Protecting the Nation's Seaports: Balancing Security and Cost

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3. The Costs of a Terrorist Attack on Terminal Island at the Twin Ports of Los Angeles and Long Beach

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Introduction

According to recent estimates, almost $30 billion was spent or budgeted by federal agencies in the period 2001–2005 to protect the U.S. homeland from terrorist attack.[1] What is the best use of these resources? How can we improve on current allocations? These are not simple questions, but a growing body of research, some funded by the U.S. Department of Homeland Security (DHS), is beginning to address their various aspects.

One approach to this question of cost-effectiveness is to estimate the economic losses from various hypothetical attacks and then identify the reductions in losses from various mitigating measures. We did this in a previous analysis, which hypothesized the effects of simultaneous radiological bomb attacks on the Los Angeles and Long Beach ports.[2] These ports account for a substantial share of local economic activity—more than 600,000 jobs and $250 billion of import and export trade.

[1] Brunet (2004).

[2] Gordon et al. (2005a).

This study is part of a research program to apply the Southern California Planning Model (SCPM) and similar economic impact nodels to estimate the economic losses from hypothetical but plausible errorist attacks on various key infrastructure installations and other mportant sites.

In this chapter, we explore another dimension of potential terrorist ttacks on the region's ports. Terminal Island, a zone of concentrated ontainer activity in the port complex, shown in the port map on p. xxiii, ccounts for about 55 percent of the twin ports' trade, and it could easily e isolated by destroying three highway bridges and one rail bridge. We ssume four simultaneous conventional bomb attacks on these bridges of size sufficient to destroy them. We then estimate the potential conomic losses associated with the closure of Terminal Island.

One major difficulty with this approach is estimating a reasonable back to business" recovery period. At the low end, one or more friction ile bridges could be built within three or four months. Such bridges ave their own problems, however: They would be close to sea level and uilt on caissons embedded into the seabed and so would probably nterfere with shipping lanes. A bridge would also have to be built for rains carrying containers to and from Terminal Island—a project that vould create a different set of problems.

At the other end of the timeline, two years would permit the total ebuilding of the bridges on their original scale, but even this would be ptimistic given institutional rather than reconstruction constraints. ecause the model is linear, any chosen time period could easily be djusted and, below, we suggest how the problems created by linearity night be addressed. As we will show, the one-year economic cost is $45 illion, split about two-thirds outside the region and one–third within. The range of effects is between $15 billion and $90 billion. Although stimating how long it would take to reopen Terminal Island and with vhat level (and degree of permanence) of infrastructure access is omewhat speculative, there is no doubt that a simultaneous four-bridge ttack would be a significant and costly event that would fully merit ubstantial resource expenditures to prevent. Similarly, if an attack were o occur, there would be substantial cost savings derived from efforts to ccelerate the reopening date.

The Los Angeles and Long Beach Ports

The Los Angeles/Long Beach ports' role in the local and national economy is widely recognized. The port complex stands in a metropolitan region of more than 16.4 million people with a labor force of almost 7.5 million and a median annual household income of $46,000; the twin ports account for 111 million tons of seaborne trade each year and constitute the fifth-largest port complex in the world after Hong Kong, Singapore, Shanghai, and Shenzhen. Directly and indirectly, the ports employ 600,000 workers, accounting for more than 7 percent of the region's labor force. In terms of containerized traffic passing through, the two ports rank first and second nationally.

To put this in perspective, their combined import and export trade flow of $250 billion in 2004 is equivalent to about 30 percent of the greater Los Angeles gross regional product. Reflecting trends in the national economy, imports are about five times larger than exports. About one-half of the imports and two-thirds of the exports are to and from areas beyond the Los Angeles region. The ports fill a national more than regional function. The loss of transshipment capabilities at these sites would have profound effects both locally and nationally.

Any major disruption of port activities would have effects beyond the disruption of international trade flows, the short-term inability of consumers to buy imported goods, or deferred export sales by producers. The supply chains for imported raw materials and intermediate inputs would also be disconnected, thus reducing the productive capacity of firms both inside and outside the region. The problem would be exacerbated by low inventories associated with a widespread shift to the usually more efficient just-in-time inventory system.

