distance of 1.5 metres between people. Although COVID-19 has impacted the number of cruises globally, there is evidence that these numbers are recovering (Puhak, 2021). As cruise activities resume, the crowding associated with cruise ships is likely to re-emerge and possibly intensify due to COVID-19 related measures. Focussing on this consideration, this paper provides a quantitative approach for assessing the impact of cruise ships on crowding through the estimation of crowding costs.

We develop a model simulating cruise passenger dispersion in the Sydney CBD as a case study. The simulation model follows a random walk mechanism to simulate the movement of individual passengers throughout the day. Sydney was chosen as a case study because with 279 cruise visits in 2019-20 (Australian Economic Consultants (AEC) Group, 2019) it received twice as many visits as the next most popular destinations in Victoria and Queensland.

2. Literature review

There has been extensive literature concerning the economics and environmental impacts of cruises in Australia such as AEC (2019) and CLIA (2016). However, limited research can be found on social impacts in general and especially crowding impact.

2.1. Crowding impacts of cruise tourism

According to Douglas et al (2018), the economic impact of the cruise tourism industry has typically been the focus of research, but social impacts, especially crowding, remain an issue in tourism destinations and is not as well researched. The negative impact of cruise tourists can be illustrated by the example of Akaroa (New Zealand), where cruise passengers were outnumbering residents five to one. This caused numerous congestion related problems, such as strain on facilities and infrastructure, crowding in public buildings and footpaths, and traffic congestion from tour buses. In addition to the inconvenience, such crowding can lead to economic implications as it negatively impacts the tourist sites' attractiveness.

This effect is pointed out by Gutberlet (2016) who explored the socio-cultural impacts on the traditional bazaar (Souq) in the district of Mutrah. 88 per cent of the German-speaking cruise tourists surveyed their experience in the Souq as being too crowded as the number of tourists entering the Souq exceeded the number of locals by 88 per cent.

The congestion caused by tourists also reduces the quality of life and raises dissatisfaction by local community members. Traffic congestion and inteference with their daily routine can lead to residents to avoiding ‘travel bubbles’ (Zapata & Brida, 2010). Cruise ships are one of the contributors to the crowding caused by the tourism industry. The issues caused by cruise tourism have increased in recent years and led to some tourist sites considering limiting them (Robbins, 2021). Smaller cities and sites can be easily overwhelmed by cruise tourism as it tends to release a large number of tourists within as short period of time. It has thus been recommended to limit cruise ships to larger cities (Avrami, 2013). Even for larger cities such as Venice, cruise tourism has been continuously criticised for its contribution to local crowding (Lakritz, 2020). Since 2010, there have been 20 to 30 million tourists arriving in Venice every year impacting the liveability of the surrounding areas, leading to a decrease in residents. For example, the number of residents in Venice lagoon and surrounding islands has halved since the 1950s due to over tourism. The intensification of this has led to cruise ships being banned from historic centres in Venice (Robbins, 2021). Sentiments are similar in other Mediterranean ports such as Dubrovnik.

In addition to cruise tourism’s impact on the community, the crowding it brought about is also found to be negatively impacting the attractiveness and success of places as a tourist site (Avrami, 2013). In an international survey by the Western Norway Research Institute, six to 25 per cent of tourists say that they are less likely to choose Norway’s Fjords as a travel destination if the nature product continues to be spoiled or influenced by unnatural visual elements.

2.2. Cost of crowding

The literature on the cost of crowding due to tourism is scarce. Within this limited literature, Neuts, et al., (2013) developed a method to quantify the crowding costs from tourists in general for Central Amsterdam. The method utilises a willingness to pay survey to obtain the local community’s perceived cost of crowding caused by tourism.

The study finds that the cost of crowding only applies after a certain crowding threshold. Below the crowding threshold, people appear to be at least indifferent to sharing a place with others and some may even consider it beneficial. When crowding levels rise above this threshold, people perceive crowding negatively and are willing to pay to reduce crowding to a more acceptable level.

The study estimates that for the average respondent, the willingness to pay is approximately 11 Euros per year to have an acceptable level of crowding of 45 to 70 people per 150m^2. Converting this figure to Australian dollars and extrapolating it to the relative crowding levels in Sydney CBD suggests that exceeding an acceptable level of visitation in Sydney by one per cent can be valued at $0.35 per year. [1]

3. Model assumptions

The simulation model is driven by a number of key assumptions, including attractions (or tourist destinations) in the Sydney CBD selected for this case study, time spent at each of the attractions, and disembarkation time of cruise ships which affects CBD crowding depending on the time of the day. These are discussed in further detail in the following sections.

