

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

FINAL REPORT

December 2002

Submitted by

Robert E. Paaswell, Ph.D.
Director and Distinguished Professor,
University Transportation Research Center
City College of New York



NJDOT Research Project Manager
Nicholas Vitillo, Manager
Bureau of Research

In cooperation with

New Jersey
Department of Transportation
Bureau of Research
and
U.S. Department of Transportation

Disclaimer Statement

“The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the New Jersey Department of Transportation, or Federal Highway Administration. This report does not constitute a standard, specification or regulation.”

1. Report No. FHWA-NJ-2003-001		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle New Jersey's Links to the 21 st Century: Maximizing The Impact of Infrastructure Investment				5. Report Date December 2002	
				6. Performing Organization Code	
7. Author(s) Robert E. Paaswell, Ph.D., Jose Holguin-Veras, Ph.D., Kaan Ozbay, Ph.D., Dimitrios Delis, Ph.D.				8. Performing Organization Report No. FHWA-NJ-2003-001	
9. Performing Organization Name and Address University Transportation Research Center City College of New York Y-Building, Room 220				10. Work Unit No.	
				11. Contract or Grant No. 75144-01-01	
12. Sponsoring Agency Name and Address New Jersey Department of Transportation Federal Highway Administration CN 600 U.S. Department of Transportation Trenton, NJ 08625 Washington, D.C.				13. Type of Report and Period Covered Final	
				14. Sponsoring Agency Code	
15. Supplementary Notes					
16. Abstract In the last 10 years, New Jersey has invested heavily in its transportation infrastructure, and numerous additional projects are planned or proposed for the next decade. Collectively, these projects have significantly improved accessibility in northern New Jersey. Highway and commuter rail travel times have dropped throughout the region as projects such as Midtown Direct and the completion of Interstate 287 connected networks and provided commuters with new travel choices. These transportation improvements have done more than change traffic patterns, however; they have spurred residential relocation and enabled economic growth. Shorter commute times have allowed New Jersey residents to move further away from their workplaces, resulting in real estate price spikes in the affected regions. Where commute times have dropped the most, economic output and employment have gone up the most. As we have seen, New Jersey's investments in transportation infrastructure have collectively improved accessibility throughout the State. In turn, individuals and businesses have taken advantage of the improvements in making relocation decisions, and economic output and employment have increased. However, infrastructure investment on its own does not spur economic growth. There are a number of factors which determine whether a particular improvement in accessibility will result in increased economic growth, or affect land use decisions. These include Economic conditions, Land availability, Institutional support, Investment, Agglomeration, Labor market barriers, and Network economies.					
17. Key Words Planning, Transportation, Economics, Real Estate Development				18. Distribution Statement No restriction	
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No of Pages 46	22. Price NA

TEAM MEMBERS

City College of New York

Dr. Robert E. Paaswell
Director and Distinguished Professor of Civil Engineering
University Transportation Research Center

Dr. Jose Holguin-Veras, Associate Professor
Principal Investigator,

Dr. Claire McKnight, Associate Professor

Dr. Joseph Berechman, Visiting Scholar
University Transportation Research Center

Dr. Ross D. Weiner, Associate Professor

Dr. Shmuel Yahalom, SUNY Maritime College

Herbert Levinson, Icon Mentor

Robert F. Baker, Research Engineer

Mark Seaman, Technical Writer

Yamilks Lopez-Genao
Victor Ochieng
Ellen Thorson

Rutgers University

Dr. Kaan Ozbay,
Principal Investigator

Dowling College

Dr. Ragghavan Srinivasan,
Principal Investigator

TABLE OF CONTENTS

EXECUTIVE SUMMARY	1
INTRODUCTION	4
BACKGROUND	6
ECONOMIC TRENDS	8
ECONOMIC BENEFITS	10
Accessibility	10
Multiplier Effects	14
Economic Growth	15
LAND USE	21
Residential Relocation	21
Commercial Relocation	26
TOOLS	36
PROJECT ANALYSIS	40
CONCLUSION	44
APPENDIX A	46

LIST OF FIGURES

Figure 1 – Study Area	5
Figure 2 – Average Peak Highway Travel Times From Each County to Every Other County (Minutes)	12
Figure 3 – Cumulative Distribution of Jobs Reached Within the Specified Travel Times from Manhattan (1990 Employment Figures)	13
Figure 4 – Sensitivity of Job Growth to Changes in Travel Time	18
Figure 5 – Travel Time Contours from an Employment Center "C"	22
Figure 6 – Travel Time Contours with an Express Connection	23
Figure 7 – Expansion of the 45-Minute Travel Zone	23
Figure 8 – Midtown Direct Connection	24
Figure 9 – Model Predictions for Commuters Who Were Married with Children	25
Figure 10 – Model Predictions for All Other Commuters	26
Figure 11 – New Jobs By County	28
Figure 12 – Distance from New York City of Relocated Firms	28
Figure 13 – Locations Of Relocating Firms	30
Figure 14 – Transportation Firms By County.....	32
Figure 15 – Warehousing Firms By County.....	33
Figure 16 – Finance, Insurance And Real Estate Firms By County	34

LIST OF TABLES

Table 1 – Average Peak Highway Travel Times From Each County to Every Other
County 11

Table 2 – Multiplier Effects of New Jersey Transit Projects..... 15

Table 3 – Impact of Travel Time Changes on Job Growth 16

Table 4 – Impact of Travel Time Changes on Income Growth 17

Table 5 – Travel Time to Midtown (minutes) 24

Table 6 – Projected Accessibility Benefits of New Jersey Transit Projects 42

EXECUTIVE SUMMARY

In the last 10 years, New Jersey has invested heavily in its transportation infrastructure, and numerous additional projects are planned or proposed for the next decade. Collectively, these projects have significantly improved accessibility in northern New Jersey. Highway and commuter rail travel times have dropped throughout the region as projects such as Midtown Direct and the completion of Interstate 287 connected networks and provided commuters with new travel choices.

These transportation improvements have done more than change traffic patterns, however; they have spurred residential relocation and enabled economic growth. Shorter commute times have allowed New Jersey residents to move further away from their workplaces, resulting in real estate price spikes in the affected regions. Where commute times have dropped the most, economic output and employment have gone up the most. The effects include the following:

Economic Growth

- **Multiplier effect.** For every \$10 million invested in transportation infrastructure improvements in northern New Jersey, economic output increases by \$21.5 million, and 207 jobs are created.
- **Economic growth.** There is a statistically significant relationship between improved accessibility and job or income growth in northern New Jersey. Assuming a baseline of 9.9% job growth and 23% income growth over the next decade (the average county growth rates in the 1990s), a 10% reduction in travel times throughout the region would result in job growth of 10.4% and income growth of 26.6%.
- **Sensitivity.** Job and income growth in counties near the region's economic center in Manhattan are more sensitive to changes in accessibility than in more distant counties.

Land Use

Residential relocation. The beginning of Midtown Direct service in 1996 affected land use in a number of ways:

- **Property values.** Residential real estate price jumped by 20% in the first year of service.
- **Urban diffusion.** Commuters tended to move further away from Manhattan in response to Midtown Direct.
- **Characteristics of movers.** Younger commuters who were married with children were more likely than others to move in response to Midtown Direct.

Commercial relocation. Firms that moved into New Jersey from out-of-state in the 1990s showed distinct locational preferences with respect to transportation and accessibility to markets:

- **Transportation facilities.** Firms relocating into New Jersey in the 1990s concentrated along transportation corridors and near Manhattan. 60% chose locations within five miles of the New Jersey Turnpike; 40% settled within ten miles of the Holland Tunnel entrance.
- **Specific industry preferences.** Location preferences varied from industry to industry. For some, such as finance and insurance, proximity to Manhattan's financial district outweighed the high cost of land in Hudson County. Others, such as warehousing, showed a statistically significant preference for locating at a distance from New York City.

Investment in transportation infrastructure does not guarantee an increase in economic activity; it may simply result in a relocation of existing economic activity. In general, transportation improvements *enable* economic activity but do not, on their own,

generate it. Certain baseline conditions must exist in order for transportation improvements to have a net economic impact:

- The economy must be strong and there must be a skilled labor force.
- Land must be available, and zoning and development policies must encourage development.
- There must be a long-term financial commitment to the investment's success.

Transportation improvements can enable new economic activity by leveraging certain economic conditions: if the improvements encourage firms in the same industry to cluster, those firms may achieve new economies of scale; if the improvements overcome barriers to labor market participation, they may encourage employment growth; and if they link markets, they may open new opportunities for competition and result in lower prices.

INTRODUCTION

New Jersey has made significant investments in transportation over the last 10 years, and numerous additional projects are planned or proposed for the next decade and beyond. These investments have improved and will continue to improve accessibility throughout the State and will increase New Jersey's attractiveness to businesses and individuals. In the past, these investments have been studied on a project basis. Each is designed to solve a problem within its corridor of influence. Collectively, however, these projects may substantially change the relative accessibility of northern New Jersey and affect economic development and land use throughout the region.

