Economic Impacts of Planned Transportation Investments in New Jersey

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Executive Summary

Planned expenditures on transportation infrastructure will generate direct and indirect economic impacts for New Jersey in the form of employment, income, gross domestic product, and state and local tax revenues. These planned transportation investments include the New Jersey Department of Transportation, NJ TRANSIT, the New Jersey Turnpike and Garden State Parkway, and the Atlantic City Expressway (South Jersey Transportation Authority).

These impacts were estimated using the state-of-the-art R/ECON™ Input-Output Model at the Center for Urban Policy Research at the Bloustein School of Planning and Public Policy. The R/ECON™ model estimates both the *direct* economic effects of the initial expenditures (in terms of jobs and income) and the *indirect* (or multiplier) effects (in additional jobs and income) of the subsequent economic activity that occurs following the initial expenditures. The model also estimates the tax revenues generated by the combined direct and indirect new economic activity caused by the initial spending.

Summary of Planned Transportation Infrastructure Spending

The New Jersey Department of Transportation estimates that total transportation infrastructure spending will total $42.5 billion in current dollars over the 10-year period from 2009-2018. This spending will include the New Jersey Department of Transportation, NJ TRANSIT, the New Jersey Turnpike and Garden State Parkway, and the Atlantic City Expressway (South Jersey Transportation Authority). For the purposes of the impact analysis, the investment totals for each expenditure item in each year were converted (discounted) to 2008 dollars using the compound annual inflation rate of New Jersey's gross domestic product between 1997 and 2006—approximately 2.2%.[1] When measured in 2008 dollars, transportation infrastructure spending totals $38 billion.

These planned investments include various highway investments, the construction of the Trans-Hudson Express Tunnel (THE Tunnel), the construction and repair of bridges, investment in new and improved public transportation, and various other smaller investments:

- Various highway investments account for $8.9 billion in expenditures (in 2008 dollars) and will include state highway operations and resurfacing projects and widening of the New Jersey Turnpike, the Garden State Parkway, and other roads.

- Transit projects are the next largest expenditure category, accounting for 22% of total real expenditures, or approximately $8.4 billion. These projects comprise construction of new rail lines and repair of existing lines, as well as purchases of train cars and buses.

- Bridges account for an additional 18.6% of total expenditures, or approximately $7.1 billion.

[1] The inflation rate for the construction industry in New Jersey was not used to discount future expenditures, as high price volatility in the sector and unusually high construction industry growth rates in recent years could result in unrealistic inflation rate estimates.

- Construction of the Hudson rail tunnel—the Trans-Hudson Express Tunnel (THE Tunnel) part of the *Access to the Region's Core* initiative to expand access to New York City by New Jersey's various commuter rail lines—is the largest single-project investment, accounting for almost 17.4% of total expenditures, or $6.6 billion in 2008 dollars.

Total Transportation Investment Impacts

While all transportation investments total $38 billion in 2008 dollars, approximately $26.6 billion (70%) are expected to generate broader economic impacts in New Jersey in the form of employment, income, GDP and tax revenues. Purchases of train cars and buses were excluded from the analysis, as these items will most likely be purchased from out-of-state vendors and thus their manufacture and sale will have no direct or indirect economic impacts within New Jersey. In addition, capital program expenditures, local system support, and capital maintenance were not included in the analysis.

In all, over the course of the 10-year period, these $26.6 billion in planned investments are estimated to generate:

- An average of 26,832 job-years annually,[2]
- $15 billion in income,
- $20.3 billion in GDP,
- $747 million in state tax revenues, and
- $797 million in local tax revenues.

Table ES.1.
Annual Impacts: All Transportation Investments

Year	Expenditures* ($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	Taxes* State ($000)	Taxes* Local ($000)
2009	2,973,710	11.2	29,966	1,667,870	2,257,625	83,875	89,172
2010	3,717,297	14.0	37,860	2,110,540	2,817,390	105,919	112,421
2011	3,574,448	13.4	36,868	2,043,262	2,726,879	103,229	109,048
2012	3,282,553	12.3	33,668	1,868,634	2,513,269	94,923	100,188
2013	2,812,087	10.6	28,663	1,591,701	2,149,854	80,119	85,030
2014	2,312,050	8.7	22,856	1,271,623	1,746,120	64,326	68,570
2015	2,288,757	8.6	22,739	1,270,439	1,744,964	63,526	67,988
2016	1,996,901	7.5	20,114	1,123,671	1,543,740	55,731	59,731
2017	1,885,770	7.1	18,414	1,039,536	1,443,838	50,317	54,836
2018	1,746,385	6.6	17,176	976,919	1,354,105	45,254	50,224
Total	**26,589,956**	**100.0**	**268,324**	**14,964,195**	**20,297,784**	**747,220**	**797,206**
Annual Average	**2,658,996**		**26,832**	**1,496,420**	**2,029,778**	**74,722**	**79,721**

*Note: All amounts are in constant 2008 dollars.

Of the total employment estimated over the period, approximately 63% is estimated to consist of direct job-years, while the remaining 37% is generated indirectly via the multiplier effects of the

[2] Note that employment impacts are expressed in "job-years." One job-year is equal to one *full-time* job lasting one year. Thus, the job-year total shown for each year represents the total jobs either directly or indirectly generated by the project in that year.

initial expenditures. The employment multiplier is approximately 1.58. Approximately 44% of the total job-years will be generated in the construction industry, with an additional 18% in various service industries, 12% in the manufacturing industry, and 12% in the retail sector.

The spending and, hence, number of jobs created peaks fairly early in the period in 2010 and 2011. Of course, this is also when the income, GDP, and tax impacts also crest. This is largely due to the intensity of construction for the THE Tunnel. The number of jobs created by the proposed program of investments in any one year varies substantially from the average over the course of the study period. In 2010, the planned transportation investments will generate 37,860 jobs-years. In contrast, in 2018, just 17,176 jobs will be generated.

The average income per job-year generated by the investment total is $55,659 in year 2009 dollars. This amount is about the same as the state's average annual pay rate. The construction jobs involved pay on average substantially more—on the order of $65,000-$72,000, depending upon the type of construction undertaken. Moreover, manufacturing jobs that support the construction efforts pay only marginally less. Thus, it is the spending by households on retail trade and personal services that lowers the average pay rate transmitted to the State's economy.

Full Report

Transportation Spending

Total estimated transportation infrastructure spending totals $42.5 billion in current dollars over the 10-year period from 2009-2018. This planned spending includes the New Jersey Department of Transportation, NJ TRANSIT, the New Jersey Turnpike and Garden State Parkway, and the Atlantic City Expressway (South Jersey Transportation Authority).

In order to accurately assess the economic impacts of these investments, the annual expenditures should be adjusted for inflation to reflect their value in real (constant dollar) terms. For the purposes of the impact analysis, the investment totals for each expenditure item in each year were converted (discounted) to 2008 dollars using the compound annual inflation rate of New Jersey's gross domestic product between 1997 and 2006—approximately 2.2%.[3]

Table 1 presents the total transportation by investment target for each year in both nominal and real dollars.

Table 1
Distribution of Transportation Infrastructure Expenditures
Nominal vs. Real Dollars

	Nominal Dollars		Real (2008) Dollars	
Year	**Amount**	**Share**	**Amount**	**Share**
2009	4,318,780,500	10.2	4,223,767,329	11.1
2010	5,065,757,000	11.9	4,845,315,518	12.8
2011	5,120,775,000	12.0	4,790,184,689	12.6
2012	4,864,583,200	11.4	4,450,420,575	11.7
2013	4,413,193,200	10.4	3,948,637,033	10.4
2014	3,988,877,000	9.4	3,490,468,905	9.2
2015	3,988,073,200	9.4	3,412,990,698	9.0
2016	3,706,837,000	8.7	3,102,518,127	8.2
2017	3,619,844,000	8.5	2,963,053,873	7.8
2018	3,435,841,200	8.1	2,750,563,217	7.2
Total	**42,522,561,300**	**100.0**	**37,977,919,965**	**100.0**

As indicated in the table, after adjusting for inflation, total expenditures over the period are estimated at approximately $38 billion, with the highest expenditure levels (25% of the total) occurring between 2010 and 2011.

Table 2 again shows the total expenditures in both nominal and real dollars, but by infrastructure component rather than by year. The table also indicates the share of total real expenditures for

[3] The inflation rate for the construction industry in New Jersey was not used to discount future expenditures, as high price volatility in the sector and unusually high construction industry growth rates in recent years could result in unrealistic inflation rate estimates.

which each category of transportation investment will account. While the amounts presented here are aggregate for the entire 10-year period, the real dollar value of the expenditures for each component has been estimated for each year, and these amounts will be used to distribute the economic impacts of each type of expenditure across the 11 years of investment.

Various highway investments account for $8.9 billion in expenditures (in 2008 dollars) and will include highway operations and resurfacing projects and widening of the New Jersey Turnpike, the Garden State Parkway, and other roads. Of this amount, 20% is allocated for state highway operations and 31% is allocated for road improvements. Nearly 40% of the $8.9 billion in highway investments is allocated for widening of the New Jersey Turnpike, the Garden State Parkway, and other roads.

Construction of the Hudson rail tunnel—the Trans-Hudson Express Tunnel (THE Tunnel) part of the *Access to the Region's Core* initiative to expand access to New York City by New Jersey's various commuter rail lines—is the largest single-project investment, accounting for almost 17.4% of total expenditures, or $6.6 billion in 2008 dollars.

Transit projects account for 22% of total real expenditures, or approximately $8.4 billion in 2008 dollars. These projects comprise construction of new rail lines and repair of existing lines, as well as purchases of train cars and buses.

Bridges account for an additional 18.6% of total expenditures, or approximately $7.1 billion in 2008 dollars. This includes $4.3 billion for the construction of new bridges.

Finally, various other expenditures account for approximately $7 billion in 2008 dollars, or 18.5% of real expenditures. Of this final category of expenditures, capital program delivery accounts for $2.4 billion and local system support/other programs accounts for $4.4 billion.