3.1. Attractions

There are two cruise terminals in Sydney, White Bay in Balmain and Sydney Cove at Circular Quay. Sydney Cove Cruise Terminal is the key international terminal in Sydney, whereas White

[1] While this is the most applicable figure in this context, crowding costs are a common parameter in a range of transport economic assessments. For example, the Transport for NSW Cost-Benefit Analysis Guidelines quantify a range of parameters for crowding on trains and buses as well as at stations.

Bay Cruise Terminal only takes smaller cruise ships that can fit under the Harbour Bridge. As the main overseas passenger terminal, Sydney Cove Cruise Terminal has been selected for this case study. Most attractions in the Sydney CBD are within a 30-minute walking distance to Circular Quay. As such, the attraction destinations consist of popular Sydney tourist destinations within a 30-minute walking distance from the Sydney Cove Cruise Terminal at Circular Quay.

The attractions were selected based on TripAdvisor's most popular sites for the Sydney CBD. Travel routes were then identified based on the quickest routes between the terminal and the tourist destinations using spatial analysis. The historical pedestrian traffic was obtained from the data collected at collection sites located between the terminal and the destinations by City of Sydney. The pedestrian data collection captures the number of pedestrians throughout the day. As they are in Sydney's main shopping area, these intersections are likely to continue to be busy even as work from home is becoming more regular.

The above travel routes are illustrated in Figure 1 where quickest walking routes are highlighted. The pedestrian count sites are allocated to the nearest walking route within a 30-metre radius as shown below.

Figure 1: Sydney CBD attractions and tourist walking routes

Source: OpenRouteService..

3.2. Time spent at attractions

The time spent in each tour attraction was obtained from anonymous Google location data, shown in Table 1.

Table 1: Time spent at attractions

Destination	Destination category	Time spent in attraction (mins)
Circular Quay	City attractions	37.5
Sydney Opera House	City attractions	37.5
Sydney Harbour	City attractions	37.5
Sydney Tower Eye	City attractions	35
Sydney Observatory	City attractions	37.5
The Rocks Market	City attractions	40
Darling Harbour	Dining	60
King St Wharf	Dining	60
Royal Botanical Garden	Parks and gardens	120

Source: (Google , 2021).

3.3. Disembarkation time

The level of pedestrian crowding in the Sydney CBD varies across the day. The disembarkation time is relevant when simulating passenger dispersion given the time of day crowding variation. According to representative cruise itineraries, cruise passengers typically begin to disembark at around 9:00am. Considering the high volume of passengers, they are expected to disembark uniformly between 9:00am and 10:00am.

4. Input data

The main input data used were pedestrian counts and pedestrian walking speeds, which are key drivers of the level of crowding at CBD tourist sites. These are discussed in further detail in the following sub-sections.

4.1. Pedestrian movement data

We simulated cruise passenger dispersion in the Sydney CBD under two movement Scenarios:

a. Free roaming in micro groups on their own illustrating pattern before the COVID-19 outbreak

