NEIGHBOURHOOD RECOVERY AND COMMUNITY WELLBEING IN CITIES FOLLOWING NATURAL DISASTERS

Findings from Christchurch, New Zealand

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Introduction

The social and physical characteristics of neighbourhood environments provide an important context for the health and wellbeing of communities and individuals (Braveman et al. 2011; Diez Roux and Mair 2010; Macintyre et al. 2002). Businesses and organizations are very much part of what constitutes the social and physical characteristics of a neighbourhood. There is an important knowledge gap in the role played by businesses in neighbourhood recovery and community wellbeing following shocks such as natural disasters. A healthy community has opportunities for people to connect and belong (Hooper et al. 2015; Ivory et al. 2011), ready access to good quality, affordable services and facilities that contribute to a healthy lifestyle (Witten et al. 2011) and places that are safe (Breetzke and Pearson 2015) and pleasant to be in (Ivory et al. 2015), and access to education and employment (Hancock 2001). There is increasing understanding that features of the neighbourhood environment are very much intertwined as part of an interconnected, interacting socioecological system. For example, physical characteristics such as streetscape and local amenity provision are associated with increased physical activity (Witten et al. 2012), but also with social activity and mental wellbeing (Baum and Palmer 2002; Cattell et al. 2008).

Residents in the city of Christchurch, New Zealand have been living with massive changes to their communities since a series of devastating earthquakes during 2010 and 2011. These resulted in many businesses and community facilities needing to move, close or adapt. The concepts and evidence from the neighbourhoods and health literature suggest such changes may affect the distribution of neighbourhood level determinants of health. We recognized the necessity of creating measures capable of quantifying changes in neighbourhood environments that can be linked to health outcomes, either for ecological analysis or for multilevel modelling of individuals statistically nested within neighbourhoods.

Chang (2010) and Alesch and Holly (2003) argue that recovery often entails adaptation, rather than necessarily a return to normal. As Christchurch residents have found, recovery in their city and neighbourhoods has meant moving forward to a ‘new normal’ state. The challenge addressed in this
chapter is to systematically capture changes in significant features of neighbourhood environments over the course of Christchurch’s long term recovery as part of a broader research agenda exploring connections between the recovery of neighbourhood environments and wellbeing.

**Changing Places, Changing Wellbeing?**

One way to understand the role that neighbourhood settings play in wellbeing and community functioning is to observe how they change over time, in other words their trajectories. Processes such as gentrification, suburbanization and urban sprawl lead to changes in who lives in given locations, what is accessible from there, how neighbours interact and what activities take place there, as well as the qualities of the built environment such as building types. Such changes usually take place over many years if not decades (Clerval 2011; Collins 2013; McDonagh 2012).

Major shocks, such as disasters, can trigger very rapid change and severe disruption to socioecological systems because they affect the capability of individuals to undertake everyday functions in their normal environments (Gardoni and Murphy 2009). The Canterbury region experienced an earthquake sequence consisting of thousands of events over many months. Most damage occurred during the major initial earthquake on 4 September 2010, and subsequent aftershocks on 22 February 2011 (the most significant single event for damage, loss of life and injuries), 13 June 2011 and 26 December 2011 (Bannister and Gledhill 2012). The ongoing nature of the seismic activity (over 10,000 aftershocks of magnitude 3.0 or higher were recorded by the end of 2014) has delayed decision-making and recovery, both from a practical perspective of wanting to avoid the need to continually repair, and from uncertainty in resolving insurance and in choosing when and where to reinvest. Factors such as social capital and local governance may also play a part in how quickly and how well rebuilding takes place after a disaster (Rumbach et al. 2016), and this can be seen in Christchurch, such as in the interplay of local and national politics in decision-making after the earthquakes (Early et al. 2015).

As well as significant loss of life and injury, there is emerging evidence of considerable health impacts during Christchurch’s recovery, notably on mental health (Winstanley et al. 2015). For many residents, the disruption and the loss of amenities and destinations in the built environment have consistently been identified as a significant source of stress (Banwell and Kingham 2015; Nielsen 2015), alongside individual and household pressures such as insurance (Fergusson et al. 2014, 2015; Nielsen 2013, 2014, 2015). Since the earthquakes, normal locations and everyday activities have been continuously disrupted, heightening the role of the neighbourhood and local environment in people’s lives. The quality of the local environment has affected where people reside, work, play, relax and learn, as well as people’s ability to access resources and participate in society and their communities.

**Neighbourhood Amenities and Businesses as Health-Related Resources**

Based on Macintyre and Ellaway’s earlier work (Macintyre and Ellaway 2000), Bernard et al. (2007) conceptualized neighbourhoods as geographically located ‘opportunity structures’ that create a system of health-related resources and relationships. In this model, neighbourhoods vary in the way in which opportunity structures are distributed. Some neighbourhood settings have many local amenities related to work and socializing, whereas others have few; that is, neighbourhood is a site where inequalities in the determinants of health can be seen. Disruption to the access and quality of amenities could make it harder for people to get to work and/or be socially active, as well as lead to loss of employment for staff and wealth for owners. For example, the loss of a local café might limit social opportunities for residents and workers.
Change in the amenity mix of a neighbourhood may also disrupt health-promoting behaviours. Research has established an association between a greater density of shops and community facilities within a neighbourhood and increased levels of physical activity, after accounting for confounding factors such as neighbourhood and individual material deprivation factors (Witten et al. 2012). If neighbourhood shops are displaced, journeys that were previously made locally on foot or bike might be replaced with car trips to more distant locations. Figure 28.1 uses Barton and Grant’s (2006) health map to explore how changes may impact everyday lives, highlighting the way in which places disappeared and activities shifted and the implications for access and social interaction.

