

Evaluating the Economic Impact of Improvements in Freight Infrastructure: An Input-Output Approach

Ethan Halpern-Givens

ehalpe2@uic.edu

Chicago Area Travel Model User Group

Wednesday April 6th 2011

Agenda

- ▶ Introduction
 - Federal Highway Administration Tool
- ▶ Project Design
 - 2020 Regional Transportation Plan
- ▶ Input-Output
 - RAS Method
 - Multiplier Analysis
 - Impact Analysis
 - Field of Influence Analysis
 - Key Sector Analysis
- ▶ Results
 - Contributions
 - Weakness
 - Future work
- ▶ Questions

Introduction

- ▶ Part of the CFIRE Broad Economic Impacts of Freight Infrastructure project being conducted by The UTC
- ▶ New approach to capture broad impacts of transportation infrastructure
 - Using existing input-output techniques
- ▶ Address a short coming of existing tools within transportation analysis
 - FHWA Broad Impacts Tool



The Federal Highway Administration: Freight Logistics Reorganization Benefits Estimation Tool

- ▶ The Federal Highway Administration (FHWA) identifies three orders of benefits regarding freight improvements
 - The tool however only evaluates the first two orders
 - Based on changes in consumer surplus

The screenshot shows the title page of a software tool. At the top left is the U.S. Department of Transportation Federal Highway Administration logo. The main title is 'Highway Freight Logistics Reorganization Benefits Estimation Tool' in white text on a green background, with 'DRAFT Version 2.5' and 'June 25, 2007' below it. A white box contains 'Basic instructions:' with a yellow square for 'denotes drop-down menu user input' and a light blue square for 'denotes keyed-in user input'. Below this, it lists the tool's components: 1. Estimation Inputs (with a note to choose from predefined values or provide custom input), 2. Conventional CBA Freight Benefits Input, 3. Summary of Results, and 4. Summary of Inputs. A 'Select Tool Mode:' section has radio buttons for 'Standard' (selected) and 'Advanced', with a note '(Ctrl+D for Standard Mode, Ctrl+A for Advanced Mode)'. A large orange 'START' button is in the bottom right. The footer includes 'HDR' and 'HLB Decision Economics Inc.' logos.

U.S. Department of Transportation
Federal Highway
Administration

Highway Freight Logistics Reorganization Benefits Estimation Tool
DRAFT Version 2.5
June 25, 2007

Basic instructions:
 denotes drop-down menu user input
 denotes keyed-in user input

The tool consists of the following components:
1 Estimation Inputs Chose from Predefined Values or provide Custom Input
2 Conventional CBA Freight Benefits Input
3 Summary of Results
4 Summary of Inputs

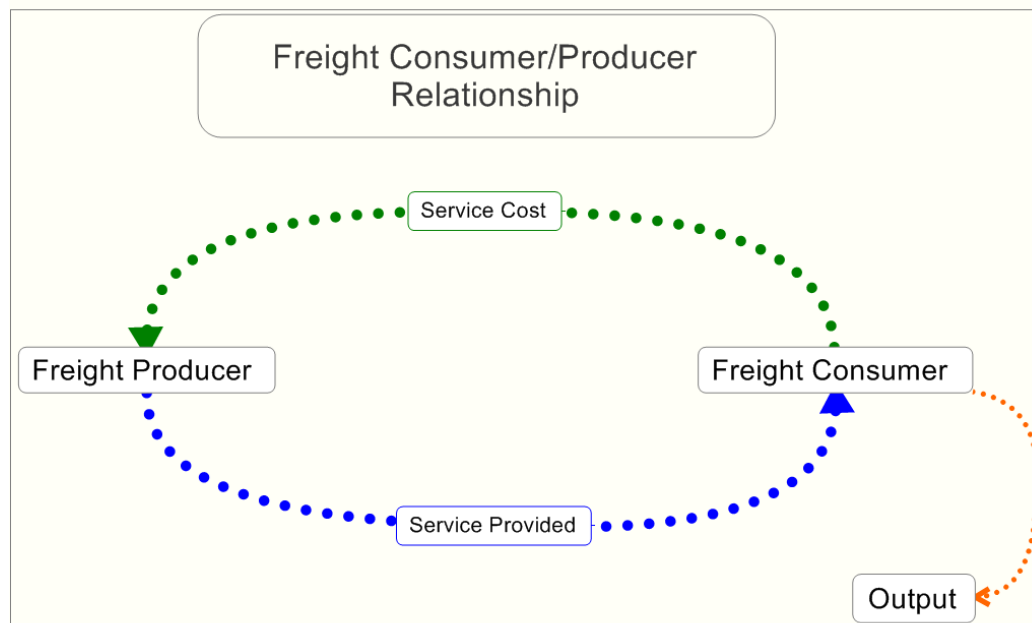
Select Tool Mode:
(Ctrl+D for Standard Mode, Ctrl+A for Advanced Mode)
 Standard
 Advanced

START

HDR | HLB
Decision Economics Inc.

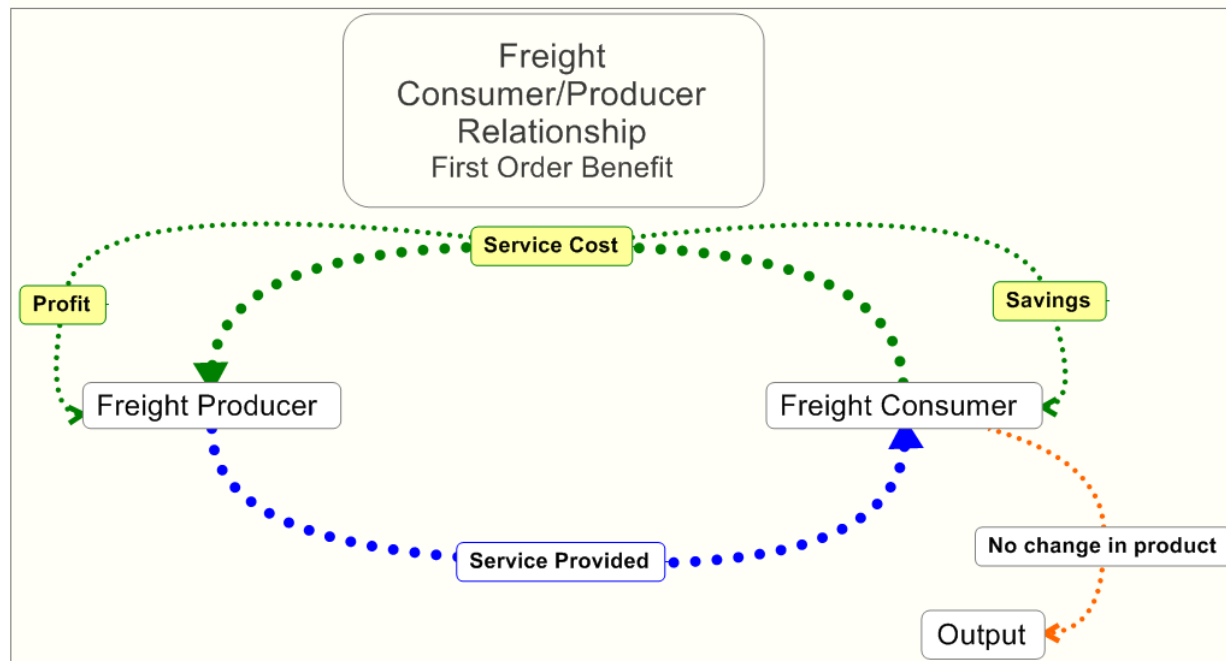
The Federal Highway Administration: Freight Logistics Reorganization Benefits Estimation Tool Continued

- ▶ Typical freight services consumer/producer relationship



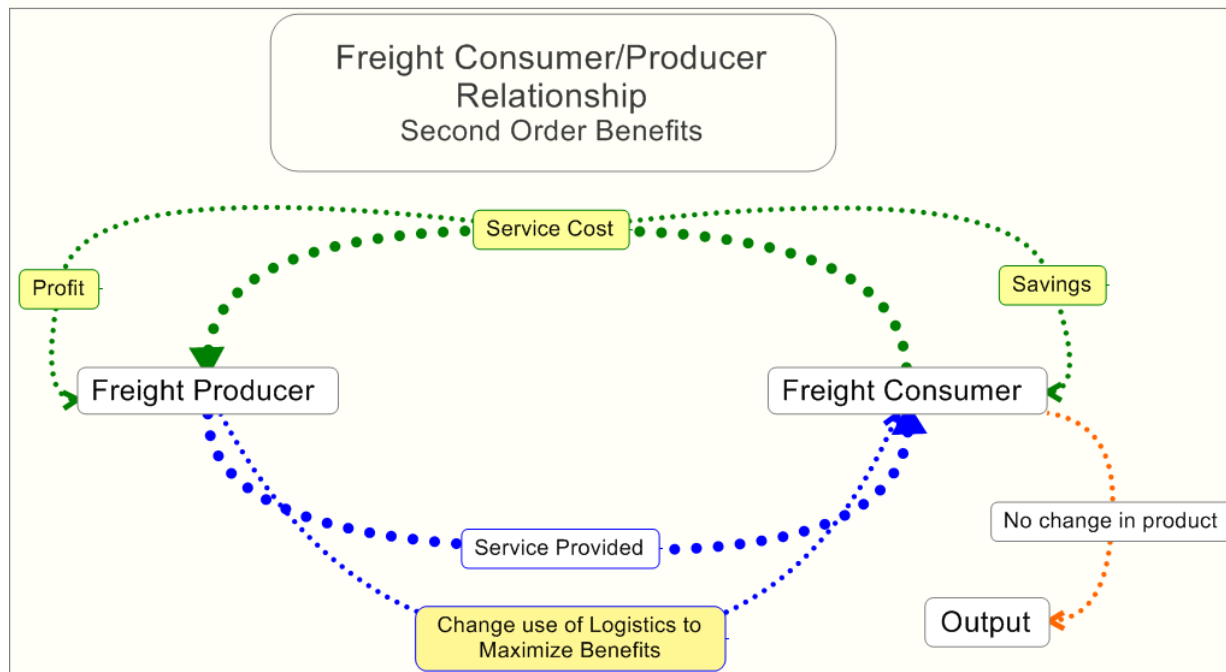
The Federal Highway Administration: Freight Logistics Reorganization Benefits Estimation Tool Continued

- ▶ Potential Benefits of Freight Services
 - First order benefits
 - Decreasing costs



The Federal Highway Administration: Freight Logistics Reorganization Benefits Estimation Tool Continued

