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THE ECONOMIC IMPACTS OF TERRORIST ATTACKS ON THE TWIN PORTS OF LOS ANGELES-LONG BEACH

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Abstract

This presentation sums up some of the recent research by the USC group on the economic impacts of terrorist attacks on the twin ports of Los Angeles-Long Beach. The research considers two types of attack - radiological bombs in the ports, and conventional bombs to blow up access freeway bridges - either together or in isolation. The analysis uses the Southern California Planning Model (SCPM), a 3,000+ zone input-output model of the five-county Southern Californian region with an endogenous transportation network. The research measures the business interruption losses associated with alternative scenarios that vary with port closure periods, bridge reconstruction and the duration of radiation plume evacuations. These losses could range up to $35 billion, of which about two-thirds are intraregional.

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Introduction

The purpose of this paper is to evaluate the economic impacts of terrorist attacks on the twin ports of Los Angeles and Long Beach. The first option we explore is a simultaneous but small radiological bomb attack on both ports combined with a conventional bomb attack on the three main access freeway overpasses. We report the results for a 120-day shutdown (although in practice there might be some operation via the Alameda Corridor rail link and via trucks on the few, highly congested surface streets). These results are based on a very spatially disaggregated regional input-output model (SCPM [the Southern California Planning Model] with more than 3,000 zones) to which we have added a highway network. The out-of-region impacts are calculated by a multiregional input output model for 50 States, Washington, DC, and the "Rest of the World (NIEMO [the National Interstate Economic Model]). There would also be a radioactive plume over a wide area. This would result in business disruption and a decline in property values. The extent of these effects is very speculative, but we examine one scenario. A quite different alternative attack would be to cut off Terminal Island, which has the more modern port terminals and accounts for about 55 percent of the twin ports trade. This would require conventional bomb attacks on three road bridges and one rail bridge. Construction of temporary bridges might take 3-4 months; the replacement of permanent bridges might take more than two years. We report a one-year closure; because of the model's linear character, these results could be scaled upwards or downwards according to scenario assumptions.

The Los Angeles and Long Beach Ports

The Los Angeles/Long Beach ports' role in the local and national economy is widely recognized. In a metropolitan region of more than 16.4 million people with a labor force of almost 7.5 million and a median household income of $46,000, the twin ports account for 111 million tons of seaborne trade, and are the fifth largest port complex in the world after Hong Kong, Singapore, Shanghai and Shenzen. Directly and indirectly, the ports employ 600,000 workers, accounting for more than seven percent of the region's labor force. In terms of containerized traffic, the two ports rank first and second nationally. To put this in perspective, their combined import and export trade flows of $300 billion (2004 data) 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 outside the region. In other words, the ports fulfill a national function, even more than a regional function. Thus, the Port of Los Angeles and the Port of Long Beach are of central importance to both the national and regional economies, and the loss of transshipment capabilities at these sites would have profound impacts both locally and nationally.

The ports are so critical because any major disruption of port activities is not merely that international trade flows are reduced. This is important because although international air freight is growing rapidly in dollar terms, the high weight items still have to be shipped by sea. However, the impacts are much wider than a short-term deprivation of imported purchases by consumers or deferred export sales by producers. The supply chains for imported raw materials and intermediate inputs are disconnected and, as a result, the productive capacity of firms both inside and outside the region is reduced (a problem accentuated 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 strike of 2002, but it is of limited relevance because the closure was widely anticipated and the loss estimates suggested at the time (a billion dollars per day) were wildly inaccurate. This number was quoted widely in many newspapers and other media outlets, but the original source remains elusive. However, this is about three-and-a-half times our upper-bound estimate (even after accounting for multiplier effects). During the strike, some carriers substituted access to the Gulf coast for service at local ports. There was also an increase in container flows through the Panama Canal. However, approximately 50 percent of all Pacific cargo ships are of post-Panamax design, and other Pacific ports do not have the draft (e.g. Oakland and Portland) or cranes sufficient 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 more than 8,000 TEU (twenty-ton-equivalent) ships have been put into service, their only West Coast destination, in addition to Los Angeles-Long Beach, is Seattle-Tacoma.

Port diversion is only one of many strategies that might be adopted to alleviate the effects of bomb attacks on the twin ports. The possibility of mitigations implies that our estimates of economic impacts are probably upper-bounded.

The Models

a. The Southern California Planning Model (SCPM)

Interindustry models, based upon the transactions flows between intermediate suppliers and end producers, are widely used to measure regional economic impacts. They trace all economic impacts, 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 upon the Minnesota Planning Group's well-known IMPLAN model, which has a high degree of sectoral disaggregation (509 sectors), originally aggregated to 17 sectors (now 47 so-called USC sectors) for small-scale area impacts. The second basic model component (which is spatial) allocates sectoral impacts across more than 3,000 geographic zones (often aggregated to 308 primarily political jurisdictions throughout Southern California (the five-county region). The key aspect of the model is to allocate the indirect and induced impacts generated by the input-output model spatially. The direct impacts 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 forwards or backwards (locally, regionally, nationally and internationally); and the induced effects measure the secondary consumption impacts 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 we use 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 trips 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 versions of SCPM 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 attack are likely to induce changes in supply, including infrastructure capacity losses that will contribute to reductions in network level service and increases in travel delays. These delays and potential infrastructure damage are not negligible, but they are swamped by the general business interruption impacts.

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 impacts will work themselves out as a change from one network equilibrium to another. The model has the capability to 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 (i.e. the decline in the number of trips with increasing distance) and congestion functions (the build-up of traffic congestion and delay costs as particular routes attract more traffic as other parts of the network are disrupted).

