

Vulnerability of community businesses to environmental disasters

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Business plays important roles in community functioning.² However, disaster research has been disproportionately focused on units of analysis such as families, households and government agencies. This paper synthesises the major findings within the business development research field and the disaster research field. It constructs a framework for evaluating business vulnerability to natural disasters. Our theoretical integration of the research conducted to date addresses five major issues. First, it defines the ways in which businesses are subject to the impacts of natural disasters. Second, it identifies the factors that determine the magnitude of business impacts after a disaster. Third, it identifies how and when businesses return to their pre-disaster level in the disaster stricken community. Fourth, it describes measures that can be taken by individual firms and community planners to reduce the impacts of environmental disasters. Fifth, it identifies needs for public policy and future research to reduce business vulnerability to environmental disasters.

Keywords: business, disasters, disaster planning, post-disaster recovery, vulnerability

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The research literature on community economic development (for example, Bergman, 1981; Blakely and Bradshaw, 2002) and business strategic planning (for example, Porter, 1985) both recognise that extreme events can have a devastating impact on business viability. In both cases, however, their emphasis has been on events—such as economic recessions and plant closings—originating in the economic system rather than the natural environment. Likewise in the disaster literature, research on business impacts has been less developed compared to the extensive literature on community impacts of environmental disasters (for a review, see Lindell and Prater, 2003). Despite recognition that businesses play an important socio-economic role in community functioning by providing products/services, employment opportunities, and taxes (Cochrane, 1992), disaster research has tended to focus on families, households and government agencies (Burby, 1998; Tierney et al., 2001). More research on business impacts is needed so that communities can better prepare for, respond to, mitigate against and recover from environmental disasters. To achieve these aims, the following five questions need to be answered. First, in what ways are businesses affected by environmental disasters? Second, what factors determine the magnitude of a disaster's impacts on local businesses? Third, how and when will businesses return to their pre-disaster levels of production, sales and profitability?

Fourth, what measures can be taken by individual firms and community planners to reduce the impacts of environmental disasters? Fifth, what are the needs for public policy and future research to reduce business vulnerability to environmental disasters?

Previous research on economic impacts of disasters

Much of the research on economic impacts of environmental disasters has tended to be carried out on highly aggregated units of analysis, with national and regional business losses being the focal point of most economic research on disaster impacts. Two early studies examining aggregate economic indexes across multiple disasters concluded that, at most, environmental disasters accelerate existing trends (Friesma et al., 1979; Wright et al., 1979). More recent studies have adopted inter-industry input-output analysis and social accounting approaches (Boisvert, 1992; Cochrane, 1974, 1997; Cole, 1995 and 1997; Gordon and Richardson, 1996; Kawashima and Kanoh, 1990; Rose and Benavides, 1997; Rose et al. 1997; Wilson, 1982), or regional econometric models (Chang, 1983; Ellson et al., 1984; Guimaraes et al., 1993; West and Lenze, 1994). Although these large-scale studies are useful for understanding the national and regional impacts of disasters, their level of aggregation has obscured the differential impacts of disasters on specific types of businesses within the affected communities. Indeed, Kroll et al. (1990) showed that aggregation level (for example, city, county, state) strongly affected conclusions about the economic impacts of the 1989 Loma Prieta earthquake. Thus, microanalytic studies are needed to provide guidance for community planners and business owners in developing better methods for reducing disaster impacts.

Consistent with this principle, other studies of the economic impacts of environmental disasters have examined the ways in which individual businesses prepare for, are disrupted by, and recover from these events. Dahlhamer and D'Souza (1997), Dahlhamer and Reshaur (1996), Drabek (1991 and 1995), Lindell and Perry (1998), Mileti et al. (1993), Tierney (1997a), Tierney and Dahlhamer (1998), and Whitney et al. (2001) have found that disasters disrupt businesses through a variety of mechanisms in addition to direct physical damage to buildings, equipment, vehicles and inventories. Specifically, disruption of infrastructure such as water/sewer, electric power, fuel (natural gas), transportation and telecommunications frequently forces businesses to shut down in the aftermath of a disaster (Alesch et al., 1993; Kroll et al., 1990; Tierney, 1997b; Tierney and Nigg, 1995; Webb et al., 2000). For example, Tierney (1997b) reported extensive lifeline service interruption after the 1993 Midwest floods caused many business closures in Des Moines, Iowa, even though physical damage was confined to a small area. Moreover, disasters can cause population dislocation, losses in discretionary income among those victims who remain in the impact area (which can weaken market demand for many products and services), and competitive pressure from large outside businesses.

All of these indirect effects cause small businesses to experience a high rate of failure in the aftermath of a disaster (Alesch and Holly, 1996; Alesch et al., 2001). Indeed,

these factors can produce business failures long after the precipitating event, especially if the community was already in economic decline (Bates and Peacock, 1993; Durkin, 1984; Webb et al., 2002), and among those businesses that were marginally profitable before the disaster. Small businesses experience more obstacles than large firms and chains in re-establishing pre-disaster levels of operations. This is because small firms are more likely to be located in non-engineered buildings, depend primarily on neighbourhood customers, lack the capacity to design and implement hazard management programmes, lack the financial resources needed for recovery, and lack access to governmental recovery programmes (Alesch and Holly, 1996; Alesch et al., 2001; Dahlhamer and Tierney, 1996 and 1998; Durkin, 1984; Kroll et al., 1990).

