



Variations in Pedestrian Traffic Count in Christchurch due to the September 2010 Darfield (Canterbury) Earthquake

A.J.M. Harding & F.I. Powell

Opus International Consultants, Central Laboratories, Lower Hutt, New Zealand

ABSTRACT:

There is a need for time- and cost-effective ways to track the recovery of business areas in the aftermath of natural disasters and other shock events. The purpose of this ongoing study is to test the reliability of regular pedestrian counting as an indicator for business recovery, using the Christchurch CBD as a case study. In this first stage of the study, 12 sites were selected in the CBD for regular pedestrian traffic monitoring over a 12-month period following the 4th September 2010 earthquake. These sites were selected from those used in an assessment of urban vitality in 2008 undertaken for the Christchurch City Council (Gehl Architects, 2009) so that comparative data were available. The sites were selected to represent varying earthquake damage throughout the CBD, and for their suitability for installing automatic thermal pedestrian counters. In the second stage of the study, automatic counters will be installed at selected sites and compared to manual counting data. In the third and final stage, the relationship between pedestrian numbers and business activity will be explored in conjunction with a business survey. In this paper we discuss the results of the study to-date and our findings that trend data for pedestrian counts highlight parts of the CBD where businesses might be conducting less trade due to fewer customers. We conclude that pedestrian footfalls have the potential to be a cost-effective indicator of business recovery, but this will be verified in later stages of this study.

1 INTRODUCTION

Recovery is increasingly viewed as a dynamic process with no clear endpoint (Nigg, 1995). There is a need for 'time and cost effective' ways to track the recovery of business areas in the aftermath of natural disasters and other shock events. Statistical indicators for post-disaster recovery have received relatively little attention in the literature. Indeed, much of our knowledge associated with the recovery phase has been gained through one-off surveys or focused investigations of disaster-affected communities. Chang (2009) puts a strong case forward for the use of statistical data as a readily accessible and inexpensive complement to these approaches. Statistical data can also provide baseline information for comparing conditions before and after a disaster, and measuring the journey to recovery. Chang makes reference to high-level statistics (such as the number and size of businesses), which are often collected with some time delay. For moderate events, such as the magnitude 7.1 earthquake that shook Christchurch, New Zealand, in September 2010, more sensitive indicators are required to give an accurate picture of progress

towards recovery. Anecdotal evidence from Gisborne businesses following the magnitude 6.8 earthquake in 2007, implied that footpath closures and cordons reduced pedestrian numbers and thus reduced trade. Pedestrian counts could be one such indicator of business recovery.

The purpose of this ongoing study is to investigate regular pedestrian counting as an indicator for business recovery, using the Christchurch CBD as a case study. In addition to being a non-invasive means of observational study, pedestrian counting is relatively cheap, simple to organise, and easy to replicate. Unlike questionnaires and interviews with business owners/managers, pedestrian counting gives almost instant results that can be reported on the day after counting. Pedestrian counts provide an insight into the operation of the city and can also assist local authorities in regard to traffic planning, retail forecasting, and urban design changes.

Timmermans and Van der Waerden (1992) present empirical evidence linking retail store performance and pedestrian route-choice behaviour. They found the viability of retail areas to be largely dependent upon the number of pedestrians who pass through them. Pedestrian footfalls are also linked to urban vitality, walkability, and property rents (Rogers, 2011; Chiaradia, Hillier, Schwander & Wedderburn, 2009; Thomas & Bromley, 2003). Thus, it is reasonable to assume that areas where pedestrian numbers are higher than baseline are experiencing higher turnovers, and those areas with depressed pedestrian numbers are experiencing reduced business turnover. This assumption will be verified in a later stage of this studyⁱ.

2 INDICATORS FOR BUSINESS RECOVERY

A large literature exists around the use of indicators focused on measuring changes in the environment. Indicators, when chosen carefully, can help to establish baselines, identify trends, predict problems, and assess options. Indicators should be based on information that is reliable, accessible, timely, and accurate. Comparability, simplicity, sensitivity, accessibility, transparency, and cost-effectiveness are all important aspects (Litman, 2007; Dale & Beyeler, 2001).