With so much development proposed or in progress, it becomes vital to understand these effects. The questions that arise include:

- 1. How do the planned and progressing infrastructure investments affect the accessibility of Northern New Jersey, and how can the changes be quantified?*
- 2. If such changes occur, how and to what extent will they affect land use decisions? How can such decisions be shaped to have maximum positive impact on economic development, jobs and quality of life for the people in New Jersey?*
- 3. How can the New Jersey Department of Transportation assist in this decision-making through development of appropriate planning and policy analysis tools?*

This report describes the results of our research on these questions. We begin by reviewing the parallel development of New Jersey's economy and transportation infrastructure. Next, we define accessibility and show how it has changed. At the heart of the report, we present the results of our studies, showing that improvements in accessibility have a significant impact on economic growth, and detailing the

relationships between transportation infrastructure improvements and land development. Finally, we provide a set of analytical tools and guidelines to help shape future projects for maximum positive economic impact, and we analyze proposed projects in light of these guidelines.

Our geographical focus for this study was northern New Jersey, defined as the 13 counties of the New Jersey Transportation Planning Authority, plus Mercer County. With 6.7 million residents, this region contains 79% of the State's population but only 60% of the land; population density is highest in the northeast of the region. The four largest cities in New Jersey – Newark, Jersey City, Paterson, and Elizabeth – are all located in the study area, but their populations, ranging from 110,000 to 275,000, are dwarfed by the populations of the two large cities on New Jersey's border: New York City (8 million) and Philadelphia (1.5 million).

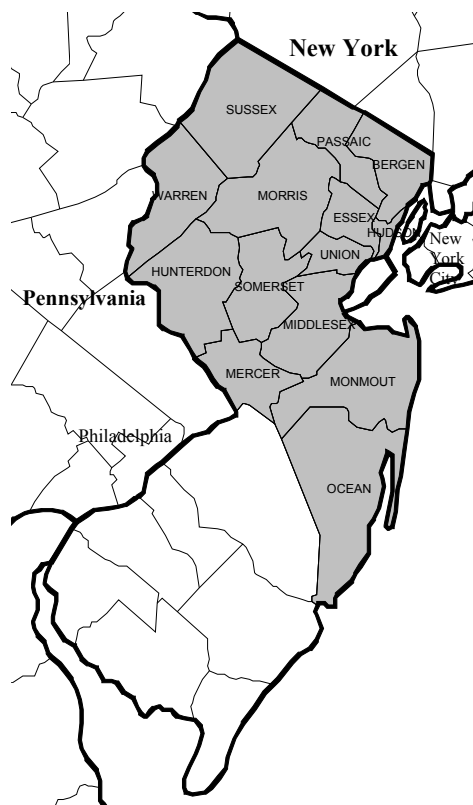


Figure 1 - Study Area

BACKGROUND

New Jersey's development patterns and potentials reflect the State's setting, its physical features, and its transportation systems.

The State's strategic location between New York City and Philadelphia makes it a natural corridor for the movement of people and goods. This setting also results in concentrations of people and jobs around those cities.

New Jersey's major physical features have influenced both development opportunities and transportation corridors. The State has four distinct physical regions: the ridges and valleys of the northwest part of the State; the southern extension of the rocky New England terrain that traverses the State along a northeast-southwest axis; the rolling central hills, where most development and transportation facilities are located; and the relatively level Atlantic coastal plain, with its rapidly growing population. Even more important perhaps, are the Hudson River on the east and the Delaware River on the south that separate New Jersey from New York City and Pennsylvania, and have impeded movement since colonial days. On the other hand, the natural harbor between New York and New Jersey has served as a major international seaport for centuries.

From early on, transportation has been the lifeblood of New Jersey's economy. Plank roads and canals; railroads and ferries; bridges, tunnels and express highways; marine ports and airports have progressively given the State a multi-modal transport system.

The earliest facilities were toll roads linking Philadelphia and New York City. By the 1850s, an extensive network of railroad lines converged on Newark and the New Jersey waterfront; trans-Hudson ferries provided the link to Manhattan. The Hudson and Manhattan (now Port Authority Trans Hudson) tubes were completed in 1908; and the Pennsylvania Railroad tunnel across the Hudson, completing the Northeast Corridor,

was placed in service in 1910. More recently, Amtrak brought high-speed service to the Northeast Corridor, inaugurating the Metroliner in 1970 and the Acela Express in 2000.

On the automobile front, the 1920s and 1930s saw the development of bridges and tunnels across the Hudson and Delaware Rivers. New facilities included the Holland Tunnel with its Pulaski Skyway connection, the Lincoln Tunnel and the George Washington Bridge. The 1950s saw completion of the New Jersey Turnpike and the Garden State Parkway. The Turnpike provided a major accessibility axis across the State, reinforcing the railroads and the Northeast Corridor. It was a major stimulus to economic development and became a locus of warehousing and other commercial development. The Parkway, conceived as part of the First Regional Plan for New York City and its Environs, contributed to development along the coastal plain. In subsequent years, interstate highways – I-80, I-280 and I-78 – were built across the State, shrinking travel times and creating new sites for commercial development.

In the last decade, New Jersey has invested substantial sums in transportation improvements. The most significant project, Interstate 287, provides a circumferential route around the most densely-settled part of the State, from the Tappan Zee Bridge in the north to Perth Amboy in the south. Its crossing of I-78 and the New Jersey Turnpike in the Woodbridge area has created a major development node.

The State also spent heavily to upgrade its commuter rail network, as New Jersey Transit embarked on a program to modernize and consolidate its system and add new service into Manhattan. Midtown Direct (opened 1996; see Residential Relocation section) and the Montclair Connection (2002) connected Hoboken-bound lines with the Northeast Corridor, giving thousands of commuters a straight shot into Manhattan. The Hudson-Bergen light rail line (2000-2002) enhanced both local and regional mobility, by tying waterfront communities to the larger transportation network. The Secaucus Transfer (scheduled to open late 2003) will link all of northern New Jersey's commuter rail lines for the first time and dramatically increased mobility within the State.

ECONOMIC TRENDS

New Jersey's economy is affected by events and trends around the world, from the information revolution to international terrorism. These trends can affect transportation by allowing for more flexible working hours, in the case of the information revolution; or by requiring redundancy and increased security, in the case of terrorism. In this section, we explore socioeconomic and demographic trends that are specific to northern New Jersey.

Heavy manufacturing in New Jersey continues its decades-long decline. From 1990-1999, manufacturing employment in the study area fell 22%, with the greatest job losses occurring in the northeastern counties – Essex, Passaic, Bergen, and Hudson Counties – and Mercer County.

Northern New Jersey also experienced a continued dispersion of population and jobs from the older urban centers towards the less densely-populated south and west. In the 1970s and 1980s, there was substantial growth in the counties along Route 1 and the Northeast Corridor, away from the older core towards Middlesex and Mercer Counties. As these counties have become more developed, with higher land prices and more congestion, growth has moved to the next ring of counties. Employment in the next years is forecast to grow at a healthy rate in Middlesex County, but the adjacent counties of Monmouth, Ocean, and particularly Somerset are also predicted to grow rapidly.

A counter-trend has brought something of a revival to urban centers in recent years. Population declines have slowed and in some cases reversed. While Bergen, Union, Essex, and Hudson Counties all lost populations in the 1980s, Bergen and Union grew in the 1990s, and the rate of decline slowed in Essex and Hudson.

This counter-trend was reinforced by trends in two important sectors. In the transportation industry, the lion's share of growth in the region went to Essex and Bergen Counties. Much of the growth in Essex County was driven by growth at Newark (Liberty) International Airport, including the expansion of Continental Airline's regional hub, and increases in international traffic. Trucking also contributed to growth. Both industries depend on good access to interstate road and rail networks.

Second, the Finance, Insurance, and Real Estate (FIRE) sector grew dramatically in Hudson County. In the two decades after 1980, Hudson County's FIRE employment more than trebled from 8,700 to 28,100. Middlesex County, with the largest concentration of FIRE employees, also grew; but in the 1990s Hudson County attracted by far the largest number of out-of-state firms. Unlike firms in the rest of the State, the Hudson County FIRE industry is tightly linked to Manhattan's financial industry and depends on good passenger transportation across the Hudson.

Both suburbanization and urban revival will continue to be strong forces in the 21st Century. Projected employment growth for the ten years ending in 2006 shows the largest job growth occurring in the suburban belt outside the urban core, especially in Middlesex and Somerset Counties; but the forecast calls for significant growth in Hudson, Essex, and Bergen Counties as well.

ECONOMIC BENEFITS

The economic benefits of a transportation investment fall into several categories. First, there is the immediate benefit to the system's users: improved accessibility. In any cost-benefit analysis, the value of travel time savings is typically the largest direct benefit. Second, the actual project construction gives a short-term stimulus to the regional economy. Third, improved accessibility may, given the right conditions, result in long-term job and income growth. This section discusses each of these benefits in turn.

Accessibility

If we are going to test for a relationship between transportation investment and economic activity, we need a way to quantify the investment. Some obvious measures include capital costs, lane or track miles added, and peak capacity improvement. These reflect the *means* by which transportation is improved, however, and not the desired end result, which is improved accessibility.