We assume that both export and import flows currently using local seaport facilities would terminate for as long as the ports were out of service. We have not yet modeled port diversion but may do so in future research, probably beginning with a survey of fleet operators. Some observers have suggested focusing on the experience provided by the West Coast lockout of 2002, when ships bound for Los Angeles–Long Beach diverted to other ports, but this incident is of limited relevance because the closure was widely anticipated and the loss estimates suggested at the time ($1 billion each day) were wildly inaccurate. This figure was cited widely in many media outlets, but the original source for it remains unknown. However, this figure is about three-and-a-half times our upper-bound estimate of the cost of a closure of Terminal Island—even after accounting for multiplier effects. During the 2002 port closure, some carriers substituted access to the Gulf Coast for service at local ports. Container flows through the Panama Canal also increased. But this would not be a viable alternative for a terrorist attack scenario, because approximately half of all Pacific cargo ships are of post-Panamax design, meaning that they are too large to fit through the Panama Canal. Other Pacific ports do not have the draft, or depth of channel, or enough cranes to absorb the current traffic moving through the ports of Los Angeles and Long Beach. The extent and duration of diversions resulting from the unscheduled closure of local ports remain difficult to predict. Although larger ships, capable of carrying more than 8,000 20-foot equivalent units (TEUs) of containers have been put into service, their only alternative West Coast destination is Seattle-Tacoma.

Although the 2002 experience might not be the best example, port diversion remains one of many mitigation strategies that might be adopted to alleviate the effects of bomb attacks on the twin ports. Such mitigation measures imply that our estimates of economic effects are probably upper bounds. Some others are discussed below.

The Southern California Planning Model

Interindustry models based on the transaction flows between intermediate suppliers and end producers are widely used to measure regional economic effects. They trace all economic effects, including those of intra- and interregional shipments, usually at a high level of sectoral disaggregation. They are demand-driven and account for losses primarily via backward and forward linkages between economic sectors.

The input-output model component in this study is built on the Minnesota Planning Group's well-known IMPLAN model, which has a high degree of sectoral disaggregation (509 sectors), aggregated to 17 sectors for small-scale area effects.[3] The second basic model component

[3] IMPLAN is an acronym for Impact Analysis for Planning.

(which is spatial) allocates sectoral effects across 1,527 geographic zones throughout Southern California (encompassing the greater Southern California five-county region, including Los Angeles, Orange, Riverside, San Bernardino, and Ventura Counties). The key aspect of the model is the spatial allocation of indirect and induced effects generated by the input-output model. The direct effects consist of the final demand changes at the source of the attack (in this case, at the ports), the indirect effects trace the interindustry linkages with other sectors, either forward or backward (locally, regionally, nationally, and internationally), and the induced effects measure the secondary consumption effects associated with the reduced spending of workers in both the direct and indirect sectors. To estimate the latter, we use a journey-to-work matrix that shows all the commuting flows between residential zones and workplace zones to trace wages earned back to the home and then a journey-to-services matrix to trace retail and personal service purchases from the home to retail and service establishments. The journey-to-services matrix includes any trip associated with a home-based transaction other than the sale of labor to an employer. This includes retail trips and other transaction trips but excludes non-transaction-based trips such as those to visit friends and relatives. Data for the journey-to-services matrix include all trips classified by the Southern California Association of Governments (SCAG) as home-to-shop trips and a subset of the trips classified as home-to-other and other-to-other trips.

The current version of the Southern California Planning Model endogenizes traffic flows. It uses Traffic Analysis Zones (TAZs), which are very small geographical units appropriate for measuring traffic flows from one node to another. This extension is important, because many types of terrorist attacks are likely to induce changes in supply, including infrastructure capacity losses that will contribute to reductions in network-level service and to increases in travel delays. These delays and potential infrastructure damages are not negligible, but they are overwhelmed by the general effects of business interruption.

When traffic flows are endogenous, any change in economic activity that affects the travel behavior of individuals or the movement of freight will influence how the transportation network is used, and these effects will work themselves out as a change from one network equilibrium to another. In an earlier paper, we accounted for the simultaneous losses of highway bridges and shipping facilities.[4] The scenario examined in this chapter is more focused and isolates Terminal Island via bridge losses. The model can estimate losses from concurrent attacks against shipping, infrastructure, and productive capacity.

Treating the transportation network explicitly endogenizes the otherwise exogenous travel behavior of households and intraregional freight flows, achieving consistency across network costs and origin-destination requirements. The model makes explicit distance decay (the decline in the number of trips with increasing distance) and congestion functions (the buildup of traffic congestion and delay costs as particular routes attract more traffic when other parts of the network are disrupted).

