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Transit user perceptions and reactions to unplanned disruptions

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Abstract

Public transport systems are complex open systems susceptible to service disruptions due to a variety of operational and infrastructure failures (e.g., mega events, strikes, accidents, medical emergencies etc.). As, demand-side transit user reactions form an important part of system resilience, this study explores transit users' frustration and behavioural reaction to service disruptions based on a primary survey in Innsbruck (Austria) and secondary data analysis from Melbourne (Australia). While these two cities differ in sizes, culture, transit infrastructure, and topology—this cross-continental comparison aims to understand passengers' perceptions and behavioural response to unplanned disruptions in public transport and its effect on travel behaviour change. The results show that unexpected service disruptions may induce anger and frustration resulting in temporary or permanent discontinued transit use; however, positive operator effectiveness in dealing with disruptions is strongly associated with reduced negative perceptions in both cities.

1. Introduction

Public transport disruptions vary according to their occurrence regularity, magnitude, duration, and impact (Christoforou et al., 2016). They may be unexpected or planned (e.g. during maintenance operations), short-term (e.g. vehicle breakdown) or long-term (e.g. line maintenance), local or global influencing the whole transit network as in the case of natural disasters, strikes or major maintenance operations (Papangelis et al., 2016). The disruptions can lead to schedule delays, crowding, slow speeds, line cancellations, facility closure, route changes, and service replacements, which translate into frustration and discomfort of users, influencing perceived service reliability and transit ridership (Watkins et al., 2011, Rodríguez-Núñez and García-Palomares, 2014).

According to Edvardsson (1998), *"Dissatisfaction and complaints do not begin, there is always an event beforehand"*. While satisfaction with transit service quality is considered as a crucial indicator of loyalty (Lai and Chen, 2011, Chen, 2008), users' perception on the overall service quality is often influenced by 'critical incidents' accumulated over time rather than momentary experience (Friman et al., 2001, Redman et al., 2013). Generally, operators conduct annual customer satisfaction surveys and evaluate the global quality of the service (De Oña et al., 2013, Eboli and Mazzulla, 2007), however, these surveys mostly include service-oriented attributes rather than user-oriented attributes (Parkan, 2002). Hence, these measures may not be able to successfully explore user's future transit use based on service disruptions. Moreover, empirical evidence has shown that on-time performance, routine service reliability, real-time information and incident management are correlated with transit user satisfaction (Friman et

al., 2001, Diana, 2012, Sarker et al., 2019), and explain patronage variations and temporary ridership loss (Chakrabarti, 2015, Chakrabarti and Giuliano, 2015).

This paper explores passenger perceptions and behavioural response to unplanned disruptions in public transport. It builds on the authors empirical research on unplanned disruptions in Innsbruck, Australia and Melbourne, Australia. Part of the rationale for the paper is to synthesises and compare findings from two very diverse contexts to provide insight into user impacts of disruptions.

The paper is structured as follows; the following section provides a context for the research, reviewing research literature on unplanned disruptions and also outlining the case study context for Innsbruck and Melbourne. This is followed by an outline of the research approaches adopted for the separate study of disruptions in Innsbruck and Melbourne. Results are then described, followed by a discussion and conclusion outlining key findings and implications for policy.

2. Research context

2.1. Unplanned disruptions and its effect on passengers

Published research has mainly focused on three important themes regarding disruption management in transit service planning and operations. The first is the resilience of transit networks and operations in managing disruptions to reduce the probability of failures, reduce their consequences, and improve recovery time. This first theme focuses mainly on the supply-side and addresses incident management strategies such as risk/vulnerability analysis, efficient and rapid event detection, timetable adjustment, network redundancy, re-routing, rolling stock, and crew scheduling (Carrel et al., 2010, Pender et al., 2014, Petkovics and Farkas, 2014, Mattsson and Jenelius, 2015, Reggiani et al., 2015, Cats et al., 2016, Christoforou et al., 2016).

