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The Economic Impacts of a Terrorist Attack on the U.S. Commercial Aviation System

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by

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I. INTRODUCTION

Apart from major changes in the nation's defense posture, we now know that the economic effects of the September 11, 2001, terrorist attacks were relatively short-term in their impact. This corroborates the idea that short-term impact studies of hypothetical attacks can be useful to policy makers allocating limited resources as they evaluate the benefits (costs avoided) of various defensive measures. Here we consider the short-term economic costs of an attack on the U.S. commercial air system. Much is now known about the post-September 11 performance of the air travel industry: It took several years to recover. However, a full accounting of the economic costs has, to our knowledge, never been undertaken. Nevertheless, a careful analysis of the after-effects of the events of September 11 are useful in estimating the economic impacts of another attack. We have a particular type of attack in mind, an attack using a shoulder-borne missile launcher to bring down a plane close to an airport on take-off or landing. This can be protected against by installing and maintaining missile deflectors on all commercial aircraft (MANPADS, i.e. Man-portable Air Defense Systems). Because this would be costly, the key question is whether the avoided costs of disruption to the national airline system following a successful attack would justify the expense. The aim of this paper is to shed light on this issue.

This paper summarizes our work on quantifying the economic impacts of a hypothetical terrorist attack on the U.S. commercial air transport system. Wherever possible, we draw on data from the post-September 11 experience. We apply IMPLAN®, a 509-sector input-output model of the U.S. economy for 2001, available from the Minnesota IMPLAN Group, Inc. (MIG). Much of our work (Gordon, Moore, II, and Richardson 2005) has focused on estimating spatially disaggregated economic impacts, but a national model is more relevant in this case. The state-by-state airline revenue losses are particularly difficult to estimate in light of the geographically dispersed nature of airline carriers and related infrastructure and vendors.

We model a seven-day shut-down of the entire U.S. commercial air transportation system, followed by a two-year period of recovery, using the post-September 11 experience of the system as a basis for our analysis. Our overall loss estimates for the two years range from $248 billion to $394 billion. Most of these impacts are post-shut down losses incurred during the recovery period.

II. PREVIOUS STUDIES

We are aware of only two other relevant precursor attempts to model substantial disruption of the commercial U.S. air transport system. Balvanyos and Lave (2005) estimated consumer surplus losses from an air travel shut down and reported that the estimated loss would be as much as $2 billion per day.

Santos and Haimes (2004) published results from an input-output impact simulation of a 10-percent U.S. air transport system shutdown associated with $12 billion in direct effects. These authors derived input-output multipliers of 1.2 (Type I) and 3.6 (Type II) for the U.S., and used these to estimate a range of total losses from $14.2 billion to $43 billion for the year.

III.. APPROACH AND ASSUMPTIONS

Our approach differs from the two cited studies in several respects. Most important of these is our treatment of the aftereffects of the attack. Our assumptions and procedures are listed here. These are deliberately conservative.

- There is an initial seven-day shutdown of the entire commercial air system.

- We only estimated demand-induced effects. We assumed no supply-side effects. Freight shipments should recover quickly. Business travelers, for the most part, will find and engage in productive activities that substitute for air travel. They will remain at work and perform other tasks.

- For losses following the seven-day-shutdown period, we assumed that air freight transport (20 percent of total air revenues) resumes immediately at its pre-attack levels Passenger travel, on the other hand, takes a considerable length of time to recover because of fear, caution and other psychological effects. This is especially true for leisure travelers, whose trips are easily postponable or for which many can find ground-based substitutes. Business travelers who fly more

regularly will return to flying sooner. Becker and Rubinstein (2004) argue that fear is a fixed cost so that the average fixed costs of fear will decline as the number of trips increase

To simulate the impacts of the shut-down, we set final demand for IMPLAN sector #391, ("air transportation") to zero. This eliminates all passenger and freight traffic. We did not consider any additional ancillary costs associated with the re-routings that occur as the system is shut down.

To simulate the gradual, post-shutdown return to normal traffic, we gathered data on the monthly air passenger losses (domestic as well as international trips) for the 24 months following September 11, 2001 (see Table 1). We then estimated polynomial trends for each type of air travel from historical data and used these to project what the monthly passenger volumes would have been had there not been an attack on September 11. The differences between projected and actual were assumed to be the monthly air travel losses (see Figure 1).

