NEW JERSEY'S LINK TO THE 21ST CENTURY: MAXIMIZING THE IMPACT OF INFRASTRUCTURE INVESTMENT

Working Paper # 9

Using Regional Multipliers to Assess the Economic Impacts of Transportation Investments in Northern New Jersey

by:

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1. Introduction

The main objective of this paper is to assess key economic impacts, mainly output, employment, and earnings, in Northern New Jersey from recent major transportation infrastructure investments, mainly in rail. This effort is part of the New Jersey 21st Century study carried out by the University Transportation Research Center, Region II, for the New Jersey Department of Transportation.

Regional multipliers, derived from input-output analysis, have been used widely to measure economic impacts. The framework for this method was initially developed in the late 1930's and has undergone many refinements by researchers and agencies including the Bureau of Economic Analysis (BEA)[1]. The fundamental purpose of the input-output framework is to study the interdependence of industries in an economy and estimate the ripple effects that an investment in one economic sector has on another. For example, if industry A increases its production by a certain amount, it will purchase additional goods and services from other industries. These industries will, in turn, acquire additional quantities of their respective inputs. Industries that produce these inputs will have to increase their output to satisfy the demand and so on. This process is regarded as the ripple effect in the economy caused by the original change.

The input-output model is constructed as an inter-industry transactions table based on economic data for a specific region. Table 1 is a hypothetical transactions table[2]. It indicates the

		Processing Sector (purchasing)						Final Demand	Total Gross Output
		A	B	C	D	E	F		
Processing Sector (producing)	A	10	15	1	2	5	6	25	64
	B	5	4	7	1	3	8	31	59
	C	7	2	8	1	5	3	14	40
	D	11	1	2	8	6	4	7	39
	E	4	0	1	14	3	2	16	40
	F	2	6	7	6	2	6	17	46
Payments		25	31	14	7	16	17		
Total Gross Outlays		64	59	40	39	40	46		

Table 1: Hypothetical input-output transactions table

distribution of the inputs purchased and the outputs sold in different industries represented by the letters A through F. Each row shows the output sold by each industry (say, in billions of $) along the left-hand side of the table to each industry across the top of the table. Each column shows the purchases made by each industry along the top of the table from the industries along the left-hand side. To illustrate, industry B sold 7 billion dollars worth of output to industry C during the time period covered by this table. Similarly, industry A sold 15 billion dollars worth of output to industry B during the same period. The table covers a finite set of industries within a given region, state, or a country. To account for industries not accounted for by the table, the

[1] For references see BEA (1997); Leontief (1936, 1966); Miernyk (1965); Miller and Blair (1985).
[2] This table and some of the following discussion has been taken from Miernyk (1965).

table contains a "sector" called 'payments'. This sector includes payments *to* the government, or imports from outside the region, or wages and other payments made to households. Similarly, on the top of the table there is a category called 'final demand'. This sector can include purchases *by* the government, exports to areas outside the region, and purchases of finished goods and services by the consumers. The last row, 'total gross outlays' shows the total value of the inputs to each of the industries. The last column, 'total gross output' shows the total output made by each industry. For each industry and the economy as a whole, total outlays have to equal total output.

One way to estimate the ripple effect of a change in a particular industry is to calculate a table of technical coefficients that represent the "amount of inputs required from each industry to produce one dollar's worth of the output of a given industry" (see Miernyk, 1965). Technical coefficients are calculated for the processing sector industries only. To calculate the technical coefficients for a particular column, each number in the column is divided by the column totals, i.e., gross outlays. For example, to compute the technical coefficients for column 1, each number in this column is divided by 64. Table 2 shows the technical coefficients[3] that were generated for Table 1.

	Industries Purchasing						
Industries Producing		A	B	C	D	E	F
	A	0.16	0.25	0.03	0.05	0.13	0.13
	B	0.08	0.07	0.18	0.03	0.08	0.17
	C	0.11	0.03	0.20	0.03	0.13	0.07
	D	0.17	0.02	0.05	0.21	0.15	0.09
	E	0.06	0.00	0.03	0.36	0.08	0.04
	F	0.03	0.10	0.18	0.15	0.05	0.13

Table 2: Coefficients Table

To illustrate the use of these coefficients let us assume a one-dollar increase in the demand for the output of industry B. This change will increase the transactions within industry B by $0.07[4], leading to the increase in the gross output of industry B by *at least* by $1.07 (the original $1 + 0.07). This change will further result in the sales from industry A to industry B generating an additional $0.268 (0.25*1.07)[5]. Similarly, sales from industry C to industry A will generate $0.032 (0.03*1.07). This procedure can be repeated for the rest of the industries shown in column 2. In addition, when industry A expands its production to meet the needs of industry B, other industries that serve industry A will face an increase in demand for their output. These calculations can be continued iteratively by including each industry in the processing sector. The final result can be represented by a table showing the total change in output resulting from the additional production by industries at the top for each dollar of delivery to final demand by industries at the left.