Table 2
Transportation Investment by Infrastructure Component, 2008-2018
Nominal and Real (2008 Dollars) Expenditures and Real Expenditure Share

		2008 Dollars		
Highways	**Nominal Dollars**	**Amount**	**Share (%)**	
Turnpike Widening (Exit 9 and Exit 6)	2,100,000,000	1,983,783,972	5.2	
Parkway Widening	632,000,000	577,703,711	1.5	
Other Widening Projects	1,101,100,000	971,549,204	2.6	
Resurfacing Projects	1,799,655,670	1,583,473,914	4.2	
Construction of New Interchanges	556,000,000	479,335,206	1.3	
Interchange Improvements	690,000,000	635,536,024	1.7	
Highway Ops (State Highways)	1,932,000,000	1,745,555,154	4.6	
Other: Shoulder Improvements	65,000,000	59,486,464	0.2	
Other: Drainage Improvements	38,000,000	34,328,850	0.1	
Other: Median Barrier Replacement	110,000,000	100,064,083	0.3	
Other: Emergency Sign Warning Replacements	700,200,000	633,090,965	1.7	
Other: Toll Plaza Rehabilitations	137,680,000	124,488,167	0.3	
Total Highways	**9,861,635,670**	**8,928,395,714**	**23.5**	
Tunnels	**Nominal**	**Real**	**Share (%)**	
Construction of Hudson Rail Tunnel	7,263,490,000	6,590,118,303	17.4	
Total Tunnels	**7,263,490,000**	**6,590,118,303**	**17.4**	
Bridges	**Nominal**	**Real**	**Share (%)**	
Bridge Repair (Combined Concrete & Steel)	966,300,000	846,689,981	2.2	
Bridge Repair (Deck Rehab & Replacement)	557,800,000	494,985,352	1.3	
Bridge Repair (Large Steel Bridges)	51,700,000	45,024,658	0.1	
Bridge Repair (Small Bridges)	437,970,000	393,757,298	1.0	
Bridge Repair (Large Concrete Bridges)	944,479,330	837,347,863	2.2	
New Bridge Construction (RE: All Bridges – Large, Small, Concrete & Steel)	4,899,100,000	4,334,491,336	11.4	
Other: Seismic Retrofit	136,000,000	118,085,694	0.3	
Total Bridges	**7,993,349,330**	**7,070,382,182**	**18.6**	#
Transit	**Nominal**	**Real**	**Share (%)**	
Construction of New Rail Lines	1,475,943,000	1,351,709,819	3.6	
Repairs to Existing Rail Lines	2,298,046,000	1,960,930,834	5.2	
Repairs of Existing Bus/LRT facilities	319,899,000	276,174,768	0.7	
Repairs to Existing Rail Stations	251,536,000	223,169,831	0.6	
Purchase of Equipment (Train Cars) *	1,159,379,300	1,010,332,957	2.7	*
Purchase of Equipment (Buses) *	1,002,053,000	895,813,964	2.4	*
Capital Maintenance *	3,000,000,000	2,659,935,613	7.0	*
Total Transit	**9,506,856,300**	**8,378,067,787**	**22.1**	
Other	**Nominal**	**Real**	**Share (%)**	
Other: Other Roadway Improvements and Capital Investments	202,930,000	189,074,980	0.5	
Capital Program Delivery *	2,760,400,000	2,440,192,633	6.4	*
Local System Support / Other Programs *	4,933,900,000	4,381,688,367	11.5	*
Total Other	**7,897,230,000**	**7,010,955,979**	**18.5**	
Grand Total	**42,522,561,300**	**37,977,919,965**	**100.0**	
Total Amount Included in Analysis of Economic Impacts	**29,666,829,000**	**26,589,956,431**	**70.0**	

* Not included in the analysis of economic impacts.

The R/ECON™ Input-Output Model

Each of the various categories of expenditures on transportation infrastructure will generate direct and indirect economic impacts in the form of employment, income, gross domestic product, and tax revenues for the state. These impacts are estimated using the state-of-the-art R/ECON™ Input-Output Model at the Center for Urban Policy Research at the Bloustein School of Planning and Public Policy.

The R/ECON™ model consists of 515 individual sectors of the New Jersey economy and measures the effect of changes in expenditures in one industry on economic activity in all other industries. For example, when a bridge is built, the expenditures on labor, materials, engineering services, and other inputs have both direct economic effects as those expenditures become incomes and revenues for workers and businesses, and subsequent indirect effects as those workers and businesses in turn spend those dollars on consumer goods, business investments, etc. These expenditures in turn become income for other workers and businesses, which are further spent, and so on. The model is able to trace the effects of changes in one part of the economy on all other parts of the economy (both within and outside of New Jersey), and accounts for the division of expenditures between those that are made within the state and those that “leak” outside the state.

In summary, the R/ECON™ model estimates both the *direct* economic effects of the initial expenditures (in terms of jobs and income) and the *indirect* (or multiplier) effects (in additional jobs and income) of the subsequent economic activity that occurs following the initial expenditures. The model also estimates the tax revenues generated by the combined direct and indirect new economic activity caused by the initial spending.

Using the R/ECON™ model, subsequent sections of this report present the annualized economic impacts attributable to each of the broad transportation expenditure categories and the specific spending components outlined above.

Economic Impacts

Annual economic impacts were estimated for all but six of the subcomponents presented in Table 2. Purchases of train cars and buses under the Transit heading were excluded from the analysis, as these items most likely will be purchased from out-of-state vendors and thus their manufacture and sale will have no direct or indirect economic impacts within New Jersey. In addition, capital program expenditures, local system support, and capital maintenance were not included in the analysis. With these expenditure items excluded, the economic analysis covers a total of $26.6 billion, or approximately 70%, of the $38 billion in estimated inflation-adjusted expenditures.

For purposes of the analysis, the economic impacts are distributed over time in direct proportion to the occurrence of the expenditures. Where possible, various line items were combined and their expenditures were analyzed in aggregate.

Note that employment impacts are expressed in "job-years." One job-year is equal to one *full-time* job lasting one year. Thus, the job-year total shown for each year represents the total jobs either directly or indirectly generated by the project in that year.

In many cases, particularly during the most intensive phases of large-scale construction projects, many of these jobs will be sustained from year to year. However, it is important to note that these are *not* permanent jobs. That is, the number of job-years indicated for any given year represents the *total* number of jobs directly or indirectly generated by the given expenditures in that year and existing for the duration of that year. Any totals for previous years are estimated to exist only for the years in which they are listed.

Highway Investments

Total highway investments account for $8.9 billion, or about 24% of the estimated transportation expenditures over the 10-year period of the analysis. The annual breakdown of these expenditures and their impacts in terms of employment, income, GDP and taxes are shown in Table 3.

In all, over the course of the 10-year period, these investments are estimated to generate:

- An average of 7,081 job-years annually,
- $4.3 billion in income,
- $6.1 billion in GDP,
- $202 million in state tax revenues, and
- $231 million in local tax revenues.

Of the total employment estimated over the 10-year period, approximately 61% is estimated to consist of direct job-years, while the remaining 39% is generated indirectly via the multiplier effects of the initial expenditures. This gives an employment multiplier of approximately 1.65.

Approximately 40% of the total job-years will be generated in the construction industry, with an additional 22% in various service industries, 10% in the manufacturing industry, and 13% in the retail sector.

Table 3
Annual Impacts: All Highway Investments

Year	Expenditures* ($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	Taxes* State ($000)	Taxes* Local ($000)
2009	1,063,677	11.9	8,359	503,548	727,235	23,928	27,381
2010	1,612,537	18.1	13,589	813,675	1,119,179	37,660	42,869
2011	1,328,617	14.9	11,154	667,733	921,022	30,957	35,250
2012	1,219,511	13.7	9,981	599,226	842,338	28,051	32,001
2013	881,247	9.9	7,157	429,699	607,476	20,181	23,037
2014	720,867	8.1	5,343	323,839	485,818	15,719	18,066
2015	706,822	7.9	5,262	318,523	476,787	15,444	17,745
2016	526,539	5.9	3,845	233,336	354,307	11,400	13,117
2017	505,931	5.7	3,602	219,082	338,425	10,810	12,461
2018	362,649	4.1	2,523	153,616	242,064	7,664	8,851
Total	**8,928,396**	**100.0**	**70,814**	**4,262,277**	**6,114,651**	**201,815**	**230,778**
Average	**892,840**		**7,081**	**426,228**	**611,465**	**20,181**	**23,078**

*Note: All amounts are in constant 2008 dollars.

The average income for all job-years generated through the highway investments is $60,190.

The impacts per $1 million of highway spending are presented in Table 4.

Table 4
Impacts per $1 million of
Highway Expenditures

Employment (job-years)	8
Income ($)	468,735
State Taxes ($)	22,375
Local Taxes ($)	25,624
Gross State Product ($)	684,486

Highways: Road Widening

For purposes of analysis, the three road widening components listed in the original spending breakdown were combined into the single category of "Road Widening." The three components are:

- Widening of the New Jersey Turnpike (Exit 9 and Exit 6)
- Widening of the Garden State Parkway
- Other Widening Projects

Together, these spending items total approximately $3.5 billion in 2008 dollars, representing 39% of highway expenditures and 9% of total transportation expenditures over the 10-year period. Table 5 presents the annual and cumulative economic impacts of these expenditures.

Table 5
Annual Impacts: Widening of Turnpike, Parkway, and Other Roads

Year	Expenditures* ($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	Taxes* State ($000)	Taxes* Local ($000)
2009	384,745	10.9	3,519	209,393	270,925	9,390	10,624
2010	912,390	25.8	8,346	496,557	642,475	22,268	25,193
2011	725,154	20.5	6,633	394,656	510,630	17,698	20,023
2012	520,099	14.7	4,757	283,058	366,236	12,694	14,361
2013	344,562	9.8	3,152	187,524	242,629	8,409	9,514
2014	228,388	6.5	2,089	124,298	160,823	5,574	6,306
2015	210,527	6.0	1,926	114,577	148,246	5,138	5,813
2016	115,084	3.3	1,053	62,633	81,038	2,809	3,178
2017	92,088	2.6	842	50,118	64,845	2,248	2,543
2018	-	0.0	-	-	-	-	-
Total	**3,533,037**	**100.0**	**32,317**	**1,922,813**	**2,487,847**	**86,228**	**97,554**
Annual Average	**353,304**		**3,232**	**192,281**	**248,785**	**8,623**	**9,755**

*Note: All amounts are in constant 2008 dollars.

In all, it is estimated that spending on road widening will generate:

- An average of 3,232 job-years annually,
- $1.9 billion in personal income,
- $2.5 billion in gross domestic product,
- $86 million in state tax revenues, and
- $98 million in local tax revenues.

Of the total employment estimated to be generated via the road widening investments made between 2009 and 2018, approximately 62% is direct employment, while 38% is indirect. The employment multiplier for all the jobs is approximately 1.6.

Approximately 35% of the job-years are expected to be generated in the construction industry, with 25% in the various service industries, 12% in the retail trade sector, and slightly over 4% each in the manufacturing and finance sectors.

The average income for all job-years generated through the road widening expenditures is $59,498.

The impacts per $1 million for road widening projects are presented in Table 6.

Table 6
Impacts per $1 million of
Road Widening Expenditures

Employment (job-years)	9
Income ($)	544,238
State Taxes ($)	24,406
Local Taxes ($)	27,612
Gross State Product ($)	704,167

Highways: Road Improvements

Because of similarities in the labor and material requirements for several types of roadwork under the highway spending category, the following subcategories were combined under the heading of "Road Improvements" for purposes of the impact analysis:

- Resurfacing Projects
- Construction of New Interchanges
- Interchange Improvements
- Other: Shoulder Improvements
- Other: Drainage Improvements

Together, these spending items total approximately $2.8 billion in 2008 dollars, representing 31% of highway expenditures and 7% of total transportation expenditures over the 10-year period. Table 7 presents the annual and cumulative economic impacts of these expenditures.

Table 7
Annual Impacts: Road Improvements

	Expenditures*		Employment	Income*	GDP*	Taxes* State	Taxes* Local
Year	**($000)**	**Share**	**(Job-Years)**	**($000)**	**($000)**	**($000)**	**($000)**
2009	352,622	12.6	1,987	123,968	224,102	6,716	7,878
2010	282,738	10.1	1,593	99,399	179,688	5,385	6,317
2011	246,489	8.8	1,389	86,655	156,651	4,694	5,507
2012	285,437	10.2	1,608	100,348	181,403	5,436	6,377
2013	222,610	8.0	1,254	78,260	141,475	4,240	4,974
2014	336,457	12.1	1,896	118,284	213,828	6,408	7,517
2015	323,150	11.6	1,821	113,606	205,371	6,155	7,220
2016	257,787	9.2	1,453	90,627	163,831	4,910	5,759
2017	275,527	9.9	1,553	96,864	175,105	5,248	6,156
2018	209,344	7.5	1,180	73,597	133,044	3,987	4,677
Total	**2,792,160**	**100.0**	**15,733**	**981,608**	**1,774,497**	**53,178**	**62,382**
Annual Average	**279,216**		**1,573**	**98,161**	**177,450**	**5,318**	**6,238**

Note: All amounts are in constant 2008 dollars.

In all, it is estimated that spending on road improvements will generate:

- An average of 1,573 job-years annually,
- $1.0 billion in personal income,
- $1.8 billion in gross domestic product,
- $53.2 million in state tax revenues, and
- $62.4 million in local tax revenues.