The second theme focuses on passenger reaction to service disruptions through social media and the relation between disruptions and ridership (Pender et al., 2014, Casas and Delmelle, 2017). Also, most studies focused on mass transit (Chakrabarti and Giuliano, 2015, Pnevmatikou et al., 2015, Zhu and Fan, 2018) and large-scale events such as employee strikes (Ferguson, 1992), track construction projects (Bernal et al., 2016), bridge collapses (Xie and Levinson, 2011) , and major service withdrawals (Nguyen-Phuoc et al., 2018c).

The last theme, to which the current study pertains, includes only a few studies and investigates the underlying factors improving passenger reactions to service disruptions. According to Papangelis et al. (2016), a significant research gap exists with respect to the motivational factors underlying transit user behavioral response to service disruptions. This is a challenge adopted for the research in developing a rigorous behavioural framework for user reactions to disruptions in Innsbruck case study.

2.2 The Innsbruck and Melbourne context

Table 1 outlines key features of the transport system in Innsbruck and how it contrasts with the Melbourne case study.

Innsbruck is the capital of Tyrol region in western Austria, with approximately 311 thousand inhabitants. The public transport agency and operator–Innsbrucker Verkehrsbetriebe und Stubaitalbahn GmbH (IVB) operates in the Innsbruck core zone with an integrated ticketing system. While, Verkehrsverbund Tirol (VVT), the Regional Transport Agency collaborates with IVB and serves in the Tyrol region.

Melbourne is a significantly larger city with 5.1M population, but interestingly it has a much lower urban density (498/km^2) than Innsbruck (1,253/km^2). Public transport usage is more than twice as much higher per capita in Innsbruck than Melbourne (224.8 vs 103.8). Higher service levels and urban density are likely to play a major part in this. Melbourne has a significantly higher levels of car ownership which also plays an important role.

Table 1: Innsbruck and Melbourne case study cities and their transport systems

Variables	Innsbruck	Melbourne
Population (000, 2019)	311.4	5,078.0
Population Density (person/km^2	1,253 (2023)	498 (2021)
Public Transport Operator	Innsbrucker Verkehrsbetriebe und Stubaitalbahn GmbH (IVB)	Public Transport Victoria (Victorian Department of Transport and Planning)
Public Transport Modes	Bus, Tram, Regional Rail	Bus, Tram, Urban Rail, Regional Rail
Ridership (M p.a., 2018-19)	70M	527M
Per capita Ridership p.a.	224.8	103.8
National Car Ownership rates (motor vehicles per 1000 people)	632	782
Unplanned Disruption Information		
Disruption frequency	Low[3] (e.g., "frequent line cancellation" – 56 responses and "missed connecting train/bus" – 244 responses out of 1,629 responses)	High; Rail: 8,151 p.a., 2010-2012[1]
Disruption Complaints (number, 2019)	Lower likelihood of complaining (All Modes - 226 out of 1,629 responses)[3]	All Modes - 1,152[2]

Notes: [1] Currie (2016)
[2]Victorian Public Transport Ombudsman, 2019
[3]Sarker (2020); Based on Author's survey in 2019

Disruption data suggests that Melbourne has a much higher volume of disruptions and complaints rate than Innsbruck. Notably, the data on unplanned disruptions from Innsbruck are based on the survey conducted in 2019.

3. Research approaches

3.1. Innsbruck research

The study conducted in Innsbruck explored underlying factors which explain the behavioural motivators underlying the relations between operational service disruptions and intentions to reduce transit use using the Affective Events Theory (AET) (Weiss and Cropanzano, 1996). This study is the first to apply AET in the transit service context, connecting affective experience in the transit environment and service satisfaction. In the current study, the behavioural framework is tailored to analyse the 'short-term' immediate reaction regarding the next transit trip after the disruptive events. As stimulus events, this study addresses *line cancellations, missed connections, non-functioning ticket machines, and vehicle breakdown* because they are among the most common recurrent service disruptions (Carrel et al., 2010). Notably, this study does not refer to real-time reactions to single specific events, but takes a retrospective view of the organizational climate. As the organizational climate, this study refers

to transit staff assistance (i.e. courtesy, empathy, respect) and system design (network coverage, operating hours, information, vehicles, and facilities). Moreover, operator efficacy (e.g., considering user needs, responsiveness, reliability, and quality assurance) is also considered to evaluate passenger's reaction. This study considers 'anger' and 'frustration' as the most common negative emotions associated with service disruptions (Edvardsson, 1998, Watkins et al., 2011, Pender et al., 2014, Papangelis et al., 2016). The indicators related to the latent constructs are elicited using a 5-point Likert scale (Likert, 1932).

