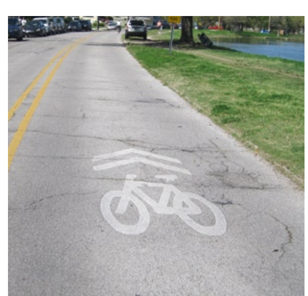
THE ECONOMIC IMPACTS OF ACTIVE TRANSPORTATION IN NEW JERSEY

Alan M. Voorhees Transportation Center



The Economic Impacts of Active Transportation in New Jersey

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This research does not necessarily reflect the official views or policies of the New Jersey Department of Transportation or anyone who provided information for this research. The authors are solely responsible for the content of this report, including errors and omissions.

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The New Jersey Bicycle and Pedestrian Resource Center (BPRC) assists public officials, transportation and health professionals, and the public in creating a safer and more accessible walking and bicycling environment through primary research, education and dissemination of information about best practices in policy and design. The Center is supported by the New Jersey Department of Transportation through funds provided by the Federal Highway Administration.

Visit the New Jersey Bicycle and Pedestrian Resource Center online at njbikeped.org

TABLE OF CONTENTS

TABLE INDEX

Executive Summary

What would be the impact on New Jersey's economy should the federal government, New Jersey Department of Transportation (NJDOT), and local governments choose not to invest in bicycling and walking-related (herein referred to as "active transportation") infrastructure and improvements? Collectively these entities have provided meaningful and substantive investments in New Jersey over the years to create and sustain active transportation options in the state. Investments in active transportation infrastructure have proven to be cost-effective and rewarding, providing significant economic contributions to state and local economies. These economic contributions include increases in bicycle and pedestrian-related tourism, jobs, home values, retail sales, and state and local taxes. While these benefits are well documented outside of New Jersey, little to no research has been conducted to assess and communicate the overall contributions of active transportation on New Jersey's economy.

The primary objective of this research was to estimate the statewide economic impacts of active transportation in New Jersey in one year. This study was conducted in 2012 and used data from calendar year 2011. The research analyzed active transportation-related capital investments (e.g., sidewalks), businesses (e.g., bike shops), and events (e.g., bicycle races) to estimate economic activity generated and jobs supported.

The final economic output was generated by inputting results into the R/ECON™ I-O model, a tool for economic input-output analysis developed by Rutgers, The State University of New Jersey. The model details the total economic effects of an activity—including multiplier effects—and is tailored specifically to New Jersey. The model consists of nearly 300 equations that enable estimations of economic activity, employment, compensation, tax revenue, and gross domestic product (GDP).

To achieve the research objective, outreach to state, regional, county, and municipal governmental agencies was conducted to identify active transportation-related infrastructure spending in 2011. Nearly 200 independent active transportation-related businesses were surveyed on their 2011 revenue and employment totals. Additionally, 300 participants in bicycling, running, and walking events in New Jersey were surveyed to gather data on spending at local businesses as part of trips to these events.

Here are the findings:

- **In total, active transportation-related infrastructure, businesses, and events were estimated to have contributed $497.46 million to the New Jersey economy in 2011.** This is comparable to the projected economic impacts of the Super Bowl that will be held in New Jersey in 2014 and nearly eight times the estimated $63 million invested in infrastructure that year.

- **The $497.46 million supported 4,018 jobs with $153.17 million in compensation, added $278.12 million to state GDP, and generated an estimated $49 million in total tax revenue, accounting for nearly three-fourths of the $63 million infrastructure investment.**

- **Governmental agencies invested an estimated $63.17 million on active transportation-related infrastructure in 2011.** This investment helped fund approximately 250 projects across the state of New Jersey in 2011.

- **Economic model output showed that these investments ($63.17 million) were estimated to generate $149.63 million in economic activity in New Jersey.** This translated into 648 jobs, approximately $44.57 million worth of wages and salary income in the state, $15.68 million in tax revenue, and contributions of $75.62 million to the GDP of New Jersey.

- **In 2011, it was estimated through surveys on revenues from bicycling, running, or walking-related equipment and services that 317 independent businesses received $267.5 million in annual revenue.** This provided 2,253 full and part-time jobs, paying out $37 million in salaries and wages.

- **Economic model output estimated that the total economic activity in New Jersey that supported active transportation-related businesses in 2011 was $290.01 million.** This activity was responsible for an estimated 3,001 jobs with $90.82 million in compensation. Furthermore, businesses contributed an estimated $41.13 million in tax revenue and $171.3 million to the GDP of New Jersey.

- **Participation in run and walk events was estimated to total 197,930 in 2011, with 44,408 participating in bicycling events for an overall total of 242,338.** Nineteen percent of participants were estimated to have traveled from outside of New Jersey to attend, with 6.7 percent of respondents indicating that their trip required an overnight stay. Participants were estimated to spend over $35 million annually in the state as part of their trips to events, with over $10 million of that spending deriving from visitors traveling from outside New Jersey.

- **The model output estimated that these active transportation-related events generated $57.82 million in economic activity in 2011.** This resulted in an estimated 369 jobs at New Jersey businesses, with compensation amounting to $17.79 million. The total estimated tax contribution in 2011 as a result of event participant spending was $6.45 million, with a contribution of $31.2 million to the state's GDP.

Introduction

What would be the impact on New Jersey's economy should the federal government, New Jersey Department of Transportation (NJDOT), and local governments choose not to invest in bicycling and walking-related (herein referred to as "active transportation") infrastructure and improvements? Collectively, these entities have provided meaningful and substantive investments in New Jersey over the years to create and sustain active transportation options in the state. Investments in active transportation infrastructure have proven to be cost-effective and rewarding, providing significant economic contributions to state and local economies. These economic impacts include increases in bicycle and pedestrian-related tourism, jobs, home values, retail sales, and state and local taxes. While these benefits are well documented outside of New Jersey, little to no research has been conducted to assess and communicate the overall impact of active transportation on New Jersey's economy.

Consequentially, the primary objective of this study was to estimate the statewide economic impact of active transportation in New Jersey during a typical year. This study was conducted in 2012 and used data from calendar year 2011. This research is important for several reasons. First, it provides an assessment of the type and magnitude of economic activity associated with investments in active transportation infrastructure and improvements. This includes active transportation-related infrastructure (e.g., sidewalks), businesses (e.g., bicycle shops) and events (e.g., bicycle races). Second, it includes consideration of the jobs and occupations associated with the construction of bike lanes, multi-use trails, pedestrian facilities, tourism, and business operations within the active transportation sector.

Princeton

INTRODUCTION

This study used a combination of data collection methods to estimate active transportation-related investments and spending activity, including:

- Informal interviews with researchers involved with similar studies in other states to better understand the barriers and challenges associated with collecting capital infrastructure investment data from state, county, and municipal agencies;
- Data collection requests to NJDOT, Metropolitan Planning Organizations (MPOs), and county and municipal governments to estimate investments in active transportation-related infrastructure in calendar year 2011;
- Analytical research of online NJDOT construction bid sheets, 2011 municipal budgets, and the list of 2011 Federal Highway Administration Trail Grant awards to estimate investments in active transportation-related infrastructure;
- Online surveys of active transportation-related businesses to gather revenues, wages and salaries, number of full-and part-time employees, and the total percentage of revenue from active transportation-related business;
- Online and intercept surveys of event participants to generate some estimate of the amount of active transportation-related tourism and spending by in-state and out-of-state participants at events throughout NJ.


