Institute for Water Resources

March 2011

Regional Economic Development (RED) Procedures Handbook

2011-RPT-01

US Army Corps of Engineers®

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Institute for Water Resources

The Institute for Water Resources (IWR) is a Corps of Engineers Field Operating Activity located within the Washington DC National Capital Region (NCR), in Alexandria, Virginia and with satellite centers in New Orleans, LA and Davis, CA. IWR was created in 1969 to analyze and anticipate changing water resources management conditions, and to develop planning methods and analytical tools to address economic, social, institutional, and environmental needs in water resources planning and policy. Since its inception, IWR has been a leader in the development of strategies and tools for planning and executing the Corps water resources planning and water management programs.

IWR strives to improve the performance of the Corps water resources program by examining water resources problems and offering practical solutions through a wide variety of technology transfer mechanisms. In addition to hosting and leading Corps participation in national forums, these include the production of white papers, reports, workshops, training courses, guidance and manuals of practice; the development of new planning, socio-economic, and risk-based decision-support methodologies, improved hydrologic engineering methods and software tools; and the management of national waterborne commerce statistics and other Civil Works information systems. IWR serves as the Corps expertise center for integrated water resources planning and management; hydrologic engineering; collaborative planning and environmental conflict resolution; and waterborne commerce data and marine transportation systems.

The Institute's Hydrologic Engineering Center (HEC), located in Davis, CA specializes in the development, documentation, training, and application of hydrologic engineering and hydrologic models. IWR's Navigation Data Center (NDC) and its Waterborne Commerce Statistical Center (WCSC) in New Orleans, LA, is the Corps data collection organization for waterborne commerce, vessel characteristics, port facilities, dredging information, and information on navigation locks.

Other enterprise centers at the Institute's NCR office include the International Center for Integrated Water Resources Management (ICIWaRM), which is a distributed, intergovernmental center, established in partnership with various Universities and non-Government organizations; and a Collaborative Planning Center which includes a focus on both the processes associated with conflict resolution, and the integration of public participation techniques with decision support and technical modeling – Computer Assisted Dispute Resolution (CADRe). The Institute plays a prominent role within a number of the Corps technical Communities of Practice (CoP), including the Economics CoP. The Corps Chief Economist is resident at the Institute, along with a critical mass of economists, sociologists and geographers specializing in water and natural resources investment decision support analysis and multi-criteria tradeoff techniques.

For further information on the Institute's activities associated with the Corps Economics Community of Practice (CoP) please contact Chief Economist, Dr. David Moser, at 703-428-6289, or via-mail at: david.a.moser@usace.army.mil. The IWR contact for the Corps Planning CoP activities is Ms. Lillian Almodovar at 703-428-6021, or: lillian.almodovar@usace.army.mil.

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Foreword

The Corps of Engineers Planning Excellence Program is designed to build planning capability now and for the future. Economics is a vital component of the planning process and updating the National Economic Development manual series is a key element of the Planning Excellence Program.

I appreciate the efforts of the interdisciplinary team across the Corps, local sponsors and others who contributed to this handbook. I am pleased to endorse its use as a tool for the Planning Community of Practice to reach out to all who are interested in our work.

Harry E. Kitch, Planning Community of Practice
Deputy Chief, Planning Civil Works

As the Corps of Engineers strives to improve its planning and decision making, economic analysis is one of its most reliable and important tools. A critical element of successful economic analysis is communication with others—in gathering data, making assumptions, developing models and presenting results.

Dr. David Moser
Chief Economist
U. S. Army Corps of Engineers

Acknowledgements

As part of the Planning Guidance Improvement Program, this Regional Economic Development (RED) Handbook is one of a series of important resource documents for performing comprehensive economic analysis within the Corps of Engineers Civil Works program. This handbook also supports the application of collaborative planning, particularly the use of the RED account in project analysis, as presented in Engineering Circular (EC) 1105-2-409 "Planning in a Collaborative Environment" (31 May 05). Ms. Lillian Almodovar of the Institute for Water Resources (IWR) has provided critical support to this effort. Mr. Darrell Nolton of IWR has been effective and generous in serving as the Program Manager for the Planning Guidance Improvement Program. This work was being performed by the Institute for Water Resources (IWR), under the direction of Lillian Almodóvar, in support of Headquarters, U.S. Army Corps of Engineers (HQUSACE). Harry Kitch is the HQUSACE proponent. Wes Bushnell of the Corps of Engineers, Huntsville Engineering Center was the principal author for the handbook and later, Kevin Knight of IWR. Susan Durden served as technical monitor and helped to kick off the effort.

