

Organizational Networks and Recovery Following the Canterbury Earthquakes

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Following a disaster, the recovery of organizations is influenced by the flow of resources and information through organizational networks. The 2010–2011 earthquakes in Canterbury, New Zealand, had major direct and indirect impacts on local organizations and the regional economy. This paper utilizes 47 organizational case studies to assess the role of organizations' networks in their response and short-term recovery activities, and to explore the effects of networks on regional reconstruction and related sectors. The results are organized around four thematic analyses, focusing on organizations' support network characteristics, the types of support mobilized to aid recovery, network adaptations for new post-quake demands, and the economic impacts of organizational networks in reconstruction. The paper discusses how organizations managed and utilized networks to reduce the impacts of the earthquakes and to adapt to altered post-quake environments. These empirical observations of post-quake organizational behavior can also inform regional economic impact and resilience modeling. [DOI: 10.1193/022013EQS041MR]

INTRODUCTION

Resilient organizations are a critical element of successful post-disaster recovery. The decisions and actions of organizations after a disaster influence overall community recovery and wider economic conditions, including labor market demand, the cost of essential goods and services, and capital investment trends. Within the mainstream disaster resilience literature, however, few studies consider the ways social and economic connectivity of organizations of all kinds (private, public, for profit, and nonprofits) shape organizational and community recovery after a disaster.

The Canterbury earthquake sequence began on 4 September 2010 at 4:35 a.m. when an M_w 7.1 earthquake struck Christchurch, New Zealand's second largest city. The epicenter was located approximately 40 km southwest of Christchurch. The first earthquake, commonly known as the Darfield earthquake, caused an estimated NZ\$4–5 billion of

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damage (Bascand 2011, Parker and Steenkamp 2012). A major M_w 6.3 aftershock occurred on 22 February 2011, claiming 185 lives and destroying a large number of buildings in the Christchurch Central Business District (CBD). In addition to these two major events, the region experienced 54 earthquakes of magnitude 5.0 or higher between September 2010 and December 2012 (Statistics New Zealand 2012b). Figures released by the Government in 2013 suggest that the estimated cost of recovery and reconstruction could reach NZ\$40 billion, though high levels of uncertainty remain. The cost of the damage is equivalent to around 19% of New Zealand's GDP (New Zealand Treasury 2013).

The September 2010 and February 2011 earthquakes have had significant impacts on the Canterbury region. Between June 2010 and June 2012, the population of the greater Christchurch area decreased by 9,200 people or 2% (Statistics New Zealand 2012a). The earthquakes have also depleted the available stock of buildings and influenced the location and timing of commercial and residential development.

The earthquakes have had varied impacts across economic sectors. Hospitality, retail, and tourism have been especially hard hit (Orchiston et al. 2012, Kachali et al. 2012, Stevenson et al. 2011). Hotel and backpacker accommodation capacity fell by about 20% regionally and by about 75% in Christchurch (Statistics NZ 2012, CERA 2012a). International guest nights dropped by a third following the February quake (Parker and Steenkamp 2012) and have not significantly improved during 2013 (Statistics New Zealand 2013). Retail spending initially fell dramatically, but by early 2013 had rebounded to levels 15% higher than before the quakes, while hospitality sales (e.g., cafés, restaurants, and bars) only returned to pre-quake levels as of early 2013 (Statistics New Zealand 2013). Similarly, tertiary education has been negatively affected, with international student visas for Canterbury tertiary institutions were down more than 40% in 2012 compared to February 2011 (Parker and Steenkamp 2012). In contrast, a number of sectors have proved relatively resilient, including agriculture, manufacturing, and exporting (Parker and Steenkamp 2012). Industries such as the construction sector, fast moving consumer goods (e.g., supermarkets) and critical infrastructure providers have been able to capitalize on opportunities created by the earthquakes. A number of these industries have experienced revenue growth, despite constraints and logistical impediments to their operations (Kachali et al. 2012, Stevenson et al. 2011).

The 2012 Household Labor Force Survey (HLFS) shows that total employment in Canterbury declined by 9%, with the greatest falls in the retail and hospitality sectors (Statistics NZ 2012c). Conversely, construction sector employment increased markedly between June 2010 and mid-2012 (Parker and Steenkamp 2012).

Those who lost jobs in retail, accommodation, and food services have not been easily able to transfer their skills to jobs in expanding sectors, such as construction, transport, and professional and scientific services. Despite a fall in aggregate employment, some industries have had difficulty recruiting workers with desired qualities. Advertised vacancies for construction and engineering jobs in Canterbury increased more than 75% between August 2011 and August 2012 (Statistics New Zealand 2012c). In the construction sector, for instance, employers experienced difficulty finding local job

applicants with the desired engineering skills and experience to meet their needs (Chang-Richards et al. 2012b).

The economic recovery of Canterbury has been slower than initially predicted by the New Zealand Institute of Economic Research and others in the early phases of the recovery process. Real GDP growth for the region between 2010 and 2012 was steady, but was dampened by a weak global economy, by the national government deleveraging to reduce the debt to GDP ratio (e.g., asset sales, at the national level), and by financial and regulatory uncertainty about the rebuild (NZIER 2012a).

As reconstruction proceeds in Canterbury, organizational responses and resourcing strategies are shaping the region's long-term economic trends and recovery. Organizations that are capable of accessing resources and opportunities collectively held in networks of relations have an enhanced capacity to respond effectively to the altered physical, social, and economic environments post-earthquake.

In this paper, we draw on information from two research projects that examine how organizations have addressed the challenges presented by the Canterbury earthquakes. The projects used 47 longitudinal case studies conducted between 2010 and 2012 to explore resource flows, organizational networks, and organizational roles in the Canterbury recovery and reconstruction process.

We present a network conceptualization of organizational resilience derived from the analysis of these case studies. We discuss the ways organizations' response and recovery processes were affected by the 2010–2011 Canterbury earthquakes, focusing on the relationship between connectivity among organizations and other entities; their ability to resource goods, services, and other necessary support; and their ability to respond and adapt to altered post-disaster environments.

The first section presents a review of literature, providing a theoretical context for examining organizational resilience from a network perspective. We then introduce the case studies, describing the data collection and analysis methods. In the results and discussion we examine organizations' support networks, focusing on networks as conduits through which resources are cultivated and mobilized to facilitate resilient responses. We explore network composition characteristics, the support mobilized through the networks, and post-quake network adaptation. We then examine the economic impacts at the sector level (specifically construction and related industries), discussing the exchanges and interactions that influence local and regional trends during post-earthquake reconstruction. We conclude with reflections based on these results, along with observations that can guide further conceptual and applied work on organizational networks and resilience.