Next, we estimated air traveler expenses for average person-trips for domestic as well as international travel (see Table 2). These estimates were derived from data provided by the Travel Industry Association of America (2005).

Final demand losses add up to $1,231 per domestic person-trip and are distributed over the IMPLAN expenditure sectors as shown (airline tickets, ground transportation, accommodations, food, gifts and shopping, and amusement). Corresponding losses per international person-trip are $2,325.

Table 3 shows estimates of final demand losses for the three periods (the seven-day shutdown, the remainder of year 1, and all of year 2) for both types of passenger traffic and for the major expenditure sectors . These are derived by applying the expenditures per passenger to one-half of the predicted trip losses on the assumption that most passengers took round-trips, in which case two boardings are associated with each trip expenditure. IMPLAN's multipliers were then applied to these direct effects.

These losses were offset by increases in consumption of telecommunication services, to simulate the substitution of teleconferencing for face-to-face business meetings. The question of whether telecommunications and travel

are substitutes or complements is unresolved. It is reasonable to expect that some telecommunications would be used to substitute for travel in the event of a shutdown of the nation's airports. However, we found no usefully identifiable data on these effects. Instead, we assumed a five percent increase in telecommunications final demand in the seven days of the air system shut down, followed by a slow return (i.e. decline) to pre-shutdown telecommunications demand over the next twenty-four months.

IV. RESULTS

We also calculated values for both Type I and Type II multipliers. The latter calculation is based on the IMPLAN Social Accounting Matrix (SAM), and incorporates a minor modification of the way that household incomes are assessed relative to the procedure IMPLAN calculates other multipliers. Applying these two results make it possible to bracket low-end and high-end impacts.

Type I effects are the direct effects from Table 3 and indirect effects consisting of losses by suppliers and vendors in the associated expenditure sectors. Type II multipliers add the induced effects of reduced spending by households with members employed in any of the directly or indirectly affected industries. Both sets of results are shown in Table 4.

For the seven-day shut-down, we predict system losses ranging from $13.5 billion to $21.3 billion, depending on the choice of multipliers. The higher bound approximates Balvanyos and Lave's (2005) cost estimates of $2 billion per day. Balavanyos and Lave take a different approach to this question, estimating costs in terms of changes in consumer surplus. The principal finding in our analysis is that up to 95 percent of the total impact of the attack is likely to occur in the post-shut-down period (this finding makes speculation about the length of the shutdown less important, e.g. whether seven days or four days as after 9/11). We estimate that net system losses over the entire two-year period would range from $248.8 billion to $393.7 billion. These total loss estimates capture the economic consequences that would follow an attack, but exclude the costs associated with the loss of life and the replacement cost of aircraft that would be incurred as the result of an attack.

V. CONCLUSIONS

The estimated cost of deploying countermeasures (man-portable air defense systems [MANPADS]) to the threat of shoulder-launched missiles to the U.S. airline fleet range from $10 billion to $100 billion, depending on the technology and objectives involved (O'Sullivan, 2005). The initial cost of equipping U.S. commercial fleet of approximately 6,800 aircraft range from $10 billion to $20 billion, based on estimates of about $1 million to $3 million per plane. However, this is not the principal cost of countermeasures. Some countermeasures deteriorate quickly and must be replaced frequently. As a result, these systems include extensive logistics, refurbishment, training, and maintenance requirements that might impose additional costs of $5 billion to $10 billion per year (USDHS, 2004).

We find large loss estimates associated with a shut-down of U.S. airports, primarily because of long-term reductions in air travel demand similar to those observed following the nation-wide airport shut-down prompted by the events of September 11, 2001. We expect that this drop in demand would be repeated following a subsequent shut-down, but it might also occur in response to the circumstances that might prompt a shut-down, such as a successful MANPADS attack. When compared to the estimated costs of MANPADS countermeasure deployment, the deployment of countermeasures may be justified for a wide range of attack probabilities as low as 0.3.