Many health-related resources or opportunity structures are provided by businesses. For example, Witten et al. (2011) referred to the local density of retail facilities as part of the infrastructure supporting physical and social activity for residents, alongside other urban form factors such as streetscape. Pearson et al. (2013) explored features of the neighbourhood environment that promote community level resilience, in this instance the capacity of a neighbourhood to provide and sustain the health and wellbeing of residents in the face of adversity. They found that, alongside the physical (for example, safe drinking water, air quality) and social (incoming residents) domains, commercially provided amenities such as cinemas, cafés, banks and pharmacies all contributed to community resilience. The loss of many of these amenities in Christchurch has affected neighbourhood resilience (Banwell and Kingham 2015) and likely also affected individual physical and emotional health.

Businesses also play an important role in facilitating social connections in a city. Co-workers can form meaningful social bonds that extend beyond the work environment, and the space where the business operates can be utilized for developing and maintaining social connections (Chamlee-Wright and Storr 2014). As well as the vital services and employment created by business, the connections and spaces facilitated by businesses in a neighbourhood can be important after a disaster. Businesses use these social connections to aid recovery, and the community can use the business space as a place to interact socially, especially when there is a shortage of private and public spaces because of property damage. For example, cafés are well recognized as places to gather and belong.

![Diagram](image-url)
Vivienne Ivory et al.

(McCreanor et al. 2006). Anecdotal reports suggest the cafés and bars in Christchurch that remained open, or which relocated to suburban areas, were in high demand as known places for people to meet with dislocated friends and family (Sachdeva 2012).

Rapid Changes in Christchurch Business Locations

The spatial distribution of businesses in an area influences trends in economic activity and is an important element in describing wellbeing. Investigating changes in where business and economic activity takes place following a disaster, and identifying contextual factors associated with those changes, can help us predict outcomes for people and places, and understand why some places may be more or less resilient in the face of natural hazards, or may recover more quickly.

Physical disruption to Christchurch and the wider Canterbury region was unprecedented in New Zealand, with insurance claims made for some 160,000 residential buildings alone (King et al. 2014), and substantial damage to horizontal infrastructure such as roads and pipes. The Christchurch Earthquake Recovery Authority (CERA) was established by the central government immediately following the February 2011 earthquake, as soon as the extent of damage and complexity of recovery was realized. Given extraordinary powers, CERA had responsibility for leading recovery efforts, both within the central city and across the wider territorial authority. Relevant to this chapter, key decisions have included: 1) the technical classifications of land (related to reducing the risk to people and buildings from liquefaction and rockfall); 2) compulsorily acquiring land from property owners in the most badly damaged areas; 3) establishing a strictly controlled cordon (often referred to as the CBD Red Zone) around the hazardous central city district; and 4) developing a comprehensive rebuild strategy focused on creating a vibrant future urban core for the whole city. The establishment of CERA was one of the most significant decisions to affect recovery (Chang et al. 2014).

A distinctive characteristic of the earthquake impact was the high level of damage to most of the central city business area, while much of the surrounding suburbs remained functional, at least in part. Prior to the earthquakes, the Christchurch central business district had been in need of revitalization, with competition from suburban malls and business parks, notably to the west. Central city businesses were spread out over a relatively large area, often in older unreinforced masonry buildings (Moon et al. 2014) and with high vacancy levels (Chang et al. 2014). Chang and Faliti-Baiamonte (2002) and Pais and Elliott (2008) argue that neighbourhood context influences how a location and business within it recover, for example by intensifying existing trends of decentralization. In the short term, this was true of Christchurch as the central city emptied and businesses dispersed to the suburbs.

Some businesses were displaced following the September 2010 earthquake. However, it was immediately apparent after the 22 February 2011 earthquake that the central city and other badly affected areas would be out of action for some time. Finding alternative premises began within hours (Bowden 2011). Businesses took a range of strategies, including moving to vacant business park premises, hotel rooms, residential properties (family homes as well as vacant houses), church halls, converted warehouses and light industrial premises.

