2. Business and Workforce Continuity

Introduction

We know from experience of previous disasters such as hurricanes and earthquakes that a large proportion of the businesses affected by these natural cataclysms will not survive. Nevertheless, it is our mission to make Oregon's businesses and workforce more resilient against the threat posed by a megathrust Cascadia earthquake. The key to business survivability begins with the survivability of the buildings that house the businesses (see Figure 2.1). Few businesses can survive without a domicile for more than a month. Experience tells us that if a business cannot reoccupy its offices within a month, it will either relocate, or dissolve.

Reoccupation of a business's workspace depends on three principal factors: the building's structure must be safe; the workforce must be able to get to the workplace; and, the building's mechanical and utility systems must be up and running. In addition, it is essential that the business's customers survive the catastrophe. This is of particular concern when a business's customers are other businesses that may be housed in buildings that do not survive. A 2011 Cascadia earthquake study by the Federal Emergency Management Agency estimated that only about 20 percent of the buildings in the Metro Region would escape damage, while 80 percent would suffer damage ranging from slight damage to a complete loss (see Figure 2.2).

Statewide, about 27 percent of commercial buildings would survive without damage and about 22 percent would suffer slight damage. The remaining buildings, which would suffer moderate (31%) or extensive (16%) damage, or be completely destroyed (4%), will not be immediately inhabitable for commercial purposes.

Figure 2.1: Windham, N.Y., September 1, 2011 -- A shop on Main Street in Windham proclaims their victory over the destruction from Hurricane Irene. The town suffered damage to homes and businesses and was included in the disaster declaration by President Obama on 9/3/11. (Source: FEMA Photo/Judith Grafe)

Commercial	None	Slight	Moderate	Extensive	Complete	Total
Metro Region	6,759	10,106	12,270	4,647	461	34,242
Outside Metro	14,333	7,596	11,878	7,904	3,072	44,785
Total	21,092	17,702	24,148	12,551	3,533	79,027

Figure 2.2: Analytical Baseline Study for the Cascadia Earthquake and Tsunami (Source: FEMA, November 18, 2011)

Evaluation of the Scenario Earthquake's Economic Impact

A magnitude 9.0 Cascadia subduction earthquake has the potential to inflict tens (and maybe even hundreds) of billions of dollars in damage to existing property and infrastructure, but the costs of the event are not limited to these billions of dollars in replacement costs. While damaged infrastructure is removed, repaired, or replaced, normal economic activity will be interrupted. Some firms may be forced to shut down or move. Some people may migrate out of the state. These spillover disruptions may permanently change the trajectory of the regional economy, imposing damages that dwarf those inflicted directly by the event.

Preparing now and creating a more resilient Oregon is essential to reducing these costs and preserving the health of our communities and our economy. Resilience will reduce the deaths and injuries that such an event will inevitably cause. Resilience will minimize the damage to our homes and office buildings, to our roads and bridges, to our energy and telecommunications transmission systems, and to our water and wastewater systems. In short, resilience will minimize the disruptions to our economy, our community, and ourselves.

Every large natural disaster is unpredictable, not only in its timing, but in its effects. We cannot say precisely how large the damages associated with a Cascadia event will be, nor forecast in detail what will be damaged, nor foresee how the loss of buildings, roads, utility infrastructure, and other elements will ripple through the economy. As best, we can draw on economic theory and the experiences from previous disasters to assess the potential effects of such an event.

HOW DO NATURAL DISASTERS AFFECT REGIONAL ECONOMIES?

Fundamentally, natural disasters break things. They break houses and buildings. They break roads and bridges. They break pipelines and transmission lines. They break water pipes and treatment plants. When things break, people and the economy suffer.

Direct Damage

What disasters break is expensive to repair. Economists use the term *direct damage* to refer to damage that disasters inflict on buildings, infrastructure, inventories, natural resources, and people (Pelling, Oezerdem, and Barakat, 2002). When news articles report that a disaster inflicted $300 billion in damages, they are reporting an estimate of the direct damage inflicted by the event. They are reporting the expected amount of money needed to replace what has been lost.

Indirect Damage

When things break, they can no longer be used to support economic activity. If key port infrastructure breaks, the port must shut down. If a bridge breaks, workers may not be able to get to work and firms may not be able to ship or receive goods. If the internet or telecommunications networks fail, firms may lose customers. If oil spills into rivers, river dependent industries, such as fishing or recreation, may be disrupted. Economists use the term *indirect damage* to refer to the loss of economic activity that results from the inability to use what breaks (Pelling, Oezerdem, and Barakat, 2002).

Figure 2.3: Branford, Conn., August 31, 2011 -- A gas station on Route 95 is closed due to loss of power from Hurricane Irene. (Source: Jocelyn Augustino/FEMA)

Thus, the benefits of greater resilience can be assessed along two lines: First, greater resilience means fewer things break, so Oregonians will need to spend less money on cleaning up, repairing, or replacing

what has been lost. Second, when fewer things break, there is less potential for extensive interruption of the economy (see Figure 2.3).

GREATER RESILIENCE MEANS LESS DIRECT DAMAGE FROM THE EVENT

Spending on resilience today means spending less on recovery later. For an event as large as a magnitude 9.0 Cascadia subduction zone earthquake, such avoided costs may be substantial. For instance, the recent earthquake in Sendai, Japan inflicted approximately $300 billion in damage, the 1995 Kobe earthquake inflicted $200 billion in damage, hurricane Katrina inflicted approximately $160 billion in damage, and the 1994 Northridge earthquake inflicted nearly $100 billion in damage (see *The Economist* online, 2011. "Natural Disasters: Counting the Costs"). For context, Katrina's direct damages equaled nearly two-thirds of total personal income in Louisiana and Mississippi in 2006 and the Northridge quake inflicted damages equal to approximately 25 percent of the Los Angeles metro area's personal income in 1994 (US Bureau of Economic Analysis, Regional Economic Accounts). By extension, if a Cascadia earthquake only inflicts damage proportionate to Hurricane Katrina, it might cost Oregon approximately $100 billion to repair what was lost.[1]

Ultimately, we cannot know precisely how much damage an earthquake in Oregon will inflict. The precise amount of initial damage will depend on the magnitude of the earthquake, the value of property and infrastructure in Oregon, and what we do to protect our property and infrastructure before the event occurs. We do know that recovery is unlikely to come cheaply.

While some (and hopefully much) of the money required to fund recovery will come from outside the region (for example, from insurance payments or the federal government), recovery will still require substantial local resources from both the private and public sectors. Money spent repairing something the region already had is money that cannot be spent pursuing other priorities. Furthermore, some of what Oregon will lose to the earthquake cannot be replaced. The direct damage estimates described above do not include damages to human health and other hard-to-value items, such as historical or culturally significant items.

GREATER RESILIENCE MEANS FEWER INTERRUPTIONS OF NORMAL ECONOMIC ACTIVITY

Disasters Depress Normal Economic Activity

Ultimately, the direct costs of a Cascadia subduction zone earthquake are likely to pale in comparison to the indirect costs. The interruption of normal economic activity could generate costs so substantial that the region may never fully recover.

In 2011, Oregon's economy produced nearly $195 billion in goods and services (US Bureau of Economic Analysis, Regional Economic Accounts). The state's firms and agencies employed over 2.2 million people who earned over $104 billion in compensation (Bureau of Economic Analysis, Regional Economic Accounts). While these workers produced goods and services in a wide variety of industries (including

[1] Oregon's 2011 total personal income was $145 billion.

agriculture, logging, wood products manufacturing, computer and electronics manufacturing, metals manufacturing, company management, and tourism), every industry depends on various factors that could be disrupted by a Cascadia event.

For a regional economy to operate smoothly, several conditions must be met:

(1) Raw materials (food, water, energy, information, and other commodities) and imported goods and services must be available and able to reach households and firms.

(2) Households must be able to provide workers to firms (and government) and they must be able to consume the goods and services that are made available by local producers. In other words, households must have their basic needs satisfied, and they must have the resources to consume.

(3) Firms must be able to combine raw materials, workers, and equipment to transform the available inputs into finished products.

(4) Finished products must be available to customers, inside and outside of the region.