Accessibility can be defined as "the ease of access between spatial opportunities"¹ and measured by:

- Minimum travel time
- Distance
- Location opportunities, such as the number of jobs or other attractions at the destination
- Various combinations of the above

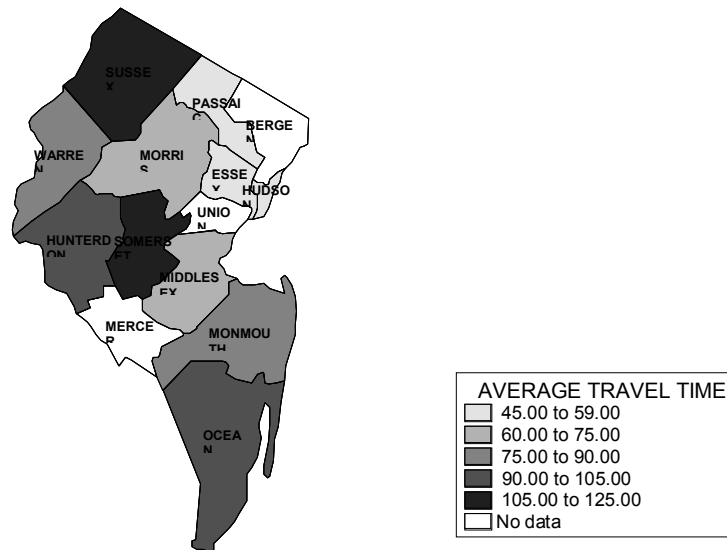
¹ David Banister and Joseph Berechman. *Transport Investment and Economic Development*. UCL Press, London, 2000, p. 174

Using techniques described in the academic literature, we calculated several accessibility indexes, all based on peak-hour highway travel times between counties in northern New Jersey and New York City.² The most basic measure of a county's accessibility is simply the average of the travel times to each of the other counties. Table 1 shows how average travel times changed from 1990 to 2000, and Figure 2 shows graphically how accessibility varies within the region.

**Table 1 - Average Peak Highway Travel Times
From Each County to Every Other County**

County	Average Travel Time, In Minutes	
	1990	2000
Bergen	60	57
Essex	53	50
Hudson	56	50
Hunterdon	91	87
Middlesex	69	64
Monmouth	87	86
Morris	66	61
Ocean	103	104
Passaic	54	51
Somerset	116	80
Sussex	122	115
Union	59	53
Warren	84	79
New York counties:		
Bronx	62	56
Kings	64	59
New York	58	52
Queens	66	61
Richmond	68	62

² In most of New Jersey, the highway system determines accessibility. The main exceptions are the Hudson shore, central Newark, and the Northeast Corridor.



**Figure 2 - Average Peak Highway Travel Times
From Each County to Every Other County (Minutes)**

Another measure takes into account the reasons for traveling by including a measure of each county's attractiveness. For example, if we look at accessibility to outdoor recreation sites, Warren County should score well, due to short travel times to the Delaware Water Gap and the Poconos. But if we are interested in economic activity, Warren County rates poorly, given its distance from the region's economic centers.

Using this attractiveness concept, we computed an accessibility index for each county based on the number of jobs in the region that are within one hour's drive. The more jobs there are within a one-hour radius of a county, the higher that county's index.

Figure 3 illustrates the data used to calculate this accessibility index for Manhattan. The leftmost data point corresponds to Manhattan itself, which contains 35% of all the employment in the northern New Jersey-New York City region. The chart shows that 80% of the region's jobs are within about 45 minutes' drive of Manhattan.

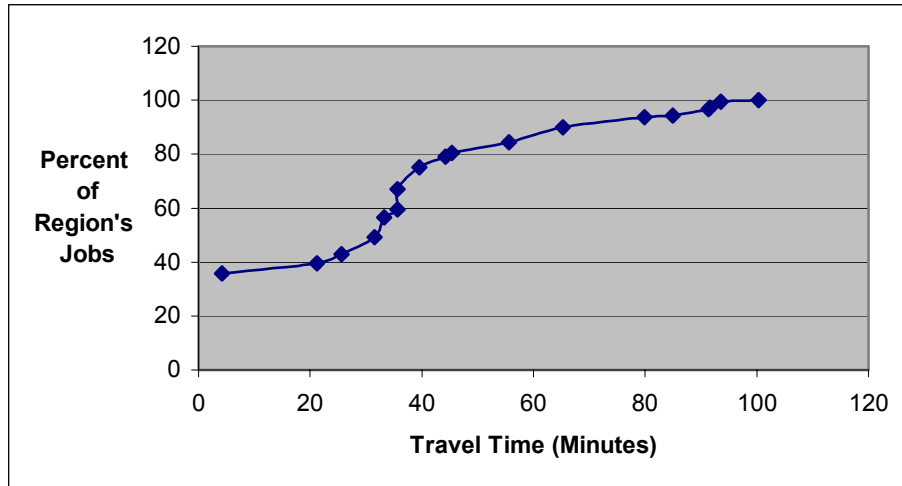


Figure 3 - Cumulative Distribution of Jobs Reached Within the Specified Travel Times from Manhattan (1990 Employment Figures)

Multiplier Effects

Our focus in this report is on the long-term economic impact of transportation investments. The actual project construction, however, has an immediate impact on jobs and economic output. When New Jersey spends money to build a transportation project, there is a ripple effect in spending throughout the regional economy. The State hires a general contractor; the general contractor buys cement; the cement manufacturer hires a new trucker; the trucker buys a new living room set; and so on. The total effect on the economy is greater than the amount of the initial investment, and the *investment multiplier* is the factor by which the initial investment's impact is multiplied.

Using multipliers obtained from the federal Bureau of Economic Analysis, we calculated the impact of a \$10 million transportation investment in northern New Jersey to be as follows:³

- \$21.5 million in economic output (including the initial \$10 million)
- 207 new jobs, in all industries
- 108 new construction jobs

Table 2 shows the predicted impact of several recent and proposed New Jersey Transit projects.

³ Here we generalize from multipliers for the construction industry. In fact, transportation investments require expenditures in several other industries as well, such as industrial machinery and transportation services. To more accurately estimate the multiplier for transportation investments, we would need to know the actual distribution of expenditures by industry.

Table 2 - Multiplier Effects of New Jersey Transit Projects

Project	Investment (\$ millions)	Total Output (\$ millions)	New Jobs	New Construction Jobs
Hudson-Bergen LRT MOS-I	992	2,134	20,534	10,693
Hudson-Bergen LRT MOS-II	1,215	2,614	25,159	13,101
Secaucus Transfer	448	965	9,282	4,834
Newark City Subway	78	168	1,617	842
Newark-Elizabeth Rail Link	209	450	4,326	2,253
Southern NJ LRT	805	1,732	16,664	8,678
Newark Airport Station	137	294	2,830	1,474
Morrisville Train Yard	47	101	975	508
Total	3,932	8,457	81,386	42,382

While the multiplier effect is clearly significant, its impact is short-term and lasts only as long as the construction. More lasting economic benefits, discussed in the next section, derive from the improved accessibility provided by the project.

Economic Growth

An investment in transportation infrastructure can propel economic growth by increasing the efficiency and profitability of businesses, stimulating capital spending by those businesses. It does this by enabling firms to exploit scale and agglomeration economies; by increasing the size of their markets; by providing access to a larger labor pool and a wider range of suppliers and raw materials; by linking disconnected markets; and by making firms and markets more receptive to innovation leading to future growth.⁴

⁴ Banister and Berechman, p. 134.

To measure the historical relationship between transportation investment and economic growth in New Jersey, we developed statistical models to determine whether counties with greater improvements in accessibility in the 1990s also had higher employment or income growth.

Using the travel-time-based measures of accessibility described in the previous section, we found that, in fact, there is a strong correlation between greater accessibility improvements and higher rates of economic growth.

On average, for all counties in the region, a 10% decrease in travel time results in a 4.8% increase in the rate of job growth and a 15.7% increase in the rate of income growth. A county with 9.9% job growth over 10 years (the actual average during the 1990s) could reap additional job growth of 0.48% if travel times dropped by 10% ($0.48\% = 9.9\% \times 4.8\%$). Similarly, a county with 23% income growth (the average during the 1990s) could grow by an additional 3.6% if travel times dropped by 10% ($3.6\% = 23\% \times 15.7\%$). Tables 3 and 4 give the model's job and income growth predictions for various levels of travel time change.

Table 3 - Impact of Travel Time Changes on Job Growth

Change in Travel Time	Predicted Increase in Job Growth Rate	Predicted Job Growth Rate, Assuming Baseline of 9.9%
-25%	16.0%	11.5%
-20%	11.6%	11.0%
-15%	7.9%	10.7%
-10%	4.8%	10.4%
-5%	2.2%	10.1%
0%	0%	9.9%
+5%	-1.9%	9.7%
+10%	-3.6%	9.5%
+15%	-5.0%	9.4%
+20%	-6.3%	9.3%
+25%	-7.4%	9.2%

Table 4 - Impact of Travel Time Changes on Income Growth

Change in Travel Time	Predicted Increase in Income Growth Rate	Predicted Income Growth Rate, Assuming Baseline of 23 %
-25%	39.3%	32.0%
-20%	31.4%	30.2%
-15%	23.6%	28.4%
-10%	15.7%	26.6%
-5%	7.9%	24.8%
0%	0%	23.0%
+5%	-7.9%	21.19%
+10%	-15.7%	19.38%
+15%	-23.6%	17.58%
+20%	-31.4%	15.77%
+25%	-39.3%	13.96%

Each county in the region differs in its sensitivity to travel time reductions. Job and income growth are most sensitive in counties at the region's core. Further out, the same increase in job or income growth rates requires a greater reduction in travel time. Figure 4 shows the relative sensitivity of job growth in each county to a 10% reduction in travel time.