Of the total employment estimated to be generated via the road improvement investments made between 2009 and 2018, approximately 55% is direct employment and 45% is indirectly generated via the multiplier effects of the expenditures, implying an employment multiplier of 1.8.

Approximately 48% of the job-years are expected to be generated in the construction industry, with an additional 17% in the various service industries, 14% in the retail trade sector, and 6% in the manufacturing sector.

The average income for all job-years generated through the highway improvement spending is $62,392.

The impacts per $1 million of road improvement spending are presented in Table 8.

Table 8
Impacts per $1 million of
Highway Improvement Expenditures

Employment (job-years)	6
Income ($)	351,559
State Taxes ($)	19,045
Local Taxes ($)	22,342
Gross State Product ($)	635,528

Highways: Highway Operations

The "Highway Operations" component of the spending breakdown comprises a variety of maintenance and repair functions aimed at alleviating congestion on the state's roads.

Together, these spending items total approximately $1.7 billion in 2008 dollars, representing 19% of highway expenditures and 4% of total transportation expenditures over the 10-year period. Table 9 presents the annual and cumulative economic impacts of these expenditures.

Table 9
Annual Impacts: Highway Operations

Year	Expenditures* ($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	Taxes* State ($000)	Taxes* Local ($000)
2009	220,343	12.6	1,885	114,036	157,859	5,258	5,972
2010	280,441	16.1	2,400	145,138	200,914	6,692	7,601
2011	221,606	12.7	1,896	114,689	158,763	5,288	6,006
2012	286,718	16.4	2,453	148,387	205,410	6,842	7,771
2013	203,284	11.6	1,739	105,207	145,637	4,851	5,510
2014	114,719	6.6	982	59,371	82,187	2,738	3,109
2015	113,992	6.5	975	58,995	81,667	2,720	3,090
2016	109,476	6.3	937	56,658	78,431	2,612	2,967
2017	96,508	5.5	826	49,946	69,140	2,303	2,616
2018	98,468	5.6	843	50,961	70,544	2,350	2,669
Total	**1,745,555**	**100.0**	**14,935**	**903,387**	**1,250,552**	**41,654**	**47,312**
Annual Average	**174,556**		**1,494**	**90,339**	**125,055**	**4,165**	**4,731**

*Note: All amounts are in constant 2008 dollars.

In all, it is estimated that spending on highway operations will generate:

- An average of 1,494 job-years annually,
- $0.9 billion in personal income,
- $1.3 billion in gross domestic product,
- $41.7 million in state tax revenues, and
- $47.3 million in local tax revenues.

Of the total employment estimated to be generated via the highway operations investments made between 2009 and 2018, approximately 63% is direct employment and 37% is indirect. The employment multiplier for the operations is approximately 1.6.

Approximately 40% of the total job-years are expected to be generated in the construction industry, with an additional 22% in the service industries, 13% in the retail trade sector, and 10% in the manufacturing sector.

The average income for all job-years generated through the highway operations spending is $60,488.

The impacts per $1 million of highway operations spending are presented in Table 10.

Table 10
Impacts per $1 million of
Highway Operations Expenditures

Employment (job-years)	9
Income ($)	517,536
State Taxes ($)	23,863
Local Taxes ($)	27,104
Gross State Product ($)	716,421

Highways: Roadway Replacements

Three additional components of the Highway category of the transportation spending breakdown were combined under the heading of "Roadway Replacements." The three components are:

- Median Barrier Replacement
- Emergency Sign Warning Replacements
- Toll Plaza Rehabilitations

Together, these spending items total approximately $857.6 million in 2008 dollars, representing 10% of highway expenditures and 2% of total transportation expenditures over the 10-year period.[4] Table 11 presents the annual and cumulative economic impacts of these expenditures.

In all, it is estimated that spending on roadway replacements will generate:

- An average of 783 job-years annually,
- $454.5 million in personal income,
- $601.8 million in gross domestic product,
- $20.8 million in state tax revenues, and
- $23.5 million in local tax revenues.

Of the total employment estimated to be generated via roadway replacement spending between 2009 and 2018, approximately 63% is direct employment and 37% is indirect. The employment multiplier is approximately 1.6.

Approximately 40% of the total job-years are expected to be generated in the construction industry, with an additional 26% in manufacturing, 12% in the retail trade sector, and 11% in the service sectors.

[4] The roadway replacement expenditures are only funded through 2015 in the breakdown provided, but are analyzed over an 10-year horizon in order to be consistent with the other components of the analysis.

Table 11
Annual Impacts: Roadway Replacements

Year	Expenditures* ($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	Taxes* State ($000)	Taxes* Local ($000)
2009	105,966	12.4	967	56,152	74,350	2,564	2,907
2010	136,969	16.0	1,250	72,580	96,102	3,315	3,758
2011	135,368	15.8	1,236	71,732	94,979	3,276	3,714
2012	127,257	14.8	1,162	67,434	89,288	3,080	3,491
2013	110,791	12.9	1,011	58,708	77,735	2,681	3,040
2014	41,302	4.8	377	21,886	28,979	999	1,133
2015	59,153	6.9	540	31,345	41,504	1,431	1,623
2016	44,192	5.2	403	23,418	31,007	1,069	1,212
2017	41,808	4.9	382	22,154	29,334	1,012	1,147
2018	54,838	6.4	501	29,059	38,476	1,327	1,504
Total	**857,643**	**100.0**	**7,829**	**454,468**	**601,754**	**20,755**	**23,530**
Annual Average	**85,764**	**10.0**	**783**	**45,447**	**60,175**	**2,075**	**2,353**

*Note: All amounts are in constant 2008 dollars.

The average income for the all job-years generated through the roadway replacement spending is $58,049.

The impacts per $1 million of roadway replacement spending are presented in Table 12.

Table 12
Impacts per $1 million of Roadway Replacement Expenditures

Employment (job-years)	9
Income ($)	529,903
State Taxes ($)	24,200
Local Taxes ($)	27,435
Gross State Product ($)	701,637

Tunnels: Trans-Hudson Express Tunnel

Total spending for the Trans-Hudson Express Tunnel is estimated at $6.6 billion, representing approximately 17% of the total transportation spending specified in the breakdown. Table 13 presents the distribution of these expenditures and their economic impacts:

Table 13
Annual Impacts: Construction of the Trans-Hudson Express Tunnel

Year	Expenditures* ($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	Taxes* State ($000)	Taxes* Local ($000)
2009	788,452	12.0	10,764	549,330	684,500	32,383	30,716
2010	1,012,446	15.4	13,823	705,391	878,962	41,583	39,443
2011	1,053,202	16.0	14,379	733,786	914,345	43,257	41,030
2012	986,914	15.0	13,474	687,602	856,797	40,534	38,448
2013	767,618	11.6	10,480	534,814	666,413	31,528	29,905
2014	593,239	9.0	8,099	413,321	515,025	24,365	23,111
2015	539,315	8.2	7,363	375,751	468,210	22,151	21,010
2016	450,942	6.8	6,157	314,180	391,489	18,521	17,568
2017	285,307	4.3	3,895	198,779	247,691	11,718	11,115
2018	112,684	1.7	1,538	78,509	97,827	4,628	4,390
Total	**6,590,118**	**100.0**	**89,973**	**4,591,462**	**5,721,260**	**270,669**	**256,736**
Annual Average	**659,012**		**8,997**	**459,146**	**572,126**	**27,067**	**25,674**

Note: All amounts are in constant 2008 dollars.

Over the 10-year period of the analysis, it is estimated that the tunnel construction expenditures will generate:

- An average of 8,997 job-years annually,
- $4.6 billion in personal income,
- $5.7 billion in gross domestic product,
- $270.7 million in state tax revenues, and
- $256.7 million in local tax revenues.

Of the employment estimated to be generated over the course of the tunnel construction, approximately 58% consists of direct job-years, while the remaining 42% is generated indirectly via the multiplier effects of the initial expenditures as they ripple through the economy. The employment multiplier is approximately 1.73.

It is estimated that approximately 29% of the total job-years will be generated in the construction industry, with an additional 19% generated in the manufacturing sector, 24% in various service industries, and 11% in the retail sector.

The average income for all job-years generated through tunnel construction is $51,032.

The impacts per $1 million of spending on construction of the Trans-Hudson Express Tunnel are presented in Table 14.

Table 14
Impacts per $1 million of
Tunnel Construction Expenditures

Employment (job-years)	14
Income ($)	696,719
State Taxes ($)	41,072
Local Taxes ($)	38,958
Gross State Product ($)	868,157

Bridge Investments

Total bridge investments account for $7.1 billion, or about 19% of the estimated transportation expenditures over the 10-year period of the analysis. The annual breakdown of these expenditures and their impacts in terms of employment, income, GDP, and taxes are shown in Table 15.

Table 15
Annual Impacts: All Bridge Investments

Year	Expenditures* ($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	Taxes* State ($000)	Taxes* Local ($000)
2009	691,769	9.8	6,252	355,048	505,841	16,355	18,542
2010	719,485	10.2	6,437	365,968	523,953	16,918	19,197
2011	769,821	10.9	6,789	386,883	557,806	17,968	20,411
2012	743,737	10.5	6,478	369,655	536,238	17,244	19,609
2013	772,738	10.9	6,689	382,105	555,985	17,861	20,319
2014	684,771	9.7	5,992	341,648	494,445	15,914	18,091
2015	664,871	9.4	5,793	330,525	479,364	15,418	17,532
2016	626,808	8.9	5,474	312,155	452,231	14,551	16,544
2017	668,762	9.5	5,905	336,169	484,393	15,613	17,737
2018	727,620	10.3	6,681	377,988	534,324	17,335	19,635
Total	**7,070,382**	**100.0**	**62,490**	**3,558,144**	**5,124,579**	**165,178**	**187,617**
Annual Average	**707,038**		**6,249**	**355,814**	**512,458**	**16,518**	**18,762**

Note: All amounts are in constant 2008 dollars.

In all, over the course of the 10-year period, these bridge investments are estimated to generate:

- An average of 6,249 job-years annually,
- $3.6 billion in income,
- $5.1 billion in GDP,
- $165 million in state tax revenues, and
- $188 million in local tax revenues.

Of the total employment estimated over the 10-year period, approximately 68% is estimated to consist of direct job-years, while the remaining 32% are generated indirectly via the multiplier effects of the initial expenditures. This gives an employment multiplier of approximately 1.48.

Approximately 54% of the total job-years will be generated in the construction industry, with an additional 13% in various service industries, 9% in the manufacturing industry, and 12% in the retail sector.

The average income for the all job-years generated through the highway investments is $56,939.

The impacts per $1 million of highway spending are presented in Table 16.

Table 16
Impacts per $1 million of
Bridge Expenditures

Employment (job-years)	9
Income ($)	528,712
State Taxes ($)	24,084
Local Taxes ($)	27,235
Gross State Product ($)	740,086

Bridge Repairs

For purposes of analysis, the five types of bridge repairs listed in the original spending breakdown have been combined into a single "Bridge Repairs" category. The five bridge repair components are:

- Combined Concrete and Steel
- Deck Rehabilitation and Replacement
- Large Steel Bridges
- Small Bridges
- Large Concrete Bridges

Together, these spending items total approximately $2.6 billion in 2008 dollars, representing 37% of bridge expenditures and 7% of total transportation expenditures over the 10-year period. Table 17 presents the annual and cumulative economic impacts of these expenditures.

In all, it is estimated that spending on bridge repairs will generate:

- An average of 1,475 job-years annually,
- $0.9 billion in personal income,

- $1.7 billion in gross domestic product,
- $49.9 million in state tax revenues, and
- $58.5 million in local tax revenues.