These basic relationships are illustrated in Figure 2.4; however, a severe natural disaster would likely affect each of these areas and break the key infrastructure that connects them. For example, a severe natural disaster could:

(1) Directly damage raw materials or inventories of imported goods.

(2) Damage the roads, bridges, pipes, or utility lines used to transport such goods to households and firms.

(3) Damage houses and households and limit both their ability to provide workers to firms and their ability to consume goods and services produced by local firms.

(4) Damage the buildings and equipment owned by firms, making production impossible.

(5) Damage the infrastructure used to transport finished products to customers (households or other firms).

If any of these (or many other possible) impacts occur, Oregon's economic output will suffer. Oregon's employers simply cannot produce and sell their goods and services if they lack the space in which to carry out production, if inputs cannot reach them, or if their outputs cannot get to their customers. When firms cannot produce and sell their goods and services, they stop contributing to the regional economy, and they may be unable to survive if the interruption lasts too long.

Firms may also struggle due to disruptions in consumption. Seventy percent of Oregon's workers work in industries that primarily serve customers in Oregon (that is, they work in the local as opposed to the traded sector). (For additional information about the distinctions between the traded and local sectors,

see Ward, Thoma, Moore, and Tapogna, 2012). Local sector firms will suffer if Oregonians (both households and firms) do not have money to spend, either because they have lost their sources of income or because they are spending their incomes on repairing or replacing what was lost. Local sector firms could also suffer if people or firms chose to leave the region entirely. Thus, even if local sector workers and firms are fully capable of continuing to produce, they could suffer because their customers have disappeared.

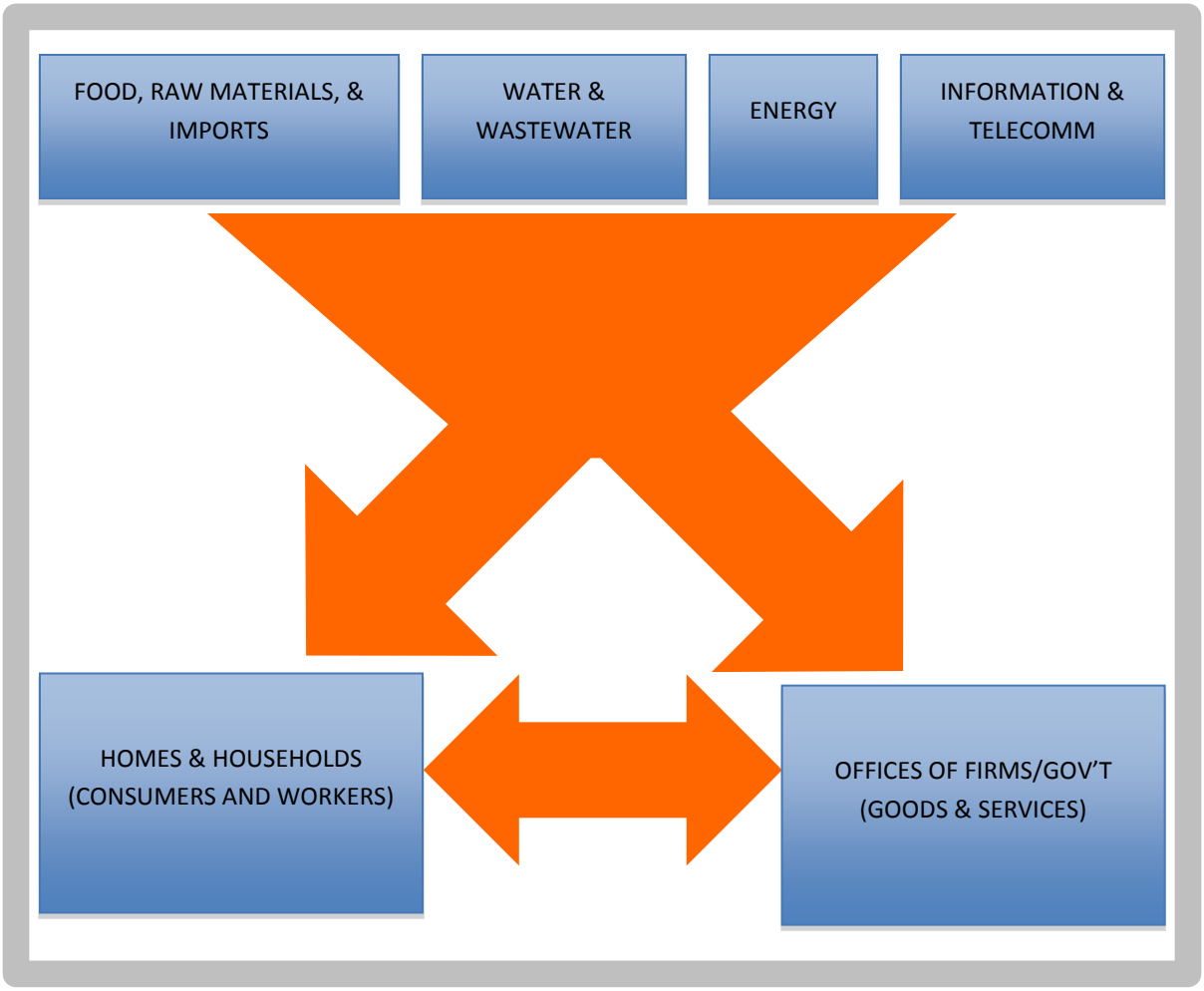

Figure 2.4: Core Economic Relationships That May Be Affected By Natural Disasters

A Disaster's Indirect Effects Are Felt over Both the Short and the Long Run

When people imagine the economic effects of a natural disaster, they typically imagine the disruptions that occur in the immediate aftermath of the event. Economists refer to these initial disruptions as the

short-run effects of the disaster[2] (Cavallo and Noy, 2010). During this period (which may last a few years), normal economic activity may be severely inhibited as resources are diverted toward cleanup and recovery efforts. The literature that examines the short-run effects of natural disasters finds that the event will depress economic outcomes for a few years, but that areas with "a better educated population, better governance, and more direct access to reconstruction resources will fare better in the disaster's aftermath" (see Noy, 2011).

Unfortunately, the effects of a natural disaster may not be limited to the time it takes to clean up and rebuild. Disasters may permanently shift the trajectory of the economy. In other words, the disaster may have long-run effects.[3]

Some economists argue that economies are resilient and generally return to "as before" conditions within a few years[4] (see DuPont and Noy, 2012). However, recent evidence suggests that disasters may have larger long-run consequences than previously thought (see DuPont and Noy, 2012; Lynham, Noy, and Page, 2012; and Coffman and Noy, 2012). Specifically, economist Ilan Noy and various co-authors have examined the long-run regional effects of the 1995 Kobe earthquake, the 1960 tsunami in Hilo, Hawaii, and the 1992 hurricane in Kauai, Hawaii (DuPont and Noy, 2012; Coffman and Noy, 2012; Lynham, Noy, and Page, 2012). In each case, these studies found that the disaster caused outcomes to deteriorate from what they likely would have been in the absence of the disaster; however, how the disaster adversely affected long-run outcomes differs across these three events.

Kobe (DuPont and Noy, 2012): The Kobe earthquake inflicted nearly $200 billion in damage (in 2010 dollars). The quake severely damaged Kobe's port–a significant source of local economic activity–as well as 80 percent of its shoe factories, 50 percent of its sake breweries, and half of its markets. While many sectors recovered to pre-earthquake levels, several sectors of Kobe's economy remain significantly below these levels. Port capacity recovered to 98 percent of pre-earthquake levels, but the number of ships handled peaked at 87.7 percent of pre-earthquake levels. Mining and manufacturing activity has only reached 81.3 percent of pre-earthquake levels. Shoe production remains at 60 percent of pre-earthquake levels. Sake breweries ship less than 50 percent of their pre-earthquake levels. Department store sales remain at only 75 percent of pre-earthquake levels.

While such changes could reflect other trends and not the influence of the earthquake, a careful analysis, which compared Kobe and its surrounding areas to parts of Japan not severely affected by the earthquake – finds evidence that the earthquake had lasting effects on local output. While output per

[2] The short run effects are generally those that occur within the first three years of the event, and long run effects are generally those occurring beyond five years.