This allows us to determine the geographical location of indirect and induced economic losses by endogenizing route and destination choice. This also enables us to allocate indirect and induced economic losses over TAZs in response to port-related direct losses in trade, employment and transportation accessibility more accurately (see Cho *et al*.,2001, for a detailed summary of an earlier version of this model). A flow chart of the model is shown in Appendix Figure 1.

b. NIEMO (the National Interstate Economic Model)

In pursuing our research goals, the choice of approaches involved difficult trade-offs. The use of linear economic models is justified by various factors, including the richness of the detailed results made possible at relatively low cost. NIEMO, for example, includes approximately 6-million multipliers. The principal insight that drives our research is that, with some effort, it is possible to integrate data from MIG, Inc.'s IMPLAN state-level input-output (IO) models with commodity flow data from the Department of Transportation's Commodity Flow Survey and various related sources, making it possible to build an operational multi-regional input-output model. The drive behind the development of NIEMO was two-fold: to assess the interstate impacts of events analyzed with our regional model (SCPM); and to allow us to extend the range of problems that we could be studied to the national level, such our examination of attacks on theme parks in 14 States or the simultaneous spread of foot-and-mouth disease in the principal livestock States.

In the sections that follow, we describe the steps involved in making these various data sources compatible, integrating them to build NIEMO and applying it to the problem at hand.

Background to Multiregional IO Construction

Many economists and planners are interested in evaluating the socioeconomic impacts of various disruptions. Occasionally, they use geographically detailed input-output (IO) models. Isard demonstrated in 1951 that traditional (national) IO models are inadequate because they cannot capture the effects of linkages and interactions between regions. To examine the full (short-term) impacts of unexpected events, such as terrorist attacks or natural disasters, on the U.S. economy, the economic links between states should be considered. Multiregional input output models (MRIOs) include interregional trade tables and avoid some of the ecological fallacies associated with aggregation (Robison, 1950). Building an operational MRIO for all the states of the U.S., however, requires highly detailed interstate shipments data.

Although Chenery (1953) and Moses (1955) had formulated relatively simplified MRIO framework in response to the earlier discussions by Isard (1951), data problems persisted and have stymied most applications. The non-existence or rarity of useful interregional trade data is the most problematic issue.. Intraregional and interregional data must be comparable and compatible, yet the currently available shipments data between states are only sporadically available and difficult to use.

It is not surprising, then, that few MRIO models have been constructed or widely used. The best known are the 1963 U.S. data sets for 51 regions and 79 sectors published in Polenske (1980) and the 1977 U.S. data sets for 51 regions and 120 sectors released by Jack Faucett Associates (1983), then updated by various Boston College researchers and reported in 1988 (Miller and Shao, 1990).

More recently, there have been two attempts to estimate interregional trade flows using data from the 1997 Commodity Flow Survey (CFS). The U.S. Commodity Transportation Survey Data on inter-regional trade flows have been available since 1977 but reporting was discontinued for some years. For the years since 1993, this data deficit can be met to some extent with the recent (CFS) data from the Bureau of Transportation Statistics (BTS), but these data are incomplete with respect to interstate flows. Based on the currently available CFS data, Jackson *et al*. (2004) used IMPLAN data (from the Minnesota Implan Group) to adjust the incomplete CFS reports by adopting gravity models constrained via distance and by making various other adjustments.

Along similar lines and using the same basic data sources, we elaborate Park *et al.* (2004), who suggested a different estimation approach that relied on an AFM (adjusted flow model) and a DFM (doubly-constrained Fratar model). To proceed in this way, it was first necessary to create conversion tables to reconcile the CFS and IMPLAN sectors.

Data

The primary requirements for building an interstate model for the U.S. of the Chenery-Moses type are two sets of data, regional coefficients tables and trade coefficients tables (Miller and Blair, 1985). Models of this type can be used to estimate inter-state industrial effects as well as inter-industry impacts on each state, based mainly on the two data sources: regional IO tables that provide intra-regional industry coefficients for each state and interregional trade tables to provide analogous trade coefficients. This implies the creation of three types of matrices: an intraregional interindustry matrix, the interregional trade matrix, and the combined interregional, interindustry matrix (in other words, the NIEMO matrix). Before creating the matrices, however, the data reconciliation problem has to be addressed.

The main steps involved in building and testing NIEMO are shown in Figure 1 We developed a set of 47 industries (we call them the USC Sectors) into which many of the other classification systems can be converted. Figure 2 shows the state of our industrial code conversion matrix among the many data sources used in this study.

The detailed conversion processes occasionally involved case-by-case reconciliations. Inevitably, some conversions involved mapping one sector into more than one. The light-gray cells of Figure 2 represent one-to-one allocations. The dark-gray cells denote bridge allocations with plausible weights specified on a case-by-case basis.