The survey was administered in German and English during August 2017 on board and through the official websites of the regional transit operators in Innsbruck and Tyrol. An intercept survey using the computer-assisted personal interviewing (CAPI) method was performed on board, covering both peak and off-peak hours. The on-board survey covered 70% of the city lines, 4 out of 6 of the suburban train lines, 40% of the regional bus lines, and the regional train line.

3.2 Melbourne research

Two sets of studies provide input to the exploration of behavioural impacts of unplanned disruptions in Melbourne. The first was a study of unplanned rail disruptions in Melbourne undertaken for Metro Trains Melbourne in 2014. Behavioural responses of rail users were measured in an online survey targeting passengers who had used rail replacement bus services during disruptions and those that had not. The survey aimed to understand rail user perceptions and likely behavioural changes resulting from disruptions. Some of the behavioural findings were reported in Currie and Muir (2017) and (Currie, 2016).

The second study was part of a PhD research program exploring public transport users' behavioural adjustments if public transport services are removed for either a short time (typically day to day unplanned disruptions) or a long time (complete withdrawal of services in the long term). A number of research methods were used in this research. A series of qualitative interviews (24) with public transport users in Melbourne were undertaken. These adopted semi structured interviews to explore how users might change their behaviour if public transport was withdrawn in either the short term (services within for up to a day) and long term (services withdrawn for 10 years or more). Results were reported in Nguyen-Phuoc et al. (2016) and (Nguyen-Phuoc et al., 2018b). In addition, these findings were used to develop a large quantitative online survey of morning peak public transport users (n=640) to measure system wide impacts of likely behavioural adjustments to disruptions. Results were report in Nguyen-Phuoc et al. (2018d), and then later used to model secondary effects on traffic congestion (Nguyen-Phuoc et al., 2018a).