THEORETICAL CONTEXT

In this paper, we are primarily concerned with the resilience of organizations, but we also consider responses to the earthquakes at the scale of industry sectors and regional economic trends. Organizational resilience refers to an organization's ability to resist the negative impacts of a crisis, to maintain or quickly restore its functionality, and to incorporate positive adaptive changes (Vogus and Sutcliffe 2007, McManus et al. 2008). Resilience is facilitated by an organization's ability to adapt its systems to address emergent issues post-crisis

(McManus et al. 2008). Rose (2004, 2007) distinguish these post-disaster organizational capacities as (1) static resilience: the ability to absorb impacts and maintain function when shocked by making use of the resources available at a given time, and (2) dynamic resilience: the speed at which an entity or system recovers from a shock to attain a desired state (Park et al. 2011, Wein and Rose 2011). Both static and dynamic resilience are facilitated through inherent and adaptive responses. Inherent organizational responses include conserving or substituting inputs in short supply, while adaptive responses are characterized by attaining higher conservation and production levels than normal (e.g., through technological change, relocation; Park et al. 2011).

Inter-organizational networks are a major influence on an organization's capacity to survive a disaster and adapt in its aftermath. Formal and informal inter-organizational relationships facilitate information sharing and the coordination of post-disaster operations (Comfort et al. 2001, Kapucu et al. 2010). They can aid access to and the distribution of supplies, enhance organizational learning (Podolny and Page 1998), and facilitate adaptive responses to changed post-disaster environments (Tierney and Trainor 2004). Examinations of the resilience of business firms (Tierney 2003, Freeman et al. 2003, Gittel et al. 2006), government and emergency response entities (Comfort et al. 2001, Tierney and Trainor 2004, Comfort et al. 2009, Kapucu et al. 2010), and nonprofits and community organizations (Kapucu 2003, 2007, Seville et al. 2011) all highlight the importance of network interactions for the resilience of organizations, as well as for economic and community resilience.

Organizational networks, which at their most basic level consist of a series of ties between actors, act as a conduit through which collectively held resources may be mobilized (Knoke and Yang 2008). Optimal communication flows in public organizations and small businesses (Comfort et al. 2001, Doerful et al. 2010), the coordination of organizations involved in response (Zagorecki et al. 2010), and strategies for avoiding and managing disrupted supply relationships (Braithwaite 2012, Christopher and Peck 2004) can improve organizational resilience and recovery outcomes. Organizational networks may also act as a form of informal insurance, as organizational investments in relationships prior to a crisis form a resource which may be drawn upon after a crisis to facilitate response and recovery (Aldrich 2010). In this way, networks are a key source of both static and dynamic resilience.

Certain network attributes improve an organization's chances of survival during "business as usual" (Hurlbert et al. 2000). For business firms, for example, trust-based relationships can act as a channel for high quality information exchange, facilitate joint problem solving, and reduce market uncertainty (Uzzi 1999). Inter-organizational relationships reinforced through trust and reciprocity make the ties more stable or durable (Kilduff and Tsai 2003, Robson et al. 2008).

Organizations may access a variety of resources through their networks in order to support their ongoing function, ranging from tangible or quantifiable goods and services through to less tangible information, advice, and personal support for employees. By virtue of their different strategic positions network members are differentially situated to access specific resources such as material supplies, information on market needs and demands, and to exert influence on other agents or policy (Lin 2005).

Strong ties, characterized by multiple dimensions (e.g., ties with friendship, reciprocity, and market components), often form among organizations in close geographic proximity. Such ties build trust and loyalties that decrease the potential cost of sharing resources and increase the likelihood of reciprocity (Knoben and Oerlemans 2008, Li et al. 2012, Sheffi 2006). Additionally, geographically concentrated network relationships among community members and organizations can aid community capacity building and economic development by raising the “cost of exit” from a community and incentivizing local reinvestment (Aldrich 2010, Pallares-Barbera et al. 2004).

Many inter-organizational relationships relevant during business as usual are also relevant post-crisis (Hurlbert et al. 2000); however, disasters can disrupt existing networks and generate new demands, meaning that organizations have to adapt their networks accordingly (van der Veen 2004). New network members may be added or pre-event roles redefined to meet resource demands that emerge throughout response and recovery (Comfort et al. 2009). Following extreme events, organizations tend to access resources through formal (i.e., contractual or market based) and informal networks more frequently and with higher intensity than during business as usual (Hurlbert et al. 2001). Similarly, organizations tend to increase information exchange, communication, and coordination in order to cope with increased complexity in crises (Comfort et al. 2001).

Entrepreneurs and new businesses often rely on kin and friendship networks to access resources (e.g., financing, information, and influence; Greve and Salaff 2003). Like new businesses, post-disaster organizations are often navigating unfamiliar territory while under serious time and resource constraints. Organizations need to make decisions quickly and improvise when resources are unavailable through traditional channels. Transactions in which an organization’s members access support from friends and family members to meet organizational needs blur the boundary between personal and professional networks. Yet, particularly in small firms, this can be a viable adaptive strategy for organizations post-disaster.

Similarly, disasters may sometimes foster an “open-resource environment in which organizations tend to collaborate with each other in order to obtain resources” (Doerfel et al. 2010, p. 128). Post-disaster cooperation (De Alessi 1975) and alliance seeking behaviors (Koria 2009) become more frequent in the aftermath of disasters. Supportive organizational networks which are (re)formed during recovery may promote business development and enhance organizations’ recovery trajectories (Chang-Richards et al. 2012).

The microeconomic processes that guide the recovery of organizations and the meso- (e.g., markets or industry sectors) and macro-economic processes that dictate the cost and pace of reconstruction and community recovery are both driven by a network of interactions (Rose 2004, van der Veen 2004, Briguglio et al. 2009). Understanding network interactions by tracing linkages between industries and across geographic areas is of paramount concern in the ongoing development of econometric, input-output (IO), and computable general equilibrium (CGE) models (e.g., Okuyama 2004, Rose and Liao 2005, and Okuyama et al. 2007). For instance, ripple effects of physical damage in one sub-area may influence economic activities in another due to inter-sectoral requirements in production or consumption (Olshansky and Chang 2009). Similarly, disruptions to crucial intermediate sectors may

affect businesses that are interconnected. For example, the cost of resources required for reconstruction can be much higher than the pre-disaster price as a consequence of disaster-related supply disruptions (Le Masurier and Wilkinson 2006, Jayasuriya and McCawley 2008) and scarcity of resources (Chang-Richards et al. 2012a). In the case of construction resources, price increases can cause recovery program cost overruns (Koria 2009, Steinberg 2007) and prolong recovery schedules (Boen 2008).

The actions, decisions, and interactions of organizations are instrumental to recovery and reconstruction, but also add uncertainty to their quality, time and cost. These uncertainties can influence the trends of reconstruction and indirectly impact economic activities in terms of production planning (Chang-Richards et al. 2012a).

RESEARCH METHODS

Our analysis draws on data from two separate studies of organizations affected by the Canterbury earthquakes. Each study used a longitudinal case study approach, following organizations between 2010 and 2012 as they responded and adapted following the earthquakes. The “Town Centers study” examined 32 organizations from three town centers heavily impacted by the Canterbury earthquakes. The “Construction Industry study” focused on 15 organizations in the construction sector, all of which were actively engaged in reconstruction related work in Canterbury (Table 1).