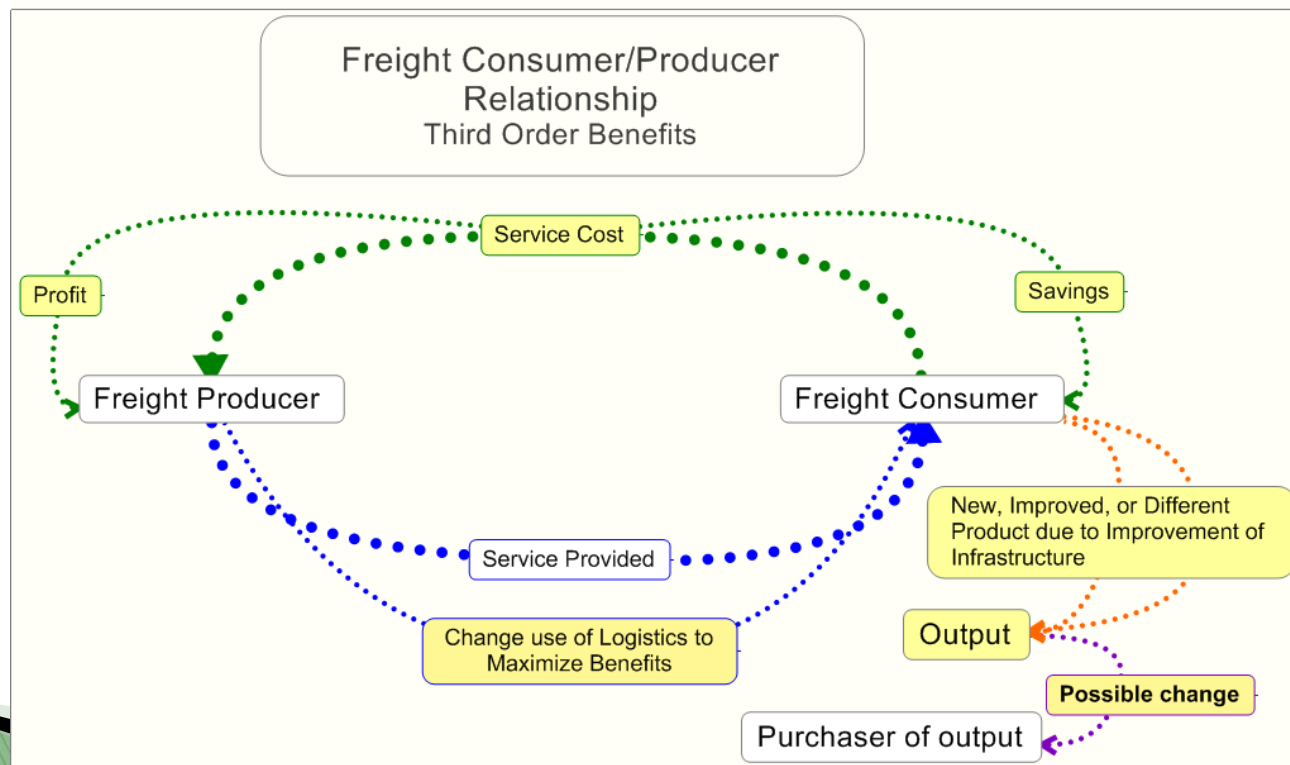
- ▶ Potential Benefits of Freight Services
 - Second Order Benefits
 - Maximization of benefit through change in logistics



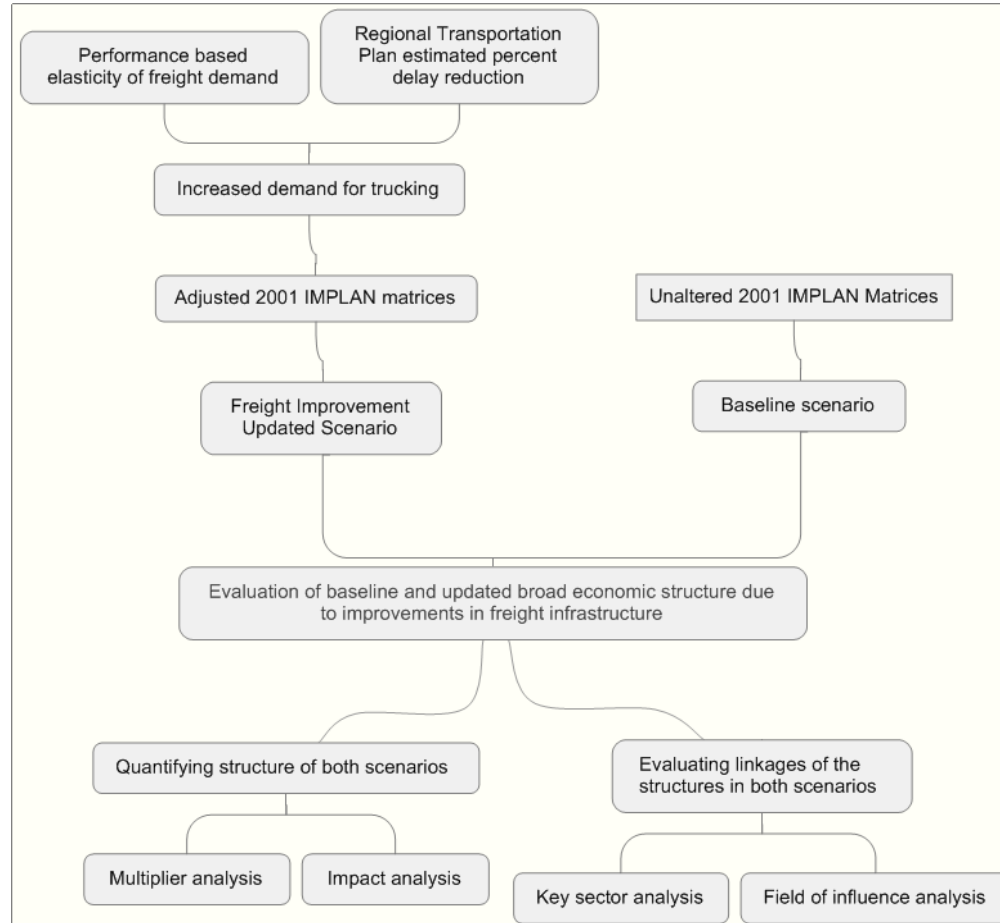
The Federal Highway Administration: Freight Logistics Reorganization Benefits Estimation Tool Continued

► Potential Benefits of Freight Services

- Third Order Benefits
 - Change in product, quality of product or demand



Project Design

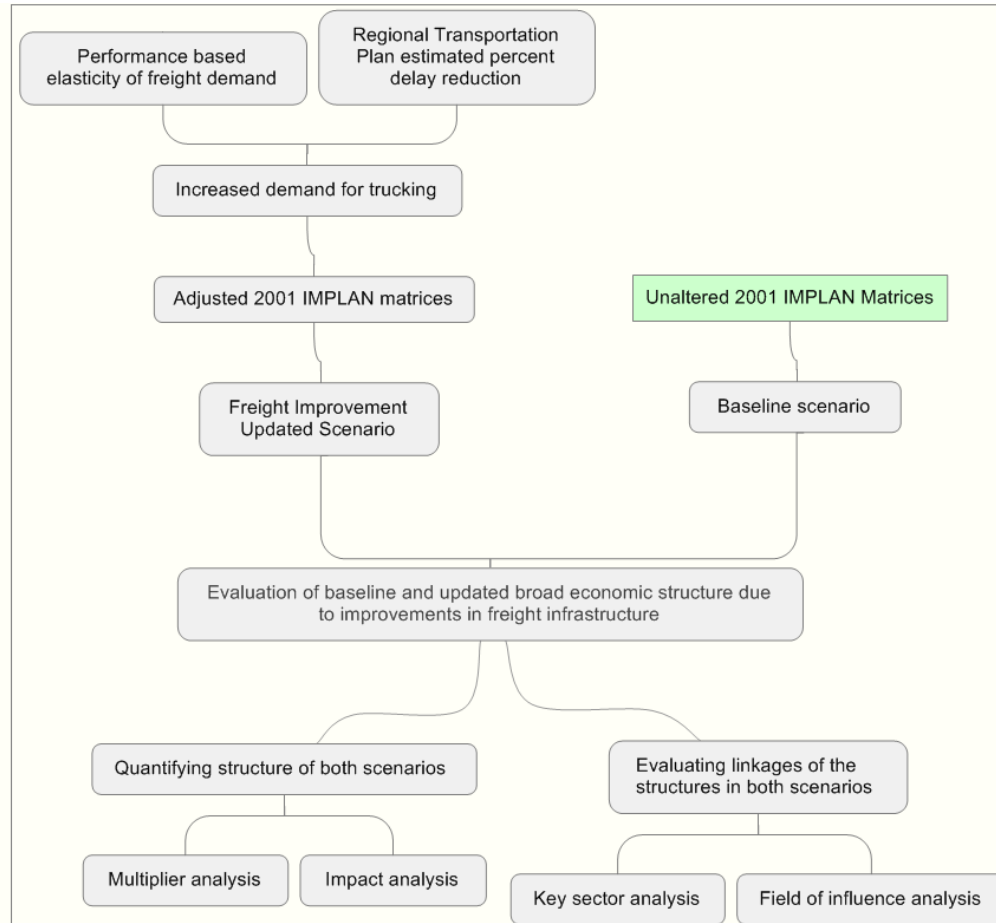


Project Design Continued

- ▶ **Geographic scope:**
 - Six county Metro Chicago region
 - Cook, Dupage, Lake, Kane, McHenry, and Will Counties
- ▶ **Data source:**
 - Input-output tables: IMPLAN 2001
 - Increased demand: FHWA and CATS
 - Impact analysis: CMAP ARRA Kennedy Expressway River Road to I-94.
- ▶ **Software**
 - Aggregation – IMPLAN
 - From 509 to 21 sectors
 - RAS, multiplier analysis, impact analysis, field of influence, key sector analysis – PyIO

IMPLAN Aggregated Sectors
11 Ag, Forestry, Fish & Hunting
21 Mining
22 Utilities
23 Construction
31-33 Manufacturing
42 Wholesale Trade
394 TRUCKING
48-49 Transportation & Warehousing
44-45 Retail trade
51 Information
52 Finance & insurance
53 Real estate & rental
54 Professional- scientific & tech svcs
55 Management of companies
56 Administrative & waste services
61 Educational svcs
62 Health & social services
71 Arts- entertainment & recreation
72 Accommodation & food services
81 Other services
92 Non NAICs