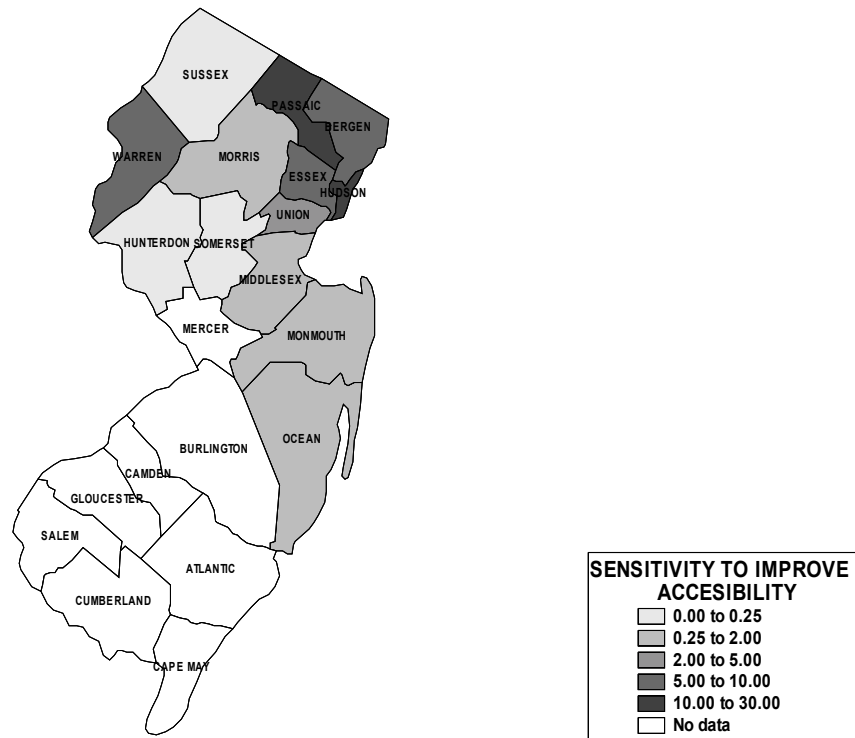


Figure 4 – Sensitivity of Job Growth to Changes in Travel Time

With economic growth and transportation infrastructure improvements, there is the classic chicken and egg conundrum: which comes first? As we've seen, improved accessibility results in increased economic activity; but it may also be that increased economic activity creates the demand and resources for building transportation projects. The literature does not provide a definitive answer to this question.

A second concern is the nature of the increased economic growth. When accessibility increases in one area and businesses move in, is the increased economic activity offset by losses in other regions? Or is there actually a net increase, due to more intensive economic activity? The data for New Jersey is silent on this point.

What we can say, however, is that in a well-developed economy such as New Jersey's, accessibility improvements *enable* economic activity but do not, on their own, *generate* it. Basic economic conditions, such as a skilled labor force and a buoyant economy, must be in place in order for transportation investments to have an economic impact.

Development requires that there be land available at an attractive cost, along with compatible zoning policies and development incentives. Public policy must support growth through zoning policies and development incentives. Finally, there must be a long-term financial commitment to the investment's success.

The Buffalo light rail system is an example of a transportation investment that failed to spur growth, despite the fact that re-energizing the downtown core was the primary impetus for the project. But the regional economy was declining and the city failed to provide incentives for retailers to return to the central business district. Furthermore, the transit system was weakened by low-fare incentives that resulted in service cuts, and changes in bus routes inadvertently made downtown less accessible.

Assuming that the economy is strong, that public policies support growth, and that the project has stable financing, the presence of certain economic "externalities" can contribute to a net increase in economic activity, and not simply a relocation of firms or residences. These externalities include:

- Agglomeration economies. In many industries there are economies of scale, or agglomeration, when firms cluster. The firms achieve efficiencies by sharing suppliers, infrastructure, and a specialized labor pool, and through the rapid exchange of technology and information. Notable agglomerations in New Jersey include the clustering of financial services in Hudson County, near Manhattan's financial center; and the concentration of pharmaceutical firms near Rutgers and Princeton.
- Labor market thresholds. The sensitivity of job growth to accessibility improvements varies across job categories: some workers are fairly insensitive to improvements in accessibility. A study of the South Bronx economy showed that shorter commutes draw unemployed executive, technical, administrative, and transport workers into the job market but have

essentially no effect on retail, wholesale, and personal services workers.⁵ An investment that overcomes these barriers could open up the labor market and have a disproportionate effect on economic activity.

- Network economies. A new transportation facility, such as a rail link, is typically part of a larger network. Due to non-linearities in network traffic flow, the addition of such a link can result in increased traffic flow over the entire network beyond just the additional traffic over the new facility.

When two disjoint networks are linked by a newly constructed facility (e.g., the Secaucus Transfer), the result may be similar to that of linking markets: the lower transportation costs promote competition and result in lower overall prices in the new, unified market. There could be a disproportionate jump in economic activity – more than would normally be expected from the reduction in travel times.

Transportation improvements can have negative economic consequences, too; for example, they can encourage sprawl. The common side effects of sprawl – congestion, accidents, and pollution – have measurable direct costs that can inhibit growth.. Negative consequences that may be harder to price include neighborhood distraction, noise, visual impact, and stress.

⁵ Joseph Berechman and Robert Paaswell. "Do accessibility improvements affect local employment? The case of the South Bronx", TRED Conference on Land Use and Transportation, Lincoln Institute, Cambridge, MA, 11-12 October, 1996.

LAND USE

The prime effect of transportation infrastructure investment is to change the relative accessibility and attractiveness of specific regions.⁶ In this section, we look at how improvements in accessibility in New Jersey have influenced land use decisions by both individuals and companies, and we present conceptual and analytical tools for predicting future development patterns.

Residential Relocation

The commute to work plays a major part in determining where individuals live, and improvements in that commute open up residential location opportunities. For New Jersey, trans-Hudson ferries have long allowed Manhattan workers to escape the city at night for a more relaxed lifestyle across the river. The rail and road networks established in the 19th century gave workers the freedom to live at an ever-increasing distance from their place of work

We can visualize the impact of improved accessibility on residential choice with the help of a simple diagram showing travel times to an employment center **C** (Figure 5). Access to the center is provided by north-south and east-west rail lines, and commuting times are shown with concentric contour lines. For example, an employee who lives at **H** has a 45-minute commute. He or she can move anywhere within the area bounded by the 45-minute contour and have a 45-minute or less commute.

⁶ Banister and Berechman, p. 148

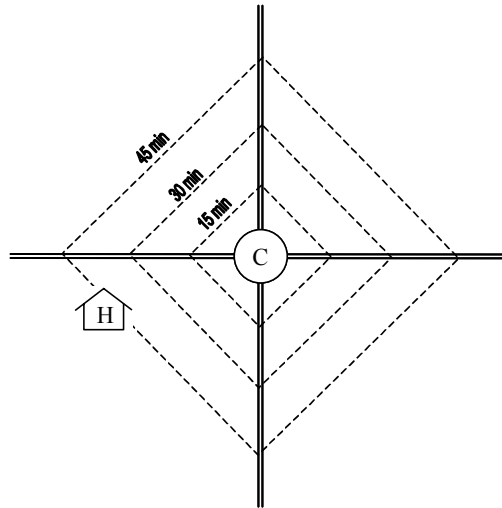


Figure 5 - Travel Time Contours from an Employment Center "C"

Suppose that an express connection is constructed between **X** and **C**, cutting the commute time for everyone west of **X** by 15 minutes. The employee at **H** now has a 30-minute commute. And the 45-minute contour has expanded dramatically westward, as shown in. Figure 6. Our employee can now consider housing opportunities further away from work without sacrificing commute time. The shaded area in Figure 7 is land newly-open to the commuter, in the sense that he or she can move here without getting a longer commute.