The Town Centers study selected case studies from a larger sample of 366 Canterbury organizations that were surveyed in 2010, 2011, and 2012 (for more on the results of these surveys, see Stevenson et al. 2011, Kachali et al. 2012, Whitman et al. 2012). The case study organizations (CSOs) were selected from this larger sample on the basis of their location—the organization’s pre-earthquake premises needed to be in Christchurch, Kaiapoi, or Lyttelton town centers¹—and their willingness to participate in ongoing research. The case studies encompass a range of organizational forms, from those run by an owner/operator to corporations with hundreds of full-time equivalent (FTE) employees.

A total of 32 organizations participated in the ongoing study and completed questionnaires issued in 2010, 2011, and 2012. Semi-structured interviews were also conducted with one or more organizational representatives who were well placed to offer a strategic overview of the organization (i.e., owners, CEOs, regional or operational managers). These interviews lasted between 1.5 and 4 hours. During the interviews, detailed information was collected on each organization’s post-disaster support networks using participant-aided sociograms (for more on this tool and method, see Bernardi 2011 and Carrasco et al. 2008). The researchers also conducted site visits to each organization’s current premises where possible.

¹ The Christchurch CBD was heavily impacted by both the September 2010 and February 2011 earthquakes. Kaiapoi, a town approximately 12 miles north of Christchurch, was most heavily damaged in the September earthquake with severe liquefaction and lateral spreading. Lyttelton, a port town about 7 miles east of Christchurch, was most heavily damaged in the February earthquake, principally as a result of shaking damage and rock fall hazards.

Table 1. Overview of case study organization (CSO) data

Study	<i>n</i>	Data collection period	Sectors represented in CSOs	CSO pre-quake locations	CSO (full-time employees)
Town Centers	32	Nov. 2010– June 2012	Retail (13) Hospitality (5) Culture & recreation (3) Financial services & real estate (3) Personal care services (2) Technical & scientific services (2) Manufacturing (1) Wholesale (1) Information media & telecoms (1) Social services (1) Engineering (6)	Christchurch CBD (12) Kaiapoi (11) Lyttelton (9)	Mean = 19 Min = 1 Max = 284
Construction Industry	15	Oct. 2011– Dec. 2012	Construction (5) Building supplies (2) Project Management Offices (2)	Christchurch	Mean = 250 Min = 30 Max = 700

The Construction Industry study focused on organizations involved in the post-earthquake repair and rebuild in Canterbury. In September 2011, a survey investigating the issues and challenges faced by construction organizations was distributed to the members of Construction Industry Council. The research team conducted follow-up interviews with 35 selected survey participant organizations in September and November 2011, and in February and May 2012. In September 2012, the research team selected 15 CSOs for more in-depth follow-up based on their willingness to participate, their size (medium to large organizations), and organizational type (i.e., exclusively construction, construction management, building supply, and engineering firms). Both studies provide data on organizational experiences, resourcing, and relationships after the earthquakes. When combined they enable a rich set of insights into networked perspectives of organizational resilience.

The cases were analyzed using thematic cross-case analysis, an approach which treats each organization as a separate case, but allows evidence from each organization to be compared to produce generalized observations. This analysis produced elements of both explanation building and hypothesis generation (Yin 2008). We approached the analysis with the intent of exploring the network elements of organizational processes following the Canterbury earthquakes. By aggregating the findings regarding these network dimensions we were able to identify issues and processes that were relevant across a range of organization types. In the following results section we present these generalized thematic findings, illustrating them with primarily qualitative data from the case studies.

RESULTS AND DISCUSSION

We begin by describing the basic form of the CSO support networks (i.e., which organizations comprise the support network and network characteristics); support mobilization (i.e., the kinds of support organizations accessed through their networks); and how organizational networks developed and changed following the earthquakes. From here we move to consider the broader impact and context of organizations' roles in interconnected networks, drawing links between organizational actions and meso- (sector) and macro- (regional) economic trends.

SUPPORT NETWORK CHARACTERISTICS

The characteristics of an organization's support network include the other organizations involved, their attributes, and the nature of the relationships between them. Here we focus on three features of the support network that were notable in the cross-case analysis: the geographic location of supporting organizations; the diversity of supporters' network positions (i.e., the social, economic, or institutional roles of the supporters); and the strength of inter-organizational ties.

Geographic proximity between organizations facilitates frequent contact, dense networks, mutual awareness of issues, aid delivery, and further tie development. In the Town Center study, over 70% of all support was accessed from organizations located within Canterbury, while 24% and 4% respectively came from elsewhere in New Zealand and internationally².

Wein and Rose (2011) note that if the time to recapture lost production following a disaster surpasses customers' willingness or ability to wait, the organization risks losing market share. We found that customer patience for delay varied by an organization's geographic proximity to the disaster area. Organizations reported that their local clients, suppliers, and creditors were often far more willing to readjust routines and accommodate earthquake disruptions than those in other parts of the country or internationally. Perhaps because they had also directly experienced the disaster, local clients and suppliers were viewed as more likely to grasp the magnitude of the disruptions and be understanding of the difficulties case study organizations experienced.

Although local supporters were the most common sources of solidarity, resources, and information, financial support was more likely to come from outside of Canterbury (approximately 40% of all post-quake financial support came from outside Canterbury in the Town Centers study). This difference in the spatiality of financial and non-financial support is in part due to the relative ease of giving monetary resources, discounts, or credit from a distance compared to delivering services or physical resources. It may also reflect a greater sense of financial security for organizations operating outside of earthquake affected areas, compared to organizations dealing with the uncertain recovery environment in Canterbury. Organizations with customers outside of the region were able to support cashflow with income from outside of the affected region, while local customers were disrupted.

² In the remaining 2%, respondents were unsure where their supporters were geographically based.

In addition to a geographic location, supporters' network positions influenced the kind of support they were able to offer. In many cases direct competitors or those working in the same industry were best positioned to provide each other with assistance; Table 2 outlines several examples of the tailored support provided by organizations with close market overlap.

Business associations and industry groups often acted as hubs that facilitated the flow of information and resources between organizations (in ways that might not have otherwise occurred). Their activities in this respect were an extension of the role they play during business-as-usual (see, e.g., McCormick et al. 2008). In the case of the Canterbury earthquakes, business associations served important roles as bridging ties with unconnected networks and brokered relationships among different network actors.

Government agencies were one of the most common sources of financial support for the case study organizations. The Earthquake Support Subsidy, for instance, was issued by the national government following both the September and February earthquakes to help employers continue paying wages during periods of diminished activity. Eligible employers applied on behalf of their employees for a fixed weekly payment for each full-time (NZ\$500) and part-time (NZ\$300) worker. This sum was then paid directly to the affected worker. Nearly half of the organizations in the Town Centers study received this subsidy after the February earthquake, and all of those found the subsidy to be important for retaining staff and maintaining their financial health in the first few months following the event.