Indicators for making comparisons across disasters should meet the following criteria (a) be consistent in definition across countries, cultures and time periods; (b) data must be readily available; and (c) measurement should be standardised in order to make reasonable comparisons across space and time. The key requirement for comparisons within a specific disaster event is that indicator results can inform policy and decision-making in the affected community (Chang, 2009).

When measuring aspects of recovery, the temporal dimension is important, as we are interested in how long it takes for the system to reach a new normality and how this normality compares to the pre-disaster normality. When making comparisons of recovery at different study areas, differences in physical damage rates should be considered. It is important to be wary of attributing all post-disaster changes to the disaster, as other factors influence urban growth and change, and recovery occurs over many years. This is particularly relevant for small or moderate-sized events, where the disaster is not severe enough to overwhelm these other factors (Chang, 2009).

2.1 Use of simple indicators in business recovery

There are a few examples of simple indicators used in business recovery research, but no mention of pedestrian footfall data for this purpose in the literature. The most notable business recovery study using indicators was conducted in New Orleans following Hurricane Katrina.

Weekly street surveys were conducted by bicycle to track patterns of business openings and closures along three major New Orleans commercial corridors. Businesses of all types that were visible from the street were recorded, with follow-up phone calls or local inquiries made where it was hard to discern business status visually. The survey simply measured which businesses reopened, where, when, and under what conditions. A database of 651 businesses was established before the storm hit and 56 new businesses were noted over a period of 15 months. The findings of this study highlighted the most vulnerable business groups (Campanella, 2007).

Other studies have employed higher-level indicators to track changes following large-scale disaster events. Chang (2009) applied high-level statistics to track recovery following the catastrophic earthquake that affected Kobe City, Japan, in 1995. In a different study, Craioveanu and Terrell (2009) used employment and wage data collected quarterly by the Louisiana Department of Labor to examine the impact of Hurricanes Katrina and Rita on business survival in Orleans Parish. They used a Bayesian spatial probability theory model to assess the impact of various firm characteristics on firm survival. Such data is often not recorded by local authorities in New Zealand.

2.2 Factors affecting levels of pedestrian traffic

Pedestrian counts are a key factor in determining the potential and rents for retail stores, because retailers are dependent upon both the chance of customer contact and the reaction of visitors to the attractiveness and ambience of a store (Monheim, 1998). Pedestrian volumes are site specific, and vary by location, street and path type, and day of the week (Clifton & Livi, 2005), so it is important to have baseline data for a number of sites against which to make comparisons. The key factors that will influence change in pedestrian traffic include weather conditions, shop closures, business openings or relocations, footpath closures, road closures and road works.

Two key studies in the USA have investigated the effects of different weather conditions on pedestrian numbers over a 12 month period. Aultman-Hall, Lane and Lambert (2009) analysed the effect of weather conditions (temperature, relative humidity, precipitation, and wind) on automated hourly pedestrian counts at one site in downtown Montpelier, Vermont. They found that cold temperatures or precipitation consistently reduced aggregate levels of walking by less than 20%. Using pedestrian traffic and weather data (temperature, cloud cover, wind and precipitation variables) collected in a previous study, Attaset, Schneider, Arnold & Ragland, (2010) investigated the effects of weather data collected at local weather stations on pedestrian traffic collected hourly by automatic counter at 13 intersections throughout Alameda County, California. Rain had the largest effect on pedestrian volumes, though clouds, wind and both hot and cold temperatures were also shown to decrease footfalls. Rain caused a 35-56% decrease in pedestrian trips, affecting discretionary trips more than commuting trips. Cloud cover was associated with a 5-24% decrease, temperatures over 27°C were associated with 5-8% decrease, and temperatures lower than 10°C and high wind speeds were also associated with small decreases in pedestrian numbers.