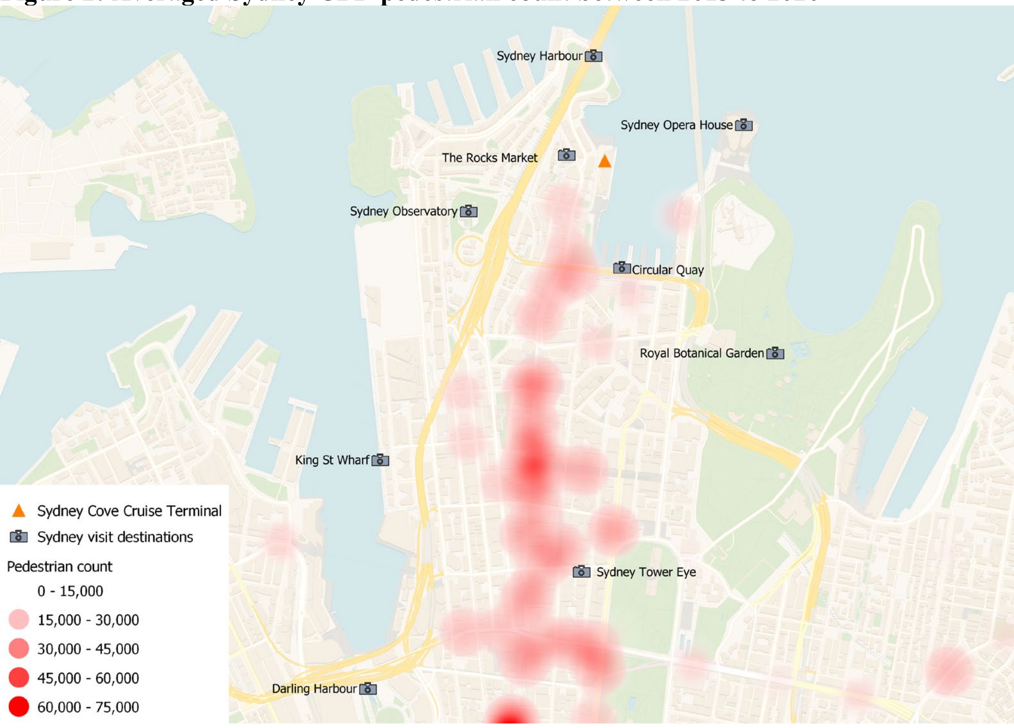
b. Controlled movement of larger groups following a strategy developed by cruise operators considering COVID-19 measures such as traceability.

4.1.1. Movement Scenario (a) – free roaming

The data is collected from 100 pedestrian count locations in the Sydney CBD between 6:00am to midnight on an average weekday. The pedestrian counts occur at hourly intervals; for each interval, the count covers ten minutes' pedestrian movement. This count is then proportionated into an hourly equivalent number. Figure 2 presents a heatmap of the resulting average daily pedestrian count between 2013 to 2020.

Although the pedestrian counts were collected on an hourly basis, the raw data was aggregated into daily pedestrian counts. For the purpose of this study, we split the daily Sydney counts data into two-minute phases. Not available for Sydney, the minute by minute distribution of pedestrians was derived using pedestrian data published by the City of Melbourne (City of Melbourne, 2021). The resulting estimates are likely to constate the lower limit of the crowding impact as cruise ship passengers are likely to be travelling in smaller groups such as family units.

Figure 2: Averaged Sydney CBD pedestrian count between 2013 to 2020



Note: The data includes a day on the weekend in March and October.

Source: (City of Sydney, 2019).

The simulation model was developed at individual passenger level and simulates the route choice of the passengers by drawing randomly generated passenger profiles including age and gender. The profile was considered as walking speed typically vary by gender and age. The key assumptions associated with the passenger profile are shown in Table 2.

Table 2: Passenger demographic profile assumptions

Passengers	Places visited	Passenger share	60 or above	Female
International	5.35	14%	74%	54%
Domestic	3.68	86%	39%	62%

Source: (Destination NSW, 2014).

To understand passenger movements, their walking speeds were considered as shown in Table 3. Walking speeds were randomised from a normal distribution using the combined mean and standard deviation based on gender and age attributes.

Table 3: Pedestrian walking speed

Category	Mean speed (m/s)	Standard Deviation
Gender		
Female	1.44	0.83
Male	1.54	0.94
Age group		
Under 60	1.50	0.25
60 or above	1.33	0.20

Source: (Truong, et al., 2018).

4.1.2. Movement Scenario (b) – controlled movement under COVID-19

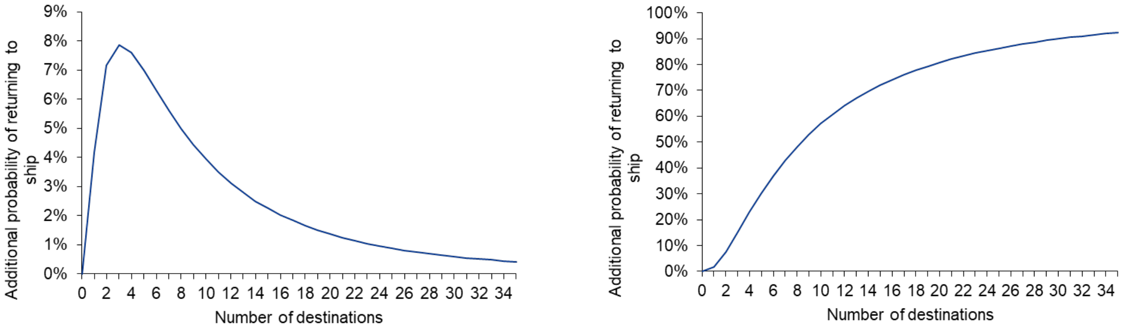
Given the COVID-19 influences, there is expected to be an increasing level of awareness of social contact and thus crowding. To provide an indication of the impact of cruise ships on crowding under the COVID-19 restrictions or considerations, a COVID-19 movement Scenarios (b) has been simulated.