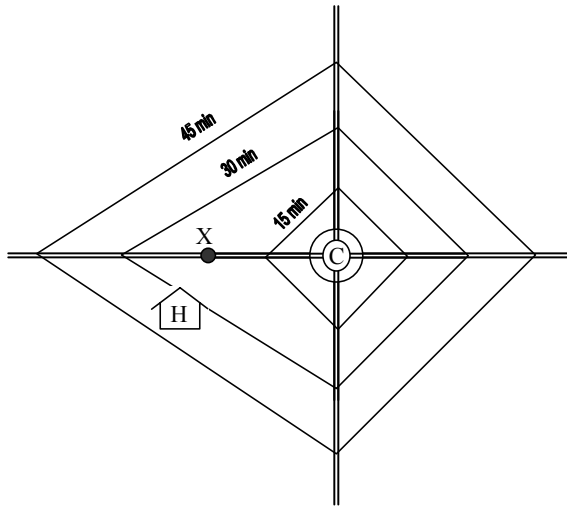


Figure 6 - Travel Time Contours with an Express Connection

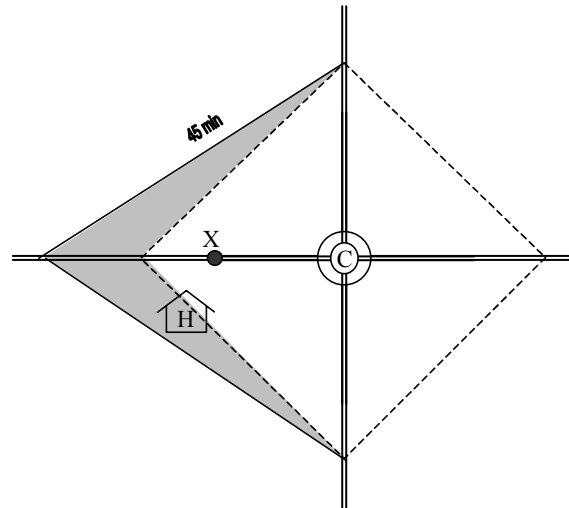


Figure 7 - Expansion of the 45-Minute Travel Zone

New Jersey Transit's Midtown Direct service, begun in 1996, is an example of a transportation improvement that opened new residential opportunities. Before the service opened, Manhattan-bound commuters on the Morris and Essex line – an electrified service with three branches, 39 stations, and 69 kilometers of track – rode the line to its terminus at Hoboken on the west shore of the Hudson (Figure 8). There they transferred either to ferry service or to the Port Authority Trans Hudson (PATH) subway to reach Lower or Midtown Manhattan. With the opening of the new service in June 1996, riders could travel directly to Penn Station in Midtown, eliminating a transfer and up to 20 minutes or more of travel time.

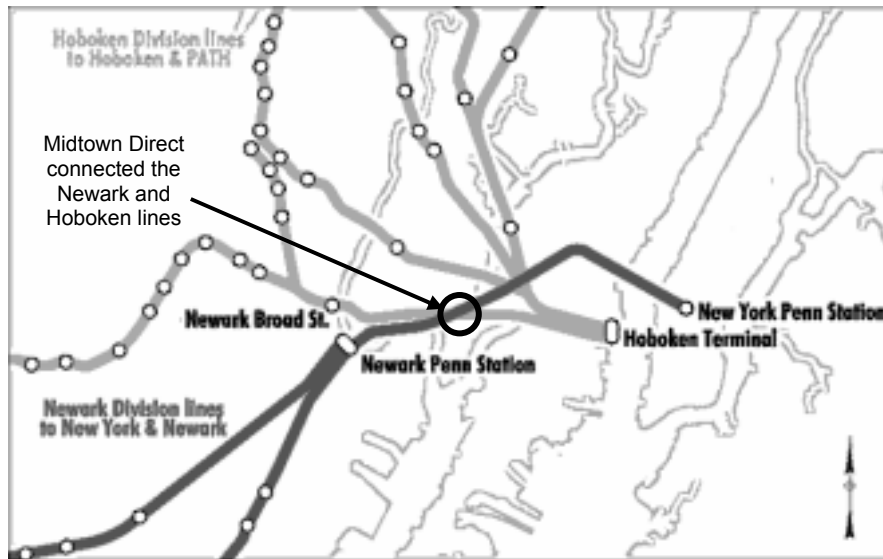


Figure 8 - Midtown Direct Connection

Table 5 - Travel Time to Midtown (minutes)

Origin	Via Hoboken & PATH	Midtown Direct
Dover	104	82
Morristown	85	64
Chatham	74	53
South Orange	58	38

Five months after the service opened, New Jersey Transit conducted an extensive ridership and quality-of-service survey of 6,000 eastbound (New Jersey to New York) morning peak-period riders. In 2001, we performed a follow-up study of 1,242 of the original survey participants. We also created a mathematical model to predict which commuters were most likely to move as a result of the new service, and to identify the aspects of the new service that most strongly influenced their move.

When the first survey was performed, ridership on the Morris and Essex branches had grown from 16,000 riders per day to 18,400 riders – a 15% increase. The survey showed that 8% of regular commuters had actually moved in response to the new

service. Our follow-up survey found that these commuters took advantage of the faster service by moving further away from work: all of the movers who originated in the northern New Jersey-New York region chose a new residence further away from New York City.

Midtown Direct also had a strong impact on the residential real estate market: price increases along the rail line outpaced the average by 15-20% in the first four years. Previous studies on the effects of commuter railroads on residential land values have found that prices are highest about one-half mile from the line, and then decline with increasing distance. Property near stations fetches an additional premium.

Using discriminant analysis modeling, we looked for the combination of factors that best predicted which commuters would move. We found that young married couples with children who reported a large improvement in the quality of their trip to work were most likely to move (Figures 9 and 10). Interestingly, the actual change in commuting time turned out *not* to be a significant factor. The apparent contradiction is significant: for these movers, overall commuting conditions, including comfort and convenience – in this case, a single seat ride into Manhattan instead of a transfer at Hoboken – were more important than the commuting time itself.

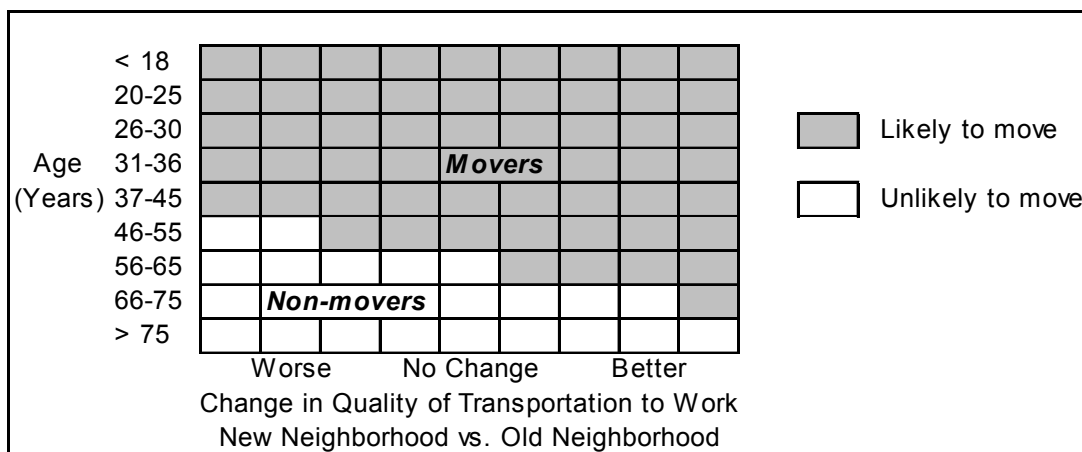


Figure 9 - Model Predictions for Commuters Who Were Married with Children

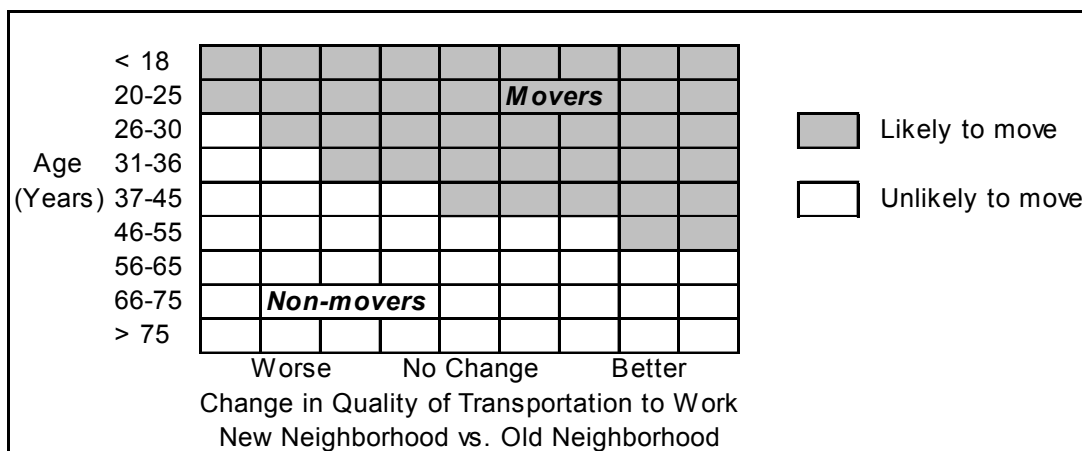


Figure 10 - Model Predictions for All Other Commuters

Commercial Relocation

For businesses considering a move or expansion, transportation infrastructure plays a major role in the location decision through the trade-off between accessibility and land values. For some firms, good access to workers, customers, suppliers or raw materials is critical, and they are prepared to pay more for that competitive advantage. Others can locate more peripherally as accessibility is less important.

For this project, we studied the location decisions of the 1,017 firms that moved into New Jersey or opened a branch in the State from 1990 through 1999. Our goals were to uncover relationships between accessibility and location decisions, both in terms of what businesses said they preferred and their actual choices.

The 1,017 firms that moved into New Jersey were a major source of economic growth: during the 1990s, they collectively created 108,000 jobs. (Overall State employment

during this period grew by a net of 162,000 to 3.28 million.⁷) The majority – 58% – of the relocated jobs came from firms originating in New York, and another 10% from Pennsylvania firms. New Jersey's lower taxes and land prices attracted many firms; an earlier survey showed that lower rent was the prime draw for companies moving from New York City.