3 METHODOLOGY

Students were contracted to conduct manual pedestrian counts using tally counters at 12 sites throughout the CBD, for two hours in the morning (10.30am-12.30pm) and two hours in the afternoon (1.00pm-3.00pm) on Wednesday 6 October, Thursday 4 November, and Wednesday 8 December 2010. In December, an additional count was undertaken between 4.00pm-6.00pm at

the request of Christchurch City Council. Pedestrian counts were recorded every quarter hour over these periods, as is consistent with vehicle traffic studies. Our intention is to replicate our study a number of times over a 12 month period. The sites were chosen based on the patterns of earthquake damage within the CBD, and to be comparable with sites used in an assessment of urban vitality in 2008 undertaken for the Christchurch City Council (Gehl Architects, 2009).

We are also assessing the feasibility of installing automated pedestrian counters at these 12 sites, and have already installed one Irisys passive infrared sensor at the end of November 2010. Pedestrian numbers were recorded manually on one side of the road only, to allow comparisons with data collected by automatic counters. As automatic counters are mounted above the ground, pedestrian numbers were counted at each site if they passed between a designated lamppost and the shop front. This differs from the methodology employed in the assessment undertaken by Gehl Architects (2009), where data were collected on both footpaths at 34 sites throughout the city for 10 minutes every hour between 8.00am and 12.00noon on a Tuesday and Wednesday in November during fine weather. The data were manipulated to determine an hourly total and an average per minute for each site. To allow comparisons between the Gehl data and our 2010 data, we halved the Gehl data at sites where both footpaths were open in 2010.

The survey sites were the same each month apart from in December when, at the Council's request, pedestrian numbers were counted at Hereford St A. To enable this additional site, no data was collected at Colombo St A in the December survey as this site was located in a part of the city that experienced little earthquake damage, and the numbers recorded here in October and November suggested that pedestrian numbers at this site were in a state of normality. On each counting day, observations were made about street closures, building closures, and footpath closures by an observer who was not counting pedestrians.

Our data collection on 6 October occurred on a warm, sunny day within the school holiday period. The urgent need to collect baseline data as soon as possible following the earthquake overrode concerns about elevated levels of pedestrian holiday traffic. The weather on 4 November was similarly warm and sunny, but did not fall within the school holiday period. On 8 December the weather was overcast with a cold southerly wind.

4 RESULTS AND DISCUSSION

The total number of pedestrians recorded at each site between 10.30am-12.30pm and 1.00pm-3.00pm on each of our counting days in October, November, and December is shown in Figure 1. It is evident that pedestrian numbers have fallen each month in 7 of the 11 sites that have been consistently surveyed. In three of the other sites, pedestrian numbers have altered little over the period. The overall number of pedestrians in the CBD has fallen since our surveys started, with 14.7% fewer pedestrians overall in November, and a fall of 4.2% from November to December. There are a number of possible explanations for the decrease in pedestrian numbers over the 3-month time period. The higher total number of pedestrians observed in October may have been artificially high because the survey was undertaken during the school holidays. The drop in numbers from November to December may be attributable to the unpleasant weather in December, but being three weeks before Christmas we anticipated higher numbers during this month.

