# Public Works Program
# —
# Multiplier and Employment-Generating Effects


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Final Report
May 1998


Economic Development Administration
U.S. Department of Commerce

# Public Works Program

# Multiplier and Employment-Generating Effects

*Prepared for:*
**U.S. Department of Commerce**
**Economic Development Administration**
**Office of Program Research and Evaluation**
**(EDA Project No. 99-06-07415)**

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MAY 1998

# CONTENTS



***(Project-by-project pages of this section are not included in this PDF.)***

# SUMMARY OF FINDINGS

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### Section I—Introduction to the Research

This is a study about the job-producing results of public works investments. It employs nearly 200 input-output and regression analyses to document the effects of Economic Development Administration (EDA) public works projects on the employment growth of their host counties. Comparisons are also made to counties where EDA projects did not take place. Both the input-output and regression analyses seek similar answers—do public works projects produce attributable permanent jobs in counties where these projects take place? Do the resulting jobs, in turn, produce other jobs? The two analyses are different in that the input-output analysis is constrained by current conditions, whereas the regression analysis allows the current structure of economic activities to change. The first presents a static view of job-creation impacts; the second, a more dynamic view. Both types of analyses are rigorous and standard econometric procedures for determining relationships between public investment and permanent job growth.

### Section II—Input-Output Analysis Findings

This section of the report examines the role of EDA-funded *direct* permanent employment and private-sector investment in producing *total (direct, indirect,* and *induced)* permanent employment and private-sector investment in counties throughout the United States. In other words, what are the direct employment and private-sector investment multiplier effects? The analysis is undertaken using the IMPLAN Model to generate indirect and induced effects from direct effects, the latter obtained from a national survey of public works grantees. Thus, the national survey generates *direct* permanent employment and private-sector investment; the IMPLAN Model generates *indirect* and *induced* permanent employment and private-sector investment. The sum of direct, indirect, and induced employment and private-sector investment yields *total* employment and private-sector investment.

Total employment and private-sector investment divided by direct employment and private-sector investment produce "multipliers" of the two direct effects.

Two sets of multipliers are shown in Table S-1. These relate to two forms of direct effects—project-related and nonproject-related. The set of lower multipliers expresses total permanent employment and private-sector investment as a function of both forms of direct permanent employment and private-sector investment. The set of higher multipliers expresses total permanent employment and private-sector investment as a function of the solely project-related form of direct permanent employment and private-sector investment. The lower multiplier for permanent employment and private-sector investment is the multiplier effect of permanent employment and private-sector investment at the site that the EDA grant specified, *as well as other direct employment that located nearby;* the higher multiplier for permanent employment and private-sector investment is the multiplier effect of permanent employment and private-sector investment solely at the site that the EDA grant specified.

The multipliers shown in Table S-1 are medians for five categories of projects and a weighted median for all projects. The overall median ratio for total permanent employment to both forms of direct permanent employment *(project and nonproject-related)* is 1.50; the equivalent median for total private-sector investment is 1.44. Thus, if an EDA public works project creates 200 *direct* permanent jobs and $6 million in *direct* private-sector

**Table S-1**
**Input-Output Analysis Results**

**Permanent Employment and Private-Sector Investment Multipliers**
**EDA Public Works Projects**
**(Median Project Employment and Private-Sector Investment)**

| Project Type | Project and Nonproject-Related Direct Employment | Project and Nonproject-Related Total Employment | Ratio: Total Employment to All Direct Employment | Ratio: Total Employment to Project-Related Direct Employment | Project and Nonproject-Related Private-Sector Investment | Project and Nonproject-Related Total Private-Sector Investment | Ratio: Total Private-Sector Investment to All Direct Private-Sector Investment | Ratio: Total Private-Sector Investment to Project-Related Direct Private-Sector Investment |
|---|---|---|---|---|---|---|---|---|
| Buildings | 84 | 133 | 1.53 | 1.53 | 568,000 | 1,715,952 | 2.61 | 2.89 |
| Industrial Parks | 310 | 464 | 1.56 | 1.63 | 6,300,000 | 13,622,184 | 1.54 | 1.66 |
| Roads | 430 | 641 | 1.51 | 1.57 | 11,448,000 | 20,716,364 | 1.37 | 1.44 |
| Tourism/Marine | 125 | 199 | 1.56 | 1.59 | 1,320,000 | 3,043,315 | 1.21 | 1.93 |
| Water/Sewer | 300 | 467 | 1.47 | 1.56 | 6,362,342 | 9,489,237 | 1.37 | 1.50 |
| **All Projects** | 250 | 416 | 1.50 | 1.57 | 4,800,000 | 7,769,567 | 1.44 | 1.58 |

Findings: The overall median ratios of total permanent employment and private-sector investment to direct permanent employment and private-sector investment are approximately 1.50 and 1.44, respectively.

**Table S-2**
**Regression Analysis Results**

**Effects of a $10,000 EDA Public Works Grant on**
**County Labor Market Conditions (Typical U.S. County)**
(95% Confidence Interval)

| Specification | Increase in County Employment | Change in Annual Compensation per Employee |
|---|---|---|
| 1 | 10 – 14 | -$1.21 to +$1.17 |
| 2 | 7 – 10 | -$0.01 to +$0.01 |
| 3* | 7 – 10 | NA |

Findings: For EDA funding of $10,000 in a public works project in a typical U.S. county, permanent employment in that county will increase between 7 and 10 jobs. This includes direct, indirect, induced, and intangible effects.

*Preferred specification

investment, *total* permanent jobs (direct, indirect, and induced) amounts to 300 and *total* private-sector investment to $8.64 million. For employment, there is some minor variation by type of project: Industrial parks exhibit the highest multipliers; water/sewer projects exhibit the lowest. For private-sector investment, there is much more variation by type of project: Buildings have by far the highest multipliers; tourism/marine projects, the lowest multipliers.

The multipliers for total permanent employment and private-sector investment versus only *project-related* direct permanent employment and private-sector investment are 5 percent higher for employment and 10 percent higher for private-sector investment. This finding indicates the relatively small amount of nonproject-related direct permanent employment and investment compared to project-related direct permanent employment and investment identified in the grantee survey.

## Section III—Regression Analysis Findings

This section of the report examines the role of EDA public works investments in the creation of permanent private-sector employment and in enhancing employee compensation in U.S. counties.

Current models of the effect of infrastructure investment on private-sector productivity have yet to establish a firm connection between the two. Studies using these models often fail to control for the potentially important effect of variations in factor prices, especially wages, in response to public investments. A comprehensive model of county employment effects is provided in this study as a basis from which to view impacts.

The analysis reported here is undertaken using information from the *Public Works Program—Performance Evaluation* to specify the level of EDA investment in a public works project in a county. The resulting jobs produced in a county reflect the numbers of jobs counted annually as reported by *County Business Patterns*. Additional regression variables, taken from both *County Business Patterns* and the *U.S. Census of Population and Housing*, are used to help identify the independent effect of EDA investment on county employment growth.

The analysis employs multiple regression as the primary econometric technique, with separate equations constructed for both employment and compensation. Variables are expressed in their logarithmic form, reducing the influence of extreme values and enabling a closer fit of the regression planes and higher $R^2$s in both equations. Regressions explain between 80 and 85 percent of the variation in county employment and about 70 percent of the variation in compensation levels.

Empirical results include the following:

- EDA investments have a statistically significant and positive effect on county total employment levels (see Table S-2).
- EDA investments have no statistically discernible effect on compensation per employee. Thus, the resulting EDA jobs are produced at the average wage of all jobs locally.
- The elasticity of total employment with respect to EDA investment is estimated at approximately .0074: that is, a 10 percent increase in EDA investment in a typical county ($4,650) is estimated to be associated with an increase of 4.2 jobs. Thus, a $10,000 EDA investment produces approximately 9 permanent jobs.
- The cost per job for the EDA program is estimated at just over $1,100 (in 1997 dollars), counting all permanent jobs generated by the facility or the increase in productivity that the facility offers (direct, indirect, induced, and intangible). This estimate is comparable to the findings in both the *Public Works Program—Performance Evaluation* and the input-output analysis, which found that the cost of a direct permanent job was about $3,000 and that the multiplier for total jobs was about 1.5. But the input-output analysis considers only jobs created by the EDA facility. There are also other jobs created by the new assets themselves, leading to changes in the structure of county economies. Thus, the overall jobs multiplier might be even higher, bringing the cost per job more in line with the regression analysis.

This study finds that EDA's Public Works Program does indeed produce permanent private-sector employment at a relatively low cost. The estimates clearly suggest that the program is having its intended effect. EDA appears to have converted its resources into permanent jobs at prevailing wages in its target counties. These counties are better off than similar counties where this type of effort is not taking place.

# SECTION I
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# INTRODUCTION TO THE RESEARCH

# INTRODUCTION TO THE RESEARCH

## Overview of the Studies

This report describes the procedures and contains the results of two studies, each using an econometric technique that may be unfamiliar to nonspecialist readers. In both of the studies—an input-output analysis and a regression analysis—the problem and the analytical technique are first introduced in relatively nontechnical terms. Next, the analytical procedures and findings are described in full technical detail. Finally, the conclusions drawn from the findings are presented, again in relatively nontechnical terms. Thus, all information is available to the technical specialist, but the nonspecialist can read the introductory and concluding material and gain the full implications of the analyses.

The report studies two aspects of infrastructure investment that have long been in question. The first study, presented in Section II, involves the scale of the multipliers associated with infrastructure expenditures. Most researchers would agree that there is a multiplier effect of permanent direct or primary investment, but by and large, its scale has eluded rigorous specification. Often the multiplier effect of such investment is optimistically placed at three, four, or even five times direct investment. Actually, the investment multiplier is significantly less—probably between 1.5 and 2.0, depending upon the type and location of the permanent facility.

The second study, presented in Section III, considers whether purposeful infrastructure investment in counties has an identifiable effect on overall employment growth in those counties. Again, researchers have long thought that there is a "seedbed" effect of infrastructure investment, but its individual significance has gone undocumented.

Both studies consider the job impacts of EDA projects long after the construction-phase impacts have passed. In particular, they look at the economy in the long run and consider the permanent jobs drawn to, or retained in, the area as a result of the EDA project. The long run, steady-state impacts of EDA projects are viewed rather than their transitory construction effects.

These two studies were made possible by the painstaking efforts at determining direct employment and private-sector investment associated with EDA public works projects undertaken for another study, the *Public Works Program—Performance Evaluation*[1] (*PWPPE*) (see Figure 1). That study was overseen by Rutgers University and a consortium of universities and professional organizations. The first study presented here, the input-output analysis, uses information from *PWPPE* to establish direct permanent employment and private-sector investment. County-specific input-output multipliers are then used to estimate indirect and induced permanent employment and private-sector investment. The second study presented here, the regression analysis, uses EDA expenditures on public works projects, taken from *PWPPE*, together with job figures for all U.S. counties, to establish a relationship between job production in counties and public works funding in these same counties.

## The Input-Output Analysis

The input-output study, undertaken by M. Henry Robison of Economic Modeling Specialists, Inc. (EMSI), applies input-output multipliers from the IMPLAN Model[2] to direct permanent

[1] Rutgers University et al. 1997.
[2] A frequently used input-output model produced by the Minnesota IMPLAN Group (MIG) in Stillwater, MN.

(Figure 1 is not included in this PDF. It is a map of the United States showing the locations of all 203 projects completed during FY 1990 and examined in this evaluation.)

employment and private-sector investment to generate total permanent employment and private-sector investment. The study, presented in Section II, begins with an explanation of both input-output analysis and its unique interpretation using the IMPLAN Model. Indirect and induced *employment* for the 175 individual counties in which projects are found are then computed using IMPLAN-derived multipliers for these counties. The same procedure is employed to derive indirect and induced *private-sector investment*. Multiplier effects are summed and expressed as medians by both project type and region of the country. In Section V of this report, each individual project is displayed with not only its specific multiplier effects but with a measure of the project's share of annual county employment growth as well. What is immediately apparent is that the employment produced as a result of EDA funding in many of these rural employment-starved counties may represent the equivalent of several *years* of aggregate employment growth. Overall, the multiplier associated with EDA public works projects is about 1.5—that is, for every two direct jobs created by public works funds another indirect/induced job is created.

**The Regression Analysis**

The regression analysis, undertaken by Andrew F. Haughwout of the Woodrow Wilson School at Princeton University, seeks to establish that EDA public works investments have independent effects on permanent job production in the counties in which they are undertaken.

The study begins with a discussion of the findings in the field, including a study funded by the EDA on programmatic job-producing effects, that was completed about twenty years ago[3]. Not much research on the impact of EDA investments has been completed in the interim. The analysis then considers research design, data employed, and the calibration of the regression equation.