There is also variation among business sectors during recovery. Whereas wholesale and retail businesses generally report significant sales losses, manufacturing and construction companies often show gains following a disaster (Durkin, 1984; Kroll et al., 1990; Webb et al., 2000). Businesses that serve a large (regional or international) market tend to recover more rapidly than those that only serve local markets (Webb et al., 2002).

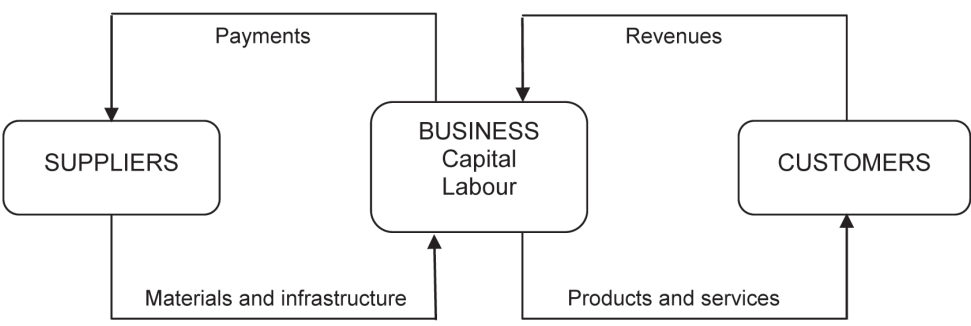
The existing research provides useful empirical evidence for understanding business impacts of environmental disasters and suggests what measures local businesses can take to reduce their hazard vulnerability. It also provides a basis for local government policies that will protect the community's economic base in the event of environmental disasters. However, none of this research has articulated a systematic model of the business impacts of environmental disasters. Such a model is presented below.

A conceptual model of disaster impacts on businesses

Businesses are entities engaging in commercial activities that involve the manipulation and assembly of productive resources to create products and services. Figure 1 depicts the process by which businesses use capital and labour to convert materials and infrastructure received from suppliers into products and services that are delivered to customers. Capital comprises fixed assets, inventories, cash, securities and accounts receivable, whereas labour is the contribution of people working with their knowledge and skills (Brigham and Houston, 2002; Schugart et al., 2002). These resources are organised into a value chain that includes purchasing, operations, sales/marketing, service, finance/accounting, research and development (product and process), supervision and general administration (Thompson and Strickland, 1996). By selling its products and services to consumers, a business generates revenues that are then returned to suppliers to make payments that maintain business continuity in a dynamic equilibrium of input and output flows. Conversely, interruption of any part of the flow has the potential to jeopardise business viability.

Government, households and other businesses all play important roles as suppliers and customers for business operations. Government is a supplier of the road network and some lifeline facilities (for example, water/sewer, electric power and fuel)

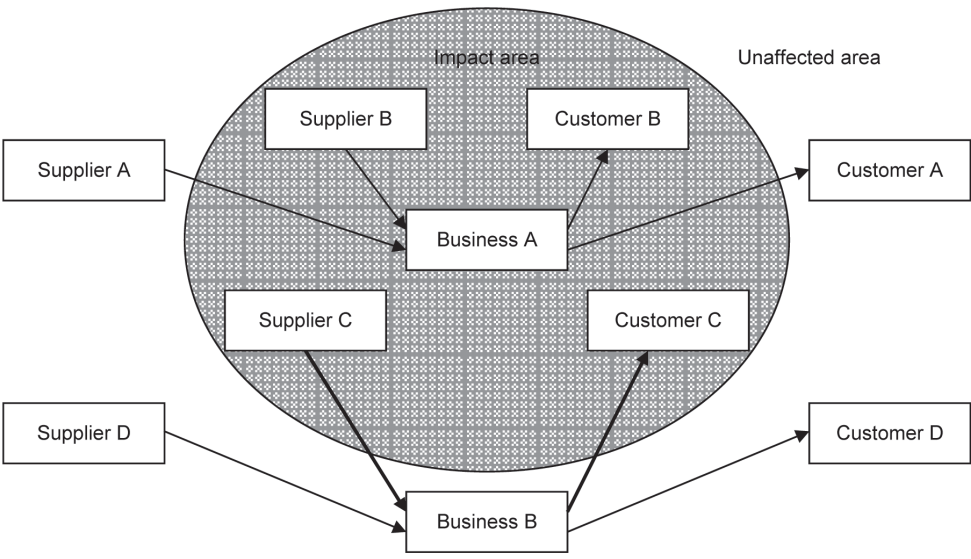
Figure 1 Conceptual model of business operations



and is also a consumer of some business products and services. Furthermore, government can influence business development through policies such as taxes, loans, land use, building construction and capital development (Blakely and Bradshaw, 2002). Households contribute to business operations as the primary suppliers of employees and, at the same time, as the major consumers of most products and services. Finally, inter-business linkages are also important; other firms continually supply those portions of infrastructure not supplied by government and also distribute or consume products and services.