Several RED case studies were furnished by Corps district and former IWR staff namely: Mark Bierman (formerly with the Los Angeles District, now with the San Francisco District), Dr. Dennis Robinson (University of Missouri), Gary Bedker (Sacramento District). Valuable review comments and support were provided by Dr. Dennis Robinson (University of Missouri), Lorraine Cordova (Alaska District), Dr. David Moser (IWR), Dr. Wen-Huei Chang (IWR), Dr. Norm Starler (IWR), Susan Durden (IWR), Erin Rooks (IWR), Rick Eberts (Rock Island District), Margaret Ryan (Kansas City District) and Jennifer Henggeler (Kansas City District).

Thank you to the many others, not mentioned by name that showed interest, and offered ideas.

Executive Summary

- **EC 1105-2-409**, Planning in a Collaborative Environment (EC 409), greatly increases the emphasis and potential application of the **Regional Economic Development (RED)** account by stating that all four Principles & Guidelines accounts (National Economic Development, Environmental Quality, Regional Economic Development and Other Social Effects) will be considered in project analysis and decision making.

- This handbook is intended to provide Corps planners with the basic concepts, methods, and procedures to integrate **RED effects** into water resources decision making.

- **The RED account is distinct from the NED account** in that it examines the potential impacts mainly to the localized or regional economic area, instead of the nation as a whole.

- **The types of RED effects are generally different from the NED effects**. A project itself could provide a sudden influx of Federal funding from outside the area, which spurs local or regional growth. Likewise, there may be gains in local and business revenues as a result of reductions in transportation costs made possible through navigation improvements.

- **RED impacts** are often identified and quantified as **transfers of economic activity within a region or between regions**, as opposed to NED effects which measure the increase in net value of national output of goods and services.

- RED impacts may also be defined as the **regional losses in employment and/or income** under the "without project" condition (most notably those experienced during chronic or catastrophic flooding or in low income, rural, or remote communities), which could be transferred to other regions of the country. On a national level, the positive and negative impacts may be cancelled out.

- **Input-Output Analysis** is at the heart of RED analysis. It measures the interdependence among industries in the regional economy. The matrices and mathematics can be daunting at times, but many customized software programs can assist the planner in computing the regional impacts of federal investments (See Chapter 6).

- Regional economic impacts are typically classified into one of three categories and should not be confused with National Economic Development impacts:

    - **Direct effects** represent the impacts the new federal expenditures have on industries which directly support the new project. Labor and construction materials can be considered direct components to the project.

- **Indirect effects** represent changes to secondary industries that support the direct industries. Rock quarries used in making cement or fuel for dredgers could be considered indirect pieces of the project.

- **Induced effects** are changes in consumer spending patterns caused by the change in employment and income within the 'direct' and 'indirect' industries. The additional income workers receive via a project may be spent on clothing, groceries, dining out, and other items in the local/regional area.

- **The types of RED information and the appropriate RED models** may vary according to the type of study, the level of detail or precision required, and the relative importance of the RED account in the overall decision.

1. Introduction

1.1 Purpose

- *What are some of the regional and local economic impacts that are induced by water resource projects? By the same token, how would adverse events impact the local and regional economies under the "without project" condition?*

- *How can we quantify a project's contributions to regional economic development? What tools are available that can aid the planner in calculating such contributions?*

This handbook describes how the regional economic development effects of water resources problems and solutions can be meaningfully addressed and included in the Corps water resources planning process. A concern for the regional and local impacts has appeared in federal water resources planning guidance, namely as the "Regional Economic Development" (RED) account in the Principles and Guidelines (P & G) (Figure 1) and in the Corps' ER 1105-2-100. However, given the P & G's rules on the Federal objective (NED), the RED is often examined in less detail for most water resources planning projects. EC 1105-2-409 "Planning in a Collaborative Environment" (US Army Corps of Engineers, 2005) is placing a much greater emphasis on the broad range of considerations in planning besides the National Economic Development (NED) effects. Moreover, increased cost sharing responsibilities by non-federal partners has fostered a growing interest in examining the local and regional impacts of project investments. Indeed, non-federal partners often use the results of the RED analysis to assess the local impacts and to drum up stakeholder support. Finally, Congress, through Section 2031 of the Water Resources Development Act of 2007, has directed the Secretary of the Army to revise the Principles & Guidelines, calling for greater emphasis on non-NED factors in the planning of water resources projects, including the environment, social effects of planning and public safety. The revised P & G should also consider "assessment methods that reflect the value of projects for low-income communities".

