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BUSINESS VULNERABILITY TO DISASTER-
RELATED LIFELINE DISRUPTION

Kathleen J. Tierney
Joanne M. Nigg

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Business Vulnerability to Disaster-Related Lifeline Disruption

Kathleen J. Tierney and Joanne M. Nigg¹

Abstract

Surveys in Memphis, Tennessee and Des Moines, Iowa indicate that business owners rate electricity as the most important lifeline service. In Des Moines, where the survey was conducted following the 1993 Midwest floods, proprietors tend to assign greater importance than Memphis business owners to other lifeline services. Data on the business impacts of the 1993 floods indicate that lifeline service interruptions were widespread, were perceived by business owners as very disruptive, and were a much more significant source of business closure than actual physical flooding.

Introduction

Engineering research on the seismic vulnerability of lifeline systems typically focuses on documenting physical damage, identifying the causes of that damage, and devising ways to reduce lifeline failures and service disruption. Complementing that perspective, social science research focuses on the direct and indirect socioeconomic impacts of lifeline disruption (Rose and Benevides, 1993; Nigg, 1995; Rose, Benevides, and Szczesniak, 1995), how lifeline service providers function organizationally in disaster situations, factors affecting the adoption of mitigation and preparedness measures by lifeline organizations (c.f., Tierney, 1992), and related topics.

Lifeline services are critical for both emergency response and community recovery. Lifeline service interruption can both intensify demands on the emergency

¹ Research Director and Director, Disaster Research Center, University of Delaware, Newark, DE 19716

response system and degrade the system's ability to respond. By forcing businesses to close and disrupting economic activity in affected communities, lifeline damage can also lead to escalating disaster losses. Several recent studies have focused on estimating the indirect economic losses that could result from earthquake-induced damage to lifelines (Applied Technology Council, 1991; Federal Emergency Management Agency, 1992; Eguchi and Seligson, 1993). However, additional research is needed to better understand the relationship between lifeline service disruption and disaster losses, as well as ways of reducing those losses.

To begin addressing these topics, the Disaster Research Center (DRC) recently conducted two studies focusing on business reliance on lifeline services and on the ways in which disaster-induced lifeline service interruptions affect business operations. The first project was conducted in 1993 in Memphis, Tennessee, a city that is at risk from the New Madrid Seismic Zone. The study involved a mail survey on a random sample of Memphis businesses, stratified by size and economic sector. In addition to obtaining owners' assessments of business dependence on different lifeline services and the extent to which lifeline outages would disrupt business operations, the study also sought information on owners' perceptions of the likelihood of an earthquake in the Memphis area and on the mitigation and preparedness measures businesses adopted to reduce earthquake-related losses. The total number of businesses included in the study was 737.

Eight months after the devastating floods that struck the Midwest in the summer of 1993, DRC conducted a second study on a representative, randomly-selected sample of 1,079 businesses in Des Moines, Iowa, a community that was particularly hard-hit by the flooding. The study used a methodological approach that closely paralleled the one used in Memphis, except that in this case data were obtained on business disruption resulting from an actual event. The survey instrument, a mail questionnaire, focused on the extent of business dependence on different lifeline services during normal operations; damage and lifeline service interruptions that businesses experienced as a result of the flooding; how businesses coped with disaster-related damage and disruption, particularly lifeline disruption; the sources of assistance businesses used to cover their losses; levels of pre-and post-disaster preparedness; and the extent to which business operations had returned to their pre-disaster levels by the time the survey was conducted.

This paper presents selected findings from these two surveys, focusing on owner's assessments of the importance of lifeline services during normal business operations and, for the Des Moines case, on actual flood-related lifeline service interruptions and their impact on business operations.

Importance of Lifeline Services to Business Operations

In both surveys, business owners were asked to rate the importance of five lifeline services--electricity, water, natural gas, sewers and wastewater treatment, and telephone services--to their ability to do business. The wording of the question regarding lifeline importance differed slightly between the two surveys; Memphis business owners were asked to rate importance on a four-point scale (very important, important, not very important, and not important at all), while a five-point scale (critical, very important, important, not very important, and not important at all) was used for the Des Moines survey. Des Moines business owners were also asked for more detailed information on lifeline importance for different business functions.