Of course, businesses vary in the geographic areas they serve; some have dispersed markets covering large areas whereas others are supplied by and serve only very local markets. A business inside the impact area (Figure 2) might have suppliers either inside or outside the disaster impact area. Similarly, its customers might be located totally inside, partially inside or totally outside the impact area. Conversely, a business located outside the impact area can be affected through supplier and

Figure 2 Businesses' relationship to the disaster impact area



customer disruptions. Indeed, it is possible for a business outside the impact area to be more severely affected than one inside the impact area.

The model presented in this section makes it possible to enumerate the ways in which environmental disasters affect businesses in terms of capital vulnerability, labour vulnerability, supplier vulnerability and customer vulnerability.

Capital vulnerability

Business capital can be classified into three categories according to the level of liquidity: fixed assets (such as buildings, equipment, furnishings and vehicles), inventories (such as raw materials, intermediate products and finished products), and cash and securities (such as cash, marketable securities and accounts receivable). Fixed assets are highly vulnerable because they have low mobility and are subject to direct physical damage by disasters. For this reason, businesses with large amounts of fixed assets are more vulnerable than those with small amounts of fixed assets (Alesch et al., 1993; Tierney, 1997a and 1997b). Similarly, businesses with large inventories are highly vulnerable because these materials have low mobility and are subject to direct physical damage. Cash, securities and accounts receivable are less vulnerable to environmental disasters because they are intangible assets that are processed electronically, so information about them can be stored in multiple locations.

Business vulnerability to environmental disasters can also be significantly affected by managers' decisions about whether to own or lease capital. Leased capital (for example, leased buildings and equipment, debt) requires businesses to generate revenue more rapidly than the interest it pays to creditors. In the aftermath of disaster, businesses with lower proportions of leased capital have greater cushions against creditors' interest payments, and thus face less financial pressure. This is a significant issue because Alesch et al. (2001), Tierney (1997b) and Webb et al. (2000) reported that many businesses avoided recovery loans from the Small Business Administration (SBA) and commercial banks because additional indebtedness would compound their financial burdens. Instead, most small businesses rely on personal savings and grants or loans from relatives.

Business size, measured by the number of employees, is a correlate of a business's ability to cope with environmental disasters (Alesch et al., 2001; Drabek 1991 and 1995; Durkin, 1984; Kroll et al., 1990; Tierney, 1997b). Small businesses have encountered many more obstacles to recover from disaster effects than large ones, but many factors can account for this finding. Large firms are more likely to spread their risk by operating in multiple locations. In addition, large businesses are more likely to be located in newer disaster-resilient facilities and more likely to have sufficient staff to employ specialists in preparing for disaster response and recovery (Lindell and Perry, 1998; Whitney et al., 2001). Moreover, large businesses are more likely to be able to afford hazard insurance, business interruption insurance, or contingency funds for disaster recovery. Large businesses also have a significant amount of financial and political influence in their communities, which gives them a high priority in governmental recovery policies and also substantial influence in ensuring

that private contractors rebuild their facilities first. Large firms and multi-branch firms are better positioned in inter-business and intra-business collaborations on supplying, purchasing and labour shifting to cope with emergencies. Finally, large businesses are likely to have much stronger input and output ties that facilitate recovery from disasters.

Labour vulnerability

Environmental disasters can disrupt businesses' labour inputs by causing significant short-term population changes in a disaster stricken community. Employee casualties (deaths, injuries, illnesses) will obviously hinder normal business operations because employees are either permanently or temporarily unavailable for work. The degree of disruption to a business depends upon the ease of employee replacement. All other factors being equal, a large labour pool and reliance on less skilled workers makes it easier to replace employees that have been displaced by a disaster. Similarly, casualties within employees' families could either reduce their work hours or require extended leaves of absence. Moreover, damage to employees' dwellings might cause victims to relocate permanently or to move into temporary housing for a lengthy period of time (Bolin and Stanford, 1998; Girard and Peacock, 1997; Quarantelli, 1982). In some cases, permanent employee dislocation causes employee turnover because the new housing is so far from the workplace that it becomes unfeasible to continue with the same employer.

However, even temporary population dislocation can disrupt business operations in many ways. For example, victim employees can become so preoccupied restoring their household routines that their working hours must be reduced or curtailed for some period of time. Such tasks include filing insurance claims, applying for building permits, applying for loans or grants, cleaning debris and repairing structural damage. Even employees who can remain in their homes can be kept from working by disrupted access to workplaces. For instance, closure of the Oakland/San Francisco Bay Bridge following the 1989 Loma Prieta earthquake required a quarter of a million commuters to rearrange their travel patterns. Many of these were forced to take longer, more costly routes to work. Damage also caused closure of the major highway linking Santa Cruz to employment centres in Santa Clara County, resulting in many people changing from private vehicles to rail or bus services (Federal Emergency Management Agency, 1999). Kroll et al. (1990) concluded that damage to transportation networks after the Loma Prieta earthquake caused significant economic impacts in the San Francisco Bay and Santa Cruz areas.