Figure 1: Regional Economic Development

The Regional Economic Development (RED) account registers changes in the distribution of regional economic activity that result from each alternative plan. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output and population.

- Principles & Guidelines, June 1983

This handbook is intended to provide Corps planners with the basic concepts, methods, and procedures to integrate regional economic development into water resources planning decisions.

1.2 Manual Structure

This manual provides a basic overview of RED analysis applicable to the Corps' Civil Works Program. The first several chapters contain information on RED itself and how it should be used throughout the planning process. Subsequent chapters describe the RED benefits by business line and provide a catalogue of the tools used in performing RED analyses. The appendix presents case studies of RED for recent Corps projects.

1.3 Audience

This manual is written principally for Corps planners in their study of water resource problems. Their planning partners and stakeholders may also find some utility in it, as might anyone else interested in water resources planning. A strong background in economics and public finance is encouraged, but not mandatory. More detailed information can be found in *"Input-Output Analysis: Foundations and Extensions*" by Miller and Blair, as well as other references cited in the Appendix.

2. RED Defined

2.1 Principles & Guidelines and the "Four Accounts"

In conducting water resources analyses, there are two primary sources of Corps guidance: the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies March 1983 (P&G) and Engineer Regulation 1105-2-100 "Planning Guidance Notebook" April 2000 (ER 100) which expands on the content of the P&G.

The P&G categorizes a system of **four accounts** into which all impacts of proposed project alternatives may be classified. The **National Economic Development (NED)** account is often expressed in monetary terms and displays the economic impacts which theoretically accrue equally to all citizens of the United States. The **Environmental Quality (EQ)** account is often expressed in non-monetary terms and displays the significant environmental, historical and cultural resource effects of a project. The **Other Social Effects (OSE)**[1] account includes such impacts as community cohesion, health, life and safety, among other things. And the **Regional Economic Development (RED)** account displays the regional and localized economic impacts surrounding a federal project.

2.2 NED vs. RED

Corps planners are most familiar with the NED account. It is referred repeatedly throughout the planning process and forms the basis of the Federal objective. Contributions to NED are defined as "the increase in the net value of the national output of goods and services". Project alternatives that reasonably provide the largest net NED contributions are referred as "NED plans". And although the identification and measurement of NED benefits is a key component of economic justification of proposed Federal projects, by themselves they do not tell the "complete story".

The RED account is often examined in less detail than NED, yet the account remains useful. Hurricane Katrina caused a significant economic hardship to not just the immediate Gulf Coast but for entire counties, watersheds, and the State of Louisiana. Besides the devastating damage to homes (which are often captured by the NED account), hundreds of thousands lost their jobs, property values fell, and tourism and tax revenues declined significantly and moved to other parts of the U.S. In this example, the RED account provided a better story of the overall impact to the region.

The distinction between NED and RED is a matter of perspective, not economics (Yoe, 1993). A non-federal partner may consider the impacts at the state, regional and local levels to be a true measure of a project's impact or benefit, whereas from the Corps' perspective, this may not constitute a national benefit. (The Federal objective of water resource planning is National Economic Development). Gains in RED to one region may be partially or wholly offset by losses elsewhere in the nation. For example, if a Federal project enables a firm to leave one state to

[1] IWR has recently published a handbook on applying Other Social Effects (OSE) to Corps planning.

locate in the newly-protected floodplain of another state, the increase in regional income for the project area may come at the expense of the former area's loss. Likewise, a navigation project that enables one port to lure domestic traffic away from another port is primarily a transfer from one region to another (providing that the traffic would have remained in the U.S.). As such, they may not influence the net value of the nation's output of goods and services (i.e., NED) and should be excluded from NED computations.