4. Results

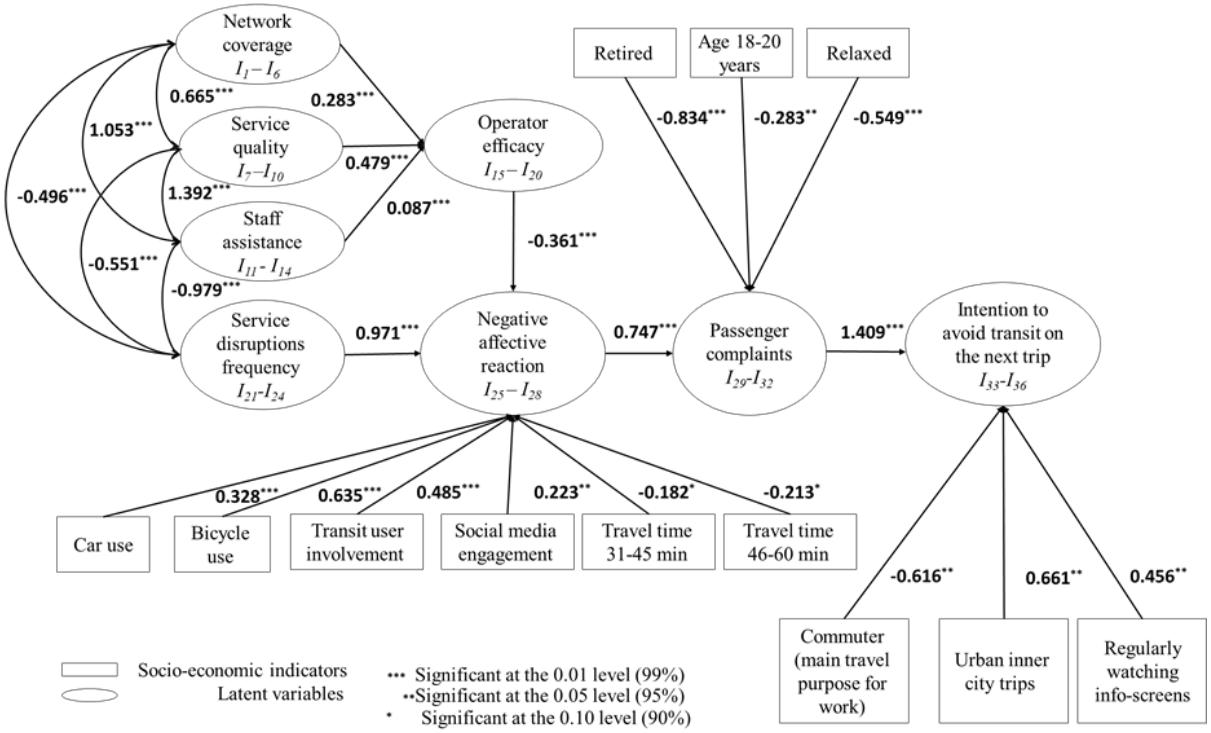
4.1 Innsbruck modelling results

Figure 1 shows the outcome structural equation model output from the research which aims to understand factors influencing negative user reactions to disruptions and how this influenced complaints and then travel behaviour changes associated with disruptions.

The results show that better perceived transit operator efficacy and lower perceived disruptive event frequency are the strongest indicators of negative emotions (being upset or angry) associated with unplanned service disruptions. Passenger complaints relate to stronger negative emotions of being upset or angry and greater intention to voice complaints is associated with

greater intentions to avoid transit on the next trip. Compared to the transit captives, the availability of other transport modes (car, bicycle) is positively associated with increased frustration over service disruptions. This result agrees with the finding of Mao et al. (2016), that multimodal transit users have a lower level of satisfaction with subway trips compared to their counterparts. The availability of alternative modes increases the frustration level with service disruptions, possibly due to regret associated with the non-chosen alternatives (Chorus et al., 2008). Social-network engagement is associated with an increased sense of being upset or angry.