This allows us to determine the geographic location of indirect and induced economic losses by endogenizing route and destination choice. It also enables us to more accurately allocate indirect and induced economic losses over TAZs in response to port-related direct losses in trade, employment, and transportation accessibility.[5]

Radiological Bomb Attack Simulations

In previous research, we explored the effects of simultaneous radiological bomb attacks on the twin ports of Los Angeles and Long Beach. These could be either brought in by container or planted very close to the port perimeter, assuming that the terrorists have access to suitable radioactive material within the United States.

The extent of the disruption would depend on the size of the bombs. In our previous research, we assumed an explosion of two small radiological dispersal devices (RDDs), each containing five pounds of high explosive, more or less simultaneously at the two ports. We estimated blast damage to be modest, with deaths and serious injuries occurring only within a range of about 15 meters and with very limited damage to physical infrastructure. The evacuation zone would include all areas with exposure of greater than 1 REM (roentgen equivalent

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[4]Gordon et al. (2005a).

[5]See Cho et al. (2001) for a detailed summary of an earlier version of this model.

man), probably within a range of five to 10 square kilometers, depending on weather conditions such as wind speed, wind direction, and precipitation. In a subsequent study, we are attempting to measure "plume effects" in terms of household disruption, business losses, and decline in real estate values. The numbers are very speculative, but our best estimate is a $4 billion loss in output and a decline of nearly 42,600 person-years of employment. Such an attack would require the closure of both ports for health rather than security reasons. The early phase of radiation exposure lasts about four days, according to Environmental Protection Agency (EPA) guidelines; the time frame for intermediate and later phases is variable and subjective and can be measured in weeks, months, and even years. When the ports might reopen would be a policy rather than a technical decision.

In the previous RDD scenario, we estimated that the closure of the Los Angeles and Long Beach ports for 15 to 120 days (for the latter case we combined the radiological bomb attacks with conventional bombs blowing up three key access bridges and overpasses) could cost the U.S. economy up to $34 billion—or more than 212,000 person-years of employment. Tables 3.1a and 3.1b show aggregate results and county-level detail. The model also provides economic results in much greater spatial detail, to the level of census tracts or traffic analysis zones if required.

We will not report in detail on the results shown in Tables 3.1a and 3.1b, because these are discussed at length elsewhere.[6] Nevertheless, a few comments are appropriate. These two widely different scenarios result in a wide range of economic effects—from $4.3 billion of lost output and 26,500 person-years of employment at the low end, to $34.1 billion of lost output and 212,200 person-years at the high end. Table 3.1a illustrates a minimum impact scenario, with the ports reopened quickly after 15 days—a policy decision, not a technical one, that would involve some degree of political risk. Table 3.1b combines the radiological bomb attack with the destruction of freeway access bridges and overpasses. Extrapolating from the accelerated rebuilding of a Santa

[6]Gordon et al. (2005a).

Table 3.1a

Output and Employment Losses from a 15-Day Closure of the Ports of Los Angeles and Long Beach

	Output ($ Millions)				Jobs (Person-Years)			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
City of Los Angeles	264	94	65	423	1,186	724	729	2,639
City of Long Beach	69	12	7	88	502	80	75	657
Los Angeles County	657	220	157	1,034	3,091	1,654	1,768	6,513
Orange County	156	62	45	262	688	480	501	1,669
Ventura County	43	18	12	73	182	121	131	435
Riverside County	37	14	13	64	163	111	147	421
San Bernardino County	53	20	16	89	230	152	186	568
Sum of five counties	946	334	243	1,522	4,354	2,519	2,733	9,606
Out of region	1,782	515	440	2,736	8,050	3,907	4,957	16,914
Total	2,728	849	683	4,259	12,404	6,427	7,690	26,521

NOTE: Columns and rows may not sum to totals because of rounding.