This is one of the few studies ever undertaken that looks at effects across all 3,135 U.S. counties to place the job-creating effects of EDA grants in context.

Two inquiries supported by multiple regression analyses are then considered. The first is whether EDA Public Works Program expenditures affect levels of employment growth in counties; the second is whether the expenditures alter wage levels in these same counties. The first analysis finds that EDA expenditures have a positive and highly statistically significant effect on job production; the second analysis finds that these same expenditures have little or no effect on the levels of compensation in the counties. The analysis concludes that the EDA Public Works Program has its intended impacts on job production in counties where it is operative and that those jobs have been produced at prevailing average wages. Compensation levels have not been significantly increased by EDA investment.

**The Importance of the Analyses**

Why have these analyses been done, and why are they specifically crafted components of the EDA research agenda? Heretofore, such results have been very difficult to obtain. In almost every estimate of the multiplier effects of direct permanent employment, the multipliers used have lacked an empirical and theoretical base and have been of a magnitude beyond the realm of credibility.

Now, multipliers are available by project type and location that have been derived from a nationally recognized input-

[3] Graham and Martin 1977.

output model, and these multipliers fall within an acceptable range.

Further, although there has always been some belief that EDA funding spurs the permanent job market, this effect has never been documented. The present study documents that there is an independent, positive, and statistically significant effect of EDA infrastructure funding on job production. In other words, EDA public works funding spurs job growth in counties at prevailing wage levels.

The input-output and regression analyses look at the same issue (but using different procedures): permanent jobs created and retained as a result of EDA projects. Input-output models track the interconnection of industries and consumer spending in a region, thereby providing estimates of the otherwise difficult-to-measure indirect and induced effects of a given activity, e.g., an EDA project. Input-output models involve certain restrictive assumptions, however, and these can be overcome to some extent through regression analysis.

The input-output analysis provides answers to questions of EDA investment impact under the current structure of employers in place. The regression analysis is an ex-post-ante analysis that indicates what can happen in the future as a result of EDA funding. The regression includes the possibility that the economic structure of a county may change and induce the growth of economic activities other than those originally present.

The input-output results are conditional on each county's current economic structure; regression estimates allow a more fluid and changing view of the impact of EDA spending. The fact that regression estimates suggest more job creation per dollar of EDA spending reflects the heightened economic activity resulting from changes in economic structure in a county.

# SECTION II
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# RESEARCH RESULTS: INPUT-OUTPUT ANALYSIS

## SECTION II—THE EFFECT OF EDA PUBLIC WORKS FUNDING ON INDIRECT AND INDUCED JOBS IN THE REGION: AN INPUT-OUTPUT ANALYSIS

### A. INTRODUCTION

Public works projects, due to the amount of capital investment associated with them, produce permanent jobs other than direct jobs. *Indirect* permanent jobs are produced as a result of suppliers to the primary industry hiring more employees as a result of increased sales and services; *induced* permanent jobs result from increases in household spending by employees in these direct and indirect jobs. Thus, a single new plant employing 500 workers in an industrial park funded by EDA could produce 700-800 *total* permanent jobs, counting the employment-generating "ripple" effects.

The purpose of the analysis that follows is to quantify these effects, using an established and tested input-output model. The model uses the direct permanent employment and private-sector investment figures documented in *PWPPE* and builds upon these direct effects to estimate indirect and induced permanent employment and private-sector investment. Once total employment and total private-sector investment figures are tallied, they are compared to the direct employment and private-sector investment figures to generate multipliers. These direct employment and private-sector investment multipliers can then, at any point in the future, be applied to estimates of intended direct job production and private-sector investment to generate the projected total employment and private-sector investment of an individual public works project.

### B. INPUT-OUTPUT ANALYSIS

Input-output (I-O) analysis is a concise means for mathematically depicting the economy of a given area. Specifically, I-O tables show the interrelations between the producers and purchasers of goods and services in an area.

These inter-industry relationships are expressed in matrices or tables. Horizontally, outputs for each sector of the economy are indicated by sales to the other sectors. Vertically, the table shows inputs or purchases made in one sector by all other sectors.

#### A Brief History

Wassily Leontief, 1973 Nobel Laureate in Economics, first used this I-O approach in 1936 when he developed models of the 1919 and 1929 U.S. economies to estimate the effects of the end of World War I on national employment. This approach gained wider acceptance and use as a standardized procedure for compiling the requisite data was developed (today's national economic census of industries), along with enhanced capability for calculations (i.e., the computer).

The federal government, however, immediately recognized the importance of Leontief's model and began publishing I-O tables of the U.S. economy in 1939. The most recently published tables are for the 1992 economy. Other countries followed suit. Indeed, the United Nations maintains a bank of tables from most member countries with a uniform accounting scheme.

Within the United States, many states, public-sector agencies, and private organizations also maintain these types of models. For example, the U.S. Maritime Administration distributes a Regional Port Impact Model. Local examples include the State of New Jersey model maintained by Rutgers University and the Port Authority of New York and New Jersey's 17-County Regional Input-Output Model.

**Advantages and Limitations of Input-Output Analysis**

I-O modeling is one of the most accepted means for estimating economic impacts. It is used by agencies throughout the world to quantify the impacts of proposed projects and programs. I-O has been used to estimate the negative impacts caused by certain events such as the World Trade Center bombing and service disruptions on the Union Pacific/Southern Pacific rail network during a strike. I-O's popularity as a means for measuring economic impacts stems from the method's ability to provide a concise and accurate means for articulating the interrelationships among industries. The models can be quite detailed. The industry detail of I-O models not only provides a consistent and systematic approach but also more accurately assesses the multiplier effects of changes in economic activity than other types of analyses.

The limitations of I-O modeling should also be recognized. The approach makes several key assumptions. First, the I-O 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 with the level of production. This assumption will not work in a technology matrix that depicts a recessional economy (e.g., 1982) and the analyst is attempting to model activity in a peak economic year (e.g., 1989), or vice versa. In a recession year, the labor-to-output ratio tends to be excessive, because firms are generally reluctant to lay off workers when it is believed that an economic turnaround is about to occur. In general, when I-O is used in "real world" applications, the I-O analysis is supplemented by either qualitative assessments or by other quantitative techniques, as is done here.

A less-restrictive assumption of the I-O approach is that technology does not change over time. This assumption is less-restrictive because the technology matrix in the United States is updated frequently and, in general, production technology does not change radically over short periods.

A final potential limitation is that the technical coefficients used in most regional (county) models are based on the assumption that production processes are spatially invariant. They assume that regional production processes are well-represented by the nation's average technology.

## C. THE DEVELOPMENT OF I-O MULTIPLIERS

I-O modeling focuses on the interrelationships of sales and purchases among sectors of the economy. I-O starts with development of the *inter-industry transactions table* or matrix, as in Table II-1. In Table II-1, agriculture, as a producing industry sector, or row, is depicted as selling $65 million of goods to manufacturing (the column). Conversely, the table shows that manufacturing (the column) purchased $65 million of agricultural production. The sum across each row of the inter-industry transaction matrix is called the *intermediate outputs vector*. The sum down each column is called the *intermediate inputs vector*.

An inter-industry matrix can be aggregated or quite detailed in terms of the sectors of the economy for which separate columns and rows are created. Research has found that detailed matrices are more accurate. The current U.S. matrix has more than 500 industries representing many four-digit Standard Industrial Classification (SIC) codes. The IMPLAN Model to be used in this analysis is also quite detailed, with 528 industrial subsectors.

**Table II-1**
**The Transaction Matrix**

| | *Purchases ($ Millions)* | | | |
|---|---|---|---|---|
| | Agri. | Man. | Serv. | Other |
| Agriculture | 10 | 65 | 10 | 5 |
| Manufacturing | 40 | 25 | 35 | 75 |
| Services | 15 | 5 | 5 | 5 |
| Other | 15 | 10 | 50 | 50 |
| Value Added | 20 | 95 | 20 | 90 |
| Total Input | 100 | 200 | 120 | 225 |

| | *Inputs ($ Millions)* | |
|---|---|---|
| | Final Demand | Total Output |
| Agriculture | 10 | 100 |
| Manufacturing | 25 | 200 |
| Services | 90 | 120 |
| Other | 100 | 225 |

A single *final demand* column is also included in Table II-1. This column, which is outside the square inter-industry matrix, includes imports, exports, government purchases, changes in inventory, private investment, and household purchases. The value added row, which is also outside the square inter-industry matrix, includes wages and salaries, profits, interest, depreciation, and indirect business taxes. Both the final demand column and the value added row equal the gross national product (assuming the table depicts the U.S. economy). In this analysis, the I-O model depicts numerous individual county economies.

By extracting household purchases from the final demand column and creating a separate column in the inter-industry matrix, and similarly, by extracting wages and salaries from the value added row and creating a separate row in this matrix, the *induced impacts* can be captured later in the multiplier calculations.

**Steps to Multipliers**

The first step used 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 Table II-1. As shown in Table II-2, the values of the cells in the direct requirements matrix are derived by dividing each cell in a column of Table II-1, the inter-industry transactions matrix, by its column total. For example, the cell for manufacturing's purchases from agriculture is 65/200 = .33. Each cell in a consuming industry column in the direct requirements matrix shows how many cents of the *input* from a producing industry are necessary to produce one dollar of the consuming industry's *output*; these are called technical coefficients—hence the term "input-output." Use of the terms "technology" and "technical" derives from the fact that a column of this matrix represents the requirements for a unit of an industry's production. It shows the needs of each industry's production process or "technology."

**Table II-2**
**The Direct Requirements Matrix**

| | Agri. | Man. | Serv. | Other |
|---|---|---|---|---|
| Agriculture | .10 | .33 | .08 | .02 |
| Manufacturing | .40 | .13 | .29 | .33 |
| Services | .15 | .03 | .04 | .02 |
| Other | .15 | .05 | .42 | .22 |

Next, in a procedure called the *Leontief Inverse*, all the mathematical equations implicit in the direct requirements matrix are simultaneously solved to generate a matrix whose cells depict the total requirements, including the direct, indirect, and induced requirements, needed to support the level of final demand shown in Table II-1. In mathematical terms, the Leontief Inverse is represented by:

$$(I-A)^{-1}$$

The resultant matrix is called the total requirements matrix. The total requirements matrix resulting from the direct requirements matrix in the example is shown in Table II-3.

Because it translates 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 of Table II-2 is shown in Table II-3.

**Table II-3**
**The Total Requirements Matrix**

| | Agri. | Man. | Serv. | 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 | 3.3 | 2.6 | 3.3 | 2.5 |

In the direct or technical requirements matrix in Table II-2, the technical coefficient for the manufacturing sector's purchase from the agricultural sector was .33, indicating that 33 cents of agricultural products must be purchased directly to produce a dollar's worth of manufacturing products. The same "cell" in Table II-3 has a .6 value. 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 increase its production by 60 cents: 33 cents of which will be sold to the manufacturing sector and 27 cents of which will be sold to other sectors in the economy. These other sectors, in turn, will use their purchases to produce materials and services that they also will need to sell (to the manufacturing sector). The sum of each column in the total requirements matrix is the *multiplier* for that sector of the economy. The relationship between the total requirements matrix and final demand is depicted mathematically as:

| $(1-A)^{-1}$ | x | Y | = | X |
|---|---|---|---|---|
| Total Requirements Matrix | x | Final Demand | = | Total Output |

**Deriving Multipliers**

*Multiplier* effects are defined as the system of economic transactions that follows a disturbance in an economy. Any disturbance affects an economy in a fashion similar to a drop 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, in turn, must change their purchasing patterns to meet the new demands placed upon them, thereby creating a smaller secondary "ripple." As other suppliers change their purchasing patterns to meet the demands placed upon them by the suppliers to the original firms, a number of subsequent "ripples" in the economy are created.

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

- A *direct effect* (the initial drop causing the ripples) is the change in purchases due to a change in economic activity.
- An *indirect effect* is the change in the purchases of suppliers to the economic activity 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 inter-industry matrix captures this effect.

Another way of viewing an industry multiplier is shown in Table II-4. In this example, the industry sector is the construction of a new industrial park and railroad siding. 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 household expenditures made by workers involved in the activity on-site and by workers in the supplying industries.

**Table II-4**
**Components of the Multiplier for the Construction of an Industrial Park and Railroad Siding**

*Direct Impact*
- Excavation/Construction Labor
- Concrete
- Steel Rail
- Bricks
- Equipment
- Finance and Insurance

*Indirect Impact*
- Production Labor
- Steel Fabrication
- Concrete Mixing
- Factory and Office Expenses
- Equipment Components

*Induced Impact*
- Expenditures by wage earners on-site and in the supplying industries for food, clothing, durable goods, entertainment, etc.