Finally, the nature of the inter-organizational ties influenced how support flowed through the network. In the case studies, strong ties were particularly important for being able to access support quickly and for enhancing flexibility in organizations' support relationships

Table 2. Support received by CSOs from organizations with close industry overlap

Nature of supporting organization(s)	Post-earthquake support
Competing pharmacies located within a few blocks of each other	Following the September earthquake, the pharmacies temporarily shared premises due to Pharmacy One suffering building damage. Following the February earthquake, Pharmacy Two lost a supplier and was able to make orders through Pharmacy One's supplier.
Competing building supply companies in central Christchurch	Assisted with each other's workload and deliveries during a period of increased demand.
IT organizations operating in Christchurch prior to the February earthquake	Formed an informal group to regularly exchange tips on marketing, development, and other post-earthquake business strategies.
Historic archiving organization based in Wellington (outside of affected region) and the Christchurch-based archiving branch of a national organizations	The Wellington-based archiving organization stored materials for the Christchurch organization, organized meetings with the local sector, offered conservation material and arranged specialized storage and relocation assistance.

post-earthquake. For organizations in the Town Centers study, supporters with whom CSOs had the longest pre-existing relationships were significantly quicker to provide support following the earthquakes and they also provided more kinds of support.

Similarly, strong relationships with suppliers (indicated as both long established relationships and relationships with friendship or emotional support content dimensions) facilitated faster and easier access to replacement or supplemental supplies (e.g., retail stock or computing equipment). In the Town Centers study, eight organizations reported that they felt they received “emotional support” from suppliers in addition to instrumental support. Strong relationships with suppliers also meant greater flexibility on payments or adjustments to previously established supply arrangements, including receiving donated supplies directly, discounts or extended credit from suppliers, and deliveries outside of normal work hours.

MOBILIZING SUPPORT

In the aftermath of the Canterbury earthquakes, the CSOs faced increased pressure on their financial and physical resources, in a manner which exceeded their ability to cope without external assistance. Each of the CSOs thus mobilized support from extra-organizational networks to address two prominent issues: workforce issues and material shortages. The support received ranged from tangible assistance, including financial and physical resources, to less tangible support such as emotional support, information, and advice.

Workforce support was considered by the CSOs to be one of the most important types of assistance following the earthquakes. Organizations able to stay open or reopen quickly following the earthquakes often faced increased demand for their goods and services, as competitors remained closed. Most affected organizations, regardless of whether they were fully operational, faced additional logistical and coordination demands due to disrupted infrastructure and supply chains. Similarly, many CSOs reported higher administrative demand caused by insurance claims, relocation requirements, and tax deferments. At the same time, local labor productivity decreased as employees had to deal with damage to their homes, disrupted families, and other personal stressors exacerbated by the earthquakes.

One of the ways the CSOs mobilized additional labor from their support networks was having family members and friends assist with administrative work, relocation management, and related tasks. Larger organizations also redistributed work to out-of-town branches or brought in additional staff members from offices in unaffected branches.

Labor resourcing was especially salient for construction-related organizations. Following the February 2011 earthquake, it was estimated that the rebuild would require around 24,000 additional construction-related workers at its peak (CESB 2011). The New Zealand Budget 2012 included a \$42 million package for trades training in the Canterbury region to address the anticipated labor shortage³, but organizations in the meantime have had to expand their hiring networks overseas to address skill shortages in engineers, management, and other

³ Policy responses such as these have major lag times before the benefits are realized, and some organizations involved in the rebuild remain skeptical about whether the tertiary education initiative will directly benefit the reconstruction. It will be at least 3–4 years before students taking advantage of tertiary education initiatives for engineering degrees will be able to practice as engineers and organizations’ workloads in Canterbury may fluctuate over time.

technical job categories. Expansion of the workforce across case study construction organizations has been significant, with a range of 10% to 60% of new employees sourced from overseas, primarily from the United Kingdom, Ireland, and the United States.

The Construction Industry study found that organizations changed their business operation models to source skilled people and integrate workforce expansion into their longer-term business development. Larger firms tended to coordinate with external training providers, such as the Building and Construction Industry Training Organization (BCITO), Industry Training Organizations (ITOs), and Christchurch Polytechnic Institute of Technology (CPIT), to address their skills shortages. Smaller organizations, however, tended to rely on their informal social relationships to form partnerships and resource labor.

Supporting the well-being of the existing labor force in Canterbury was a critical concern for organizations across all industry sectors. In surveys issued following the 2010 and 2011 earthquakes, Canterbury organizations reported that their biggest challenges related to managing staff wellbeing and dealing with stress (Stevenson et al. 2011). Staff fatigue and stress reduced productivity, increased intra-organizational conflict, and strained relations with customers and clients. During 2012, there were signs that workers in construction organizations were suffering from fatigue and having difficulty concentrating, contributing to errors and rework rates higher than the previous year.

To address these issues, medium- and larger-sized CSOs provided employees with personal counseling, remote working options for staff, opportunities to rotate to non-earthquake-related jobs (especially in the construction industry), family holiday packages, and flexible working options. Small businesses (especially micro-businesses, with five or fewer employees), however, have generally been unable to provide the same level of support. Instead, they have tended to mobilize support through extra-organizational networks, with family members and friends providing a significant amount of emotional support and supplemental labor to cover for or assist fatigued employees. Several small business owners in this study discussed the importance of community members “checking in” on staff, and receiving encouragement, empathy, and a sense of solidarity from members of their network.

Organizations also mobilized support from their networks to access material resources, supplies, and to manage commercial accommodation shortages. CSOs’ suppliers were the most common source of support following the earthquake, though depending on the nature of the relationships, the quality or quantity of support varied. In some cases, suppliers proactively contacted the CSOs to assess lost stock, discuss future supply needs, and coordinate changes; this helped ensure continuity of supply but also positively reinforced the supply relationship. In the Town Centers study, eight organizations reported that they felt they received “emotional support” from suppliers in addition to instrumental support, including donated supplies, discounts or extended credit, and supplemental deliveries outside of normal work hours. In instances where suppliers could not fulfill short-term needs, CSOs made informal arrangements with other (non-supplier) organizations to access required stock. For example, two CSOs (a retail shop and a building supplies company) temporarily made orders through another organization’s supplier until they were able to reestablish their supply relationship or find a new supplier.

Some CSOs were unable to access suitable premises. Damage from the February 2011 earthquake, along with governmental responses (e.g., the CBD cordon and mandated

building demolitions), caused critical supply shortages in commercial accommodation (Chang-Richards et al. 2013b). Some organizations responded to this shortage by choosing to operate jointly with another organization from the same premises, as part of a co-location strategy. Four CSOs temporarily co-located with another organization, while another four decided to permanently co-locate with another organization. The advantages of co-location include reduced operating expenses, potentially reduced workload due to shared functions, and reduced staff costs (e.g., two retailers combined premises and now each owner/operator only works three days per week), opportunities for co-marketing, and for sharing innovations or strategies.