Under movement Scenario (b), we assumed that cruise passengers travel in groups of 50 with a constant walking speed of 3.35km per hour. This walking speed is two standard deviations below the minimum mean walking speed to cater for the slower group members. All other assumptions under the movement Scenario (b) are identical to the movement Scenarios (a) discussed above. Alternate forms of transport such as bicycles would have a similar impact as the focus of this scenario is the movement of passengers around the CBD at the same speed.

4.2. Cruise passenger movements

The Sydney cruise passenger survey indicates that passengers, on average, visit three to four destinations. We can approximate the underlying probability function by plotting the number of destinations visited on the x axis, and the probability of returning to the terminal after each number of tourist sites visited on the y axis. Assuming a passenger visits at least one destination, the function is skewed to the right, indicating some passengers visit more than five destinations (so the average is three to four destinations as above). Therefore, we assume the probability function follows a log-normal distribution as shown in the left panel of Figure 3.

Figure 3: Log normal distribution function (left) and cumulative function (right) on cruise passenger movements



The cumulative distribution function is illustrated in the right panel of Figure 3, further demonstrating that the more destinations the passengers have visited, the more likely it is for them to return to the terminal after the mean of three to four destinations. Passengers are expected to maximise their time onshore, and once they return to the cruise terminal, they will not leave again. Passengers are assumed to only visit each destination once, therefore they either visit other destinations or return to the cruise terminal.

5. Crowding costs

Following Neuts, et al., (2013), we assume crowding costs to be linear. Each percentage increase in visitors as a result of cruise passengers corresponds to a cost to the local community, namely non-cruise individual's willingness to pay (WTP) for avoiding crowding. The WTP values are shown in Table 4 in AUD. Intersections are assumed to be of constant size and pedestrians are spread across all waiting points in an intersection for simulation purpose.

Table 4: People's WTP of crowding

Level of crowding	Description	Individual WTP of 1% increase
Crowded (baseline)	25 people/intersection	**$0**
Very crowded	Excess of 25 people/intersection	**$0.35**

Note: The willingness to pay is converted to AUD and indexed to Dec 20 using ABS 6401 Tables 1 and 2.
Source: (Neuts, et al., 2013).

The cost of crowding is the product of the WTP of avoiding crowding (above the crowded baseline) for the local community and the additional pedestrians brought by the cruise ships. For example, if there were 20 pedestrians at a particular intersection, and a cruise ship brings in ten additional pedestrians, this results in an excess of five pedestrian above the crowded baseline (of 25 people). The 20 per cent increase (five over 25) to the baseline is reflected in the local community's willingness to pay of $7 per person (applying $0.35 to 20 per cent increase), resulting in an overall crowding cost of $140 per year.

6. Simulation model

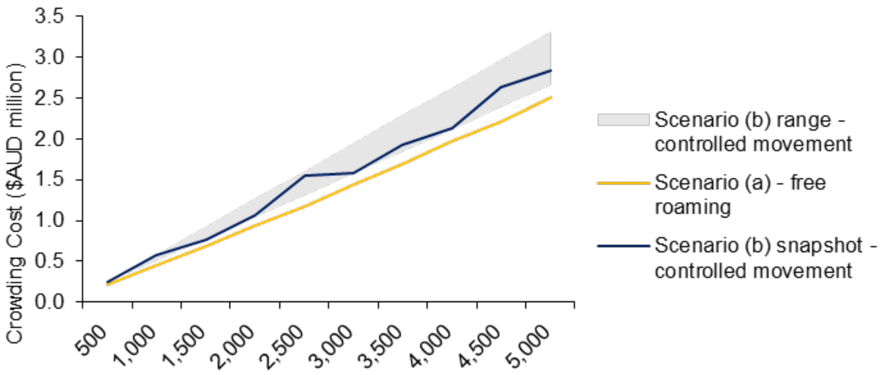
A passenger demographic profile is generated for each passenger in order to simulate their movements throughout the day in the Sydney CBD. This includes a set of destinations visited provided they return to the ship prior to 7:30pm for an 8:00pm departure. This simulation was tested for ships of varying sizes, running from 500 to 5,000 passengers in increments of 500 for movement scenarios (a) and (b). Aggregating the number of passengers at each intersection across two-minute phases and comparing it with the baseline pedestrians (without the cruise ship tourists) resulted in an incremental cost of crowding for residents due to cruise tourism.