A business's internal labour organisation—defined in terms of the coordination of employees' working times and locations—also affects the scale of disaster impacts. Businesses with flexible forms of labour organisation can return to operation shortly after the event, but this response varies by type of business. After the 1989 Loma Prieta earthquake, flexible work hours were widely used in the FIRE (finance, insurance and real estate) sector (40.6 per cent of affected companies) and manufacturing sector (45.5 per cent), but significantly less in construction firms (22.2 per cent)

in the Oakland and Santa Cruz areas. However, employees' work locations are less flexible than work hours, so only 10 per cent of companies in the FIRE sector and almost none in the manufacturing and construction sectors allowed employees to work at home (Kroll et al., 1990).

Supplier vulnerability

Tierney and Nigg (1995) and Tierney (1997b) reported that varying degrees of interruption were experienced with water/sewer, electric power, fuel (such as natural gas pipelines), telecommunications, and transportation after the 1993 Midwest flood and 1994 Northridge earthquake. Loss of lifeline services was among the main reasons for business closure after these disasters. Their research found that lifelines vary significantly in the immediacy of their disruptive effects: Nigg's (1995) study in Memphis and Shelby County reported business owners' estimates of how long their businesses could continue in operation after different types of infrastructure loss: none for electricity, four hours for telephone, 48 hours for water/sewer, and 120 hours for natural gas.

Disasters can close down suppliers, which forces a business to adjust to materials shortage for a certain period, even if it does not experience any physical damages. Neighbourhood grocery stores depend on regional distribution centres for their supplies. If a distribution centre suffers severe damage and is forced to shut down, the grocery stores it serves must either find new business partners or also suspend operations. This 'domino' effect on production operations produces an economic multiplier in which indirect losses ripple out from the direct losses. Thus, businesses experience *direct* losses when their capital assets are physically damaged and *indirect* losses when they are functionally connected to other businesses that have themselves experienced either direct or indirect losses (Committee on Assessing the Costs of Natural Disasters, 1999).

Customer vulnerability

For the same reasons as they lose employees, businesses can also lose customers during the disaster aftermath either because of population casualties or, more likely, short-term population dislocation. In addition, demographic changes in disaster stricken communities can destroy the established customer base of local businesses (Girard and Peacock, 1997; Smith, 1996; Smith and McCarty, 1996). A long period of regaining customers could be fatal for some firms, especially small ones (Alesch et al., 2001; Bolin, 1993). Furthermore, disasters can cause consumer preferences to change and thus influence the market demand for some products and services. Following a major disaster that causes extensive building damage, victims will tend to decrease their consumption of luxury goods and services. For those businesses that provide only these products and services, a disaster can cause an immediate drop in sales.

This problem is especially difficult for impacted businesses serving a market that is geographically limited to the disaster impact area (Alesch and Holly, 1996; Alesch et al., 2001; Webb et al., 2000 and 2002). Businesses of this kind, usually small

wholesale and retail firms, face the loss of all their sales because of short-term customer losses (due, for example, to temporary or permanent relocation because of housing damage). By contrast, businesses serving regional or international markets experience less impact on their sales, a phenomenon that explains why manufacturing in the San Francisco Bay area experienced smaller losses than general wholesale and retail businesses after the Loma Prieta earthquake (Kroll et al., 1990). As is the case with consumers, inter-business purchasing partnerships are also subject to disaster-induced disruption. If a major buyer suffers serious disaster impact and decreases its purchases, then the provider business will soon experience decreased sales unless it can find alternative customers.

It is important to recognise that some demand shifts rather than disappears. Specifically, households put more of their expenditures into reconstructing their homes and replacing damaged furnishings. Consequently, disaster relevant industries such as construction, building materials, and home/office furnishings can experience increasing demand from disaster stricken communities to meet short-term needs for reconstruction of residential, commercial and industrial structures and infrastructure (Committee on Assessing the Costs of Natural Disasters, 1999). In addition, a large influx of construction crews into a community stimulates demand for hotels and restaurants (Alesch et al., 2001; Webb et al., 2002). One less obvious consequence of this shift in demand is a compensating shift in supply, as when building supply outlets find themselves facing competition from large outside wholesalers whose sales volume allows them to sell at lower prices. Furthermore, local demand for construction materials experiences a precipitous drop after reconstruction is finished and remains at a depressed level for several years before returning to a stable replacement rate for these products. This 'second wave' disaster continues the pressure on local firms' sales.