Duke Farms, Hillsborough

INTRODUCTION

The research team used input-output modeling to consider three types of economic contributions from active transportation activities: direct, indirect, and induced:

- *Direct Impact*: The direct impact of a project is defined as the change in economic activity in the industry under study resulting from a particular project, investment, business operation, or program. The impact can be quantified by examining the magnitude and profile of project expenditures, including sales, disbursements to vendors, wages paid, and taxes and fees paid.
- *Indirect Impact*: The indirect impact is defined as the effect of increased economic activity in those sectors that supply services, materials, and machinery necessary to support the study industry. For example, an increase in orders for bicycles will result in an increased demand for parts (direct impact). This increase in demand for parts generates additional activity in industries involved in providing raw materials, energy, and transportation for manufacturing parts, which in turn provide stimulus to the industries supplying those industries. This ripple effect stemming from a change in final demand for products and services in the industry under study is multiplied throughout the economy and can account for a significant portion of the total effect.
- *Induced Impact*: The induced impact is the effect of increased consumer spending by wage earners in the study industry and other supporting industries. The ripple effect from this spending can also be followed through the economy.


Morey's Piers, Wildwood

INTRODUCTION

The ratio between the total economic impact and direct economic impact is called the *multiplier*. A *multiplier* of 2.3 indicates that for every job directly generated by the industry under study, an additional 1.3 jobs are supported by the ripple effects within the region, for a total impact of 2.3. The multiplier effect is derived from input-output methods, which are based on the assumptions of economic base theory.

For this study, results were input into the R/ECON™ I-O model, a tool for economic input-output analysis developed by Rutgers, The State University of New Jersey. The model's output describes the total economic effects of an activity—including multiplier effects—and is tailored specifically to New Jersey. A full history and technical description of the R/ECON™ I-O model can be found in the Appendix of this report.

The team identified three focus areas for the study: active transportation-related capital investments, active transportation-related businesses, and active transportation-related events. The team examined spending in capital investments in order to understand the overall direct and indirect economic effects of spending each year, and to create a point of comparison for better understanding the other components of the study. The business component of the study identified how active transportation users contribute to the economy by spending money at active transportation-related businesses. Finally, information collected from cycling, walking, and running events highlighted the level of contribution from both in-state and out-of-state visitors.

Newark

INTRODUCTION

The results of the study show that over a one-year period these three components of active transportation-related activities contributed an estimated $497 million to New Jersey's economy. Furthermore, through direct, indirect, and induced impacts, approximately 4,000 jobs were generated with over $153 million in compensation. Local, state, and federal governments received about $49 million in tax revenue, of which over $278 million was estimated to have been added to New Jersey's GDP.

The remainder of the study is divided into four parts. The section on Prior Studies highlights results from prior studies the research team examined as part of this research. The section on Input-Output Model Results gives a detailed explanation of the methodology used to obtain data from the three active transportation-related sectors and the economic impacts of each on New Jersey's economy in 2011. The Summary of Findings briefly highlights the model input and output results found in previous chapter, and the Conclusion conveys the meaning and importance of the results.

Atlantic City Marathon

Prior Studies

Studies on the economic impacts and benefits of active transportation have been conducted in other states, cities, and regions, including Colorado (2000), Maine (2001), Wisconsin (2005), Minnesota (2009), Iowa (2012), and Vermont (2012). While many of these studies focused specifically on the economic contributions and benefits of bicycling, others focused on economic benefits derived specifically from pedestrian-related infrastructure improvements and investments. Below is a brief summary of studies the research team reviewed as part of this study:

Active Transportation-related Capital Investments

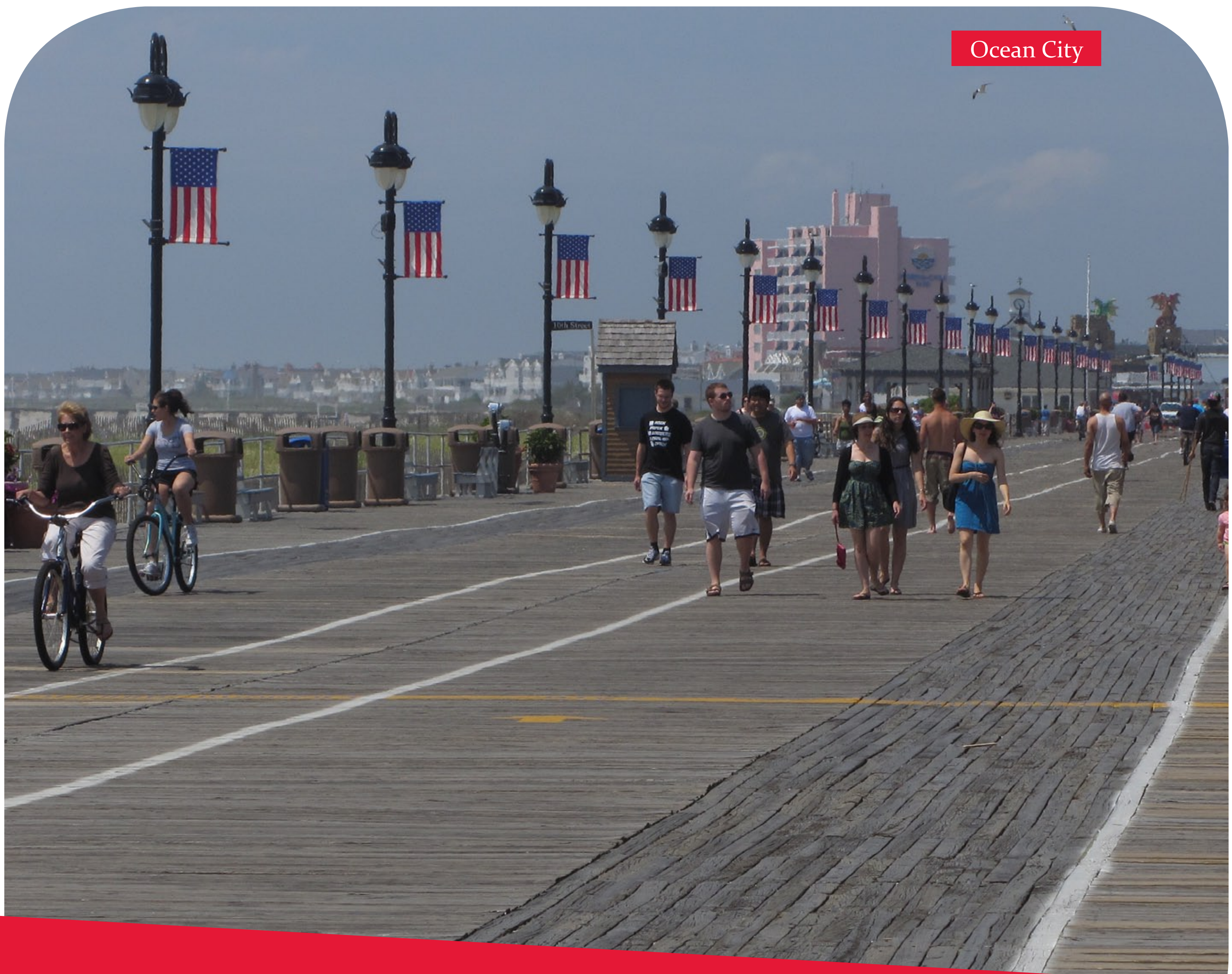
- *Vermont*: By analyzing data provided by the Vermont Department of Transportation and economic modeling, the study concluded that bicycle and pedestrian-related infrastructure and program spending contributed $9.8 million to the Vermont economy in on year, including direct and indirect employment of 233 people and a payroll of $9.9 million.[1]

Active Transportation-related Businesses

- *Colorado*: Based on reviews of corporate annual reports and household and business surveys, the study concluded that bicycle manufacturing and retail in the state resulted in over $1 billion in

annual revenue, as well as over 1,600 jobs.[2]