Mail redirection data have been used to map the pattern of movement by business in the first year following the February 2011 event (Ivory et al. 2014) (Figure 28.2). Not everyone moved immediately; some could not find suitable or affordable premises, while others delayed until insurance settlements were completed and/or the shape of the recovery was more apparent. Some businesses also moved to other cities. Overarching all options was the sudden, severe shortage of space, leading to adaptive strategies such as co-location (Stevenson et al. 2014), but also delays and multiple relocations. Alongside the movement of people and businesses in Christchurch, the recovery and rebuild added further disruption across the city as horizontal infrastructure (pipes, roads, cables, etc.) and residential repairs programs progressed.
Figure 28.2 Pattern of business relocation following the February 2011 Christchurch earthquakes.
Existing clusters of commercial buildings and vacancies in suburban areas provided immediate spaces for central city businesses to shift into. Alongside this, communities could continue with some normality of access to local services and businesses. This is not to say that individual communities and businesses outside of the central city were unaffected. Residential areas in the city’s eastern suburbs were significantly damaged, with businesses in these areas negatively impacted. However, at a city level, the functioning of many lost and displaced businesses was readily restarted or replaced by opportunities in several major existing suburban centres. These suburban areas became important enablers of people’s ability to work and go about their activities in a ‘new normal’ manner. Thus community wellbeing and the ability of individual neighbourhoods to adapt and recover were likely dependent on recovery of both people and businesses.

From Business Recovery to Neighbourhood and City Recovery

Such sudden and significant change has major implications for how organizations maintained economic activity in a new and often quite different location, and for neighbourhood settings as businesses came and went during the recovery and rebuild periods (Xiao and Nilawar 2013). Such disruption is significant not just for business and the economic wellbeing of the city, but also for the ability of businesses to continue to provide the opportunity structures for wellbeing, with the potential for uneven recovery across the city and region (Pais and Elliott 2008).

There is little research into how business disruption and movement following shock events affect wider urban recovery over time. Studies tend to look at either economic activity recovery (e.g., Dahlhamer and Tierney 1998; Kachali et al. 2015; LeSage et al. 2011) or social or physical factors influencing recovery (e.g., Aldrich 2015; Binder et al. 2015; Brown, C. et al. 2015; Contreras et al. 2016), but rarely focus on more than one type of recovery (Xiao and Van Zandt 2012). Studies also tend to look at recovery years after an event, or over long intervals (e.g., 5, 10 and 20 years after an event), meaning the full spatial and temporal variability in recovery is not observed. There are few studies that have looked at how recovery progresses year upon year, or that make the connection between recovery trajectories of businesses and those of the communities they move to and from.

Xiao and Van Zandt (2012) looked at the experience of Hurricane Ike in 2008 in Galveston, Texas, and found that the return of households and businesses to the city’s neighbourhoods was mutually dependent, with the return of people increasing the chance of business returning and vice versa. Gong and Keenan (2012) examined the movement of financial services out of Manhattan into the suburbs following the terrorist attack on 11 September 2001. Although the suburbs initially benefited from this relocation, this did not continue long term, as businesses relocated again one month to two years after the initial event. Giglio (2002) also looked at the impact terrorist attacks had on cities and found that in the short term economic activity and social life were disrupted, but cities were soon dominated by an economic boom resulting from repair work. Chang (2000) found a similar trend for the Port of Kobe, Japan, where the Great Hanshin earthquake of 1995 accelerated pre-event economic trends, in this case a continued but sharpened decline. In contrast, the impact of Hurricane Katrina on the city of New Orleans and the surrounding counties seems to be longer lasting, with displacement of economic activity from the core, most damaged counties to nearby ‘edge’ counties. It may be that the scale of damage and time taken to rebuild means that businesses and people become permanently settled in locations that have continued to function normally over the recovery (Xiao and Nilawar 2013). These studies did not make connections between economic trends and the overall recovery or trends in community wellbeing.

Disaster-related change and disruptions pertinent to Christchurch businesses include direct effects such as: damage to premises, assets and stock; damage or disruption to local infrastructure such as water, sewage and transportation networks (Brown, C. et al. 2015); and enforced exclusion barriers...
and cordons (Stevenson et al. 2011). Indirect effects included: disruptions to mobility of staff, customers and suppliers, such as relocation or closure, or restricted access due to damaged road networks or damage to customer and supplier premises (Kachali et al. 2015); and damage to the surrounding neighbourhood, even if the physical location of the business itself was not damaged. Relocation decisions were forced where there was significant damage to business premises (Kachali et al. 2015), or could be a strategic decision because of destruction in the surrounding community and environment which might greatly impact the viability of the business (Kachali et al. 2010). Kachali et al. (2015) found that changes in staff emotional wellbeing, customer issues and non-structural damage were the three most disruptive factors to business continuity. C. Brown et al. (2015) also found that customer issues such as more difficult access following relocation were the most disruptive factor and correlated with reduced business recovery outcomes. What is obvious is the importance of ‘place’ and changes in ‘place’ to business recovery, given the reliance many businesses have on proximity to customers, suppliers, transport networks and the surrounding environment (Gong and Keenan 2012; Gordon and McCann 2000; Koschatzky and Zenker 1999; Malmberg and Maskell 2002; Stam 2007; Xiao and Nilawar 2013).