Figure 1. NIEMO Modeling Steps

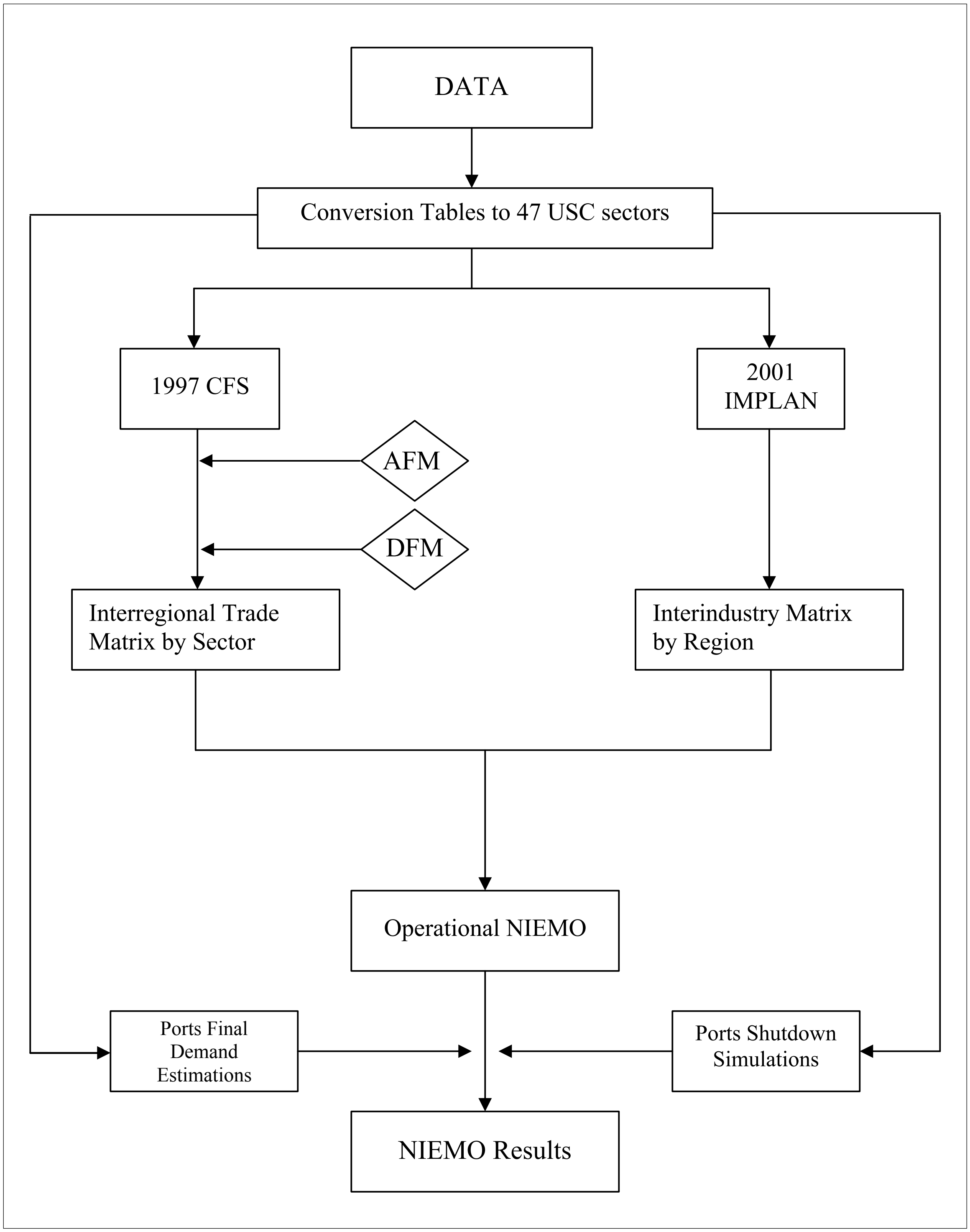


Figure 2. Industrial Code Conversions (current $)

CODE	USC	SCTG	BEA	NAICS	IMPLAN (2001)	SIC	HS	SITC	WCUS
USC		*C, E*	*C, E*	*C, E*	*C, E*	*C, W*	*C, E*	*C, W*	*C, W*
SCTG	*C, E*		*C, E*	*C, E*	*C, E*	*P*	*C, E*	*C, W*	*C, W*
BEA	*C, E*	*C, E*		*A*	*A*	*P*	*A*	*P*	*P*
NAICS	*C, E*	*C, E*	*A*		*A*	*C, W*	*C, E*	*P*	*P*
IMPLAN (2001)	*C, E*	*C, E*	*A*	*A*		*P*	*C, E*	*P*	*P*
SIC	*C, W*	*P*	*P*	*C, W*	*P*		*P*	*P*	*P*
HS	*C, E*	*C, E*	*A*	*C, E*	*C, E*	*P*		*C,W*	*C,W*
SITC	*C, W*	*C, W*	*P*	*P*	*P*	*P*	*C, W*		*C, E*
WCUS	*C, W*	*C, W*	*P*	*P*	*P*	*P*	*C, W*	*C, E*	

Notes
C: Created
A: Available from other sources
P: Possible to create
E: Bridge allocations evenly made, where necessary, without any weights
W: Bridge allocations made with plausible weights

Code Descriptions
USC: USC sectors newly created
SCTG : Standard Classification of Transported Goods (http://www.bts.gov/cfs/sctg/welcome.htm)
BEA: Bureau of Economic Analysis (http://www.bea.doc.gov)
NAICS : North American Industry Classification System (http://www.census.gov/epcd/www/naics.html)

IMPLAN: IMPLAN 509-sector codes
SIC : Standard Industrial Classification
(http://www.osha.gov/oshstats/sicser.html)
HS : Harmonized System
(http://www.statcan.ca/trade/htdocs/hsinfo.html)
SITC: Standard International Trade Classification available from WISERTrade
(http://www.wisertrade.org/home/index.jsp)
WCUS: Waterborne Commerce of the United States
(http://www.iwr.usace.army.mil/ndc/data/datacomm.htm)