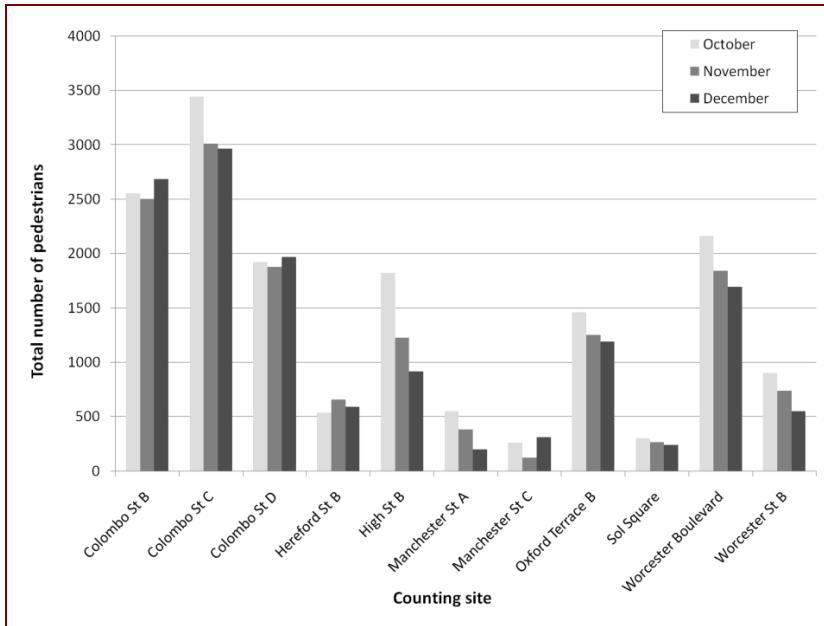


Figure 1: Total number of pedestrians recorded (10.30am-12.30pm and 1-3pm)

When the share of pedestrians is compared across the sites, as shown in Figure 2 as a percentage of the total pedestrians recorded across all of these 11 sites, we observe that month on month Colombo Street, which has been relatively unaffected by the earthquake, has increased its share of the CBD's pedestrians. At the same time, the Lower High Street, Manchester Street A, Worcester Boulevard and Worcester St B sites have experienced a fall in their share of pedestrians. The trend towards a greater proportion of pedestrians along Colombo St in the lead up to the Christmas period may reflect people's consumption habits. Whilst the Oxford Terrace and Worcester Boulevard areas are popular, numbers have dropped off here with Christmas approaching, as these streets are more oriented towards tourism, hospitality, and offices.

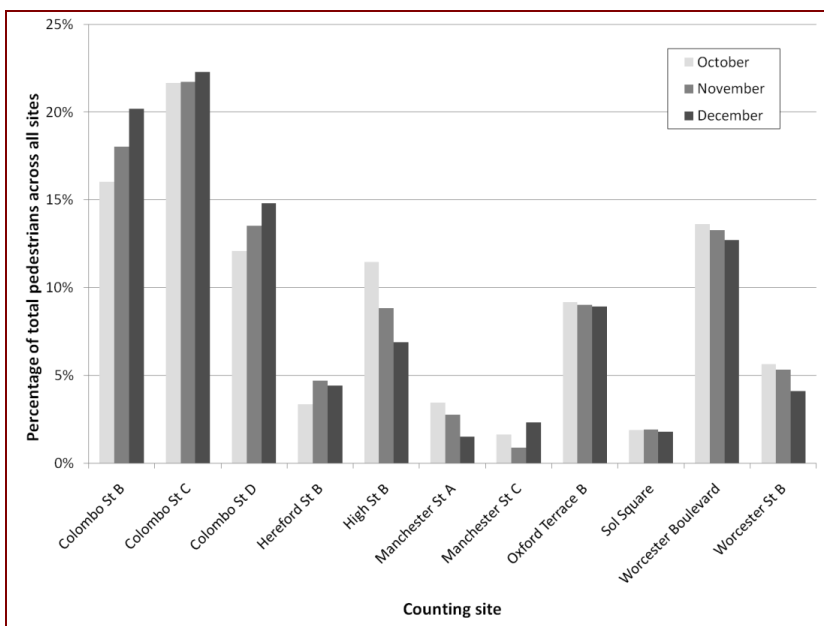


Figure 2: Share of pedestrians at each site as a percentage of the total pedestrians recorded

When compared to the baseline Gehl data, for almost all sites, aside from the Worcester St sites, pedestrian numbers are lower than those recorded in 2008. Overall, early evening pedestrian numbers are lower than those recorded in 2008, which may reflect fewer workers finishing work in the city around 5pm as some businesses have closed due to the earthquake.