Figure 1: Innsbruck - factors explaining negative disruption reactions, passenger complaints and mode Shift (Estimated Structural Model - [updated results based on Sarker (2020)])



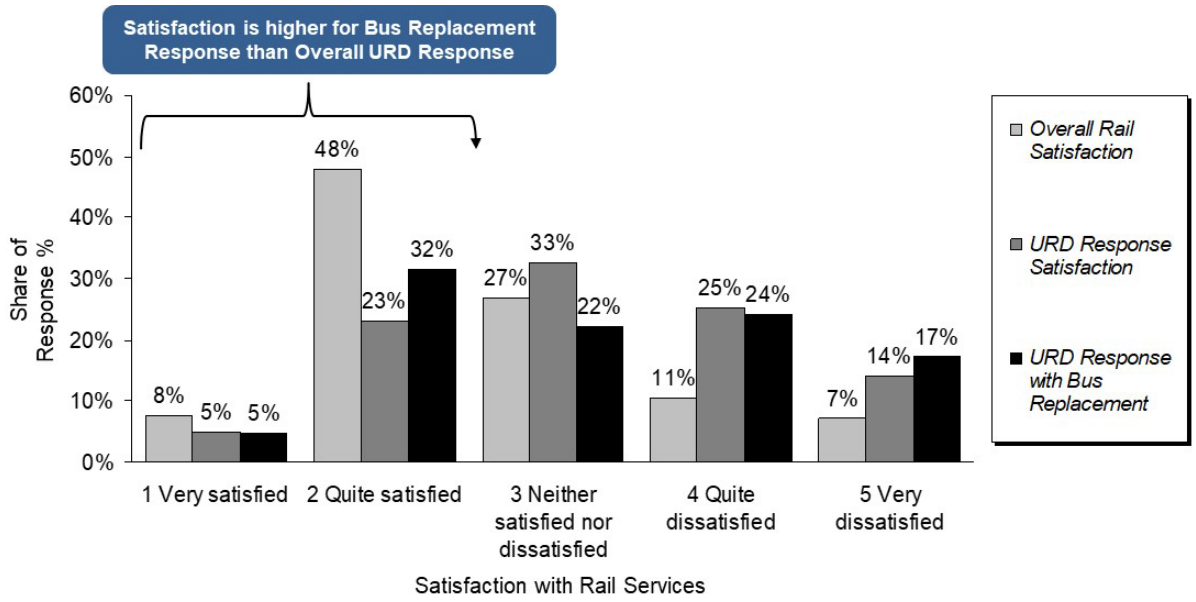
Moreover, the results show that negative reactions to disruptions were strongly correlated to passenger complaints notably for middle (working age) passengers and those with a less relaxed outlook. A high degree of complaints was also strongly associated with a high intention to avoid transit on the next trip. A higher frequency of commuting decreases the probability of avoiding transit on the next trip suggesting a degree of reliance of commuters on transit in the peak. The model results also show that inner-city transit users are more prone to opt out on their next trip following service disruptions, possibly due to the greater number of alternative solutions (e.g., the shared city-bike system, car-sharing). Also, longer travel times (more than 30 minutes) are associated with weaker sensitivity to service disruptions.