Data for NIEMO Construction

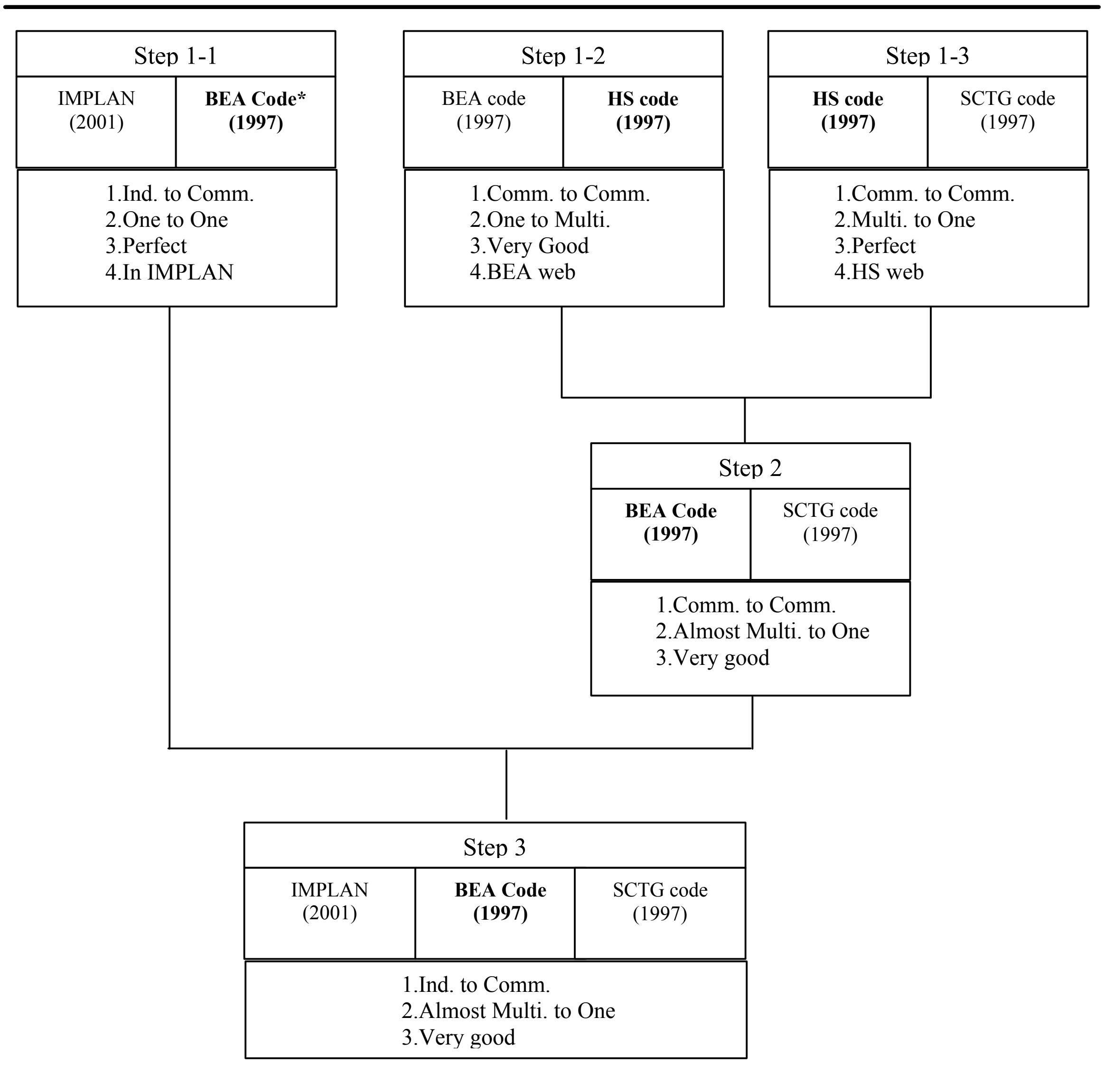
It is clear that the major problem in developing an inter-state interindustrial model stems from the fact that it is difficult to obtain data describing trade flows between the states (Lahr, 1993). Since 1993, however, CFS data have been used, in spite of the fact that there are still problems such as high sampling variability or disclosure of individual company status in the data. The existence of many unreported values has required relying on other data sources to approximate completeness. It is not surprising, therefore, that since the work by Polenske (1980) and Faucett Associates (1983), there has been no comprehensive inventory of MRIO flows.

The 1997 CFS reports trade flows between U.S. states for 43 SCTG sectors while the IMPLAN Total Commodity Output data file includes their 509 sector values, available for all states. CFS includes the movement of foreign imports in its data as domestic movements. This means that all commodities coming into a U.S. port are listed as *outbound from that port* and inbound to the next destination; likewise, all commodities going to a port from anywhere in the U.S. are outbound from the origin and inbound to the port. For these reasons, foreign imports in 2001 IMPLAN are added to the IMPLAN Total Commodity Output tally.

In the current application, the 1997 CFS data were used as a baseline and updated to 2001 year using 2001 IMPLAN data. The imminent release of 2002 CFS data, to be matched to 2002 IMPLAN data, will simplify this approach in the near future.

Differences between various industry classification systems from different data sources makes data reconciliation especially difficult in the absence of standardized and tested conversion bridge(s). The estimation of 2001 trade flows from 1997 CFS, therefore, required various intermediate conversion steps between the SCTG code system used in the 1997 CFS and the IMPLAN system of sectors, not always one-to-one matched pairs. Figure 3 shows the data reconciliation steps when creating a SCTG-IMPLAN conversion bridge enabling the aggregation of 509 IMPLAN sectors to 43 SCTG sectors. A flow chart of NIEMO is shown in Appendix Figure 2.

Figure 3. Data Reconciliation Steps, SCTG and IMPLAN



< NOTE >

*Bold: Used as Bridge Code
1: Ind. = Industry, Comm.= (Commodity)
2: One =One sector, Multi. =Sectors more than one
3: (Merged) Data Status
4: Source and Abbreviation
BEA: Bureau of Economic Analysis (http://www.bea.doc.gov)
SCTG : Standard Classification of Transported Goods (http://www.bts.gov/cfs/sctg/welcome.htm)
HS : Harmonized System (http://www.statcan.ca/trade/htdocs/hsinfo.html)

Radiological Bomb Attack at the Ports

We explored simultaneous radiological bomb attacks on the twin ports of Los Angeles and Long Beach. These could either be brought in by containers or planted within the country 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. We assumed the explosion of two small RDDs (radiological dispersal devices), each of them containing 5lbs of high explosive, more or less simultaneously at the two ports. Blast damage would be modest, with deaths and serious injuries occurring only within a range of about 15 meters and with very limited damage to physical infrastructure. In any event, such an attack would require the closure of both ports on health even more than on security grounds. The early phase of exposure lasts about 4 days (EPA guidelines); the time frame for intermediate and later phases is variable and subjective (weeks, months, even years). When the ports might reopen would be a policy rather than a technical decision.

Although we estimated that the closure of the Los Angeles and Long Beach Ports for anywhere from 15 to 120 days (for the latter case we combined the radiological bomb attacks with conventional bombs blowing up three key access bridges/overpasses), Table 1 reports only the latter case (with county level data). It could cost the US economy up to $34 billion – or more than 212,000 person-years of employment. The model is also capable of providing economic results in much greater spatial detail, to the level of census tracts or traffic analysis zones if required.

Plume Effects

We attempt to measure the "plume effects" in terms of household disruption, business losses and the decline in real estate values. The numbers are very speculative, but our best estimate is a $4 billion loss in output and close to a decline of 42,600 person-years of employment.