To facilitate the use of input-output models for empirical analysis, the BEA provides regional input-output multipliers for each cell in the input-output matrix. These multipliers are in-fact

[3] The coefficients have been rounded off to the second decimal
[4] In table 2, 0.07 is the coefficient when B is the producing industry and B is also the purchasing industry
[5] In table 2, 0.25 is the coefficient when A is the producing industry and B is the purchasing industry

parameters used to distinguish between the initial effect of an exogenous change and its total effect on the regional economy. The BEA estimates these multipliers by adjusting national level industry-by-industry tables for a specific region, a process known as the "calculation of location quotients". Location quotients are the ratio of an industry's share of the regional wages and salaries, to that industry's share of national wages and salaries. A detailed discussion of the method used to derive regional multipliers is provided in Appendix A, U.S. Department of Commerce and Bureau of Economic Analysis (BEA, 1997). Through the use of these multipliers, the economic impact of public investments can be obtained.

The BEA provides two categories of multipliers: I. *final-demand multipliers* for output, for earnings, and for employment, and II. *Direct effect multipliers* for earnings and for employment. Final-demand multipliers are used to estimate the total change in output, the total change in earnings, and the total change in the number of jobs in the region, if the change in output delivered to final demand by the specific industry (e.g., construction, transportation, etc.) is known. The direct effect multipliers are used to estimate the total change in the number of jobs and earnings in the region, if the initial change in earnings and jobs in the specific industry is known. Next we describe the specific multipliers for the study area.

2. Multipliers for the Study Area

The study area in the New Jersey 21st Century project includes the following counties in Northern New Jersey: Bergen, Essex, Hudson, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean, Passaic, Somerset, Sussex, Union, and Warren. In this analysis only one set of multipliers were purchased describing the entire region (Northern New Jersey) was obtained from BEA[6].

BEA provided multipliers for 38 industry aggregations and 471 specific industries. As an example, Table 3 shows the total multipliers for the study area, for *selected* industry aggregations.

How can these can the multipliers in Table 3 be used to assess the effect of an investment on total output, earnings, and jobs?

Column 1 (Output): Each entry measures the total dollar change in output in all row industries that results from a $1 change in output delivered to final demand by the industry corresponding to the entry. For example, an investment of 10 million dollars ($10,000,000) in the construction industry, i.e., 10 million dollar change in output delivered to final demand by the construction industry, would lead to a total change in output in the regional economy of $21,151,000 (2.1510*10,000,000)[7], i.e., the initial investment of 10,000,000 plus additional output of $11,151,000.

[6] A key reason was the high cost of purchasing the entire set of 14 multipliers amounting to over $3,000. In addition, it is doubtful if data on transport investments were available at the county level to justify a specific set of multiplier for each county.
[7] If the change in output is delivered to the final demand by the transportation industry, 2.1478 (the final demand output multiplier for the transportation industry) should be used instead of 2.1510. Similarly, if the change in output is delivered to the final demand by the wholesale trade industry, 1.8749 should be used.

Industry Aggregation	Final-Demand Multipliers			Direct Effect Multipliers	
	Output (1)	Earnings (2)	Jobs [a] (3)	Earnings (4)	Jobs (5)
Construction	2.1510	0.6436	20.7	1.9728	1.9203
Coal mining	1.0000	0.0000	0.0	0.0000	0.0000
Industrial machinery & equipment	1.9286	0.5146	13.2	1.9159	2.2714
Wholesale trade	1.8749	0.5388	13.7	1.7911	2.1823
Real estate	1.3503	0.1291	6.4	3.4583	1.8932
Business services	2.0695	0.7179	20.2	1.7166	1.8858
Transportation	2.1478	0.6046	18.5	2.0726	2.1107

Table 3. Total Multipliers for the Study Area for Selected Industry Aggregations
Notes: [a] per million dollars

Column 2 (Earnings): Each entry measures the total dollar change in earnings of households employed in all row industries that results from a $1 change in output delivered to final demand by the industry corresponding to the entry. Hence, an investment of $10,000,000 in the construction industry would lead to the total dollar change in earnings of households of $6,436,000 (0.6436*10,000,000).

Column 3 (Jobs): Each entry in Column 3 measures the total change in the number of jobs in all row industries that results from a $1 million change in the output delivered to final demand by the industry corresponding to the entry. Hence, an investment of $10,000,000 in the construction industry would lead to approximately 207 new jobs (20.7*10,000,000 / 1,000,000).

Column 4 (Earnings): Each entry in Column 4 measures the total dollar change in earnings of households employed in all row industries that results from a $1 change in earnings paid directly to households employed by the industry corresponding to the entry. Hence, a $10,000,000 change in earnings for households employed in the construction industry would lead to a total change in earnings of $19,728,000 (1.9728*10,000,000); i.e., $9,728,000 of earnings in addition to the initial $10,000,000 investment.

Due to the relationship between the final demand and direct effect multipliers, the total change in earnings can be used to find the change in earnings for households employed in the construction industry (i.e., the additional earnings they will enjoy from the overall change in earnings in the economy). This can be done by dividing the total change in earnings by the direct effects multiplier for earnings. For example, using the final demand multipliers, we found that a $10,000,000 investment in construction would result in change in earnings of $6,436,000. The corresponding change in the earnings of households employed in construction would then be $3,262,368 ($6,436,000 / 1.9728). Hence, the additional earnings generated to households in the economy would be $3,173,632 ($6,436,000 - $3,262,368).