4.2 Melbourne research results and comparison with Innsbruck findings

Figure 2 illustrates results from the user impacts of unplanned rail disruptions in Melbourne. It shows Melbourne rail user satisfaction in three groups;

a. Overall satisfaction with rail services in general
b. Satisfaction rail authority responses to unplanned rail disruption in general
c. Satisfaction with rail authority responses to unplanned rail disruption responses involving pro-active provision of replacement bus services.

Figure 2: Melbourne rail user satisfaction – Overall with Unplanned Rail Disruption (URD) responses and overall with involving bus replacement services



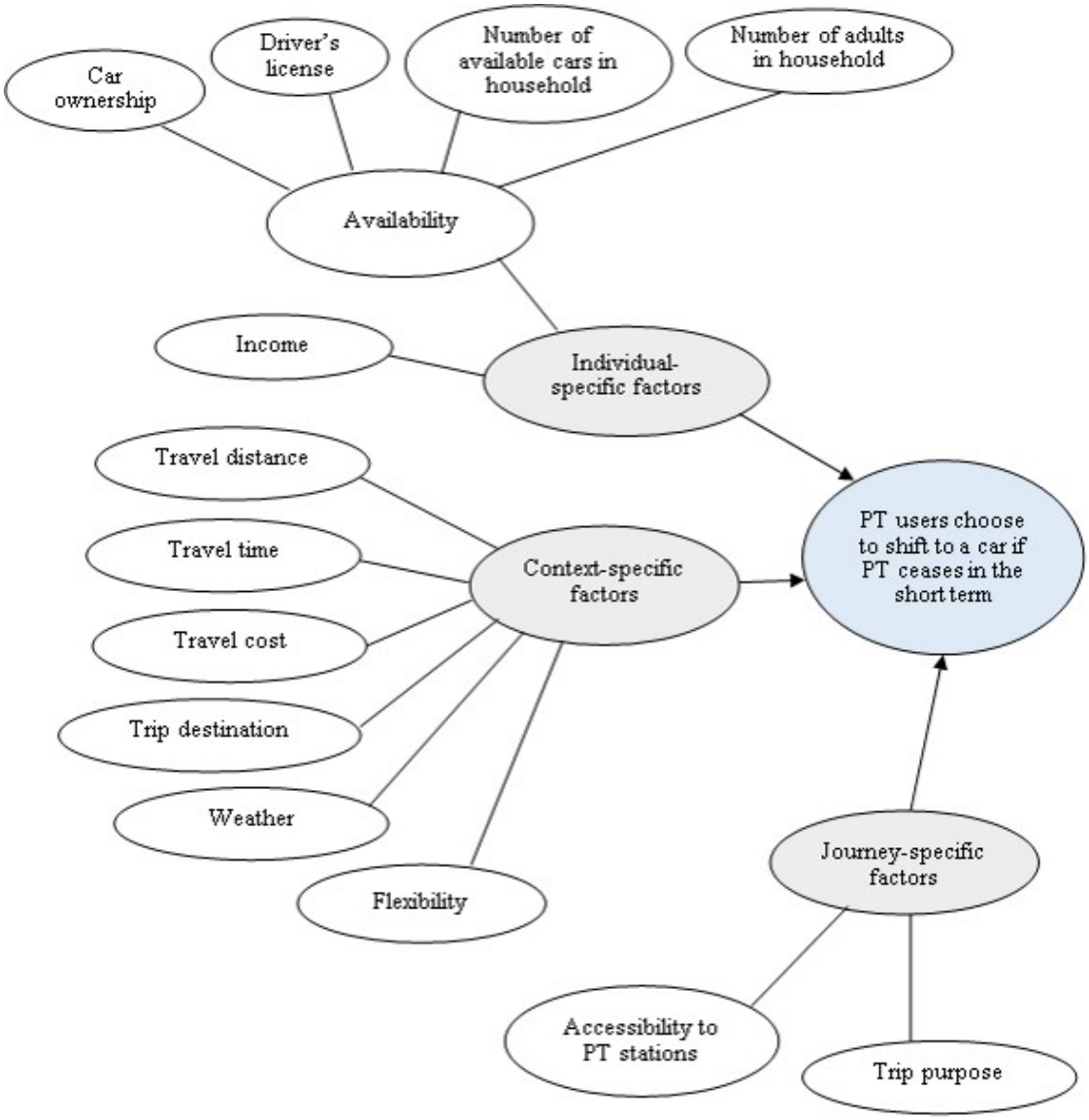
Source: Updated results sourced from Currie and Muir (2017)

These results indicate that while overall rail satisfaction is quite high, satisfaction with unplanned rail disruption responses is quite low; 56% of rail users have positive satisfaction with rail in general while only 28% are positive about responses to unplanned rail disruptions. These findings are quite consistent with the Innsbruck research (Figure 1) where disruption frequency was clearly associated with disruption frequency.

Interestingly, the Melbourne findings about bus replacement responses (Figure 2) suggest that when the authority provides bus replacement services positive satisfaction levels improve (38% are positive compared to 28% for URD responses in general). This suggests that pro-active intervention in disruptions is at least in part appreciated by passengers. This finding matches the results for Innsbruck (Figure 1) where good operator efficacy (such as a pro-active response to a disruption like providing replacement buses) acts to reduce negative emotional responses to disruptions. Figure 3 shows a summary of qualitative interview findings in Melbourne for the research exploring factors influencing users to shift to car use when services are withdrawn in the short term.

The research found that car availability was a dominant factor influencing choice to change mode. This directly correlates to the findings in Innsbruck (Figure 1) where car users (choice travellers) were more strongly associated with negative emotions results from disruptions with strong links to complaint behaviour and mode shift. There are also strong links between the Innsbruck findings and other findings shown in Figure 3. Travel distance/time factors were shown to be influential in mode shift decisions; short distance/time traveller in inner areas had more alternative travel options available if they wish to change modes and this was also found to be influential in Innsbruck.