Blast damage would be quite limited, with deaths and serious injuries within a range of perhaps 50 meters and with moderate damage to physical infrastructure, except at ground zero. The outer evacuation zone would include all areas with exposure > 1 REM. We assume a hypothetical radiation plume, a long narrow rectangle 4 kilometers long and more than 200 meters wide with an inner and more contaminated zone of about 100 meters radius (an area of 0.03 km^2), an oversimplification of plume representations that are not open source. The critical early phase of exposure lasts about 4 days (EPA guidelines); the time frame for intermediate and later phases is variable and subjective (weeks, months, even years). We assume a one-week evacuation in the Outer Zone. With respect to the Outer Zone, this may be conservative because some firms and households may trickle back with a lag after given permission to return. Health factors may dictate an immediate evacuation, but because the health effects are long-term, the decision to allow a return will be determined by political rather than scientific considerations.

The more speculative economic impact consequences of a radiological bomb attack relate to the radiation plume. They depend on so many variables: the size of the bomb, the amount of the radioactive release, the wind direction and prevailing climatic conditions, and the downwind population and business densities. Moreover, much depends on the public policy reaction, for example, whether to mandate an evacuation (and if so, when to allow people to come back) or whether to proceed in a more measured if less cautious manner. Given these uncertainties, we report here only our best estimate of the *maximum* economic impacts of the plume to compare with the economic effects of the interruption of trade to and from the ports. By maximum, we mean under a reasonable set of assumptions.

Specifically, we assume in the first year after the attack a 25 percent drop in residential property values, a 25 percent reduction in retail trade (net input-output effects are very modest here because shopping and services consumption shifts to other locations outside the plume area) and a 10 percent fall in other business activities (and also that these businesses leave the region; an alternative assumption is that the businesses might relocate elsewhere in the region in which case the impacts would be primarily redistributional from a spatial perspective and the net effects would be minimal).

As for travel behavior, we assume that driving through the plume area (with advice about windows, the use of air conditioning and regular car washing) will be permitted rather than the more extreme measure of closing entry and exit roads (especially the freeways). However, there are network effects as the average length of personal trips increase as plume area residents are forced to shop and access services outside their neighborhoods. Although there are fewer total trips, longer trips and more congestion results in significantly higher network costs. Our calculations of the additional network costs yield an estimate of $1.63 billion, based on a personal trip imputed cost of $13 per hour and a freight trip cost of $35 per PCE (Passenger Car Equivalent, based on the assumption that one truck is the equivalent of 2.25 cars).

Based on Census 2000, there are 401,147 persons living in the 30 TAZs of the impact area. The evacuated population would be 377,442. Table 2 summarizes the input-output consequences of reduced economic activity and lower property values in the outer plume area. The total output loss is more than $4.1 billion, of which only a small part (about $167 million) is associated with the decline in property values. Two-thirds of the losses take place within Los Angeles County and almost one-quarter leak outside the region. In terms of jobs, the total job losses are 44,555 person-years of employment.

For comparison, we have also undertaken another study of a radiological bomb attack, in this case on a downtown Los Angeles office building (probably the former Library Tower now the Union Bank building mentioned by President Bush as a second airplane attack target in addition the World Trade Center). However, there are several other large office buildings in the immediate vicinity, so the precise target (especially with a radiological bomb) is not of much significance. A radiological bomb attack on downtown Los Angeles might be a $6 billion event. If a similar attack were mounted in more CBD-oriented metropolitan areas (such as New York, Chicago or San Francisco), the economic impacts would be much larger. An attack on downtown would much less damaging a similar attack on the ports because the economic disruptions resulting from closure of America's largest port complex (in terms of $ of trade) would be far greater than a disruption to Los Angeles' financial and office sector.

An important difference between an attack on the ports and an attack on downtown is that the critical public policy reactions might vary significantly in the two cases. In the ports case, there would be more economic pressure for the ports to reopen quickly and it would be feasible to put the port workers and/or the military back to handling trade. In the downtown case, there are public spaces and the general public involved and this might imply much more caution in allowing activities to resume sooner rather than later, especially in the inner plume zone.

Interstate Impacts

One of the aims of our research team is to integrate our regional model (SCPM) with our national model (National Interstate Economic Model, i.e. NIEMO). NIEMO is the first operational interstate input-output model for the U.S. As pointed out above, it provides results for 47 major industrial sectors for all fifty states, the District of Columbia, and a leakage region: "The Rest of the World." Our early studies of the economic impacts lumped together all the out-of-region impacts under the category of "Regional Leakages". NIEMO enables us to break this total down into individual state impacts. However, hitherto the numbers are not precisely comparable. Regional leakages for a 120-day ports shutdown in Table 1 amount to about $21.3 billion, while extracting the equivalent leakages from NIEMO in Table 3 (via subtracting the local direct impacts and the Southern Californian component of the California indirect impacts, about 63.2 percent) yields a total of about $13.1 billion.

What accounts for the discrepancies? First, SCPM includes both backward and some forward linkages (i.e. both demand and supply effects) via freight shipments; hitherto, NIEMO has no supply component, but we are working on it. Second, SCPM measures induced impacts, while because of limited interstate commerce in services and in the interests of conservative estimates we have limited NIEMO to direct and indirect effects. Third, as a related point, NIEMO does not yet have a services component except in the intrastate sectors; it is probably not a highly significant element in the ports example, but it is a major issue on our things to do list. In consequence, the results in Table 3 should be interpreted as an indication of the proportional distribution of interstate impacts rather than their absolute amounts.

A Conventional Bomb Attack on Terminal Island's Bridges

In the alternative scenario, we explore another dimension of potential terrorist attacks on the region's ports. Terminal Island accounts for about 55 percent of the twin port's trade, and it could easily be isolated by taking down four bridges (three highway bridges and one rail bridge). We assume four simultaneous conventional bomb attacks on these bridges of a size sufficient to destroy them. We then estimate the potential economic losses associated with the closure of Terminal Island. The major problem is to estimate a reasonable "back to business" recovery period. One "bookend" is 3-4 months, paralleling the 120 closure of the radiological bomb attack. This would allow the building of one or more military-type pontoon bridges. However, these would be close to sea level and built on caissons embedded into the seabed, they would probably interfere with shipping lanes, and a pontoon bridge for container trains is problematic. The other “bookend” would be two years to permit the total rebuilding of the bridges on their original scale, an optimistic scenario given institutional rather than reconstruction constraints. Because the model is linear, any chosen time period could easily be adjusted.[1] The one-year economic cost is $45 billion, split about two-thirds outside the region and one –third within (Table 4). The “bookend” range of impacts is between $15 billion and $90 billion (Table 5). Although how long it would take to reopen Terminal Island and with what level (and degree of permanence) of infrastructure access is somewhat speculative, there is no doubt that this would be a significant and costly event that fully merits substantial resource expenditures to prevent. Similarly, if an attack were to occur, there would be substantial cost savings derived from efforts to accelerate the reopening date.