ADAPTIVE NETWORK RESPONSES

Following a major disaster, the content and structure of social relations are disrupted and need to be renegotiated in response to the changed environment. Organizations affected by the Canterbury earthquakes were forced to reevaluate and adjust who they needed to work with and how these connections could be (re)formed and maintained. At the most basic level, organizations had to forge relationships with new network members to satisfy their emerging needs. These new relationships were often brokered by existing network members. For example, four CSOs were able to use their networks to mobilize contacts in the media to promote the reopening or relocation of their business.

The earthquakes also led to an increased focus on building resilience through goal-directed network development, where organizational relationships were purposively developed to help achieve collective network goals (Kilduff and Tsai 2003). Alliance-like partnerships have increased among New Zealand construction organizations to meet the demand surge and avoid potential resource constraints that can arise as a result. Several large organizations with bases in Canterbury prior to the earthquakes have formed joint ventures to increase their ability to secure contracts. Small construction organizations have tended to form partnerships and alliance-like clusters for mutual support and to attract skilled expertise.

SCIRT (The Stronger Christchurch Infrastructure Rebuild Team), a project management alliance established with responsibility for rebuilding horizontal infrastructure (water, sewerage, roads, etc.) following the quakes, is a paradigmatic example of post-earthquake partnership. SCIRT is an alliance between a series of infrastructural asset owners (including the Canterbury Earthquake Recovery Authority, Christchurch City Council, and New Zealand Transport Agency) and five implementation teams from large construction companies.

Outside the construction industry, CSOs have also been spurred by the earthquakes to restructure their business relationships. One CSO greatly accelerated a planned acquisition of a competitor in order to accommodate part of their organization that had lost its premises in the Christchurch CBD, and two CSOs undertook previously unplanned restructures (a merger and an acquisition) in large part due to the loss of a building and other market changes.

For some of the CSOs, the earthquakes have accelerated the integration of new technologies into their operational systems. Many businesses have restructured their networks through innovative technology and techniques, including utilizing social media, new IT software, satellite phones, web-based seminars, video conference facilities and GPS. This has allowed them to effectively manage higher workloads, an expanded workforce and new

Table 3. Innovations and technological improvements in organizational network connections

Organization type	Post-earthquake technology adoption
Information technology company	Transferred emails and a number of client services to the cloud, and digitally replicated data across multiple locations, increasing information redundancy but also increasing efficiency and improving the client experience.
Accounting firm	Implemented new cloud computing system to ensure that all client records would be accessible in the event of a disruption. This has given both staff and clients greater flexibility and is projected to increase profitability.
Gift retailer	After the demolition of the retail shop, the retailer began designing and wholesaling a line of earthquake related products to stores and online distributors nationally and internationally. Using low-cost online platforms, a blog and a social networking website, the organization marketed the new line of products and coordinated ordering, reducing overheads and greatly increasing sales compared to pre-quake.
Building supply wholesaler	Adopted monitoring systems, including GPS, to enable plant managers to track truck movements and review drivers' performance. This acted as a real time tool for plant managers to identify things that were done well during the delivery process and helped solve problems quickly.

organizational relationships. Flows of information and expertise have been created among onshore engineering consultancies and offshore partners, facilitated by virtual communications and cloud based data sharing and storage. Using these virtual networks some CSOs have shifted their labor resourcing priority from pure “take-in” engineers through recruitment to outsourcing jobs through new forms of partnerships overseas. In retail and IT CSOs, these developments have not only enhanced their ability to reach a larger consumer market outside of Canterbury, but also improved network resilience in the face of potential further local disruptions. In construction CSOs, these technologies have also helped the organizations to manage relationships with the public by keeping them informed of the ongoing reconstruction work (several specific examples are outlined in Table 3).

INTERCONNECTED NETWORKS AND RECONSTRUCTION

The challenges of organizational recovery come not just from the earthquakes, but also from the ways other organizations respond, as well as the wider market and industrial trends in the post-quake environment. The construction stimulus caused by the earthquakes, for example, is being moderated by resource availability and constraints on inputs from other sectors (such as real estate). Similarly, scarcity of resources has led to changes in the relative price structure in related markets. For instance, the limited availability of structural engineers with seismic experience increased the cost of building assessment and slowed the reconstruction pace, despite structural engineers being recruited extensively from such seismically active countries as the United States, Chile, Italy, and Spain (Chang-Richards et al. 2013).

Salary increases in the construction sector from the second half of 2012 were in the range of 5–20% and varied from business to business and from job to job. It was of some concern to CSOs that wages of the Christchurch based construction workforce would continue to rise in 2013 in view of the tight labor market. The competition for limited resources among project management offices, between rebuilds and new builds, between housing recovery and commercial rebuilds, were likely to add more uncertainties to the time and cost of the reconstruction in 2013.

Migration of overseas workers has placed more pressure on the already constrained rental market in Christchurch. Rents for new rental contracts have increased by 18% in Christchurch since the end of 2010, compared with the 7% increase nationwide (Parker and Steenkamp 2012). Furthermore, organizations located near the Christchurch CBD are facing inflated lease prices for the same or similar properties occupied prior to the earthquakes. There are also far fewer suitable properties and locations available.

Some industry sectors are less resilient than others to disruptions to the built environment. Hospitality CSOs found it especially difficult to relocate quickly in the aftermath of the earthquake given their need for specialized facilities, safety and zoning regulations, and a need for visibility and access for customers. Similarly these organizations often rely on other sectors (e.g., accommodations, event venues and tourism operators) to attract customers. Thus, for these sectors there appears to be a greater dependence on dynamic resilience to restore building stock and coordinate redevelopment processes.

Widespread temporary residential accommodation shortages are also a concern. In most cases, company housing for incoming workers has been manageable but costly. The need for most single-stay accommodation has largely been met by Christchurch's hotel and motel facilities and other boarding houses. The real concern to the case study's construction organizations is the shortage of suitable and affordable accommodation for workers' families.

The systemic effects of the earthquakes highlight two important issues. First, the rate of recovery depends on the availability of resources across the reconstruction activities. Second, the decisions within organizations around resource usages for business development in the disaster context can influence wider markets, such as labor and housing. The decisions and actions of organizations after a disaster influence overall community recovery and wider economic conditions including labor market demand, the cost of essential goods and services, and capital investment trends. Thus, we conceptualize each organization as part of interconnected networks through which the repercussions of decisions and actions can ripple and magnify to influence wider system behaviors.

CONCLUSIONS

Using longitudinal case studies following the devastating 2010–2011 Canterbury earthquakes, this paper has examined organizational networks and their implications for post-earthquake resourcing, reconstruction, and the early phases of recovery. The analysis focused on both the role of networks in facilitating organizational resilience and recovery and the network interactions that shape broader macroeconomic recovery processes. The results and discussion were structured around four themes: network composition, mobilizing support, adaptive network responses, and interconnected networks and reconstruction. A number

of conclusions can be drawn regarding how organizational networks can be understood and managed to increase organizational and economic resilience.