It is not always evident what recovery of an area will look like, especially given that the neighbourhood is unlikely to look the same as in the past (Alesch and Holly 2003). Business composition is one aspect of overall neighbourhood recovery. At any given point in time, an area experiences an interaction of: physical factors, such as building stock, landscape features and provision of infrastructure; economic factors, such as property values, prosperity or deprivation; and social factors, such as socio-demographic composition, resident turnover and social cohesion. What is particularly revealing in Christchurch’s rapid state of change was the recursive nature of these factors. Lack of buildings (through earthquake damage) in one area led to an increase in business activity in another area where buildings or spaces were available, leading to changes in the character and vitality of both neighbourhoods. Consequently, some neighbourhoods have become more desirable and prosperous, motivating new building developments and attracting new businesses and activities. In some instances, the character of the neighbourhood has changed from a minor suburban centre to a significant commercial centre, or from being predominantly light industrial to having higher proportions of professional and retail operations. In such places, fast food outlets now vie with coffee baristas and craft beer (Preece 2013). In other areas, individual businesses and their buildings may have survived the earthquakes, but the loss of households from land damage in the vicinity, or severe disruption to transport networks, meant that businesses were no longer viable unless they moved to more accessible areas with more customers (Moody 2013).

Measuring Neighbourhood Recovery over Time

As discussed above, our chapter views Christchurch’s neighbourhoods as opportunity structures with the potential to positively or negatively impact on the health and wellbeing of their inhabitants. This is particularly relevant during the earthquake recovery period, when changes to neighbourhood structures and processes have been large and ongoing. Our approach recognized that changes in neighbourhood levels of economic activity could indicate several recovery processes: changes in access to businesses and services for residents, including access to health-related resources; how well suburban centres were coping; and wider processes of redistribution across the city. To understand what long term recovery looks like and how it affects health, we need the tools to measure changes that will affect opportunities to undertake normal community functions such as working, consuming, providing and using services, and so on.

Capturing the complexity of disaster recovery and outcomes over time is challenging (Chang 2010; Webb et al. 2000) and requires multiple methods and data sources. As with the broader
neighbourhoods and health research field, secondary data sources are commonly used to measure post-disaster environments and changes (Webb et al. 2000). In New Zealand, there is a long-standing official reporting programme for indicators including regional spending trends, business demographics, population migration, poverty and employment. For example, census data have been used to create small area measures of material deprivation that have been instrumental in identifying the contribution of poverty to health inequalities in New Zealand. This information can be used to examine dynamics between neighbourhoods, but its usefulness following major disasters is limited when change is accelerated and intensified. Both scale and temporality become issues in the face of rapid change. Many statistics are reported at the city or regional level in the years following a major disaster event. However, they do not inform us of the often uneven rate or direction of recovery in a neighbourhood compared to other areas. Likewise, many population statistics are only generated annually or with the census (in New Zealand this is five-yearly).

Xiao and Nilawar (2013) make the pertinent point that scale is important: ‘The larger the unit of analysis, the less damage and negative effects one would observe’ (p. 648). During the recovery period, data are most valuable at relatively fine geographic scales and temporal periods, reflecting the intensity of the recovery process and the ways in which ongoing effects are unevenly distributed across the city. Obtaining access to frequently updated information on spatial and temporal patterns within Christchurch has proved to be challenging. Surveys are often administered, but can be burdensome on participants, and data releases can have a significant time lag from data collection. Survey data can also be costly to update over time, and are often not representative of all people and places, thus limiting their ability to be examined alongside datasets such as the census. Chang et al. (2014) demonstrated the value of existing secondary datasets to observe recovery, but recognized the need for information at the correct spatial and temporal scale, so that alternative, informal sources are also valuable. Chang (2010) and D. Brown et al. (2008) recommended using a range of indicators to observe recovery processes. Information that is routinely captured can provide valuable indicators of the effect of a major disaster on a neighbourhood by providing evidence of pre-event trends and the new post-event paths. These long term datasets become powerful tools for monitoring change when integrated with more bespoke data relating to disaster events. They become even more valuable when insights from quantitative approaches such as these are combined with rich, in-depth qualitative studies of place and recovery (Banwell and Kingham 2015; Thornley et al. 2015).

Focusing on the role played by business location in the recovery of Christchurch’s neighbourhoods, we explored methods for using secondary data to observe how economic activity was changing at neighbourhood level, and identify neighbourhood level factors associated with that change. This included information about commercial and residential building damage, repairs and rebuilding, land damage, land planning decisions, and the movement of the ground itself.

Neighbourhoods can be approximated by census area units (CAUs), the second smallest non-administrative geographic units. At the 2013 census, there were a total of 126 CAUs in Christchurch and a mean population of 2,785 residents in each CAU (Statistics New Zealand 2014). Sourcing data at CAU scale was at times problematic, particularly when much information specific to the disaster event and ongoing recovery was collected for operational not statistical purposes, or was the result of surveying a sub-population and not structured in a way that enabled meaningful aggregation. For example, the Canterbury Wellbeing Index, published regularly following the Canterbury earthquakes, draws on a range of datasets of varying geographies, temporal scales and populations of interest that are not necessarily reportable at CAU level. The serial, cross-sectional Canterbury Wellbeing Survey is sourced from the responses of a random selection of residents from across greater Christchurch (including Christchurch city, and Waimakariri and Selwyn districts) (Morgan et al. 2015). The inconsistencies in geography and absence of information for some areas created challenges for integrating information at a neighbourhood level for long term analyses. These are,
however, valuable tools for monitoring change at larger scales over time and have provided substantial insight into earthquake impacts for the wellbeing of Christchurch’s residents.