Estimating the full costs of a major disruption in any large industry is a challenging task. Where we have needed to make assumptions, our choices have erred on the conservative side. However, , the input-output methodology we use to estimate economic impacts does not accommodate many of the substitutions that economic agents can find when they have time to investigate the adjustments available to them. Our conservative modeling assumptions help to counter this limitation.

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Table 1. Number of Monthly Air Passengers, 1999-2004

Year	Type	January	February	March	April	May	June	July	August	September	October	November	December	Total
1999	Domestic	41,036,190	40,719,445	49,893,855	48,297,891	48,166,998	50,899,806	53,705,361	52,182,372	44,613,266	49,501,618	47,908,281	46,286,717	573,211,800
	International	9,960,297	8,879,168	11,210,638	10,455,436	10,859,652	11,708,162	12,957,704	13,127,099	10,860,605	10,924,093	10,158,967	9,869,726	130,971,547
	Monthly total	50,996,487	49,598,613	61,104,493	58,753,327	59,026,650	62,607,968	66,663,065	65,309,471	55,473,871	60,425,711	58,067,248	56,156,443	704,183,347
2000	Domestic	41,557,193	43,729,534	52,990,192	50,354,369	52,325,210	54,724,492	55,621,547	54,515,661	46,398,645	50,958,213	49,659,124	47,075,544	599,909,724
	International	10,192,898	9,860,251	11,958,099	11,643,945	12,024,434	13,083,128	14,231,008	13,968,466	11,709,233	11,195,364	10,554,355	10,868,254	141,289,435
	Monthly total	51,750,091	53,589,785	64,948,291	61,998,314	64,349,644	67,807,620	69,852,555	68,484,127	58,107,878	62,153,577	60,213,479	57,943,798	741,199,159
2001	Domestic	44,109,939	43,180,235	53,058,085	50,794,947	51,122,786	53,473,441	55,805,088	56,405,712	30,546,484	40,290,718	40,691,635	40,901,001	560,380,071
	International	11,000,962	9,738,886	12,013,455	11,581,797	11,502,673	12,722,468	13,726,350	13,728,413	8,184,100	7,455,906	7,558,632	8,915,944	128,129,586
	Monthly total	55,110,901	52,919,121	65,071,540	62,376,744	62,625,459	66,195,909	69,531,438	70,134,125	38,730,584	47,746,624	48,250,267	49,816,945	688,509,657
2002	Domestic	38,557,639	38,644,502	48,500,814	45,437,855	47,127,122	49,277,700	51,256,869	51,315,219	40,275,540	48,378,381	45,185,895	50,021,864	553,979,400
	International	9,286,653	8,411,103	10,709,653	9,614,915	10,156,679	11,259,303	12,171,349	12,306,136	9,739,036	9,886,525	9,312,268	10,437,949	123,291,569
	Monthly total	47,844,292	47,055,605	59,210,467	55,052,770	57,283,801	60,537,003	63,428,218	63,621,355	50,014,576	58,264,906	54,498,163	60,459,813	677,270,969
2003	Domestic	43,342,568	41,465,828	50,387,896	47,364,610	49,413,135	52,541,303	56,144,210	54,320,947	44,575,728	50,347,404	47,456,128	50,132,111	587,491,868
	International	10,212,099	8,739,037	10,119,337	8,751,524	9,212,897	10,832,970	12,304,750	12,532,510	9,875,102	10,059,026	9,803,950	10,882,026	123,325,228
	Monthly total	53,554,667	50,204,865	60,507,233	56,116,134	58,626,032	63,374,273	68,448,960	66,853,457	54,450,830	60,406,430	57,260,078	61,014,137	710,817,096
2004	Domestic	44,158,311	45,660,468	54,563,833	53,653,714	53,338,190	57,289,444	59,997,823	57,726,626	47,905,667	54,476,781	51,945,573	52,770,682	633,487,112
	International	10,699,049	9,763,902	11,499,015	11,257,596	11,359,680	12,612,501	14,065,609	13,638,885	10,860,263	11,067,822	10,382,041	11,529,836	138,736,199
	Monthly total	54,857,360	55,424,370	66,062,848	64,911,310	64,697,870	69,901,945	74,063,432	71,365,511	58,765,930	65,544,603	62,327,614	64,300,518	772,223,311