The first theme, **network characteristics**, concerned an organization's support network attributes and its repercussions for an organization's post-disaster recovery. Although many supporters in CSO networks were also coping with the effects of the earthquakes, Canterbury organizations tended to draw the majority of their support from organizations within the affected region. *Accessing support from these local ties was important for maintaining pre-existing relationships, as well as for reinforcing a sense of community as organizations and places recover.* On the other hand, *extra-regional ties are an important asset for organizations that require financial, labor, and other kinds of instrumental support post-disaster.*

Having supporters in a variety of network positions increases the diversity of support that an organization can access. *In many cases direct competitors or those working in the same industry were best positioned to provide assistance because of familiarity with each other's operations and similar supply channels.* Supportive responses were in many cases facilitated through strong relationships managed informally through trust and reciprocity. *Strong ties increased the speed of support and increased flexibility in network relations following the earthquakes.*

Under the theme of **mobilizing support**, we discussed the type of support that organizations accessed from their networks to address two prominent issues across the CSOs: (1) workforce resourcing and management and (2) accessing material resources (particularly commercial accommodation). The short-term response to recapture lost productivity or address demand surge is often to work longer hours and add additional shifts, but this can lead to burnout in the medium to long-term, increased accident rates, and strained relationships. Our research shows that *organizations were able to utilize their support networks to redistribute workloads following the earthquakes.* They did this by using support networks to outsource certain jobs, sending work to other branches outside of the affected area, and utilizing informal networks to help overworked staff cope with increased demands.

In addition to this challenge, *labor productivity decreased in the aftermath of the earthquakes.* Organizations thus need to be cognizant of the emotionally draining effect of major crises, and to manage staff wellbeing early in the response and recovery process to avoid burnout, accidents, damaged relationships among staff and with customers, and to avoid long-term staff attrition. Similarly, *organizations were able to navigate resource shortages by working with other organizations to combine resources (i.e., through co-location and supply sharing).*

In the third theme, **adaptive network responses**, evidence showed that *the earthquakes acted as a stimulus for many organizations to re-evaluate underperforming segments of their business and form beneficial partnerships.* The case studies also showed that in Canterbury, *the earthquakes catalyzed technology adoption and upgrades, increasing organizations' efficiency and operability.* This confirms a trend seen in other crises, the productivity effect (Albala-Bertrand 1993). Disasters destroy productive capital and can result in capital replacements using the most recent technologies or the creation of new technologies both of which potentially increase productivity and performance (Okuyama 2004, Hallegatte and Przyluski 2010).

In the fourth theme, **interconnected networks and reconstruction**, we described aspects of the interaction between micro/macroeconomic earthquake impact and response. Although there are many ways to explore and develop an understanding of this issue, this paper focused on the organizational, sectoral, and regional economic interactions relevant to the short- to medium-term reconstruction in Canterbury. *The decisions made by construction organizations in response to increased demand had an effect on economic conditions including labor market demand, the cost of essential goods and services (including rental housing), and capital investment trends.*

The network perspective of organizational resilience presented in this paper can inform the way researchers develop economic impact modeling, and the way we conceptualize and explore the interactions between micro and macroeconomic resilience. Microeconomic inputs, as considered in Wein and Rose (2011), include the productive elements of the economy specified as physical (plant and equipment) and working (financing) capital, labor, infrastructure, and materials. Organizations in Canterbury have mobilized support from their networks to increase their capacity to cope with disruptions to these inputs, finding temporary solutions, making long term adaptations, implementing new technology and innovations, and finding ways to make existing inputs more efficient or productive (e.g., collocation, labor redistribution, sharing suppliers).

Finally, for those interested in developing theoretical and applied approaches to organizational resilience, the case studies presented here offer insights into support mobilization and network management/adaptation. The approach taken is also one route toward a more nuanced and interconnected perspective on organizational resilience. We intend our work to prompt further discussion around other aspects of organizational connectivity and resilience. We see the need for further exploration of spatial, political, and sociocultural networks and their influence on post-disaster organizational behavior, actions, and capacities.

REFERENCES

- Albala-Bertrand, J. M., 1993. *The Political Economy of Large Natural Disasters with Special Reference to Developing Countries*, Clarendon Press, Oxford.
- Aldrich, D. P., 2010. Fixing recovery: Social capital in post-crisis resilience, *Political Science Faculty Publications*, Paper 3, Purdue University, available at <http://docs.lib.purdue.edu/pspubs/3>
- Bascand, G., 2011. Gross Domestic Product: December 2010 quarter, Statistics New Zealand, available at http://www.Statistics.govt.nz/browse_for_Statistics/economic_indicators/GDP/GrossDomesticProduct_HOTPDDec10qtr.aspx
- Bernardi, L., 2011. A mixed-methods social networks study design for research on transnational families, *Journal of Marriage and Family* 73, 788–803.
- Boen, T., 2008. Reconstruction of houses in Aceh, three years after the December 26, 2004 tsunami, in *International Conference on Earthquake Engineering and Disaster Mitigation*, available at <http://know.brr.go.id/dc/reports/20080408>
- Braithwaite, A., 2012. Overcoming Operational Glitches: Supply-chain Recovery is a Competitive Capability. *LCP Consulting and Mission Mode Solutions*. 1–16.
- Briguglio, L., Cordina, G., Farrugia, N., and Vella, S., 2009. Economic vulnerability and resilience: Concepts and measurements, *Oxford Development Studies* 37, 229–247.