Table 28.1 outlines a range of economic and social information that is systematically collected and available for all CAUs in Christchurch, and could therefore be used to observe and compare neighbourhood level recovery. These data are available for many years before the 2010 start to the earthquake sequence, so they provide a valuable understanding of historical trends within and across the city.

Table 28.1 also includes some of the earthquake specific data that were captured by various agencies and made available to the research community. These can be broken into three broad groups: the damage to residential and commercial buildings and the subsequent demolitions and repair programme for each; the direct damage to land from ground movement and liquefaction; and the government’s decision-making on future land-use planning which saw many neighbourhoods in Christchurch classified as ‘red-zoned’ areas and deemed no longer fit for occupation. Datasets were reviewed with experts to determine their appropriateness for modelling. Factors included the potential for bias, quality, and completeness of coverage and utility as a proxy over the course of recovery.

It was decided for the purpose of this study to use a dataset of modelled GDP as the economic variable of interest. The data are based on taxation data, businesses by industry in each area, filled jobs by industry in each area and inputs from known GDP at the territorial authority level to model GDP for census area units. We acknowledge the difficulties in using modelled economic data at such small spatial scales, and that the GDP values assigned to each area are a function of the model’s assumptions. However, for this study – to compare economic vitality of small areas in Christchurch – the

<table>
<thead>
<tr>
<th>Domain</th>
<th>Dataset</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic vitality</td>
<td>Electronic card transactions (Paymark)</td>
<td>Number of transactions. Value of transactions. Industry type.</td>
</tr>
<tr>
<td></td>
<td>Census area unit GDP (modelled by Infometrics)</td>
<td>Annual modelled GDP by industry and area.</td>
</tr>
<tr>
<td>Building consents</td>
<td>National building consent statistics (StatsNZ)</td>
<td>Commercial building consents, building units, value.</td>
</tr>
<tr>
<td></td>
<td>National population statistics (StatsNZ)</td>
<td>Residential dwelling consents, building units, value.</td>
</tr>
<tr>
<td>Building consents</td>
<td>New Zealand Deprivation Index (University of Otago Department of Public Health)</td>
<td></td>
</tr>
<tr>
<td>Earthquake event</td>
<td>Commercial building demolitions (Canterbury Earthquake Recovery Authority)</td>
<td>Location of commercial building demolitions due to earthquakes.</td>
</tr>
<tr>
<td>impact data</td>
<td>Residential dwelling and land damage (Earthquake Commission)</td>
<td>Net value of damage to residential land and dwellings due to earthquakes.</td>
</tr>
</tbody>
</table>
modelled data provided a more comprehensive overview of all industries, compared to other datasets such as electronic card transactions which are biased toward the retail and hospitality sector. We therefore treat the modelled GDP data as a proxy measure for the number of businesses in an area.

Comparing Neighbourhood Recovery Trajectories in Christchurch

Our goal was to capture aspects of change within and between neighbourhoods over time. However, because it was not yet clear what ‘recovery’ looked like, let alone what was good or poor recovery, we wanted to identify areas in Christchurch where the early stages of neighbourhood recovery were unexpectedly high or low, given levels of damage and disruption.

A two-stage modelling process was undertaken. First, the overall association between economic activity and neighbourhood built and social factors, including levels of earthquake-related damage and rebuild, was modelled. Then the spatial variability in that relationship was mapped to identify neighbourhoods where higher and lower rates of recovery change were occurring.

Data for residential dwelling consents and commercial building consents showed high positive skew. To mitigate this, each variable was log transformed and an optimized constant value added to make the skewness as close to zero as possible. The log transformed equation was:

\[ f(x_i) = \log (x_i + c) \]

where \( f \) is the transformation function, \( x_i \) is the i'th observed value, and \( c \) is the optimized skewness value that is calculated for each variable.

The datasets spanned different time periods. The economic data were published in February each year, consent and building repair information was date/month specific, and population estimates were for the entire calendar year. Thus the models for each year of interest (2010–2014) were for the 12 months up to and including February, with all datasets aggregated to this period and population estimates for that calendar year applied. Thus the 2010 model covered March 2009 to February 2010 and provided a baseline for the relationship between economic activity and the built and social environment as it was before the first earthquake in September 2010.

We fitted separate linear regression models for each year of interest, where the dependent variable \( (\chi_1) \) was gross domestic product (GDP), measured as the annual sum in NZ$ modelled at each CAU across Christchurch city. Independent variables were tested for multicollinearity by calculating the variance inflation factor (VIF). Residential dwelling and commercial building consents were shown to have a high level of multicollinearity, so these were combined to a single additive variable. All of the final independent variables in the model showed low levels of multicollinearity, according to the VIF.

\[ Y = \beta_0 + \beta_1 \chi_1 + \beta_2 \chi_2 + \beta_3 \chi_3 + \beta_4 \chi_4 + \beta_5 \chi_5 + \beta_6 \chi_6 + \beta_7 \chi_7 + \beta_8 \chi_8 + \epsilon \]

To identify neighbourhoods with better or worse than expected economic recovery trajectories given the level of damage sustained from the earthquakes, the models were adjusted for a range of potential confounders. The independent variables of interest were: count of commercial building demolitions \( (\chi_2) \); net value of repairs and rebuilds for residential housing \( (\chi_3) \); count of residential dwelling and commercial building consents \( (\chi_4) \); total estimated population for the year \( (\chi_5) \); and percentage change in estimated population from the previous year \( (\chi_6) \).