Based upon the above discussion, Table 1 lists these four dimensions of business vulnerability, the underlying key factors for each dimension, operationalisation of each factor, and the expected direction of causal effect of each factor on business vulnerability. Regarding the capital dimension of business vulnerability, the mobility, ownership and size of a business are three major determinants. These three factors are expected to have negative effects on the level of business vulnerability, which means that businesses with higher capital mobility, higher proportion of owned capital, and larger size are less vulnerable to disasters. For the labour dimension of business vulnerability, two major determinants are ease of employee replacement and flexibility of labour organisation. A business has a lower level of vulnerability if it has a large labour pool in relation to its employment level and methods of labour organisation that are flexible enough to accommodate the disruption caused by disaster impacts. The supplier dimension of business vulnerability is determined by dependence on lifeline infrastructure and dependence on other businesses. In both cases, the higher level of dependence will lead to higher levels of vulnerability. For the customer dimension of business vulnerability, market diversification and level of reconstruction relevance are two major determinants. These two factors both

Table 1 Dimensions of business vulnerability

Vulnerability dimensions	Key factors	Operationalisation	Expected direction of effect
Capital	1. Capital mobility	1. Proportion of fixed assets, inventories, cash/securities	-
	2. Capital ownership	2. Proportion of owned capital	-
	3. Business size	3. Number of employees	-
Labour	1. Ease of employee replacement	1. Availability of the labour pool	-
	2. Flexibility of labour organisation	2. Flexible work hours and/or flexible work locations	-
Supplier	1. Lifeline infrastructure dependence	1. Operation duration without different lifeline infrastructure	+
	2. Inter-business dependence	2. Operation duration without inter-business supplies	+
Customer	1. Market diversification	1. Regional/national/local market coverage	-
	2. Reconstruction relevance	2. Reconstruction related or not	-

negatively affect the level of business vulnerability, which means that businesses with larger market shares outside the impact area and those with services/products that are needed for post-disaster reconstruction are less vulnerable. Although previous research in disaster literature provides some empirical evidence supporting each dimension of the business vulnerability listed above, few studies have captured all aspects of business vulnerability. More research is needed to fully test the causal relations depicted in the table.

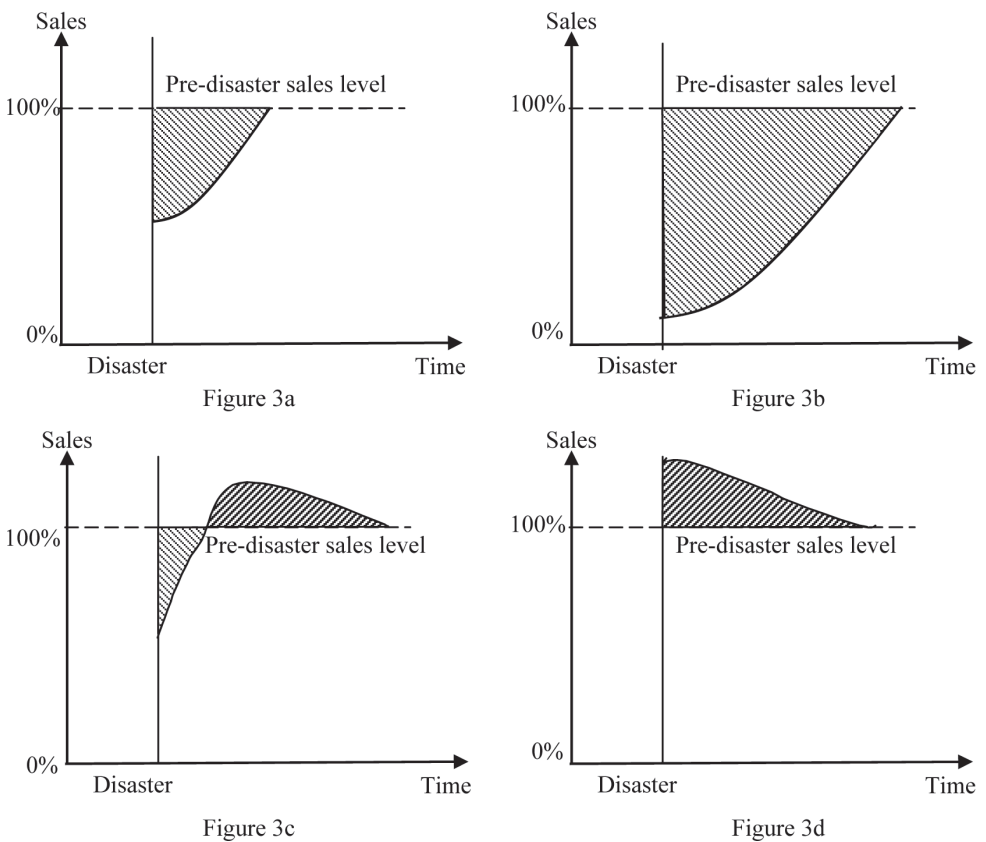
Modelling business recovery and production losses/gains