- *Iowa*: Sixty-one bicycle specific retail establishments in Iowa were surveyed and estimated to have revenues totaling over $18 million.[3]
- *Wisconsin*: The study used economic modeling to estimate that bicycle manufacturing, wholesale/distribution, retail and service, and other services contributed a combined $556 million and over 3,400 jobs to the state's economy.[4]
- *Vermont*: A business survey found that bicycle and pedestrian-oriented businesses generated $30.7 million in revenue, supporting 561 employees and a payroll of $9.9 million.[1]
- *Boulder, Colorado*: Using an economic survey, the study found that more than forty independent bicycle-related businesses and organizations in the city contributed over $52 million in direct economic activity in 2010. These businesses and organizations were associated with at least 330 full-time jobs.[5]


Ocean City

Active Transportation-related Events

- *Colorado*: Based on household and business surveys, bicycle tours, races, and charity rides generated an estimated over $6 million annually in revenue.[2]
- *Iowa*: A survey of bicycle organizations and clubs found the economic value of volunteers for bicycle organizations and events to be estimated at $339,000.[3]
- *Vermont*: A survey of running and bicycling event participants found event participants, family, and friends spent an estimated $6 million, supporting 160 jobs with earnings of $4.7 million.[1]

Other

- *Colorado*: Based on household and business surveys, Colorado found that nearly 700,000 tourists in the state engaged in bicycling, contributing between $141 million and $193 million in revenue to Colorado resorts.[2]
- *Iowa*: The study surveyed bicycle commuters, bicycle retail businesses, and bicycle organizations and clubs and found that cyclists who commuted to work contributed nearly $52 million annually in economic impacts to the state.[3]

- *Maine*: The study's survey of tourists concluded that the economic impact of bicycle tourism in 1999 was approximately $61.3 million.[6]
- *Minnesota*: Using surveys, the study examined the spending habits of trail users and concluded that in 2008, walkers and hikers spent $1.4 billion (at state trails), cyclists spent $427 million, and runners spent $121 million.[7]
- *Charleston, South Carolina*: The study included a cost-benefit analysis of a multi-use path proposed by a local bicycling and walking advocacy group. It found that for every $1 invested in the multi-use path, the community would see a return of $1.92 to $9.32 in benefits associated with reductions in air pollution, congestion, direct medical care cost, gasoline usage, and increases in tourism.[8]
- *Northern Outer Banks, North Carolina*: The study determined the economic impact of investments in bicycle facilities in the northern region of the Outer Banks. Utilizing surveys of bicyclists using the facilities and tourists at visitor's centers, the study determined that the annual economic impact of northern Outer Banks bicycle facilities was $60 million, a conservative estimate, with 1,400 jobs created or supported annually. The total cost of constructing the facilities was $6.7 million.[9]

Jersey City Bike Tour

Input-Output Model Results

Active Transportation-related Capital Investments

Estimating the funding of active transportation infrastructure investment serves two main purposes. First, it quantifies and identifies the return on investments from funding active transportation infrastructure by allowing comparisons to be made to other federal, state, and municipal investments. Second, it demonstrates that active transportation infrastructure investment has its own positive contribution to the economy of New Jersey.

Currently, New Jersey has no official comprehensive cataloging system for active transportation-specific projects and investments at any level of government. Moreover, since many capital projects are funded over a number of years, quantifying the exact spending value for one year—our objective—can be challenging. Therefore, to estimate active transportation-related infrastructure investments in the calendar year 2011,

Atlantic City

this component of the study required a combination of primary research and secondary data collection from the state Department of Transportation, metropolitan planning organizations, counties, and municipalities.

Comparatively, active transportation-related investments by NJDOT were relatively less challenging to locate and quantify, since the funding is primarily administered and awarded through their grant programs. NJDOT funding was administered through the following federal and state programs:

- Office of Bicycle and Pedestrian Programs
- Transit Village Grant Program
- Bikeways Grants
- Centers of Place Grants
- Municipal Aid Grants
- Safe Streets to Transit Grants
- ARRA Transportation Enhancement Recipients

Princeton

MODEL RESULTS

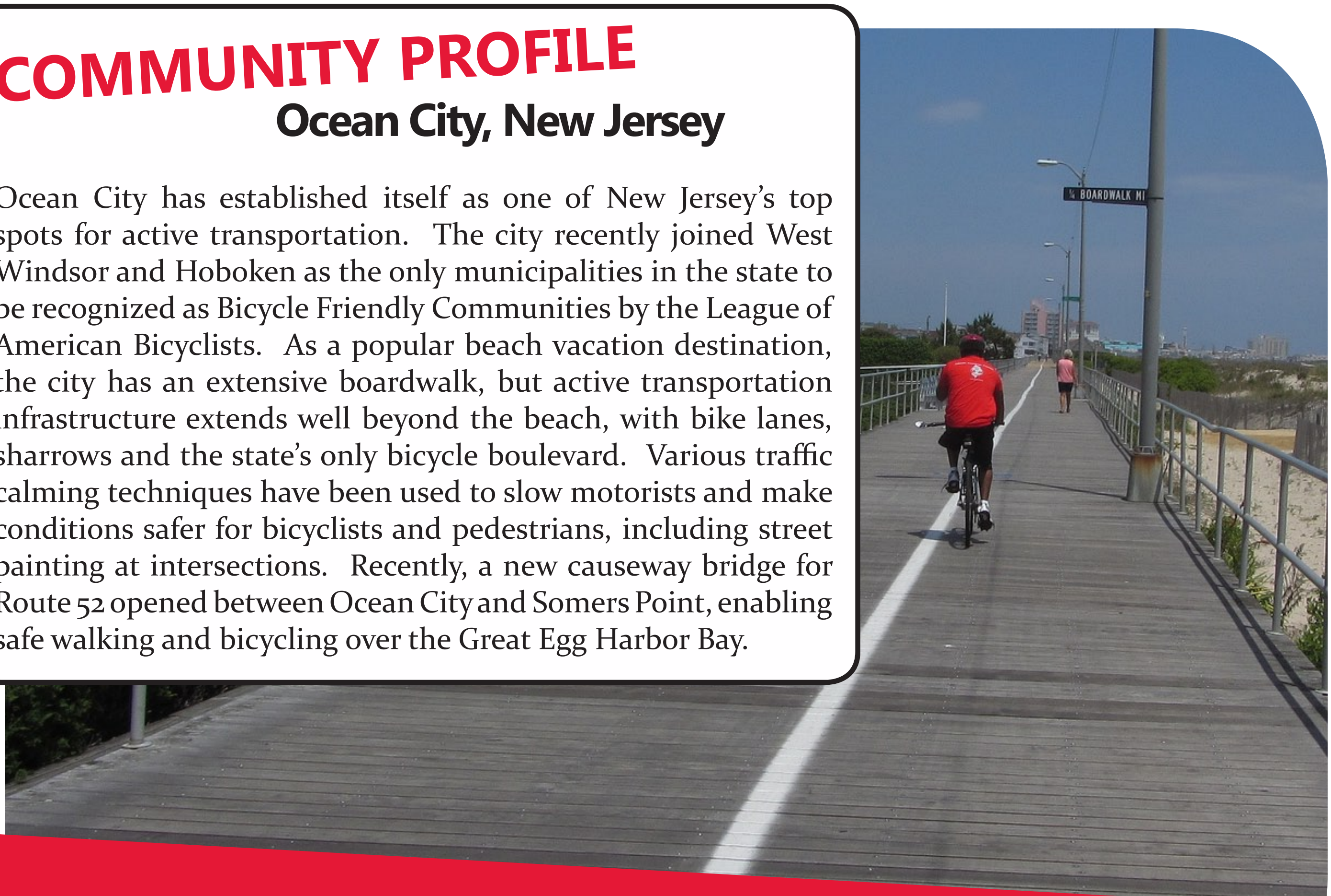
To identify other active transportation-related investments by NJDOT—particularly those bicycle and pedestrian improvements that are sub-components of larger highway projects—the research team analyzed NJDOT construction bid sheets from 2011. NJDOT bid sheets break down capital projects into their individual material requirements, such as sidewalks, pedestrian signal heads, and bicycle safety grates. Since the team was only interested in active transportation-related investments, only items that were obvious bicycle and pedestrian improvements (e.g., sidewalks, handicap ramps, etc.) were catalogued and other more subjective elements (e.g., widened shoulders) were not included. In this regard, the total spending value should be considered a rough estimate that is potentially conservative for a typical year. The team also contacted the three metropolitan planning organizations, North Jersey Transportation Planning Authority (NJTPA), Delaware Valley Regional Planning Commission (DVRPC), and South Jersey Transportation Planning Organization (SJTPO) to eliminate duplicity of investments and identify projects that had not been catalogued by the research team.