Results of the annual linear regression modelling are presented in Table 28.2. In 2010, the baseline year pre-earthquakes, residential dwelling and commercial building consents and total population were all statistically significantly associated with neighbourhood GDP. For 2011, the first year post-earthquakes, two damage variables were added – net insurance claim value of residential building damage and count of commercial building demolitions. Commercial demolitions showed
a statistically significant association with neighbourhood GDP. In fact, an increase in commercial demolitions was associated with increased neighbourhood GDP; neighbourhoods where demolitions took place may still have had some functioning businesses that experienced increased activity owing to an overall shortage across the city, or these neighbourhoods may have been commercial centres with a high neighbourhood GDP regardless of demolitions.

**Table 28.2 Outputs of annual multiple linear regression models**

<table>
<thead>
<tr>
<th>Dependent variable: neighbourhood gross domestic product (total $NZ millions year to end February 2010)</th>
<th>Independent variables</th>
<th>Estimate</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential dwelling and commercial building consents (count year to date February 2010, log transformed)</td>
<td>6.951e+2</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Total estimated population 2010</td>
<td>-9.238e-2</td>
<td>0.005</td>
<td></td>
</tr>
<tr>
<td>Change in total estimated population from previous year</td>
<td>-1.870e+3</td>
<td>0.141</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent variable: neighbourhood gross domestic product (total $NZ millions year to end February 2011)</th>
<th>Independent variables</th>
<th>Estimate</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net value of residential building damage (related to earthquakes up to end February 2011)</td>
<td>-5.738e-7</td>
<td>0.165</td>
<td></td>
</tr>
<tr>
<td>Count commercial building demolitions (related to earthquakes up to end February 2011)</td>
<td>2.076e+0</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Residential dwelling and commercial building consents (count year to date February 2011, log transformed)</td>
<td>2.395e+2</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Total estimated population 2011</td>
<td>-3.584e-2</td>
<td>0.006</td>
<td></td>
</tr>
<tr>
<td>Change in total estimated population from previous year</td>
<td>1.359e+2</td>
<td>0.495</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent variable: neighbourhood gross domestic product (total $NZ millions year to end February 2012)</th>
<th>Independent variables</th>
<th>Estimate</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net value of residential building damage (related to earthquakes up to end February 2012)</td>
<td>-1.457e-6</td>
<td>0.004</td>
<td></td>
</tr>
<tr>
<td>Count commercial building demolitions (related to earthquakes up to end February 2012)</td>
<td>9.988e-1</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Residential dwelling and commercial building consents (count year to date February 2012, log transformed)</td>
<td>2.848e+2</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Total estimated population 2012</td>
<td>-1.419e-2</td>
<td>0.403</td>
<td></td>
</tr>
<tr>
<td>Change in total estimated population from previous year</td>
<td>-3.539e+1</td>
<td>0.908</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent variable: neighbourhood gross domestic product (total $NZ millions year to end February 2013)</th>
<th>Independent variables</th>
<th>Estimate</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net value of residential building damage (related to earthquakes up to end February 2013)</td>
<td>-2.131e-6</td>
<td>&lt;0.001</td>
<td></td>
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<tr>
<td>Count commercial building demolitions (related to earthquakes up to end February 2013)</td>
<td>1.079e+0</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Residential dwelling and commercial building consents (count year to date February 2013, log transformed)</td>
<td>2.224e+2</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Total estimated population 2013</td>
<td>-4.279e-3</td>
<td>0.793</td>
<td></td>
</tr>
<tr>
<td>Change in total estimated population from previous year</td>
<td>-5.204e+2</td>
<td>0.232</td>
<td></td>
</tr>
</tbody>
</table>

(continued)
From 2012 to 2014, residential building damage, commercial demolitions and building consents (residential and commercial) were statistically associated with neighbourhood GDP. Commercial building demolitions occurred relatively rapidly, and buildings which required demolition were generally uninhabitable immediately after the February 2011 earthquake, so it was logical for this variable to immediately influence the model. In contrast, residential dwelling damage took much longer to account for and value, with dollar figures being retrospectively attributed to events by insurers. High damage values did not necessarily mean that people could not inhabit their homes, so some of the effect of residential building damage on neighbourhood GDP was most likely observed later in the recovery period as the repair programme began in earnest and forced large numbers of people from their homes at least temporarily.