In general, pedestrian numbers on Colombo St were similar to those observed in 2008, though not in the early evening. The particularly low results in the southern and eastern parts of the city appear to be related to the earthquake damage (especially on Manchester St) and resultant cordons and business closures in place. Vehicle access is fully restricted in places, and one-way in other areas where particular buildings and sections of the footpath are cordoned off. Building, and therefore employer, closures may be impacting pedestrian numbers in these areas. Street and business closures here may also be diverting pedestrian traffic to the more central and western parts of the city.

The pattern of areas in the CBD in which businesses may be at risk of reduced turnover is shown in Figure 3. The footfall data collected at the three sites along Manchester St and eastern Hereford St indicate that, post-earthquake, the eastern side of the CBD continues to experience depressed pedestrian numbers. Interestingly, the High St site, in an area of boutique fashion shops, is also on the (south) eastern side of the CBD, but businesses appear to be less at risk as pedestrian numbers are not so much lower than they had been in 2008. Other sites appear to be experiencing reasonable and even high pedestrian numbers, aside from the southern Colombo St site, which is at moderate risk of lower pedestrian numbers. These findings support anecdotal concerns about businesses in the south and eastern parts of the city experiencing reduced patronage and turnover.

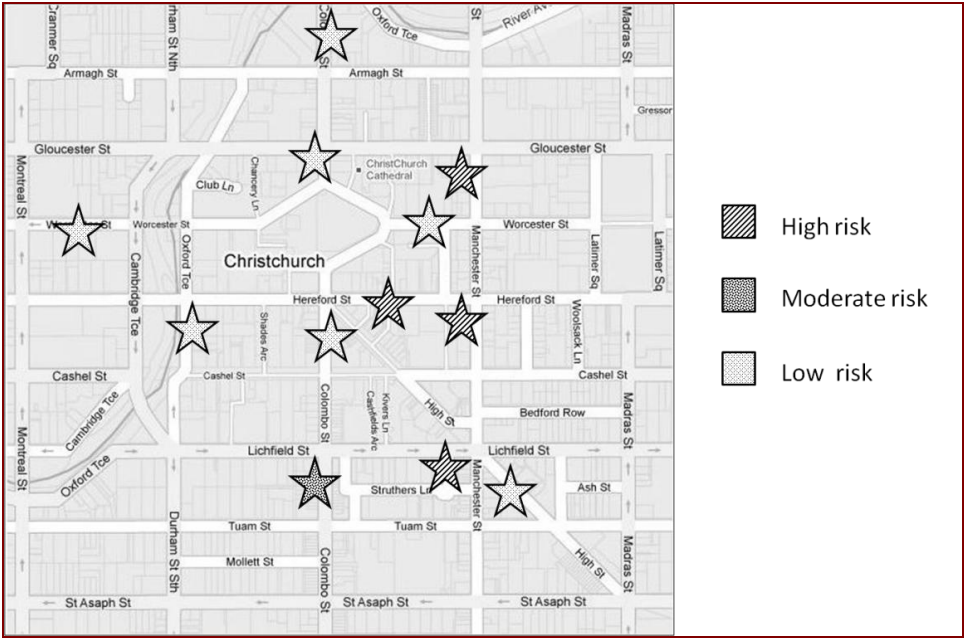


Figure 3: Map showing location of counting sites and risk of reduced customer numbers

To demonstrate an area of high risk, the results for the upper Manchester St site are shown in Figure 4. This site is located at 235 Manchester St outside a small open-air car park. Access to this part of Manchester Street between Gloucester and Worcester streets was restricted due to earthquake-related demolition sites, with the road only open to northbound traffic. Pedestrian

movement was restricted because unsafe buildings were cordoned off. Between 6 October and 4 November, the block of buildings including and to the south of the counting site had been cordoned, and it is not clear whether the affected businesses have relocated, closed temporarily, or closed permanently. The footpath here remained closed between the November and December counting dates, but temporary safety barriers had been established so that pedestrians could walk on the road along this section of the street. Pedestrian numbers are clearly depressed at this site in comparison to the 2008 Gehl data, and the number of pedestrians declined each month. The higher footfalls in October could be attributed to more stores being open here, in comparison to the later months. In addition, the footpath opposite the counting site was closed in October, diverting pedestrian traffic past the counting site. The street and building closures in this section of the city have adversely affected pedestrian numbers.