One can also view the construction of an industrial park with a rail siding as a change in investment in the regional economy that will have ripple effects throughout it. In simplified terms, in I-O analysis, this change in investment is considered a change in final demand and can be either positive or negative. Further, if the dollar value of outputs required by final demand markets changes, then the total output or sales will also change as industries adjust to the new demand levels. Mathematically, this is depicted as:

$$(1-A)^{-1} \quad x \quad \Delta Y \quad = \quad \Delta X$$

| | | | | |
|---|---|---|---|---|
| Total Requirements Matrix | x | Change in Final Demand | = | Change in Total Output |

In impact analysis practice, **ΔY** 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,* because it is the *vector* of numbers 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. The impacts resulting from the construction of a project, for example, are one-time impacts. Recurring impacts are impacts that continue permanently as a result of new or expanded ongoing expenditures. The ongoing operations of buildings in an industrial park, for example, generate recurring impacts to the economy. The multipliers that are produced for this study are recurring; they are applied to recurring direct jobs and indicate the multiplier effect of those recurring jobs.

**Regional Input-Output Analysis**

Because of data limitations, *regional* I-O analysis has some additional considerations beyond those for the nation. By regional I-O analysis, it is meant anything below the national level—a state, region within a state, or an individual county. For the purposes of this study, the following discussion refers to county-level analysis. The main considerations are those regarding the depiction of county technology and the adjustment of the technology to account for intercounty trade by industry.

County technology matrices are not readily available. An accurate county-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.[4] Because of the expense, county analyses generally have used national technology as a surrogate for county technology. This substitution does not affect the accuracy of the model as long as county industry technology does not vary widely from the nation's average.[5]

What this means is that it is known at the national level that the dollar demand for an automobile requires a corresponding response by suppliers of goods for this product nationally. In supply, the "technology" of a car requires the labor and materials to produce, among other things, four tires and a windshield. At the county level, it is assumed that demand for the automobile will dictate a similar response and require the same "technology" (four tires and a windshield), except that most of the materials and labor will come from outside the county. National "technology" multiplied by a county purchase coefficient will produce the impacts of the demand for a car in a county on the suppliers of goods and services within the county. Obviously, in this example, the impact on county suppliers will be very small because most of the automobile suppliers are beyond the county's borders. However, the national "technology" is still a good estimate of what conceptually would have to be produced in the county.

Even when county technology varies widely from the nation's average for one or more industries, model accuracy may not be significantly affected. This is because intercounty trade may mitigate the error that would be induced by the technology. In estimating economic impacts by employing a county I-O model, national technology must be converted to a county equivalent by a vector of regional (county) purchase coefficients (RPCs),[6] **r**, in the following manner:

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

or

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

[4]The most recent statewide survey-based model was developed for Kansas in 1986. The development of this model leaned heavily on work done in 1965 for the same state. In addition, the model was aggregated to a 35-sector level, making it inappropriate for numerous applications, since the industries in the model did not represent the very detailed sectors that are generally analyzed.

[5]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 is discussed in the following text, such differences may be unimportant after accounting for interregional (intercounty) trade patterns.

[6]A regional (county) purchase coefficient (RPC) for an industry is the proportion of the region's demand for a good or service that is fulfilled by within-county production—i.e., how much of county demand for a good is answered by supply of a good within the county. Thus, each industry's RPC varies between zero (0) and one (1), with (1) 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.

where the vector-matrix product **rA** is an estimate of the county's direct requirements matrix. Thus, if national technology coefficients—which can vary widely from their county 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 a minor source of error in economic impact measurement.

### IMPLAN Input-Output Multipliers

IMPLAN is a regional I-O modeling software package originally designed by the U.S. Forest Service and currently maintained on a commercial basis by the Minnesota IMPLAN Group (MIG) of Stillwater, Minnesota. MIG provides software and data for the construction of I-O models for any county or combination of counties in the United States. IMPLAN represents a particular application of I-O theory and has a long tradition in the economic literature. IMPLAN today is the dominant tool of the rural and urban economic development community as well as support agencies routinely involved in regional economic development and impact assessments.

IMPLAN uses employment and income data from the Bureau of Economic Analysis's Regional Economic Information System (REIS). REIS is the most inclusive economic data available. It is used to provide control totals to the more-detailed ES-202 wage and salary data from the Bureau of Labor Statistics. It also provides information on self-employment, proprietors income, and data on sectors not included in the ES-202 data (e.g., agriculture, government, and railroads).

## D. THE IMPACTS OF EDA FUNDING ON PERMANENT EMPLOYMENT: PROJECT-RELATED JOBS

*PWPPE* provides survey estimates of permanent employment impacts of the following types:

A) Project, direct
B) Project, indirect
C) Nonproject, direct

As described earlier, *indirect* permanent employment refers to those employment impacts in linked business-supplying sectors, whereas *induced* permanent employment refers to those jobs generated as a result of income creation and its associated consumer spending.[7] Indirect permanent employment impacts are estimated in I-O models by so-called "Type I" multipliers; indirect and induced permanent employment impacts are estimated by "Type II" multipliers.

Employment effects described in category B, above, are roughly the same as the indirect effects estimated by Type I I-O multipliers. From the perspective of I-O organization, a complete accounting of EDA project impacts would include the following categories:

A) Project, direct
B) *Project, indirect*
*B′*) *Project, induced*
C) Nonproject, direct
*C′*) *Nonproject, indirect*
*C″*) *Nonproject, induced*

For the most part, permanent employment impacts in categories A, B, and C are obtained from the PWPPE surveys, whereas employment impacts in categories *B′*, *C′*, and *C″* are estimated in nonsurvey fashion using a regional I-O model.

[7] See, for example, Miller and Blair 1985.

**Multiplier Estimates of Indirect Jobs**

In this analysis, there are two sources of estimates of project indirect impacts included in category B. One estimate comes from PWPPE surveys (a minority of cases); another is provided by the Type I IMPLAN multiplier (the majority of cases). By their nature, indirect effects are more obscure than direct effects; *this is the principal reason that the IMPLAN Models are constructed—i.e., to provide relatively complete estimates of otherwise untraceable indirect effects.*

When both sources of indirect permanent employment estimates exist, usually the IMPLAN estimate is larger than the survey estimate. In these cases the I-O estimate is used. Still, the research team is reluctant to disregard local knowledge of indirect effects, particularly where these exceed the IMPLAN estimate; in these cases, the PWPPE estimate is used. Thus, the general approach is to take the larger of the PWPPE survey or IMPLAN indirect job effect estimates.

IMPLAN regional input-output models were individually constructed for each of the approximately 175 counties identified as hosting an EDA project. Ideally, the specific collection of industries associated with the direct job impacts identified in the PWPPE survey will be known. The analyst can then apply specific industry IMPLAN multipliers to direct job estimates (created or retained) to obtain estimates of indirect and induced jobs. However, the PWPPE surveys provide no breakout of total jobs by SIC grouping. Because of this constraint, regionwide, all-sector average employment multipliers are estimated and applied to the direct PWPPE survey job estimates.

Following standard procedures, regionwide, all-sector employment multipliers are computed as the weighted average of individual sector multipliers, using regional total industry output as weights.[8] Indirect jobs are estimated by applying an indirect-to-direct IMPLAN multiplier.

**Multiplier Estimates of Induced Jobs**

Following from every new job created by an EDA public works project is a stream of new personal consumption spending. Similarly, associated with every permanent job retained is an existing stream of personal consumption spending. The jobs in consumer and related sectors created or retained by this spending are called “induced job effects.” The I-O models for counties hosting EDA public works projects provide the estimates of these induced job effects.

Induced jobs are estimated by applying an induced-to-direct IMPLAN multiplier. In cases where there is a survey estimate of project indirect employment (category B above), the ratio of the induced-to-direct to the indirect-to-direct employment multipliers is used to derive a multiplier (yielding a survey-derived, induced-to-indirect multiplier).

**Total Employment**

The totals of all project-related job effects appear in the tables of Section V of this report as the sum of the direct, indirect, and induced permanent job effects.

## E. THE IMPACTS OF EDA FUNDING ON PERMANENT EMPLOYMENT—NONPROJECT-RELATED JOBS

Nonproject-related employment reflects jobs created when excess capacity exists along a road or water/sewer line that was installed for a particular project. The jobs are not related to the project but are considered other direct jobs.

[8] See, for example, Hamilton and Jensen 1983.

A permanent job classified as nonproject-related will also have multiplier effects. These effects are estimated using the same indirect and induced multipliers of the county-level I-O models that are used for project-related jobs. The effects are added to the nonproject-related direct effects (from the PWPPE survey); the sum provides a measure of the total nonproject-related job effects.

## F. THE IMPACTS OF EDA FUNDING ON PRIVATE-SECTOR INVESTMENT

PWPPE project profiles include a survey estimate of both project-related and nonproject-related *direct private-sector investment*. An example of a project-related investment might be the construction of a new manufacturing plant whose owners are drawn to the area by an EDA-funded water/sewer or road project.

In addition to project-related *direct* private-sector investment, EDA-funded projects create indirect and induced investment as well. New businesses are launched to supply the original businesses and to respond to the needs of worker households. In theory, this investment would include new buildings, machinery, social infrastructure, and even new homes to house newly arriving indirect and induced workers and their families.

New project-related and nonproject-related, indirect/induced, private-sector investment is estimated by establishing a ratio of capital stock to labor in the national economy, i.e., the national capital-labor ratio. It is assumed that one-fourth of any new capital is located outside a region at corporate headquarters, branch plants, and so on. What remains is the “regional capital-labor ratio.” The regional capital-labor ratio is applied to the various categories of indirect/induced job creation to arrive at an accompanying estimate of project-related and nonproject-related, indirect/induced, private-sector investment—that is, private investment beyond the amounts shown as project-related and nonproject-related direct in the PWPPE survey.

The U.S. Department of Commerce “National Income and Product Accounts” (NIPAs) estimate annual depreciation of the national fixed capital stock. Focusing on business capital alone, the estimate is the “consumption of non-residential fixed capital.”[9] In this respect, a 5-year average (1991 to 1995) is used and is expressed in 1997 dollars. The depreciation period for items covered in the NIPAs varies greatly. Reflective of tax law, standard periods range from 3 to 20 years. Without benefit of specific information, an overall average capital life of 7 years is assumed; thus, the value of the national capital stock is calculated as 7 times the annual depreciation estimate.

Average annual employment in the nation for the same years covered by the average annual depreciation (1991 to 1995) is also computed. Employment estimates are obtained from U.S. Department of Commerce.[10] The value of the national capital stock divided by national employment provides the national capital-labor ratio, which is used to calculate indirect and induced private-sector investment.

## G. RESULTS: SUMMARY OF DIRECT AND TOTAL PERMANENT EMPLOYMENT AND PRIVATE-SECTOR INVESTMENT IMPACTS

An important purpose of the EDA Public Works Program is to bring relief to economically distressed regions by assisting them in the creation of new jobs and the retention of existing jobs. These

[9] U.S. Department of Commerce 1997.
[10] U.S. Department of Commerce 1996.

**Table II-5**
**Permanent Employment and Private-Sector Investment Multipliers**
**EDA Public Works Projects**
**(Median Project Employment and Private-Sector Investment)**

| Project Type | Project and Nonproject-Related Direct Employment | Project and Nonproject-Related Total Employment | Ratio: Total Employment to All Direct Employment | Ratio: Total Employment to Project-Related Direct Employment | Project and Nonproject-Related Private-Sector Investment | Project and Nonproject-Related Total Private-Sector Investment | Ratio: Total Private-Sector Investment to All Direct Private-Sector Investment | Ratio: Total Private-Sector Investment to Project-Related Direct Private-Sector Investment |
|---|---|---|---|---|---|---|---|---|
| Buildings | 84 | 133 | 1.53 | 1.53 | 568,000 | 1,715,952 | 2.61 | 2.89 |
| Industrial Parks | 310 | 464 | 1.56 | 1.63 | 6,300,000 | 13,622,184 | 1.54 | 1.66 |
| Roads | 430 | 641 | 1.51 | 1.57 | 11,448,000 | 20,716,364 | 1.37 | 1.44 |
| Tourism/Marine | 125 | 199 | 1.56 | 1.59 | 1,320,000 | 3,043,315 | 1.21 | 1.93 |
| Water/Sewer | 300 | 467 | 1.47 | 1.56 | 6,362,342 | 9,489,237 | 1.37 | 1.50 |
| **All Projects** | 250 | 416 | 1.50 | 1.57 | 4,800,000 | 7,769,567 | 1.44 | 1.58 |

direct jobs, through business and household expenditures, create additional indirect and induced jobs. The sum of these jobs is the total employment created by the grant.