Input-Output Tables



Input-Output – Transactions

Sector/Sector 2001 Transactions Matrix In Millions	11 Ag, Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	494 Trucking	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional- scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts- entertainment & recreation	72 Accommodation & food services	81 Other services	92 Non-NAICS	
11 Ag, Forestry, Fish & Hunting		5.1	0.0	0.0	1.5	148.9	0.1	0.0	0.0	0.0	0.1	0.0	1.6	0.1	0.0	3.8	0.0	0.7	0.4	7.5	0.2	0.4
21 Mining	0.4	268.2	893.0	75.4	1802.7		2.1	24.4	0.6	0.8	2.0	0.4	3.1	1.7	0.2	0.7	0.1	4.1	0.2	2.8	4.1	106.9
22 Utilities	4.7	19.4	10.9	62.2	967.1		198.7	72.5	6.9	240.3	56.3	74.4	537.3	70.5	60.0	74.2	12.9	216.7	36.6	173.1	146.8	100.6
23 Construction	2.1	0.8	135.5	29.2	227.6		115.5	81.0	9.0	126.1	78.7	167.8	484.3	78.7	65.9	28.9	91.1	187.2	38.8	99.4	133.5	634.3
31-33 Manufacturing	58.6	164.0	207.6	4749.1	24903.6		1342.9	1562.3	375.2	554.9	1259.9	303.1	392.5	856.7	133.6	444.9	78.1	2545.1	123.3	1633.1	2438.3	910.6
42 Wholesale Trade	24.8	40.7	58.7	1049.8	7579.1		1359.4	376.9	272.4	167.7	305.6	72.8	97.6	180.6	22.5	167.8	31.0	798.6	36.8	584.2	524.6	274.9
48-49 Transportation & Warehousing	4.6	21.6	429.2	145.4	1039.5		736.2	1170.8	288.9	428.5	165.2	497.8	231.4	282.9	6.0	162.7	21.8	491.2	24.7	84.1	166.4	98.1
494 Trucking	5.6	17.6	21.5	352.2	1702.6		57.7	164.2	638.5	45.8	42.2	11.9	27.1	27.5	5.2	37.8	5.9	100.9	7.9	92.0	86.4	65.4
44-45 Retail trade	0.6	4.3	5.4	1870.4	224.2		263.9	58.2	80.7	283.7	34.5	43.7	235.6	103.6	0.1	196.3	3.5	174.3	15.6	99.8	360.6	399.6
51 Information	0.9	5.6	19.1	178.9	443.5		326.0	163.5	31.6	221.4	1247.3	327.6	194.1	422.8	134.6	129.1	36.3	305.4	37.5	81.1	153.4	58.7
52 Finance & insurance	8.2	36.7	71.9	380.8	1123.8		575.1	389.9	156.2	470.2	230.4	10348.7	874.4	381.4	14.7	186.0	42.6	832.4	70.5	192.1	191.0	1294.6
53 Real estate & rental	21.4	255.1	38.5	373.7	1791.2		947.5	572.4	128.0	1165.8	617.5	1255.8	1746.5	1030.2	258.9	358.7	247.4	1968.2	186.5	612.8	765.8	499.0
54 Professional- scientific & tech svcs	6.0	50.0	186.6	1496.5	2622.9		1916.7	934.5	121.3	1465.2	1265.0	2133.3	1235.0	2020.7	763.7	558.7	78.9	1384.5	206.6	358.2	508.4	634.0
55 Management of companies	0.1	72.1	3.7	24.7	1793.4		652.9	53.0	49.4	911.4	63.2	275.8	39.2	68.8	0.0	173.7	3.6	289.0	27.9	28.5	114.7	1.3
56 Administrative & waste services	0.9	8.4	51.0	311.0	605.3		1159.0	897.3	34.1	612.4	288.8	526.3	1531.0	1286.4	8.4	672.6	78.7	1535.0	108.2	137.4	410.2	326.5
61 Educational svcs	0.0	1.0	23.9	7.3	68.3		108.8	28.8	2.8	45.1	33.7	82.2	26.5	50.2	0.0	50.9	285.7	79.5	66.5	5.9	131.6	12.7
62 Health & social services	0.0	0.0	0.0	0.0	0.0		0.0	0.3	1.3	0.1	0.0	0.0	0.0	3.2	0.0	0.9	0.7	164.5	0.5	0.1	0.7	0.0
71 Arts- entertainment & recreation	0.5	20.4	2.2	12.9	76.6		45.6	6.4	1.5	22.1	213.9	64.6	35.4	111.8	1.1	26.4	6.2	36.8	299.5	55.5	34.5	2.5
72 Accommodation & food services	0.3	2.7	33.1	36.4	373.6		185.0	241.9	6.8	124.6	62.0	367.0	186.8	329.7	0.4	115.6	8.3	436.1	11.7	78.9	82.5	8.4
81 Other services	6.4	4.0	14.1	430.5	2202.7		467.3	243.4	337.2	251.8	272.0	197.3	287.7	281.8	145.2	311.4	29.1	393.9	65.1	137.6	238.5	294.8
92 Non-NAICS	1.7	15.7	13.6	63.8	1155.3		343.8	507.3	26.2	122.2	299.5	662.3	452.0	170.3	28.1	62.2	8.8	132.1	19.5	84.0	89.8	89.8

Outputs

Inputs

Input-Output – Direct Requirements

Sector/Sector 2001 Baseline Direct Requirements Matrix	11 Ag, Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	494 Trucking	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional- scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts- entertainment & recreation	72 Accommodation & food services	81 Other services	92 Non-NAICS
11 Ag, Forestry, Fish & Hunting	0.0078	0.0000	0.0000	0.0000	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0005	0.0000	0.0000
21 Mining	0.0006	0.0789	0.1125	0.0025	0.0149	0.0000	0.0011	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0002	0.0002	0.0019
22 Utilities	0.0072	0.0057	0.0014	0.0020	0.0080	0.0045	0.0034	0.0010	0.0090	0.0020	0.0012	0.0131	0.0013	0.0061	0.0040	0.0026	0.0061	0.0071	0.0121	0.0070	0.0018
23 Construction	0.0032	0.0002	0.0171	0.0010	0.0019	0.0026	0.0038	0.0013	0.0047	0.0028	0.0027	0.0118	0.0015	0.0067	0.0015	0.0184	0.0053	0.0075	0.0070	0.0064	0.0115
31-33 Manufacturing	0.0903	0.0482	0.0262	0.1553	0.2052	0.0307	0.0732	0.0557	0.0208	0.0444	0.0048	0.0096	0.0162	0.0136	0.0238	0.0158	0.0718	0.0239	0.1145	0.1171	0.0165
42 Wholesale Trade	0.0382	0.0120	0.0074	0.0343	0.0625	0.0310	0.0177	0.0404	0.0063	0.0108	0.0012	0.0024	0.0034	0.0023	0.0090	0.0063	0.0225	0.0071	0.0410	0.0252	0.0050
48-49 Transportation & Warehousing	0.0071	0.0003	0.0341	0.0048	0.0080	0.0168	0.0349	0.0429	0.0104	0.0038	0.0079	0.0057	0.0073	0.0008	0.0087	0.0044	0.0139	0.0067	0.0039	0.0080	0.0018
494 Trucking	0.0085	0.0052	0.0027	0.0115	0.0140	0.0013	0.0077	0.0948	0.0017	0.0015	0.0002	0.0007	0.0005	0.0005	0.0020	0.0012	0.0028	0.0015	0.0065	0.0041	0.0012
44-45 Retail trade	0.0009	0.0013	0.0007	0.0012	0.0018	0.0060	0.0027	0.0120	0.0106	0.0012	0.0007	0.0058	0.0020	0.0000	0.0105	0.0007	0.0049	0.0030	0.0070	0.0173	0.0072
51 Information	0.0014	0.0016	0.0024	0.0039	0.0037	0.0074	0.0077	0.0047	0.0083	0.0440	0.0052	0.0047	0.0080	0.0137	0.0069	0.0074	0.0086	0.0073	0.0057	0.0074	0.0011
52 Finance & insurance	0.0127	0.0108	0.0091	0.0125	0.0093	0.0131	0.0183	0.0232	0.0176	0.0081	0.1639	0.0214	0.0072	0.0015	0.0100	0.0086	0.0235	0.0137	0.0135	0.0092	0.0234
53 Real estate & rental	0.0329	0.0750	0.0048	0.0122	0.0148	0.0216	0.0268	0.0190	0.0437	0.0218	0.0199	0.0427	0.0195	0.0263	0.0192	0.0501	0.0555	0.0361	0.0430	0.0368	0.0090
54 Professional- scientific & tech svcs	0.0093	0.0147	0.0235	0.0490	0.0216	0.0438	0.0438	0.0180	0.0550	0.0446	0.0338	0.0302	0.0383	0.0776	0.0299	0.0160	0.0390	0.0400	0.0251	0.0244	0.0115
55 Management of companies	0.0002	0.0212	0.0005	0.0008	0.0148	0.0149	0.0025	0.0073	0.0342	0.0022	0.0044	0.0010	0.0013	0.0000	0.0093	0.0007	0.0081	0.0054	0.0020	0.0055	0.0000
56 Administrative & waste services	0.0015	0.0025	0.0064	0.0102	0.0050	0.0265	0.0420	0.0051	0.0230	0.0102	0.0083	0.0374	0.0244	0.0008	0.0360	0.0159	0.0433	0.0210	0.0096	0.0197	0.0059
61 Educational svcs	0.0000	0.0003	0.0030	0.0002	0.0006	0.0025	0.0013	0.0004	0.0017	0.0012	0.0013	0.0006	0.0010	0.0000	0.0027	0.0578	0.0022	0.0129	0.0004	0.0063	0.0002
62 Health & social services	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001	0.0046	0.0001	0.0000	0.0000	0.0000
71 Arts- entertainment & recreation	0.0007	0.0060	0.0003	0.0004	0.0006	0.0010	0.0003	0.0002	0.0008	0.0075	0.0010	0.0009	0.0021	0.0001	0.0014	0.0012	0.0010	0.0580	0.0039	0.0017	0.0000
72 Accommodation & food services	0.0004	0.0008	0.0042	0.0012	0.0031	0.0042	0.0113	0.0010	0.0047	0.0022	0.0058	0.0046	0.0062	0.0000	0.0062	0.0017	0.0123	0.0023	0.0055	0.0040	0.0002
81 Other services	0.0098	0.0012	0.0018	0.0141	0.0182	0.0107	0.0114	0.0501	0.0094	0.0096	0.0031	0.0070	0.0053	0.0148	0.0167	0.0059	0.0111	0.0126	0.0097	0.0115	0.0053
92 Non-NAICS	0.0027	0.0046	0.0017	0.0021	0.0095	0.0078	0.0238	0.0039	0.0046	0.0106	0.0105	0.0111	0.0032	0.0029	0.0033	0.0018	0.0037	0.0038	0.0059	0.0043	0.0016