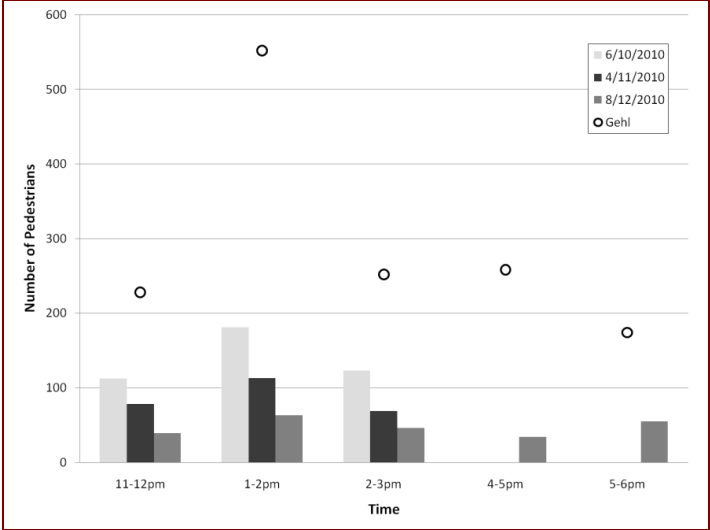


Figure 4: Hourly pedestrian counts compared with Gehl data for Manchester St A

In comparison, pedestrian numbers recorded at the site on Worcester St outside Club Tower (64 Worcester St) were higher than those recorded in the Gehl study (Fig. 5). The findings at this site demonstrate the importance of contextual knowledge. First, this part of the city experienced little earthquake damage, so businesses have continued to operate unhindered. Second, the Gehl data points are likely to be artificially low on this graph, as the majority of pedestrians along this section of the street use one side of the road only. The side where we locate our counter is wide, sunny, and has places where people can eat. One of our counters estimated that around 15-20% of people along this road walk on the other footpath or along the road. However, even if these data points had not been halved for consistency, our results would indicate that this part of the city is experiencing elevated pedestrian traffic counts. Lastly, in 2010 the Christchurch City Council, a major employer in Christchurch, relocated from Tuam St to a site with entrances to Worcester St and Hereford St, not far from the Arts Centre. This move will have changed pedestrian travel patterns in this part of the city, increasing footfalls along western Worcester St. This makes the baseline data less relevant than at other sites, as there was no major employer in this part of the city when the Gehl data was recorded. Regardless of these factors, it is clear that pedestrian numbers are high in this part of the city. The higher pedestrian numbers in October probably reflect school holiday visitors to the Arts Centre area of the city.

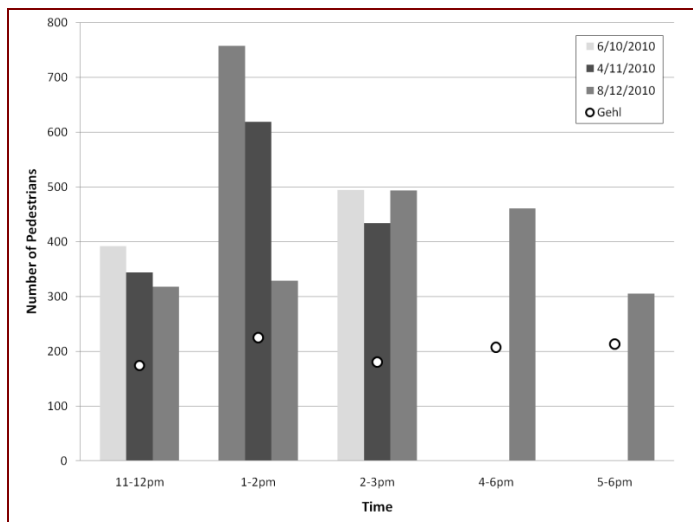


Figure 5: Hourly pedestrian counts compared with Gehl data for Worcester Boulevard