Be sure to explain the difference between NED and RED to non-federal sponsors and stakeholders. Non-federal interests are often concerned with local or regional development, while the Corps' project formulation and evaluation is centered on **national** economic efficiency or **national** environmental quality.

There are indeed instances in which RED effects closely resemble the NED effects. For example, a federal investment could provide a region with a unique form of economic development that could not be transferred from competing parts of the country. NED benefits could also overlap with RED or even trigger additional RED benefits. Inland navigation projects often reduce shipping transportation costs, in which the savings are presumably passed on to all U.S. consumers as an NED benefit. The gains in efficiency could also reduce a particular commodity's price and landside costs enough to divert additional revenues to the local businesses, along with rises in local income and/or local employment (RED). Sometimes there may be an overlap between NED and RED effects, *but it is important to bear in mind that the two accounts are generally not additive.*

	Primary National Economic Development (NED) Effects	Primary Regional Economic Development (RED) Effects
Flood Risk Management	Flood Damages Prevented	Regional Change in Jobs, Income, Revenues
Commercial Navigation	Reduced Transportation Costs	Regional Change in Jobs, Income
Ecosystem Restoration	Ecosystem Outputs (ER metrics) Gains in Recreation Values	Regional Change in Jobs, Income, Increased Tax Revenues in area

2.3 Guidance Concerning the RED Account

The RED account has been given less emphasis in the Corps' past or current guidance. Perhaps the most extensive statement on RED appeared in the Principles & Guidelines earlier version, the Principles and Standards (P & S):

> "Through its effects—both beneficial and adverse—on a region's income, employment, population, economic base, environment, social development and other factors, a plan may exert a significant influence on the course and direction of regional development. The regional development account embraces several types of beneficial effects, such as (a) increased regional income; (b) increased regional employment; (c) population distribution; (d) diversification of the regional economic base; and (e) enhancement of environmental conditions of special regional concern."

In practice, District planners often assumed the NED and RED effects to be similar (apart from the obvious transfers from other regions). Certainly, the NED benefits such as the reduced flood

damages in a specific floodplain would also accrue to that same region. Consequently, when displaying information on the 4 P & G accounts for their flood risk management studies, many field planners entered identical values for NED and RED effects (Figure 2).

Figure 2: Example of 4 P & G Summary of Accounts Table Used in a Corps Feasibility Study

Summary Comparison of Detailed Plans for Duck Creek, Ohio			
	No Action	NED Plan	Locally-Preferred Plan
Plan Description	Without Project Condition	Reach DC-A 25-yr protection; Reach DC-B 600-yr protection; Reach DC-C 100 yr	Reaches DCA, DCB, DCC uniform 100-yr protection
Impact Assessment			
A. National Economic Development (NED)			
Project Cost	$0	$13,895,000	$14,817,000
Annual Cost	$0	$1,357,000	$1,445,000
Annual Benefits	$0	$1,721,000	$1,783,000
Annual Net Benefits	$0	$364,000	$338,000
BCR	N/A	1.27	1.20
	Ranks 3rd	Ranks 1st	Ranks 2nd
B. Environmental Quality (EQ)			
1) Air/ Noise	Normal noise levels created by traffic. Ranks 1st.	Temporary increase in noise levels during 4-yr construction period. Ranks 2nd.	Temporary increase in noise levels during 4-yr construction period. Ranks 3rd.
2) Water Quality	Existing WQ poor due to discharges into stream from combined sewer outfalls & flood runoff from industrial areas. Ranks 3rd.	Temporary increased turbidity levels during 4-yr construction period. Contamination from flood runoff partially eliminated in DCA and fully eliminated in DCB & DCC. Ranks 2nd.	Temporary increased turbidity levels during 4-yr construction period. Contamination from flood runoff eliminated for all reaches. Ranks 1st.
3) Threatened & Endangered Species	No endangered species in study area.	No impact.	No impact.
4) Cultural Resources	No cultural resources or historic properties in study area.	No impact.	No impact.
C. Regional Economic Development (RED)			
	Same as NED impacts. Ranks 3rd.	Same as NED impacts. Ranks 1st.	Same as NED impacts. Ranks 2nd.
D. Other Social Effects			
	Continued loss of life and community cohesion	Reduced loss of life	Reduced loss of life

Source: Planning Manual

The same cannot be said for navigation projects, however, since the savings in transportation costs are often spread over larger areas, which are nearly impossible to fully trace. A significant amount of the containerized cargo entering the Los Angeles/Long Beach port system, for example, ultimately ends up on the East Coast, where consumers reap the benefits of a more efficient transportation system in the form of reduced prices.