Though the bulk of infrastructure improvements for active transportation comes from federal and state funding sources, investment also originates from municipalities and counties using other revenue sources. Thus, to estimate active transportation-related investments at the county and municipal level in calendar year 2011, the research team examined 2011 budgets online from each county and municipal website. In

COMMUNITY PROFILE

Ocean City, New Jersey

Ocean City has established itself as one of New Jersey's top spots for active transportation. The city recently joined West Windsor and Hoboken as the only municipalities in the state to be recognized as Bicycle Friendly Communities by the League of American Bicyclists. As a popular beach vacation destination, the city has an extensive boardwalk, but active transportation infrastructure extends well beyond the beach, with bike lanes, sharrows and the state's only bicycle boulevard. Various traffic calming techniques have been used to slow motorists and make conditions safer for bicyclists and pedestrians, including street painting at intersections. Recently, a new causeway bridge for Route 52 opened between Ocean City and Somers Point, enabling safe walking and bicycling over the Great Egg Harbor Bay.



cases where budgets were not available online or were otherwise unclear, the team contacted county and municipal staff for clarification.

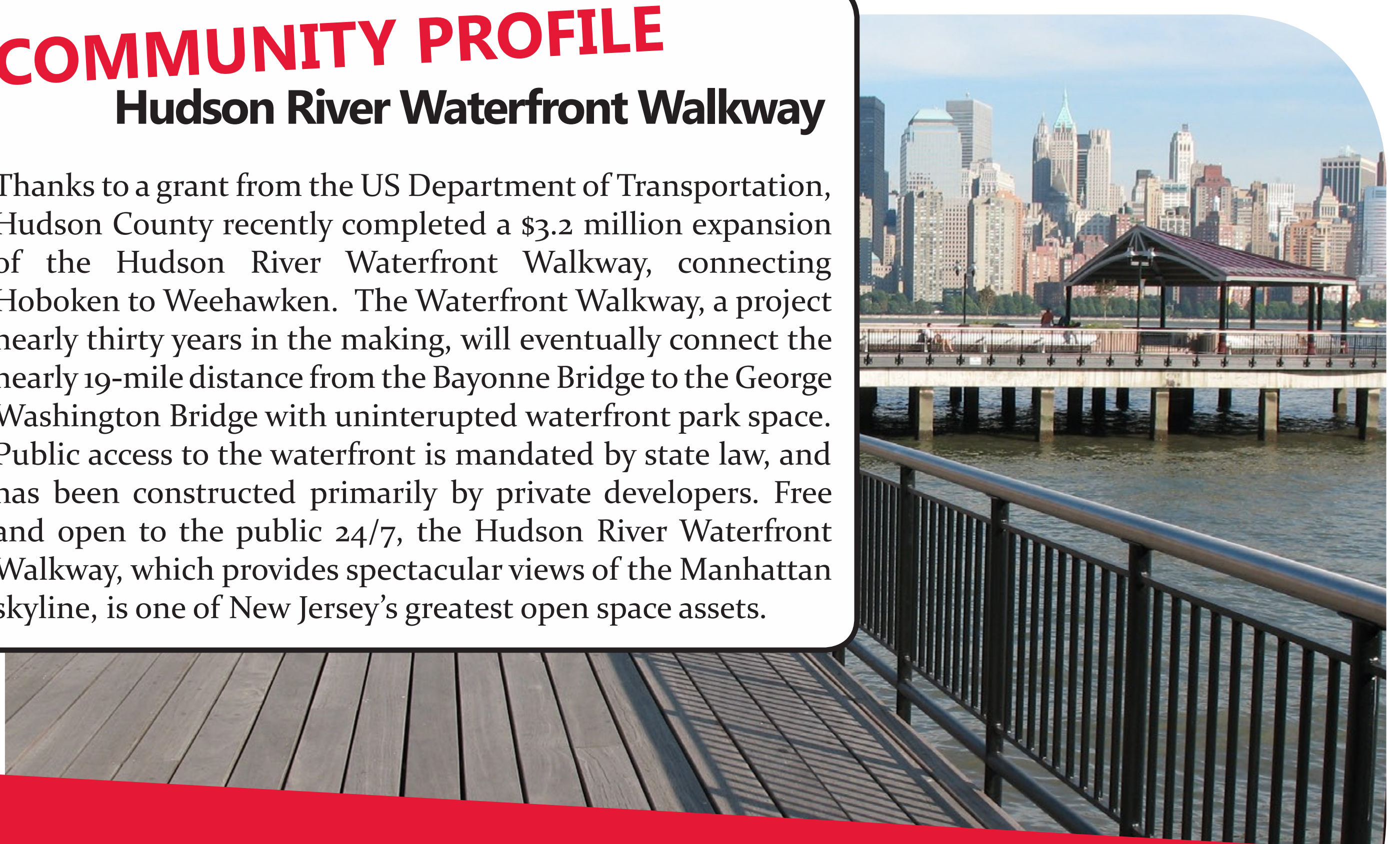
Finally, the research team cataloged off-street paths and trails by examining county parks spending for 2011 and the list of recipients of the Federal Highway Administration's Recreational Trails Program. FHWA's recreational trails grants—typically smaller than other transportation grants—were awarded to a diverse range of recipients, including municipalities, county parks departments, conservancies, reservations, universities, and private foundations.

So, in total, how much did these agencies invest in active transportation-related infrastructure in calendar year 2011? Collectively active transportation-related infrastructure investments were estimated to be $63.17 million. The $63 million worth of investments was allocated to over 250 different projects throughout New Jersey and covered a wide range of active transportation improvements, such as sidewalks and curb ramps, crosswalks, bike lanes, streetscaping, wayfinding, waterfront walkways, plazas, trails, boardwalks, and many other improvements for walkers, runners, and bicyclists. It should be noted, however, that $16.08 million of the $63.17 million was received via the American Recovery and Reinvestment Act (ARRA) of 2009—a one-time funding mechanism used by the federal government to stimulate the economy. Therefore, it is fair to assume that funding in a typical year would be lower.

COMMUNITY PROFILE

Hudson River Waterfront Walkway

Thanks to a grant from the US Department of Transportation, Hudson County recently completed a $3.2 million expansion of the Hudson River Waterfront Walkway, connecting Hoboken to Weehawken. The Waterfront Walkway, a project nearly thirty years in the making, will eventually connect the nearly 19-mile distance from the Bayonne Bridge to the George Washington Bridge with uninterupted waterfront park space. Public access to the waterfront is mandated by state law, and has been constructed primarily by private developers. Free and open to the public 24/7, the Hudson River Waterfront Walkway, which provides spectacular views of the Manhattan skyline, is one of New Jersey's greatest open space assets.