Table 17
Annual Impacts: Bridge Repairs

Year	Expenditures* ($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	Taxes* State ($000)	Taxes* Local ($000)
2009	229,762	8.8	1,295	80,775	146,020	4,376	5,133
2010	251,382	9.6	1,416	88,376	159,761	4,788	5,616
2011	288,163	11.0	1,624	101,306	183,136	5,488	6,438
2012	293,991	11.2	1,657	103,355	186,840	5,599	6,568
2013	313,560	12.0	1,767	110,235	199,276	5,972	7,006
2014	265,009	10.1	1,493	93,166	168,421	5,047	5,921
2015	262,217	10.0	1,478	92,185	166,646	4,994	5,858
2016	244,814	9.4	1,379	86,067	155,586	4,663	5,470
2017	248,596	9.5	1,401	87,396	157,990	4,735	5,554
2018	220,311	8.4	1,241	77,452	140,014	4,196	4,922
Total	**2,617,805**	**100.0**	**14,750**	**920,312**	**1,663,690**	**49,857**	**58,487**
Annual Average	**261,781**		**1,475**	**92,031**	**166,369**	**4,986**	**5,849**

*Note: All amounts are in constant 2008 dollars.

Of the total employment estimated to be generated via spending on bridge repairs between 2009 and 2018, approximately 58% is direct employment and 42% is indirect. The employment multiplier is approximately 1.7.

Approximately 48% of the total job-years are expected to be generated in the construction industry, with an additional 17% in the service sectors and almost 15% in the retail trade sector.

The average income for the all job-years generated through the bridge repair spending is $62,394.

The impacts per $1 million of highway spending are presented in Table 18.

Table 18
Impacts per $1 million of
Bridge Repair Expenditures

Employment (job-years)	6
Income ($)	351,559
State Taxes ($)	19,045
Local Taxes ($)	22,342
Gross State Product ($)	635,528

New Bridges

The economic impacts analysis of the construction of new bridges comprises two of the line items enumerated in the transportation investment breakdown:

- Bridge Construction
- Bridge Widening

Together, these spending items total approximately $4.3 billion in 2008 dollars, representing 61% of bridge expenditures and 11% of total transportation expenditures over the 10-year period. Table 19 presents the annual and cumulative economic impacts of these expenditures.

Table 19
Annual Impacts: New Bridges

	Expenditures*		Employment	Income*	GDP*	Taxes*	
						State	Local
Year	($000)	Share	(Job-Years)	($000)	($000)	($000)	($000)
2009	460,540	10.6	4,942	273,479	358,774	11,943	13,367
2010	460,930	10.6	4,946	273,710	359,078	11,953	13,379
2011	473,240	10.9	5,079	281,020	368,668	12,272	13,736
2012	435,108	10.0	4,669	258,377	338,962	11,283	12,629
2013	443,967	10.2	4,764	263,637	345,864	11,513	12,886
2014	404,886	9.3	4,345	240,430	315,418	10,499	11,752
2015	388,105	9.0	4,165	230,465	302,345	10,064	11,265
2016	367,765	8.5	3,947	218,387	286,500	9,537	10,675
2017	406,251	9.4	4,360	241,240	316,481	10,535	11,792
2018	493,699	11.4	5,298	293,169	384,606	12,802	14,330
Total	**4,334,491**	**100.0**	**46,515**	**2,573,914**	**3,376,697**	**112,401**	**125,811**
Annual Average	**433,449**		**4,652**	**257,391**	**337,670**	**11,240**	**12,581**

*Note: All amounts are in constant 2008 dollars.

In all, it is estimated that spending on new bridges will generate:

- An average of 4,652 job-years annually,
- $2.6 billion in personal income,
- $3.4 billion in gross domestic product,
- $112 million in state tax revenues, and
- $126 million in local tax revenues.

Of the total employment estimated to be generated via spending on new bridges between 2009 and 2018, approximately 70% is direct employment and 30% is indirect. The employment multiplier is approximately 1.4.

Approximately 56% of the total job-years are expected to be generated in the construction industry, with an additional 12% in the service sectors, 11% in the retail trade sector, and 9% in manufacturing.

The average income for all job-years generated through spending on new bridges is $55,335.

The impacts per $1 million of new bridge investments are presented in Table 20.

Table 20
Impacts per $1 million of
New Bridge Expenditures

Employment (job-years)	11
Income ($)	593,821
State Taxes ($)	25,932
Local Taxes ($)	29,026
Gross State Product ($)	779,030

Bridges: Seismic Retrofitting

The final component of bridge investments analyzed was seismic retrofitting. Estimated spending for this component is approximately $118 million in 2008 dollars, representing 1% of bridge expenditures and 0.3% of total transportation expenditures over the 10-year period. Table 21 presents the annual and cumulative economic impacts of these expenditures.

Table 21
Annual Impacts: Seismic Retrofitting

	Expenditures*		Employment	Income*	GDP*	Taxes*	
						State	Local
Year	($000)	Share	(Job-Years)	($000)	($000)	($000)	($000)
2009	1,467	1.2	15	794	1,046	36	41
2010	7,174	6.1	74	3,883	5,115	177	202
2011	8,419	7.1	87	4,557	6,003	208	237
2012	14,638	12.4	152	7,923	10,436	362	411
2013	15,210	12.9	158	8,233	10,845	376	428
2014	14,876	12.6	154	8,052	10,606	368	418
2015	14,549	12.3	151	7,875	10,373	360	409
2016	14,229	12.0	148	7,702	10,145	352	400
2017	13,915	11.8	144	7,532	9,921	344	391
2018	13,609	11.5	141	7,367	9,703	336	383
Total	**118,086**	**100.0**	**1,224**	**63,918**	**84,193**	**2,919**	**3,319**
Annual Average	**11,809**		**122**	**6,392**	**8,419**	**292**	**332**

*Note: All amounts are in constant 2008 dollars.

In all, it is estimated that spending on seismic retrofitting will generate:

- An average of 122 job-years annually,
- $63.9 million in personal income,
- $84.2 million in gross domestic product,
- $2.9 million in state tax revenues, and
- $3.3 million in local tax revenues.

Of the total employment estimated to be generated via spending on seismic retrofitting between 2009 and 2018, approximately 70% is direct employment and 30% is indirect. The employment multiplier is approximately 1.4.

Approximately 39% of the total job-years are expected to be generated in the construction industry, with an additional 34% in manufacturing, 11% in retail trade, and 8% in the service sectors.

The average income for all job-years generated through spending on seismic retrofitting is $52,221.

The impacts per $1 million of seismic retrofitting investments are presented in Table 22.

Table 22
Impacts per $1 million of
Seismic Retrofitting Expenditures

Employment (job-years)	10
Income ($)	541,283
State Taxes ($)	24,721
Local Taxes ($)	28,109
Gross State Product ($)	712,981

Transit Investments

Total transit investments account for $3.8 billion, or about 10% of the estimated transportation expenditures over the 10-year period of the analysis. In addition to construction of new rail lines and repairs to existing rail lines and transit stations, this category of investments also includes purchase of new train cars and buses. However, because these purchases will be made outside the state, they will not have economic impacts within New Jersey. As such, while these amounts are included in the total transit investment, no economic impact analysis is provided for these expenditures.

The annual breakdown of the transit expenditures (with impacts in New Jersey) and their impacts in terms of employment, income, GDP, and taxes are shown in Table 23.

In all, over the course of the 10-year period, these investments are estimated to generate:

- An average of 4,370 job-years annually,
- $2.5 billion in income,

- $3.2 billion in GDP,
- $106 million in state tax revenues, and
- $118 million in local tax revenues.

Table 23
Annual Impacts: All Transit Investments

Year	Expenditures* ($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	Taxes* State ($000)	Taxes* Local ($000)
2009	375,332	9.8	4,202	235,688	307,809	10,184	11,362
2010	340,575	8.9	3,782	211,146	276,209	9,152	10,220
2011	390,680	10.2	4,316	240,555	314,693	10,442	11,666
2012	308,600	8.1	3,566	201,558	263,817	8,646	9,620
2013	371,937	9.8	4,205	236,824	309,004	10,201	11,370
2014	299,825	7.9	3,325	186,871	242,933	8,076	9,015
2015	366,856	9.6	4,243	240,789	314,155	10,308	11,465
2016	391,645	10.3	4,632	263,569	345,142	11,241	12,481
2017	424,109	11.1	5,000	284,767	372,346	12,144	13,487
2018	542,427	14.2	6,427	366,359	479,295	15,609	17,327
Total	**3,811,985**	**100.0**	**43,699**	**2,468,126**	**3,225,402**	**106,003**	**118,014**
Annual Average	**381,199**		**4,370**	**246,813**	**322,540**	**10,600**	**11,801**

*Note: All amounts are in constant 2008 dollars.

Of the total employment estimated over the 10-year period, approximately 70% is estimated to consist of direct job-years, while the remaining 30% are generated indirectly via the multiplier effects of the initial expenditures. The employment multiplier is approximately 1.44.

Approximately 58% of the total job-years will be generated in the construction industry, with an additional 13% in various service industries, 12% in the retail sector, and 7% in the manufacturing industry.

The average income for all job-years generated through the transit investments is $56,480.

The impacts per $1 million of transit project investments are presented in Table 24.

Table 24
Impacts per $1 million of
Transit Project Expenditures

Employment (job-years)	11
Income ($)	649,074
State Taxes ($)	27,864
Local Taxes ($)	31,016
Gross State Product ($)	848,315

Transit: New Rail

Construction of new rail lines accounts for approximately $1.4 billion in 2008 dollars, representing 37% of transit expenditures and 3.7% of total transportation expenditures over the 10-year period. Table 25 presents the annual and cumulative economic impacts of these expenditures.

Table 25
Annual Impacts: New Rail Lines

Year	Expenditures* ($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	Taxes* State ($000)	Taxes* Local ($000)
2009	210,105	15.5	2,290	126,748	166,153	5,529	6,186
2010	245,463	18.2	2,675	148,079	194,115	6,460	7,227
2011	301,656	22.3	3,288	181,977	238,553	7,939	8,882
2012	109,512	8.1	1,194	66,064	86,603	2,882	3,224
2013	154,982	11.5	1,689	93,495	122,562	4,079	4,563
2014	128,509	9.5	1,401	77,525	101,627	3,382	3,784
2015	65,843	4.9	718	39,721	52,070	1,733	1,939
2016	55,788	4.1	608	33,655	44,118	1,468	1,643
2017	40,370	3.0	440	24,353	31,925	1,062	1,189
2018	39,482	2.9	430	23,818	31,222	1,039	1,162
Total	**1,351,710**	**100.0**	**14,733**	**815,435**	**1,068,948**	**35,574**	**39,800**
Annual Average	**135,171**		**1,473**	**81,544**	**106,895**	**3,557**	**3,980**

*Note: All amounts are in constant 2008 dollars.

In all, it is estimated that spending on new rail lines will generate:

- An average of 1,473 job-years annually,
- $815 million in personal income,
- $1.1 billion in gross domestic product,
- $36 million in state tax revenues, and
- $40 million in local tax revenues.

Of the total employment estimated to be generated via spending on new rail line projects between 2009 and 2018, approximately 70% is direct employment and 30% is indirect. The employment multiplier is approximately 1.44.

Approximately 56% of the total job-years are expected to be generated in the construction industry, with an additional 12% in service, 11% in retail trade, and 9% in manufacturing.

The average income for all job-years generated through spending on new rail lines is $55,348.

The impacts per $1 million of new rail investments are presented in Table 26.