[3] Economic theory does not provide a clear expectation for the direction or magnitude of long run effects. Cavallo et al. (2010) summarize the competing theories.

[4] This position was effectively summarized by John Stuart Mill in 1872 when he stated, "…what has so often excited wonder, the great rapidity with which countries recover from a state of devastation; the disappearance, in a short time, of all traces of the mischiefs done by earthquakes, floods, hurricanes, and the ravages of war. An enemy lays waste to a country . . . and yet in a few years after, everything is much as it was before."(Mill, 1872). Many economists espoused similar sentiments in the wake of the recent 2010 Tohoku earthquake.

capita initially spiked with recovery efforts, it fell as recovery efforts waned. In 2010, output per person was 13 percent lower than it likely would have been in the absence of the earthquake. For context, if Oregon were to experience a 13 percent decline in output per capita, output would fall by over $6,200 per person, and Oregon's output per capita would fall from 9th to 23rd among all states.

Hilo (Lynham, Noy, and Page, 2012): In 1960, a tsunami generated by the magnitude 9.5 Valdivia earthquake in Chile (the largest earthquake ever recorded) struck Hilo, Hawaii. This tsunami killed 61 people and inundated 600 acres, completely destroying half of the buildings in the inundation zone. An analysis that compared the affected area to other Hawaiian islands that were not significantly affected by the tsunami found that, 15 years after the event, Hilo was short of people, firms, and jobs.

Fifteen years after the tsunami, Hilo's population was nine percent below the levels it likely would have achieved in the absence of the tsunami. The total number of establishments remained depressed and unemployment remained elevated–33 percent higher than expected. Finally, sugar, the island's most important industry, remained depressed following the tsunami.

Kauai (Coffman and Noy, 2012): In 1992, Hurricane Iniki struck Kauai (but largely missed the other Hawaiian islands). While the hurricane did not cause significant mortality, it did severely damage local infrastructure. The loss of infrastructure appears to have had significant long-term consequences. Twenty years after the event, population and employment on Kauai remain well below (15 percent) the levels expected in the absence of the hurricane.

Combined, these three studies suggest that disasters can substantially disrupt long-run economic performance. Thus, greater resilience may help Oregon avoid large long-run consequences such as severe losses to output per capita (such as occurred in Kobe) or population and employment (such as occurred in Hilo and Kauai). This is not inconsistent with how regional economists expect regions to respond to non-natural economic disasters. Frequently, when regional economies suffer adverse regional shocks, the economy shrinks and then grows from the new lower base at the same rate as before—never catching up to where it would have been in the absence of the shock (Blanchard, Katz, Hall, and Eichengreen, 1992).

Figure 2.5: Carrollton, New Orleans, LA, 9-17-05 -- Small business owners are planning on returning to New Orleans. After three weeks many areas are still without power and utilities. (Source: MARVIN NAUMAN/FEMA photo)

Natural Disasters Do Not Uniformly Affect Residents

The above discussion focuses on the effects of natural disasters on aggregate measures of economic activity (such as output per capita) but ignores potentially important distributional consequences of disasters. Even if the disaster produced no adverse effect on aggregate outcomes, the avoided distributional effects may be sufficient to justify investments in greater resilience. Disasters affect incumbent residents and they are the ones whose homes are damaged, whose jobs may be lost, and whose businesses may close. Even if the economy recovers, those who benefit from the recovery may be different from those who lost during the destruction. Evidence shows that poorer residents are particularly likely to suffer following a natural disaster because they lack access to resources to help them absorb the adverse shock (Sawada and Shimizutani, 2008).

RESILIENCE AND REGIONAL ECONOMIES

In sum, greater resilience may benefit Oregonians in three major ways. First, greater resilience means less stuff will break, so Oregonians will spend less money later removing, repairing, or replacing items damaged by the event. Second, less breakage means smaller interruptions to normal economic activities in both the short and long run. Finally, greater resilience means fewer losses to the incumbent residents–particularly the poor who suffer the most when disasters strike.

While we cannot say with certainty how large such benefits may be, experiences with previous disasters suggest that the adverse consequences of disasters (and thus the benefits of greater resilience) may be large. Direct damages may reach into the hundreds of billions of dollars (amounts equal to half or more of Oregon's annual output). If damages are similar in magnitude to those inflicted by Hurricane Katrina, Oregonians will need to work for almost a year (at normal levels) to replace what the disaster destroys. Indirect damages are very difficult to estimate. When the disaster breaks things, what is broken can no longer be used to support the economy. As a result, the damage inflicted by the disaster may ripple through the economy reducing population, output, income, and employment over both the short and long run (Figure 2.5). Several recent case studies suggest that, in the 15 years following a major disaster, outcomes (population, employment, or income) fall 10-15 percent below levels they might otherwise have reached in the absence of the disaster.

Business Workforce Interdependency

Businesses and the business workforce do not exist in a vacuum. Without a government and a system of laws and enforcement of commercial instruments (such as contracts), a strong banking system to provide access to capital, and a transportation network to bring in and distribute raw materials and manufactured goods, businesses cannot thrive. Even businesses whose products are "intellectual capital," such as consultants, and personal services companies such as barbers or physical therapists, require strong information, communications, and municipal utility infrastructure to function successfully.

Figure 2.6 depicts some of the interdependencies of business, government, the public (both workforce and customers), banking, transportation, public and private infrastructure, and the healthcare sector. This figure is specifically intended to reflect the relationships following a major catastrophe and to serve as a guide for recovery. With the possible exception of the healthcare sector, the relationships depicted are also applicable to the interdependency of everyday commerce. The one notable omission is the education sector, which is a subset of both government (public schools) and business (private schools). Schools are likely to become major refugee and triage centers in the immediate aftermath of a Cascadia earthquake and tsunami, but from the standpoint of business recovery, schools are primarily important as a place where workers' children can spend their days, thus freeing up parents to return to work.