Figure 3: Melbourne transit users factors influencing choice to use car if transit ceases in the short-term

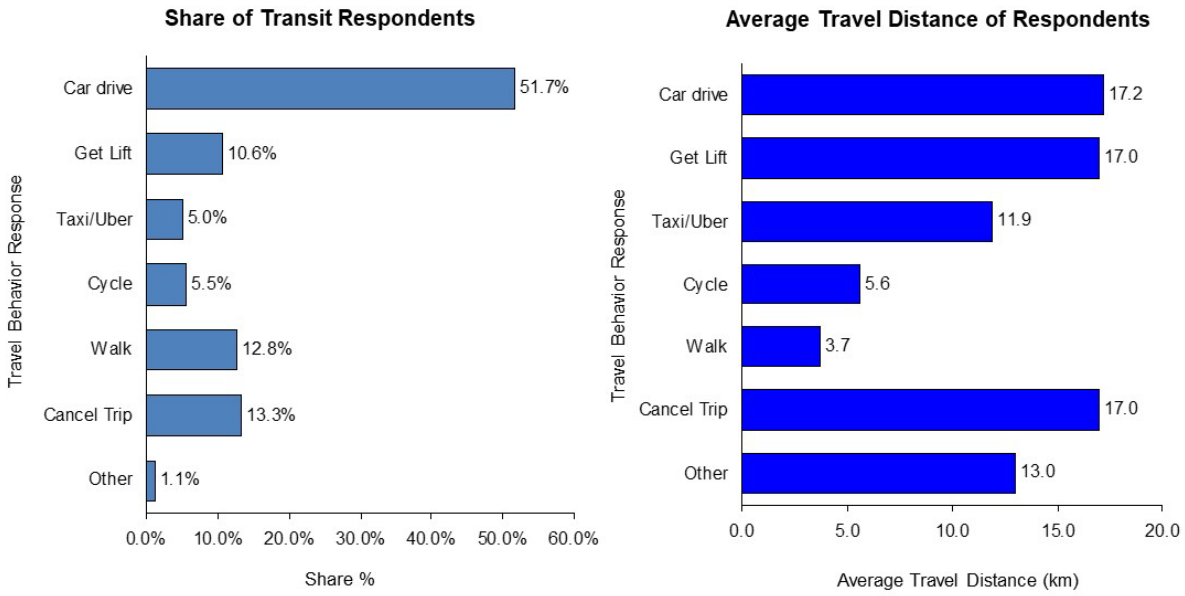


Source: based on findings reported in Nguyen-Phuoc et al. (2018d)

The Melbourne results also suggested wider influences which may influence mode shift decisions which were not highlighted in Innsbruck; the cost of travel is important as well as CBD locations; parking cost will influence transit users to stay on public transport in Melbourne while this was not shown to be so significant in Innsbruck. Weather was also a concern; Melbourne riders were concerned that good weather was needed to use alternatives modes (e.g., bikes). This is likely to be important in Innsbruck too; however, it was not highlighted in the behavioural results.

Figure 4 shows the behavioural adjustments Melbourne transit riders would make if public transport was withdrawn in the Melbourne quantitative study (n=640).

Figure 4: Melbourne transit users' travel behavior reaction to unplanned service withdrawl



Source: New analysis of results earlier reported in Nguyen-Phuoc et al. (2018d)

This suggests a strong car driver shift as a result of transit disruptions in Melbourne. The research explored factors influencing shift to car driving in a disruption with the major factors being:

- Having a driving licence
- Having easy access to parking
- The flexibility a car provides.

For those not shifting to car driving, the major influences were difficulties finding a car park, traffic congestion and the high cost of parking at destinations (mainly the CBD).

In general, the above conclusions are reflected in the Innsbruck research; with car driving strongly associated with negative emotional responses to disruptions. Travel distance/time is again influential. Although the Melbourne results suggest parking availability is important, but this is not reflected in the Innsbruck analysis.

Melbourne users who shift to getting a lift in Figure 4 are also longer distance travellers. This choice was strongly influenced by lift availability; others were also concerned that they didn't want to get a lift as they preferred a degree of independence in travel choices.

Active travel (walk/cycle) in Figure 4 is strongly associated with shorter distance trips. Good walking environments, short travel and safe bike availability were highlighted as reasons to choose active travel, and as reasons for not choosing these options when these facilities were unavailable.