Outputs

Inputs

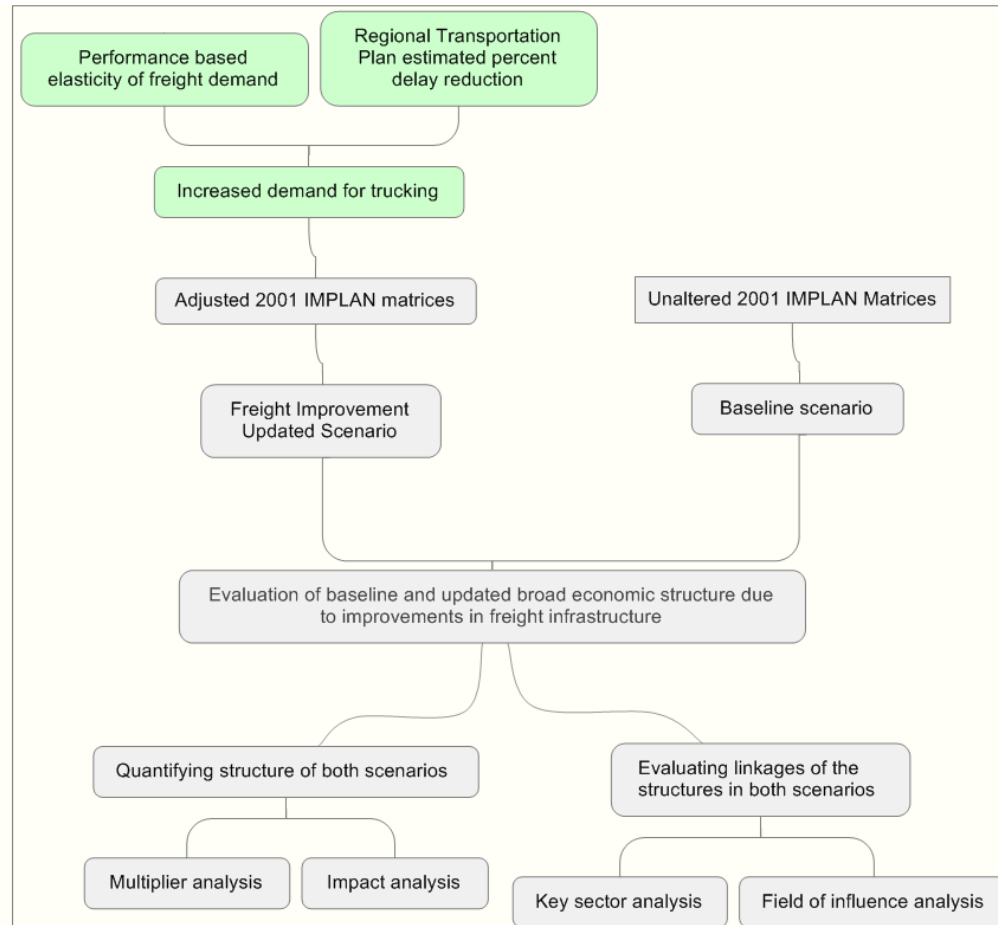
Input-Output – Leontief Inverse

Sector/Sector 2001 Baseline Leontief Inverse Matrix	11 Ag, Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	394 TRUCKING	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts entertainment & recreation	72 Accommodation & food services	81 Other services	92 Non-NAICS	
11 Ag, Forestry, Fish & Hunting	1.0081	0.0001	0.0001	0.0003	0.0016	0.0001	0.0002	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0003	0.0000	0.0002	0.0002	0.0007	0.0002	0.0000
21 Mining	0.0038	1.0879	0.1236	0.0068	0.0221	0.0017	0.0039	0.0023	0.0021	0.0016	0.0006	0.0023	0.0008	0.0013	0.0014	0.0011	0.0030	0.0019	0.0047	0.0041	0.0029	
22 Utilities	0.0094	0.0085	1.0034	0.0054	0.0118	0.0062	0.0060	0.0037	0.0110	0.0036	0.0023	0.0146	0.0024	0.0071	0.0055	0.0042	0.0089	0.0092	0.0150	0.0099	0.0025	
23 Construction	0.0047	0.0022	0.0182	1.0028	0.0040	0.0041	0.0058	0.0034	0.0065	0.0041	0.0041	0.0133	0.0023	0.0077	0.0028	0.0208	0.0074	0.0096	0.0089	0.0083	0.0120	
31-33 Manufacturing	0.1238	0.0732	0.0543	0.2094	1.2748	0.0502	0.1108	0.0981	0.0383	0.0665	0.0139	0.0226	0.0274	0.0254	0.0404	0.0311	0.1057	0.0428	0.1572	0.1601	0.0266	
42 Wholesale Trade	0.0495	0.0197	0.0155	0.0519	0.0854	1.0375	0.0295	0.0561	0.0115	0.0175	0.0038	0.0062	0.0068	0.0056	0.0141	0.0109	0.0333	0.0128	0.0550	0.0389	0.0080	
48-49 Transportation & Warehousing	0.0116	0.0104	0.0002	0.0041	0.0161	0.0000	1.0021	0.0042	0.0000	0.0000	0.0110	0.0000	0.0001	0.0000	0.0110	0.0000	0.0102	0.0101	0.0110	0.0102	0.0000	
394 TRUCKING	0.0119	0.0077	0.0055	0.0056	0.0205	0.0028	0.0113	1.1073	0.0031	0.0031	0.0008	0.0017	0.0014	0.0013	0.0034	0.0024	0.0056	0.0030	0.0102	0.0077	0.0020	
44-45 Retail trade	0.0026	0.0028	0.0029	0.0039	0.0045	0.0078	0.0054	0.0159	1.0125	0.0027	0.0019	0.0080	0.0030	0.0014	0.0122	0.0031	0.0075	0.0052	0.0094	0.0198	0.0086	
51 Information	0.0033	0.0038	0.0045	0.0094	0.0072	0.0100	0.0109	0.0083	0.0112	1.0476	0.0076	0.0066	0.0096	0.0157	0.0090	0.0095	0.0118	0.0099	0.0084	0.0103	0.0020	
52 Finance & insurance	0.0200	0.0189	0.0165	0.0223	0.0191	0.0201	0.0290	0.0367	0.0257	0.0138	1.1986	0.0295	0.0113	0.0046	0.0155	0.0145	0.0345	0.0214	0.0225	0.0172	0.0298	
53 Real estate & rental	0.0406	0.0901	0.0204	0.0051	0.0283	0.0295	0.0380	0.0322	0.0529	0.0289	0.0281	1.0495	0.0243	0.0315	0.0260	0.0591	0.0670	0.0461	0.0533	0.0473	0.0125	
54 Professional- scientific & tech svcs	0.0193	0.0268	0.0350	0.0068	0.0399	0.0554	0.0593	0.0350	0.0685	0.0550	0.0462	0.0392	1.0448	0.0850	0.0392	0.0246	0.0542	0.0523	0.0391	0.0385	0.0164	
55 Management of companies	0.0033	0.0250	0.0047	0.0077	0.0214	0.0172	0.0060	0.0119	0.0361	0.0042	0.0059	0.0025	0.0025	1.0009	0.0113	0.0020	0.0116	0.0074	0.0062	0.0099	0.0012	
56 Administrative & waste services	0.0069	0.0091	0.0128	0.0088	0.0132	0.0333	0.0521	0.0146	0.0303	0.0157	0.0138	0.0436	0.0288	0.0054	1.0417	0.0221	0.0528	0.0285	0.0172	0.0273	0.0084	
61 Educational svcs	0.0005	0.0008	0.0036	0.0010	0.0014	0.0032	0.0021	0.0014	0.0023	0.0018	0.0019	0.0011	0.0013	0.0003	0.0034	1.0617	0.0031	0.0150	0.0011	0.0073	0.0005	
62 Health & social services	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0002	1.0047	0.0001	0.0000	0.0000	0.0000	
71 Arts- entertainment & recreation	0.0011	0.0073	0.0014	0.0011	0.0014	0.0016	0.0009	0.0008	0.0014	0.0087	0.0016	0.0013	0.0026	0.0005	0.0019	0.0017	0.0017	1.0621	0.0047	0.0023	0.0002	
72 Accommodation & food services	0.0018	0.0022	0.0058	0.0034	0.0053	0.0058	0.0138	0.0033	0.0063	0.0035	0.0078	0.0059	0.0072	0.0011	0.0075	0.0028	0.0145	0.0038	1.0074	0.0058	0.0008	
81 Other services	0.0144	0.0050	0.0052	0.0015	0.0270	0.0143	0.0174	0.0604	0.0131	0.0130	0.0054	0.0097	0.0074	0.0167	0.0198	0.0087	0.0166	0.0165	0.0155	1.0173	0.0069	
92 Non-NAICS	0.0055	0.0077	0.0051	0.0052	0.0144	0.0103	0.0281	0.0084	0.0072	0.0129	0.0137	0.0129	0.0046	0.0042	0.0052	0.0036	0.0074	0.0061	0.0095	0.0078	1.0027	

Outputs

Inputs

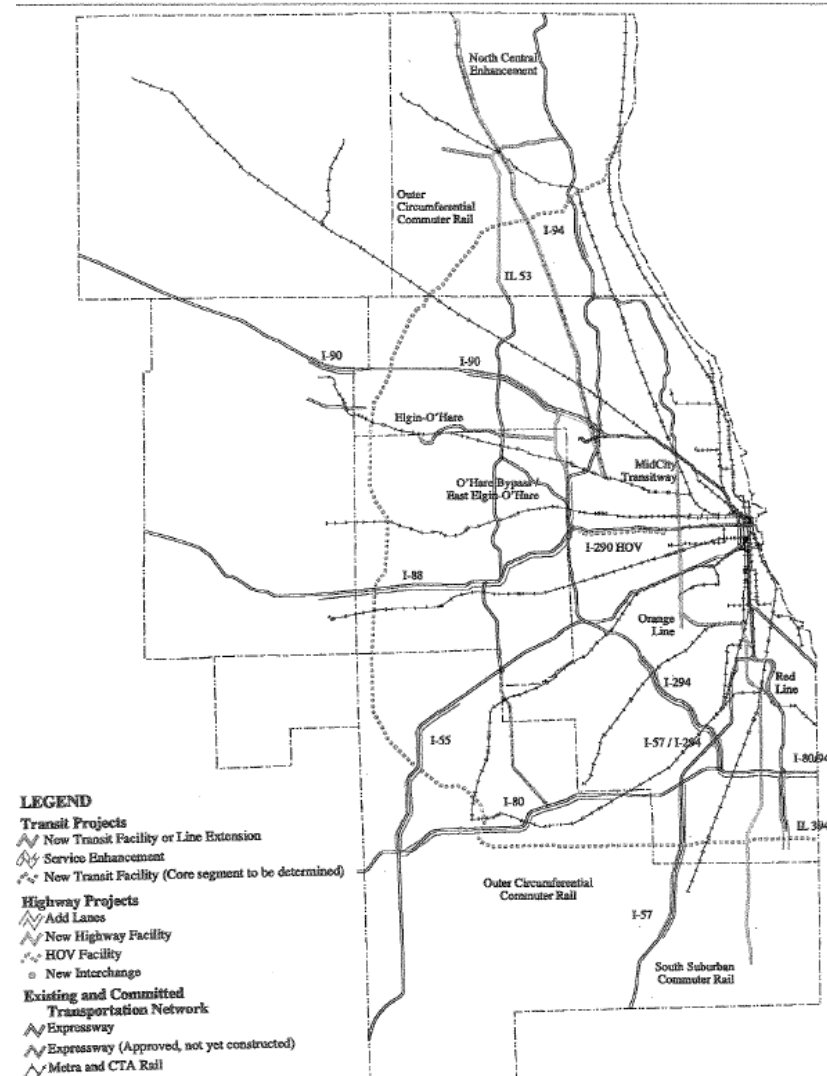
Increased Demand for Trucking



Chicago Area Transit Study 2020 Regional Transportation Plan

- ▶ 20 capital improvement projects
- ▶ \$12.3 Billion
- ▶ Expressway lanes expand by 16%
- ▶ Delay reduction 4.9%

FIGURE 5.1
2020 RTP HIGHWAY AND TRANSIT PROJECTS



(CATS, 1997)

Increased Demand for Trucking

- ▶ Increase in demand in this study is achieved by increasing output for trucking
 - Increase in output is calculated by multiplication of delay reduction and performance elasticity
 - Delay reduction estimate is a result of the proposed CATS 2020 Regional Transportation Plan
 - Performance elasticity is estimated from the FHWA Benefit Tool
 - Based on 18 central corridors

(CATS, 1997)

(HLB Decision Economics, 2008)

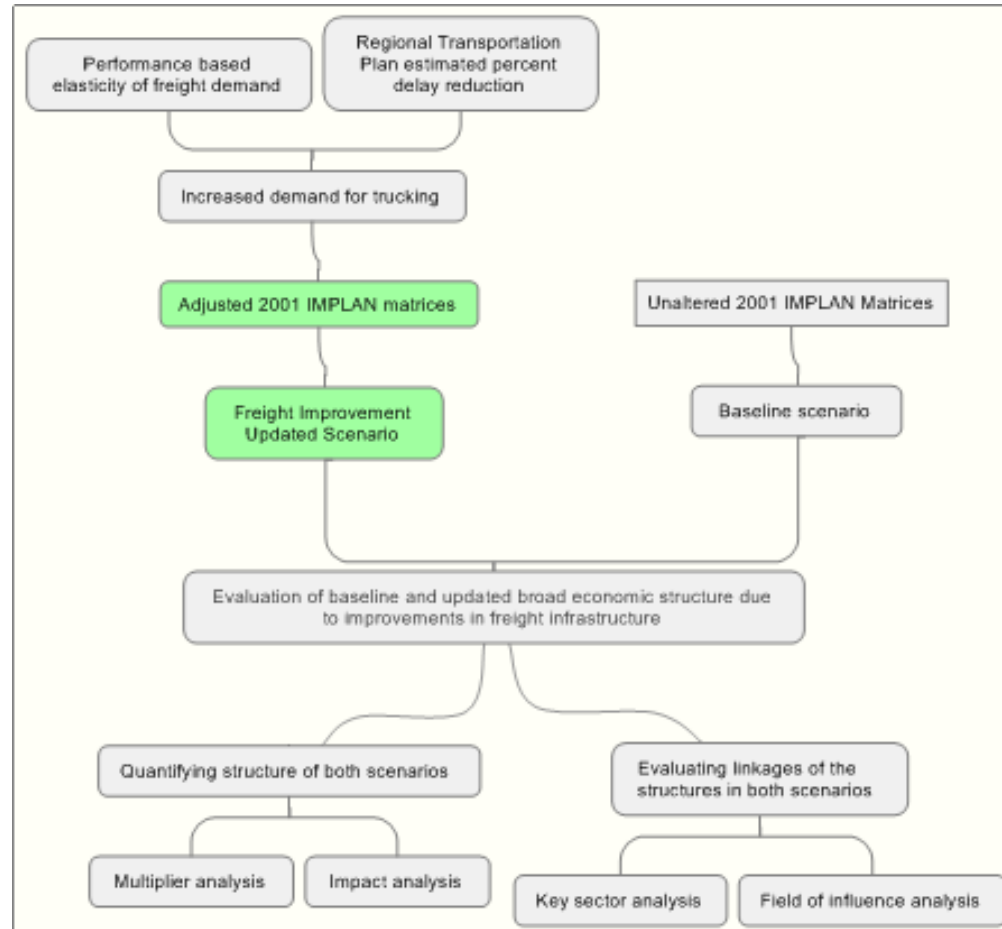
Increased Demand for Trucking Continued

- ▶ Original trucking output (O^0) = \$6,737.7 Mil.
- ▶ Performance elasticity (e) = 0.0175
- ▶ Delay reduction (d) = 4.9%
- ▶ Increased demand (D) = $e * d = 0.08575\%$
- ▶ New trucking output $o = O^0 * D = \$5.7$ Mil.
- ▶ New total trucking output (O^1) = $O^0 + o = \$6,743.4$ Mil.