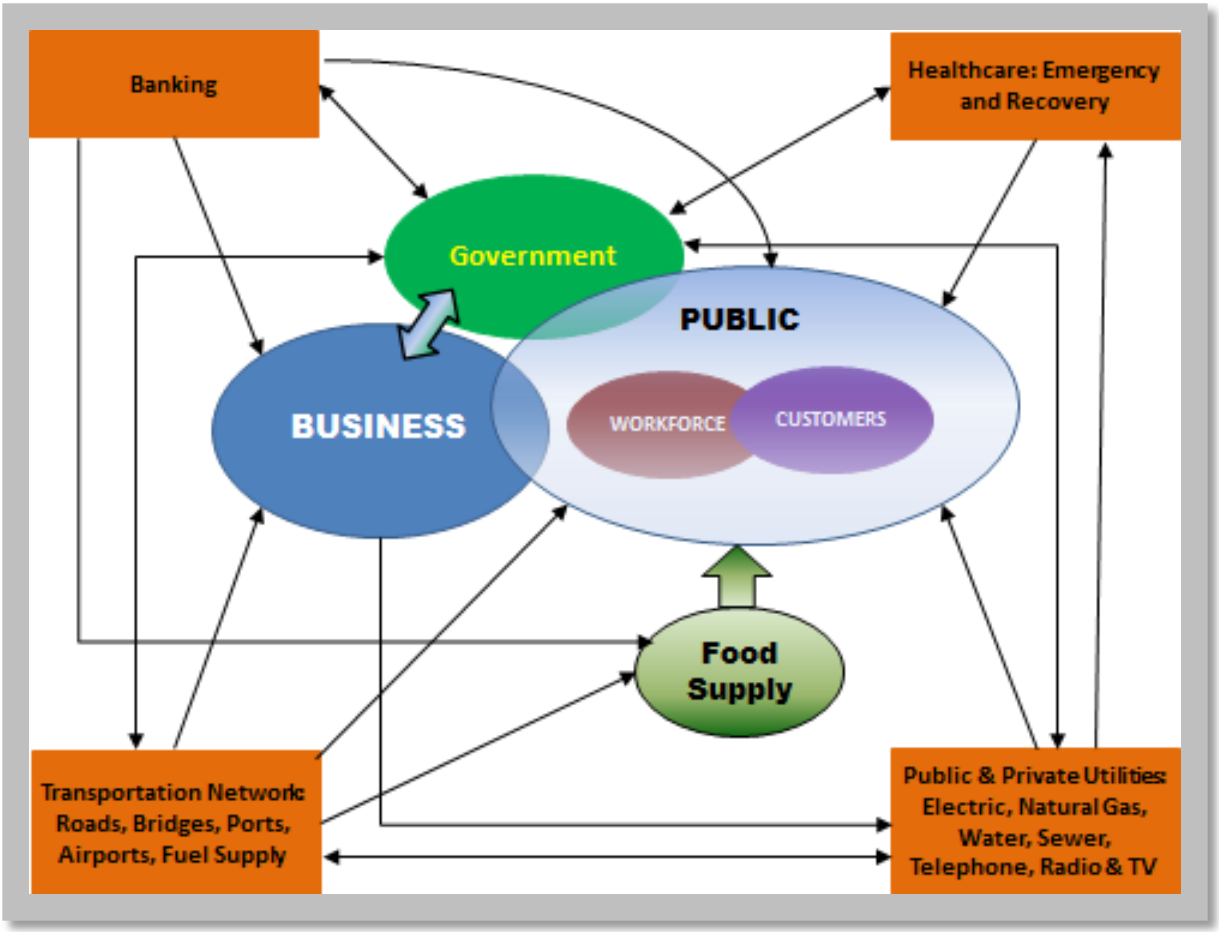

Figure 2.6: Business Workforce Interdependency

Some relationships, such as business interdependency with the healthcare sector are imputed through the business/workforce/public-to-healthcare relationship. In other words, to the extent that businesses rely on a healthy workforce and customers, who in turn rely on the healthcare sector for health-related services, the business sector relies on the healthcare sector through a sort of transitive property.

Recommendations

- **Rehabilitate or Replace vulnerable Oregon public schools**
  - *Finding*: The Department of Geology and Mineral Industries 2007 report assessed more than 1,100 public education buildings in Oregon at a high or very high risk of collapse in a major seismic event. Parents cannot return to work after a major seismic event if their children are unable to attend school.

- *Action Needed*: The State of Oregon shall establish (in addition to the General Obligation bond-funded Seismic Rehabilitation Grants Program) a statewide sinking or reserve fund, outside of the Oregon Emergency Management department budget, to fully fund the Seismic Rehabilitation Grant Program for public education facilities.

GOVERNMENT

Government, in addition to enforcing contracts and other commercial instruments, also provides security so that businesses can operate free from fear of being looted or robbed. Government's security mission also extends to the public (see Figure 2.7). In the aftermath of Hurricane Katrina, looting of non-essential[5] items by some members of the public was well documented. Some shop owners resorted to defending their property with personal firearms. Similar acts were documented when Hurricane Andrew devastated South Florida in 1992 and caused some homeowners to be without power for weeks.[6]

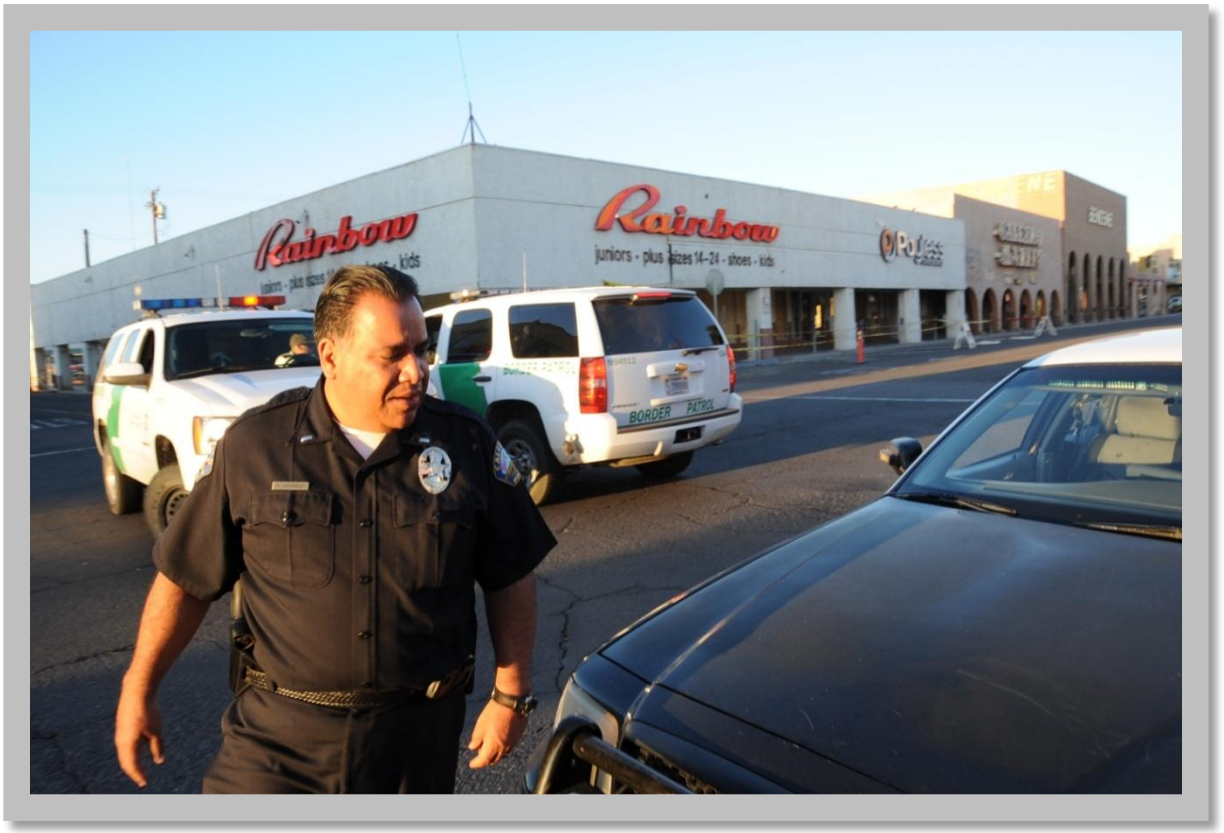

Figure 2.7: Calexico, Calif., April 6, 2010 -- Calexico Police Lt. Gonzalo Gerrado and US Border Patrol agents patrol the damaged businesses and public facilities to mitigate looting and theft. A magnitude 7.2 earthquake rocked the city on Easter leaving many facilities, roads, and public buildings closed, broken, and exposed. (Source: Adam DuBrowa/FEMA)

[5] By "non-essential" we mean non-food, or non-food preparation items such as gas or charcoal grilles, fuel, and so on. Looting of entertainment devices, such as TV's and X-Boxes, furniture, and so on were well documented, as was the lack of police presence in the immediate aftermath of the hurricane.

[6] Within Miami-Dade County more than 25,500 homes were actually destroyed and another 100,000 plus were damaged.

Hurricane damage and devastation differs from the expected impacts of a Cascadia subduction zone earthquake in that much of the damage resulting from hurricanes such as Katrina and Andrew is to smaller wood frame buildings, a type of construction typically used for single-family homes. After Katrina, for example, much of the central business core of New Orleans either survived or was quickly re-inhabitable, but much of the housing stock was destroyed. Similarly, Hurricane Andrew destroyed 63,000 homes leaving 175,000 to 250,000 people homeless (Dorschner 1992). We expect most wood-frame homes to survive a Cascadia earthquake, but we expect power and the other private and public utilities to be down in some neighborhoods for several weeks or months.

Security in the central business districts of the state is likely to be more easily accomplished than in some residential neighborhoods. The main commercial areas of the state – Portland, Eugene-Springfield, Salem, and to some extent, Albany, Corvallis, Grants Pass, and Medford – are relatively small compared to the residential areas of the cities and their suburbs. For example, in the City of Portland, the downtown commercial core[7] makes up less than seven tenths of one percent of Portland's 145.4 square miles (376.6 square KM) of area. The remaining area is largely residential neighborhoods, local or neighborhood commercial areas[8], parks and industrial areas (principally in northwest, north and northeast Portland). Keeping the neighborhoods secure is expected to be a major challenge for the Portland Police Bureau and, more likely than not, National Guard troops.