7. Results

Figure 4 shows that the crowding cost under Scenario (a) of free roaming passengers has a positive linear relationship with the number of cruise passengers. For example, a cruise ship with a passenger capacity of 1,000 would result in crowding costs of $0.6 million per year, and a larger cruise ship with a passenger capacity of 4,000 would result in crowding costs of $2.0 million per year. The crowding costs are more varied under Scenario (b) with controlled movement with the cruise tourists travelling in groups. It can be noted that as passengers move in groups of 50 under Scenario (b), any intersection visited would be considered crowded. However, this only occurs during their two-minute period of visitation and thus their impact would be sporadic though high in intensity. Scenario (a) in contrast would see crowding costs distributed more evenly.

This variability arises as passengers move in groups, thus introducing some volatility based on the mix of the group (e.g. walking speed etc) into the results. For example, a cruise ship with a passenger capacity of 1,000 would result in a crowding cost that ranges from $0.5 million to $0.6 million per year while 4,000 passengers would result in a crowding cost that ranges from $2.2 to $2.7 million per year. The widening range in crowding costs from $0.1 to $0.6 million per year highlights the greater volatility with increased numbers of passengers.

Figure 4: Crowding Costs Attributed to Cruise Ship Passengers



7.1. Crowding costs

Table 5 ranks the top three most crowded intersections by their contribution to the overall crowding cost under Scenario (a). It presents the aggregated daily as well as the phase (time) with the highest crowding. For example, for movement Scenario (a), the Oz Jet Boating and Circular Quay East intersection have a throughput of 3,900 passengers per day. This translates into a 20 per cent overall crowding at all intersections, and a 12 per cent daily increase in pedestrian counts. In the simulation. this intersection sees the greatest number of cruise passengers at 10:56am, with 150 cruise passengers passing within the two-minute phase. This is a 241 per cent increase of the baseline pedestrian count at that specific time. These insights can be interpreted in a similar manner for movement Scenario (b).

Table 5: Summary of top 3 most crowded intersections for 4,500 passengers

Percentage of overall crowding cost	Site description	Number of cruise pax	% daily increase from baseline	Max pax phase	Number of cruise pax at phase	% phase increase from baseline
Movement Scenario (a) – free roaming						
20%	By Oz Jet Boating, Circular Quay East	3,900	12%	10:56	150	241%
18%	Outside the Museum of Contemporary Art	4,000	12%	10:02	200	322%
8%	Conservatorium of Music, Royal Botanic Garden	1,550	5%	13:52	100	86%
Movement Scenario (b) – controlled movement in groups						
25%	By Oz Jet Boating, Circular Quay East	4,369	14%	10:50	36	58%
21%	Outside the Museum of Contemporary Art	3,792	12%	9:58	80	111%
9%	Between King Street and Market Street	4,217	37%	11:12	34	129%

7.3. Crowding costs with 4,500 passengers

The largest vessel to visit Sydney was the "Ovation of the Seas", which has a maximum passenger capacity of 4,905. As such for this simulation, the crowding costs of 4,500 passengers per year, representing a megaship, was modelled. The results showed that under movement Scenario (a) and (b), the potential crowding costs are $2.2 and $2.6 million per year respectively for the local community as shown in Figure 5 and 6.

Figure 5: Cruise passenger crowding costs to local community in Sydney CBD under Scenario (a)