(CATS, 1997)

(HLB Decision Economics, 2008)

Adjusting Matrices



RAS Method

- ▶ Iterative method for balancing a new matrix based on an existing matrix with at least one change
 - Simple – only column and row sums
 - Modified – some known values

$$A^t = [R][A^0][S]$$

Applied to

$$\sum_j^n r_i x_{ij}^0 s_j = u_i^t \text{ and } \sum_i^n r_i x_{ij}^0 s_j = v_j^t$$

Where

$[R] = r_i$ *Diagonal Matrices of row*

$[S] = s_j$ *and column oriented multipliers*

$A^t =$ *Updated Matrix*

$A^0 =$ *Original Matrix*

$x_{ij}^0 =$ *Sectoral Output*

$v_j^t =$ *Intermediate Input*

$u_i^t =$ *Intermediate Output*

RAS Method Continued

5.086933	0.015341	0.002733	1.51582	148.8891	0.060638	0.022676	0.001047	0.042481	0.105836	0.031178	1.565191	0.10494	0.00013	3.751113	0.006767	0.679443	0.421712	7.459616	0.183684	0.35766
0.361017	268.2332	893.006	75.424	1802.695	2.073735	24.39603	0.5916	0.837462	1.960481	0.437491	3.118499	1.736033	0.192634	0.689029	0.121721	4.080254	0.189623	2.772867	4.084241	106.8717
4.672941	19.3981	10.93628	62.17779	967.1129	198.6822	72.47576	6.947254	240.2962	56.34512	74.40577	537.3356	70.51377	59.97962	74.24538	12.91503	216.7479	36.5791	173.1027	146.8167	100.6479
2.1081	0.810423	135.4845	29.22458	227.637	115.5212	80.98029	9.026551	126.1	78.72321	167.7705	484.273	78.69296	65.88064	28.88632	91.12934	187.1779	38.83796	99.44479	133.5215	634.3312
58.63253	163.9656	207.6404	4749.125	24903.55	1342.937	1562.262	375.1981	554.8865	1259.875	303.0704	392.5434	856.656	133.6321	444.9409	78.14545	2545.059	123.3412	1633.137	2438.258	910.5834
24.83313	40.72536	58.6697	1049.771	7579.091	1359.363	376.9128	272.3517	167.657	305.6121	72.75462	97.62643	180.6241	22.49518	167.8301	30.99471	798.6097	36.79496	584.153	524.5509	274.857
4.636104	21.553	429.2956	145.4445	1039.543	736.2556	1170.78	288.9101	438.502	165.2768	497.761	231.3918	382.8887	6.004164	162.6955	21.82805	491.3295	34.68439	84.11803	166.4461	98.12482
5.55028	17.59169	21.47335	352.1751	1702.579	57.65981	164.174	638.5462	45.83984	42.22573	11.9338	27.12103	27.47347	5.153303	37.78648	5.922647	100.9359	7.893305	92.02738	86.36195	65.36594
0.58328	4.305458	5.423228	1870.449	224.1634	263.8713	58.16037	80.68802	283.689	34.49886	43.69567	235.6073	103.643	0.134522	196.2862	3.451405	174.2682	15.64104	99.84718	360.5682	399.6143
0.909314	5.579999	19.07575	178.9192	443.5404	326.0439	163.5471	31.56719	221.395	1247.297	327.6157	194.0517	422.828	134.5907	129.0901	36.3257	305.4006	37.50465	81.07953	153.4141	58.6923
8.242861	36.68509	71.90141	380.7767	1123.794	575.1057	389.9062	156.2203	470.2065	230.4018	10348.7	874.4224	381.4398	14.74207	185.9806	42.57558	832.4166	70.52486	192.1152	190.9542	1294.633
21.37578	255.0714	38.47086	373.6964	1791.206	947.5307	572.3583	128.0225	1165.801	617.5231	1255.812	1746.471	1030.226	258.9448	358.6541	247.4467	1968.163	186.5034	612.793	765.7767	498.9884
6.015656	49.99896	186.6056	1496.544	2622.879	1916.664	934.5229	121.3414	1465.249	1264.961	2133.314	1235.004	2020.719	763.7021	558.7387	78.86127	1384.498	206.6196	358.2433	508.3842	633.9791
0.106073	72.14805	3.653798	24.69967	1793.43	652.9193	53.02261	49.36047	911.4219	63.24127	275.7817	39.23797	68.78315	0	173.7459	3.646641	289.0293	27.90034	28.50656	114.7246	1.29713
0.945798	8.35771	50.9635	310.9624	605.296	1159.032	897.3295	34.13379	612.3707	288.7893	526.2917	1530.96	1286.408	8.36251	672.5771	78.70386	1535.043	108.2143	137.3666	410.2345	326.5164
0.001612	1.015886	23.92773	7.279264	68.34661	108.7843	28.78571	2.769397	45.05927	33.72615	82.24393	26.47574	50.18031	0.036629	50.88395	285.6592	79.4679	66.47775	5.91049	131.5853	12.74369
0	0	0	0	0	0	0.300183	1.319572	0.094253	0	0.035891	0	3.17449	0	0.891666	0.728856	164.4997	0.507457	0.056916	0.73063	0
0.451484	20.43378	2.19276	12.91122	76.57497	45.63405	6.400532	1.491173	22.14304	213.8534	64.5663	35.35624	111.7808	1.054283	26.39989	6.160535	36.81159	299.4744	55.50123	34.49619	2.48562
0.292286	2.712946	33.06487	36.44283	373.5908	185.0247	241.9381	6.812844	124.6471	62.01213	367.0299	186.8387	329.7054	0.417595	115.5769	8.308138	436.118	11.7357	78.91736	82.49126	8.413024
6.383162	3.95237	14.09109	430.499	2202.737	467.3282	243.3554	337.2471	251.8491	272.0147	197.2866	287.7069	281.7584	145.2018	311.4497	29.14711	393.8589	65.06014	137.6185	238.5177	294.7836
1.73893	15.65036	13.599	63.79451	1155.275	343.7753	507.2743	26.24657	122.157	299.4505	662.2649	452.0029	170.2786	28.12917	62.18983	8.781835	132.1292	19.48016	84.02367	89.75465	89.81019
649.6	3399.6	7935.4	30571.7	121334	43799.5	21342.6	6737.7	26657.8	28353.3	63153.9	40898.9	52765.7	9836.7	18658	4939.7	35467.9	5159.2	14259.3	20827.3	55213.8

Original Output

649.6	3399.6	7935.4	30571.7	121334	43799.5	21342.6	6743.4	26657.8	28353.3	63153.9	40898.9	52765.7	9836.7	18658	4939.7	35467.9	5159.2	14259.3	20827.3	55213.8
-------	--------	--------	---------	--------	---------	---------	--------	---------	---------	---------	---------	---------	--------	-------	--------	---------	--------	---------	---------	---------

Updated Output

(IMPLAN, 2001)