How does this investment compare to other transportation spending in the state? To put it into context, the combined $63 million in active transportation-related projects by the state, MPO's, counties and municipalities, represents only one percent of the $4.37 billon in total state transportation spending in 2011.[10] Furthermore, the Route 7 Wittpenn Bridge—a single project over the Hackensack River—is slated to cost $650 to $700 million, whereas the $63 million discussed here was spread out over 250 projects throughout New Jersey.[11] Finally, when compared with possible roadway expansion costs, it is estimated that $63 million would pay for only slightly more than a single mile of interstate in an urban area.[12]

What was the economic impact of the $63 million investment in active transportation-related investments? As Table 1 demonstrates, the $63 million invested in active transportation-related infrastructure generated an estimated $149.63 million in economic output/activity, including 648 jobs and approximately $44.57 million in wages and salary across a variety of sectors, and an estimated $75.62 million to the gross domestic product (GDP) of New Jersey in 2011.

Table 1

2011 NJ Active Transportation Infrastructure Construction Economic Contribution

Supersector	*Output ($1,000)*	*Employment (jobs)*	*Compensation ($1,000)*	*GDP ($1,000)*
Agriculture, Forestry, Fishing, Hunting	871	4	162	330
Mining	5,914	36	2,721	3,333
Utilities	2,248	2	259	1,203
Construction	44,244	174	13,777	19,862
Manufacturing	28,238	77	5,977	9,031
Wholesale Trade	8,015	30	2,727	5,141
Retail Trade	6,698	57	2,136	3,959
Transportation and Warehousing	6,471	30	1,956	3,163
Information	3,361	7	740	1,868
Finance, Insurance, Real Estate, Rental, Leasing	17,966	25	2,826	11,360
Professional and Business Services	11,455	78	5,114	8,071
Educational Services, Health Care, Social Assistance	8,550	69	4,079	5,198
Arts, Entertainment, Recreation, Accomodation, Food Services	3,464	45	1,233	1,879
Other Services (except Governement)	2,137	14	858	1,217
Direct Effects	**61,454**	**236**	**18,825**	**27,529**
Indirect/Induced Effects	**88,179**	**412**	**25,741**	**48,086**
Total Effects	**149,632**	**648**	**44,565**	**75,615**
Multipliers	**2.435**	**2.747**	**2.367**	**2.747**

Table 2

Active Transportation-Related Infrastructure	
Effects per Million Dollars of Initial Expenditure	
Employment / Jobs	10.26
Compensation	$705,357
Federal Taxes	$111,545
State Taxes	$50,616
Local Taxes	$85,971
GDP	$1,196,807

It is also estimated that infrastructure investment generated around $15.68 million in tax revenue, with $5.43 million at the local level, $3.2 million at the state level, and $7.05 million at the federal level—thereby offsetting some of the initial expenditure.

Another way to look at these impacts is to consider the effects per million dollars of initial expenditure. As shown in Table 2, for every million dollars of initial expenditure on infrastructure, 10.26 jobs are supported with $705,357 in compensation, $111,545 in federal taxes, $50,616 in state taxes, $85,971 in local taxes, and $1,196,807 added to GDP.


D&R Canal Towpath Trail

Active Transportation-related Businesses

As more and more Americans, and specifically New Jerseyans, are encouraged to walk and bicycle more, whether recreationally or as commuters, active transportation-related businesses may continue to experience significant growth. Active transportation supports numerous businesses, and these types of businesses in New Jersey are reaping many benefits from increased active transportation participation. New Jersey's active transportation industry includes specialty retail stores, general sporting goods stores, manufacturers, and wholesalers that receive revenue from bicycling, running, or walking-related equipment and services. As part of this study, the team analyzed active transportation-related businesses to identify and estimate their collective impact on New Jersey's economy.

Due to the reluctance of corporations to release data and the difficulty in extracting data specific to active transportation-related revenue in New Jersey, the research team did not include data from mass merchants (Wal-Mart, Sports Authority, etc.) in this study. Instead, the team focused only on independent businesses. These independent active transportation-related businesses were identified from a variety of sources (i.e., Manta and Dun and Bradstreet), and the team referred to the North American Industry Classification System (NAICS) to narrow their search to specific industries. Businesses that were no longer in operation or had no specific ties to the active transportation industry were removed.

COMMUNITY PROFILE

Trenton Bike Exchange

The Trenton Boys & Girls Club Bike Exchange is an all-volunteer effort that collects, repairs, and sells bikes to help low income families get decent bikes at low cost and raise money for the Boys & Girls club. Since being founded in 2008, the Bike Exchange has sold over 7,000 bikes and raised over $320,000 (net after expenses) for the after school programs of the Trenton Boys & Girls Club. The Trenton Bike Exchange has around 120 volunteers, and all bike shops in Mercer County have agreed to serve as drop points for the Exchange. After the success of the Trenton Exchange, Boys & Girls Club exchanges have been opened in Newark, Plainfield, and New Brunswick.

MODEL RESULTS

When all businesses had been vetted, the final list contained 317 independent active transportation-related businesses. Each business was contacted, generally by phone, and encouraged to complete an online survey (available in Appendix). The online survey focused on 2011 revenue and employment figures. As such, businesses were required to confirm revenue from bicycle-related (e.g., equipment, parts, service, rental, etc.) or running/walking-related (e.g., shoes, equipment, clothing, etc.) business. The list of questions asked in the survey included:

- What was your company's estimated annual revenue from bicycle-related business and running/walking-related business in 2011?
- What percentage did this bicycle and running/walking related revenue comprise of your company's total revenue in 2011?
- What percentage of your revenue do you estimate came from New Jersey residents?
- How many employees did your company employ in 2011?
- What would you estimate your company's total wages and salaries were in 2011?

The link to the online survey was successfully sent to nearly 200 businesses over the summer months of 2012. The remaining 117 businesses did not wish to receive the link or could not be reached. Fifty-three businesses completed the survey, comprising 16.7 percent of the 317 independent businesses identified on the list. The research team believes that businesses were less willing to complete surveys over the summer because it is the time of the year when most businesses in the industry are serving their peak customer load.

Ramapo Rally, Mahwah

The research team calculated estimates of revenue, number of full-time employees, number of part-time employees, and total salaries and wages for the 317 independent businesses based on survey responses. Low, midpoint, and high estimates were calculated for business revenue because survey respondents were asked to choose the range of revenue that reflected their business rather than specify an exact number. The annual revenue ranges selected most often by businesses were $250,000 to $500,000 and $500,000 to $750,000. Based on the survey results, on average, the low annual revenue estimate per business was $550,000, the mid $840,000, and the high $1,135,000. Midpoint values were used throughout the study in all calculations. When multiplying these revenue estimates out over the 317 identified independent businesses in New Jersey, the low estimate of total annual revenue for the state industry was $175,000,000, the mid $267,500,000, and the high $360,000,000.