ER 1105-2-100 contains little follow-up guidance on how the RED account is to be applied. In its formulation section, the Regional Economic Development and Other Social Effects accounts are regarded to be "discretionary"[2]. ER100 does allow the Corps to recommend exceptions to NED plans, called Locally-Preferred Plans, which could theoretically capture significant regional economic impacts, provided that the Assistant Secretary of the Army for Civil Works (ASA (CW)) grants the exception.

ER 100 permits the liberal inclusion of beneficial categories but cautions: "This multi-purpose approach is recommended since numerous entities within the boundaries of any watershed must agree with and support watershed improvements and management initiatives in order to successfully implement effective system-wide solutions."

Other references to RED have appeared as part of the National Environmental Policy Act (NEPA), in which Environmental Assessments and Environmental Impact Statements (EIS) describe the environmental, economic and social impacts of federal projects. EISs encourage careful examination of the impacts projects have on communities and to seek remedial actions if necessary. Finally, ER 1105-2-100 Chapter 3, Section 9(c), which contains guidance pertaining to watershed studies list several areas of possible investigation, one of which is regional economic development.

EC 1105-2-409 (EC409) has strengthened the case for considering RED impacts in the formulation and evaluation of projects. EC 409 encourages collaboration and evaluation of all four P & G accounts, though the weight of each account may vary depending on the types of problems in the study area, stakeholder preferences, and the study authority. In 2006, the Corps of Engineers South Pacific Division developed a sample template for feasibility studies, which includes a table to illustrate the effects of regional economic activity (Figure 3). It emphasized regional income and employment.

Figure 3: Regional Economic Development Account

	PLAN A	PLAN B	PLAN C
Employment & Labor Force			
Business & Industrial Activity			
Local Government Finance			

There are times when the RED effects may appear to have less influence in the overall decision, but there is general consensus that such effects deserve to be examined and considered throughout the planning process. At the very least, non-federal project sponsors would likely have a strong interest in the RED account since potential local and regional effects of Federal projects serve important functions in generating local support.

[2] ER 1105-2-100 "Planning Guidance Notebook" April 22, 2000 pg 2-6

2.4 Effects Associated with RED Analysis

Three main effects are typically associated with RED analysis: **direct effects, indirect effects,** and **induced effects.** These are discussed in more detail in Chapter 3. It is probably best to present and explain these effects separately instead of combining them.

2.4.1 Direct Effects

Direct effects represent those changes in the immediate effects associated with the change in the total sales for a particular industry. In other words, in the impact region in which a project is located, direct effects represent that proportion of the expenditure in each industry that flows to material and service providers in that region. For example, an increase in the demand for cotton of $10 million will cause the farm sector to produce $10 million worth of cotton. By the same token, a Corps flood risk management (FRM) project that requires 500,000 tons of cement worth $2,000,000, would provide a direct benefit of $2,000,000 to the local cement industry (assuming all of the cement was produced locally). These effects are entirely separate from the NED benefits defined by the reduced flood damages, which planners calculate in accordance with Corps guidelines. As it will be explained later, some of the outputs "leak" to areas outside the study area or to other industries. A consumer buying a manufactured good, say a $10.00 t-shirt at Wal-Mart will probably generate only $3.00 in output to the apparel industry (which may wind up in China as well) while the remaining $7.00 will go towards retail, wholesale, transportation, etc.

2.4.2 Indirect Effects

Indirect effects can be described as the changes in the inter-industry purchases as they respond to the new demands of the directly affected industries. Thus, following our cotton example, $10 million worth of cotton will require for the fertilizer industry to produce an additional $1 million worth in fertilizer, $0.2 million in seeds, $0.5 million in pesticides, etc. The cement firm for the Corps FRM project must in turn contract with other industries for equipment and other materials in manufacturing the cement.

2.4.3 Induced Effects

Induced effects are the resulting changes in spending patterns of increases in income to directly and indirectly affected industries. The construction firm and their supporting firms may require additional personnel or raise wages/provide bonuses in order to meet demand. Increases in local employment increase total income and the amount of funds expended in the local economy. As more income is spent by workers, more and more local industries will flourish in support of the increased demand. Employees of the construction firm may eat out more often, take their clothing to a dry cleaner, or purchase a second car.