Considering all EDA regions, the median public works project generated 250 direct permanent jobs and 416 total permanent jobs. This amounts to a total employment multiplier of approximately 1.50 (Table II-5). Industrial parks, water/sewer, and road projects appear to have been the most successful in producing total employment, generating an average of 460 to 640 direct permanent jobs, with multipliers for total permanent jobs ranging from 1.47 to 1.56.

Another objective of the EDA Public Works Program is the ability to stimulate private-sector investment. Direct private-sector investment occurs through industries directly linked to the EDA grant—a new building in an industrial park, for example. Indirect private-sector investment also occurs through businesses that supply the directly linked businesses.

The 200-plus EDA projects considered in this study stimulate a median $4.8 million in direct private-sector investment and another $3.0 million in indirect and induced investment, for a sum of $7.8 million in total private-sector investment. In terms of EDA project types, roads, industrial parks, and water/sewer projects create the most direct private-sector investment: medians of $11.5 million, $6.3 million, and $6.4 million, respectively. Total median private-sector investment amounts to $20.7 million, $13.6 million, and $9.5 million, respectively, for roads, industrial parks, and water/sewer projects. As with employment, the EDA project types generate roughly similar amounts of total-to-direct private-sector investment, with the multiplier varying between about 1.4 and 1.5.

Tables V-1 through V-6 present details for each of the 200-plus EDA projects. These tables are found at the beginning of each of the regional groupings of Section V. Each table has exactly the same information that is summarized in Table II-5. Tables V-1 through V-6 contain the project- and nonproject-related direct effects and total effects for both employment and private-sector investment.

A final piece of information summarized below and found in the individual project profiles is the job-years of county permanent employment for each project. In the predominantly rural counties that typically host public works projects, these projects represent considerable amounts of permanent employment (Table II-6). The median project contributes an increment of permanent employment that is equivalent to more than 75 percent of the level of annual county employment growth. This figure varies considerably by project type. For road projects it is the equivalent of 2.6 times annual county employment growth; for individual buildings, the project's permanent employment addition is equivalent to almost 25 percent of annual county employment growth. EDA projects are not trivial capital investments in these primarily rural counties.

**Table II-6**
**EDA Permanent Employment Impacts—Calculated Years of Annual Job Creation in the Host Counties**

| Project Type | Annual Years of Job Production for the Median Project |
|---|---|
| Buildings | .23 |
| Industrial Parks | .77 |
| Roads | 2.59 |
| Tourism/Marine | .33 |
| Water/Sewer | 1.10 |
| **All Projects** | .77 |

## H. CONCLUSIONS

*A rigorous I-O model is used to generate total permanent employment and private-sector investment from direct permanent employment and private-sector investment. The multiplier effects of EDA public works projects are found to be approximately 1.5. Thus, if the median project generates 300 permanent employees and $6 million in private-sector investment, approximately 450 permanent employees and $9 million in total private-sector investment are likely to be generated in the local (county) economy. EDA public works projects have a calculable multiplier that is relatively consistent across project types and regions and is similarly consistent for employment and private-sector investment. EDA projects have a definite ripple effect in a county—their jobs create more jobs.*

*Do EDA investments increase national, county, or community incomes? The analysis contained here shows specific counties where public works projects created significant jobs and new incomes, in some cases amounting to the equivalent of several years of typical annual growth.*

*The issue of new job and income growth at the national level is more complex. The use of the I-O model in the context of EDA public works projects does not address the issue of national economic growth; rather, it aims specifically at the more predictable, and potentially more significant, employment and income effects at a smaller geographic area, i.e., a single county.*

# SECTION III
—
# RESEARCH RESULTS: REGRESSION ANALYSIS

# SECTION III—THE EFFECT OF EDA PUBLIC WORKS FUNDING ON OVERALL JOB PRODUCTION IN THE COUNTY IN WHICH THE INVESTMENT TAKES PLACE: A REGRESSION ANALYSIS

## A. INTRODUCTION

Public infrastructure, defined here as publicly constructed roads, buildings, and other long-lived capital facilities, is an important component of the nation's stock of wealth and can be an important contributor to both the quality of life and economic productivity. EDA funds public works projects in economically distressed communities around the nation. This section reviews the most recent literature on the economic effects of such public capital investments and uses modern statistical tools to explore the effects of the EDA program on economic outcomes in the counties where the capital investment takes place.

Consensus on the benefits of public infrastructure investments is just beginning to emerge from the now-extensive academic literature, although there has been wide agreement that early estimates of the productivity benefits of such spending were too large. *The findings of this study are that these investments moderately increase hiring in the recipient counties, suggesting that EDA infrastructure investments are an effective economic development tool.*

## B. INFRASTRUCTURE RESEARCH AND THE EDA PUBLIC WORKS PROGRAM

### The EDA Public Works Program

The shortcomings of aggregative approaches to estimating infrastructure's value to firms make them unsuitable as analytic tools for answering many of the nation's important infrastructure questions. These approaches, by failing to control for the price effects that may occur when infrastructure stocks change, confound the *level* of economic activity that is generated by a given investment with changes in the geographic *distribution* of activities (Haughwout 1998). The EDA Public Works Program aims to provide permanent private-sector jobs and to raise incomes in distressed communities. For this goal to be realized, the investments that EDA makes must enhance the attractiveness of the target sites as places to do business. In order to discern the effect of these investments, the possibility that price changes may contaminate analyses of aggregate use of factors of production, like labor, must be taken seriously.

Moreover, infrastructure studies have typically done a relatively poor job of controlling for the cost of the investments they are measuring. Because public expenditures require public revenues, the omission of taxes and debt from econometric investigations of the effect of state and local infrastructure on growth tends to understate the effect of these investments. But EDA public works investments, because they are financed from the national tax base, do not raise these issues; therefore it is relevant to measure the EDA Public Works Program from the perspective of a place-based development strategy. Do EDA public works investments increase permanent private-sector employment, wages—or both?

The principal previous study of the impact of EDA funding on local labor markets was conducted in the mid 1970s (Graham and Martin 1977). In this study, the authors used statistical methods to examine the relationships between EDA investments and county personal income, per capita income, employment, and unemployment. The authors used simple regression equations to demonstrate that EDA investments had significantly positive impacts on their income measures. They were not able to conduct similar analyses for county employment. The study was limited by several factors. First, the authors' measures of income included both wage and nonwage income. But there was little reason to expect that EDA investments would influence such income as stock dividends or government transfer payments, which were included in personal income. In addition, the regressions contained few controls for other non-EDA-related influences on local economic outcomes. The authors suggested that annual employment data like those available from the Census Bureau's *County Business Patterns* series would allow the detection of employment impacts. Finally, the study failed to consider the possibility that wage and employment effects may move together, which would lead to ambiguity in their results.

**Recent Studies of the Economic Effects of Infrastructure Investments**

Multiple regression estimation of aggregate production and cost functions has become the dominant method for evaluating the economic returns to public infrastructure investments. Aggregate production functions (APFs) attempt to determine whether public investments have any effect on total private-sector output produced (Gross Domestic or Gross Regional Product). Aggregate cost functions (ACFs) attempt to determine whether more public capital reduces the costs of producing a given amount of private output. The percentage increase in total output that is caused by a 1 percent increase in public capital stock is called the output elasticity of public capital.

There have been many applications of these methods, particularly since Aschauer (1989) estimated that, for the nation as a whole, the output elasticity of public capital was an astonishingly large and statistically significant 0.39. This means that a 1 percent increase in infrastructure stock would increase output by 0.39 percent. If this estimate is correct, infrastructure pays for itself very quickly by generating new private wealth. Aschauer's study opened a veritable growth industry in infrastructure research, much of which utilized aggregate production, or analogous cost function, approaches.

Aschauer's study was based on national time series data. But because economic time series like GDP and infrastructure tend to grow together over time, it is difficult to tell whether one causes the other in any consistent way (Aaron 1990; Hulten and Schwab 1991). This problem led researchers to begin exploration of the substantial *interregional* variations in public capital provision within the United States. The interregional approach seems to offer both statistical and practical advantages. For statistical purposes, the fact that interregional studies can exploit variation across regions as well as over time means that the estimated relationship between public investments and economic growth will be more reliable. In practical terms, analyses focused on the state and local sectors capture most of the public investment that is made for the purpose of enhancing economic development.

Munnell (1990) and Eberts (1986) estimated APFs using data sets that included information on states (Munnell) and metropolitan areas (Eberts) over time. (Because they have multiple observations on each unit of analysis, such data sets are often called "panel" data sets.) Each found significantly positive output responses, although the implied output elasticities were far lower than Aschauer's original estimates. Nonetheless, Munnell's estimated state-level output elasticity of 0.15 was large enough to provoke continued interest in the possibility that infrastructure contributed substantially to private-sector productivity, and that a renewed focus on such investment might increase national output.

More recent refinements to the aggregate production approach have focused more thoroughly on the model's statistical properties. In Holtz-Eakin (1994) and Garcia-Mila, McGuire, and Porter (1996), correction of the estimates for unobserved state-level characteristics reduced the estimated elasticity of public-sector capital to zero, suggesting that Munnell's findings resulted from correlations between infrastructure and unmeasured state characteristics. The outcome of the APF research, then, was that infrastructure's contribution to private-sector productivity is indistinguishable from zero.

In a parallel set of papers, several authors have applied ACFs to data sets similar to those used for analysis of aggregate production functions. In the ACF approach, the marginal productivity of public capital is measured by calculating its role in reducing private production costs. This measurement is accomplished by estimating the reductions in aggregate private input use that additional infrastructure allows. ACF estimates have generally been more supportive than recent APF results of the argument that there is a positive role for public capital in production. Berndt and Hannsson (1991) reported that public capital was a significant cost-reducing factor in a study of the Swedish economy, while Nadiri and Mamuneas (1994) found cost reductions for twelve U.S. manufacturing industries. Finally, in a paper particularly relevant to the current discussion, Morrison and Schwartz (1996) reported that application of the aggregate cost approach to a panel of American states revealed a significant role for infrastructure in reducing private production costs, even when unmeasured state factors were controlled for. This result appears to conflict directly with the findings of Holtz-Eakin and Garcia-Mila, McGuire, and Porter, who reported that, after controlling for unmeasured state effects, the marginal productivity of public capital was indistinguishable from zero.

The two major approaches to the estimation of infrastructure productivity proceed from contrasting views of what firms take as given in making their production decisions (Friedlander 1990; Berndt 1991). Advocates of aggregate production functions argue that productive inputs (employment, private capital stock, and the like) are given, and firms make output decisions based on the availability of these factors. Under this hypothesis, the question of infrastructure productivity becomes whether additions to public capital stocks increase the output that can be obtained from given input stocks. ACF authors, however, prefer the assumption that input *prices*, not quantities, are taken as given by producers. This hypothesis would appear to be an accurate depiction of competitive firms; such actors would be expected to treat prices as given. Morrison and Schwartz concur with Berndt, who suggested that ACF estimates are thus free of the crucial problem that plagues the APF method: that the variables taken as given determinants of productive performance (private capital and labor stocks) are in fact reflections of that performance. If this is true, then APF estimates will be unreliable. This argument has a long history in the applied production theory literature. In this literature, authors have emphasized that whereas input use is a decision of producers, input prices will, in a competitive economy, be taken as given by any particular firm.

The microeconomics argument in favor of cost functions, however, is less persuasive when regions (e.g. counties), not firms, are the units of analysis. At the regional level, neither prices nor quantities of inputs are given. With costless mobility, the value of unpriced, nontraded amenities like a favorable climate (or infrastructure stock) will be at least partially reflected in local factor prices (Rosen 1979; Roback 1982; Blomquist, Berger, and Hoehn 1988; Haughwout 1998). It is thus crucial when examining the effects of changes in the environment of a particular region to be attentive to the possibility that factor prices may change as the productive environment changes.

Regions like U.S. states or counties have complex factor (land, capital, and labor) markets. At this level of analysis, land is a fixed factor with a price that varies across regions; private capital supply is perfectly elastic at a fixed national price; and labor supply is variably elastic. Thus, both wages and labor supply are determined on a region-by-region basis (Rosen 1979; Roback 1982; Blomquist, Berger, and Hoehn 1988). These hypotheses about what regions take as given are crucial, since they determine whether factor prices, quantities—or neither—can be treated as explanatory variables in regional analysis. Both the APF and ACF approaches implicitly test the hypothesis that some regions (those with relatively large infrastructure stocks) offer higher equilibrium productivity than others. Confirmation of this hypothesis would surprise regional economists, who would expect long-run productivity differentials to induce relocations to infrastructure-rich regions.