Table 26
Impacts per $1 million of
New Rail Line Expenditures

Employment (job-years)	11
Income ($)	603,262
State Taxes ($)	26,318
Local Taxes ($)	29,444
Gross State Product ($)	790,812

Transit: Rail Repairs

Repairs to existing rail lines account for approximately $2.0 billion in 2008 dollars, representing 53% of transit expenditures and 5.3% of total transportation expenditures over the 10-year period. Table 27 presents the annual and cumulative economic impacts of these expenditures.

Table 27
Annual Impacts: Rail Repairs

Year	Expenditures* ($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	Taxes* State ($000)	Taxes* Local ($000)
2009	114,277	5.8	1,390	79,498	104,383	3,372	3,736
2010	68,809	3.5	837	47,868	62,852	2,030	2,249
2011	60,560	3.1	736	42,130	55,317	1,787	1,980
2012	173,586	8.9	2,111	120,757	158,557	5,122	5,674
2013	152,463	7.8	1,854	106,063	139,263	4,498	4,984
2014	87,865	4.5	1,068	61,124	80,258	2,592	2,872
2015	230,272	11.7	2,800	160,191	210,335	6,794	7,527
2016	304,211	15.5	3,699	211,628	277,873	8,975	9,944
2017	328,233	16.7	3,991	228,339	299,815	9,684	10,729
2018	440,655	22.5	5,358	306,547	402,504	13,001	14,404
Total	**1,960,931**	**100.0**	**23,843**	**1,364,144**	**1,791,158**	**57,856**	**64,100**
Annual Average	**196,093**		**2,384**	**136,414**	**179,116**	**5,786**	**6,410**

*Note: All amounts are in constant 2008 dollars.

In all, it is estimated that spending on repairs to existing rail lines will generate:

- An average of 2,384 job-years annually,
- $1.4 billion in personal income,
- $1.8 billion in gross domestic product,
- $58 million in state tax revenues, and
- $64 million in local tax revenues.

Of the total employment estimated to be generated via spending on rail repairs between 2009 and 2018, approximately 70% is direct employment and 30% is indirect. The employment multiplier is approximately 1.43.

Approximately 62% of the total job-years are expected to be generated in the construction industry, with an additional 11% in the service sectors, 12% in the retail trade sector, and 6% in manufacturing.

The average income for all job-years generated through spending on rail repairs lines is $57,214.

The impacts per $1 million of rail repair investments are presented in Table 28.

Table 28
Impacts per $1 million of
Rail Repair Expenditures

Employment (job-years)	12
Income ($)	695,662
State Taxes ($)	29,504
Local Taxes ($)	32,688
Gross State Product ($)	913,422

Transit: Repairs to Rail Stations and Bus/LRT Facilities

Repairs to rail stations and to bus/LRT facilities were combined for purposes of the analysis. Together these expenditure components total approximately $499 million in 2008 dollars. They represent approximately 13% of transit expenditures and 1.3% of total transportation expenditures over the 10-year period. Table 29 presents the annual and cumulative economic impacts of these expenditures.

In all, it is estimated that spending on bus and rail station repairs will generate:

- An average of 512 job-years annually,
- $289 million in personal income,
- $365 million in gross domestic product,
- $13 million in state tax revenues, and
- $14 million in local tax revenues.

Of the total employment estimated to be generated via spending on station and other facility repairs between 2009 and 2018, approximately 67% is direct employment and 33% is indirect. The employment multiplier is approximately 1.49.

Approximately 41% of the total job-years are expected to be generated in the construction industry, with an additional 23% in the service sectors, 12% in manufacturing, and 11% in retail trade.

Table 29
Annual Impacts: Repair of Bus and Rail Stations

Year	Expenditures* ($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	Taxes* State ($000)	Local ($000)
2009	50,950	10.2	523	29,441	37,272	1,283	1,440
2010	26,302	5.3	270	15,199	19,241	662	743
2011	28,464	5.7	292	16,448	20,823	717	805
2012	25,503	5.1	262	14,737	18,656	642	721
2013	64,492	12.9	662	37,266	47,179	1,624	1,823
2014	83,451	16.7	856	48,222	61,049	2,101	2,359
2015	70,740	14.2	726	40,877	51,750	1,781	2,000
2016	31,646	6.3	325	18,287	23,151	797	894
2017	55,506	11.1	569	32,074	40,606	1,398	1,569
2018	62,291	12.5	639	35,995	45,569	1,568	1,761
Total	**499,345**	**100.0**	**5,123**	**288,546**	**365,296**	**12,574**	**14,114**
Annual Average	**49,934**		**512**	**28,855**	**36,530**	**1,257**	**1,411**

*Note: All amounts are in constant 2008 dollars.

The average income for all job-years generated through spending on station and facility repairs is $56,324.

The impacts per $1 million of station and facility repair investments are presented in Table 30.

Table 30
Impacts per $1 million of
Station Repair Expenditures

Employment (job-years)	10
Income ($)	577,850
State Taxes ($)	25,180
Local Taxes ($)	28,266
Gross State Product ($)	731,550

Other Transportation Investments

In addition to the highway/road, tunnel, bridge, and transit investments analyzed above, the $38 billion total transportation investments include approximately $7 billion in "other" expenditures unaccounted for elsewhere in the breakdown. Over 97.4% of these expenditures is allocated for capital program delivery, local system support and other programs, and investments that are not included in the economic impact analysis.

The remaining $189 million are allocated to "Other Roadway Improvements" and "Turnpike Rock Stabilization." Together, these components represent 2.7% of "Other" transportation investments, and 0.5% of the total transportation investment portfolio over the 10-year period of the analysis. The annual breakdown of the $189 million in expenditures and their impacts in terms of employment, income, GDP, and taxes are shown in Table 31.

Table 31
Annual Impacts: All Other Investments

	Expenditures*		Employment	Income*	GDP*	Taxes*	
Year	**($000)**	**Share**	**(Job-Years)**	**($000)**	**($000)**	**State ($000)**	**Local ($000)**
2009	54,479	28.8	388	24,257	32,240	1,025	1,170
2010	32,253	17.1	230	14,361	19,087	607	693
2011	32,128	17.0	229	14,305	19,013	604	690
2012	23,791	12.6	170	10,593	14,079	447	511
2013	18,548	9.8	132	8,259	10,976	349	398
2014	13,349	7.1	95	5,944	7,900	251	287
2015	10,894	5.8	78	4,851	6,447	205	234
2016	967	0.5	7	430	572	18	21
2017	1,662	0.9	12	740	983	31	36
2018	1,005	0.5	7	447	595	19	22
Total	**189,075**	**100.0**	**1,348**	**84,187**	**111,892**	**3,556**	**4,062**
Annual Average	**18,907**		**135**	**8,419**	**11,189**	**356**	**406**

*Note: All amounts are in constant 2008 dollars.

In all, over the course of the 10-year period, these investments are estimated to generate:

- An average of 135 job-years annually,
- $84.2 million in income,
- $111.9 million in GDP,
- $3.6 million in state tax revenues, and
- $4.1 million in local tax revenues.

Of the total employment estimated over the 10-year period, approximately 66% is estimated to consist of direct job-years, while the remaining 34% is generated indirectly via the multiplier effects of the initial expenditures. The employment multiplier is approximately 1.5.

Approximately 49% of the total job-years will be generated in the construction industry, with an additional 10% in manufacturing, 7% in services, and 8% in retail trade.

The average income for all job-years generated through these expenditures is $62,453.

The impacts per $1 million of "Other" investments are presented in Table 32.

Table 32
Impacts per $1 million of
Other Transportation Expenditures

Employment (job-years)	7
Income ($)	445,255
State Taxes ($)	18,807
Local Taxes ($)	21,482
Gross State Product ($)	591,785

Total Transportation Investment Impacts

All transportation investments listed in the 10-year breakdown total $38 billion. Of this amount, approximately $26.6 billion (70%) are expected to generate broader economic impacts in New Jersey in the form of employment, income, GDP, and tax revenues. The annual breakdown of these expenditures and their impacts is provided in Table 33.

Table 33
Annual Impacts: All Transportation Investments

	Expenditures*					Taxes*	
Year	($000)	Share	Employment (Job-Years)	Income* ($000)	GDP* ($000)	State ($000)	Local ($000)
2009	2,973,710	11.2	29,966	1,667,870	2,257,625	83,875	89,172
2010	3,717,297	14.0	37,860	2,110,540	2,817,390	105,919	112,421
2011	3,574,448	13.4	36,868	2,043,262	2,726,879	103,229	109,048
2012	3,282,553	12.3	33,668	1,868,634	2,513,269	94,923	100,188
2013	2,812,087	10.6	28,663	1,591,701	2,149,854	80,119	85,030
2014	2,312,050	8.7	22,856	1,271,623	1,746,120	64,326	68,570
2015	2,288,757	8.6	22,739	1,270,439	1,744,964	63,526	67,988
2016	1,996,901	7.5	20,114	1,123,671	1,543,740	55,731	59,731
2017	1,885,770	7.1	18,414	1,039,536	1,443,838	50,317	54,836
2018	1,746,385	6.6	17,176	976,919	1,354,105	45,254	50,224
Total	**26,589,956**	**100.0**	**268,324**	**14,964,195**	**20,297,784**	**747,220**	**797,206**
Annual Average	**2,658,996**		**26,832**	**1,496,420**	**2,029,778**	**74,722**	**79,721**

*Note: All amounts are in constant 2008 dollars.

In all, over the course of the 10-year period, these investments are estimated to generate:

- An average of 26,832 job-years annually,
- $15 billion in income,
- $20.3 billion in GDP,
- $747 million in state tax revenues, and
- $797 million in local tax revenues.

Of the total employment estimated over the period, approximately 63% is estimated to consist of direct job-years, while the remaining 37% is generated indirectly via the multiplier effects of the initial expenditures. The employment multiplier is approximately 1.58. Approximately 44% of the total job-years will be generated in the construction industry, with an additional 18% in various service industries, 12% in the manufacturing industry, and 12% in the retail sector.

Note from Table 33 that the spending and, hence, number of jobs created peaks fairly early in the period in 2010 and 2011. Of course, this is also when the income, GDP, and tax impacts also crest. This is largely due to the intensity of construction for the THE Tunnel.

Thus, while we tend to speak about employment in the average, the number of jobs created by the proposed program of investments in any one year varies substantially from the average over the course of the study period. For example, in 2010, the 37,860 jobs-years are more than 10,000 job-years above the 26,832 job-year average for the period. Naturally the peak employment contrasts strongly when juxtaposed against the program's nadir for job created, which is this year 2018, when just 17,176 jobs are slated for creation—a difference of 20,684 job-years.

The average income per job-year generated by the investment total is $55,659 in year 2009 dollars. This amount is about the same as the state's average annual pay rate. The construction jobs involved pay on average substantially more—on the order of $65,000-$72,000, depending upon the type of construction undertaken. Moreover, manufacturing jobs that support the construction efforts pay only marginally less. Thus, it is the spending by households on retail trade and personal services that lowers the average pay rate transmitted to the State's economy.

Table 34 displays the effects of $1 million of spending (in 2008 dollars) for each infrastructure type as effected during the modeling process. One can view such an exhibit as providing an apples-to-apples comparison of their probable economic impacts. Of course, fundamentally it also supplies the state with a means of estimating any generic project for the project types listed.

In comparing the project types, one is immediately struck by the variation in the level of statewide impacts provided by the array of 12 different project types: job-years created range from 6 to 14 per million dollars, income ranges from about $351,600 to $696,700, and GDP from about $635,500 to $913,400. Construction of the Hudson rail tunnel and rail repairs tend to yield the largest overall economic impacts, while road improvements and bridge repairs yield the smallest overall economic gains of the group.