Figure 4 presents the direct, indirect and induced impacts of a federal program for the State of North Carolina. Figure 5 lists the impact's components for the restoration of a Corps recreational facility.

Figure 4: Economic Impacts of Federal Expenditures on Employment, Labor Income, and Capital Income: North Carolina State Fiscal Year (2003)

	Economic Impacts of Federal Expenditures	Economic Impacts of State & Local Expenditures	Economic Impacts of Total Expenditures
Employment[1]			
Direct Impacts	57,738	34,751	92,489
Indirect Impacts	12,066	7,243	19,309
Induced Impacts	43,940	26,385	70,325
Total Impacts	**113,744 jobs**	**68,380 jobs**	**182,124 jobs**
Labor Income[2]			
Direct Impacts	$1,857,157,998	$1,115,689,427	$2,972,847,425
Indirect Impacts	$436,380,583	$262,417,396	$698,797,979
Induced Impacts	$1,524,323,030	$915,342,114	$2,439,665,144
Total Impacts	**$3,817,861,699**	**$2,292,842,764**	**$6,110,704,463**
Capital Income[3]			
Direct Impacts	$310,423,367	$186,369,112	$496,792,479
Indirect Impacts	$252,410,077	$151,467,201	$403,877,278
Induced Impacts	$619,650,077	$372,115,364	$991,765,441
Total Impacts	**$1,182,483,521**	**$709,951,650**	**$1,892,435,171**

Notes:
[1] Employment includes both full-and part-time jobs.
[2] Labor Income includes wages, salaries, sole proprietorship income, and partnership income. Values are 2003-year dollars.
[3] Capital income includes rental income, interest income, and corporate divided income. Values are in 2003-year dollars.

Figure 5: Components of the Impact for the Rehabilitation of a Recreational Facility

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

Source: Corps of Engineers

2.5 RED Metrics

ER100 defines RED metrics solely as changes in the distribution of regional economic activity

(e.g., income and employment). Urban planning departments, city governments, and policy makers often consider income and employment to be the most important metrics of federal investment, but there are several others applicable to RED analysis. Value added, business taxes, or indices (localized price index, quality of life) could also be used to describe the changes in regional economic activity (Figures 6 and 7). The project delivery team (PDT) should agree on the outputs most applicable to the project authority and the type of study at hand. These outputs should be meaningful and directly address the needs and problems of the study area.

Figure 6: Primary RED Metrics

- **Employment**
- **Labor Income Generated**
- **Direct Business Taxes**
- **Indirect Business Taxes**
- **"Value Added"**
- **Population Distribution**
- **Total Sales by Sector**

Figure 7: Other Potential RED Metrics

- **Additional Income Tax Revenues**
- **Additional Sales Tax Collections**
- **Business Revenues**
- **Personal Income, Per Capita Income**
- **Change in Surplus/Deficit of Local Budget**
- **Regional Competitiveness/Diversity**

As shown in a primer prepared by the Economic Development Research Group, the various measures of economic impacts may have different applications and interpretations (Weisbrod, 1997)***.***

Employment reflects the number of additional jobs created by economic growth or the losses by contraction. This is one of the most popular measures of economic impacts because it is the easiest for the public to understand. However, job counts do not always necessarily reflect the *quality or permanency* of employment opportunities. In the context of RED modeling, one annual job is equivalent to one person being employed during a single year. One person being employed for five years is equivalent to five annual jobs. Employment impacts may be measured in a number of "person years".

Labor Income/ Personal Income are generally self-explanatory. These effects rise as salaries rise and/or additional workers are hired. Either or both of these conditions can occur as a result of business revenue growth. As long as nearly all of the affected workers live in the study area, this is a reasonable measure of the personal income benefit of a project or program. Sponsors often publicize the additional income and the tax receipts as a means of selling the project to the public.