Land values may explain the migration of New York firms to New Jersey; but according to a pilot survey performed by our research team, northern New Jersey's main attraction is its proximity to the huge regional market. We found that in the 1990s, three-quarters of the incoming businesses moved to northern New Jersey, 59% moved to the densely populated region within 25 miles of New York City, and 40% settled within ten miles of the Holland tunnel entrance. Figure 11 shows the firms' new locations, and Figure 12 graphically illustrates the importance of proximity to New York City.

⁷ Although employment grew by 162,000, the actual number of jobs created was far higher; but several hundred thousand jobs were also lost, hence the relatively low net total.

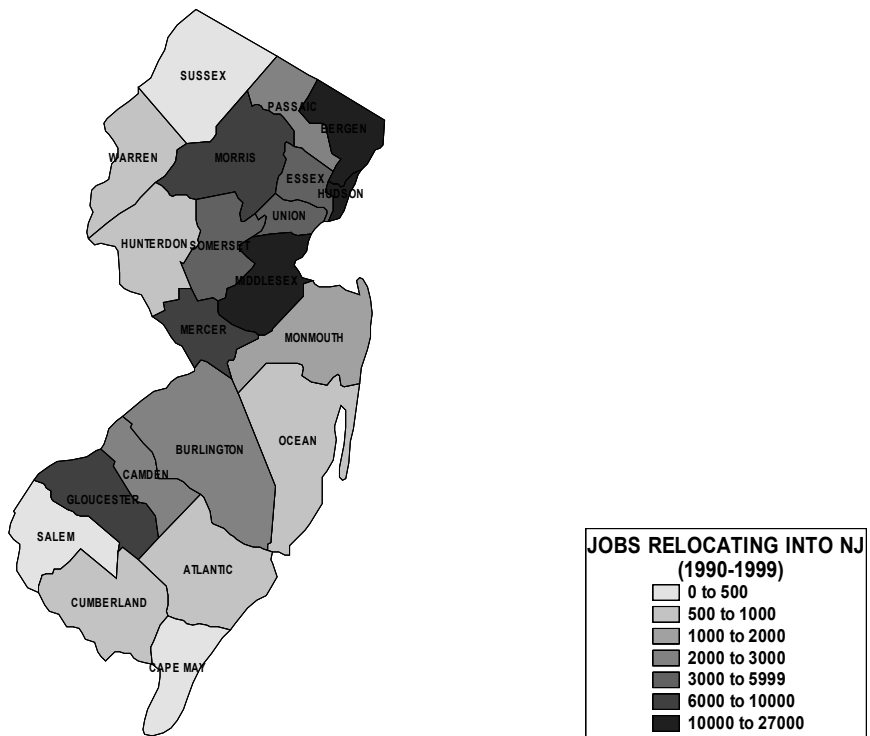


Figure 11 - New Jobs By County

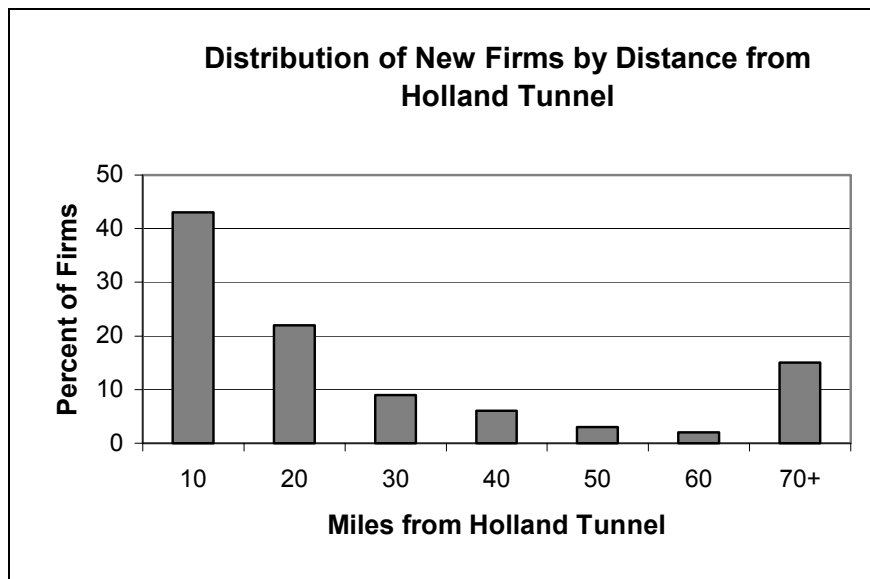


Figure 12 – Distance from New York City of Relocated Firms

Proximity to New York City actually brings access to several economic centers, in both New York and New Jersey:

- **Midtown and Lower Manhattan**, home to 35% of the region's jobs; the regional and global financial capital, providing access from New Jersey to deal making, legal work, financing and banking and an extremely large range of associated skills.
- **The New Jersey Hudson shore**, an emerging center for back-office operations of the legal and financial services industries, for new manufacturing, and for technology start-ups.
- **The Ports**: the Port of Newark and Newark Liberty International Airport, principal regional freight hubs linking New York and New Jersey to the West and South with both rail service and fast truck access via the Northeast Corridor.

Northern New Jersey's access to these economic centers gives the State a major competitive advantage in attracting new firms.

Once a company has decided to move to northern New Jersey, how does it choose a specific site? A 1985 survey of Fortune 500 companies found that rail and highway accessibility are the two most important constraints on final site selection. In New Jersey, commercial settlement patterns in the 1990s relative to the transportation network are clear (Figure 13). Sixty percent of the new firms chose locations within five miles of the New Jersey Turnpike. Far fewer firms were attracted to the Garden State Parkway, from which trucks are barred, confirming the importance of good freight transportation for most businesses.

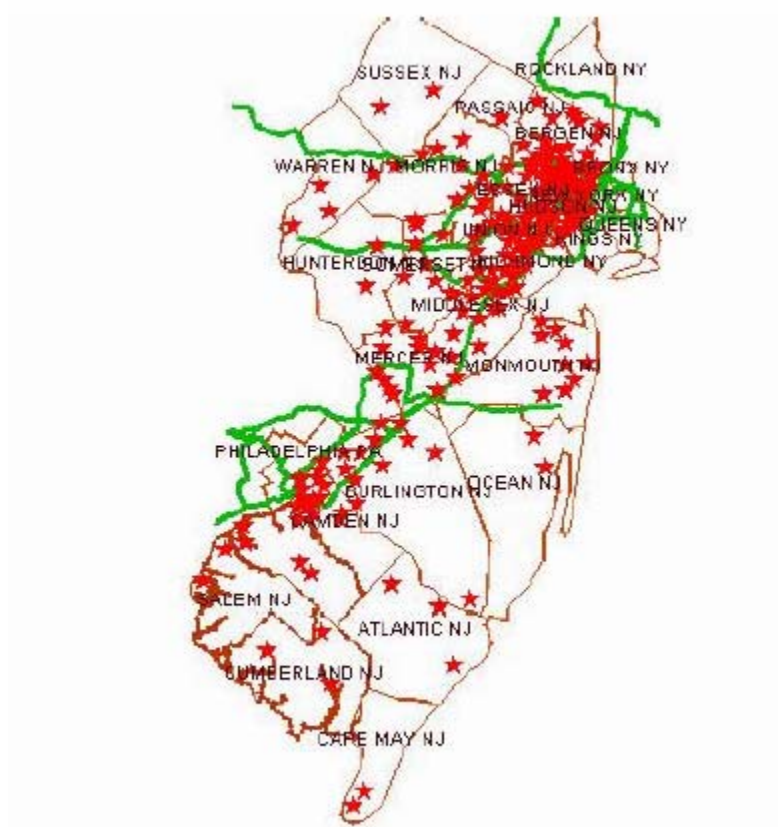


Figure 13 – Locations Of Relocating Firms

Although proximity to both customers and transportation facilities are the top factors in site selection, their relative importance varies from industry to industry. Across all companies, we found a strong correlation between location and shorter travel times to New York City. But this attraction is not uniform. Within New Jersey, some industries show a preference for more distant locations from New York City and Philadelphia. We found statistically significant patterns for the following industries:

Industry ▼	Accessibility Preference ►	Close to NYC	Close to Phila.	Far from NYC	Far from Phila.
Food and apparel manufacturers		x			
Retail trade: sporting goods, hobby, book, and music stores		x			
Finance and insurance		x	x		
Transportation		x			
Accommodation and food services		x			
Professional, scientific, and technical services		x			
Health care and social assistance			x		
Construction				x	
Warehousing				x	
Administrative and support and waste management/remediation services					x

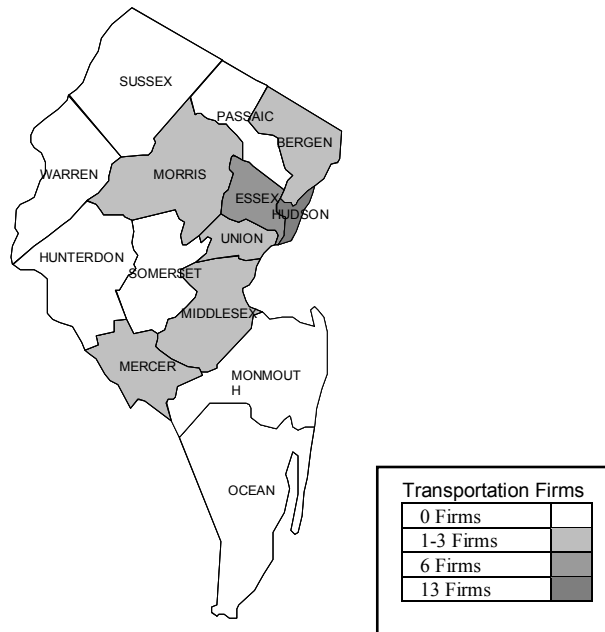


Figure 14 -Transportation Firms By County

A total of 33 transportation firms moved into New Jersey in the 1990s, including 22 from New York. The movement of transportation businesses from New York to New Jersey follows a long term trend. Given the high cost of land, congestion within New York City, and the more direct connections to the rest of the country from New Jersey, the large freight industry associated with the New York/New Jersey port has tended to migrate from the east side of the Hudson River to the west side. 13 of the relocating firms moved to Hudson County and another 6 to Essex County.