Roback (1982), Blomquist, Berger, and Hoehn (1988), and Haughwout (1997, 1998) address this problem by assuming that profit rates and utility levels are taken as given by regions. Under their models, local prices of factors of production that are either perfectly or partially fixed in place (land and labor) adjust to reflect the value of unpriced, nontraded regional attributes like clean air, a pleasant climate and, as is argued here, infrastructure. In this context, the value of infrastructure services may be partially captured in equilibrium regional land and labor prices, which adjust to shut off interregional migration of firms and households, establishing an interregional equilibrium in which no actor has an incentive to change his/her location. It is crucial for the researcher to recognize that the dependent variables chosen for the analysis are likely to have important effects on the outcome, perhaps even predetermining the results.

In summary, because of methodological drawbacks in current research, it is clear that the nation's infrastructure questions have not been answered, recent findings on the aggregate productivity of public infrastructure notwithstanding. There is thus a call for an analysis of the EDA program, as an example of public investment oriented to promoting economic development.

## C. RESEARCH DESIGN

Multiple regression analysis is used here to examine the effect of EDA public works funding on county labor markets. This method requires the construction of an equation that relates the variables of interest—in this case, county employment, wages, and EDA funding levels. Here, the equation tests the hypothesis that EDA funding is positively related to county economic health.

**Model**

For this study, a simple model of wage and employment growth in U.S. counties is postulated. Production by a typical firm located in county *c* is given by

(1) $X_c=x(K_c,N_c,L_c,G_c,Z_c)$

where *X* is total output produced by the firm. *K*, *N*, and *L* are, respectively, private capital, labor, and land employed by firms. *G* is a vector of publicly provided inputs that potentially contribute to output. *Z* is a vector of other county and regional traits that may contribute to output, and *c* indexes counties.

As has been noted elsewhere (see above and Haughwout 1997, 1998), it is extremely hazardous to attempt direct interpretation of the effect of public-sector variables *(G)* from econometric estimates of aggregated versions of equation (1). A more reliable method is to examine the effect of EDA programs on local land and labor markets. Doing so requires estimation of labor- and land- demand equations.

From (1), it is possible to derive an aggregate land-demand relation

(2) $L_c{*}=l(r,w_c,R_c,G_c,Z_c){*}X^*_c$

and

(3) $N_c{*}=n(r,w_c,R_c,G_c,Z_c){*}X^*_c$

which represents labor demand. Here, *r* is the (nationally determined) price of private capital; *w* and *R* represent the local wage and land price, and *X* is aggregate output. The last three variables differ across counties.

According to the logic developed in the previous section, if firms are constrained to zero profits in the long run, then the long-run equilibrium prices of land and labor will reflect the value to firms (and households) of the characteristics of a given place. Imposing the constraints of zero economic profit rates ($p_0$) and fixed utility levels ($V_0$), and substituting those conditions into (3) yields the following relationships (see Haughwout 1997 for details of this derivation):

(4) $w_c=w(r,R_c(G_c), G_c,Z_c,V_0)$

(5) $N{*}_c=n\{r,w_c(G_c),R_c(G_c),G_c,Z_c\}{*}X^*_c$

Equation (4) says that county wages are determined by the national price of capital, county land prices, county infrastructure's direct effects, other county- and state-level effects, and the level of national well-being. Note that infrastructure may affect county land prices, meaning that it may ultimately affect wages both directly and indirectly, through the local land market.

Equation (5) describes the determination of total county employment. It is directly affected by the price of capital, infrastructure, land prices, and county- and state-specific effects. Note that county wage rates and land prices may also influence county employment, and infrastructure may therefore have indirect effects on employment as well.

There are, thus, three potential avenues through which EDA funding may influence local labor market outcomes. These are, in descending order of likely importance:

1. EDA funding may directly induce hiring by raising the marginal productivity of labor, holding wages constant.
2. EDA funding may influence wages, which will lead to changes in hiring.

3. EDA funding may influence land prices, which might lead indirectly to changes in hiring.

Since the data do not allow careful examination of the effect of public investments on land values, the effect of EDA investments on local labor markets is measured by examining whether they are significantly correlated with local employment and employee compensation, controlling for county land values. Analyses of whether these effects persist when simultaneity in local wage and employment determination are controlled for, are also included.[11] It is important to recognize that the employment equation will provide estimates of the *total* impact of the EDA investment, including not only the effect of the construction of the facility, but also the long-run impact of the existence of the facility.

## D. DATA AND ECONOMETRIC SPECIFICATION

### Data

The data used for the analysis come from a variety of public sources, along with internal EDA information described in *PWPPE.* Employment data by county are taken from the Census Bureau's annual *County Business Patterns* (CBP) data set, a source widely used in the analysis of county-level labor market conditions. CBP reports, for each Standard Industrial Classification industry, total (full- and part-time) employment, annual payroll, the number of establishments, and the size distribution of establishments. This includes data for FICA-covered employees and excludes agriculture, government, and self-employed workers. These data provide information regarding aggregate employment by county, the average compensation received by employees, and information about whether the county economy is dominated by a few large firms, is characterized by many small firms, or has a mixture of firm sizes.

In addition to the above data, information from the 1990 *Census of Population and Housing* is utilized to control for various other characteristics of county economies. In particular, the Census provides information on both the racial makeup of the population and the median house value in the county in 1990. These are important control variables, as previous research (see Haughwout 1998) and the results reported below reveal. In each year, there are approximately 3,200 observations, one for each county in the nation. The entire data set covers the years 1988 through 1994, yielding a total of more than 22,000 observations. The analysis is focused on the 15,591 observations with complete information for the years 1990-1994 (Table III-1).

### County Choice and Measuring Employment

Two distinct but related questions are relevant to the study of EDA Public Works Program investments. The first concerns the effect of grant size in a county containing an EDA project ("EDA counties"). One could examine data on EDA counties and determine whether the size of EDA's commitment in these counties is related to growth in their permanent employment or wages. The answer to this question is important, as it would suggest whether additional EDA investment in EDA counties would improve their labor market conditions. It would, however, be difficult to draw inferences from these results that would be applicable to other counties that did not

[11] While it would also be useful to look at the effect on private investment, reliable private investment data at detailed geographic levels are unavailable.

**Table III-1**
**Descriptive Statistics for Key Variables**

| Variable Name | Description | Mean | Std Dev |
|---|---|---|---|
| EDA | EDA average grant value per county* | 46,501 | 225,910 |
| GREM9094 | Percentage growth in employment, 1990-94 | 0.083 | 1.142 |
| GRWA9094 | Percentage growth in payroll per worker, 1990-94 | 0.151 | 0.099 |
| GREM8890 | Percentage growth in employment, 1988-90 | 0.023 | 2.616 |
| GRWA8890 | Percentage growth in payroll per worker, 1988-90 | 0.032 | 0.296 |
| LPAY | Natural logarithm of payroll per worker | 9.767 | 0.239 |
| LTEMPMM | Natural logarithm of employment | 8.633 | 1.989 |
| LHV90 | Natural logarithm of 1990 house value | 10.789 | 0.444 |

*Total grant amount for projects receiving final funding in 1990 divided by 3,200 counties (in 1997 dollars).

receive EDA-funded projects ("non-EDA counties").

Clearly, it is also worth knowing whether expansion of EDA funding into other counties would expand opportunities there. A finding that additional EDA dollars in an EDA county has no effect on permanent employment in that county does *not* imply that EDA funding in all counties has no effect on labor market conditions. Instead, it may simply show that EDA has fully explored opportunities for job creation in the counties in which it invests. Thus, a related question is whether the counties receiving some investment had permanent employment that grew faster than those that did not. In order to answer this second question, the analysis must compare labor market outcomes in EDA counties with those in non-EDA counties.

The current research can address each question by including data on both types of counties. The effect of a dollar of EDA spending on county labor markets may be interpreted for both EDA and non-EDA counties, allowing inferences to be drawn about both the presence and the size of EDA's financial commitment.

What labor market effects are included? The analysis is intended to capture the permanent effects of EDA investments on county labor markets. The EDA financing leads to the creation of long-lived capital assets. These assets provide productivity benefits to the county long after the actual construction of the facility is completed. As firms use the new infrastructure, they may increase employment or wage rates as a reflection of higher labor productivity in recipient counties. These new private earnings will circulate through a county's economy, potentially generating increases in earnings in other sectors that are not directly related to the initial investment.

Another source of impacts is less certain. It is possible that EDA commitment to a county sends a signal that federal, state, and local officials are committed to development in that county, and this may induce some firms to locate, remain, or expand in the county. The analysis reported here is designed to capture all of the projects' direct, indirect, induced, and intangible effects. As such, they may be viewed as the most comprehensive measure of the labor market effects of EDA funding available.

**Table III-2**
**Correlation Coefficients for Key Variables**

| | EDA | GREM9094 | GRWA9094 | GREM8890 | GRWA8890 | LPAY | LTEMPMM | LHV90 |
|---|---|---|---|---|---|---|---|---|
| EDA | 1.000<br>**100** | -0.001<br>3 | -0.019<br>70 | 0.086<br>**99** | 0.060<br>**99** | 0.079<br>**99** | 0.141<br>**99** | 0.067<br>**99** |
| GREM9094 | -0.001<br>3 | 1.000<br>**100** | 0.149<br>**99** | -0.144<br>**99** | 0.044<br>**98** | 0.045<br>**99** | 0.331<br>**99** | -0.013<br>52 |
| GRWA9094 | -0.019<br>70 | 0.149<br>**99** | 1.000<br>**100** | -0.041<br>**98** | -0.235<br>**99** | 0.088<br>**99** | -0.057<br>**99** | -0.027<br>**96** |
| GREM8890 | 0.086<br>**99** | -0.144<br>**99** | -0.041<br>**98** | 1.000<br>**100** | 0.561<br>**99** | 0.270<br>**99** | 0.562<br>**99** | 0.243<br>**99** |
| GRWA8890 | 0.060<br>**99** | 0.044<br>**98** | -0.235<br>**99** | 0.561<br>**99** | 1.000<br>**100** | 0.561<br>**99** | 0.338<br>**99** | 0.220<br>**99** |
| LPAY | 0.079<br>**99** | 0.045<br>**99** | 0.088<br>**99** | 0.270<br>**99** | 0.561<br>**99** | 1.000<br>**100** | 0.617<br>**99** | 0.546<br>**99** |
| LTEMPMM | 0.141<br>**99** | 0.331<br>**99** | -0.057<br>**99** | 0.562<br>**99** | 0.338<br>**99** | 0.617<br>**99** | 1.000<br>**100** | 0.578<br>**99** |
| LHV90 | 0.067<br>**99** | -0.013<br>52 | -0.027<br>86 | 0.243<br>**99** | 0.220<br>**99** | 0.546<br>**99** | 0.578<br>**99** | 1.000<br>**100** |

Pearson correlation coefficient: percent probability that this relationship is genuine and not random.

## Correlations of Public Works Investments with Subsequent Economic Growth

To determine the effect of EDA funding on the attractiveness of locations and the demand for labor, several statistical tests are specified and estimated. The first step is to calculate the correlation between EDA investment and the subsequent growth in employment for the period 1990-1994. Simple Pearson correlation coefficients, presented in Table III-2, suggest that EDA public works grants and subsequent county economic growth are *negatively* correlated, although in neither case do the data allow rejection of the hypothesis that the variables are uncorrelated. In other words, counties that received EDA public works grants grew no faster than those that did not, ostensibly suggesting that the program had no discernible employment effect at the county level. However, it should be remembered that since EDA funding occurs in areas with relatively high levels of current (and expected future) economic distress, it may be that other traits of the target counties led to slower-than-average growth in jobs and wages after the EDA funding occurred.[12] Viewed in this light, a positive association between public works investments and subsequent county wage and employment growth might be taken as evidence that EDA invests in counties that are already poised for growth, in effect subsidizing growth that was already planned or underway. The finding that EDA grants and subsequent growth are uncorrelated undermines this argument somewhat.

In order to isolate the independent effects of EDA grants on county labor market conditions, controls for other effects that may determine the direction taken by the local labor market must be included in the regression equations. EDA grants are not

[12]See Rutgers University et al. 1997 for details on the distress in EDA target counties and regions.

large enough to convert distressed counties into booming ones. Instead, the relevant question is whether EDA public works projects have any effect on employment and wages in distressed counties, *given* the variety of other factors affecting local labor market conditions. For answering this question, multiple regression analysis is the ideal tool.

**Multiple Regression Estimates of the Effects of the EDA Public Works Program on County Labor Market Outcomes**

Multiple regression analysis is widely used in policy settings. The method has both analytic and predictive uses. For example, in understanding and forecasting the behavior of the economy, public-sector agencies like the Congressional Budget Office use regression equations to estimate the effects of such variables as different types of government spending on economic growth. They then can use the regression results to predict the macroeconomic effects of changes in spending by program or location.