Of course, Table 34 alone should not be used to identify which projects are most important to the State. The interplay of transportation efficiency issues and state budget priorities, not the economic impacts of project construction, should be employed to identify what projects will be put in place.

Table 34
Impacts per $1 Million in Transportation Expenditures, 2008-2018
Real (2008) Dollars

Investment Component	Employment (job-years)	Income ($)	Taxes ($) State	Taxes ($) Local	Gross State Product ($)
Highways					
Road Widening	9	544,238	24,406	27,612	704,167
Road Improvements	6	351,559	19,045	22,342	635,528
Highway Operations	9	517,536	23,863	27,104	716,421
Roadway Replacements	9	529,903	24,200	27,435	701,637
Total Highways	**8**	**477,384**	**22,604**	**25,848**	**684,854**
Tunnels					
Construction of Hudson Rail Tunnel	14	696,719	41,072	38,958	868,157
Total Tunnels	**14**	**696,719**	**41,072**	**38,958**	**868,157**
Bridges					
Bridge Repairs	6	351,559	19,045	22,342	635,528
New Bridges	11	593,821	25,932	29,026	779,030
Seismic Retrofitting	10	541,283	24,721	28,109	712,981
Total Bridges	**9**	**503,246**	**23,362**	**26,536**	**724,795**
Transit					
New Rail	11	603,262	26,318	29,444	790,812
Rail Repairs	12	695,662	29,504	32,688	913,422
Repairs to Rail Stations and Bus/LRT Facilities	10	577,850	25,180	28,266	731,550
Total Transit	**11**	**647,465**	**27,808**	**30,959**	**846,121**
Other Transportation Investments					
Other Transportation Investments	7	445,255	18,807	21,482	591,785
Total Other Transportation Investments	**7**	**445,255**	**18,807**	**21,482**	**591,785**
Grand Total	**10**	**562,776**	**28,102**	**29,981**	**763,363**

Appendix A:
Input-Output Analysis—
Technical Description and Application

This appendix discusses the history and application of input-output analysis and details the input-output model, called the R/Econ™ I-O model, developed by Rutgers University. This model offers significant advantages in detailing the total economic effects of an activity (such as historic rehabilitation and heritage tourism), including multiplier effects.

Estimating Multipliers

The fundamental issue determining the size of the multiplier effect is the "openness" of regional economies. Regions that are more "open" are those that import their required inputs from other regions. Imports can be thought of as substitutes for local production. Thus, the more a region depends on imported goods and services instead of its own production, the more economic activity leaks away from the local economy. Businesspeople noted this phenomenon and formed local chambers of commerce with the explicit goal of stopping such leakage by instituting a "buy local" policy among their membership. In addition, during the 1970s, as an import invasion was under way, businessmen and union leaders announced a "buy American" policy in the hope of regaining ground lost to international economic competition. Therefore, one of the main goals of regional economic multiplier research has been to discover better ways to estimate the leakage of purchases out of a region or to determine the region's level of self-sufficiency.

The earliest attempts to systematize the procedure for estimating multiplier effects used the economic base model, still in use in many econometric models today. This approach assumes that all economic activities in a region can be divided into two categories: "basic" activities that produce exclusively for export, and region-serving or "local" activities that produce strictly for internal regional consumption. Since this approach is simpler but similar to the approach used by regional input-output analysis, let us explain briefly how multiplier effects are estimated using the economic base approach. If we let **x** be export employment, **l** be local employment, and **t** be total employment, then

$$\mathbf{t} = \mathbf{x} + \mathbf{l}$$

For simplification, we create the ratio **a** as

$$\mathbf{a} = \mathbf{l}/\mathbf{t}$$

so that $\mathbf{l} = \mathbf{at}$

then substituting into the first equation, we obtain

$$\mathbf{t} = \mathbf{x} + \mathbf{at}$$

By bringing all of the terms with t to one side of the equation, we get

$$\mathbf{t} - \mathbf{at} = \mathbf{x} \text{ or } \mathbf{t}\,(1-\mathbf{a}) = \mathbf{x}$$

Solving for **t,** we get $\mathbf{t} = \mathbf{x}/(1-\mathbf{a})$

Thus, if we know the amount of export-oriented employment, **x,** and the ratio of local to total employment, **a**, we can readily calculate total employment by applying the economic base multiplier, 1/(1-**a**), which is embedded in the above formula. Thus, if 40 percent of all regional employment is used to produce exports, the regional multiplier would be 2.5. The assumption behind this multiplier is that all remaining regional employment is required to support the export employment. Thus, the 2.5 can be decomposed into two parts the direct effect of the exports, which is always 1.0, and the indirect and induced effects, which is the remainder—in this case 1.5. Hence, the multiplier can be read as telling us that for each export-oriented job another 1.5 jobs are needed to support it.

This notion of the multiplier has been extended so that **x** is understood to represent an economic change demanded by an organization or institution outside of an economy—so-called final demand. Such changes can be those effected by government, households, or even by an outside firm. Changes in the economy can therefore be calculated by a minor alteration in the multiplier formula:

$$\Delta\mathbf{t} = \Delta\mathbf{x}/(1-\mathbf{a})$$

The high level of industry aggregation and the rigidity of the economic assumptions that permit the application of the economic base multiplier have caused this approach to be subject to extensive criticism. Most of the discussion has focused on the estimation of the parameter **a**. Estimating this parameter requires that one be able to distinguish those parts of the economy that produce for local consumption from those that do not. Indeed, virtually all industries, even services, sell to customers both inside and outside the region. As a result, regional economists devised an approach by which to measure the *degree* to which each industry is involved in the nonbase activities of the region, better known as the industry's *regional purchase coefficient*. Thus, they expanded the above formulations by calculating for each $\boldsymbol{i}$ industry

$$\mathbf{l}_i = \mathbf{r}_i\mathbf{d}_i$$

and $\mathbf{x}_i = t_i - \mathbf{r}_i\mathbf{d}_i$

given that $\mathbf{d}_i$ is the total regional demand for industry $\boldsymbol{i}$'s product. Given the above formulae and data on regional demands by industry, one can calculate an accurate traditional aggregate economic base parameter by the following:

$$\mathbf{a} = \mathbf{l}/\mathbf{t} = \Sigma\mathbf{l}_{ii}/\Sigma\mathbf{t}_i$$

Although accurate, this approach only facilitates the calculation of an aggregate multiplier for the entire region. That is, we cannot determine from this approach what the effects are on the various sectors of an economy. This is despite the fact that one must painstakingly calculate the regional demand as well as the degree to which they each industry is involved in nonbase activity in the region.

As a result, a different approach to multiplier estimation that takes advantage of the detailed demand and trade data was developed. This approach is called input-output analysis.

Regional Input-Output Analysis: A Brief History

The basic framework for input-output analysis originated nearly 250 years ago when François Quesenay published *Tableau Economique* in 1758. Quesenay's "tableau" graphically and numerically portrayed the relationships between sales and purchases of the various industries of an economy. More than a century later, his description was adapted by Leon Walras, who advanced input-output modeling by providing a concise theoretical formulation of an economic system (including consumer purchases and the economic representation of "technology").

It was not until the twentieth century, however, that economists advanced and tested Walras' work. Wassily Leontief greatly simplified Walras's theoretical formulation by applying the Nobel prize-winning assumptions that both technology and trading patterns were fixed over time. These two assumptions meant that the pattern of flows among industries in an area could be considered stable. These assumptions permitted Walras's formulation to use data from a single time period, which generated a great reduction in data requirements.

Although Leontief won the Nobel Prize in 1973, he first used his approach in 1936 when he developed a model of the 1919 and 1929 U.S. economies to estimate the effects of the end of World War I on national employment. Recognition of his work in terms of its wider acceptance and use meant development of a standardized procedure for compiling the requisite data (today's national economic census of industries) and enhanced capability for calculations (i.e., the computer).

The federal government immediately recognized the importance of Leontief's development and has been publishing input-output tables of the U.S. economy since 1939. The most recently published tables are those for 1987. Other nations followed suit. Indeed, the United Nations maintains a bank of tables from most member nations with a uniform accounting scheme.

Framework

Input-output modeling focuses on the interrelationships of sales and purchases among sectors of the economy. Input-output is best understood through its most basic form, the *interindustry transactions table* or matrix. In this table (see Figure 1 for an example), the column industries are consuming sectors (or markets) and the row industries are producing sectors. The content of a matrix cell is the value of shipments that the row industry delivers to the column industry. Conversely, it is the value of shipments that the column industry receives from the row industry. Hence, the interindustry transactions table is a detailed accounting of the disposition of the value of shipments in an economy. Indeed, the detailed accounting of the interindustry transactions at the national level is performed not so much to facilitate calculation of national economic impacts as it is to back out an estimate of the nation's gross domestic product.

Figure 1
Interindustry Transactions Matrix (Values)

	Agriculture	Manufacturing	Services	Other	Final Demand	Total Output
Agriculture	10	65	10	5	10	$100
Manufacturing	40	25	35	75	25	$200
Services	15	5	5	5	90	$120
Other	15	10	50	50	100	$225
Value Added	20	95	20	90		
Total Input	100	200	120	225		

For example, in Figure 1, agriculture, as a producing industry sector, is depicted as selling $65 million of goods to manufacturing. Conversely, the table depicts that the manufacturing industry purchased $65 million of agricultural production. The sum across columns of the interindustry transaction matrix is called the *intermediate outputs vector*. The sum across rows is called the *intermediate inputs vector*.

A single *final demand* column is also included in Figure 1. Final demand, which is outside the square interindustry matrix, includes imports, exports, government purchases, changes in inventory, private investment, and sometimes household purchases.

The *value-added* row, which is also outside the square interindustry matrix, includes wages and salaries, profit-type income, interest, dividends, rents, royalties, capital consumption allowances, and taxes. It is called value added because it is the difference between the total value of the industry's production and the value of the goods and nonlabor services that it requires to produce. Thus, it is the *value* that an industry *adds* to the goods and services it uses as inputs in order to produce output.

The value-added row measures each industry's contribution to wealth accumulation. In a national model, therefore, its sum is better known as the gross domestic product (GDP). At the state level, this is known as the gross state product—a series produced by the U.S. Bureau of Economic Analysis and published in the Regional Economic Information System. Below the state level, it is known simply as the regional equivalent of the GDP—the gross regional product.

Input-output economic impact modelers now tend to include the household industry within the square interindustry matrix. In this case, the "consuming industry" is the household itself. Its spending is extracted from the final demand column and is appended as a separate column in the interindustry matrix. To maintain a balance, the income of households must be appended as a row. The main income of households is labor income, which is extracted from the value-added row. Modelers tend not to include other sources of household income in the household industry's row. This is not because such income is not attributed to households but rather because much of this other income derives from sources outside of the economy that is being modeled.

The next step in producing input-output multipliers is to calculate the *direct requirements matrix*, which is also called the technology matrix. The calculations are based entirely on data from Figure 1. As shown in Figure 2, the values of the cells in the direct requirements matrix are derived by dividing each cell in a column of Figure 1, the interindustry transactions matrix, by its column total. For example, the cell for manufacturing's purchases from agriculture is 65/200 = .33. Each cell in a column of the direct requirements matrix shows how many cents of each producing industry's goods and/or services are required to produce one dollar of the consuming industry's production and are called *technical coefficients*. The use of the terms "technology" and "technical" derive from the fact that a column of this matrix represents a recipe for a unit of an industry's production. It, therefore, shows the needs of each industry's production process or "technology."