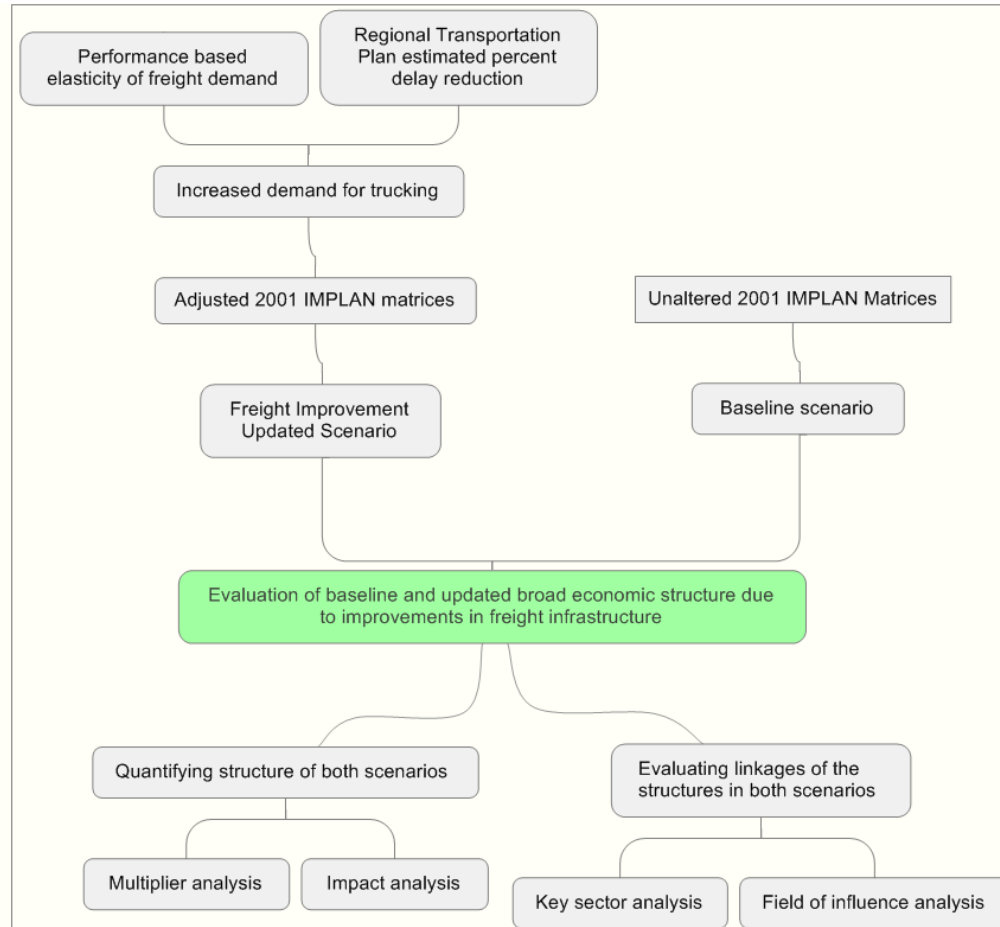
RAS Method Continued

Difference between Original and updated tables

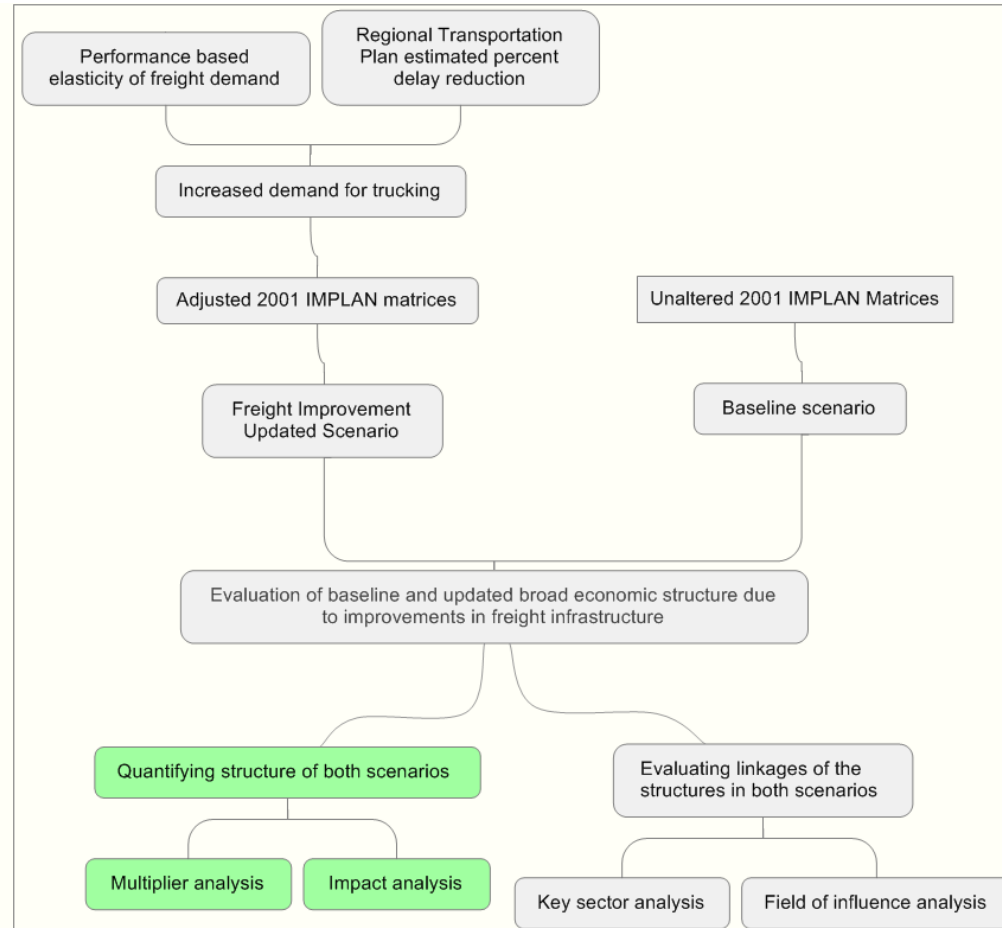
Sector/Sector 2001 RAS Updated Total Requirements Matrix	11 Ag, Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	394 TRUCKING	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional-scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts-entertainment & recreation	72 Accommodation & food services	81 Other services	92 Non-NAICS	
11 Ag, Forestry, Fish & Hunting	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
21 Mining	0.000000	0.000001	-0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
22 Utilities	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
23 Construction	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
31-33 Manufacturing	0.000018	0.000001	0.000000	0.000001	0.000000	0.000000	0.000000	0.000047	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000001	0.000000
42 Wholesale Trade	0.000007	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000034	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
48-49 Transportation	0.000001	0.000000	-0.000001	0.000000	0.000000	0.000000	0.000000	0.000036	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
394 TRUCKING	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000089	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
44-45 Retail trade	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000010	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
51 Information	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000004	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
52 Finance & insurance	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000020	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
53 Real estate & rental	0.000006	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000016	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000001	0.000000	-0.000001	0.000000	-0.000001	0.000000	0.000000	0.000000	0.000000
54 Professional-scientific & tech	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000015	0.000001	0.000000	0.000000	0.000000	0.000000	-0.000003	0.000000	0.000000	0.000000	-0.000001	0.000000	0.000000	0.000000	0.000000
55 Management of companies	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000006	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
56 Administrative & waste services	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000004	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
61 Educational svcs	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
62 Health & social services	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000
71 Arts-entertainment &	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	-0.000004	0.000000	0.000000	0.000000
72 Accommodation & food services	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
81 Other services	0.000002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000043	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
92 Non-NAICS	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000003	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Blue cells are above average change, yellow cells are below average change, gray cells have no change. Outlined cells are the 10 highest and lowest values.

Evaluation



Quantifying Change



Multiplier Analysis

- ▶ For this project type I (direct and indirect) output multipliers
 - Multipliers are column sum of the Leontief inverse

The Leontief inverse is given as

$$B = (b_{ij})$$

Out multipliers are given as

$$O_j$$

Then

$$O_j = \sum_{i=1}^n b_{ij}$$

Multiplier Analysis Continued

- ▶ Greater efficiency means money goes through fewer rounds of spending

Baseline and Updated Output Multipliers			
	Baseline Scenario	Updated Scenario	Change
11 Ag, Forestry, Fish & Hunting	1.34204	1.34198	-0.00007
21 Mining	1.40909	1.40909	-0.00001
22 Utilities	1.39867	1.39867	0.00000
23 Construction	1.55185	1.55184	-0.00001
31-33 Manufacturing	1.61932	1.61931	-0.00001
42 Wholesale Trade	1.33182	1.33182	0.00000
48-49 Transportation & Warehousing	1.49277	1.49276	-0.00001
394 Trucking	1.55422	1.55370	-0.00052
44-45 Retail trade	1.36067	1.36067	0.00000
51 Information	1.31314	1.31314	0.00000
52 Finance & insurance	1.36923	1.36923	0.00000
53 Real estate & rental	1.27965	1.27965	0.00000
54 Professional- scientific & tech svcs	1.19807	1.19807	0.00000
55 Management of companies	1.21849	1.21849	0.00001
56 Administrative & waste services	1.27242	1.27242	0.00000
61 Educational svcs	1.29122	1.29123	0.00001
62 Health & social services	1.47058	1.47058	0.00000
71 Arts- entertainment & recreation	1.36424	1.36424	0.00000
72 Accomodation & food services	1.45757	1.45757	0.00000
81 Other services	1.45327	1.45327	0.00000
92 Non-NAICS	1.14737	1.14737	0.00000

(Miller and Blair, 1985)

Impact Analysis

- ▶ For this project type I (direct and indirect) impact analyses were conducted

$$X = (I - A)^{-1}F$$

where

X = output

$(I - A)^{-1}$ = The Leontief Matrix

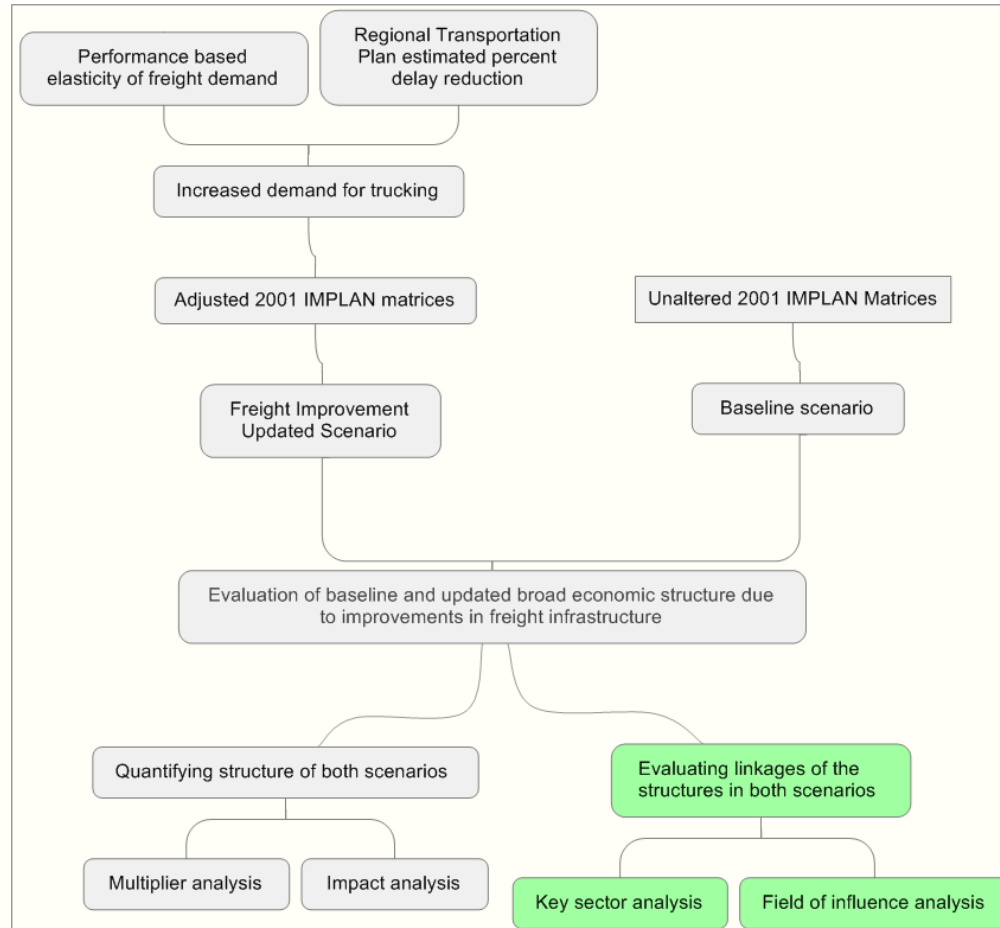
F = Final Demand

Impact Analysis Continued

- ▶ \$16.07 Million Total
 - \$14.22 Million outside funds
 - Almost unnoticeable decrease in updated scenario

Impact Analysis for the American Recovery and Reinvestment Act Kennedy Expressway Repaving		
All Values in Millions of 2001 Dollars	Baseline Scenario	Updated Scenario
11 Ag, Forestry, Fish & Hunting	0.00450	0.00450
21 Mining	0.09629	0.09629
22 Utilities	0.07715	0.07714
23 Construction	14.25945	14.25945
31-33 Manufacturing	2.97751	2.97747
42 Wholesale Trade	0.73746	0.73744
48-49 Transportation & Warehousing	0.16219	0.16218
394 Trucking	0.23628	0.23626
44-45 Retail trade	0.90894	0.90894
51 Information	0.13308	0.13307
52 Finance & insurance	0.31743	0.31743
53 Real estate & rental	0.35702	0.35701
54 Professional- scientific & tech svcs	0.95015	0.95014
55 Management of companies	0.10945	0.10944
56 Administrative & waste services	0.26687	0.26687
61 Educational svcs	0.01447	0.01447
62 Health & social services	0.00014	0.00014
71 Arts- entertainment & recreation	0.01580	0.01580
72 Accomodation & food services	0.04893	0.04893
81 Other services	0.30593	0.30592
92 Non-NAICS	0.08821	0.08820
Total Impact	22.06724	22.06710

Linkage Analysis



Field of Influence Analysis

- ▶ Three orders of field of influence analysis
 - First order FOI evaluates the probable impact of a change in one inter-industry relationship to the Leontief inverse
 - Second order FOI evaluates the probable impact of a change to one sector of the Leontief Inverse
 - Third order FOI estimates the impact of a change to the entire Leontief Inverse.