*Multiple regression* analysis is a method of analyzing the effects of a set of independent variables on a dependent variable of interest. Regression analyses allow the estimation of regression coefficients, which express the effect of a change in an independent variable on the dependent variable, holding all other effects constant. The most common method of estimating regression coefficients is ordinary least squares (OLS), which is a mathematical procedure that finds the set of coefficients that fits the data best. OLS estimates produce fitted values for the dependent variable that are, on average, equal to the actual values. In addition, the sum of squared errors generated is as small as possible.

*R-squared* is the multiple correlation coefficient, and summarizes the combined ability of the independent variables to explain variation in the dependent variable. *Regression coefficients* indicate the effect of a one-unit change in each independent variable on the dependent variable, all other factors being equal. *Diagnostic statistics* gauge the robustness of the estimated relationships, i.e., the probability that they did not happen by chance. For individual regression coefficients, the appropriate diagnostic statistic is the t-statistic (the ratio of the estimated coefficient to its estimated standard error). Usually a level of $|t| > 1.96$ is used to determine statistical significance in an exploratory analysis of this type. F-statistics indicate the joint importance of groups of regression statistics.

The conditional relationship between EDA public works and county labor markets is first explored by examining their effects on both employment and employee compensation in U.S. counties. Separate equations are specified for each. For employment, equations of the form

$$\log(EMP_{jt}) = \boldsymbol{YEAR_t}\beta'_0 + \boldsymbol{STATE_j}\beta'_1 + \beta'_2 EDA_j + \boldsymbol{ECON_{jt}}\beta'_3 + \boldsymbol{DEMOG_{jt}}\beta'4 + \in_{jt}$$

are estimated, where $EMP_{jt}$ represents total employment in county *j* during year *t*, $\boldsymbol{YEAR_t}$ is a vector of year fixed effects dummies (for years 1990-1994); $\boldsymbol{STATE_j}$ is a vector of state fixed effects; $EDA_j$ is the total value of FY 1990 EDA's public works grants in the county (measured in constant 1990 dollars); $\boldsymbol{ECON_{jt}}$ and $\boldsymbol{DEMOG_{jt}}$ are, respectively, vectors of economic and demographic effects expected to influence local employment; and $\in_{jt}$ is a residual term.

It is important to note that the relationship expressed in this regression equation incorporates the permanent employment effects of EDA funding.

These are the jobs that result from the creation of a new capital asset, namely the EDA-financed facility. This set of impacts has been the focus of the economic development literature, since these are the jobs that reflect the long-lasting contribution of EDA investments to county productive capacity. The econometric estimates described below are quantitatively and qualitatively similar when only 1994 data are used, suggesting that the reported employment effects are long lasting.

Payroll equations take a similar form:

$$\log(PAY_{jt})=\mathbf{YEAR_t}\Delta'_0 + \mathbf{STATE_j}\Delta'_1 + \Delta'_2 EDA_j + \mathbf{ECON_{jt}}\Delta'_3 + \mathbf{DEMOG_{jt}}\Delta'_4 + \mu_{jt}$$

where $PAY_{jt}$ is compensation per employee (in constant 1990 dollars), and $\mu_{jt}$ is the residual. The other variables are defined above. The lists of economic and demographic factors included in wage and employment regressions differ slightly. In addition, it is quite likely that employment and compensation are simultaneously determined, an issue discussed and further controlled for below.

The state and year fixed effects are crucial to the model and reflect the impact of a wide variety of factors on county employment patterns. Wheat (1986) reported that a variety of state-level locational and economic factors influenced manufacturing employment growth over the period 1963-1977. In addition, recent infrastructure research (see, for example, Holtz-Eakin 1994; Garcia-Mila, McGuire, and Porter 1996) has suggested that the inclusion of controls for such unmeasured factors has dramatic impact on the estimated value of infrastructure investments. These controls allow increased confidence that the regression coefficients are not simply picking up the effect of state-level characteristics that happen to be correlated with the variables of interest, especially EDA public works investments.[13]

The effect of EDA's public works grants on local labor market conditions is revealed by the coefficients $\beta_2$ and $\Delta_2$ in these regressions. A statistically significant positive association between EDA activity and the level of employment or employee compensation would suggest that the program is contributing to local employment or supporting wages in distressed areas.

## E. RESULTS FOR EMPLOYMENT AND COMPENSATION

### *Employment*

Tables III-3 and III-4 report, respectively, the results of a series of specifications of the employment and compensation regression equations. In each specification, the logarithm of the relevant factor serves as the dependent variable; this helps to control for extremes in the size and level of economic development of counties. It should be realized, however, that when using logarithms, the regression equation produces results that are right on target for the average county, but get less accurate as counties diverge from the mean. Coefficient estimates are interpretable as percentage effects; for example, the coefficient on LEDA is interpreted as the percentage change in county employment that is associated with a 1 percent change in EDA public works funding.[14]

[13]Ideally, county controls would be included, but as these would number in the thousands, they are not feasible alternatives to the state dummy variables used here.

[14]Qualitatively similar results are obtained when EDA investment is measured in 1990 dollars, rather than as a natural logarithm.

Specification One, in the first column of Table III-3, reports the results for county employment for the period 1990-1994. As noted in the table, the regression is estimated using Ordinary Least Squares (OLS). Each specification reported here includes a series of state and time fixed effects to control for a variety of unmeasured factors that contribute to variations in county employment growth. In particular, Specification One models the log level of county employment as a function of the size distribution of firms, the metropolitan area status of the county (whether it is part of a metropolitan area), the proportion of county residents who are African-American, a proxy for the price of land in the county (LHV90), and the amount of EDA public works spending in the county. Thus, this is a version of equation (5) that can be estimated with OLS.

The $R^2$ for this regression is about 0.80, meaning that approximately 80 percent of the variation in log county employment is explained by the variables included in the model. This is a relatively high degree of association for a data set that combines time-series and cross-sectional data. Each of the variables reported is significantly related to county employment with very high levels of confidence. Of particular note is the effect of EDA public works spending, reported in the table's final line.

*In this specification, a 1 percent increase in EDA spending is estimated to increase county permanent employment by .0101 percent. This is an addition of approximately twelve jobs in the average county.*

This model includes no controls for the recent pattern of county wage and employment growth. There are at least two reasons to believe that recent labor market behavior may influence levels of employment and the estimated effect of EDA public works grants on that level. First, it may take time for labor markets to adjust to new equilibria. Thus, today's employment may be influenced not only by today's conditions, but also by recent labor market activity. For example, a county that has witnessed large recent wage increases may not see reductions in hiring immediately; these effects may take place with a lag. Second, if EDA grants are targeted to counties that had high employment growth prior to the 1990-94 period, the finding of a positive effect of EDA grants on local employment may be attributed to the fact that EDA simply encouraged growth that was already underway, not that EDA serves as a spark to growth in distressed communities. Finally, the inclusion of measures of recent labor market activity may strengthen the overall fit of the model, providing more confidence in its estimates.

Specification Two, reported in the second column of Table III-3, is identical to Specification One, with the exception of the inclusion of two additional independent variables: the percentage growth in county employment and in wages over the period 1988-1990. Both variables are individually statistically significant with high levels of confidence, and have the expected signs. The F-statistic for the joint hypothesis that the coefficients on these variables are both due to random chance is 2,360; this allows rejection of that hypothesis with very high confidence. The equation $R^2$ rises to nearly 0.85. In spite of its beneficial effect on the fit of the regression, the addition of these two variables to the model does not have much effect on most of the other coefficient estimates. While most move closer to zero, as expected, none switch signs and all remain statistically significant. Again, the effect of EDA public works spending is significantly positive, although the coefficient falls by

**Table III-3**
**EDA Funding and County Employment**

| | | *Specification One* | *Specification Two* | *Specification Three* |
|---|---|---|---|---|
| | | | *Dependent Variables:* | |
| Independent Variables | Estimation Method -> | LTEMPMM OLS | LTEMPMM OLS | LTEMPMM 2SLS |
| | | (1990-1994) | (1990-1994) | (1990-1994) |
| SMSHARE | (%) | -0.162 *** | -0.126 *** | -0.112 *** |
| s.e. | | 0.002 | 0.001 | 0.008 |
| BIGSHARE | (%) | 1.578 *** | 1.349 *** | 0.941 *** |
| s.e. | | 0.072 | 0.064 | 0.235 |
| URBAN | (1 = MSA county) | 0.637 *** | 0.498 *** | 0.454 *** |
| s.e. | | 0.018 | 0.016 | 0.028 |
| BLACK | (%) | 0.002 *** | 0.001 *** | ------- |
| s.e. | | 0.001 | 0.001 | |
| LHV90 | (natural log of $1990) | 1.436 *** | 1.159 *** | 0.962 *** |
| s.e. | | 0.024 | 0.022 | 0.107 |
| GREM8890 | (%) | ------- | 0.238 *** | 0.266 *** |
| s.e. | | | 0.004 | 0.015 |
| GRWA8890 | (%) | ------- | -0.276 *** | -0.835 *** |
| s.e. | | | 0.022 | 0.305 |
| LPAY | (log of $1990) | ------- | ------- | 1.422 |
| s.e. | | | | 0.775 |
| LEDA | (natural log of $1997) | 0.0101 *** | 0.0074 *** | 0.0074 *** |
| s.e. | | 0.0008 | 0.0007 | 0.0007 |
| Observations: | | 15,591 | 15,591 | 15,591 |
| R-square: | | 0.7989 | 0.8458 | 0.8550 |
| Adjusted R-square: | | 0.7981 | 0.8451 | 0.8545 |
| F-statistic for inclusion of omitted variables: | | ------- | 2,360 | ------- |
| (95% critical value) | | | 2.995 | |
| (p-value) | | | ~0 | |

*** Statistically significant at the 99% confidence level.
All regressions include year and state fixed effects, results for which are available upon request.
See Table III-1 for variable definitions.

more than a quarter, to 0.0074. The second row of Table III-3 reports the Specification Two estimated impact of EDA grants in terms of jobs at prevailing compensation levels. *The crucial findings, that EDA grants are associated with higher employment than would otherwise be present and that the effects are relatively substantial, remain intact.*

Specification Three is described on page 43.

***Employee Compensation***

Table III-4 reports the results of regressions designed to predict the effect of EDA public works spending on employee compensation. The results follow a pattern identical to that in Table III-3: the first column reports the results of a specification that excludes consideration of recent labor market behavior, while Specification Two includes these measures. Again, the influence of recent history on current behavior is statistically significant, as indicated by the very high F-statistic reported at the bottom of the second column. The regressions fit the compensation data less well than they do the employment data: the $R^2$ for Specification One is just over 0.52, indicating that the regression explains about 52 percent of the variation in county-to-county compensation per employee over time. It is worth noting that the inclusion of 1988-1990 growth in compensation and employment significantly improves this measure, as the equation $R^2$ rises to nearly 0.70, meaning that 70 percent of the variation in this measure is explained by Specification Two. Again, this level of joint association is consistent with other cross-section and time-series data studies of infrastructure impacts (see Garcia-Mila, McGuire, and Porter 1996). The independent variables are individually statistically significant with levels of high confidence, with the notable exception of LEDA, the measure of EDA public works spending. In neither of the first two specifications reported is this variable statistically significant at standard confidence levels. Indeed, although in both cases the coefficient estimate is positive, its t-statistic is below 1.0, suggesting that there is no discernible effect of EDA activity on county employee compensation.