"Value Added" also referred as Gross State Product (GSP), Gross Regional Product (GRP) or Gross Metropolitan Product (GMP) (provides a broader measure of the impact of a large scale project (e.g., port projects) and that essentially reflects the sum of wage income and corporate profit generated in a large study area. However, as today's economy is increasingly global, the GSP or GRP/GMP can over-estimate the true income impact on a local area, since it often includes dividends to business owners who may not reside in the study area, as well as reinvestments in corporate facilities outside of the study area. Thus, while GSP/GRP/GMP may best describe the total impact on overall economic activity in a geographic area, the personal income (wage) measure is often preferred as a more conservative measure of income benefit to residents of the area. Value added includes employee compensation, proprietary income, other proprietary income and indirect business taxes. Employee compensation is wage and salary payments as well as benefits, including: health and life insurance, retirement payments, and any other non-cash compensation. It includes all income to workers paid by employers. Proprietary income consists of payments received by self-employed individuals as income. This is income recorded on Federal Tax Form 1040C. Proprietary income includes income received by private business owners, doctors, lawyers and so forth. Any income a person receives for payment of self-employed work is counted. Other property type income consists of payments from interest, rents, royalties, dividends, and profits. This includes payments to individuals in the form of rents received on property, royalties from contracts, and dividends paid by corporations. This also includes corporate profits earned by corporations. Indirect business taxes consist primarily of excise and sales taxes paid by individuals to businesses. These taxes occur during the normal operation of these businesses but do not include taxes on profit or income (MIG, Inc).

Business Revenues (also referred to as business output or sales volume) is the broadest measure of economic activity, as it encapsulates the most categories and provides the largest numbers. Revenues include the full (gross) level of business revenue, which pays for costs of materials and costs of labor, as well as generating net business income (profits). This can be a misleading measure of economic development benefit since it does not distinguish between a high value added activity (generating substantial local profit and income) and a low value added activity (generating relatively little local profit or income from the same level of sales).

Indirect Business Taxes consist primarily of excise and sales taxes paid by individuals to businesses. Non-Federal sponsors often have a keen interest in this metric since it measures the project's repayment to the local economy. As with increased income, sponsors often publicize the additional tax receipts as a means of promoting the project to the public.

Population Distribution can be a compelling argument for RED. If a group of disadvantaged people are made better off in a local area as a result of a project, then the reduction in the number of people requiring public assistance could arguably be considered an RED benefit. Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, was issued to combat the fact that poor and minority groups often have been exposed to greater human health and safety risks than society at large and have borne more than their share of the negative effects of development.

It is important to remember that many RED metrics may overlap each other. Portions of business output (revenues), for example, impact workers' incomes and generate profits, which

are also the components of "Value Added". Property values may also reflect investment of personal income and corporate profits. For these reasons, the different measures of economic impact (income, value added and output) cannot be added together, but described separately.

2.6 Presentation of RED Effects

Presentation of RED effects should include baseline information such as median income, employment, population, or major industries. To the extent practical, the analysis should then provide reasonable estimates of the *changes* in the area's output, income and employment as a result of Federal investment or lack of Federal investment. The planner should identify the appropriate industrial sectors and the types of employment as well as the level of skill required—unskilled, semi-skilled and highly skilled. The planner should attempt to link the impacted industries to the project and describe their perceived dependence on the project.

Figure 8 presents the economic characteristics of two economic areas defined for an RED analysis as part of a flood risk management project performed by the Los Angeles District. The non-federal sponsor was interested in the county-level impacts since Riverside County is a large one and given the relatively small project, much of the economic impact would be felt within the county. The PDT also examined the four counties surrounding Riverside County (Los Angeles, Orange, San Bernardino, and San Diego) in order to fully capture the effects of the economic "shock" associated with the project, as well as to understand the magnitude of the impacts that are not captured by the county. Figure 9 presents the direct, indirect, and induced effects on output, employment, labor income and indirect business taxes. This case study is described in detail in Appendix A. In this case, the District did not include the reduced flood benefits with the other RED benefits.