Cities are dynamic places and pedestrian numbers reflect the ebb and flow of city life. In small cities, like Christchurch, numbers will change in response to businesses or large firms relocating, transport and urban design changes, and new shops, bars, or restaurants opening. It is important to be aware of these contextual issues in order to isolate the progress towards recovery at each site and the impacts that things like street, building and footpath closures are having on businesses nearby. Pedestrian count data can draw attention to areas of concern, and will complement more detailed business surveys which are harder to organise, can only be carried out infrequently, are expensive, and involve a time delay with regard to obtaining results and providing information for change. Thus, pedestrian counts and business surveys may be complementary. However, this co-relationship will be explored in a later state of this study.

Manual pedestrian counting is relatively cheap, simple to organise, and easy to replicate. It is a non-intrusive means of observational study that allows for the quick survey of sites and prompt analysis of data. The protocol for manual counting is simple, but the data collection must be rigorous to be comparable over time. This means that whilst subcontractors do not require special training, they must be provided with a clear protocol. Observation of surrounding conditions is also a key part of methodology, as numbers without some context in terms of nearby damage, cordons and closures cannot reflect the true picture of what is going on. Whilst the subcontractors were encouraged to note down any observations, they are not easily able to be interrogated afterwards. Knowledge of the non-shock changes occurring in the city is important, for example, a major employer moving from one part of the city to another will result in changes to pedestrian flows.

In comparison with manual counting, automatic pedestrian counters can be counting all day, every day. This provides insight into spikes during holidays and special events, as well as the impacts of weather and street changes. The initial capital costs are in the order of \$1,500 plus installation, but in the long run automatic counters provide rich continuous data more cheaply than manual counters. Other considerations include the regular battery changing and data download that must be carried out onsite. In addition, the data analysis takes longer than a manual count. However, the data can be compared to weather station data and events known to be taking place in the city. One key disadvantage of automated counting over manual counting is that it is harder to investigate anomalies. For example, a person can observe a large group of

protesters walking past and make note of this, but an automatic counter will not observe the reason for a spike in pedestrian numbers.

Regardless of the counting method, pedestrian numbers fulfil the majority of requirements of a good indicator as outlined by Litman (2007) and Dale and Beyeler (2001). When collected following a clear and consistent protocol, the information is accurate and comparable. Pedestrian counts are a simple, timely, and cost-effective measure. Our results demonstrate that pedestrian traffic is sensitive to changes in accessibility, but that the transparency and reliability of the findings are dependent on contextual knowledge about factors like the location of street, footpath and building closures, and the movements of large employers.

5 CONCLUSIONS

This study is ongoing, and will continue to employ manual counting methods as well as automatic passive thermal counting units. From our results to-date, we conclude that with adequate contextual information pedestrian counts are a useful indicator of business recovery after a shock event. Our findings in Christchurch show that pedestrian numbers can highlight areas where businesses are experiencing low patronage. Footfall data can also be used to provide quantitative evidence in support of anecdotal accounts about businesses in an area realising lower turnovers, and inform policy decisions.

We acknowledge the limitations associated with counting pedestrians, but advocate pedestrian counting as a simple and cost-effective complement to anecdotal evidence and more thorough surveys. Pedestrian footfall data can also assist with urban design, traffic management, and other local authority concerns. Thus, we encourage local authorities to adopt pedestrian counts as a matter of routine. In the unfortunate instance of a shock event, such data will also act as baseline data against which to compare post-shock recovery over time. The reliability of automatic counters and relationships between business turnover and pedestrian numbers will be explored in later stages of this research.