This finding should come as no surprise. The typical EDA public works grant, even though it may fund as much as one year's employment growth, is still quite small relative to the total size of an average county economy. Although it is plausible that the grants may influence the location of employment across counties, it is much less likely that they affect compensation in these counties, for several reasons. First, county wage determination is a complex matter, and the prevalence of cross-county commuting suggests that many counties are only one part of a larger labor market. In this context, it is implausible that a $400,000 grant in Linden, NJ, for example, will significantly affect employee compensation levels in Union County and, by extension, the entire northern New Jersey labor market. Even for those counties that are essentially labor markets unto themselves, it is unlikely that EDA public works grants are large enough to generate wage changes across all industries. *Taken together, the results in the first two specifications of Tables III-3 and III-4 suggest that the EDA public works program provides recipient counties with additional jobs at prevailing county compensation levels.*

***Simultaneous Equations Methods***

Notably absent from the specification of county permanent employment is a measure of county compensation levels, and the converse. Clearly, a well-specified model of employment must include compensation, although the relationship between these variables is much more complex than might be suggested by a

**Table III-4**
**EDA Funding and County Payroll**

| | | *Specification One* | *Dependent Variables:* *Specification Two* | *Specification Three* |
|---|---|---|---|---|
| Independent Variables | Estimation Method -> | LPAY OLS | LPAY OLS | LPAY 2SLS |
| | | (1990-1994) | (1990-1994) | (1990-1994) |
| SMSHARE | (%) | -0.012 *** | -0.012 *** | -0.010 *** |
| s.e. | | 0.0003 | 0.0003 | 0.002 |
| BIGSHARE | (%) | 0.419 *** | 0.287 *** | 0.284 *** |
| s.e. | | 0.015 | 0.012 | 0.027 |
| URBAN | (1 = MSA county) | 0.035 *** | 0.031 *** | 0.030 *** |
| s.e. | | 0.004 | 0.003 | 0.009 |
| BLACK | (%) | 0.0008 *** | 0.001 *** | 0.0007 *** |
| s.e. | | 0.0001 | 0.0001 | 0.0001 |
| LHV90 | (natural log of $1990) | 0.180 *** | 0.139 *** | 0.136 *** |
| s.e. | | 0.005 | 0.004 | 0.020 |
| GREM8890 | (%) | ------- | -0.019 *** | -0.020 *** |
| s.e. | | | 0.001 | 0.004 |
| GRWA8890 | (%) | ------- | 0.393 *** | 0.394 *** |
| s.e. | | | 0.004 | 0.006 |
| LTEMPMM | (natural log) | ------- | ------- | 0.002 |
| s.e. | | | | 0.017 |
| LEDA | (natural log of $1997) | 0.000005 | 0.000015 | ------- |
| s.e. | | 0.000162 | 0.000130 | |
| Observations: | | 15,591 | 15,591 | 15,591 |
| R-square: | | 0.5223 | 0.6948 | 0.6959 |
| Adjusted R-square: | | 0.5205 | 0.6936 | 0.6947 |
| F-statistic for inclusion of omitted variables: | | | 4,387 | |
| (95% critical value) | | | 2.995 | |
| (p-value) | | | ~0 | |

*** Statistically significant at the 99% confidence level.
All regressions include year and state fixed effects, results for which are available upon request.
See Table III-1 for variable definitions.

simple supply-demand framework (Haughwout 1998 contains a summary and an example). In particular, as argued in Part B of this section, when a geographic area offers a productive advantage, this advantage is very likely to be correlated with wages. In other words, the fact that, from a microeconomic perspective, increases in wages mean reductions in employment does not imply that wages and employment will be inversely related when the regions (e.g., counties) are the units of observation. The lesson of Haughwout (1998) is that extreme caution must be exercised in interpreting the results of regression results based on aggregate data.

Nonetheless, this relationship is explored here for purposes of completeness. The third columns of Tables III-3 and III-4 report the results of a simultaneous-equations approach to the estimation of EDA public works program impacts. This third specification allows a test of the hypothesis that the EDA Public Works Program expenditures are positively associated with county-level employment, even after wage differences are taken into account.

The problem of simultaneity encountered here is well known in the statistical literature, and methods have been devised to account for it. Here, we utilize the Two-Stage Least Squares (2SLS) approach. In the first stage, the 2SLS approach uses OLS to estimate the relationships between all independent variables and each dependent variable. In the second stage, fitted values of each dependent variable are included in OLS regression equations. This simultaneous-equations approach requires the adoption of an identification restriction, which in this case means the inclusion of at least one variable in each equation that is absent from the other. For the employee compensation equation, it is easy to decide to exclude the size of EDA public works grants in the county, as both theory and the empirical evidence in the first two specifications of Table III-4 suggest that the size is conditionally independent of county-level compensation. It is less obvious which variable to exclude from the employment equation, since there are solid theoretical and empirical reasons for including each. In the Table III-3 results, BLACK is excluded, on the theory that conditions in the local economy are more fundamental to total employment than the characteristics of the local population.

Nonetheless, to further validate this assumption, the model was estimated with each of the independent variables omitted (except the state and year controls and LEDA). The results shown in Table III-3 are typical of the estimates retrieved from those regressions. *In particular, the coefficient estimate on EDA public works investment was positive and statistically significant with at least 99 percent confidence under each of these identification assumptions, with point estimates ranging from 0.0072 to 0.0076, a very tight interval.* These results lend substantial confidence to the basic message: *EDA public works investments are correlated with county employment, as confirmed by a wide variety of econometric specifications; that is, EDA public works investments do, in fact, create jobs.*

The use of the simultaneous-equations procedure has only modest effects on the coefficient estimates. Of primary importance here is the effect of EDA public works grants on local employment, which is, as noted above, statistically significantly positive in all specifications, with a relatively narrow range of estimated effects. The point estimate reported in Table III-3 is 0.0074, identical to four decimal places to the estimate reported for the OLS model. *The robustness of the*

**Table III-5**
**EDA Public Works Program Job Benefits and Cost per Job ($1997)**

Estimated job effects of a $10,000 increase in EDA public works program funding.
Evaluated for average U.S. county

| | | Point Estimates | | 95% Confidence Intervals | | | |
|---|---|---|---|---|---|---|---|
| | | | | Lower Bound | | Upper Bound | |
| Specification | Method | Estimated job effect | Implied cost/job | Estimated job effect | Implied cost/job | Estimated job effect | Implied cost/job |
| 1 | OLS | 12 | $ 823 | 10 | $ 969 | 14 | $715 |
| 2 | OLS | 9 | 1,115 | 7 | 1,359 | 11 | 946 |
| 3 | 2SLS | 9 | 1,119 | 7 | 1,353 | 10 | 953 |

*estimated effect of the program on county employment is very reassuring, as it suggests that the correlations uncovered here do not result from some unintended distortion in the regression equation.*

## F. EDA COST PER JOB

The cost for EDA to create direct, indirect, and induced jobs in counties can be calculated using the aforementioned statistical parameters (see Table III-3, Specification Three). The job effects of $10,000 in EDA spending are determined as follows. Ten thousand dollars ($10,000) is 21.5 percent of the mean EDA spending across all counties ($46,501). If the percentage is multiplied by the coefficient relating EDA spending to county-level jobs (Table III-3, Specification Three) [0.215 x 0.0074], the resulting number is the percentage change in county employment that the change in EDA spending is estimated to induce: [0.001592]. A $10,000 increase in EDA spending in the typical county would increase employment in that county by 0.159%. This number is then added to the natural logarithm of jobs in the typical county: 8.6325 + 0.001592 = 8.634092. Converting to numerical levels by exponentiating yields the following: exp(8.6325) = 5,611 jobs (pre-increase amount); exp(8.634092) = 5,620 jobs (post-increase amount). The jobs attributed to the EDA funding is the difference between the two, or nine jobs (5,620 - 5,611 = 9). The cost per job in 1990 dollars is $10,000 ÷ 9, or $1,119. Jobs created by EDA funding and resulting costs per job are shown for the three specifications in Table III-5 and for each project in each county for Specification Three in Section V.

## G. CONCLUSIONS

The results here suggest that the level of employment in U.S. counties is significantly influenced by the presence and size of EDA public works funding. In addition, jobs associated with the EDA investment program are relatively inexpensive, with estimated median costs ranging from $715 to $1,359 per job (counting direct, indirect, and induced jobs). No significant effect of the public works program on employee compensation as measured here is found, but this finding is not surprising and is consistent with existing theories of regional labor market performance.

*The finding that, wages constant, employment rises in conjunction with EDA funding strongly suggests that this funding is productive: firms react to EDA public works grants by expanding employment and output. In other words, firms are more productive in places where EDA invests than they are without the benefit of EDA assets, other factors remaining equal. While the exact size of the productivity benefits provided by EDA public works cannot be calculated from these estimates, only a positive productivity is plausible, given the labor market effects. This is intuitive, since EDA public works investments are planned in consultation with local economic development officials in order to provide capital assets that the area critically needs.*

By creating public wealth that may be shared by many employers, the EDA Public Works Program, like state and local governments, increases the productivity of labor in those places in which it invests. To the extent that the EDA Public Works Program is focused on distressed areas, and the *PWPPE* suggests that it is, it provides a counterbalance to negative factors that are already in place in these areas—slowing their decline or hastening their recovery.

*Thus, despite its small size, the EDA Public Works Program is a significant (in both a statistical and numerical sense) contributor to the productive capacity of the country. Again, this is not surprising, given that the EDA Public Works Program, unlike the majority of federal government programs, invests exclusively in productive assets.*

*This analysis provides an important piece of the economic development performance puzzle. It is a careful examination of the impacts of one of the primary national programs designed to address decline in distressed areas. This study finds that EDA's Public Works Program does indeed produce permanent private-sector employment at a relatively low cost. The estimates clearly suggest that the program is having its intended effect. EDA appears to have converted its resources into permanent jobs at prevailing wages in its target counties. These counties are better off than similar counties where this type of effort is not taking place.*

# SECTION IV
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# RESEARCH TEAM, ACKNOWLEDGMENTS, GLOSSARY, REFERENCES

# SECTION IV—RESEARCH TEAM AND ACKNOWLEDGMENTS

## RESEARCH TEAM

The foregoing research was funded by the Economic Development Administration. The research was undertaken by Rutgers University, Center for Urban Policy Research (CUPR); Economic Modeling Specialists, Inc. (EMSI); and Princeton University, Woodrow Wilson School. The Rutgers-EMSI-Princeton team was led by Robert W. Burchell.

### Robert W. Burchell, Ph.D.

Dr. Burchell has served as principal or co-principal investigator on more than sixty research contracts in a thirty-year career at Rutgers University. He has conducted studies for the Federal Transit Administration, U.S. Department of Agriculture, Fannie Mae, U.S. Department of Housing and Urban Development, and other federal, state, and local agencies.
For the past five years, his work has been concentrated primarily in the areas of economic impacts and costs of infrastructure development.

### M. Henry Robison, Ph.D.

Dr. Robison has twenty years of experience and numerous significant publications in the field of regional economic impact modeling and analysis. He is recognized for theoretical work blending regional input-output and spatial trade theory, and for development of community-level input-output modeling and analysis. He served for ten years as a faculty member and consultant to the University of Idaho, producing a wide array of grants and contract research. He is presently the Senior Research Economist at the Center for Business Development and Research, University of Idaho, and the Principal Research Scientist for EMSI.

### Andrew F. Haughwout, Ph.D.

Dr. Haughwout is Assistant Professor of Public and International Affairs at the Woodrow Wilson School and Faculty Associate, Office of Population Research, at Princeton University. Professor Haughwout has written about the effects of city taxes on fiscal stability, the accumulation of assets and liabilities by state and local governments, and the impacts of infrastructure investments on firms and households. His recent work appears in such publications as *Regional Science and Urban Economics, Journal of Urban Economics,* and the *National Tax Association's Papers and Proceedings*. His work is at the leading edge of his field and complements nicely with standard input-output analysis.

### Naveed A. Shad

Mr. Shad is a research associate at CUPR and a Ph.D. candidate at Rutgers' Bloustein School of Planning and Public Policy. He specializes in issues of land use, growth management, and geographic information systems. In addition to private-sector experience, he has worked on projects for the U.S. Department of Commerce, North Jersey Transportation Planning Authority, and the State of South Carolina.

### William R. Dolphin

Mr. Dolphin is a computer specialist at CUPR. He has more than twenty-five years of experience at Rutgers as a programmer for mainframe and micro-computers. He is skilled in Basic, FORTRAN, SAS, SPSS, spreadsheet, database, and other statistical and graphic computer applications. He has developed computer models as part of studies for the U.S. Department of Housing and Urban Development, the U.S. Department of Transportation, the Twentieth Century Fund, the New Jersey Department of Transportation, and other public and private organizations.

## RESEARCH ORGANIZATIONS

### Rutgers University
### Center for Urban Policy Research

For nearly three decades, CUPR has conducted a broad spectrum of urban research. In particular, CUPR has concentrated its efforts in analysis of infrastructure, public finance, economic impacts and forecasting, land use, environmental policy, and geographic information systems.

CUPR has undertaken economic impact and infrastructure studies for the National Academy of Science, National Trust for Historic Preservation, Environmental Protection Agency, New York Metropolitan Transportation Commission, States of South Carolina and New Jersey, Southeast Michigan Council of Governments, and North Jersey Transportation Planning Authority.

### Economic Modeling Specialists, Inc.

EMSI is a consulting firm specializing in regional economic modeling and analysis. EMSI has constructed semi-survey economic models in a variety of settings from small rural communities to large and interconnected multistate regions. EMSI has analyzed issues pertaining to energy and natural resource policy, transportation policy, fiscal impacts, firm siting, and a wide variety of issues pertaining to regional economic development and land-management planning. EMSI's clients have included the States of Hawaii, Utah, and Idaho, the U.S. Forest Service, the U.S. Department of the Interior, an assortment of county and city governments, and private firms.