- Carrasco, J. A., Hogan, B., Wellman, B., and Miller, E. J., 2008. Collecting social network data to study social activity-travel behaviour: an egocentric approach, *Environment and Planning B: Planning and Design* **35**, 961–980.
- Canterbury Earthquake Recovery Authority (CERA), 2012a. *Canterbury Economic Indicators: October 2012 Quarterly Report*, available at <http://cera.govt.nz/sites/cera.govt.nz/files/common/canterbury-economic-indicators-quarterly-report-october-2012.pdf>
- Canterbury Earthquake Recovery Authority (CERA), 2012b. *Economic Recovery Programme for Greater Christchurch: Te Whakaara Tahua*, available at <http://cera.govt.nz/sites/cera.govt.nz/files/common/cera-economic-recovery-programme-for-greater-christchurch-december-2012.pdf>
- Canterbury Employment and Skills Board (CESB), 2011. *Employment Opportunities in Canterbury*, Department of Labour, Wellington, New Zealand, available at <http://www.dol.govt.nz/publications/research/employment-opportunities-canterbury/eoc.pdf>
- Chang-Richards, Y., Wilkinson, S., Seville, E., and Potangaroa, R., 2012a. Changes in resource need for post-disaster reconstruction: a longitudinal study in China, *Building Research and Information* **40**, 327–336.
- Chang-Richards, Y., Wilkinson, S., and Seville, E., 2012b. *Resourcing of the Canterbury rebuild: Changes and emerging themes*, The University of Auckland, BRANZ, Resilient Organizations, June 2012.
- Chang-Richards, Y., Wilkinson, S., Seville, E., and Brunson, D., 2013a. *Resourcing of the Canterbury rebuild: Case studies of construction organizations*, The University of Auckland, BRANZ, Resilient Organizations.
- Chang-Richards, Y., Wilkinson, S., Seville, E., and Potangaroa, R., 2013b. *Resource challenges for housing recovery: A longitudinal study of the Australian bushfires*, *Disaster Prevention and Management*, in press.
- Christopher, M., and Peck, H., 2004. Building the resilient supply chain, *International Journal of Logistics Management* **15**, 1–14.
- Comfort, L. K., Sungu, Y., Johnson, D., and Dunn, M., 2001. Complex systems in crisis: Anticipation and resilience in dynamic environments, *Journal of Contingencies and Crisis Management* **9**, 144–158.
- Comfort, L., Oh, N., and Ertan, G., 2009. The dynamics of disaster recovery: Resilience and entropy in hurricane response systems 2005–2008, *Public Organiz. Rev.* **9**, 309–323.
- Dacin, M. T., Ventresca, M. J., and Beal, B. D., 1999. The embeddedness of organizations: Dialogue & directions, *Journal of Management* **25**, 317–356.
- De Alessi, L., 1975. Toward an analysis of postdisaster cooperation, *The American Economic Review* **65**, 127–138, available at <http://65.182.2.242/docum/crid/Abril2006/CD2/pdf/eng/doc6410/doc6410-contenido.pdf>
- Doerfel, M. L., Lai, C. H., and Chewning, L. V., 2010. The evolutionary role of interorganizational communication: Modeling social capital in disaster contexts, *Human Communication Research* **36**, 125–162.
- Freeman, S. F., Hirschhorn, L., and Triad, M. H., 2003. *Moral purpose and organizational resilience: Sandler O'Neill & Partners, L.P., in the aftermath of September 11, 2001* *Academy of Management BEST PAPERS 2003*, Omnipress, Madison, WI, B1–B6.
- Gittell, J. H., Cameron, K., Lim, S., and Rivas, V., 2006. Relationships, layoffs, and organizational resilience: Airline industry responses to September 11, *Journal of Applied Behavioral Science* **42**, 300.

- Greve, A., and Salaff, J. W., 2003. Social networks and entrepreneurship, *Entrepreneurship, Theory, & Practice* **28**, 1–22.
- Hallegette, S., and Przulski, V., 2010. The economics of natural disasters: Concepts and methods, in *Policy Research Working Paper 5507*, edited by The World Bank, Sustainable Development Network and Office of the Chief Economist, Geneva.
- Hurlbert, J. S., Beggs, J. J., and Haines, V. A., 2001. Social networks and social capital in extreme environments. *Social capital: Theory and research*, 209–231.
- Hurlbert, J. S., Haines, V. A., and Beggs, J. J., 2000. Core networks and tie activation: What kinds of routine networks allocate resources in nonroutine situations?, *American Sociological Review* **65**, 598–618.
- Jayasuriya, S., and McCawley, P., 2008. Reconstruction after a major disaster: Lessons from the post-tsunami experience in Indonesia, Sri Lanka, and Thailand, in *ADB Working Paper 125*, ADB Institute, Tokyo.
- Kachali, H., Stevenson, J. R., Whitman, Z., Seville, E., Vargo, J., and Wilson, T., 2012. Organisational resilience and recovery for Canterbury organisations after the 4 September 2010 earthquake, *Australasian Journal of Disaster and Trauma Studies* **2012–1**, 11–19, available at http://www.massey.ac.nz/~trauma/issues/2012-1/AJDTS_2012-1_Kachali.pdf
- Kapucu, N., 2003. Coordinating without hierarchy: Public-nonprofit partnerships, *paper presented at National Association of Schools and Institutes of Administration (IASIA) Annual Conference, Public Administration: challenges of inequality and exclusion, 14–18 September 2003, Miami, Florida*, available at www.iasia.org
- Kapucu, N., 2007. Non-profit response to catastrophic disasters, *Disaster Prevention and Management* **16**, 551–561.
- Kapucu, N., Arslan, T., and Collins, M. L., 2010. Examining intergovernmental and Interorganizational Response to Catastrophic Disasters Toward a Network-Centered Approach, *Administration & Society* **42**, 222–247.
- Kilduff, M., and Tsai, W., 2003. *Social Networks and Organizations*, SAGE Publications Limited, Thousand Oaks, CA, 172 pp.
- Knoben, J., and Oerlemans, L. A. G., 2008. Ties that spatially bind? A relational account of the causes of spatial firm mobility, *Regional Studies* **42**, 385–400.
- Knoke, D., and Yang, S., 2008. *Social Network Analysis (Second Edition)*, Sage Publications, Inc., Thousand Oaks, CA, 144 pp.
- Koria, M., 2009. Managing for innovation in large and complex recovery programmes: Tsunami lessons from Sri Lanka, *International Journal of Project Management* **27**, 123–130.
- Le Masurier, J., and Wilkinson, S., 2006. Barriers to post disaster reconstruction: Report on workshop, in *Resilient Organizations Research Report: Resilient Organizations*, available at <http://www.resorgs.org.nz/images/stories/pdfs/barriers%20to%20post-disaster%20reconstruction%20workshop.pdf>
- Li, P. F., Bathelt, H., and Wang, J., 2011. Network dynamics and cluster evolution: changing trajectories of the aluminium extrusion industry in Dali, China, *Journal of Economic Geography* **12**, 1–29.
- Lin, N., 2005. A network theory of social capital, in *Handbook on Social Capital*, Dario Castiglione, Jan van Deth, and Guglielmo Wolleb, Eds., Oxford University Press, New York, 600 pp.