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 a rail bridge (Badger Bridge) parallel to the Heim Bridge that handles 21 percent of Terminal Island trade (see Maps 1and 2 which show Terminal Island and its location relative to the ports’ other facilities). These bridges are all high design facilities that 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 till too low to facilitate problem-free movement.

Our simulations revealed that if an attack that makes these bridges inaccessible for twelve months will create economic losses of almost $45 billion per year, accounting for job losses of nearly 280,000 person-years.

The geographical distribution of impacts is also shown in Table 5. About 65 percent of both output and job impacts are experienced outside the region. Of the regional impacts, 68 percent occur within Los Angeles County, although the impacts in the other counties are not negligible, especially in Orange County the northern parts of which are relatively close to the ports. Not surprisingly, within Los Angeles County, about one-half of the impacts occurred in the two port cities, overwhelmingly in Los Angeles rather than Long Beach, in part because its large size captured high shares of the indirect (intermediate linkage) and induced (secondary consumption effects), in part because the bulk of the facilities on Terminal Island are owned by the Port of Los Angeles not by the Port of Long Beach.

Network costs increase by $58 million per year. This represents only a 0.04 percent increase in travel delays. The explanation is that there are substantial reductions in freight travel costs because many of the port-related trucks are not on the road, but these are offset by increased personal travel delays. In this case, these delays largely result from increased congestion on both freeways and arterial roads resulting from the fact that cars no longer have the convenient link from San Pedro, Wilmington, Harbor City, Palos Verdes and other cities in the Los Angeles Harbor area to Long Beach via the Vincent Thomas Bridge. This value is lower than the increase in delay costs of $90 million associated with the 120-day scenario in the radiological bomb plus bridge access study because the Terminal Island scenario represents only a partial elimination of port capacity and the disruptions of transportation infrastructure were more localized. It is important to note that these are delay costs; we have not made precise estimates of bridge repair costs.

It is difficult to determine how quickly access to Terminal Island could or would be restored. If under normal circumstances bridge repairs on this scale take up to two years, then our approach can be used to approximate the benefits of speedier repairs, including the installation of temporary facilities. High capacity temporary bridges might be constructed relatively quickly, but these low-design facilities would block ship traffic in the channels separating Terminal Island from the remainder to the port complex.

Current estimates from the California Department of Transportation are that the costs of the replacement span for the Oakland Bay Bridge are over $6 billion. This span carries 275,000 passenger-car equivalents each day, approximating the scale of the Vincent Thomas Bridge. 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 reasonable. It is unknown to what extent these costs might rise if construction was 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 is a no-brainer. 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.

Conclusions

This paper sums up some of the research that our Economic Modeling team at CREATE have been working on for the past two years. The research is both methodological and substantive. The methodological path is to integrate more closely two models (one regional, one national) in the input-output, but spatially disaggregated, mode. The substantive approach is to consider the business interruption consequences of bomb attacks, both radiological and conventional, at the twin ports of Los Angeles-Long Beach. The SCPM-NIEMO models are applicable to a much wider range of attacks than those examined here, such as airports and theme parks. However, the integrated model needs more work to overcome the well-known limitations of the input-output approach, especially from the price-substitutions potential. Also, as far as NIEMO is concerned, the rise of information technology makes the introduction of tradable services into the commodity-dominated multiregional input-output framework more critical.

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Table 1: Output and Employment Losses Associated with 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
County of Los Angeles	5,252	1,759	1,260	8,271	24,722	13,233	14,142	52,097
County of Orange	1,247	496	357	2,100	5,502	3,841	4,009	13,352
County of Ventura	345	143	93	581	1,459	971	1,052	3,482
County of Riverside	296	115	102	513	1,306	890	1,175	3,371
County of San Bernardino	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

Table 2 : Radiation Plume Scenario and Effects

	Output ($1,000s)				Jobs			
	Direct	Indirect	Induced	Total*	Direct	Indirect	Induced	Total*
County of Los Angeles	1,840,260	361,255	435,811	2,637,326	22,319	3,302	4,876	30,498
County of Orange	0	132,022	138,458	270,480	0	1,247	1,558	2,806
County of Ventura	0	28,196	34,667	62,863	0	256	388	644
County of Riverside	0	26,532	38,225	64,756	0	250	446	697
County of San Bernardino	0	35,639	47,766	83,405	0	331	555	886
Sum of Five Counties	1,840,260	583,644	694,926	3,118,830	22,319	5,387	7,823	35,530
Regional Leakages	595,019	214,999	188,964	998,983	5,024	1,868	2,129	9,019
Regional Total	2,435,279	798,643	883,891	4,117,813	27,345	7,257	9,955	44,555

Table 3: Sum of Intra- and Interstate Effects: LA/LB Ports, Shutdowns for 120days ($m.)

State	LA/LB	Interstate Impacts of NIEMO							
Southern CA	4,874.58	AL	106.35	IN	209.76	NE	99.9	RI	19.14
Rest of CA	5,545.64	AK	12.17	IA	142.25	NV	51.6	SC	66.12
Direct_Impact_EXPORT	16,233.20	AZ	211.83	KS	126.21	NH	28.48	SD	26.52
Direct_Impact_IMPORT	56,107.13	AR	100.69	KY	115.05	NJ	167	TN	132.92
US Total	89,817.26	CO	123.88	LA	307.54	NM	26.1	TX	1,546.39
Rest of World	492.02	CT	63.28	ME	21.25	NY	216.38	UT	125.31
World Total	90,309.29	DE	20.04	MD	45.09	NC	130.76	VM	9.51
		DC	2.47	MA	86.01	ND	19.22	VA	66.99
		FL	123.19	MI	216.96	OH	303.19	WA	313.64
		GA	102.26	MN	133.34	OK	106.47	WV	41.75
		HI	21.31	MS	57.91	OR	198.81	WI	208.17
		ID	48.57	MO	141.71	PA	243.81	WY	25.71
		IL	279.47	MT	64.21				

Table 4: Highway Access Bridges to Terminal Island

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

Table 5: Output and Employment Effects associated with 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
County of Los Angeles	6,907	2,342	1,664	10,914	32,213	17,629	18,692	68,535
County of Orange	1,663	660	472	2,796	7,371	5,118	5,302	17,791
County of Ventura	462	189	123	774	1,961	1,290	1,390	4,641
County of Riverside	393	152	134	680	1,744	1,185	1,546	4,475
County of San Bernardino	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

Appendix Figure 1.