One direct implication of these findings is a classification of businesses into groups experiencing similar levels of sales losses following a disaster. Specifically, small wholesale and small retail businesses are generally quite vulnerable to disasters, but wholesale and retail chains, as well as companies in the construction, manufacturing and FIRE sectors have only moderate vulnerability. Professional services companies such as law firms generally have low vulnerability. However, this generalisation must be qualified by the need to take into account businesses' variations in exposure to environmental hazards within a community as well as the structural vulnerability

of their capital assets. In the latter case, decreased structural vulnerability—generally created by more stringent building codes and enforcement—can substantially decrease the absolute level of vulnerability of a given business sector even though the rank order of the different sectors remains the same. For example, local building construction practices are significantly more stringent in the state of California than in other seismic zones (such as the New Madrid Seismic Zone; see, for example, Prater and Lindell, 2000). Thus, business vulnerability analysis should be conducted at the community level because each community varies in its exposure to environmental hazards, the vulnerability of businesses' capital assets, and the vulnerability of these businesses to direct and indirect losses. For these reasons, it is not currently possible to define uniquely the vulnerability of each economic sector in the North American Industry Classification System.

This discussion of vulnerability also enables us to conceptualise changes in production, sales and profits—and thus the dynamics of business recovery. In particular, four cases illustrate firms' variation in their post-disaster sales levels. According to Figure 3, gains and losses in sales (the ordinate) over time (the abscissa) are defined by the area enclosed within the (vertical) disaster line, (horizontal) pre-disaster sales level, and (diagonal) recovery curve. Gains are represented by the size of the area

Figure 3 Patterns of changes in business sales after environmental disasters



above the pre-disaster sales level; losses are represented by the size of the area below the pre-disaster sales level (the shaded area in each panel). The first case is defined by businesses in the impact area having minimal hazard vulnerability. Such businesses (for example, professional services) experience only small decreases in sales after impact and return quickly to pre-disaster levels (Figure 3a). The second case consists of businesses that are also in the impact area, but have moderate vulnerability. Such businesses (for example, large manufacturers) experience larger initial drops in their sales levels so recovery takes longer (Figure 3b). By contrast, the third case consists of businesses that experience initial sales losses because they are inside (thus experiencing direct losses) or near (thus experiencing indirect losses) the impact area. However, they later experience an increase in demand for their products/services during the disaster aftermath (Figure 3c). Recovery related businesses in the building construction, construction materials, and hospitality (for example, hotels and restaurants) industries exemplify such a pattern. The fourth case describes recovery related businesses just outside the impact area. Not only do they avoid initial losses, but they can also take advantage of expanded demand in the stricken community to reap gains in the disaster aftermath (Figure 3d).

Effects of hazard adjustments on business vulnerability

Hazard adjustment refers to practices taken to respond to environmental threats in ways that reduce threats to personal safety, property and community functioning. It is well documented that achievement of community emergency preparedness takes place by pre-impact planning, training and exercising of four groups of activities: emergency assessment, hazard operations, population protection and incident management (Lindell et al., 2006 and 2007; Perry and Lindell, 2006). These emergency preparedness principles should be similar for a business, but the contents are somewhat different from those for a community. Emergency assessment consists of actions that evaluate the potential impacts of an imminent disaster (for example, monitoring an approaching hurricane); hazard operations consist of last-minute actions to protect physical assets (for example, covering inventory with plastic sheets); population protection aims at protecting employees from impact (for example, stocking first aid supplies); and incident management actions coordinate an emergency response (for example, establishing back-up communications). Actions in the recovery phase include inventoring and salvaging damaged goods, protecting undamaged property, and re-establishing contact with suppliers and customers (Federal Emergency Management Agency, n.d.).

Studies examining business hazard adjustment provide some anecdotal data about their implementation and effectiveness. Eguchi and Munroe (1992) reported that before the 1989 Loma Prieta earthquake, the Pacific Gas and Electric Company (PG&E) had a mutual aid plan with Southern California Gas (SCG) addressing emergency inventories, resources and labour sharing. PG&E also engaged in regular drills involving recovery and restoration of services. After the Loma Prieta earthquake,

with support from SCG, PG&E restored disrupted gas services to 50,000 homes within two weeks—four weeks less than the estimated duration. Alesch and Holly (1996) likewise reported cases of mutual emergency coordination on purchasing and distribution among businesses that facilitated a quick recovery following the 1994 Northridge earthquake. Suppliers extended credit periods for victims, whereas customers expedited payment on invoices and, in some cases, even temporarily increased their purchases. In the aftermath of Hurricane Andrew, many corporations in Miami–Dade County mobilised resources to protect their work force (Sanchez et al., 1995). Businesses used emergency relief services such as transportation, financial assistance, housing, clean-up, and reconstruction materials support to facilitate employees' rapid return to normal conditions. Businesses in the San Francisco Bay area affected by the Loma Prieta earthquake introduced several emergency mechanisms (for example, expanded business hours, new shipping schedules, flexible employee working time, temporary relocation) to minimise operational losses (Kroll et al., 1990). Chemical plants on the Texas Gulf Coast were actively involved in county hurricane emergency management, and consequently executed shutdown procedures well before the landfall of Hurricane Bret and resumed normal operations shortly after the hurricane made landfall (Richards, 1999). In summary, business hazard adjustments might take many different forms depending upon the distinctive nature of their core operations.