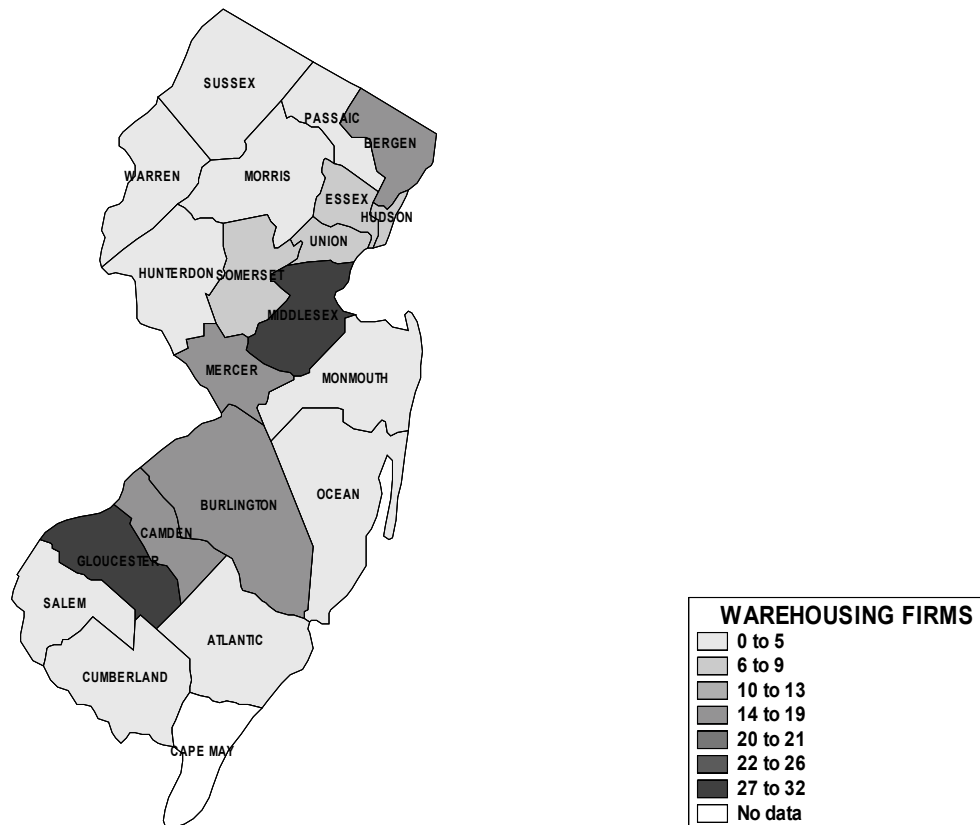
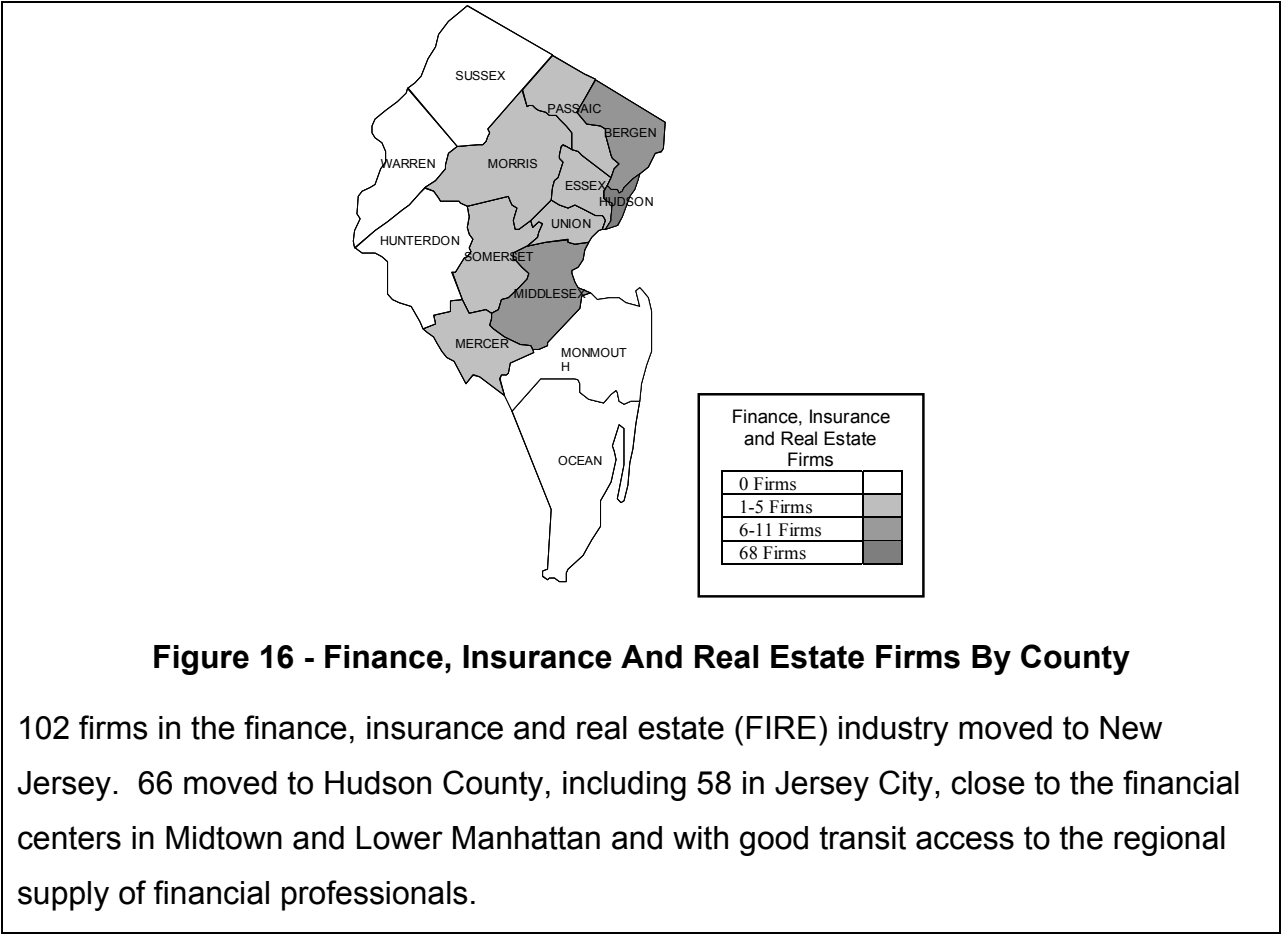


Figure 15 -Warehousing Firms By County

A total of 173 warehousing firms moved into New Jersey in the 1990s. 87 of these came from Pennsylvania (out of 99 firms overall from Pennsylvania). Another 33 moved from New York. In contrast to transportation firms, warehousing firms typically locate at a distance from New York along the interstate highways, where they can find cheap land but still enjoy good access to the retail and commercial centers.



Firms moving to Northern New Jersey balance conflicting demands when choosing a site. They need access to customers, suppliers and employees; but they also demand reasonable rents and space to expand. The trade-off is different for each industry. For the financial services industry, the benefits of locating near Wall Street compensate for the higher rents along the Hudson shore. Warehousing firms, on the other hand, need acres of cheap land and convenient freight access, so they build facilities near highways and rail lines at a distance from the urban centers. New Jersey's great competitive advantage in attracting firms of all types is that it combines good land values with excellent access to markets and skilled labor.

TOOLS

In the preceding sections, we described our findings on the relationship between transportation investments and increased economic activity. Our research developed a number of analytical tools that can be used to plan future projects and predict their economic impacts. In the following table, each tool is presented with its mathematical formulation and instructions for application.