Continuity of government following a Cascadia event will depend on the immediate functionality of critical and essential facilities, such as police, fire, emergency operations and critical care centers.

Recommendations

► **Assess seismic performance of critical and essential public buildings**

- *Finding*: The seismic vulnerability of critical and essential public buildings throughout Oregon has not been fully assessed.

- *Action Needed*: The State of Oregon shall direct local jurisdictions to determine the seismic resilience of all critical and essential public buildings.

[7] The commercial core here is the area west of the Willamette River extending to the I-405 freeway, about 13 city blocks, and south from Union Station to Portland State University and I-405. This area also includes the RiverPlace and Pearl District neighborhoods and the Old Town/China Town Districts.

[8] These commercial districts include the Hawthorne District, the Broadway District, the Albina District, the Lloyd District, The Goose Hollow, Multnomah Village, Interstate Avenue, MLK, St. Johns, and so on. These areas include a significant inventory of mostly service businesses, restaurants, theaters, and in the case of the Lloyd District, a major shopping mall.

FOOD SUPPLY

Given that businesses cannot survive without their workforces or their customers, and given that people cannot survive for long without food, the food supply is inexorably linked to the survival of businesses. It is unlikely that a large proportion of the population currently stores more than a few days' worth of food—and probably stores even less water—in their homes. It is almost certain that a Cascadia subduction zone earthquake will cause all private and public utilities to fail; this means there will be no municipal water or sewer service, no electricity, no telephone, and no television, radio, or internet. Without power, local grocery stores will be unable to keep frozen foods frozen or fresh meats and dairy cold enough to prevent spoiling. It is likely that most of the food in the grocery stores will be distributed (as opposed to sold) to the public because the store's registers will not work without power and there would be no sense in letting frozen foods, meats, and dairy products spoil in the store.

Because stores are routinely resupplied several times each week, the amount of food actually held in an individual store is probably no more than what is required to supply the surrounding neighborhood for a few days. In particular, fresh fruits, vegetables, and dairy products are typically replenished several times a week, so the quantities kept in stock are not large. With supplies already limited, a related concern is that people will hoard food out of fear that stores will run out completely. In the near term, such hoarding will exacerbate the erosion of the food supply.

Figure 2.8: Brooklyn, N.Y., Dec. 4, 2012 -- Local Red Hook business, Cornell Paper and Box Company, continues cleanup of boxes at the warehouse that was flooded during Hurricane Sandy. (Source: Jocelyn Augustino/FEMA)

Once the food supply at local grocery stores is exhausted, the government will have to set up food distribution centers to support the population until local grocery stores regain electrical power and municipal services and can be resupplied. That resupply activity also requires the transportation and distribution network to be functioning (see Figure 2.8). Transportation lifelines have to be open for trucks to deliver the food, and truckers have to know where the lifeline routes are located and which bridges have been seismically braced and are safe to use following the earthquake. The transportation of supplies by truck is further dependent on the fuel supply. Currently, Oregon's liquid fuel supply is severely constrained. The main liquid fuel depot in the Portland Metro area is a "tank farm" located in Northwest Portland, adjacent to Highway 30, built on soils that are highly susceptible to liquefaction.

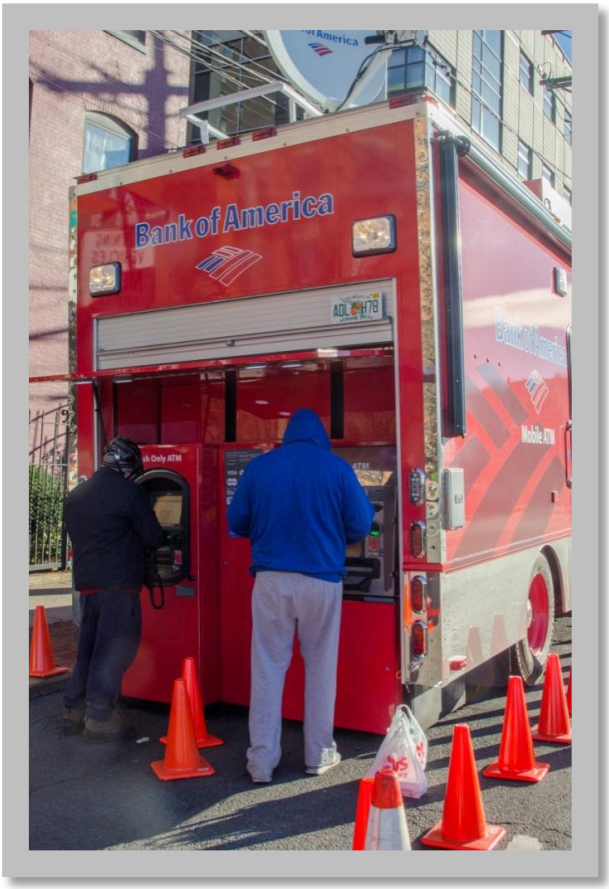

Figure 2.9: Hoboken, N.J., Nov. 3, 2012 -- Bank of America and other banks have set up mobile ATMs for survivors of Hurricane Sandy to get cash to spend at stores that are open for cash customers. (Source: Photo by Liz Roll/FEMA)

Finally, the resupply of food is dependent on a functioning banking system. All commercial transactions at grocery stores involve a debit or credit card issued from a bank (or the Oregon Trail cards issued by the state), a check (which is nearly always scanned to prevent fraud), or cash. Even after electrical power is restored and communications between stores and banks re-established, the banks themselves have to be functioning in order to assure the stores that transactions will result in actual payment (see Figure 2.9). Even cash purchases will require banks to have cash to distribute, and the banks' own information systems have to be functioning in order for them to distribute cash to their customers via bank teller or ATM network.

Recommendations

► **Strengthen transportation lifelines**

- *Finding*: Transportation has been identified as a major linkage in the business recovery chain. Inability to access office buildings due to failed bridges will have a devastating effect on business recovery efforts.

- *Action Needed*: The Oregon Department of Transportation (ODOT) shall identify and repair major lifeline routes in and out of major business centers statewide. Prioritize and seismically upgrade these lifelines by 2030. The state must also arrange for alternate modes of transportation in and out of the major population areas in Oregon.

PUBLIC & PRIVATE UTILITIES, INFRASTRUCTURE AND TRANSPORTATION

In Figure 2.6 above, the transportation network is shown as a separate sector from the utilities and infrastructure sector, but these sectors have strong interdependencies. Utilities cannot be repaired if roads and bridges are impassable. Likewise, the communication infrastructure is interdependent with the transportation network. If communications systems are down, repair crews have no way of knowing where they are needed most.

It is axiomatic that workers need a functioning transportation system in order to get to the workplace; one only needs to look at rush hour traffic, on a bad day, across the Interstate Bridge linking Vancouver, Washington and Portland, Oregon to observe an example of how the transportation network affects the workplace. On December 14, 2007, the City of Portland allowed contractors working on separate projects[9] to close all but one lane of SW 4th and SW 6th Avenue on or near SW Harrison Street, near the southern end of downtown. All traffic traveling north through the downtown core from the I-405 freeway, Barbur Boulevard, and SW 1st Avenue[10] were squeezed down to two traffic lanes on 4th and 6th Avenues and two northbound lanes of Naito Parkway. The result was gridlock, with cars taking more than an hour to move through downtown.[11] What happened that night, similar to many other December nights that year, illustrates what can be expected following a Cascadia earthquake, with many roads impassable and many bridges closed. The challenge of getting the workforce home after a Cascadia event that occurs during the workday may be dwarfed by the challenge of getting the workforce back to work.

The Willamette River bisects all of Oregon's major commercial centers: Portland, Salem, Eugene, Corvallis, and Albany. In Portland, nine bridges—the St. Johns, Fremont, Broadway, Steel, Burnside, Morrison, Hawthorne, Ross Island, and Sellwood—were all built before modern seismic codes were in force. Multnomah County bridge engineers have stated that they do not expect their bridges to collapse into the river; however none are expected to be passable prior to inspection in the event of a Cascadia earthquake. What this means is that many of the workers in the downtown core of Portland will not be able to get home if they live east of the river. The west side Highway 26 tunnels, built in the 1960s, may not be passable following a Cascadia earthquake. Highway 26 is a major transportation artery between Portland and its west side suburbs (though the tunnels can be circumvented via SW Jefferson Street).