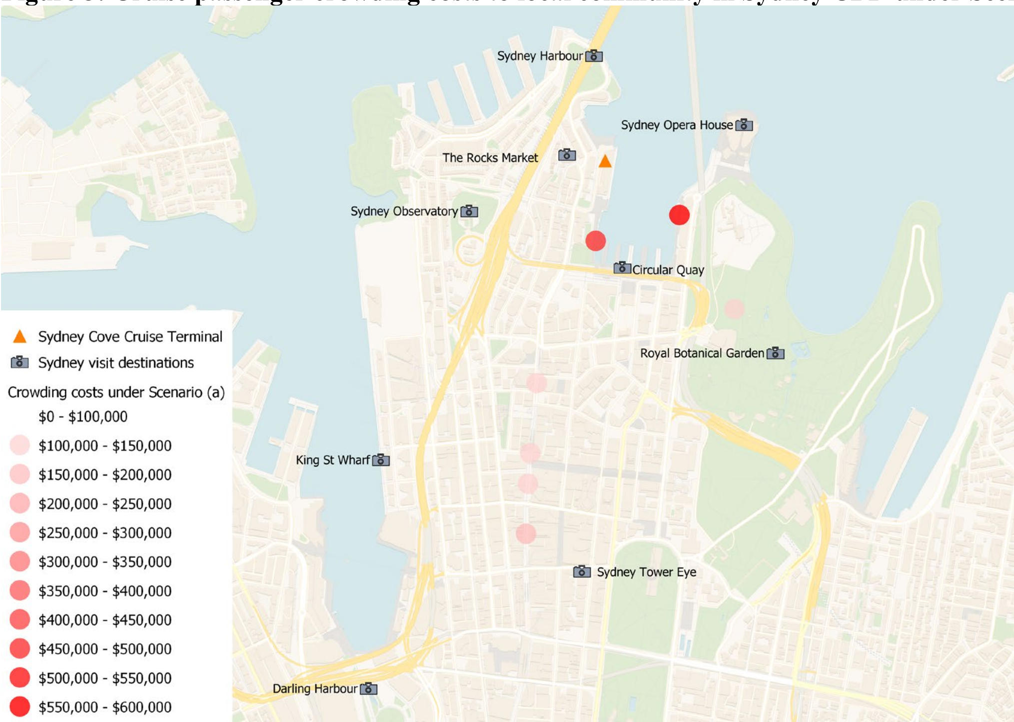
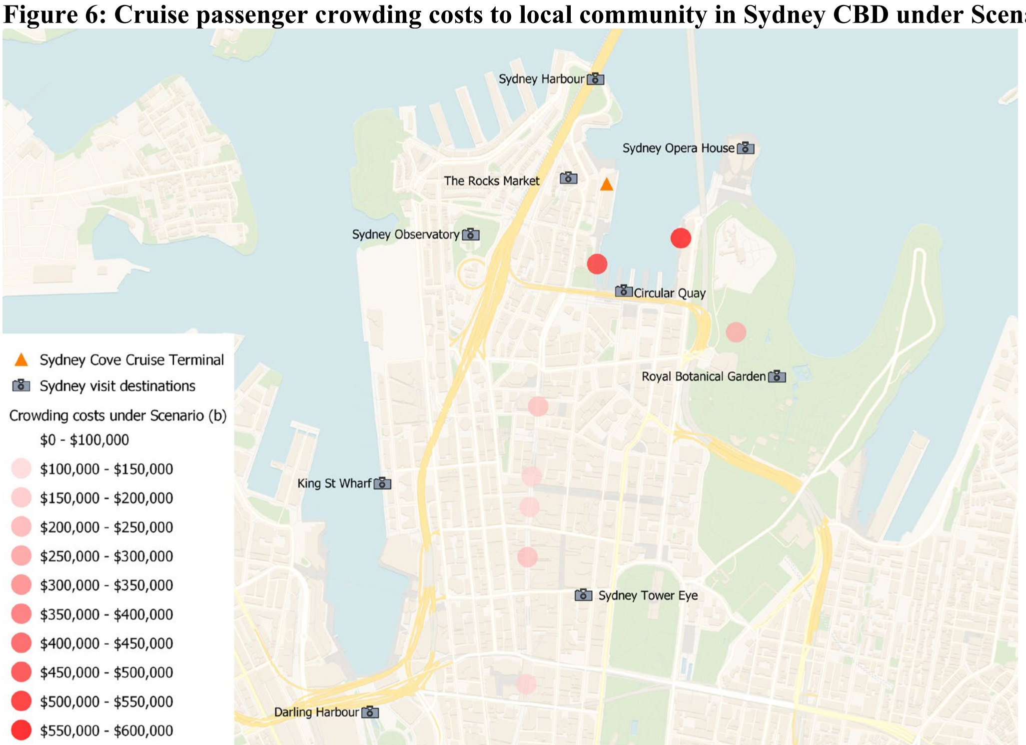


Figure 6: Cruise passenger crowding costs to local community in Sydney CBD under Scenario (b)



Although crowding costs under both scenarios are relatively similar, larger costs occur at locations closer to the terminal under Scenario (b). Crowding under free roaming tends to be spread more evenly throughout the day especially when further away from the terminal. However, when passengers travel in groups with controlled movement, crowding costs are higher compared to free roaming. This is primarily due to its movement pattern where passengers tend to travel through intersections in larger groups and at a less constant flow. Figure 7 and 8 shows the crowding throughout the day for intersections that are close and far from the cruise terminal respectively.