Table 3.1b

Output and Employment Losses from a 120-Day Closure of the Ports of Los Angeles and Long Beach

	Output ($ Millions)				Jobs (Person-Years)			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
City of Los Angeles	2,113	753	520	3,385	9,492	5,788	5,831	21,111
City of Long Beach	554	93	53	700	4,008	640	601	5,249
Los Angeles County	5,252	1,759	1,260	8,271	24,722	13,233	14,142	52,097
Orange County	1,247	496	357	2,100	5,502	3,841	4,009	13,352
Ventura County	345	143	93	581	1,459	971	1,052	3,482
Riverside County	296	115	102	513	1,306	890	1,175	3,371
San Bernardino County	424	161	129	715	1,842	1,218	1,487	4,548
Sum of five counties	7,564	2,674	1,941	12,179	34,831	20,154	21,865	76,850
Out of region	14,256	4,116	3,520	21,892	64,401	31,259	39,655	135,316
Total	21,820	6,791	5,461	34,071	99,232	51,413	61,520	212,165

NOTE: Columns and rows may not sum to totals because of rounding.

Monica Freeway overpass after the Northridge earthquake in 1994, it would take a minimum of 120 days to restore full access to the ports.

As for how losses are broken down geographically, we will defer that discussion until we examine the Terminal Island attack scenario, outlined below.

These earlier results are primarily presented for comparison with the Terminal Island scenario. Both are significant events. Our assessment, however, is that a Terminal Island attack would be much easier to carry out, and (under certain assumptions about the length of disruption) might be more devastating in terms of economic effects. However, it would not inflict the potentially more serious psychological damage associated with a more general radiological bomb attack on the port complex.

The 120-day estimates were based on scenarios in our earlier research that involve destruction of various access bridges, which significantly multiplies the downtime of the ports. The ports could reopen earlier and shippers could resort to congested surface streets but at a substantial efficiency cost. Thus, an additional $90 million dollars in transportation network delay costs are incurred in the 120-day scenario. This scenario includes a loss of network capacity in this period because of bridge damage and a reduction in transportation demand because of the ports' closure. The model estimates the associated changes in network flows and costs (Table 3.2). The results appear quite modest when expressed in percentage terms, but the absolute dollar amounts are far from negligible. Although the Terminal Island scenario is measured over a longer period, its proportionate effect is less than that of a radiological bomb attack, because the transportation network consequences are much more geographically constrained.

Terminal Island Attack Simulation

Researchers at the University of Southern California Center for Research and Economic Analysis of Terrorism Events (CREATE) have developed several approaches to the formation of plausible terrorist attack scenarios, such as the radiological bomb scenario. Our models make it possible to estimate the economic effects of these scenarios.

Table 3.2

Change in Transportation Network Delay Costs for Multiple Impact Scenarios

	$ Millions			Percent Change[a]		
	Freight Travel Costs[b]	Personal Travel Cost[c]	Total Costs	Freight Travel Costs	Personal Travel Cost	Total Costs
15-day radiological scenario	–25	–24	–49	–2.39	–0.49	–0.81
120-day radiological scenario	–117	207	90	–1.42	0.52	0.19
Terminal Island scenario—one year	–338	395	58	–1.34	0.32	0.04

NOTES: The table shows changes in the monetary value of transportation flows resulting from several different scenarios. These values can change as a result of less capacity on the transportation network, raising costs, and fewer trips on the network, lowering costs. The 15-day radiological scenario is a 15-day halt at the port complex because of an RDD attack. The 120-day radiological scenario is a 120-day halt at the port complex because of an RDD attack and closure of roads into the port complex. The Terminal Island scenario—one year involves the destruction of three road bridges and one railroad bridge into Terminal Island and a one-year closure of only that part of the port complex. Total cost values may not sum to totals because of rounding.

[a]Percentage changes are changes from what would be experienced under normal operating conditions. For example, the percentage change in freight travel costs for the 15-day radiological scenario is the percentage difference over a period of 15 days under normal conditions.

[b]Freight trip cost is assumed to be $35.00 per passenger car equivalent (PCE) per hour.

[c]Personal trip cost is assumed to be $13.00 per PCE per hour.

Because our previous work determined that many of the ports' vulnerabilities arise from restricted highway access to most of the docks, we decided to further study the implications of bridge attacks intended to isolate all or part of the port complex. In particular, freight going to and from Terminal Island now accounts for a significant portion of combined port activities. Port authorities were unable to provide exact figures (primarily because of the reluctance of each highly competitive port to release data that would be available to the other), but the best estimate is 55 percent of total trade dollars.