[9] On SW 4th Avenue it was the Cyan Apartment Project and on SW 6th it was the Portland State University Student Recreation Center.
[10] SW 1st Avenue's northbound lane ends at SW Harrison and traffic heading north has to either go east to Naito Parkway or west to SW 4th, SW 2nd Avenue (and 3rd) was abandoned when the South Auditorium Urban Renewal Development was built in the 1960's.
[11] A snowstorm at the time contributed to traffic slowing, but this condition would mirror the problems we would face in the aftermath of a Cascadia earthquake.

Figure 2.10: Sea Bright, N.J., Jan. 25, 2013 -- Some businesses have permanently relocated to higher ground after being destroyed by Hurricane Sandy. (Source: Photo by Liz Roll/FEMA)

Before a business can reopen following a Cascadia earthquake, the building it occupies has to be certified to be structurally safe, it has to be served by municipal and private utilities, and the communications infrastructure must be operating. A business that cannot reopen within a month of a major earthquake or other disaster resulting in extended service disruption will likely never reopen at its previous location (see Figure 2.10). Potable water, sewage systems, heating (natural gas or electric), and ventilating systems must be operable before workers can reoccupy a business. To a lesser extent, but nevertheless important in our ever more technologically oriented business environment, the communications infrastructure must be re-established before businesses can be re-established. These requirements set the performance benchmarks for the transportation and utility infrastructure sectors.

Recommendations

► **Improve seismic performance of infrastructure for rapid community recovery**

- *Finding*: Business and community cannot recover within two to four weeks due to inadequate seismic performance of infrastructure.

- *Action Needed*: Upgrade existing infrastructure and increase seismic design standards for new infrastructure over the next 50 years to enable business and community recovery within two to four weeks.

Considerations for Different Sectors

As with all state economies, there are multiple business sectors in Oregon, and a Cascadia earthquake will affect each differently. A manufacturer, for example, could sustain significant damage to machines and equipment used to make products and suffer from the lack of raw materials in the immediate aftermath of the earthquake prior to repair of roads and bridges. In addition, even if the manufacturer is able to resume production quickly, the firm may not be able to ship products to market because the transportation system may not be available.

Service providers come in all shapes and sizes, from small consulting practices to large medical clinics. These will be affected differently by a Cascadia earthquake depending on the service they provide and the customer base. Companies that provide consulting services within the locality or region may not have a customer base for some time into the recovery. Others, like doctors' offices for example, will be pressed into service during the immediate recovery period and most likely for some months. However, it is also unknown how those services will be reimbursed or how liability for "bad outcomes" will be dealt with. It is our assessment that small service businesses like sundry shops will not survive in the central business cores that suffer significant damage, particularly those businesses dependent on sales to building occupants who may not return to their place of employment for some time (see Figure 2.11).

Figure 2.11: Bound Brook, N.J., August 30, 2011 -- Business owner, Brijo Garcia returns to clean up his internet store after Hurricane Irene swept through the Bound Brook area. (Source: Andrea Booher/FEMA)

Even though the goal is to have businesses up and running in two to four weeks, it seems unlikely that most customers will be making anything beyond the most essential purchases. Clothing stores, tailors, and other retail stores will suffer a prolonged period of depressed sales. These types of businesses should prepare for a Cascadia earthquake by building capital sufficient to help the business endure a prolonged disruption.

Some retail businesses, such as home repair,[12] plumbing supply, hardware, lumberyards and so on, will likely see their sales skyrocket during the immediate aftermath of a Cascadia earthquake. One problem facing homeowners who suffer earthquake-related damage to their homes will be finding construction contractors to repair the damage (assuming they cannot repair it on their own). Hurricane Andrew in 1992 drew hundreds of contractors to South Florida from as far away as Portland, Oregon. Many of the contractors in South Florida were there to repair roofs damaged in the Hurricane's high winds; an earthquake will cause different types of structural damage that will require more sophisticated contractors and likely require the services of structural engineers (see Figure 2.12). However, the potential exists for unlicensed contractors to enter the region affected by a Cascadia earthquake, and local building officials and the police will have to be aware of this potential problem.

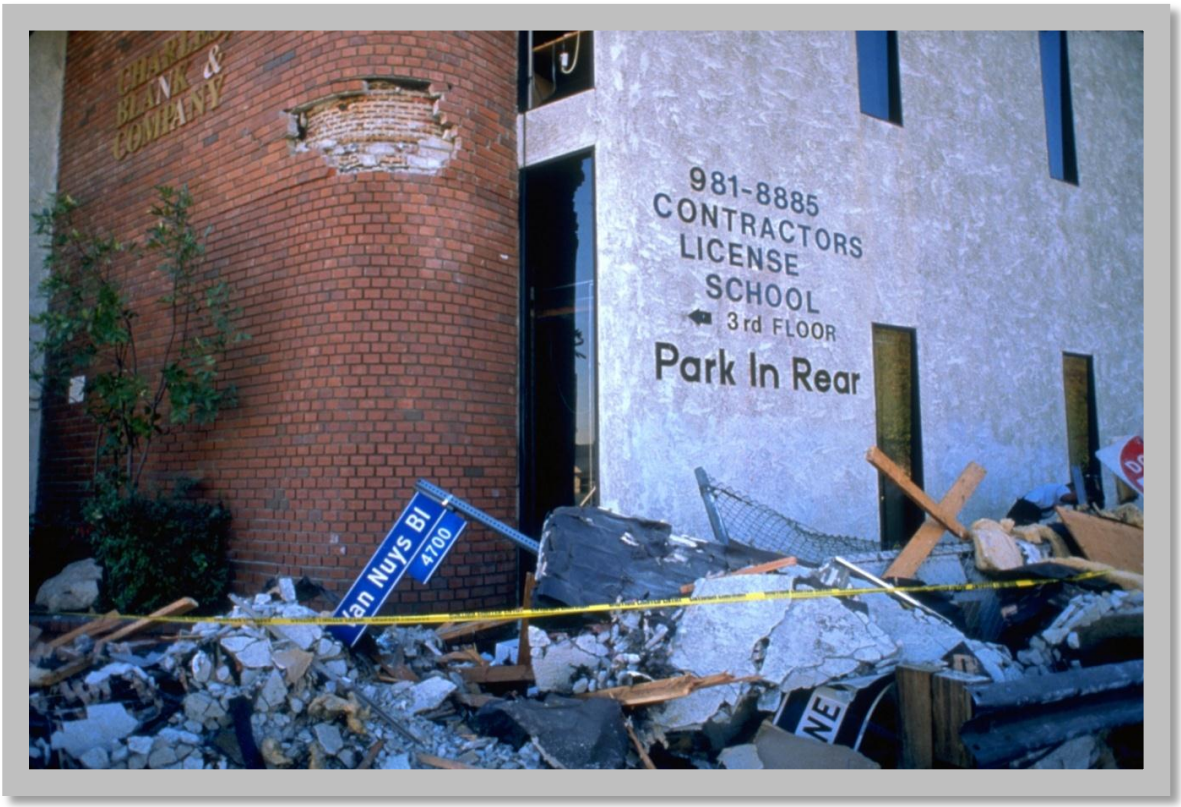

Figure 2.12: Northridge Earthquake, Calif., January 17, 1994 -- Approximately 114,000 residential and commercial structures were damaged and 72 deaths were attributed to the earthquake. Damage costs were estimated at $25 billion. (Source: FEMA News Photo)

[12] Companies like Home Depot and Lowes, for example

Businesses that offer services outside the affected region[13] are likely to be the least affected by a Cascadia earthquake. The demand for their services may not suffer, and their recovery will be more closely linked to the public infrastructure recovery discussed above. Once they can reoccupy their buildings or offices, they will be able to resume work.

A large portion of Oregon's Willamette Valley remains in agricultural production. Other than damage to equipment, many of these types of businesses will suffer minimal impact to their operations from a Cascadia earthquake. The notable exceptions are agricultural businesses located at or near the Oregon Coast. Some of these businesses suffered significant losses in the 2007 flooding and windstorms; losses from a major tsunami are likely to be much greater. For further discussion of the special challenges facing coastal enterprises, see Chapter Three.