According to the business survey respondents, active transportation-related businesses employed on average 3.27 full-time employees and 3.84 part-time employees, or an estimated 2,253 full-and part-time employees statewide. Survey responses suggest that on average, businesses spend between $70,652 and $163,043 on total salaries and wages each year (with a midpoint of $116,043). For all independent active transportation-related businesses in the state, total salaries and wages are estimated at a low of $22,400,000,

COMMUNITY PROFILE

Cycle Craft

Cycle Craft is the oldest bicycle retail store in Morris County, having been in business since 1970. With stores in Parsippany and Long Valley, and a repair and rental facility near Kittatinny Valley State Park, Cycle Craft sells major bicycle brands, performs service and provides cycling instruction and repair lessons. As a community partner, Cycle Craft support sports, school, and scouting activities and puts on several bike rides annually to support charitable causes. The business employs 6 to 8 full-time staff, growing to more than 20 employees during peak season. A typical year sees Cycle Craft sell around 1,800 bicycles, with combined annual revenue for the stores totally over $2 million.

a mid of $37,000,000, and a high of $51,700,000. Consequentially, salaries and wages are estimated to be between 12.8 percent and 14.4 percent of revenue. This compares favorably to the 2002 Economic Census Industry Ratios, which suggests payroll is 13.3 percent of revenue for specialty sporting goods stores.[13]

This data was used as the input into the economic model to estimate direct, indirect, and induced effects. As shown in Table 3, the model output estimates that the total economic activity in New Jersey that supported active transportation-related businesses in 2011 was $290.01 million. This activity was responsible for an estimated 3,001 jobs with $90.82 million in compensation and an estimated $171.3 million added to the state GDP.

Table 3

2011 NJ Active Transportation-Related Businesses Economic Contribution

Supersector	*Output ($1,000)*	*Employment (jobs)*	*Compensation ($1,000)*	*GDP ($1,000)*
Agriculture, Forestry, Fishing, Hunting	1,673	8	295	610
Mining	48	0	21	26
Utilities	4,168	3	500	2,324
Construction	331	1	103	149
Manufacturing	21,435	69	4,994	7,000
Wholesale Trade	23,244	87	7,909	14,908
Retail Trade	114,321	2,151	36,453	67,571
Transportation and Warehousing	6,149	35	2,034	3,272
Information	9,402	21	2,098	5,151
Finance, Insurance, Real Estate, Rental, Leasing	42,591	52	5,726	27,427
Professional and Business Services	28,574	172	13,947	20,076
Educational Services, Health Care, Social Assistance	18,144	145	8,658	11,027
Arts, Entertainment, Recreation, Accomodation, Food Services	7,646	98	2,728	4,166
Other Services (except Governement)	12,284	158	5,358	7,596
Direct Effects	**127,807**	**2,253**	**42,174**	**76,721**
Indirect/Induced Effects	**162,202**	**748**	**48,649**	**94,582**
Total Effects	**290,009**	**3,001**	**90,823**	**171,303**
Multipliers	**2.269**	**1.332**	**2.154**	**2.233**

Table 4

Active Transportation-Related Businesses	
Effects per Million Dollars of Revenue	
Employment / Jobs	11.22
Compensation	$339,522
Federal Taxes	$56,852
State Taxes	$66,177
Local Taxes	$30,742
GDP	$640,378

Active transportation-related businesses also contributed significantly to government revenues in 2011, with an estimated $8.22 million in local taxes, $17.7 million in state taxes, and $15.21 million in federal taxes, for a total of $41.13 million.

As Table 4 shows, for every million dollars of revenue, these businesses support 11.22 jobs with $339,522 in compensation, $56,852 paid to federal taxes, $66,177 to state, $30,742 to local, and $640,378 contributed to state GDP.

New Brunswick

Active Transportation-related Events

Because of the importance of tourism to New Jersey's economy, of which active transportation is a valuable element, the research team hoped to include a tourism-related component in this study. However, given the complexities of determining what constitutes active transportation tourism and finding a way to measure it in the state, the team focused on one defined tourism-related element: bicycling, running, and walking events.

Every year in New Jersey, thousands of people from within and outside the state participate in formal and informal races and events. For many, this means spending money at New Jersey businesses for equipment, maintenance, food, shopping, entertainment, transportation, accommodations, and more. To understand the economic impact resulting from these races and events, the research team analyzed and quantified participants' spending at events throughout the state.

The research team consulted Running in the USA—the largest online directory of races and race results—for a full listing of running and walking events, with corresponding event participation numbers and registration fees for each event in 2011. The research team also received demographic data (age, sex, hometown) for nearly 200 run and walk events in New Jersey from Compuscore, a website that provides professional race timing and results for running, triathlon, duathlon, mountain biking, and track events. For bicycling-specific events in 2011, the research team collected event participation numbers, registration fees, and demographic data for each event from USA Cycling. Collectively, these sources helped the research team compile a fairly comprehensive list of bicycling, running, and walking events and participation numbers from 2011.

New Brunswick

MODEL RESULTS

To complement and fully vet the data collected from the above-mentioned sources, the research team contacted event coordinators to identify missing events and gather unknown participation counts. Where participation counts could not be discovered, an average based on known events was used. It is estimated that participation in run and walk events totaled 197,930 and bicycling events 44,408, for a total of 242,338 participants in 2011. The map below shows where these participants traveled from to attend events.

The research team developed a survey (available in the Appendix) for event participants in order to collect data on spending habits. The survey included the following questions:

- What was the name of the event you attended?
- What type of activity did you participate in at this event (bicycling, running or walking)?
- What state do you live in?
- If you are from out of state, did you travel to New Jersey specifically for this event?
- How many days did you stay in the area?
- How many people did you travel with to the event (including yourself)?

MODEL RESULTS

Additionally, event participants were asked to estimate how much they spent on each of the following goods or services in New Jersey:

- Registration/Event Fees
- Charitable Giving (In addition to or in lieu of registration fee)
- Transporting Bicycle
- Bicycle Maintenance/Repair
- Bicycle Supplies/Gear
- Running/Walking Supplies/Gear
- Eating/Drinking Establishments
- Other Food/Snack/Drink Purchases
- Retail/Shopping
- Recreation/Entertainment
- Automobile-Related (gasoline, etc.)
- Airfare
- Other Transport (train, bus, etc.)
- Accommodations/Lodging
- Other Purchases

COMMUNITY PROFILE

Atlantic City Marathon

Drawing in nearly 4,000 people to the Jersey Shore, the annual Atlantic City Marathon is the third oldest marathon in the United States, having been run for 54 years. More than just a marathon, the event also includes a half-marathon, 5K, 10K and a Kids Run. The races raise money to support numerous charitable organizations, including the Milton & Betty Katz Early Childhood Scholarship Programs. While drawing thousands to the boardwalk, casinos, restaurants and shops of Atlantic City, the marathon also works with hotels and other local businesses to organize race weekend promotions. Temporary vendors and entertainment are brought in for the event, which has become a destination for many runners.

MODEL RESULTS

To collect data from event participants, the research team sent survey links to coordinators of upcoming events to have a link to an online version of the survey emailed out to registered participants following the conclusion of the event. Surprisingly, getting event coordinators to distribute the survey link to their event participants proved to be much more difficult than initially expected, so a paper version of the survey was created and intercept surveying (with permission) was conducted at several events. In total, participants in ten bicycling, running, and walking events from different areas of the state were survyed. Three hundred survey responses were collected from event participants. Responses were then used to calculate average spending values for in-state attendees, out-of-state attendees, and all attendees. These values were multiplied by the estimated 197,930 run and walk event participants and 44,408 bicycle participants. While this approach provides some understanding of the contribution of event participant spending, it does not necessarily include the effects of some other uncalculated activities, such as items that were donated by sponsors (e.g., food, shirts, prizes), which can be quite substantial.

Bicycling, running and walking participants are estimated to have spent over $35 million as part of their trips to active transportation-related events in 2011. Over $10 million of this spending is estimated to have derived from visitors traveling from outside the state, as shown in Table 5. Eighty-one percent of respondents traveled from within New Jersey, with most out-of-state visitors coming from neighboring New York and Pennsylvania. Nearly seven percent of respondents indicated that their trip required an overnight stay. It is also important to note that over $6 million was donated to charity.