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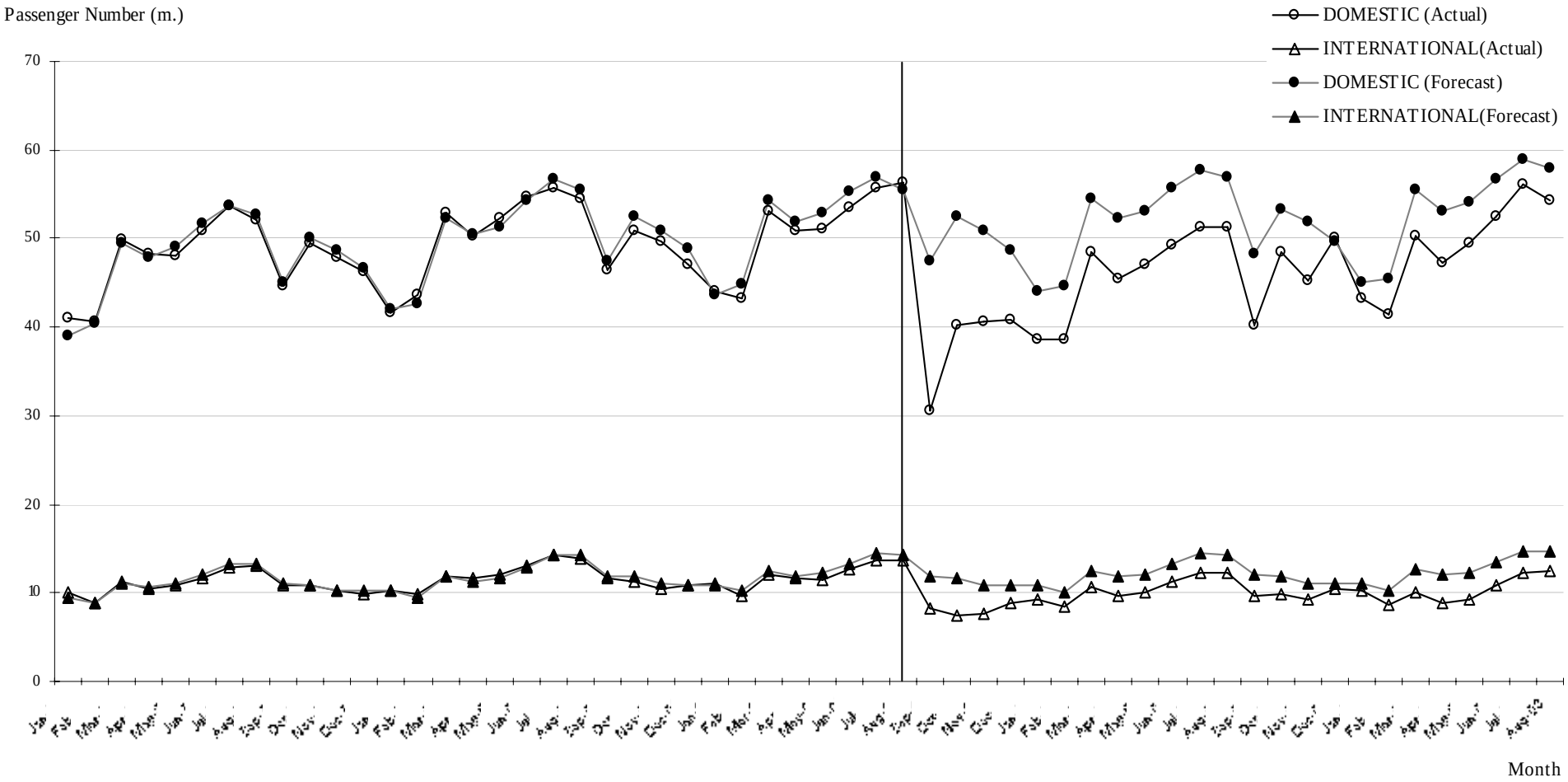
Source: Bureau of Transportation Statistics, U.S. Department of Transportation



Source: Calculations by the authors.