Tables 1 and 2 summarize these importance assessments. In Memphis (Table 1), a very large majority of the business respondents rated electrical and telephone services as "very important" to their operations (82% and 78%, respectively). Only 4% and 5%, respectively, indicated that electric power and telephones were "not very" or "not at all" important to their business activities. Water, wastewater treatment, and natural gas were also seen as important by Memphis businesses, but the proportion rating these services as very important were clearly not as substantial, and a much larger number of businesses viewed these services as relatively less important to their ability to continue operating.²

IMPORTANCE	LIFELINE SERVICES				
	Electric	Water	Natural Gas	Water Treatment	Telephone
Very Imp	82%	27 %	18%	23%	78%
Important	14	34	29	32	17
Not Very					
Important	3	31	39	33	3
Not Imp					
at all	1	8	13	13	2
Total	100%	100%	99%*	101%*	100%

*Does not total 100% due to rounding

Table 1. Lifeline Importance for Business Operations--Memphis Sample

A related question in the Memphis survey asked how long businesses could stay in operation if they lost each of the five lifeline services. Again, electricity was seen as the lifeline service most critical to business operations, with 59% of the

² Space constraints preclude a full discussion of how business size and type were related to assessments of lifeline importance. However, we do want to note that such effects were evident in both surveys.

businesses reporting they would have to shut down immediately if they were left without electricity.

The survey responses for Des Moines (Table 2) resembled those of Memphis in some ways, but they differed in others. In Des Moines, electricity was once again seen as the most important lifeline service, with 90% of the respondents rating electricity as either "critical" or "very important" to business operations. However, natural gas was rated the second most important lifeline. Also in contrast with the Memphis data, the other three lifelines were viewed as almost as critical for operations as natural gas and as comparable to one another in their importance, with 30% or more of the respondents indicating that each of the other three services were "critical" to operations. In general, Des Moines businesses had a greater tendency than Memphis businesses to rate water and wastewater treatment as highly important to the functioning of their businesses. For example, while nearly half of Memphis businesses rated wastewater treatment as relatively unimportant to their operations, less than 10% of Des Moines owners rated the service as unimportant.

These data indicate that in general business proprietors consider electricity to be the most critical lifeline service. They also suggest that business dependence on natural gas varies by region. Additionally, the Des Moines data appear to show that once businesses have experienced an actual disaster that seriously disrupts lifelines, they tend to have a much greater appreciation of the importance of other lifeline services.

IMPORTANCE	LIFELINE SERVICES				
	Electric	Water	Natural Gas	Water Treatment	Telephone
Critical	55%	29%	37%	34%	36%
Very Imp	35	34	27	29	36
Important	8	30	26	28	15
Not Very Important	2	8	8	7	8
Not Imp at all	0	1	2	1	5
Total	100%	102%*	100%	99%*	100%

*Does not total 100% due to rounding

Table 2. Lifeline Importance for Business Operations--Des Moines Sample

Business Impacts of Lifeline Disruption in Des Moines

In contrast with the Memphis survey, which focused in a non-disaster context on businesses that were at risk, the Des Moines survey was conducted following a major natural disaster, the 1993 Midwest floods. In addition to physically damaging

homes, businesses, and other structures, the floods created a "lifeline disaster" for the city of Des Moines. The inundation of the water works left 300,000 residents without potable water, and electrical power stations were flooded, resulting in power outages that affected 35,000 households and the entire downtown business district. While only some sections of the community suffered direct flood damage, the entire community was affected by the damage that was done to water treatment and sewage facilities, and flood-related electrical service interruptions were extensive. Therefore, this event provided a useful setting for examining how both physical flooding and lifeline service interruptions affected business operations.

As shown in Table 3, 80% of the businesses in Des Moines reported being without water as a result of the flooding. Nearly 40% lost sewer service, and 34% reported being without electricity due to the flooding. Twenty-three percent of the businesses lost their phones, and a relatively small proportion, about 6%, reported that the disaster interrupted natural gas service.

With respect to sectoral differences in flood-related lifeline service interruption, businesses in the manufacturing and construction sector were more likely than other businesses to report that they lost electricity, telephone service, and natural gas as a result of the flooding. Loss of water service was so widespread that rates of service interruption did not vary significantly by sector.