Recommendations

► **Plan for business continuity**

- *Finding*: Although there are numerous resources for business continuity planning, we are unaware of evidence that the majority of businesses in Oregon have a business continuity plan.

- *Action Needed*: Assess hazards that could impact business; develop business continuity/ continuity of operations plan; partner with public sector to assess public/private building stock pre-event and help with post-event recovery. Business and building owners should be encouraged to review their business continuity plans and level of seismic vulnerability with respect to the Cascadia earthquake and to seismically upgrade their buildings. Employees must be trained to be their own first responders.

► **Expand emergency operation efforts to support private business for rapid resumption**

- *Finding:* To date, the State has not included the private sector in its Emergency Operation Centers (EOC).

- *Action Needed:* Encourage all Emergency Operation Centers to pursue public/private partnerships to enhance communication and coordination with the private sector after a major seismic event.

Cascadia Earthquake Aftermath

In the initial aftermath of a Cascadia earthquake, escaping the building safely will be the highest priority for businesses and their workers (Figure 2.13). Making workplaces safe before the event, as discussed in the previous section, will increase the chances that building occupants can exit unharmed. Several considerations need to be addressed by businesses in preparing for the immediate aftermath of a Cascadia subduction zone earthquake.

[13] Examples of these types of firms would be attorneys with overseas clients, accounting firms, architects and engineers that have a significant amount of their business outside the region, software developers, advertising agencies, and so on.

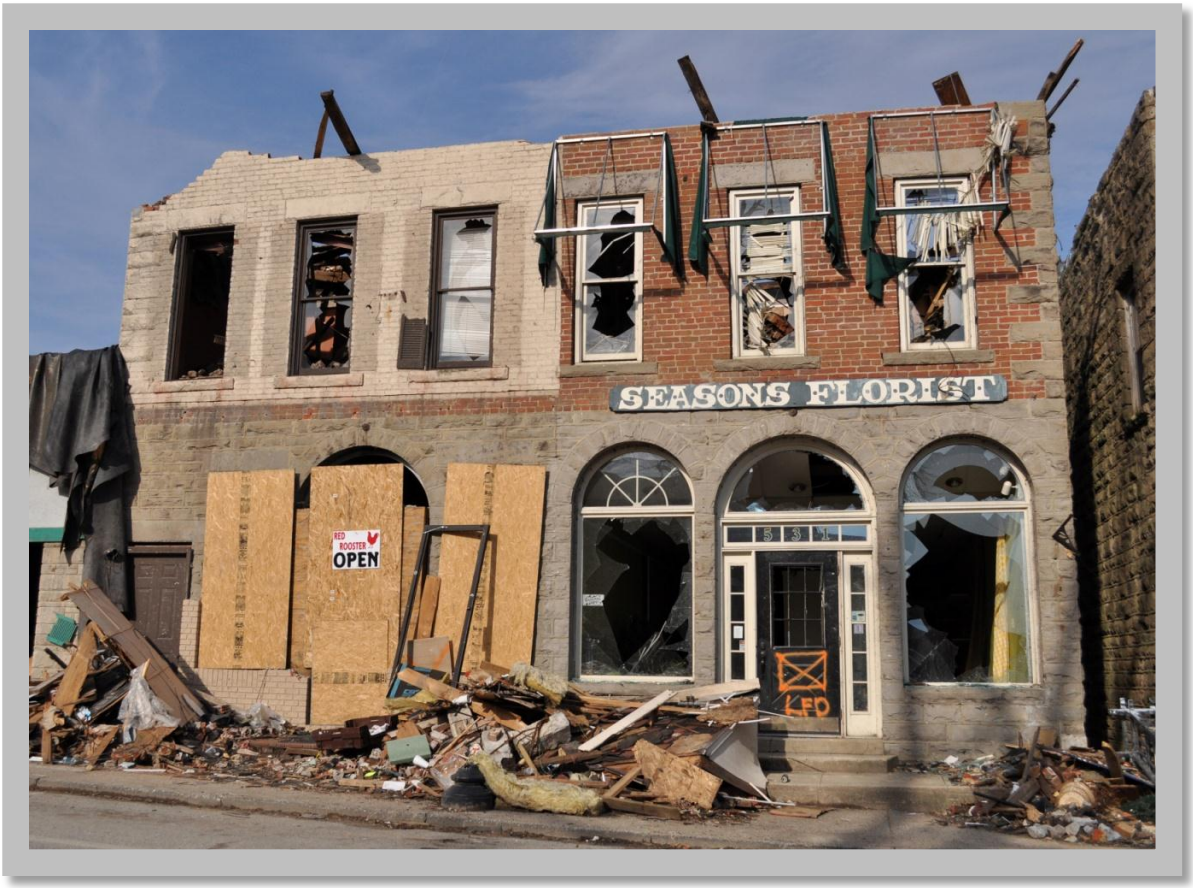

Figure 2.13: West Liberty, Ky., March 19, 2012 -- Destroyed buildings, many with historical significance, line the streets of downtown West Liberty. FEMA is working with Commonwealth and local officials to remove debris and demolish buildings that cannot be saved. (Source: Photo by Marilee Caliendo/FEMA)

If a Cascadia earthquake occurs during the workday (a one in three chance), workers will be in their offices or industrial plants during the event. In areas of the state where the Willamette River bisects the cities—Portland, Salem, Albany, Corvallis/Lebanon, and Eugene/Springfield—it is possible that a large number of workers will be trapped on the "wrong side" of the river. This will be a particular concern in Portland, where none of the ten bridges that currently carry automobile traffic is likely to be cleared by local officials to allow auto traffic for up to 72 hours, even if the bridge appears to have sustained no damage. The most recently constructed Willamette River bridge in Portland is the Fremont Bridge, built in 1976. Some renovations have been performed on the Broadway, Morrison, and Hawthorne Bridges in recent years, but the Multnomah County Bridge Division maintains that these upgrades have only brought the bridges up to level where those bridges were reinforced so that they will not collapse. The Sellwood Bridge is currently being reconstructed to modern seismic standards by Multnomah County and a new light rail bridge is currently being constructed by Tri-Met between the State-owned Marquam and Ross Island Bridges. The Marquam Bridge was opened in October 1964, and has had some seismic strengthening done since, but it is not expected to be immediately usable following a Cascadia earthquake, and may require some repairs before re-opening. The Ross Island Bridge is second only to

the existing Sellwood Bridge as the most unsafe bridge crossing the Willamette River in Portland due to unstable foundation on the east side, and is unlikely to be usable following a Cascadia earthquake.

It is likely that many of the workers in Portland's downtown core who live on the east side of the Willamette River would be forced to shelter in their office buildings, if those structures are safe enough for that purpose. In absence of that, local downtown parks and open spaces would be natural shelter and triage sites.

Buildings that do survive and are capable of sheltering-in workers will face significant challenges related to building security and liability. Most large buildings in downtown Portland have a large number of tenants, and it is unlikely that any one person in a building knows all of the building occupants by sight. This means that there is a distinct possibility that someone who does not work a particular building may end up sheltering-in there. Building owners will have to provide first for the security of their tenants.

Figure 2.14: Mt. Olive, N.J., Nov. 12, 2012 -- After almost two weeks without power in the town of Mt. Olive, shop owners want to let people know the power has been restored and the mall is open for business. (Source: Photo by Sharon Karr)

A second concern for building owners is health and sanitary conditions (Figure 2.14). It is unlikely that water and sewer systems will work in the immediate aftermath of a Cascadia earthquake. Persons sheltering in a downtown office building will not be able to use or will have limited use of its

bathrooms.[14] Sheltering –in is probably only going to be acceptable for one night, and only if an earthquake strikes in the mid to late afternoon on a short rainy or snowing winter day. If an earthquake strikes during a summer workday, when daylight extends well past 9 PM, it is likely that most workers will try to find some way to get home, even those who work on the opposite side of the river from where they live. Nevertheless, businesses in Oregon's river-bisected cities need to plan for the possibility that people could have to shelter-in for several days, even if that possibility seems remote.