Figure 1. Forecasts of Monthly Domestic and International Air Passengers

Table 2. Passenger Air Travel Expenditures by Major Sector

Domestic Travel				
Economic Sector	$ per Party[1]	Persons per Party[2]	$ per Person	Percentage
Airline Tickets	$455	1.4	$325	26.39%
Transportation	$272		$194	15.78%
Accommodations	$394		$281	22.85%
Food	$243		$174	14.10%
Gifts/Shopping	$230		$164	13.34%
Amusement	$130		$93	7.54%
Total	$1,724		$1,231	100.00%
International Travel				
Economic Sector	$ per Party[3]	Persons per Party[4]	$ per Person	Percentage
Airline Tickets[5]	--	--	$667	28.67%
Transportation	$413	1.56	$265	11.38%
Accommodations	$1,005	1.47	$684	29.41%
Food	$391	1.58	$247	10.63%
Gifts/Shopping	$455	1.56	$291	12.51%
Amusement	$290	1.69	$172	7.40%
Total	$2,554		$2,325	100.00%

Source: Maplesden, Helen, et al. (2002) "Expenditure Patterns of Travelers in the U.S.," 2002 edition. Travel Industry Association of America: Washington, DC.

Notes:
1. Aggregate 'Average Trip Spending' on Air from Table 14 (p.45), excluding N/A entries
2. 'Average Trip Party Size' for Business Travelers from Table 3 (p.22)
3. Aggregate 'Average Trip Spending' on Business from Table 28 (p.78), excluding N/A entries. This is for Air-transportation.
4. Proportions of 'Average Trip Party Size' for 'International Travelers' calculated from Table 25 (p.74)
5. The average ticket price per person is assumed as $1,000 for international airline tickets. We use 66.7% of this value to account for the share of tickets that may have been purchased abroad. See: http://www.lawa.org/lax/statistics/tcom-1201.pdf

Table 3. Final Demand Losses (and Gains) from Terrorist Attacks ($millions)

Reductions: Domestic Passengers(M)[1]	Reductions: International Passengers(M)[1]	IMPLAN Sector	Sector Description	$ per Domestic Passenger	$ per International Passenger	All Domestic Travel ($M)	All International Travel ($M)	Total Travel ($M)
First Seven Days[2]								
4.63[4]	1.12[4]	391	Air Transportation	--	--	--	--	-1,873.12
		392~395	Other Transportations	194.29	264.58	-900.15	-297.53	-1,197.68
		479~480	Accommodations	281.43	683.96	-1,303.89	-769.15	-2,073.04
		405, 481	Food	173.57	247.11	-804.18	-277.88	-1,082.06
		408~412	Gifts/Shopping	164.29	290.91	-761.16	-327.15	-1,088.30
		475~478	Amusement	92.86	172.04	-430.22	-193.47	-623.69
			Sub-Total Losses	906.43	1658.60	-4,199.59	-1,865.18	-7,937.89
		422	Telecommunications[3]	--	--	--	--	167.22
			Net Losses	906.43	1,658.60	-4,199.59	-1,865.18	-7,770.67
Remainder of the First Year								
48.003[4]	14.294[4]	391	Airline Tickets	325.00	666.67	-15,600.85	-9,529.11	-25,129.96
		392~395	Other Transportations	194.29	264.58	-9,326.22	-3,781.79	-13,108.02
		479~480	Accommodations	281.43	683.96	-13,509.31	-9,776.27	-23,285.58
		405, 481	Food	173.57	247.11	-8,331.88	-3,532.05	-11,863.93
		408~412	Gifts/Shopping	164.29	290.91	-7,886.15	-4,158.22	-12,044.36
		475~478	Amusement	92.86	172.04	-4,457.39	-2,459.15	-6,916.54
			Sub-Total Losses	1,231.43	2,325.27	-59,111.80	-33,236.60	-92,348.40
		422	Telecommunications[3]	--	--	--	--	15,258.83
			Net Losses	1,231.43	2,325.27	-59,111.80	-33,236.60	-77,089.58
Second Year								
25.642[4]	12.469[4]	391	Airline Tickets	325.00	666.67	-8,333.73	-8,312.83	-16,646.56
		392~395	Other Transportations	194.29	264.58	-4,981.92	-3,299.09	-8,281.01
		479~480	Accommodations	281.43	683.96	-7,216.46	-8,528.44	-15,744.90
		405, 481	Food	173.57	247.11	-4,450.76	-3,081.22	-7,531.99
		408~412	Gifts/Shopping	164.29	290.91	-4,212.66	-3,627.47	-7,840.12
		475~478	Amusement	92.86	172.04	-2,381.07	-2,145.27	-4,526.34
			Sub-Total Losses	1,231.43	2,325.27	-31,576.60	-28,994.32	-60,570.92
		422	Telecommunications[3]	--	--	--	--	4,795.63
			Net Losses	1,231.43	2,325.27	-31,576.60	-28,994.32	-55,775.29