REFERENCES:

- Attaset, V., Schneider, R.J., Arnold, L.S. & Ragland, D.R. 2010. Effects of weather variables on pedestrian volumes in Alameda County, California. *Presented at the 89th Annual Meeting of the Transport Research Board, Washington, D.C. 10-14 January, 2010.*
- Aultman-Hall, L., Lane, D. & Lambert, R.R. 2009. Assessing the Impact of Weather and Season on Pedestrian Traffic (09-2765). *Presented at the 88th Annual Meeting of the Transportation Research Board, Washington, D.C. 11-15 January 2009.*
- Brown, D., Saito, K., Spence, R. & Chenvidyakarn, T. 2008. Indicators for measuring, monitoring and evaluating post-disaster recovery. *Presented at the sixth International Workshop on Remote Sensing for Disaster Response for Disaster Response, University of Pavia, Italy, 11-12 September, 2008.*
- Campanella, R. 2007. *Street survey of business reopening in post-Katrina New Orleans.* Accessed from <http://cbr.tulane.edu/PDFs/campanella3.pdf> on 15 September 2010.
- Chang S.E. 2009. Urban disaster recovery: a measurement framework and its application to the 1995 Kobe earthquake. *Disasters*, Vol 34(2) 303-327.
- Chiaradia, A., Hillier, B., Schwander, C. & Wedderburn, M. 2009. Spatial centrality, economic vitality/viability: compositional and spatial effects in Greater London. In Koch, D., Marcus, L. & Steen, J. (eds.) *Proceedings of the 7th International Space Syntax Symposium; Stockholm, 8-11 June 2009.* Article 16, 1-19.

- Clifton, K.J. & Livi, A.D. 2005. Gender differences in walking behaviour, attitudes about walking, and perceptions of the environment in three Maryland communities. *Research on women's issues in transportation: Volume 2: Technical papers, Report of a conference, No. 35*, Transportation Research Board of the National Academies, Washington, D.C.
- Craioveanu, M. & Terrell, D. 2009. The impact of storms on firm survival: a Bayesian spatial econometric model for firm survival. *Paper presented at the Ninth Annual Missouri Economics Conference, University of Missouri, Columbia, 27-28 March 2009*.
- Dale, V.H. & Beyeler, S.C. (2001). Challenges in the development and use of ecological indicators. *Ecological Indicators*, Vol 1(1) 3-10.
- Ercolano, J.M., Olson, J.S. & Spring, D.M. 1997. Sketch-plan method for estimating pedestrian traffic for central business districts and suburban growth corridors. *Transportation Research Record*, Vol 1578, 38-47.
- Gehl Architects, 2009. *Christchurch public space public life*. Accessed from <http://www.ccc.govt.nz/cityleisure/projectstoimprovechristchurch/publicspacepubliclifestudy/index.aspx> on 8 September 2010.
- Litman, T. 2007. Developing Indicators for Comprehensive and Sustainable Transport Planning. *Transportation Research Record*, Vol 2017, 10-15.
- Monheim, R. 1998. Methodological aspects of surveying the volume, structure, activities and perceptions of city centre visitors. *Geojournal* Vol 45, 273-287.
- Nigg, J.M. 1995. Disaster recovery as a social process. *Wellington after the quake: The challenge of rebuilding*. Wellington New Zealand: The New Zealand Earthquake Commission.
- Rogers, C. 2011. Lambton Quay has highest foot count. *The Dominion Post* 19/1/11 pgC1
- Thomas, C.J. & Bromley, R.D.F. 2003. Retail revitalization and small town centres: The contribution of shopping linkages. *Applied Geography* Vol 23, 47-71.
- Timmermans H. & Van der Waerden P. 1992. Store performance, pedestrian movement, and parking facilities. In: Heinritz G. (ed.), *The Attraction of Retail Locations*. Verlag Michael Lassleben, Kallmünz/Regensburg.

ⁱ The large earthquake that took place in Christchurch on 22 February 2011 caused extensive damage to the CBD, and as a result, the second and third stages of this study have been postponed.