Recommendations

- **Communicate gaps between current and target relief and resilience ratings**
  - *Finding*: The impact of a Cascadia earthquake and tsunami will be severe, especially for coastal communities. Earthquake ground shaking will damage buildings and infrastructure and disrupt lifelines. In addition, there will be near total destruction in the tsunami inundation areas that will result in large displacements of residents and visitors. Based on current expected levels of service disruption, the standard recommendation for the public to be prepared for 72 hours should be revised to at least two weeks or longer.

  - *Action Needed*: With an overall goal to increase awareness, a dual ratings system is proposed to give citizens information about the status of emergency preparedness and resilience efforts in their communities.

    - Adoption of a two-level ratings system. The first level would indicate the time period that citizens should anticipate relying on emergency supplies. The second level would indicate the time anticipated necessary for 90 percent restoration of roads and services.
    - The rating system should follow the four zones proposed by the Oregon Resilience Plan: tsunami zone, coastal earthquake only, valley, and eastern zone. Standards and methodology need be developed for the system to be consistent across zones, and applicable at the community level.

Cascadia Earthquake Business Planning

BUSINESS STRATEGIES RELATED TO BUILDING STRUCTURES

One of the primary goals of pursuing disaster resilience in Oregon is to expedite building re-occupancy and restore public/private services such as transportation and power back to a 90% level within two to four weeks. Following a damaging earthquake the buildings occupied by businesses will need to be evaluated for the extent of damage and level of occupancy using the three-tiered Applied Technology Council (ATC)-20 methodology (see Figure 2.15):

[14] Even flush valve toilets will function by gravity, and it is possible that some facilities can remain open for urination, but without water service, actual flushing to push fecal matter down the toilet will not happen, and toilet facilities will quickly become clogged and unsanitary.

- Green-Tagged: Structures that survived the earthquake and are immediately available for occupancy (as noted above, statewide this is about 27 percent of all commercial buildings).

- Yellow-Tagged: Structures that survived with limited access but require structural repair prior to re-occupancy (about 67 percent of all commercial buildings fall into this category). The time to re-occupy will depend on several factors including location, damage to infrastructure in the surrounding area, and the extent of damage to the building.

- Red-Tagged: Structures that have collapsed or are otherwise unsafe for occupancy due to damage (in the case of collapse, the building and its contents would be a complete loss). About 5 percent of all commercial buildings will fall into this category.

For pre-earthquake business planning with respect to business operations[15]:

Businesses in Green-Tagged buildings will need to have municipal and public utilities restored to the building within two to four weeks or tenant businesses may move their operations elsewhere, at least temporarily. Building owner-occupied businesses are probably less likely to relocate, but still will find it hard to survive much more than one month of inactivity due to their inability to get to their buildings. In addition, building owner-occupied businesses, particularly small businesses, probably have a large share of their net worth tied up in their buildings. This means that they are disproportionately likely to suffer losses from fire, or from burglary and looting, following a Cascadia earthquake. For businesses in Green-Tagged buildings, the business strategy following a Cascadia earthquake would be to back up intellectual capital off-site, and retrieve important documents or equipment following the event, as soon as it is safe to re-enter the building. Of course, this will be limited to the things that can be carried out by hand. If possible, a business may need to plan to set up shop temporarily in a building, such as a residence, which has not been damaged and is situated in a location the key business personnel can reach, continue minimal business operations if possible, and monitor reconstruction of transportation, infrastructure and utilities so that the business can re-occupy the building as soon as practicable.

For businesses in Yellow-Tagged buildings, restoring municipal services is less critical because it is likely to take several months to a year before these buildings will be structurally repaired to the extent required to allow reoccupation. Business strategy in these buildings will be to move to another location as soon as they can access the building and move business-related intellectual capital and equipment out. This will likely have to occur within one month for the reasons cited above, and moving will require at least some transportation lifelines to be open.

[15] Here we separate "Business Operations Strategy" from other Business responsibilities such as making the business as safe as possible and caring for workers housed in the business's building.

Figure 2.15: Northridge Earthquake, Califonira, January 17, 1994 – Post-earthquake damage assessment teams coordinate between inspections to business buildings. (Source: Photo by Andrea Booher/FEMA News Photo)

For businesses in Red-Tagged buildings, restoring municipal services is irrelevant because the buildings and their contents will be a complete loss. Following earthquakes in California, businesses located in Red-Tagged buildings were not allowed to re-enter to retrieve equipment or intellectual capital, even if they agreed to hold the government harmless should the building collapse when they were inside. Businesses that occupy buildings unlikely to survive a seismic event in a condition that can be reoccupied need to have their intellectual capital backed up off-site and should be insured against a seismic event.

Recommendations

► **Institutionalize post-earthquake assessment inspection process**

- *Finding*: The State of Oregon has only a passive approach to training and registering certified structural inspectors and certified plan examiners as Applied Technology Council (ATC)-20 post-earthquake damage assessment inspectors and no formal process for deployment.

- *Action Needed*: State shall sponsor annual ATC-20 trainings at no cost to qualified engineers and certified plan examiners and indemnify all trained ATC-20 inspectors. The state must negotiate mutual aid agreements with professional associations and our neighboring states to increase ATC-20 certification and disaster response capacity.

► **Develop seismic rating system for buildings to promote resilience**

- *Finding*: Oregon does not have a seismic rating system for the expected performance of buildings subject to earthquake ground motions.

- *Action Needed*: State should develop a seismic rating system modeled after Structural Engineers Association of Northern California rating system. The objective of this system is (1) to make buildings more resilient and usable after a Cascadia event and (2) to help communicate seismic risk to the general public.

► **Incentivize seismic upgrade of existing buildings**

- *Finding:* The majority of buildings in Oregon were built before the code change of 1994 and thus do not meet current seismic building code standards. Seismic upgrading of these buildings is expensive and is typically only done when there is a change-in-use of the building, or when the buildings are substantially modified. If only a small portion of these buildings will be seismically upgraded over the next fifty years, then the potential loss of the business and workforce housing in these buildings will seriously impact the recovery of the economy following the Cascadia earthquake.

- *Action Needed:* The State should consider incentives and other options to encourage building owners to seismically upgrade their buildings.

► **Reduce community vulnerability from unreinforced masonry (URM) buildings/non-ductile concrete buildings**

- *Finding*: The Historic Preservation League of Oregon (HPLO) estimates there are between 5,000 and 10,000 unreinforced masonry (URM) buildings in Oregon.

- *Action Needed*: State shall adopt the findings and recommendations in the 2012 HPLO Special Report, *Resilient Masonry Buildings*, and extend the recommendations to all non-ductile concrete buildings.

BUSINESS STRATEGIES FOR COASTAL COMMUNITIES

The Oregon Coast can anticipate that a Cascadia subduction zone earthquake offshore will generate a tsunami similar to the March 2011 Tohoku earthquake in Japan. The Department of Geology and Mineral Industries has published numerous inundation maps that show whole communities including, for example, downtown areas of Cannon Beach and Seaside as being prone to complete inundation. Likewise, low-lying areas including Lincoln City, Neskowin, Rockaway, Tillamook, and Bandon will be inundated. Businesses in these tsunami inundation zones will be wiped out even more completely than businesses housed in Red-Tagged Buildings discussed above.

Figure 2.16: New Orleans, La., October 9, 2005 - This souvenir shop is open for business in New Orleans despite the sidewalk being blocked by crushed vehicles and debris leftover from Hurricanes Katrina and Rita. (Source: Robert Kaufmann/FEMA)

Businesses located in tsunami inundation zones should consider the business strategies outlined for businesses housed in Red-Tagged buildings. A high proportion of the businesses in Oregon's coastal communities cater to the tourist industry (see Figure 2.16). Most of these firms are small (or very small) businesses that would not be expected to survive following a tsunami. Even if a business had sufficient capital to relocate, it is unlikely that the tourist industry will recover rapidly enough to support business start-up. Local authorities may need to keep tourists out of the inundation zones, for safety reasons, for months or years after a tsunami.

In the event of a tsunami similar to the Tohoku event, coastal business owners' first concern will be personal survival, not business survival. Oregon's coastal communities face resilience challenges so unique that they are addressed in detail in Chapter Three.

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