Accessibility (page 4)	Accessibility can be measured by travel time or attractiveness of the destination or a combination. We found that two different measures consistently predicted employment and income growth. (The travel times in these formulas were obtained from the North Jersey Transportation Planning Authority and calculated from congested highway speeds produced by the calibrated Tranplan model.) In the formulations below, t_{ij} is the travel time between counties i and j and N is the number of counties in the region (18, including the 5 boroughs of New York City). The first measure is simply the average travel time from each county to all others. The accessibility of county i is then $\frac{1}{N-1} \sum_{j=1}^N t_{ij}$ The second measure is a gravity-like index: unlike the average travel time index, higher values of this index indicate greater accessibility. The accessibility of county i is computed as $\sum_{\substack{j=1 \\ i \neq j}}^N t_{ij}^{-2}$ The average travel time index was best at predicting income growth, while the gravity index was best at predicting employment growth.
-----------------------------------	---

Investment Multiplier (page 14)	The investment multiplier quantifies the ripple effect of spending on infrastructure investments. For construction projects in northern New Jersey: if K is the cost of the capital project, then Total increase in economic output = $2.15 \times K$ Total number of new jobs = $0.0000207 \times K$ Total number of new construction jobs = $0.0000108 \times K$
Economic Growth (page 15)	Employment and income growth rates are strongly correlated to improvements in accessibility. Our models show how a given change in network travel time results in changes in the employment and income growth rates. To use the models, you need baselines for the job and income growth rates – the expected growth given current travel conditions. In the table below, find the predicted change in network travel time in column (1). Multiply the baseline job growth rate by the figure in column (2) and the baseline income growth rate by the figure in column (3) to determine the expected job and income growth rates. For example, with expected job growth of 9.9% and expected income growth of 23%, a 10% reduction in network travel time results in additional job growth of $9.9\% \times 4.8\% = 0.48\%$, and additional income growth of $23\% \times 15.7\% = 3.6\%$.

Economic Growth (continued)	(1) Change in Network Travel Time	(2) Predicted Increase in Job Growth Rate	(3) Predicted Increase in Income Growth Rate
	-25%	16.0%	39.3%
	-20%	11.6%	31.4%
	-15%	7.9%	23.6%
	-10%	4.8%	15.7%
	-5%	2.2%	7.9%
	0%	0.0%	0.0%
	+5%	-1.9%	-7.9%
	+10%	-3.6%	-15.7%
	+15%	-5.0%	-23.6%
	+20%	-6.3%	-31.4%
	+25%	-7.4%	-39.3%
Household Relocation	When transportation improves, some people respond by moving to a new residence. In the case of Midtown Direct, we found that young commuters who were married and had children were most likely to relocate. More significantly for the transportation planner, we could not differentiate movers from non-movers on the basis of reduced travel time; but the movers were significantly more likely to report an improvement in the quality of the transportation to work. The implication is that commuters respond to changes in the overall characteristics of their commute – including improved comfort and convenience, and the elimination of transfers – and not simply reduced travel times.		

PROJECT ANALYSIS

New Jersey is in the midst of a major program of upgrading and enhancing its existing passenger rail network. Several projects are under construction, while a wide range of additional projects are being considered for development.

These projects affect accessibility in different ways. Some effects are purely local but nevertheless dramatic; others have the potential to change accessibility throughout the region. These effects can be divided into three classes:

1. The project opens up an undeveloped region. Most rail projects provide accessibility to areas that were previously inaccessible by rail. If the new line is linked to a larger network, then the area's accessibility to and from a wide region may go up dramatically. Economic development may follow if appropriate land use policies and incentives are in place.
2. The project provides additional service to a developed area. Projects that add capacity or bring new lines into an existing destination can have a major impact on its accessibility. The additional capacity may encourage agglomeration, which in turn can boost economic growth.
3. The project connects existing networks. The projects with potentially the largest impact are those that create links or reduce bottlenecks between existing networks. Accessibility across the region may increase as travel times drop between places far from the physical link. The increased accessibility reduces the power of local monopolies and can result in lower costs throughout the region.

Most of the projects currently and are being considered for development by New Jersey Transit fall into more than one of these categories. The Hudson-Bergen

light rail line, for example, provides access to parts of the New Jersey waterfront previously inaccessible by rail, but also increases service to existing transit destinations such as Hoboken. Table 6 rates the predicted impact on accessibility of selected New Jersey Transit projects.

Table 6 - Projected Accessibility Benefits of New Jersey Transit Projects

Level of Impact				
Low		Medium		High
Project	Opens an undeveloped region	Reduces travel time to a developed area	Taps a Wide Area	Notes
Hudson-Bergen light rail extension				Extension of line taps new catchment area to north. Interchanges with PATH create major focal points.
Secaucus Transfer				Links the Hoboken and Newark networks. Provides complementary access to Manhattan.
Newark City Subway extension				Extends to built-up area with limited development potential.
Newark-Elizabeth rail link (first operable segment)				May benefit central Newark.
Montclair Connection				Improves access to Manhattan and downtown Newark.
Newark Airport station				Lack of local access and parking limits the potential for development around the station
West Shore line				Serves developing area. Development opportunities near stations. Provides direct route to downtown Newark.
Northern Branch				Serves corridor that lacks rail service. Some development potential.
Newark-Elizabeth rail link (2 nd , 3 rd segments)				Improves access to central Newark.
West Trenton line				Serves growing areas in Somerset and Middlesex. Potential for development around stations.

Level of Impact	Low	Medium	High	
Project	Opens an undeveloped region	Reduces travel time to a developed area	Taps a Wide Area	Notes
Phillipsburg extension via Raritan Valley line				Development depends on suitability of available land.
Phillipsburg extension via Boonton line				Provides new rail access for Montclair.
Newark City Subway extension to Paterson				

CONCLUSION

As we have seen, New Jersey's investments in transportation infrastructure have collectively improved accessibility throughout the State. In turn, individuals and businesses have taken advantage of the improvements in making relocation decisions, and economic output and employment have increased.

However, infrastructure investment on its own does not spur economic growth. There are a number of factors which determine whether a particular improvement in accessibility will result in increased economic growth, or affect land use decisions. These include the following:

1. **Economic conditions.** The economy must be strong and there must be a skilled labor force.
2. **Land availability.** Land must be available at a reasonable cost.
3. **Institutional support.** Zoning and development policies must encourage development.
4. **Investment.** There must be a long-term financial commitment to the investment's success.
5. **Agglomeration.** If improved accessibility encourages firms of the same industry to cluster geographically, these firms may be able to share common resources and collectively benefit from economies of scale.
6. **Labor market barriers.** Transportation improvements that encourage new workers to enter the labor force by providing new access to job sites can have a disproportionate affect on economic growth.
7. **Network economies.** When networks are linked, accessibility improvements may ripple throughout the new joint network.

Furthermore, "accessibility improvements" encompasses more than simple travel time reductions. Cost, convenience, and job availability at the destination are also important. Commuters who moved in response to the Midtown Direct service were more strongly influenced by overall factors such as the single seat ride into Manhattan, than they were by the reduced travel time. This confirms that factors such as convenience, cleanliness, and customer service can have a significant impact on riders' decisions.

APPENDIX A: List of Working Papers

Working Paper No. 1, Outlining Objectives, Approach and Structure of Study, Joseph Berechman and Robert E. Paaswell, September 27, 1999.

Working Paper No. 2, Discussion of Alternative Modeling Frameworks, José Holguín-Veras, Ph.D., September 24, 1999.

Working Paper No. 3, A Draft Working Paper on Available Data and Data Source Description and Review of Selected Related Papers, Dilruba Ozmen, M.Sc., Kaan Ozbay, Ph.D., Joseph Berechman, Ph.D., Robert Paaswell, Ph.D, Jose Holguin Veras, Ph.D., November 30, 1999

Working Paper No. 4, Socio-Economic Characteristics of Northern New Jersey, Claire E. McKnight, July 24, 2000.

Working Paper No. 5, Employment Trends in the Study Area, Raghavan Srinivasan, and Claire McKnight, October 18, 2000.

Working Paper No. 6, Presentation of Available Land Use Data Using TransCAD, Kaan Ozbay, Ph.D. and Dilruba Ertekin, M.Sc. April 13, 2001.

Working Paper No. 7, Development of the Service Employment Multiplier, Ellen Thorson, Jose Holguin-Veras, and Claire E. McKnight, April 11, 2001.

Working Paper No. 8, Business Relocation Patterns and Trends, Ross D. Weiner,, Shmuel Yahalom,, Claire E. McKnight, Herbert Levinson, and Robert E. Paaswell,, April 2002.

Working Paper No. 9, Using Regional Multipliers to Assess the Economic Impacts of Transportation Investments in Northern New Jersey, Raghavan Srinivasan, and Joseph Berechman, November 24, 2001.

Working Paper No. 10, The Residential Relocation Impacts Of Midtown Direct A Descriptive Analysis, Victor Ochieng, Herbert S. Levinson, Robert E. Paaswell, and Jose Holguin-Veras, and Claire E. McKnight, June 2002.

Working Paper No. 11, Multivariate Analysis Of The Relationship Between Transit Accessibility And Residential Location Choice, José Holguín-Veras, Robert Paaswell, Wendy Avilés, Victor Ochieng and Claire McKnight, February 8, 2002.

Working Paper No. 12, Empirical Analysis Of The Relationship Between Accessibility And Economic Development, Kaan Ozbay, Dilruba Ertekin, and Joseph Berechman, March 3, 2002.