### Princeton University
### The Woodrow Wilson School of Public and International Affairs

The Woodrow Wilson School of Public and International Affairs has more than fifty regular faculty members, most of whom have joint appointments with the Departments of Economics, Politics, or Sociology. The Woodrow Wilson School has research programs in demography, development, domestic policy, international studies, and survey research. The principal research units are the Center of Domestic and Comparative Policy Studies, the Center of International Studies, the Office of Population Research, and the Survey Center. The Center for Domestic and Comparative Policy Studies has undertaken multiple studies of the economic impacts of public works projects.

## ACKNOWLEDGMENTS

This study would have been impossible without the assistance of the EDA headquarters office, including:

Phillip A. Singerman, Assistant Secretary for Economic Development

Awilda R. Marquez, Deputy Assistant Secretary, Program Research & Evaluation

John B. Fieser, Economist, Research and National Technical Assistance

John J. McNamee, Director, Research and National Technical Assistance

Also essential to the research effort were the support and accommodation rendered by EDA Regional Office Directors:

John E. Corrigan, Philadelphia
William J. Day, Jr., Atlanta
Pedro R. Garza, Austin
C. Robert Sawyer, Chicago
A. Leonard Smith, Seattle
John D. Woodward, Denver

## GLOSSARY

*Aggregate cost function*
The relationship between the total costs incurred by a region's private firms and the region's prices of productive inputs (labor and private capital), its public capital stock, and the amount of output produced by those firms.

*Aggregate production function*
The relationship between the total output produced in a region and the region's stocks of productive inputs (labor, private capital, public capital).

*Capital outlay*
Expenditures for the construction or improvement of fixed assets such as roads, utilities, buildings, and marine/tourism infrastructure.

*Construction*
The building of a capital improvement.

*Construction job*
A job that lasts for only the period of time that a capital facility is being built.

*Construction spending*
The amount of money spent for a capital improvement including rights-of-way, design, and soft costs.

*Correlated*
Associated with or related to.

*Database/Data set*
An aggregation of information of a specific type.

*Dependent variable*
In regression analysis, the variable on the left side of the equation, usually indicated as $Y_i$, which is assumed to be caused by, or related to, the independent variable, $X_{ji}$.

*Diagnostic statistics*
Parameters that gauge the robustness of estimated relationships; i.e., the probability that they did not happen by chance. The t-statistic is a diagnostic statistic.

*Direct effects*
Permanent employment and private-sector investment attributable specifically to the capital improvement.

*Direct requirement matrix*
A table that shows each industry's need for the other industry's production or "technology" per unit of its own production.

*Economic impacts*
Permanent employment and private-sector investment generated by the capital improvement.

*Employment*
Jobs, both full- and part-time, the mix of which is determined by typical employment patterns of the local industries involved.

*Employment elasticity of public capital*
The percentage change in total employment induced by a 1 percent increase in the available stock of public capital.

*F-value*
A diagnostic statistic used in regression analysis to determine whether a set of independent variables improves the predictive power of the equation. In the case of simple regression, it is identical to the t-value. It tests the null hypothesis that the regression coefficients on the set of independent variables of interest are zero against the alternative hypothesis that at least one of the coefficients is not zero.

*Factor markets*
The set of conditions that determines both the level of utilization and the price for a material or labor input.

*Final demand column*
The demands placed on the economy displayed in the inter-industry transactions table; these are made typically by government purchases, exports, and inventory accumulation.

*Gross regional product (GRP)*
A measure of regional income, similar to the national concept of gross domestic product; includes labor income net of all taxes, profit-type income, interest, dividends, rents, and capital consumption allowances.

*Impact vectors*
A set of ratios that translates the dollar value of capital investment into spending across numerous sectors.

*Income*
Defined as labor income (wages, salaries, and proprietors' income).

*Independent variable(s)*
The $X_{ji}$ or exogenous variables assumed to cause, or be related to, $Y_i$ in regression analysis.

*Indirect effects*
Permanent employment and private-sector investment that occur as a result of direct effects employment.

*Induced effects*
Permanent employment and private-sector investment that occur as a result of the needs of direct-effects.

*Industry*
A category of employer.

*Infrastructure*
Capital components of the existing and future public works system.

*Input-output model*
A technique that measures the relationship between inter-industry linkages in a geographic area and relates specific inputs needed to produce specific outputs.

Inter-industry transactions table *or matrix*
A table that displays the value of goods or services among industries.

*Intermediate inputs vector*
The sum of all material and labor inputs to production.

*Intermediate outputs vector*
The difference between gross output and final demand.

*Leontief Inverse*
The total requirements matrix.

*Log transformations*
A calculation that takes logarithms of a multiplicative relationship to convert a nonlinear model into a model that is linear in logs.

*Mean*
The arithmetic average.

*Median*
The middle value of a set of numbers.

*Multiple regression*
A method of analyzing the effects of a set of independent variables on a dependent variable of interest.

*Multiplier*
A number usually varying between 1 and 3 which, when applied to permanent jobs and private-sector investment, represents an increment in these indices.

*Multiplier effects*
The sum of the multiple layers of permanent jobs and private-sector investment created by an additional unit of input. The difference between total effects and direct effects.

*National Income and Products Accounts*
A set of accounts produced by the U.S. Bureau of Economic Analysis to estimate national gross domestic product, among other things.

*Nonproject-related*
Unintended employment or private-sector investment that locates proximate to other capital investment, drawing on the unused capacity of this investment.

*Output elasticity of public capital*
The percentage change in output induced by a 1 percent increase in the available stock of public capital.

*Permanent job*
A job that is equivalent to regular employment of the type mentioned. This is full-time, recurring employment that lasts as long as the capital facility is occupied.

*Project-related*
Employment or private-sector investment that comes about due to the specific purpose or intent of the capital investment.

*Public works investments*
Expenditures by a public or private entity on roads, utilities, marine/tourism infrastructure, buildings, or other capital facilities.

*$R^2$*
The square of the multiple correlation coefficient; summarizes the combined usefulness of the independent variables in explaining variation in the dependent variable. It is the proportion of the total variation in the dependent variable that is explained by the regression model.

*Recurring employment*
Employment impacts that will exist year after year.

*Recurring effects*
Permanent employment and private-sector investment year after year.

*Regional input-output analysis*
I-O analysis for a region (as opposed to a country).

*Regional Purchase Coefficient (RPC)*
The portion of the region's demand for a good or service that is fulfilled by producers within the region.

*Regression*
A method of analysis using least squares to examine data and draw conclusions about dependency relationships that may exist.

*Standard Industrial Classification (SIC)*
A universal organization of industries into categories according to the type of product produced.

*t-value or ratio*
A key diagnostic statistical test to evaluate the statistical significance of individual regression coefficients ($\beta_j$). It is formed by taking the ratio of the estimated regression coefficient ($\beta_j$) to its estimated standard error [se($\beta_j$)].

*Total effects*
The sum of direct, indirect, and induced effects.

*Total requirements matrix (Leontief Inverse)*
A table that translates the direct economic effects of an event into the total economic effects of the modeled economy.

*Value added*
The value that industry adds to the goods and services it uses as inputs in order to produce output; the difference between the total value of an industry's production and the value of the goods and non-labor services purchased.

*Value added row*
The difference between gross output and intermediate inputs.

*Variance*
The measure of dispersion around the mean of a random variable.

## REFERENCES

Aaron, H. 1990. "Discussion of 'Why is Infrastructure Important?'" In A. Munnell, ed., *Is There a Shortfall in Public Capital Investment?* Boston, MA: Federal Reserve Bank of Boston.

Aschauer, D. 1989. "Is Public Expenditure Productive?" *Journal of Monetary Economics* 23: 177–200.

Berndt, E. 1991. *The Practice of Econometrics: Classic and Contemporary* Reading, MA: Addison-Wesley.

Berndt, E., and B. Hannsson. 1991. *Measuring the Contribution of Public Infrastructure Capital in Sweden*. Working Paper No. 3842, National Bureau of Economic Research.

Blanchard, O., and L. Katz. 1991. *Regional Evolutions.* Brookings Papers on Economic Activity, Macroeconomics 1.

Blomquist, G.; M. Berger; and J. Hoehn. 1988. "New Estimates of Quality of Life in Urban Areas." *American Economic Review* 78: 89–107.

Eberts, R. 1986. *Estimating the Contribution of Public Capital Stock to Metropolitan Manufacturing Production*. Working Paper No. 8610. Cleveland, OH: Federal Reserve Bank of Cleveland.

Friedlander, A. 1990. "Discussion of 'Infrastructure and Regional Economic Performance.'" In A. Munnell, ed., *Is There a Shortfall in Public Capital Investment?* Boston, MA: Federal Reserve Bank of Boston.

Garcia-Mila, T.; T. McGuire; and R. Porter. 1996. "The Effect of Public Capital in State-Level Production Functions Reconsidered." *Review of Economics and Statistics* 78: 177–80.

Graham, R., and R. Martin. 1977. *The Economic Impact on Local Areas of the Program of the Economic Development Administration (EDA).* Washington, DC: EDA.

Hamilton, J., and R. Jensen. 1983. "Summary Measures of Interconnectedness for Input-Output Models." *Environment and Planning Analysis* 15: 55–65.

Haughwout, A. 1997. "An Interregional Equilibrium Model of Local Public Goods Provision." Mimeo, Woodrow Wilson School, Princeton University.

Haughwout, A. 1998. "Aggregate Production Functions, Interregional Equilibrium, and the Measurement of Infrastructure Productivity," forthcoming *Journal of Urban Economics*.

Holtz-Eakin, D. 1994. "Public-Sector Capital and the Productivity Puzzle." *Review of Economics and Statistics* 76 (1): 12–21.

Hulten, C., and R. Schwab. 1991. "Is There Too Little Public Capital?" Paper presented at conference on Infrastructure Needs and Policy Options for the 1990s, American Enterprise Institute.

Maclennan, D., and J. Parr, eds. 1979. *Regional Policy: Past Experience and New Directions*. Oxford, England: Martin Robertson & Company Ltd.

Miernyk, W. 1965. *The Elements of Input-Output Analysis*. New York, NY: Random House, Inc.

Miller, R., and P. Blair. 1985. *Input-Output Analysis: Foundations and Extensions*. Englewood Cliffs, NJ: Prentice Hall.

Morrison, C., and A. Schwartz. 1996. "State Infrastructure and Productive Performance." *American Economic Review* 86: 1095–1111.

Munnell, A. 1990. "How Does Infrastructure Affect Regional Economic Performance?" In A. Munnell, ed., *Is There a Shortfall in Public Capital Investment?* Boston, MA: Federal Reserve Bank of Boston.

Nadiri, M., and T. Mamuneas. 1994. "Infrastructure and Public R&D Investments, and the Growth of Factor Productivity in U.S. Manufacturing Industries." National Bureau of Economic Research (NBER). Working Paper No. 4845.

Polenske, K. 1972. "The Implementation of a Multiregional Input-Output Model of the United States." In A. Brody and A. P. Carter, eds., *Contributions to Input-Output Analysis.* Amsterdam, the Netherlands: North-Holland.

Richardson, H. 1985. "Input-Output and Economic Base Multipliers: Looking Backward and Forward." *Journal of Regional Science* 25 (4): 607–62.

Roback, J. 1982. "Wages, Rents, and the Quality of Life." *Journal of Political Economy* 90: 1257–78.

Rosen, S. 1979. "Wage-Based Indexes and the Quality of Life." In P. Mieszkowski and M. Straszheim, eds., *Current Issues in Urban Economics.* Baltimore, MD: Johns Hopkins Press.

Rutgers University et al. 1997. *Public Works Program—Performance Evaluation*. Washington, DC: Economic Development Administration (May).

Schaffer, W. 1976. *On the Use of Input-Output Models for Regional Planning*. Leiden, the Netherlands: Martinus Nijhoff.

U.S. Bureau of the Census. 1988-1994. County Business Patterns computer files.

U.S. Department of Commerce. 1996. Regional Economic Information System (REIS) on CD-ROM.

U.S. Department of Commerce. 1997. "National Income and Product Accounts, 1929-96." *Survey of Current Business* 77 (5).

Wheat, L. 1986. "The Determinants of 1963-77 Regional Manufacturing Growth: Why the South and West Grow." *Journal of Regional Science* 26 (4): 635–59.

# SECTION V
# —
# INPUT-OUTPUT AND REGRESSION ANALYSES PROJECT PROFILES

## PROJECT PROFILES

**Project No.** **Project Name** **Page No.**

***REGION 1—Philadelphia***

***REGION 4—Atlanta***

*Buildings*



*Industrial Parks*



*Roads*



*Tourism/Marine*



*Water/Sewer*

***REGION 5—Denver***

*Buildings*



***REGION 6—Chicago***

*Buildings*