(Sonis and Hewings 1991)

Field of Influence Analysis Continued

- ▶ First order field of influence is calculated in this study
 - First order FOI evaluates the probable impact of a change in one inter-industry relationship to the Leontief inverse (i.e. a single cell)
 - Useful for identifying specific relationships that may have greater than average potential

$$B' = B \frac{1}{Q(E)} \left(\sum_{k=1, k \neq i_s}^n \sum_{j=1, j \neq j_s} F_k^{e_j i_s} \dots e_{j k i k} \right)$$

Where $Q(E)$ = the ratio the determinants of B, B', F_k .
Field of influence first order is given as

$$F[i, j] = \begin{pmatrix} b_{1i} \\ \vdots \\ \cdot \\ \vdots \\ b_{ni} \end{pmatrix} (b_{j1} \quad \cdot \quad \cdot \quad \cdot \quad b_{jn})$$

$A[a_{ij}]$ = Direct requirement matrix

$E[e_{ij}]$ = A Matrix containing changes to direct requirement matrix

$B[b_{ij}]$ = Leontief inverse matrix = $(I - A)^{-1}$

$B'[b'_{ij}]$ = Leontief inverse matrix after change in direct requirement matrix
= $(I - A - E)^{-1}$

Baseline Scenario Field of Influence Analysis

Baseline Scenario Field of Influence Analysis with Change Occuring in Row 8 Column 5																					
Sector/Sector 2001 Baseline	11 Ag. Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	394 TRUCKING	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional-scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts-entertainment & recreation	72 Accomodation & food services	81 Other services	92 Non-NAICS
11 Ag. Forestry, Fish & Hunting	0.00002	0.00001	0.00001	0.00003	0.00016	0.00001	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001	0.00000	0.00001	0.00001	0.00002	0.00002	0.00000
21 Mining	0.00028	0.00017	0.00012	0.00047	0.00288	0.00011	0.00025	0.00022	0.00009	0.00015	0.00003	0.00005	0.00006	0.00006	0.00009	0.00007	0.00024	0.00010	0.00035	0.00036	0.00006
22 Utilities	0.00046	0.00027	0.00020	0.00077	0.00470	0.00018	0.00041	0.00036	0.00014	0.00024	0.00005	0.00008	0.00010	0.00009	0.00015	0.00011	0.00039	0.00016	0.00058	0.00059	0.00010
23 Construction	0.00042	0.00025	0.00018	0.00070	0.00428	0.00017	0.00037	0.00033	0.00013	0.00022	0.00005	0.00008	0.00009	0.00009	0.00014	0.00010	0.00035	0.00014	0.00053	0.00054	0.00009
31-33 Manufacturing	0.01215	0.00718	0.00533	0.02055	0.12511	0.00493	0.01088	0.00963	0.00376	0.00652	0.00137	0.00222	0.00269	0.00250	0.00397	0.00305	0.01037	0.00420	0.01543	0.01571	0.00261
42 Wholesale Trade	0.00694	0.00410	0.00304	0.01174	0.07147	0.00281	0.00621	0.00550	0.00215	0.00373	0.00078	0.00127	0.00153	0.00143	0.00227	0.00174	0.00592	0.00240	0.00882	0.00898	0.00149
48-49 Transportation	0.00671	0.00396	0.00294	0.01134	0.06905	0.00272	0.00600	0.00532	0.00207	0.00360	0.00076	0.00122	0.00148	0.00138	0.00219	0.00168	0.00572	0.00232	0.00852	0.00867	0.00144
394 TRUCKING	0.13708	0.08103	0.06013	0.23185	1.41157	0.05557	0.12272	0.10867	0.04239	0.07359	0.01544	0.02504	0.03032	0.02815	0.04476	0.03442	0.11698	0.04735	0.17410	0.17727	0.02945
44-45 Retail trade	0.00197	0.00116	0.00086	0.00333	0.02025	0.00080	0.00176	0.00156	0.00061	0.00106	0.00022	0.00036	0.00043	0.00040	0.00064	0.00049	0.00168	0.00068	0.00250	0.00254	0.00042
51 Information	0.00103	0.00061	0.00045	0.00174	0.01056	0.00042	0.00092	0.00081	0.00032	0.00055	0.00012	0.00019	0.00023	0.00021	0.00033	0.00026	0.00088	0.00035	0.00130	0.00133	0.00022
52 Finance & insurance	0.00454	0.00269	0.00199	0.00768	0.04678	0.00184	0.00407	0.00360	0.00140	0.00244	0.00051	0.00083	0.00100	0.00093	0.00148	0.00114	0.00388	0.00157	0.00577	0.00588	0.00098
53 Real estate & rental	0.00399	0.00236	0.00175	0.00674	0.04104	0.00162	0.00357	0.00316	0.00123	0.00214	0.00045	0.00073	0.00088	0.00082	0.00130	0.00100	0.00340	0.00138	0.00506	0.00515	0.00086
54 Professional-scientific & tech	0.00434	0.00256	0.00190	0.00734	0.04468	0.00176	0.00388	0.00344	0.00134	0.00233	0.00049	0.00079	0.00096	0.00089	0.00142	0.00109	0.00370	0.00150	0.00551	0.00561	0.00093
55 Management of companies	0.00147	0.00087	0.00064	0.00248	0.01513	0.00060	0.00132	0.00116	0.00045	0.00079	0.00017	0.00027	0.00032	0.00030	0.00048	0.00037	0.00125	0.00051	0.00187	0.00190	0.00032
56 Administrative & waste services	0.00181	0.00107	0.00079	0.00306	0.01861	0.00073	0.00162	0.00143	0.00056	0.00097	0.00020	0.00033	0.00040	0.00037	0.00059	0.00045	0.00154	0.00062	0.00229	0.00234	0.00039
61 Educational svcs	0.00017	0.00010	0.00008	0.00029	0.00177	0.00007	0.00015	0.00014	0.00005	0.00009	0.00002	0.00003	0.00004	0.00004	0.00006	0.00004	0.00015	0.00006	0.00022	0.00022	0.00004
62 Health & social services	0.00003	0.00002	0.00001	0.00005	0.00029	0.00001	0.00002	0.00002	0.00001	0.00001	0.00000	0.00001	0.00001	0.00001	0.00001	0.00001	0.00002	0.00001	0.00004	0.00004	0.00001
71 Arts-entertainment &	0.00010	0.00006	0.00004	0.00017	0.00102	0.00004	0.00009	0.00008	0.00003	0.00005	0.00001	0.00002	0.00002	0.00002	0.00003	0.00002	0.00008	0.00003	0.00013	0.00013	0.00002
72 Accomodation & food services	0.00041	0.00024	0.00018	0.00070	0.00424	0.00017	0.00037	0.00033	0.00013	0.00022	0.00005	0.00008	0.00009	0.00008	0.00013	0.00010	0.00035	0.00014	0.00052	0.00053	0.00009
81 Other services	0.00748	0.00442	0.00328	0.01266	0.07706	0.00303	0.00670	0.00593	0.00231	0.00402	0.00084	0.00137	0.00165	0.00154	0.00244	0.00188	0.00639	0.00258	0.00950	0.00968	0.00161
92 Non-NAICS	0.00104	0.00061	0.00046	0.00176	0.01070	0.00042	0.00093	0.00082	0.00032	0.00056	0.00012	0.00019	0.00023	0.00021	0.00034	0.00026	0.00089	0.00036	0.00132	0.00134	0.00022

Blue cells are above average change, yellow cells are below average change, gray cells have no change. Outlined cells are the 10 highest and lowest values.

Updated Scenario Field of Influence Analysis

Updated Scenario Field of Influence Analysis with Change Occurring in Row 8 Column 5																					
Sector/Sector 2001 RAS Updated	11 Ag, Forestry, Fish & Hunting	21 Mining	22 Utilities	23 Construction	31-33 Manufacturing	42 Wholesale Trade	48-49 Transportation & Warehousing	394 TRUCKING	44-45 Retail trade	51 Information	52 Finance & insurance	53 Real estate & rental	54 Professional-scientific & tech svcs	55 Management of companies	56 Administrative & waste services	61 Educational svcs	62 Health & social services	71 Arts-entertainment & recreation	72 Accommodation & food services	81 Other services	92 Non-NAICS
11 Ag, Forestry, Fish & Hunting	0.00002	0.00001	0.00001	0.00003	0.00016	0.00001	0.00001	0.00001	0.00000	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001	0.00000	0.00001	0.00001	0.00002	0.00002	0.00000
21 Mining	0.00028	0.00016	0.00012	0.00047	0.00287	0.00011	0.00025	0.00022	0.00009	0.00015	0.00003	0.00005	0.00006	0.00006	0.00009	0.00007	0.00024	0.00010	0.00035	0.00036	0.00006
22 Utilities	0.00046	0.00027	0.00020	0.00077	0.00469	0.00018	0.00041	0.00036	0.00014	0.00024	0.00005	0.00008	0.00010	0.00009	0.00015	0.00011	0.00039	0.00016	0.00058	0.00059	0.00010
23 Construction	0.00042	0.00025	0.00018	0.00070	0.00428	0.00017	0.00037	0.00033	0.00013	0.00022	0.00005	0.00008	0.00009	0.00009	0.00014	0.00010	0.00035	0.00014	0.00053	0.00054	0.00009
31-33 Manufacturing	0.01214	0.00717	0.00532	0.02053	0.12499	0.00492	0.01087	0.00961	0.00375	0.00652	0.00137	0.00222	0.00268	0.00249	0.00396	0.00305	0.01036	0.00419	0.01542	0.01570	0.00261
42 Wholesale Trade	0.00693	0.00410	0.00304	0.01173	0.07141	0.00281	0.00621	0.00549	0.00214	0.00372	0.00078	0.00127	0.00153	0.00142	0.00226	0.00174	0.00592	0.00240	0.00881	0.00897	0.00149
48-49 Transportation	0.00670	0.00396	0.00294	0.01133	0.06899	0.00272	0.00600	0.00531	0.00207	0.00360	0.00075	0.00122	0.00148	0.00138	0.00219	0.00168	0.00572	0.00231	0.00851	0.00866	0.00144
394 TRUCKING	0.13704	0.08102	0.06012	0.23183	1.41144	0.05556	0.12271	0.10856	0.04238	0.07358	0.01544	0.02503	0.03031	0.02815	0.04475	0.03442	0.11697	0.04735	0.17408	0.17726	0.02945
44-45 Retail trade	0.00196	0.00116	0.00086	0.00332	0.02023	0.00080	0.00176	0.00156	0.00061	0.00105	0.00022	0.00036	0.00043	0.00040	0.00064	0.00049	0.00168	0.00068	0.00250	0.00254	0.00042
51 Information	0.00102	0.00061	0.00045	0.00173	0.01055	0.00042	0.00092	0.00081	0.00032	0.00055	0.00012	0.00019	0.00023	0.00021	0.00033	0.00026	0.00087	0.00035	0.00130	0.00133	0.00022
52 Finance & insurance	0.00454	0.00268	0.00199	0.00768	0.04674	0.00184	0.00406	0.00359	0.00140	0.00244	0.00051	0.00083	0.00100	0.00093	0.00148	0.00114	0.00387	0.00157	0.00576	0.00587	0.00098
53 Real estate & rental	0.00398	0.00235	0.00175	0.00673	0.04100	0.00161	0.00356	0.00315	0.00123	0.00214	0.00045	0.00073	0.00088	0.00082	0.00130	0.00100	0.00340	0.00138	0.00506	0.00515	0.00086
54 Professional-scientific & tech	0.00433	0.00256	0.00190	0.00733	0.04464	0.00176	0.00388	0.00343	0.00134	0.00233	0.00049	0.00079	0.00096	0.00089	0.00142	0.00109	0.00370	0.00150	0.00551	0.00561	0.00093
55 Management of companies	0.00147	0.00087	0.00064	0.00248	0.01511	0.00059	0.00131	0.00116	0.00045	0.00079	0.00017	0.00027	0.00032	0.00030	0.00048	0.00037	0.00125	0.00051	0.00186	0.00190	0.00032
56 Administrative & waste services	0.00180	0.00107	0.00079	0.00305	0.01859	0.00073	0.00162	0.00143	0.00056	0.00097	0.00020	0.00033	0.00040	0.00037	0.00059	0.00045	0.00154	0.00062	0.00229	0.00233	0.00039
61 Educational svcs	0.00017	0.00010	0.00008	0.00029	0.00177	0.00007	0.00015	0.00014	0.00005	0.00009	0.00002	0.00003	0.00004	0.00004	0.00006	0.00004	0.00015	0.00006	0.00022	0.00022	0.00004
62 Health & social services	0.00003	0.00002	0.00001	0.00005	0.00029	0.00001	0.00002	0.00002	0.00001	0.00001	0.00000	0.00001	0.00002	0.00001	0.00001	0.00001	0.00002	0.00001	0.00004	0.00004	0.00001
71 Arts-entertainment &	0.00010	0.00006	0.00004	0.00017	0.00101	0.00004	0.00009	0.00008	0.00003	0.00005	0.00001	0.00002	0.00002	0.00002	0.00003	0.00002	0.00008	0.00003	0.00013	0.00013	0.00002
72 Accommodation & food services	0.00041	0.00024	0.00018	0.00070	0.00423	0.00017	0.00037	0.00033	0.00013	0.00022	0.00005	0.00008	0.00009	0.00008	0.00013	0.00010	0.00035	0.00014	0.00052	0.00053	0.00009
81 Other services	0.00747	0.00442	0.00328	0.01264	0.07698	0.00303	0.00669	0.00592	0.00231	0.00401	0.00084	0.00137	0.00165	0.00154	0.00244	0.00188	0.00638	0.00258	0.00949	0.00967	0.00161
92 Non-NAICS	0.00104	0.00061	0.00046	0.00176	0.01069	0.00042	0.00093	0.00082	0.00032	0.00056	0.00012	0.00019	0.00023	0.00021	0.00034	0.00026	0.00089	0.00036	0.00132	0.00134	0.00022

Blue cells are above average change, yellow cells are below average change, gray cells have no change. Outlined cells are the 10 highest and lowest values.