Research on household hazard adjustments (see Committee on Disaster Research in the Social Sciences, 2006, and Lindell and Perry, 2000, for a review) suggests that businesses engaging in preparedness and mitigation activities would be less vulnerable to environmental disasters. However, the findings of recent studies on business hazard adjustment adoption are inconsistent with this expectation (Dahlhamer and D'Souza, 1997; Dahlhamer and Reshaur, 1996; Webb et al., 2000). Instead, these researchers found no significant relation between a business's hazard adjustment and the magnitude of the impacts it experienced. To explain the discrepancy, they suggested that most business hazard adjustments involve employees' life safety rather than continuity of business operations. Indeed, these studies used a checklist similar to those employed in studies of household disaster preparedness to evaluate a business's preparedness adoption level. Alternatively, the failure to find a significant relationship between hazard adjustment and business impact might arise from selective adoption of hazard adjustments by those at greatest risk. Specifically, it might be that businesses with the greatest levels of hazard adjustment were those that had the greatest initial level of hazard vulnerability. If this were the case, their greater level of hazard adjustment actions might have cancelled out their greater level of hazard vulnerability—thus resulting in comparable levels of damage regardless of the level of hazard adjustment.

Implications for policy and future research

Emergency response plans have long drawn wide support from scientists and practitioners as an effective way to guide the immediate response to a disaster (Dynes

et al., 1972; Lindell and Perry, 1992; Tierney et al., 2001). A more recent emphasis has been the development of pre-disaster recovery plans (Comerio, 1998; Geis, 1996; Mileti, 1999; Schwab et al., 1998; Wilson, 1991). Such plans have been found to be effective in accelerating community recovery and integrating mitigation measures into the reconstruction process (Spangle Associates and Robert Olson Associates, 1997; Wu and Lindell, 2004). However, most policy initiatives in these discussions have been directed towards household recovery (for example, sheltering and housing), so business recovery has been neglected. Nonetheless, economic development and employment are major issues in the local political agenda, so local government needs to take steps before and after a disaster to protect its economic base by enhancing local businesses' ability to cope with disaster impacts.

Because businesses vary significantly in their vulnerability to disaster impacts, local planners need to work with the businesses in their own communities (Federal Emergency Management Agency, 1997 and n.d.). This vulnerability assessment should identify businesses that are located in hazard-prone areas, assess their structural vulnerability, and evaluate their needs for emergency response and disaster recovery after different types (hurricanes, earthquakes, floods) and intensities of environmental disasters. Local jurisdictions should use the information in the vulnerability assessment to revise their plans for emergency response (Federal Emergency Management Agency, 1996) and disaster recovery (Schwab et al., 1998) in order to meet the needs of local businesses. Changes in these emergency response and disaster recovery plans could have important effects on business recovery because local agencies can establish temporary locations for displaced businesses in the immediate aftermath (Durkin, 1984), restore disrupted road network and lifeline service in a timely manner (Alesch and Holly, 1996; Kroll et al., 1990), expedite building inspection and permit issuing (Kroll et al., 1990), and protect local businesses, especially small firms, from the sudden influx of legitimate and fly-by-night competitors into the community (Alesch et al., 2001).

This vulnerability assessment can be accomplished through collaboration between community economic development planners and emergency managers. Such cooperation is important because it fulfils statutory obligations of both parties. Economic planners benefit from the hazard analyses conducted by emergency managers, which, in turn, will enrich the emerging practice of community economic development contingency planning (Bergman, 1981; Blakely and Bradshaw, 2002). Conversely, emergency managers can save time and effort by obtaining detailed information directly from economic development planners about the community's economic base—including an inventory of businesses, their employment levels, and linkages among industries.

In addition, procedures for providing congregate care for displaced households can be readily adapted to accommodate displaced small businesses. For example, Durkin (1984) reported that many retail outlets displaced by the Coalinga earthquake were directed into a local college gymnasium. These businesses were able to operate from temporary booths for about one month until alternative accommodation

was available. Procedures that have been incorporated into a community's pre-impact recovery plan, such as monitoring contractors and retail prices (Wu and Lindell, 2004) can also be extended to facilitate local business recovery. For example, local construction companies can be given a head start by allowing them to register for post-disaster reconstruction before a disaster strikes. Moreover, government contracts for infrastructure restoration can give bonus points to those contractors that utilise local firms. To alleviate the discounted price of construction materials that undercuts the sales of local firms (Alesch et al., 2001), local jurisdictions can promote the establishment of pre-impact group marketing that facilitates pre-disaster ties between local businesses and prospective customers (Blakely and Bradshaw, 2002). Local government involvement in such marketing efforts is especially important for small businesses, which generally lack adequate resources for advertising. Businesses can avoid this vulnerability by adopting 'just in time' manufacturing, but adoption of this strategy can shift vulnerability to networks of telecommunications (placing orders for new materials and receiving orders for completed products) and transportation (delivering raw materials and finished products).