- Ministry of Business, Innovation, Employment (MBIE), 2012. Quarterly Labour Market Report: September 2012, available at <http://www.dol.govt.nz/publications/lmr/labour-market-report/labour-market-report-sept-2012.pdf>
- McCormick, L. E., Hawley, J. D., and Meléndez, E., 2008. The economic and workforce development activities of American business associations, *Economic Development Quarterly* **22**, 213–227.
- McManus, S., Seville, E., Vargo, J., and Brunson, D., 2008. Facilitated process for improving organizational resilience, *Natural Hazards Review* **9**, 81–90.
- New Zealand Treasury, 2013. Budget Economic and Fiscal Update, available at <http://www.treasury.govt.nz/budget/forecasts/befu2013/befu13-pt3of11.pdf>
- New Zealand Institute of Economic Research (NZIER), 2012a. Canterbury after the earthquakes: April 2012, available at <http://nzier.org.nz/publications/canterbury-after-the-earthquakes-april-2012-update>
- New Zealand Institute of Economic Research (NZIER), 2012b. Consensus Forecasts: Slow recovery at home, rising risks abroad, available at <http://nzier.org.nz/publications/slow-recovery-at-home-rising-risks-abroad>
- Okuyama, Y., 2004. Modeling spatial economic impacts of an earthquake: input-output approaches, *Disaster Prevention and Management* **13**, 297–306.
- Okuyama, Y., 2007. Economic modelling for disaster impact analysis: Past, present, and future, *Economic Systems Research* **19**, 115–124.
- Olshansky, R., and Chang, S., 2009. Chapter 2. Planning for disaster recovery: emerging research needs and challenges, *Progress in Planning* **72**, 200–209, available at <http://www.scarp.ubc.ca/sites/default/files/Olshansky,%20Chang%20-%202009%20-%20Planning%20for%20disaster%20recovery%20emerging%20research%20needs%20and%20challenges.pdf>
- Orchiston, C., Vargo, J., and Seville, E., 2012. Outcomes of the Canterbury earthquake sequence for tourism businesses, in *Resilient Organizations Research Report: Resilient Organizations*, available at <http://www.resorgs.org.nz/News/what-happens-to-tourism-following-disaster.html>
- Pallares-Barbera, M., Tulla, A. F., and Vera, A., 2004. Spatial loyalty and territorial embeddedness in the multi-sector clustering of the Berguedà region in Catalonia (Spain), *Geoforum* **35**, 635–649.
- Park, J. Y., Cho, J., and Rose, A., 2011. Modeling a major source of economic resilience to disasters: recapturing lost production, *Nat Hazards* **58**, 163–182.
- Parker, M., and Steenkamp, D., 2012. The economic impact of the Canterbury earthquakes, *Reserve Bank of New Zealand Bulletin*, September 2012, **75**, 13–25, available at http://www.rbnz.govt.nz/research_and_publications/reserve_bank_bulletin/2012/2012sep75_3parkersteenkamp.pdf
- Podolny, M. M., and Page, K. L., 1998. Network forms of organization, *Annual Review of Sociology* **24**, 57–76.
- Rose, A., 2004. Economic Principles, Issues, and Research Priorities in Hazard Loss Estimation, in *Modeling Spatial and Economic Impacts of Disasters*, Y. Okuyama and S. Chang, Eds., Springer, Berlin, 14–36.
- Rose, A., and Huyck, C., 2012. Improving catastrophe modeling for business interruption insurance needs, presented at *Insurance Markets and Catastrophic Risks*, 10–11 May 2012, Cambridge, MA, available at create.usc.edu

- Rose, A., and Liao, S. Y., 2005. Modeling regional economic resilience to disasters: A computable general equilibrium analysis of water service disruptions, *Journal of Regional Science* **45**, 75–112.
- Rose, A., 2007. Economic resilience to natural and man-made disasters: Multidisciplinary origins and contextual dimensions, *Environmental Hazards* **7**, 383–398.
- Seville, E., Hawker, C., and Lyttle, J., 2011. *Shaken But Not Stirred: A University's Resilience in the Face of Adversity: the 4th September 2010 Earthquake*, University of Canterbury, Christchurch, New Zealand, available at http://resorgs.org.nz/images/stories/pdfs/Organizationsfacingcrisis/resilience_tested_a_year_of_10000_aftershocks_pdf.pdf
- Sheffi, Y., 2006. Building a resilient organization, *The Bridge* **37**, National Academy of Engineering, 30–36, available at <http://www.nae.edu/bridgecom.nsf/weblinks/CGOZ-6ZQRSV>
- Smith-Doerr, L., and Powell, W. W., 2005. Networks and economic life. In *The handbook of economic sociology*, Neil J. Smelser and Richard Swedberg, Eds., Princeton, Princeton University Press, 379–402.
- Statistics New Zealand, 2012a. Canterbury: The recovery by the numbers, available at http://www.Statistics.govt.nz/tools_and_services/services/newsletters/economic-news/aug-12-article-canterbury-by-numbers.aspx
- Statistics New Zealand, 2012b. Earthquake Information Portal, available at http://www.Statistics.govt.nz/tools_and_services/services/earthquake-info-portal.aspx
- Statistics New Zealand, 2012c. Household Labour Force Survey, June 2012 quarter, available at http://www.Statistics.govt.nz/browse_for_Statistics/income-and-work/employment_and_unemployment/household-labour-force-survey-info-releases.aspx
- Statistics New Zealand, 2013. Christchurch Retail Trade Indicator: March 2013 Quarter, available at http://www.Statistics.govt.nz/browse_for_Statistics/industry_sectors/RetailTrade/ChristchurchRetailTradeIndicator_HOTPMar13qtr.aspx
- Steinberg, F., 2007. Housing reconstruction and rehabilitation in Aceh and Nias, Indonesia—Rebuilding lives, *Habitat International* **31**, 150–166.
- Stevenson, J. R., Vargo, J., Seville, E., Kachali, H., McNaughton, A., and Powell, F., 2011. The recovery of Canterbury's organizations: A comparative analysis of the 4 September 2010, 22 February and 13 June 2011 earthquakes, in *Resilient Organizations Research Report*, Resilient Organizations, Christchurch, New Zealand.
- Tierney, K. J., 2003. Conceptualizing and Measuring Organizational and Community Resilience: Lessons from the Emergency Response Following the September 11, 2007 Attack on the World Trade Center, Preliminary Paper #329, Disaster Research Center, University of Delaware.
- Tierney, K. J., and Trainor, J. E., 2003. Networks and resilience in the World Trade Center disaster, *MCEER Research Accomplishments 2003–2004*, The Research Foundation of the State of New York, MCEER, 157–172.
- Uzzi, B., 1999. Embeddedness in the making of financial capital: How social relations and networks benefit firms seeking financing, *American Sociological Review* **64**, 481–505.
- Van der Veen, A., 2004. Disasters and economic damage: macro, meso, and micro approaches, *Disaster Prevention and Management* **13**, 274–279.
- Vogus, T. J., and Sutcliffe, K. M., 2007. Organizational resilience: Towards a theory and research agenda, Systems, Man and Cybernetics, ISIC, IEEE International Conference, 3418–3422.
- Wein, A., and Rose, A., 2011. Economic resilience lessons from the ShakeOut Earthquake scenario, *Earthquake Spectra* **27**, 559–573.

- Whitman, Z., Stevenson, J. R., Kachali, H., Seville, E., Vargo, J., and Wilson, T. M., 2014. Organisational resilience following the Darfield earthquake of 2010, *Disasters* **38**, 148–177.
- Yin, R. K., 2008. *Case Study Research: Design and Methods*, Fifth Edition, Sage Publications, Thousand Oaks, CA, 312 pp.
- Zagorecki, A., Kilkon, K., and Comfort, L. K., 2010. Interorganizational information exchange and efficiency: Organizational performance in emergency environments, *Journal of Artificial Societies and Social Simulation* **13**, available at <http://jasss.soc.surrey.ac.uk/13/3/3.html>

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