Figure 2
Direct Requirements Matrix

	Agriculture	Manufacturing	Services	Other
Agriculture	.10	.33	.08	.02
Manufacturing	.40	.13	.29	.33
Services	.15	.03	.04	.02
Other	.15	.05	.42	.22

Next in the process of producing input-output multipliers, the *Leontief Inverse* is calculated. To explain what the Leontief Inverse is, let us temporarily turn to equations. Now, from Figure 1 we know that the sum across both the rows of the square interindustry transactions matrix (**Z**) and the final demand vector (**y**) is equal to vector of production by industry (**x**). That is,

$$\mathbf{x} = \mathbf{Zi} + \mathbf{y}$$

where **i** is a summation vector of ones. Now, we calculate the direct requirements matrix (**A**) by dividing the interindustry transactions matrix by the production vector or

$$\mathbf{A} = \mathbf{ZX}^{-1}$$

where $\mathbf{X}^{-1}$ is a square matrix with inverse of each element in the vector **x** on the diagonal and the rest of the elements equal to zero. Rearranging the above equation yields

$$\mathbf{Z} = \mathbf{AX}$$

where **X** is a square matrix with the elements of the vector **x** on the diagonal and zeros elsewhere. Thus,

$$\mathbf{x} = (\mathbf{AX})\mathbf{i} + \mathbf{y}$$

or, alternatively,

$$\mathbf{x} = \mathbf{Ax} + \mathbf{y}$$

solving this equation for **x** yields

$$\mathbf{x} = \quad (\mathbf{I}-\mathbf{A})^{-1} \quad \mathbf{y}$$

Total =	Total *	Final
Output	Requirements	Demand

The Leontief Inverse is the matrix $(\mathbf{I}\text{-}\mathbf{A})^{-1}$. It portrays the relationships between final demand and production. This set of relationships is exactly what is needed to identify the economic impacts of an event external to an economy.

Because it does translate the direct economic effects of an event into the total economic effects on the modeled economy, the Leontief Inverse is also called the *total requirements matrix.* The total requirements matrix resulting from the direct requirements matrix in the example is shown in Figure 3.

Figure 3
Total Requirements Matrix

	Agriculture	Manufacturing	Services	Other
Agriculture	1.5	.6	.4	.3
Manufacturing	1.0	1.6	.9	.7
Services	.3	.1	1.2	.1
Other	.5	.3	.8	1.4
Industry Multipliers	.33	2.6	3.3	2.5

In the direct or technical requirements matrix in Figure 2, the technical coefficient for the manufacturing sector's purchase from the agricultural sector was .33, indicating the 33 cents of agricultural products must be directly purchased to produce a dollar's worth of manufacturing products. The same "cell" in Figure 3 has a value of .6. This indicates that for every dollar's worth of product that manufacturing ships out of the economy (i.e., to the government or for export), agriculture will end up increasing its production by 60 cents. The sum of each column in the total requirements matrix is the *output multiplier* for that industry.

Multipliers

A *multiplier* is defined as the system of economic transactions that follow a disturbance in an economy. Any economic disturbance affects an economy in the same way as does a drop of water in a still pond. It creates a large primary "ripple" by causing a *direct* change in the purchasing patterns of affected firms and institutions. The suppliers of the affected firms and institutions must change their purchasing patterns to meet the demands placed upon them by the firms originally affected by the economic disturbance, thereby creating a smaller secondary "ripple." In turn, those who meet the needs of the suppliers must change their purchasing patterns to meet the demands placed upon them by the suppliers of the original firms, and so on; thus, a number of subsequent "ripples" are created in the economy.

The multiplier effect has three components—direct, indirect, and induced effects. Because of the pond analogy, it is also sometimes referred to as the *ripple effect*.

- A *direct effect* (the initial drop causing the ripple effects) is the change in purchases due to a change in economic activity.

- An *indirect effect* is the change in the purchases of suppliers to those economic activities directly experiencing change.

- An *induced effect* is the change in consumer spending that is generated by changes in labor income within the region as a result of the direct and indirect effects of the economic activity. Including households as a column and row in the interindustry matrix allows this effect to be captured.

Extending the Leontief Inverse to pertain not only to relationships between *total* production and final demand of the economy but also to *change*s in each permits its multipliers to be applied to many types of economic impacts. Indeed, in impact analysis the Leontief Inverse lends itself to the drop-in-a-pond analogy discussed earlier. This is because the Leontief Inverse multiplied by a change in final demand can be estimated by a power series. That is,

$$(\mathbf{I}\text{-}\mathbf{A})^{-1}\,\boldsymbol{\Delta}\mathbf{y} = \boldsymbol{\Delta}\mathbf{y} + \mathbf{A}\,\boldsymbol{\Delta}\mathbf{y} + \mathbf{A}(\mathbf{A}\,\boldsymbol{\Delta}\mathbf{y}) + \mathbf{A}(\mathbf{A}(\mathbf{A}\,\boldsymbol{\Delta}\mathbf{y})) + \mathbf{A}(\mathbf{A}(\mathbf{A}(\mathbf{A}\,\boldsymbol{\Delta}\mathbf{y}))) + \ldots$$

Assuming that $\boldsymbol{\Delta}\mathbf{y}$—the change in final demand—is the "drop in the pond," then succeeding terms are the ripples. Each "ripple" term is calculated as the previous "pond disturbance" multiplied by the direct requirements matrix. Thus, since each element in the direct requirements matrix is less than one, each ripple term is smaller than its predecessor. Indeed, it has been shown that after calculating about seven of these ripple terms that the power series approximation of impacts very closely estimates those produced by the Leontief Inverse directly.

In impacts analysis practice, $\boldsymbol{\Delta}\mathbf{y}$ is a single column of expenditures with the same number of elements as there are rows or columns in the direct or technical requirements matrix. This set of elements is called an *impact vector*. This term is used because it is the *vector* of numbers that is used to estimate the *economic impacts* of the investment.

There are two types of changes in investments, and consequently economic impacts, generally associated with projects—*one-time impacts* and *recurring impacts*. One-time impacts are impacts that are attributable to an expenditure that occurs once over a limited period of time. For example, the impacts resulting from the construction of a project are one-time impacts. Recurring impacts are impacts that continue permanently as a result of new or expanded ongoing expenditures. The ongoing operation of a new train station, for example, generates recurring impacts to the economy. Examples of changes in economic activity are investments in the preservation of old homes, tourist expenditures, or the expenditures required to run a historical site. Such activities are considered changes in final demand and can be either positive or negative. When the activity is not made in an industry, it is generally not well represented by the input-output model. Nonetheless, the activity can be represented by a special set of elements that are similar to a column of the transactions matrix. This set of elements is called an economic disturbance or impact vector. The latter term is used because it is the vector of numbers that is used to estimate the impacts. In this study, the impact vector is estimated by multiplying one or more economic *translators* by a dollar figure that represents an investment in one or more projects. The term translator is derived from the fact that such a vector *translates* a dollar amount of an activity into its constituent purchases by industry.

One example of an industry multiplier is shown in Figure 4. In this example, the activity is the preservation of a historic home. The *direct impact* component consists of purchases made specifically for the construction project from the producing industries. The *indirect impact* component consists of expenditures made by producing industries to support the purchases made for this project. Finally, the *induced impact* component focuses on the expenditures made by workers involved in the activity on-site and in the supplying industries.

Figure 4
Components of the Multiplier for the
Historic Rehabilitation of a Single-Family Residence

Direct Impact	Indirect Impact	Induced Impact
Excavation/Construction Labor Concrete Wood Bricks Equipment Finance and Insurance	Production Labor Steel Fabrication Concrete Mixing Factory and Office Expenses Equipment Components	Expenditures by wage earners on-site and in the supplying industries for food, clothing, durable goods, entertainment

Regional Input-Output Analysis

Because of data limitations, regional input-output analysis has some considerations beyond those for the nation. The main considerations concern the depiction of regional technology and the adjustment of the technology to account for interregional trade by industry.

In the regional setting, local technology matrices are not readily available. An accurate region-specific technology matrix requires a survey of a representative sample of organizations for each industry to be depicted in the model. Such surveys are extremely expensive.[5] Because of the expense, regional analysts have tended to use national technology as a surrogate for regional technology. This substitution does not affect the accuracy of the model as long as local industry technology does not vary widely from the nation's average.[6]

Even when local technology varies widely from the nation's average for one or more industries, model accuracy may not be affected much. This is because interregional trade may mitigate the error that would be induced by the technology. That is, in estimating economic impacts via a

[5]The most recent statewide survey-based model was developed for the State of Kansas in 1986 and cost on the order of $60,000 (in 1990 dollars). The development of this model, however, leaned heavily on work done in 1965 for the same state. In addition the model was aggregated to the 35-sector level, making it inappropriate for many possible applications since the industries in the model do not represent the very detailed sectors that are generally analyzed.
[6]Only recently have researchers studied the validity of this assumption. They have found that large urban areas may have technology in some manufacturing industries that differs in a statistically significant way from the national average. As will be discussed in a subsequent paragraph, such differences may be unimportant after accounting for trade patterns.

regional input-output model, national technology must be regionalized by a vector of regional purchase coefficients,[7] **r**, in the following manner:

$$(\mathbf{I}\text{-}\mathbf{rA})^{-1}\,\mathbf{r}\cdot\Delta\mathbf{y}$$

or

$$\mathbf{r}\cdot\Delta\mathbf{y} + \mathbf{rA}\,(\mathbf{r}\cdot\Delta\mathbf{y}) + \mathbf{rA}(\mathbf{rA}\,(\mathbf{r}\cdot\Delta\mathbf{y})) + \mathbf{rA}(\mathbf{rA}(\mathbf{rA}\,(\mathbf{r}\cdot\Delta\mathbf{y}))) + \ldots$$

where the vector-matrix product **rA** is an estimate of the region's direct requirements matrix. Thus, if national technology coefficients—which vary widely from their local equivalents—are multiplied by small RPCs, the error transferred to the direct requirements matrices will be relatively small. Indeed, since most manufacturing industries have small RPCs and since technology differences tend to arise due to substitution in the use of manufactured goods, technology differences have generally been found to be minor source error in economic impact measurement. Instead, RPCs and their measurement error due to industry aggregation have been the focus of research on regional input-output model accuracy.

A Comparison of Three Major Regional Economic Impact Models

In the United States there are three major vendors of regional input-output models. They are U.S. Bureau of Economic Analysis's (BEA) RIMS II multipliers, Minnesota IMPLAN Group Inc.'s (MIG) IMPLAN Pro model, and CUPR's own REcon™ I–O model. CUPR has had the privilege of using them all. (R/Econ™ I–O builds from the PC I–O model produced by the Regional Science Research Corporation's (RSRC).)

Although the three systems have important similarities, there are also significant differences that should be considered before deciding which system to use in a particular study. This document compares the features of the three systems. Further discussion can be found in Brucker, Hastings, and Latham's article in the Summer 1987 issue of *The Review of Regional Studies* entitled "Regional Input-Output Analysis: A Comparison of Five Ready-Made Model Systems." Since that date, CUPR and MIG have added a significant number of new features to PC I–O (now, R/Econ™ I–O) and IMPLAN, respectively.

Model Accuracy

RIMS II, IMPLAN, and RECON™ I–O all employ input-output (I–O) models for estimating impacts. All three regionalized the U.S. national I–O technology coefficients table at the highest levels of disaggregation (more than 500 industries). Since aggregation of sectors has been shown to be an important source of error in the calculation of impact multipliers, the retention of maximum industrial detail in these regional systems is a positive feature that they share. The systems diverge in their regionalization approaches, however. The difference is in the manner that they estimate regional purchase coefficients (RPCs), which are used to regionalize the

[7]A regional purchase coefficient (RPC) for an industry is the proportion of the region's demand for a good or service that is fulfilled by local production. Thus, each industry's RPC varies between zero (0) and one (1), with one implying that all local demand is fulfilled by local suppliers. As a general rule, agriculture, mining, and manufacturing industries tend to have low RPCs, and both service and construction industries tend to have high RPCs.

technology matrix. An RPC is the proportion of the region's demand for a good or service that is fulfilled by the region's own producers rather than by imports from producers in other areas. Thus, it expresses the proportion of the purchases of the good or service that do not leak out of the region, but rather feed back to its economy, with corresponding multiplier effects. Thus, the accuracy of the RPC is crucial to the accuracy of a regional I–O model, since the regional multiplier effects of a sector vary directly with its RPC.