The Terminal Island docks are accessed by three major highway bridges—the Vincent Thomas Bridge, the Gerald Desmond Bridge, and the Commodore Schuyler F. Heim Lift Bridge—and, parallel to the Heim Bridge, by a rail bridge (Badger Bridge), which handles 21 percent of Terminal Island trade (Table 3.3; see also the port map, p. xxiii). These bridges are all high enough to permit ship traffic in the waters between the coast and Terminal Island. The Desmond Bridge, for example, is 250 feet above the water, although some experts consider that it is still too low to facilitate problem-free movement.

Our current simulations revealed that an attack making these bridges inaccessible for 12 months would create economic losses of almost $45 billion per year, accounting for job losses of nearly 280,000 person-years.

As shown by the data in Table 3.4, the overall output multiplier—or total economic activity changes generated by initial changes in economic activity—is 1.564 ($44.9 billion ÷ $28.7 billion) and the corresponding job multiplier—or total employment changes generated by initial changes in employment—is 2.142 (280,000 ÷ 130,700). The local multipliers have different values (the city of Long Beach local multiplier is only 1.40 whereas the Orange County multiplier is 2.41). But the local multipliers are difficult to interpret in economic terms because indirect and induced effects freely spill over administrative boundaries, and we believe that terrorist attack consequences must be evaluated more in regional and national than in local terms. Indirect effects are more

Table 3.3

Highway and Rail Access Bridges to Terminal Island

Bridge	City	Year Built	Span (feet)
Vincent Thomas Bridge	Los Angeles	1964	6,500
Gerald Desmond Bridge	Long Beach	1968	5,134
Commodore Schuyler F. Heim Lift Bridge	Long Beach	1946	3,976
Badger Rail Bridge	Long Beach	1997	3,976

Table 3.4

Output and Employment Losses from a One-Year Closure of Terminal Island

	Output ($ Millions)				Jobs (Person-Years)			
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total
City of Los Angeles	2,848	1,001	687	4,537	13,087	7,708	7,707	28,503
City of Long Beach	621	123	70	815	4,143	851	792	5,787
Los Angeles County	6,907	2,342	1,664	10,914	32,213	17,629	18,692	68,535
Orange County	1,663	660	472	2,796	7,371	5,118	5,302	17,791
Ventura County	462	189	123	774	1,961	1,290	1,390	4,641
Riverside County	393	152	134	680	1,744	1,185	1,546	4,475
San Bernardino County	563	214	170	949	2,460	1,621	1,963	6,044
Sum of five counties	9,990	3,559	2,565	16,115	45,749	26,842	28,894	101,485
Out of region	18,686	5,441	4,625	28,754	84,920	41,445	52,116	178,482
Total	28,677	9,001	7,190	44,869	130,669	68,288	81,010	279,967

NOTE: Columns and rows may not sum to totals because of rounding.

important than induced effects in terms of output but less important in terms of jobs. This is easily explained by the labor intensity of retail trade that dominates the induced effects, whereas the suppliers of intermediate inputs tend to be capital-intensive.

The geographic distribution of effects is also shown in Table 3.4. About 65 percent of both output and job effects are experienced outside the region. Of the regional effects, 68 percent occur within Los Angeles County. The effects in the other counties are not negligible, especially in Orange County, whose northern portions are relatively close to the ports. Not surprisingly, within Los Angeles County, about one-half of the effects occurred in the two port cities, overwhelmingly in Los Angeles rather than in Long Beach. This was due in part because Los Angeles's large size captured high shares of the indirect (intermediate linkage) and induced (secondary consumption) effects and in part because the bulk of the facilities on Terminal Island are owned by the Port of Los Angeles, not the Port of Long Beach.

Figure 3.1 maps detailed spatial employment loss results for the region under the Terminal Island scenario. The map shows the absolute number of job losses in each TAZ throughout the region. The darker the shade, the larger the job loss. Note that job losses are not clustered around the ports but instead are widely dispersed throughout the region, because trade flow interruptions have more than highly localized effects. Unlike other applications of the model, the regional and national implications are probably more important than the local effects in this case. The fact that effects are so widely dispersed could be helpful for local governments seeking to show that they too should participate in any federal budget allocations that emphasize port security.