Rutgers Day, New Brunswick

Table 5

2011 NJ Run, Walk and Bike Event Participant Spending Estimates			
Spending Category	***Spending from In-State Participants***	***Spending from Out-of-State Participants***	***Total Combined Spending***
Registration/Event Fees	$5,634,449	$1,262,491	$6,896,939
Charitable Giving	$5,483,411	$920,063	$6,403,474
Bicycle Maintenance and Gear	$1,415,286	$402,120	$1,817,406
Running/Walking Supplies and Gear	$3,258,604	$265,516	$3,524,120
Food, Shopping and Entertainment	$5,466,981	$3,524,170	$8,991,151
Transportation	$2,968,062	$2,675,238	$5,643,300
Accommodations/Lodging	$546,287	$1,010,426	$1,556,714
Other purchases	$435,387	$90,363	$525,750
Total Spending	**$25,208,467**	**$10,150,386**	**$35,358,853**

The surveys also provide some insight into the demographics of these events, portraying participants as predominately middle-aged, white, and affluent. The survey found: 78.5 percent were white, non-Hispanic; 81 percent were between the ages of 35 and 64; and 56 percent had annual household incomes over $100,000. For gender, there was a contrast between run and walk events and bicycling events. Fifty-seven percent of run and walk respondents were female, compared with the 37.3 percent of bicycle respondents. Still, since only 20 percent of all bicycle commuters in the state are female, this may suggest a significant potential for female bicyclists to become commuters under better circumstances, such as the right policies and infrastructure.[14]

Atlantic City Marathon

So what was the economic impact from active transportation-related events in calendar year 2011? The model estimated that spending at active transportation-related events contributed $57.82 million to the New Jersey economy in 2011. This economic activity supported an estimated 369 jobs at New Jersey businesses, with compensation amounting to $17.79 million, and total estimated contribution of $31.2 million to the GDP of New Jersey (Table 6).

Table 6

2011 NJ Active Transportation-Related Events and Races Economic Contribution

Supersector	*Output ($1,000)*	*Employment (jobs)*	*Compensation ($1,000)*	*GDP ($1,000)*
Agriculture, Forestry, Fishing, Hunting	563	3	100	207
Mining	14	0	6	7
Utilities	863	1	101	471
Construction	79	0	24	35
Manufacturing	8,300	18	1,321	2,026
Wholesale Trade	1,917	7	652	1,229
Retail Trade	3,332	29	1,063	1,969
Transportation and Warehousing	2,777	12	807	1,326
Information	1,657	4	370	909
Finance, Insurance, Real Estate, Rental, Leasing	8,004	10	1,084	5,149
Professional and Business Services	4,385	29	2,003	3,076
Educational Services, Health Care, Social Assistance	3,374	27	1,610	2,050
Arts, Entertainment, Recreation, Accomodation, Food Services	14,942	191	6,029	9,038
Other Services (except Governement)	7,613	40	2,615	3,707
Direct Effects	**26,165**	**226**	**8,790**	**13,376**
Indirect/Induced Effects	**31,653**	**143**	**8,996**	**17,824**
Total Effects	**57,818**	**369**	**17,786**	**31,200**
Multipliers	**2.210**	**1.634**	**2.023**	**2.332**

Table 7

Active Transportation-Related Events	
Effects per Million Dollars of Spending	
Employment / Jobs	12.29
Compensation	$591,987
Federal Taxes	$94,153
State Taxes	$69,602
Local Taxes	$50,787
GDP	$1,038,469

The total estimated tax contribution in 2011 as a result of event participant spending was $6.45 million: $1.53 million at the local level, $2.09 million at the state level, and $2.83 million at the federal level.

For every million dollars spent by participants at these events, 12.29 jobs are supported with $591,987 in compensation, $94,153 in federal taxes, $69,602 in state, $50,787 in local, and a contribution to state GDP of $1,038,469 (Table 7).

Jersey City Bike Tour

Summary of Findings

In total, active transportation-related infrastructure investment, business activity, and spending by participants at active-transportation events are estimated to have contributed the following to the New Jersey economy in 2011 (Table 8):

- $497.46 million in economic activity
- 4,018 jobs with $153.17 million in compensation
- $278.12 million added to GDP
- $11.5 million in tax revenue at the local level
- $20.66 million in tax revenue at the state level
- $16.91 million in tax revenue at the federal level

Table 8

2011 Economic Contributions of Active Transportation in NJ

Component	*Output ($1,000)*	*Employment (jobs)*	*Compensation ($1,000)*	*GDP ($1,000)*
Infrastructure Investment	149,632	648	44,565	75,615
Businesses	290,009	3,001	90,823	171,303
Events and Races	57,818	369	17,786	31,200
Total Effects	**497,459**	**4,018**	**153,174**	**278,119**

Duke Farms, Hillsborough

SUMMARY OF FINDINGS

Investment in active transportation-related infrastructure from local, state, federal, and private sources in New Jersey was estimated to be $63.17 million in 2011. Within the state, this investment generated an estimated:

- $149.63 million in economic activity
- 648 jobs with $44.57 million in compensation
- Contributions to GDP of $75.62 million
- $15.68 million in tax revenue

Independent active transportation-related businesses in New Jersey generated an estimated $267.5 million in revenue in 2011. Within the state, this resulted in an estimated:

- $290.01 million of economic activity
- 3,001 jobs with $90.82 million in compensation
- Contributions to GDP of $171.3 million
- $41.13 million in tax revenue

Participants in active transportation-related events and races in New Jersey in 2011 spent an estimated $35.36 million as part of their trips to the events, $10.15 million of which was from out-of-state visitors. Within the state, this generated an estimated:

- $57.82 million in economic contributions
- 369 jobs with $17.79 million in compensation
- Contributions to GDP of $31.2 million
- $6.45 million in tax revenue
- Total overall tax revenue of $49.07 million


Trenton

Conclusions

In this study, the research team analyzed active transportation-related infrastructure investment, business activity, and spending by participants at active transportation-related events to determine their individual and collective economic impact on New Jersey's economy. The team used a combination of primary and secondary data collection methods, including online and intercept surveys, for input into the R/ECON™ I-O model developed by Rutgers, The State University of New Jersey. Through the use of the model, the team successfully quantified the estimated economic impacts of these activities for one year.

The results of the study show that over a one-year period, these three components of active transportation-related activity are estimated to have contributed $497 million to the economy of New Jersey. Furthermore, through direct, indirect and induced impacts, an estimated 4,000 jobs were generated with over $153 million in compensation. Local, state, and federal governments received an estimated $49 million in tax revenue, with over $278 million estimated to be added to New Jersey's GDP from these three components of active transportation.

What does this mean? Ultimately, these findings suggest that active transportation contributes significantly to the economy of New Jersey. The $63 million estimated to have been spent on active transportation-related infrastructure in 2011 is less than one percent of all transportation spending in the state for that year. Active transportation businesses (generated $290 million in economic activity) and events (generated $57.8 million) rely on quality infrastructure. If quality infrastructure did not exist, many people would

Ocean City

likely continue to walk, run, and bicycle. However, a lower level of participation would be expected and consequently there would be less need for active transportation-related businesses. The same can be said of events. Though they often involve formal street closings and temporary accommodations, for the remainder of the year the participants of these events need places to bicycle, walk, and run that are safe and of a high quality.