The techniques for estimating the RPCs used by CUPR and MIG in their models are theoretically more appealing than the location quotient (LQ) approach used in RIMS II. This is because the former two allow for crosshauling of a good or service among regions and the latter does not. Since crosshauling of the same general class of goods or services among regions is quite common, the CUPR-MIG approach should provide better estimates of regional imports and exports. Statistical results reported in Stevens, Treyz, and Lahr (1989) confirm that LQ methods tend to overestimate RPCs. By extension, inaccurate RPCs may lead to inaccurately estimated impact estimates.

Further, the estimating equation used by CUPR to produce RPCs should be more accurate than that used by MIG. The difference between the two approaches is that MIG estimates RPCs at a more aggregated level (two-digit SICs, or about 86 industries) and applies them at a desegregate level (over 500 industries). CUPR both estimates and applies the RPCs at the most detailed industry level. The application of aggregate RPCs can induce as much as 50 percent error in impact estimates (Lahr and Stevens, 2002).

Although both RECON™ I–O and IMPLAN use an RPC-estimating technique that is theoretically sound and update it using the most recent economic data, some practitioners question their accuracy. The reasons for doing so are three-fold. First, the observations currently used to estimate their implemented RPCs are based on 20-years old trade relationships—the Commodity Transportation Survey (CTS) from the 1977 Census of Transportation. Second, the CTS observations are at the state level. Therefore, RPC's estimated for substate areas are extrapolated. Hence, there is the potential that RPCs for counties and metropolitan areas are not as accurate as might be expected. Third, the observed CTS RPCs are only for shipments of goods. The interstate provision of services is unmeasured by the CTS. IMPLAN replies on relationships from the 1977 U.S. Multiregional Input-Output Model that are not clearly documented. RECON™ I–O relies on the same econometric relationships that it does for manufacturing industries but employs expert judgment to construct weight/value ratios (a critical variable in the RPC-estimating equation) for the nonmanufacturing industries.

The fact that BEA creates the RIMS II multipliers gives it the advantage of being constructed from the full set of the most recent regional earnings data available. BEA is the main federal government purveyor of employment and earnings data by detailed industry. It therefore has access to the fully disclosed and disaggregated versions of these data. The other two model systems rely on older data from *County Business Patterns* and Bureau of Labor Statistic's ES202 forms, which have been "improved" by filling-in for any industries that have disclosure problems (this occurs when three or fewer firms exist in an industry or a region).

Model Flexibility

For the typical user, the most apparent differences among the three modeling systems are the level of flexibility they enable and the type of results that they yield. R/Econ™ I–O allows the user to make changes in individual cells of the 515-by-515 technology matrix as well as in the 11 515-sector vectors of region-specific data that are used to produce the regionalized model. The 11 sectors are: output, demand, employment per unit output, labor income per unit output, total value added per unit of output, taxes per unit of output (state and local), nontax value added per unit output, administrative and auxiliary output per unit output, household consumption per unit of labor income, and the RPCs. Te PC I–O model tends to be simple to use. Its User's Guide is straightforward and concise, providing instruction about the proper implementation of the model as well as the interpretation of the model's results.

The software for IMPLAN Pro is Windows-based, and its User's Guide is more formalized. Of the three modeling systems, it is the most user-friendly. The Windows orientation has enabled MIG to provide many more options in IMPLAN without increasing the complexity of use. Like R/Econ™ I–O, IMPLAN's regional data on RPCs, output, labor compensation, industry average margins, and employment can be revised. It does not have complete information on tax revenues other than those from indirect business taxes (excise and sales taxes), and those cannot be altered. Also like R/Econ™, IMPLAN allows users to modify the cells of the 538-by-538 technology matrix. It also permits the user to change and apply price deflators so that dollar figures can be updated from the default year, which may be as many as four years prior to the current year. The plethora of options, which are advantageous to the advanced user, can be extremely confusing to the novice. Although default values are provided for most of the options, the accompanying documentation does not clearly point out which items should get the most attention. Further, the calculations needed to make any requisite changes can be more complex than those needed for the R/Econ™ I–O model. Much of the documentation for the model dwells on technical issues regarding the guts of the model. For example, while one can aggregate the 538-sector impacts to the one- and two-digit SIC level, the current documentation does not discuss that possibility. Instead, the user is advised by the Users Guide to produce an aggregate model to achieve this end. Such a model, as was discussed earlier, is likely to be error ridden.

For a region, RIMS II typically delivers a set of 38-by-471 tables of multipliers for output, earnings, and employment; supplementary multipliers for taxes are available at additional cost. Although the model's documentation is generally excellent, use of RIMS II alone will not provide proper estimates of a region's economic impacts from a change in regional demand. This is because no RPC estimates are supplied with the model. For example, in order to estimate the impacts of rehabilitation, one not only needs to be able to convert the engineering cost estimates into demands for labor as well as for materials and services by industry, but must also be able to estimate the percentage of the labor income, materials, and services which will be provided by the region's households and industries (the RPCs for the demanded goods and services). In most cases, such percentages are difficult to ascertain; however, they are provided in the R/Econ™ I–O and IMPLAN models with simple triggering of an option. Further, it is impossible to change any of the model's parameters if superior data are known. This model ought not to be used for evaluating any project or event where superior data are available or where the evaluation is for a change in regional demand (a construction project or an event) as opposed to a change in regional supply (the operation of a new establishment).

Model Results

Detailed total economic impacts for about 500 industries can be calculated for jobs, labor income, and output from R/Econ™ I–O and IMPLAN only. These two modeling systems can also provide total impacts as well as impacts at the one- and two-digit industry levels. RIMS II provides total impacts and impacts on only 38 industries for these same three measures. Only the manual for R/Econ™ I–O warns about the problems of interpreting and comparing multipliers and any measures of output, also known as the value of shipments.

As an alternative to the conventional measures and their multipliers, R/Econ™ I–O and IMPLAN provide results on a measure known as "value added." It is the region's contribution to the nation's gross domestic product (GDP) and consists of labor income, nonmonetary labor compensation, proprietors' income, profit-type income, dividends, interest, rents, capital consumption allowances, and taxes paid. It is, thus, the region's production of wealth and is the single best economic measure of the total economic impacts of an economic disturbance.

In addition to impacts in terms of jobs, employee compensation, output, and value added, IMPLAN provides information on impacts in terms of personal income, proprietor income, other property-type income, and indirect business taxes. R/Econ™ I–O breaks out impacts into taxes collected by the local, state, and federal governments. It also provides the jobs impacts in terms of either about 90 or 400 occupations at the users request. It goes a step further by also providing a return-on-investment-type multiplier measure, which compares the total impacts on all of the main measures to the total original expenditure that caused the impacts. Although these latter can be readily calculated by the user using results of the other two modeling systems, they are rarely used in impact analysis despite their obvious value.

In terms of the format of the results, both R/Econ™ I–O and IMPLAN are flexible. On request, they print the results directly or into a file (Excel® 4.0, Lotus 123®, Word® 6.0, tab delimited, or ASCII text). It can also permit previewing of the results on the computer's monitor. Both now offer the option of printing out the job impacts in either or both levels of occupational detail.

RSRC Equation

The equation currently used by RSRC in estimating RPCs is reported in Treyz and Stevens (1985). In this paper, the authors show that they estimated the RPC from the 1977 CTS data by estimating the demands for an industry's production of goods or services that are fulfilled by local suppliers (*LS*) as

$$LS = D^{e(-1/x)}$$

and where for a given industry

$x = k\, Z_1^{a1} Z_2^{a2}\, P_j\, Z_j^{aj}$ and *D* is its total local demand.

Since for a given industry RPC = *LS*/*D* then

$$\ln\{-1/[\ln(\ln LS/\ln D)]\} = \ln k + a_1 \ln Z_1 + a_2 \ln Z_2 + S_j\, a_j \ln Z_j$$

which was the equation that was estimated for each industry.

This odd nonlinear form not only yielded high correlations between the estimated and actual values of the RPCs, it also assured that the RPC value ranges strictly between 0 and 1. The results of the empirical implementation of this equation are shown in Treyz and Stevens (1985, table 1). The table shows that total local industry demand (Z_1), the supply/demand ratio (Z_2), the weight/value ratio of the good (Z_3), the region's size in square miles (Z_4), and the region's average establishment size in terms of employees for the industry compared to the nation's (Z_5) are the variables that influence the value of the RPC across all regions and industries. The latter of these maintain the least leverage on RPC values.

Because the CTS data are at the state level only, it is important for the purposes of this study that the local industry demand, the supply/demand ratio, and the region's size in square miles are included in the equation. They allow the equation to extrapolate the estimation of RPCs for areas smaller than states. It should also be noted here that the CTS data only cover manufactured goods. Thus, although calculated effectively making them equal to unity via the above equation, RPC estimates for services drop on the weight/value ratios. A very high weight/value ratio like this forces the industry to meet this demand through local production. Hence, it is no surprise that a region's RPC for this sector is often very high (0.89). Similarly, hotels and motels tend to be used by visitors from outside the area. Thus, a weight/value ratio on the order of that for industry production would be expected. Hence, an RPC for this sector is often about 0.25.

The accuracy of CUPR's estimating approach is exemplified best by this last example. Ordinary location quotient approaches would show hotel and motel services serving local residents. Similarly, IMPLAN RPCs are built from data that combine this industry with eating and drinking establishments (among others). The results of such an aggregation process is an RPC that represents neither industry (a value of about 0.50) but which is applied to both. In the end, not only is the CUPR's RPC-estimating approach the most sound, but it is also widely acknowledged by researchers in the field as being state of the art.

Advantages and Limitations of Input-Output Analysis

Input-output modeling is one of the most accepted means for estimating economic impacts. This is because it provides a concise and accurate means for articulating the interrelationships among industries. The models can be quite detailed. For example, the current U.S. model currently has more than 500 industries representing many six-digit North American Industrial Classification System (NAICS) codes. The CUPR's model used in this study has 517 sectors. Further, the industry detail of input-output models provides not only a consistent and systematic approach but also more accurately assesses multiplier effects of changes in economic activity. Research has shown that results from more aggregated economic models can have as much as 50 percent error inherent in them. Such large errors are generally attributed to poor estimation of regional trade flows resulting from the aggregation process.

Input-output models also can be set up to capture the flows among economic regions. For example, the model used in this study can calculate impacts for a county as well as the total New Jersey state economy.

The limitations of input-output modeling should also be recognized. The approach makes several key assumptions. First, the input-output model approach assumes that there are no economies of scale to production in an industry; that is, the proportion of inputs used in an industry's production process does not change regardless of the level of production. This assumption will not work if the technology matrix depicts an economy of a recessional economy (e.g., 1982) and the analyst is attempting to model activity in a peak economic year (e.g., 1989). In a recession year, the labor-to-output ratio tends to be excessive because firms are generally reluctant to lay off workers when they believe an economic turnaround is about to occur.

A less-restrictive assumption of the input-output approach is that technology is not permitted to change over time. It is less restrictive because the technology matrix in the United States is updated frequently and, in general, production technology does not radically change over short periods.

Finally, the technical coefficients used in most regional models are based on the assumption that production processes are spatially invariant and are well represented by the nation's average technology. In a region as large and diverse as New Jersey, this assumption is likely to hold true.