The second stage of modelling sought to observe how much the relationship between neighbourhood built and social factors, and economic activity varied across the city. After fitting each annual model, deviance residuals were generated for each CAU to identify individual neighbourhoods with over (high) and under (low) prediction. Residual values were calculated as the difference between observed and predicted values under the model. Negative residual values indicated that observed economic performance was better than expected based on the model prediction, and vice versa for positive residual values. The distribution of neighbourhoods along this positive–negative spectrum was used to identify areas that have regularly under- or over-performed relative to neighbourhoods within the model. This approach has been previously used by Pearson et al. (2013) in their calculation of a neighbourhood resilience index for New Zealand. All analyses were conducted using R version 3.1.0 (R Core Team 2014). The residual values for each neighbourhood are presented in Figure 28.3. Areas have been first split into two groups with positive and negative values, each of which was then categorized into three equal sized tertiles, creating six groups in total.

In the pre-earthquake year ending February 2010, there was an overall trend of relatively good economic vitality in Christchurch’s central and suburban centres given the number of building consents and population factors. Immediately after the earthquakes, in the 2011 model, there was a significant reversal in vitality for many areas, most dramatically in the three neighbourhoods that constitute the central business district. This was expected given the CBD Red Zone cordon that was quickly established, gradually shrinking as demolitions occurred and buildings were made safe until June 2013. Within this cordon area were the majority of Christchurch’s major commercial buildings.

The 2012 model captured neighbourhood outcomes a year on from the most severe earthquakes in the sequence. Business and residential relocations had largely taken place as needed, and the demolition of individual buildings around the city was under way. Compared to 2010, there was an upturn in economic activity in the relatively undamaged western neighbourhoods of Christchurch.

### Table 28.2 (continued)

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Estimate</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net value of residential building damage (related to earthquakes up to end February 2014)</td>
<td>−2.339e−6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Count commercial building demolitions (related to earthquakes up to end February 2014)</td>
<td>1.228e+0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Residential dwelling and commercial building consents (count year to date February 2014, log transformed)</td>
<td>1.981e+2</td>
<td>0.015</td>
</tr>
<tr>
<td>Total estimated population 2014</td>
<td>−1.426e−2</td>
<td>0.445</td>
</tr>
<tr>
<td>Change in total estimated population from previous year</td>
<td>−6.032e+2</td>
<td>0.232</td>
</tr>
</tbody>
</table>

Dependent variable: neighbourhood gross domestic product (total $NZ millions year to end February 2014)
Figure 28.3  Modelled relative annual neighbourhood outcomes in Christchurch (2010–2014).

Basemap credit: Land Information New Zealand and Eagle Technology Group Ltd.
These areas could accommodate retail, industrial and professional services in existing building stock, and construction of new commercial property, particularly around the airport, was quickly begun. In contrast, the central and eastern areas of the city had relatively poor outcomes, as would be expected given the CBD Red Zone and significant damage to those neighbourhoods. This pattern largely persisted until 2014, the most recent year of GDP data included in the model, though there was a weakening in how much better western neighbourhoods performed, even given their relatively less damaged state.

**Trajectories of Recovery?**

The integration of multiple sources of secondary data reveals the beginnings of long term recovery from the damaging 2010/2011 earthquakes in Christchurch, and how that recovery is varying across neighbourhoods. Recognizing the key role played by businesses and the services they provide in shaping opportunities for living well, and drawing on good quality, accessible data on business location and economic activity, we found that the change in location of economic activity in Christchurch has been substantial, rapid and ongoing. Given the magnitude of change, shifts in economic activity are likely to represent significant transitions in urban form across Christchurch, with implications for how people live their daily life and their opportunities to live well.

Businesses displaced from the central city have relocated across the city, though initial moves tended to be to the less damaged west and north. The neighbourhood characteristics of many business locations have undergone rapid change, including damage to land and buildings, construction of new or replacement commercial and residential property, and movement of people and businesses into and out of neighbourhoods.

Within this, we found wide variation in economic performance, suggesting that broader contextual factors may be underpinning uneven economic recovery across the city. One explanation may be the unusual, and often less than ideal, contexts many businesses have had to cope with. Factors such as proximity and accessibility for clients and related businesses and transport links, identified as significant everyday criteria (Gordon and McCann 2000) and networks (Stevenson et al. 2014), have all been compromised. The disruption associated with high levels of demolitions and land damage within a neighbourhood is likely to represent a place where everyday activities such as work and shopping are challenging, access to health resources is more challenging, and stress levels are increased.

Given the prolonged nature of recovery required following such a devastating event, such changes are intuitively expected but seldom able to be observed and therefore explored (Chang 2010). The use of formal and informal secondary data and analytical tools, bringing together multiple indicators of contextual factors and economic activity through spatial linkage into a single analysis to investigate neighbourhood level annual change, allowed us insight into the complexity of the recovery process. This provides a useful approach for ongoing longitudinal research on recovery, as the data can be relatively easily updated and new indicators added to the models. In time, with new data points and greater incorporation of social factors (such as gathering places and social cohesion), these methods will contribute to a greater understanding of what recovery looks like in different Christchurch neighbourhoods and communities.