Table 3.2 compared changes in transportation costs across all three types of scenarios—the baseline scenarios, the RDD scenarios, and the Terminal Island scenario. In the case of the Terminal Island scenario, network costs increase by $58 million per year (obtained by subtracting the baseline one-year effect from the Terminal Island one-year effect). This represents only a 0.04 percent increase in travel delays. There would be substantial reductions in freight travel costs because many port-related trucks are not on the road, but these would be offset by increased personal travel delays attributable to the absence of the Vincent Thomas Bridge linking harbor-area cities to Long Beach. This $58 million value is lower than the increase in delay costs associated with the 120-day RDD scenario because the Terminal Island scenario represents only a partial elimination of port capacity. These are delay costs only and do not include estimates of bridge repair costs.

It is difficult to determine how quickly access to Terminal Island could be restored. Our approach can be used to approximate the benefits of repairs faster than the normal two years, including the installation of temporary facilities. High-capacity temporary bridges might be constructed relatively quickly, but their design would place them close to the water, blocking ship traffic in the channels.

Table 3.5 scales the total losses for the Terminal Island scenario by six-month increments up to two years. The annual loss is equivalent to about 6 percent of gross regional product and about 3.7 percent of regional jobs. Also, as mentioned above, 64 to 65 percent of these losses occur in the rest of the United States, not within the region. The