LIFELINE SERVICES					
SECTOR	Electric	Water	Natural Gas	Water Treatment	Telephone
Whole & Retail	30%	80%	3%	39%	21%
Man & Const	41	82	12	34	32
Bus/Prof	37	80	7	43	23
Services	37	78	3	44	25
F.I.R.E.	25	82	6	34	13
Other*	34	80	6	39	23
All					

*Agriculture, fishing, forestry, mining, transportation, and communication firms

Table 3. Percent of Des Moines Businesses Reporting Lifeline Service Interruption, by Sector

The loss of lifeline services placed severe constraints on business operations. As Table 4 indicates, a very high proportion of those surveyed rated lifeline service loss as "disruptive" or "very disruptive." On average, loss of telephone service was seen as most disruptive by business owners (67% indicating it was "very disruptive"), followed closely by electrical service (65%).

DISRUPTIVENESS	LIFELINE SERVICES				
	Electric	Water	Natural Gas	Water Treatment	Telephone
Very Disruptive	65%	42%	23%	43%	67%
Disruptive	22	40	20	42	25
Not Very Disruptive	9	13	23	11	6
Not at all Disruptive	4	4	34	3	2

Table 4. Owner Assessments of Disruptiveness of Service Interruption (in Percentages)

The Des Moines survey also obtained information on both disaster-related business closures and the reasons why businesses were forced to close. Of the total sample of 1,079 businesses, 448, or about 41%, were closed for some period of time during the flooding. Rates of business closure were highest for large manufacturing and construction firms,³ large companies in the service sector, and small manufacturing and construction firms. More than half of all businesses in these categories were forced to close for some period of time.

Asked to indicate why their businesses had to close (Table 5), proprietors most frequently cited loss of water (64%), loss of electricity (42%), loss of sewer or waste water services (35%), and loss of customers (34%). Other common reasons for closure included the loss of telephone service, the fact that employees could not get to work, and inability of the business to deliver its products or services because of the floods. Of the businesses that closed, only about 20% cited actual flooding as a reason for closing.

Loss of Water	64%
Loss of Electricity	42
Loss of Sewer/ Water Service	35
Few or No Customers	34
Loss of Phone Service	28
Employees Couldn't Get to Work	26
Unable to Deliver Products	26
Evacuated Due to Flood Threat	21
Building Flooded	20

Table 5. Most Common Reasons for Business Closure

When asked to single out the most important reasons why their businesses closed, respondents emphasized loss of water, flooding of the business property, and loss of electricity. Other reasons cited as important included the need to evacuate

³ In this study, large firms were defined as those with twenty or more employees.

because of the threat of flooding, loss of customers, an official order that required downtown businesses to vacate, and the inability of employees to get to work.

These data indicate that actual flooding was a comparatively rare source of business disruption in Des Moines, and that the loss of critical lifeline services, particularly water, was a much more important cause of business closure, affecting a significantly larger number of businesses. The survey results also suggest that while the physical damage disasters produce is one important source of business interruption, various other factors, such as loss of customers, lack of employee access, and disruption of the flow of supplies, also need to be taken into account.

Conclusions

Estimating the economic impacts and indirect losses resulting from earthquakes and other disasters requires an understanding of the factors that contribute to business interruption. The survey findings discussed here indicate that disaster-induced lifeline failures are among the most important factors to consider. Business owners in both communities studied indicate that their operations are heavily dependent on electrical power, but other major lifeline services, particularly telephone service and natural gas, are also seen as very important. In Des Moines, where businesses had recently experienced a major disaster, owners were more likely to assign importance to all five lifelines, suggesting that actual disaster experience highlights business dependence on lifeline services.

Based on their experience in the 1993 floods, Des Moines business owners considered the loss of telephone and electrical services to be extremely disruptive. Lifeline service outages were among the most important reasons why Des Moines businesses closed during the floods; compared with lifeline service interruption, actual physical flooding was a problem for a relatively small segment of the business community.

Underlying many current loss reduction strategies is the assumption that mitigating damage to structures and building contents and encouraging firms to prepare for disasters will help ensure continuity of business operations. Such approaches are undoubtedly important, but they tend to downplay a point that this study highlights: that business interruption is very often attributable to factors originating outside the business property, such as lifeline failures and the disruption of the flow of customers and supplies. Mitigation and preparedness measures undertaken at the level of the individual business must be balanced by macro-level approaches that focus on maintaining the functionality of communities and local economies.

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