Figure 7: Crowding at a site next to the cruise terminal (Site: By Oz Jet Boating, Circular Quay East)

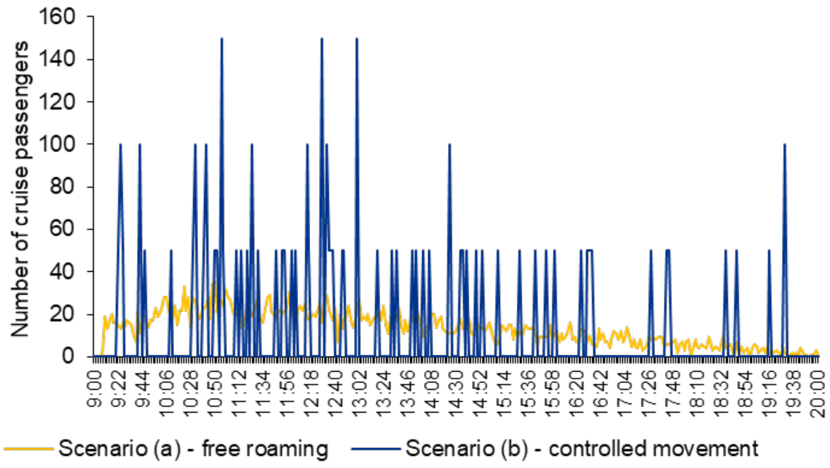
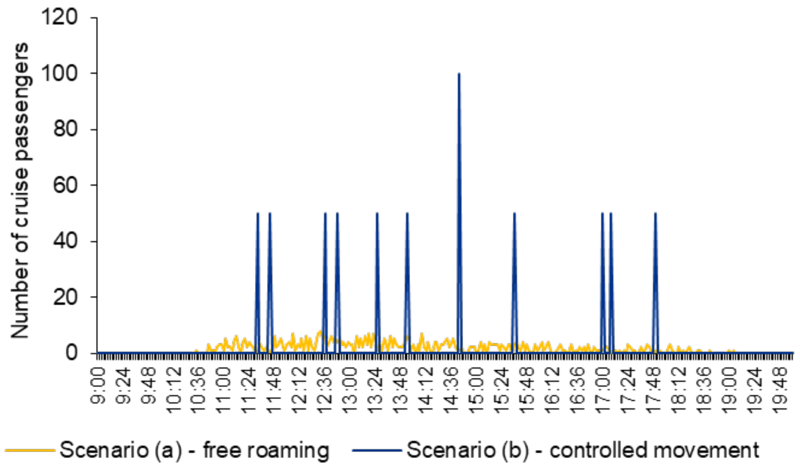


Figure 8: Crowding at a site far from the cruise terminal (Site: Between George Street and Pitt Street)



8. Conclusions

This paper presented the simulation of cruise passenger dispersion in the Sydney CBD and quantified the cost of cruise ship induced crowding to the local community. Given the recent COVID-19 social distancing measures and awareness, a scenario where passengers travel in controlled groups is also simulated. We found that crowding costs are higher when cruise passengers travel in groups and costs increase as passenger numbers increase. This finding highlights the need to crowd manage to mitigate these costs to the community.

Under the free roaming scenario (without COVID-19 or any distance controls), cruise passengers are free to move throughout the CBD. As they quickly disperse and become part of the street traffic, this results in a reduced impact of crowding compared to controlled movement in groups. Hence, freedom of movement appears to be better for managing crowding.

Additionally, travelling in groups can lead to higher crowding costs for intersections far away from the cruise terminal at certain times of the day. This is can be an issue at red lights and intersections, where such groups can create bottlenecks and exacerbate crowding impacts.

The approach presented in this paper found that for a megaship of 4,500 passengers, the potential crowding cost for the local community was between $2.2 and $2.6 million per year.

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