Notes:
1. The reduction in passengers was calculated by multiplying 7/31 by the monthly passenger volume for August 2001.
2. Losses of during a seven-day interruption in service (1.9178% of one year) estimated based on a reduction in final demand in the IMPLAN air transportation sector (#391).

3. We assume final demand for Telecommunications services increases by 5% during the 7 days shutdown and then decreaseds linearly, month-to-month, over the next two years.
4. Because all passengers are assumed to board with round-trip tickets, we applied one-half of reported air passenger trips to the cost/trip estimates.

7 Days	IMPACTS			Type I Multipliers	IMPACTS		Type (II) SAM Multipliers
Economic Sector	Direct	Indirect	Total		Induced	Total	
First Seven Days							
Air Transportation[1]	-1,873	-1,685	-3,558	1.8995	-1,922	-5,480	2.9256
Other Transportations	-1,198	-1,042	-2,239	1.8696	-1,162	-3,402	2.8402
Accommodations	-2,073	-1,169	-3,242	1.5639	-1,861	-5,103	2.4616
Food	-1,082	-892	-1,974	1.8246	-1,171	-3,146	2.9071
Gifts/Shopping	-1,088	-694	-1,783	1.6380	-1,139	-2,921	2.6842
Amusement	-624	-344	-968	1.5513	-640	-1,608	2.5782
Telecommunications[2]	167	90	257	1.5372	126	383	2.2891
Seven-Day Totals	-7,771	-5,736	-13,507	1.7139	-7,770	-21,277	2.7381
Remainder of the First Year							
Airline Tickets	-25,130	-22,604	-47,734	1.8995	-25,785	-73,519	2.9256
Other Transportations	-13,108	-11,399	-24,507	1.8696	-12,722	-37,229	2.8402
Accommodations	-23,286	-13,131	-36,417	1.5639	-20,902	-57,319	2.4616
Food	-11,864	-9,783	-21,647	1.8246	-12,843	-34,490	2.9071
Gifts/Shopping	-12,044	-7,684	-19,728	1.6380	-12,601	-32,329	2.6842
Amusement	-6,917	-3,813	-10,730	1.5513	-7,102	-17,832	2.5782
Telecommunications[2]	15,259	8,198	23,456	1.5372	11,472	34,928	2.2891
First-Year Totals	-77,090	-60,216	-137,306	1.7592	-80,484	-217,790	2.8252
Second Year							
Airline Tickets	-16,647	-14,973	-31,620	1.8995	-17,081	-48,701	2.9256
Other Transportations	-8,281	-7,201	-15,482	1.8696	-8,037	-23,519	2.8402
Accommodations	-15,745	-8,879	-24,624	1.5639	-14,133	-38,757	2.4616
Food	-7,532	-6,211	-13,743	1.8246	-8,154	-21,897	2.9071
Gifts/Shopping	-7,840	-5,002	-12,842	1.6380	-8,202	-21,044	2.6842
Amusement	-4,526	-2,496	-7,022	1.5513	-4,648	-11,670	2.5782
Telecommunications[2]	4,796	2,576	7,372	1.5372	3,605	10,977	2.2891
Second-Year Totals	-55,775	-42,185	-97,960	1.7473	-56,650	-154,610	2.7720
Total Two-Year Losses	-140,636	-108,137	-248,773	1.7525	-144,904	-393,676	2.7993

Table 4. Simulation Results ($millions)

Notes:
1. Losses of during a seven-day interruption in service (1.9178% of one year) estimated based on a reduction in final demand in the IMPLAN air transportation sector (#391).
2. We assume final demand for Telecommunications services increases by 5% during the 7 days shutdown and then decreaseds linearly, month-to-month, over the next two years.