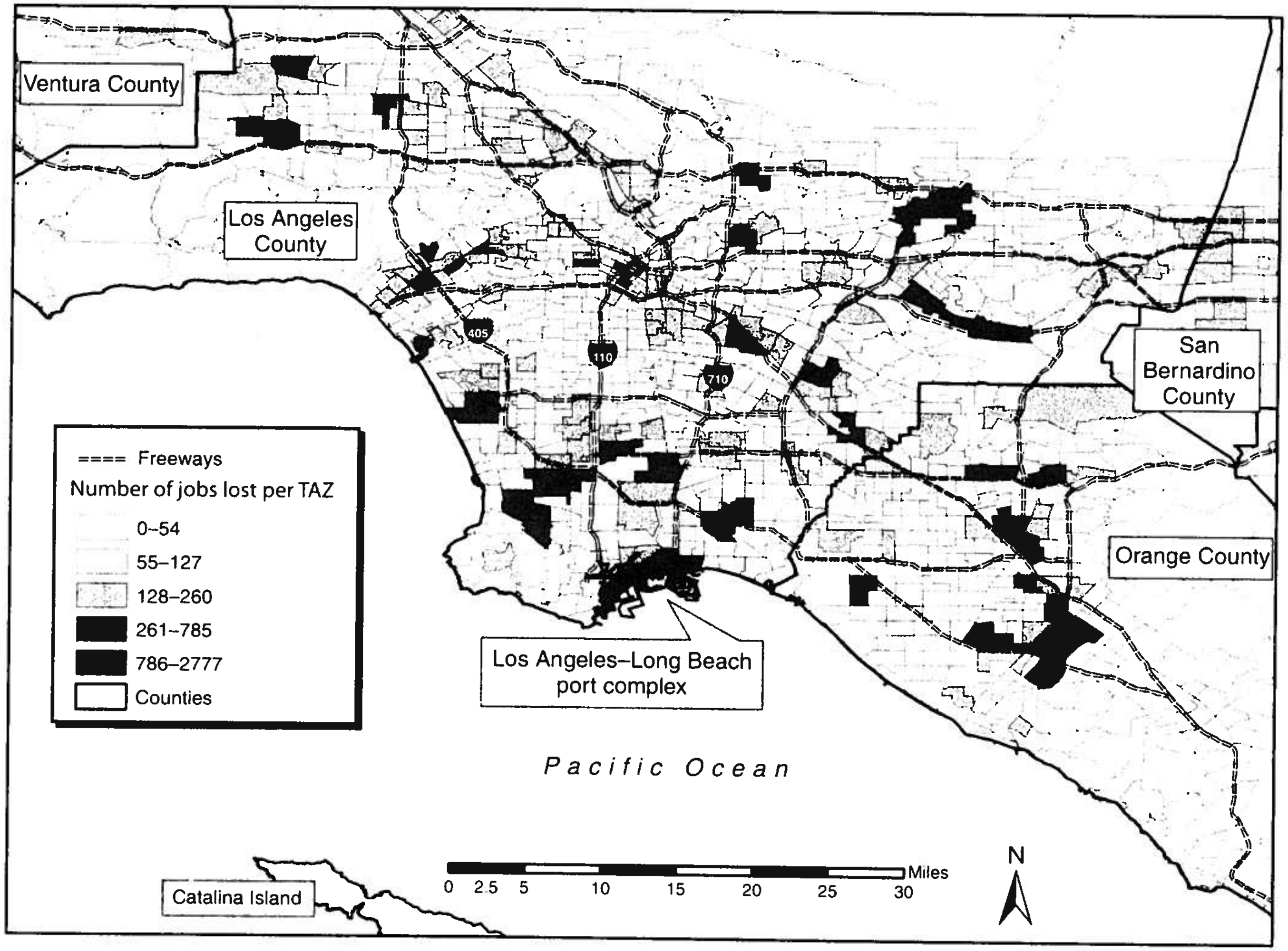

Figure 3.1—Spatial Distribution of Job Losses from a One-Year Closure of Terminal Island

Table 3.5

Total Output and Highway Network Losses for Alternative Bridge Reconstruction Periods

Length of Bridge Loss	Output Loss ($ Millions)	Network Loss ($ Millions)	Total Loss ($ Millions)
24 months	89,700	115.8	89,900
18 months	67,300	86.9	67,400
12 months	44,900	57.9	44,900
6 months	22,400	29.9	22,500

NOTE: Rows may not sum to totals because of rounding.

benefits of accelerated repairs are approximated by the differences between Row 1 of Table 3.5 and the row corresponding to the actual repair period. The differences are quite large. The implications are obvious: It is highly cost-effective to analyze emergency bridge reconstruction options and put into place plans for the protection of the Terminal Island access routes or their speedy replacement.

The San Francisco–Oakland Bay Bridge carries 275,000 passenger car equivalents each day, approximating the scale of the Vincent Thomas Bridge. The California Department of Transportation estimates the costs of the Bay Bridge replacement span at more than $6 billion. The other bridges now serving Terminal Island are comparatively smaller and would be cheaper to replace. Assuming a $12 billion total reconstruction cost for all bridges is conservative but plausible. It is unknown to what extent these costs might rise if construction were accelerated. Accepting the linearity assumptions associated with our alternative loss estimates, accelerating access to all three bridges would have an economic benefit of $3.75 billion per month.

Planning now to protect these facilities or for reconstruction or rapid temporary replacement of these critical bridges requires little, if any, deliberation. The costs of accelerated repairs to the Santa Monica Freeway bridges following the Northridge earthquake were easily justified. Our modeling approach makes it possible to be specific ex ante about the efficiency gains of accelerated repairs.

Qualifications and Comparisons

Standard objections to the use of models of this type are the linearity assumptions and the treatment of consequences as a single event. Proponents of these counterarguments contend that costs are likely to follow a non-linear path, perhaps rising incrementally after a few days (see Stephen S. Cohen, Chapter 4), then falling over time as behavioral adjustments are made. Although in the presentation of results we posit finite closures followed by full-scale reopening, the model can be adapted to non-linear time paths by decomposing the time frame into a set of linear phases of different dimensions that, when combined, simulate a non-linear path. Indeed, in a study of terrorist attacks on American theme parks, we used the model in non-linear fashion with periods of closure, followed by operation at a low capacity, and then a gradual return to pre-attack levels of activity over an 18-month period.[7]

As yet, there is considerable uncertainty about the length of time that Terminal Island might be unavailable. The two-year estimate, with its $90 billion of economic losses, might be an overestimate for several reasons. Although there may be some potential for diversion of ships to other ports, especially in the longer run, the evidence suggests that this is a limited option, primarily because of the restricted ability of other West Coast ports (except for Seattle-Tacoma) to accommodate the new container ships that account for an increasing proportion of total trade.

The construction of temporary bridges on grounded pillars would certainly accelerate truck access to Terminal Island, probably to within a three- to four-month range, but a temporary rail bridge would be more problematic. Overall, the costs in terms of disruption to the shipping lanes are difficult to determine and remain an issue for further study.

The database for the model dates from 2001, primarily dictated by the lag in U.S. Commodity Flow Survey (CFS) data. Because there has been a significant growth in trade since then, economic effects using an updated model with 2004–2005 data would be even larger than those derived here.

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[7]Gordon et al. (2005b).