Column 5 (Jobs): Each entry in Column 5 measures the total change in the number of jobs in all row industries that results from a change of one job in the industry corresponding to the entry. Hence, a change of 10,000 jobs in the construction industry (from the transportation investment) would lead to a total change of 19,203 jobs (1.9203*10,000).

Again, due to the relationship between the final demand and direct effect multipliers, the total change in the number of jobs can be used to estimate the change in jobs in the construction industry. For example, using the final demand multipliers, we found that a $10,000,000 investment in construction resulted in 207 jobs. The corresponding change in construction jobs would then be approximately 108 (207 / 1.9203). Additional jobs in the economy would then be 99 new jobs (207-108).

3. Choice of Multipliers

The choice of the multipliers to start the analysis depends on the data that are available. If data on initial changes in employment and earnings are available, the analysis can begin with the direct effect multipliers. If data on initial changes in final demand are available, the analysis can begin with final-demand multipliers. If the estimates of initial changes in final demand, earnings, and employment, are available, the analysis can select any of the multipliers. In theory, the results in both cases should be consistent. However, in practice, the estimates will probably differ and the estimates based on the direct-effect multipliers are preferable[8].

4. Application in the NJ21 project

New Jersey Transit provided information on total investment on eight proposed rail projects. These investments will be made over several years[9]. In order to estimate the impact of these investments, it is necessary to determine which industry multipliers to use, i.e., construction, industrial machinery, transportation services, etc. To determine that, we need information on the distribution of the investment expenditures with respect to industries. At this time, this information is not available. Since BEA does not provide specific multipliers for railroad investment, we have assumed that the investment corresponds to a change in output delivered to final demand is attributable to the construction industry only[10]. Hence, only the construction multipliers were used.

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[8] For more discussion see: "Regional Multipliers", BEA (1997).

[9] At this time, data are not available on when exactly these investments will be made. Hence, it is difficult to predict the time period over which these impacts will be felt.

[10] The shortcomings of this approach are quite obvious. First, the results from the analysis might be biased, since railroad investments involve other activities than just construction (e.g., electrification, signaling, control, etc'). Moreover, this approach does not permit distinction between railroad investment and, say, a housing investment. The analysis will be modified when further information becomes available.

Table 4 shows the results of the analysis. It includes the initial investment and the expected changes in earnings and jobs in the study area[11]. As Table 4 shows, NJ Transit is expected to invest a total of $3.9 billion on these projects. These investments are associated with *direct earnings* of approximately $1.3 billion and *direct employment* of approximately 42,000 jobs, in the construction industry. In addition, these investments are expected to lead to *additional output* of $4.5 billion, *additional earnings* of $1.25 billion and *additional employment* of 39,000 jobs, in the study region. Further analysis will include the effect of these investments on specific industrial sectors.

[11] At this time, data are not available to provide estimates of these impacts at the county level or at a more disaggregate level.

	Final Demand Multiplier			Direct Effect Multiplier	
	Output (1)	Earnings (2)	Employment (3)	Earnings (4)	Employment (5)
Construction	2.151	0.6436	20.7	1.9728	1.9203

	millions of $ (except for employment)								
NJ Transit Projects	Investment (millions of $) (6)	Output (7) = (1)*(6)	Total earnings (8) = (2)*(6)	Total employment (9) = (3)*(6)	Direct earnings (10) = (8)/(4)	Direct employment (11) = (9)/(5)	Additional Output (12) = (7) - (6)	Additional Earnings (13) = (8) - (10)	Induced Jobs (14) = (9) - (11)
Hudson-Bergen LRT MOS-I	$992.0	$2,133.8	$638.5	20,534	$323.6	10,693	$1,141.8	$314.8	9,841
Hudson-Bergen LRT MOS-II	$1,215.4	$2,614.3	$782.2	25,159	$396.5	13,101	$1,398.9	$385.7	12,057
Secaucus Transfer	$448.4	$964.5	$288.6	9,282	$146.3	4,834	$516.1	$142.3	4,448
Newark City Subway	$78.1	$168.0	$50.3	1,617	$25.5	842	$89.9	$24.8	775
Newark-Elizabeth Rail Link	$209.0	$449.6	$134.5	4,326	$68.2	2,253	$240.6	$66.3	2,073
Southern NJ LRT	$805.0	$1,731.6	$518.1	16,664	$262.6	8,678	$926.6	$255.5	7,986
Newark Airport Station	$136.7	$294.0	$88.0	2,830	$44.6	1,474	$157.3	$43.4	1,356
Morrisville Train Yard	$47.1	$101.3	$30.3	975	$15.4	508	$54.2	$14.9	467
TOTAL	$3,931.7	$8,457.1	$2,530.4	81,386	$1,282.7	42,382	$4,525.4	$1,247.8	39,004

Note. Multipliers used are for the 14 county study area.
All the investment is assumed to be in the construction industry

Table 4. Results of multiplier analysis for study area

5. References

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