Local government can also organise assistance from other businesses to ameliorate the impacts of a disaster by shortening the time that victimised firms take to return to normal operations. Support from the business community can include emergency labour support (Eguchi and Munroe, 1992), extended credit from suppliers, accelerated payments for products and services, and above normal levels of purchases made by regular customers (Alesch and Holly, 1996). Such arrangements by local planners are sorely needed because federal programmes such as SBA loans and Federal Emergency Management Agency (FEMA) recovery programmes are often ineffective in facilitating business recovery following environmental disasters (Alesch and Holly, 1996; Alesch et al., 2001; Durkin, 1984; Kroll et al., 1990; Tierney, 1997b). The most frequently cited reasons include a slow application process and demanding loan requirements. Local governments in disaster impact areas can take actions to establish and maintain closer ties with these federal agencies so that arrangements on the locations of programme offices, streamlined loan application processes, and local staffing/resource support can be implemented to improve the accessibility of these programmes immediately after disaster impact. Indeed, this vertical integration with higher-level government agencies will facilitate the recovery of both households and businesses (Berke, 1995; Berke et al., 1993).

In particular, the emergency response and disaster recovery needs of small businesses deserve special attention from local officials because they are more vulnerable to disaster impacts than their larger counterparts. This is particularly unfortunate because small business is a crucial contributor to community employment and local government revenue generation. Indeed, the development of small business has been a long-standing revitalisation strategy used by local economic development planners and community development corporations, especially in socio-economically distressed neighbourhoods (Blakely and Bradshaw, 2002; Porter, 1997). Disaster research has repeatedly shown that these neighbourhoods are disproportionately

vulnerable to environmental disasters and experience more difficulties in returning to normality after an event (Bates and Peacock, 1993; Blaikie et al., 1994; Bolin and Stanford, 1998; Comerio, 1998; Peacock and Girard, 1997). For these reasons, it is very likely that policy initiatives facilitating small businesses' emergency response and disaster recovery will gain support from different local government agencies, non-government organisations and residents—an important condition for successful formulation and implementation of hazard mitigation policies (Prater and Lindell, 2000).

In addition to developing policies that help businesses after disasters, local government agencies need to encourage businesses to engage in more effective hazard management before disasters strike. However, disaster research has revealed relatively low levels of hazard adjustment adoption, so community hazard awareness programmes need to be carefully examined before targeting local businesses. Current research and local practices of risk communication are disproportionately oriented towards households (Lindell and Perry, 2004), but business owners and managers also need to be informed of threatening environmental hazards and alternative hazard adjustments. Many corporations have begun to integrate environmental issues into their strategic plans (Douglas and Judge, 1995; Makower, 1993; Newman and Breeden, 1992; Stead and Stead, 1992; Taylor, 1992), but their primary focus has been the reduction of environmental pollution and resource depletion—not the reduction of vulnerability to environmental disasters. There are clear indications that businesses fail to protect their capital assets before disasters occur because they do not know what can be done (Alesch and Holly, 1996).

The discussion presented in this paper only begins to illustrate the uniqueness of businesses' adjustments to environmental hazards. Future research is needed to identify which hazard adjustments are suitable for businesses in general, and which are suitable only for businesses of a particular size or in a particular economic sector. Future research also needs to examine the ways in which local planners and emergency managers can more successfully construct hazard messages, adopt appropriate communications channels, and select message source—all of which are critical components of an effective hazard awareness programme (Lindell and Perry, 2004). Furthermore, research is needed to identify other policy tools, such as incentives and sanctions, that can effectively induce businesses to adopt hazard adjustments (Lindell et al., 2006 and 2007).

One challenge for business disaster preparedness is that investments in hazard mitigation and emergency preparedness decrease short-term profitability. For example, employee losses can be avoided by cross-training, but this requires an initial investment and might also require refresher training if the alternative tasks are complex. Overstaffing is another strategy to ensure continued labour availability, but this also produces continuing costs. Contracts for outsourcing can limit the routine costs, but the effectiveness of this strategy after a disaster might depend upon the survival of the telecommunications and transportation networks. Thus, further research is required to identify additional hazard adjustments, and to increase the effectiveness and reduce the costs of existing adjustments. Other research questions raised by this

business impacts and vulnerability analysis include the more detailed qualitative description and quantitative measure of households' consumption changes before and after a natural disaster, and the impact of population dislocation on the viability of businesses in disaster impact areas.

Because this is a preliminary model, further research is needed to provide a closer examination of the emergency response and disaster recovery demands of different business sectors in communities with different natural hazard threats, various impact intensities, and different socio-economic and socio-demographic settings. Also needed is a more detailed understanding of the ways in which local jurisdictions can facilitate businesses' emergency response and disaster recovery. The business impacts model, which shows how business impacts can result from input disruption (for example, building/equipment damage, inventory damage, infrastructure failure, workforce losses) and output disruption (for example, customer loss, demand shifts) can serve as a starting point for research along this line.

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- ² This work was supported by the National Science Foundation under Grant CMS 0219155, and by the Mid-America Earthquake Center under Subaward 98-269. None of the conclusions expressed here necessarily reflect views other than those of the authors.

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