Overall, the Melbourne findings show much correlation with the Innsbruck model (Figure 1). There is one important area where this is not the case; In Innsbruck (Figure 1); being a commuter has a strong negative association with intention to avoid transit temporarily. Yet in Melbourne, the results in Figure 4 suggest a much higher acceptance of mode shift from transit with disruptions for commuters. The difference may be well explained by higher car ownership and use in Melbourne compared to Innsbruck. Moreover, higher levels of per capita public

transport use in Innsbruck may also explain the willingness to stick to transit for Innsbruck commuters.

5. Discussion and conclusions

This research has compared research findings on unplanned rail disruptions in Innsbruck Austria with those in Melbourne Australia. The focus has been user perceptions of disruptions and the travel behaviour responses of users to these disruptions.

The Innsbruck research (Figure 1) is one of the first to translate an organizational behavioural model into transit context to identify factors influencing user perceptions of disruptions and its known effects to travel behaviour change. Despite the significantly different context of Melbourne for the Australian case study research, there are many areas where the two sets of research have similar findings:

- Positive operator effectiveness in dealing with disruptions is strongly associated with reduced negative perceptions in both cities
- Mode shift from transit was strongly influenced by car ownership in both cities
- Mode shift from transit was strongly influenced be inner city/short distance travel in both cities as more alternatives to travel were available

The Melbourne research suggests some contrasting effects to the Innsbruck research:

- Parking availability and cost were major influences in Melbourne not highlighted in the Innsbruck model.
- Weather was also highlighted as an influential factor on Melbourne (for cycling and walking) but not the Innsbruck model
- A significant share of Melbourne transit commuters seems amenable to mode shift to car driving as a result of disruptions. This was not the case in Innsbruck where transit commuting has quite strongly negatively linked to mode change.

The latter is an interesting point of difference in the two sets of research. Higher car ownership and lower general per capita levels of transit user might explain this. However, the lower levels of disruption occurring in Innsbruck may also be influential. Clearly this would be a useful area for future research.

There are a number of implications this research has for practice. The study in Innsbruck shows that, while cognitive judgment-based service quality perspective is the most common tool for LOS evaluation, affective assessment is equally important in determining user loyalty, and convincing people to use transit in a car-oriented environment. The traditional view is that once the regular service is maintained with relatively high quality, users would tolerate reasonable service disruptions. This study's results show that even a low proportion of unexpected service disruptions may induce anger and frustration, and result in temporary or permanent discontinued use. The results parallel the findings of Schweitzer (2014), showing that both high-quality and poor-quality service providers are criticized by Twitter posts. The model results show that voicing complaints and opt out are complementary. Also, these results show that higher social media engagement is associated with higher frustration and thus may serve as an amplifier of "hot" negative emotions. These two results point to the need to provide official channels to help "air out" user frustration, potentially being helpful to retain ridership even for service disruptions. Some official systems include cumbersome complaint procedures, limited possibility for posting complaints via online forms, and precise details of the incidents, including the exact time and place, bus number and driver's identification. These barriers

prevent users from complaining to operators and may revert them to easier complaint channels through social media. According to Schweitzer (2014), the transit operators who have more interactive information exchanges with their users, receive more favourable opinions. Thus, the ability to complain through official channels and responsiveness to complaints should be better promoted among transit operators.

For all transit operators the findings illustrate the need to:

a. Reduce unplanned disruptions
b. Reduce their impact on users; and
c. Deal competently with disruptions when they occur.

The results also imply that cities with higher car ownership and lower transit are more vulnerable to disruption impacts on ridership. Having a higher level of unplanned disruption activity in these cities is not a positive influence on ridership. It also has implications for traffic congestion, where shifts to car driving result. The mitigating influences of car parking availability and parking cost are also important influences where should be considered in future research.

The research suggests a number of areas for future research. Clearly there is much potential to apply the behavioural model adopted in Innsbruck in wider contexts. There is also scope to explore the influence of parking and weather effects as additions to this model. An exploration of what "Operator Efficacy" means to users would also be useful in shaping policy responses to disruptions.

Overall, it is evident that there is much to learn about how to better manage unplanned transit disruptions in cities in both Europe and Australasia. Understanding what drives users' reactions is clearly an important facet of this endeavour.

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