**Implications for Long Term Community Recovery and Wellbeing**

A range of studies have made connections between community recovery from disasters and emotional wellbeing. For instance, Gruebner et al. (2015) observed geographical variation in mental health outcomes in post-Hurricane Sandy New York City consistent with proximity to the most exposed and damaged seaward areas. Three years after the Great East Japan earthquake and tsunami,
Tsuboya et al. (2016) found that damage to property and disrupted access to health services were a stronger predictor of persistent adverse mental health impacts than the loss of a loved one. Looking at Christchurch after the earthquakes, Hogg et al. (2016) used community profiles to measure spatial variations in mental health, although the authors acknowledged the challenges in validating such measures. Because the profiles were created for 2010, 2011 and 2012, these cannot follow later recovery, in part because not all data sources are updated annually at community scales. If we are to understand the longer term impacts on wellbeing of major disasters, we need measures that capture how communities and cities rebuild and change over the whole course of recovery.

Disasters disrupt socioecological systems, with impacts on services (such as those provided by businesses) that affect the capability of individuals to undertake everyday functions and feel safe. In addition, the neighbourhood context influences how a location (and businesses within it) recovers after an event. From a resilience perspective (Norris et al. 2008), what matters is whether the disruption is transient, and Christchurch and its neighbourhoods adapt and grow to thrive, or whether the consequences of the shock lead to continued dysfunction. The extent of damage to Christchurch’s buildings, and subsequent relocations, is likely to have led to a significant redistribution of the determinants of health across the city. Further, our results suggest there are likely to be areas where the rate of change itself may be an influencing factor in the health and wellbeing of residents. Slower rates of recovery may impact residents’ wellbeing, for example if they are faced daily with signs of unrepaired damage or a lack of investment. Very rapid recovery could be stressful if it leads to increased traffic, displacement of long-standing local businesses and amenities, and disruption to social ties. On the other hand, rebuilding can provide improved amenities, for example high quality cycleways (Christchurch City Council n.d.) and playgrounds (Ryan 2017). Fully observing the context of recovery and resilience requires spatial information on the changing built, social, physical and economic environment that can be spatially and temporally linked to health and wellbeing outcomes. Identifying when and how changes in the built environment contribute to social and economic recovery will increase understanding of the mechanisms that lead to both vulnerable and thriving communities.

The analyses presented here model the association between economic activity and neighbourhood factors, including earthquake-related ones. If there were comparable data available for social activity, such as the neighbourhood density of social networks, or level of social interactions, would there be a different spatial pattern of recovery? Ultimately there is no clear answer without good quality data at the appropriate spatial and temporal scales. This remains a challenge for a number of programmes seeking to develop indices to monitor processes such as resilience (Stevenson et al. 2015) and non-economic wellbeing outcomes such as happiness (http://thehappycitylab.com/). However, the relationship between economic and social activity is likely to be reasonably close given that, in New Zealand towns and cities, businesses are sites of interaction through employment, retail and service consumption, and as local institutions. Businesses play a vital role in making (good) places and facilitating overall recovery, be it at neighbourhood scale through creating local amenities that support healthy lifestyles, or at city scale through providing means of employment and key services such as childcare, finance and recreation. Of course, not all economic activity offers health-promoting resources. After all, land-use patterns mean neighbourhood centres provide greengrocers and libraries alongside fast food and alcohol outlets (Pearce et al. 2008).

If 2011 was a period of emergency and response to disaster, 2012 onwards marked the beginning of planning for and embarking on recovery in Christchurch. At the time of writing, much of the rebuilding of the central city is still underway, with many new buildings occupied around the fringes of the central city, but a dense core is only now emerging. The return of people living in this area is also slowly taking place. With aspirations to have 20,000 people living in the central city, compared to fewer than 8,000 before the earthquakes (O’Callaghan 2013), this will be a decades-long process.
The secondary datasets used here have established a platform to monitor ongoing recovery in Christchurch. The datasets include neighbourhood level data on economic vitality, business statistics, building consents, population and socioeconomic factors, and event specific data including building damage, land damage and land-use decision-making. Using multiple secondary data sources across economic, built environment and, to some extent, social domains, we are able to populate indicators of neighbourhood recovery, and consider the relationship between these domains and the physical impacts of the event itself. This allows us to compare recovery across neighbourhoods, showing evidence of comparatively ‘better’ and ‘worse’ than expected economic activity, and hence neighbourhood recovery, between areas.

**Conclusion**

By measuring variations in our everyday environments, we can start to understand the role they play in the wellbeing of our cities, communities and individuals. With such insights, we can better plan for, and invest in, changes to our environments to ensure they contribute to wellbeing rather than exacerbate health inequalities. Major disasters, such as Christchurch’s earthquakes, dramatically change the everyday environment for many residents – immediately, over the recovery period and potentially permanently. Guided by a determinants of health approach, the methods presented here allow us to systematically observe the nature of adaptation in Christchurch and identify areas where recovery efforts may be best targeted to reduce vulnerability amongst population groups and locations. Such uses of secondary data, alongside fine-scale measures such as the Neighbourhood Recovery Index, provide researchers and recovery agents with tools to develop a deeper understanding of the long term earthquake impacts, and therefore to plan for the resilience of the city and for the health and wellbeing of Christchurch’s people.

**References**


Macintyre, S., Ellaway, A., and Cummins, S. 2002. Place effects on health: How can we conceptualise, operationalise and measure them? Social Science and Medicine, 55, 125–139.