Key Sector Analysis

- ▶ Key sector analysis identifies sectors that likely will have a greater than average impact on the economy by measuring forward and backward linkages
- ▶ Key sectors have forward and backward linkages greater than 1
 - Backward linkages represent the amount a sector demands from other sectors
 - Forward linkages represent how much a sector is demanded by others

Where

$$B = (I - A)^{-1} = b_{ij}$$

$B_j = \text{column multiplier}, B_i = \text{row multiplier}$

$(BL_j) = \text{Backward Linkage}, (FL_i) = \text{Forward Linkage}$

$$BL_j = \frac{\frac{1}{n} \sum_{i=1}^n b_{ij}}{\frac{1}{n^2} \sum_{i,j=1}^n b_{ij}} = \frac{\frac{1}{n} B_j}{\frac{1}{n^2} V} = \frac{B_j}{\frac{1}{n} V} \quad \text{And} \quad FL_i = \frac{\frac{1}{n} \sum_{j=1}^n b_{ij}}{\frac{1}{n^2} \sum_{i,j=1}^n b_{ij}} = \frac{\frac{1}{n} B_i}{\frac{1}{n^2} V} = \frac{B_i}{\frac{1}{n} V}$$

$$\text{where } B_j = \sum_{i=1}^n b_{ij} \text{ and } B_i = \sum_{j=1}^n b_{ij} \text{ and } V = \sum_{i=1}^n \sum_{j=1}^n b_{ij}$$

Key Sector Analysis Continued

Key Sectors for Baseline and Updated Scenarios								
Sector	Baseline Scenario			Updated Scenario			Difference Between Scenarios	
	Forward Linkage	Backward Linkage	Key Sector?	Forward Linkage	Backward Linkage	Key Sector?	Forward Linkage	Backward Linkage
11 Ag, Forestry, Fish & Hunting	0.7358	0.9753	No	0.7358	0.9753	No	0.0000	0.0000
21 Mining	0.9302	1.0241	No	0.9302	1.0241	No	0.0000	0.0000
22 Utilities	0.8362	1.0165	No	0.8362	1.0165	No	0.0000	0.0000
23 Construction	0.8379	1.1278	No	0.8379	1.1278	No	0.0000	0.0000
31-33 Manufacturing	2.0004	1.1768	Yes	2.0004	1.1769	Yes	0.0000	0.0000
42 Wholesale Trade	1.1405	0.9679	No	1.1405	0.9679	No	0.0000	0.0000
48-49 Transportation & Warehousing	1.0067	1.0849	Yes	1.0067	1.0849	Yes	0.0000	0.0000
394 Trucking	0.8936	1.1295	No	0.8936	1.1292	No	0.0001	0.0004
44-45 Retail trade	0.8728	0.9889	No	0.8728	0.9889	No	0.0000	0.0000
51 Information	0.8840	0.9543	No	0.8840	0.9543	No	0.0000	0.0000
52 Finance & insurance	1.1783	0.9951	No	1.1783	0.9951	No	0.0000	0.0000
53 Real estate & rental	1.3307	0.9300	No	1.3307	0.9300	No	0.0000	0.0000
54 Professional- scientific & tech svcs	1.4104	0.8707	No	1.4104	0.8707	No	0.0000	0.0000
55 Management of companies	0.8714	0.8855	No	0.8714	0.8856	No	0.0000	0.0000
56 Administrative & waste services	1.0874	0.9247	No	1.0874	0.9248	No	0.0000	0.0000
61 Educational svcs	0.8102	0.9384	No	0.8102	0.9384	No	0.0000	0.0000
62 Health & social services	0.7307	1.0687	No	0.7307	1.0688	No	0.0000	0.0000
71 Arts- entertainment & recreation	0.8040	0.9915	No	0.8040	0.9915	No	0.0000	0.0000
72 Accomodation & food services	0.8108	1.0593	No	0.8108	1.0593	No	0.0000	0.0000
81 Other services	0.9679	1.0562	No	0.9679	1.0562	No	0.0000	0.0000
92 Non-NAICS	0.8602	0.8339	No	0.8602	0.8339	No	0.0000	0.0000

Results

Summary of Results		
Top Three Values	Baseline Scenario	Updated Scenario
Multiplier	Manufacturing (33-34) Trucking (394) Construction (22)	Manufacturing (33-34) Trucking (394) Construction (22)
Field of Influence	Trucking (394) to Manufacturing (33-34) Trucking (394) to Construction (22) Trucking (394) to Other Services (81)	Trucking (394) to Manufacturing (33-34) Trucking (394) to Construction (22) Trucking (394) to Other Services (81)
Key Sector	Manufacturing (33-34) Transportation & Warehousing (48-49) N/A	Manufacturing (33-34) Transportation & Warehousing (48-49) N/A
Relaxed Key Sector Forward	Manufacturing (33-34) Professional & Scientific Services (54) Real Estate & Rental (53)	Manufacturing (33-34) Professional & Scientific Services (54) Real Estate & Rental (53)
Relaxed Key Sector Backward	Manufacturing (33-34) Trucking (394) Construction (22)	Manufacturing (33-34) Trucking (394) Construction (22)

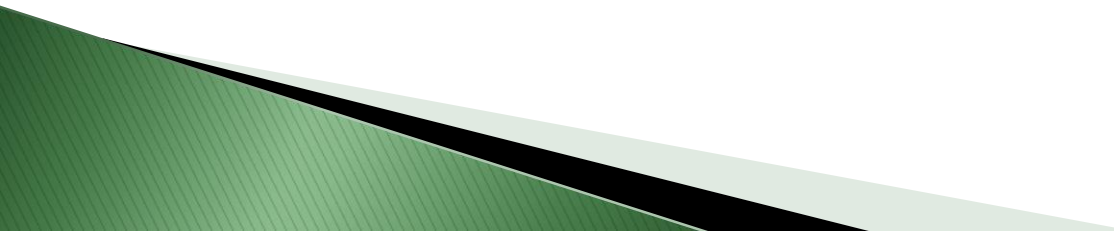
Weaknesses

- ▶ Lacks geographic element
- ▶ Assumed increased demand economy wide
- ▶ Benefit is somewhat less clear
 - For who?
- ▶ Only updates one sector
- ▶ Not as thorough as other methods (equilibrium)
- ▶ Only as good as data available
 - Simple RAS does not capture all the changes

Contributions

- ▶ This project provides a useful framework for
 - A novel use of existing methods which will allow for more types of freight infrastructure impacts to be evaluated
 - More rounded approach
- ▶ Accessible in same manner as the FHWA first and second order tool

Future Work

- ▶ More recent data
 - ▶ Inclusion of partial survey or expert data
 - Use of the modified RAS method
 - ▶ Industry specific demand data
 - ▶ Reduced aggregation
- 

Thank you!

Questions?

ehalpe2@uic.edu

Sources

- ▶ Chicago Metropolitan Agency for Planning. *Proposed American Recovery and Reinvestment Act Projects*. Chicago: CMAP, 2009.
- ▶ HDR|HLB Decision Economics Inc. *Freight Benefit/Cost Study: Phase III - Analysis of Regional Benefits of Highway – Freight improvements: Final Report*. The Federal Highway Administration, 2008.
- ▶ Hewings, Geoffrey J.D. "The Empirical Identification of Key Sectors in an Economy: A Regional Perspective." *The Developing Economies*, 1982: 173-195.
- ▶ Kawamura, Kazuya, P.S. Sriraj, and Peter Lindquist. "CFIRE Grant Year 3 Research Proposal: Broad Economic Benefits of Freight Transportation Infrastructure Improvement." September 20, 2009.
- ▶ Lahr, Michael. "A Strategy for Producing Hybrid Regional Input-Output Tables." In *Input-Output Analysis: Frontiers and Extensions*, by Michael L. Lahr and Erik Dietzenbacher, 211-242. New York, NY: Palgrave, 2001.
- ▶ McGilvray, James W. "Linkages, Key Sectors and Development Strategy." In *Structure, system, and economic policy: proceedings of Section F of the British Association for the Advancement of Science, held at the University of Lancaster 1-8 September 1976*, by Wassily W. Leontief, 49-56. London, UK: Cambridge University Press, 1977.
- ▶ Miernyk, William H. "The Elements of Input-Output Analysis ." *The Web Book of Regional Science: Hosted by the Regional Research Institute at West Virginia University*. January 1965. <http://www.rr.i.wvu.edu/WebBook/Miernykweb/new/index.htm> (accessed September 1, 2010).
- ▶ MIG, Inc. "IMPLAN Professional Version 2.0: User Guide." Stillwater, MN: Minnesota IMPLAN Group, February 2004.
- ▶ Miller, Ronald E, and Peter D. Blair. *Input-Output Analysis: Foundations and Extensions*. Englewood Cliffs, New Jersey: Prentice-Hall, Inc. , 1985.
- ▶ Nazara, Sushasil, Doug Guo, Geoffrey J.D. Hewings, and Chokri Dridi. "PyIO: Input-Output Analysis with Python- REAL 03-T-23." *The Regional Economics Applications Laboratory (REAL)*. October 2003. <http://www.real.illinois.edu/d-paper/03/03-T-23.pdf> (accessed June 8, 2010).
- ▶ Planting, Mark A., and Jiemin Guo. "Increasing the Timeliness of U.S. Annual I-O Accounts." *The Bureau of Economic Analysis Papers*. 2002. <http://www.bea.gov/papers/pdf/Timeliness.pdf> (accessed September 1, 2010).
- ▶ Sonis, Michael, Joaquim J.M. Guilhoto, Geoffrey J.D. Hewings, and Eduardo B. Martins. "Linkages, Key Sectors, and Structural Change: Some New Perspectives." *The Developing Economies*, 1995: 233-270.
- ▶ The Chicago Area Transportation Study. *2020 Regional Transportation Plan*. Chicago : The Chicago Area Transportation Study, 1998.
- ▶ Wu, Patrick. "PyIO 2.0 Quick Start." *The Regional Economics Applications Laboratory (REAL)*. July 6, 2009.
- ▶ <http://www.real.illinois.edu/pyio/PyIO%202%20quick%20start%20manual%20v1.1.pdf> (accessed July 8, 2010).