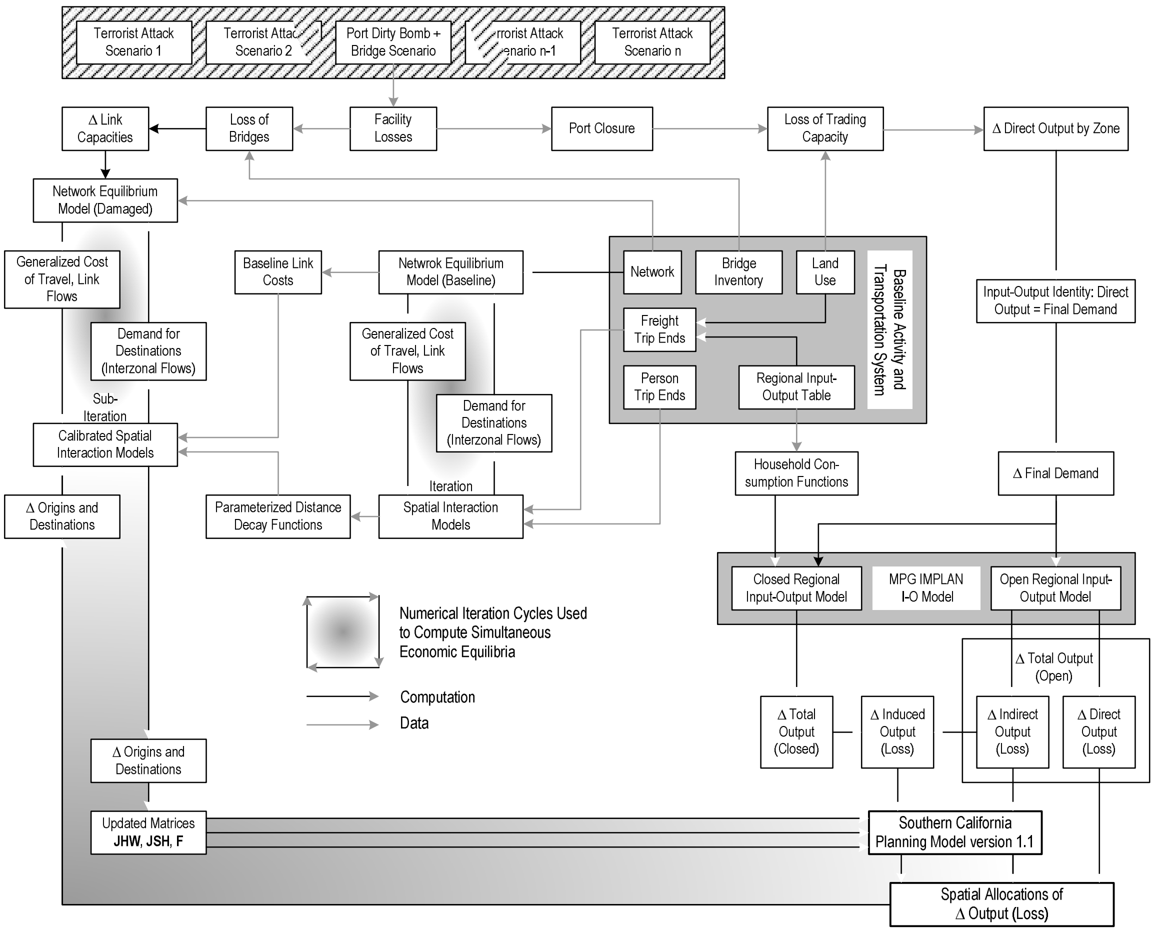
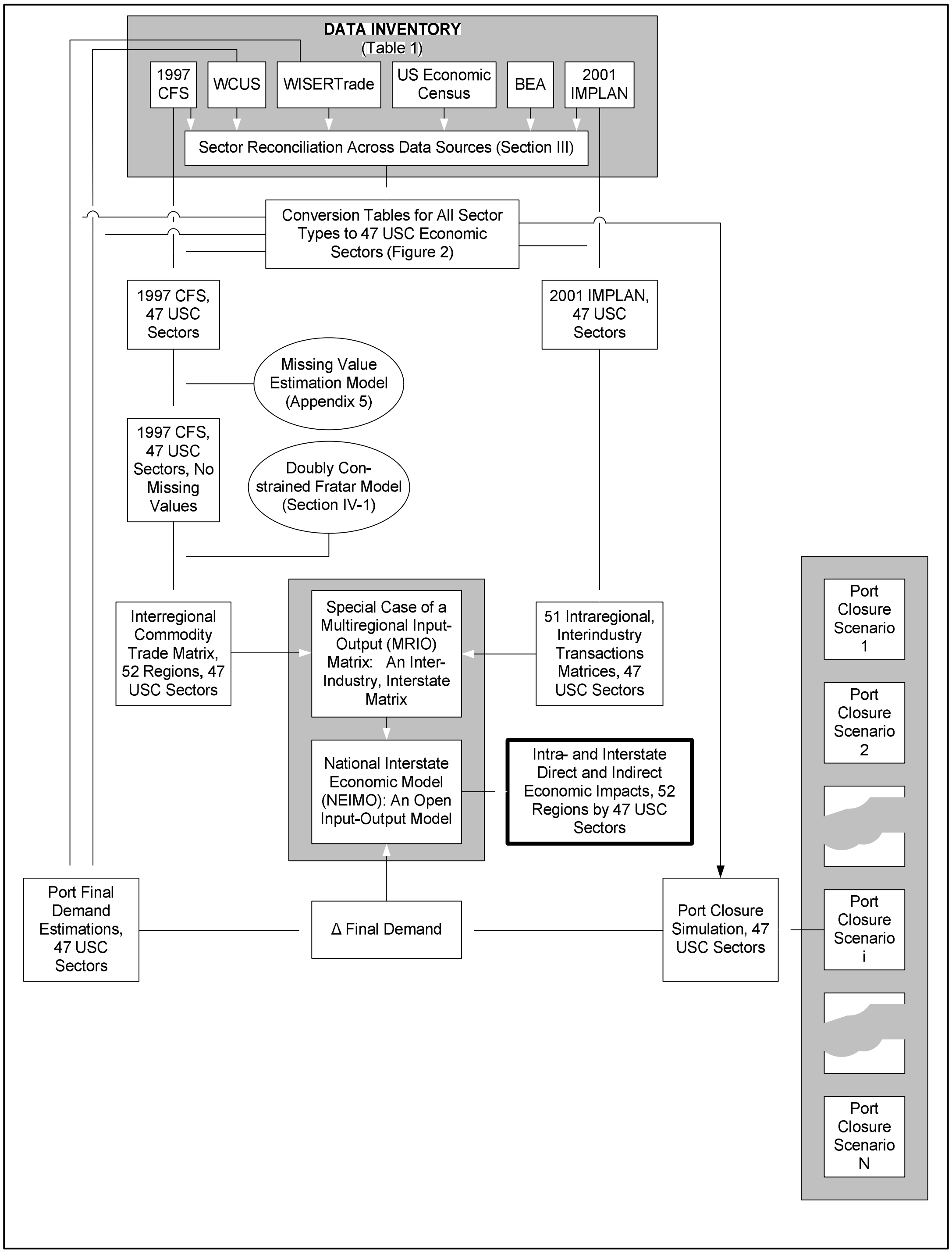
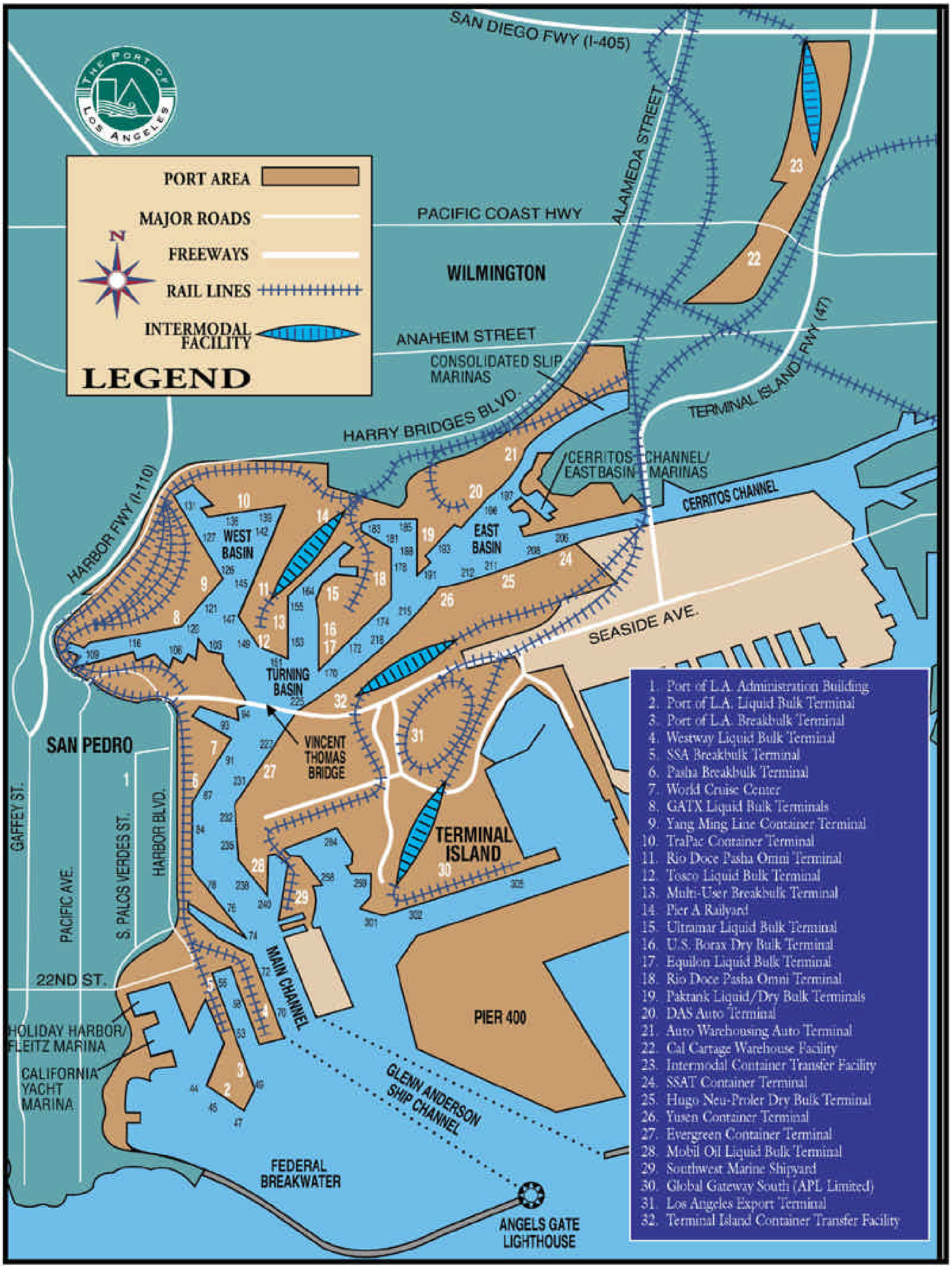


Figure 1: SCPM2 Data Flows and Calculations

Appendix Figure 2.





Map 1: Terminal Island and Port of Los Angeles

Map 2: Terminal Island and Port of Long Beach