Furthermore, the research team's findings suggest that many participants in events do not currently use active transportation for utility (i.e., non-recreational) purposes, making them an ideal target audience for future infrastructure investments. This study estimated that 197,930 people participated in run/walk events in New Jersey in 2011 and 44,408 in bicycle events. According to the 2011 American Community Survey, an estimated 126,204 people (3.1 percent of commuters) in New Jersey use walking as their primary means of commuting to work and only 12,397 use bicycling (0.3 percent).[15] Given these relatively low numbers, it could be hypothesized that an opportunity exists to make active transportation a part of the daily lives of the participants in these events. To do so, however, safe and attractive infrastructure must be conveniently accessible.

Active transportation is already touted in New Jersey and beyond for the financial, health, and mobility benefits that it provides. Given the findings of this study, quantifiable economic contributions can be publicized as an additional benefit. The estimated $497 million in economic activity from one year is nearly eight times the estimated $63 million in infrastructure investment. The estimated $497 million in economic activity is also more than the $480 million in estimated spending from the 2013 Super Bowl in Louisiana[15] and competitive with the projected economic impacts ($550 million) for the Super Bowl being held in New Jersey in 2014.[16] Who knew that the economic impacts of active transportation in New Jersey are comparable to hosting a Super Bowl each year?

Perhaps more importantly, the $49 million in estimated related tax revenues comprise nearly three-fourths of the investment amount, suggesting that governments receive a good return on their investment. Consequentially, this study demonstrates that active transportation is an important economic asset to New Jersey, and as such government agencies should give significant consideration to promoting and investing in its infrastructure and use.


Duke Farms, Hillsborough

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APPENDIX 1

Business and Event Surveys

Exit this survey

Bike/Ped Business Survey

67%

* 1. Did you have any revenue from bicycle-related (eg. equipment, parts, service, rental, etc.) or running/walking-related (eg. shoes, equipment, clothing, etc.) business in 2011?

- [x] Yes
- [ ] No

Prev | Submit

Exit this survey

Bike/Ped Business Survey

100%

2. What was your company's estimated annual revenue from bicycle-related business (eg. equipment, parts, service, rental, etc) and running/walking-related business (eg. shoes, equipment, clothing, etc.) in 2011?

3. What percentage did this bicycle and running/walking related revenue comprise of your company's total revenue in 2011?

- Less than 10%
- 10% - 20%
- 20% - 30%
- 30% - 40%
- 40% - 50%
- 50% - 60%
- 60% - 70%
- 70% - 80%
- 90% - 100%

4. What percentage of your revenue do you estimate came from New Jersey residents?

- Less than 10%
- 10% - 20%
- 20% - 30%
- 30% - 40%
- 40% - 50%
- 50% - 60%
- 60% - 70%
- 70% - 80%
- 90% - 100%

5. How many employees did your company employ in 2011?

Full-Time Employees:

Part-Time Employees:

6. What would you estimate your company's total wages and salaries were in 2011?

Prev | Submit

RUTGERS
Edward J. Bloustein School
of Planning and Public Policy

New Jersey Bicycling Event Survey

The Alan M. Voorhees Transportation Center at Rutgers, The State University of New Jersey is conducting a study for the NJ Department of Transportation on the economic contributions of bicycling and walking in the state. Your participation will help in quantifying the impact of events such as this one. There are no known risks to participating in this study.

1) What state do you live in? ____________________________________

2) If you are from out of state, did you travel to New Jersey specifically for this event? _____Yes ____No

3) How many days did you stay in the area? _______ days

4) How many people did you travel with (including yourself)? __________ people

5) If you are on an overnight trip, how many nights will you stay at each of the following places of accomodation in New Jersey?

___Rental Home/Condo ___ Bed and Breakfast ___Hotel ___ Home of Friends or Relatives
___Motel ___ RV or Campsite ___Hostel ___Time Share
___Other (please specify) ____

6) During your trip to this event, in general, how much do you estimate you will spend on each of the following goods or services in New Jersey? Check "N/A" if you had no spending on an item in New Jersey.

	Under $20	$20 to $50	$50 to $100	$100 to $200	$200 to $300	$300 to $500	$500 to $700	$700 or more	N/A
Registration/Event Fees:									
Charitable Giving (In addition to or in lieu of registration fee):									
Transporting Bicycle:									
Bicycle Maintenance/Repair:									
Bicycle Supplies/Gear:									
Eating/Drinking Establishments:									
Other Food/Snack/Drink Purchases:									
Retail/Shopping:									
Recreation/Entertainment:									
Automobile-Related (gasoline, etc.):									
Airfare:									
Other Transport (train, bus, etc.):									
Accomodations/Lodging:									
Other Purchases Not Listed Here:									

7) Are you: _______ Male __________ Female

8) Which of the following ranges does your age fall into?

___0 to 17 ___18 to 24 ___25 to 34 ___35 to 44 ___45 to 54 ___55 to 64 ___65 and older

9) Which race or ethnicity best describes you? (Check all that apply)
________ White, Not Hispanic ________ White Hispanic ________ Black, Not Hispanic
________ Black Hispanic ________ Asian, Not Hispanic ________ Asian Hispanic
________ Native American ________ Other

10) Which category best describes your household income for 2011? (check one)

_______ Under $15,000 ________ $50,000 - $75,000 ________ $150,000 - $300,000
_______ $15,000 - $25,000 ________ $75,000 - $100,000 ________ $300,000 - $500,000
_______ $25,000 - $50,000 ________ $100,000 - $150,000 ________ $500,000 or more

APPENDIX 2

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. Businessmen 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, relatedly, 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 $\mathbf{x}$ be export employment, $\mathbf{l}$ be local employment, and $\mathbf{t}$ be total employment, then

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

For simplification, we create the ratio $\mathbf{a}$ 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 $\mathbf{t}$, 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 ***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 ***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's 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

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

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,

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

Assuming that $\Delta\mathbf{y}$—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, $\Delta\mathbf{y}$ 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.[1] 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.[2]

[1]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.

[2]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.

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 regional input-output model, national technology must be regionalized by a vector of regional purchase coefficients,[3] **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 R/ECON's own I–O model. R/ECON 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, R/ECON 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 R/ECON™ 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 450 industries). Since aggregation of sectors has been shown to be an important source of error in the calculation of impact multipliers, the retention of

[3]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.

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 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 R/ECON 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 R/ECON-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 R/ECON 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 450 industries). R/ECON 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 R/ECON™ 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 30-year 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. R/ECON™ 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 Quarterly Covered Employment and Wage data, 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 462-by-462 technology matrix as well as in the eleven 462-sector vectors of region-specific data that are used to produce the regionalized model. The eleven vectors of measures 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. The 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 462-by-462 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 462-sector impacts to the supersector and three-digit NAICS 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 an Excel® file. 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 in the R/ECON™ I–O model for 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

$x = \mathrm{k}\, Z_1^{\mathrm{a}1} Z_2^{\mathrm{a}2}\, \mathrm{P}_j\, Z_j^{\mathrm{a}j}$ and D is its total local demand.

Since for a given industry RPC = LS/D then

$$\ln\{-1/[\ln(\ln LS/\ln D)]\} = \ln \mathrm{k} + \mathrm{a}_1 \ln Z_1 + \mathrm{a}_2 \ln Z_2 + \mathrm{S}_j\, \mathrm{a}_j \ln Z_j$$

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 R/ECON'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 result of such 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 R/ECON'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 about 500 industries representing many six-digit North American Industrial Classification System (NAICS) codes. R/ECON's model used in this study has the same number. 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 could have estimated impacts for each major island as well as the total territory economy, if the data on employment and imports had been made available.

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., 2007) and the analyst is attempting to model activity in a peak economic year (e.g., 2006). 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.