Another objection is that the methodology ignores the fine details of supply chain logistics. This study is about modeling economic effects. Certainly, the supply logistics consequences of a terrorist attack on the ports—such as the extent to which port activities could be switched to still operational parts of the complex; the effects on domestic rail and truck operations; the consequences for importers in terms of lost sales, increased inventory costs, and use of storage space capacity and for trading partner economies; and the scope for trade diversion—are not fully accounted for, except to the extent that they are picked up in indirect effects in the input-output model. These supply chain implications would probably mandate behavioral adjustments that would mitigate the effects of an attack, either by post-event responses or ex ante preparations. Thus, their inclusion would not impair the overall argument that we are presenting upper-bound estimates.

Giving attention to one of these issues, to what extent could the remaining port facilities in the Los Angeles–Long Beach complex compensate for the loss of Terminal Island? Although it must be possible to increase throughput to some degree, our assessment is that the scope would be limited. The major constraint is the limited number of shipping berths. In recent years, trade has been expanding much faster than port capacity; this explains the relentless drive for port expansion. Another problem is the extent to which the unions would resist a move to 24-hour, seven-day-a-week operation. We believe that a successful terrorist attack on the scale envisaged would overcome the traditional resistance of the International Longshore and Warehouse Union (ILWU) to this change, but this is not assured. Yet another option is for the president to declare a state of emergency and order the National Guard or other military resources into the ports to accelerate freight flow through the remaining terminals.

The scale of potential economic damages suggests that there would be high societal returns from prevention and protection strategies. We have no knowledge of what is currently in place or what technological or personnel opportunities for prevention and protection now exist. Yet, given the span of these bridges, it is difficult to conceive that it would be possible to prevent an 18-wheeler loaded with conventional bombs from driving to the middle of a bridge, parking, and immediately detonating.

The more interesting logistical question is whether three such trucks could be exploded simultaneously (plus whatever is needed to take the rail bridge out) without intervening mishaps in terms of timing. If some access remained after the attack, the loss estimates produced in this chapter would be too high.

A further question is whether the bridges would be totally destroyed. It is impossible to predict this in advance. Damage to a segment of the span that kept the rest of the bridge in place would obviously be faster and cheaper to restore. Consultation on this issue with bridge engineers and bomb experts would be needed to attempt to answer this question. Given our argument that speed of restoration is the key to minimizing economic losses, this is a critical question.

An economic analysis of hypothetical terrorist attacks is difficult. Our approach is to consider vulnerabilities that might be seen as attractive to potential attackers. Terminal Island's large share of U.S. foreign trade and its few connections to the mainland are examples.

This approach is distinct from an approach based on the history of port closure effects caused by organized shutdowns by labor unions. These are always anticipated, giving all the parties time to make substitute arrangements and, thereby, dampen any adverse economic effects. As a result, we believe that past labor strikes have but limited value in predicting the outcomes from a terrorist attack.

Second, labor-related port closures may be inappropriate for comparison to a radiological attack. If the attack were radiological rather than conventional, the length of the closure would be a political decision and therefore of unknown duration. At some stage, the government could decide to bring in the military with protective clothing, but when that might happen is unknown and problematic.

Third, in the Terminal Island case, 55 percent of the output would be down for a significant period without the construction of temporary bridges. Such bridges would result in some access, but we have little idea about the consequential effects. Our results, always conservative, assume that the shipping lane problem from the temporary bridges would not interfere with subsequent trade.

Finally, it could be argued that the effects of a terrorist strike on Terminal Island would simply delay economic activity rather than eliminate it. We believe that production and consumption delayed is not the equivalent of production and consumption denied. But even delays of production and consumption can result in significant transactions costs.

Conclusions

This chapter has demonstrated that a relatively simple terrorist attack (simultaneously blowing up three bridges plus a related rail bridge accessing Terminal Island at the Los Angeles–Long Beach port complex) could inflict massive damage to both the Southern California and the national economy. The extent of such damage depends on the length of the interruption in shipping activity, which in turn would depend on policy decisions regarding the pace of rebuilding: quick fixes such as temporary bridges or permanent bridge reconstruction. A benchmark annual estimate is $45 billion of output losses and 280,000 person-years of employment. These estimates can be scaled up or down according to the best "guesstimate" of the length of interruption. Also, our estimates are upper-bounded, and we have mentioned several mitigating interventions that might lower these losses. Regardless of the extent of these interventions, one clear implication is the high payoff of protection and prevention strategies (for example, what would be the full economic costs of inspecting every vehicle accessing the bridges?). Our research also suggests a substantial benefit, in the event of a successful attack, of ex ante prepared strategies to accelerate restoration.

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