Figure 8: Economic Indicators

Indicator	5-County Region	Riverside County
Population (1,000s)	19,700	1,870
Households (1,000s)	6,359	588
Employment (1,000s)	10,900	560
Gross Income Per Household[3]	$104,253	$83,966
Total Income (1,000s)	$662,896,300	$49,443,185

Source: IMPLAN

[3] Includes all wages and income, including proprietor's income

Figure 9: Construction Expenditure Impacts to a Riverside County Flood Project

Category*	5-County Region Impacts (,000)				Riverside County Impacts (,000)				Region Total > County Total
	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	
Output	$14,308	$4,612	$6,767	$25,687	$14,308	$3,514	$4,880	$22,709	13%
Employment	115	34	52	201	112	34	44	189	6%
Labor Income	$6,090	$1,747	$2,267	$10,105	$5,922	$1,432	$1,587	$8,942	13%
Indirect Business Taxes	$75	$176	$397	$649	$64	$144	$322	$531	22%

2.7 Relationship between OSE and RED

There is not a hard and fast line between the OSE and RED accounts. The OSE account often considers income, employment and other economic variables in the context of a community's well-being. RED impacts tend to have more of an economic focus but can certainly exert influence on the OSE account. For instance, an area that has been plagued by severe unemployment[4] may experience a spike in jobs and income with a large federal project. The additional income and tax revenues, as cited in RED, could be put towards roads, schools, and police, all of which play a role in the community (OSE). At the same time, rapid economic growth and population in-migration (RED) could over-stimulate a local area, creating negative "boomtown" social effects such as over-taxed community services and erosion of sense of community (Dunning & Durden, 2008). When dealing with low income or disadvantaged communities, both categories should be fully examined.

2.8 RED and Secondary Recreation Effects

Projects aimed at improving degraded ecosystems, reducing flood risk, or minimizing navigation hazards may often provide benefits to recreation-based industries. For example, breakwaters may reduce hazardous wave conditions and increase the number of available days for recreational boating, which will in turn, benefit businesses dependent on boaters. The increased recreational opportunity days could be captured in the NED account whereas the gains in local or regional jobs and revenues would fall under the RED account. Likewise, restored ecosystems may support businesses in nearby areas as a consequence of increased eco-tourism. While recreation benefits are often expressed in NED terms in the form of the added value of the recreation experience, the local jobs and revenues supporting such recreation could be captured as RED effects. The planner should be prepared to evaluate such incidental effects of project improvements, from both the NED and RED perspectives.

[4] For areas having severe and chronic unemployment, Corps projects can provide NED benefits per Corps policy by providing jobs and reducing an area's dependence on public assistance. There are stringent criteria for claiming this benefit category and it has rarely been applied.

2.9 Catastrophic Events

Catastrophic storms can create severe and long-term hardships to a specific region of the country. Hurricane Katrina killed more than 1,800 people, severely damaged an area approximately the size of the United Kingdom (over 90,000 square miles), and impacted the lives of over a million people as houses, bridges, roads, power and communications infrastructure washed away. It is widely considered to be the most costly natural disaster in U.S. history—one estimate put the figure at over $100 billion-- forcing thousands from their homes, closing entire industries (in some cases permanently), and discouraging future investment to the New Orleans area. The 2006 Interagency Performance Evaluation Taskforce (IPET) Report provided a well-documented look at the lasting impacts of Katrina. The NED effects such as damaged homes and infrastructure are well documented in the report. The RED effects such as lost jobs, income and tax revenues are also included and are still being felt in the region, as large numbers of businesses have relocated to Houston and other areas.

https://ipet.wes.army.mil/

Other areas of the US remain very vulnerable to catastrophic flooding. One area in particular is the Central Valley of California, where rampant development behind an aging levee system has placed millions at risk.

There may be a silver lining to catastrophic impacts, when taken in the context of RED. A select number of industries could actually benefit in the aftermath of storms. Industries associated with the clean-up, dewatering and reconstruction often creates many temporary jobs and income for the region. While it is never a good idea to couch catastrophic events in opportunistic terms, the RED analyst should at least think about both the positive and negative effects associated with catastrophic events[5].

A common error, mainly when evaluating the RED effects in recreation and tourism settings is when analysts apply multipliers to total visitor spending, especially when many of the manufactured goods (souvenirs) that visitors buy are not locally made. If none of the goods bought by visitors are made locally, there will be no direct effect for the manufacturing sector in that region.

2.10 Summary and Look Ahead

By now, you have seen how RED is defined and how it can be applied to Corps planning settings. In the following chapter, we will provide more of the “nuts and bolts” of RED analysis. Concepts such as Input-Output Analysis and the Multiplier Effect are highlighted. These topics, together, provide the foundation for the material that follows in subsequent chapters.

[5] For more information on the positive and negative impacts of catastrophic events, see Harold Cochrane’s report “Socio-Economic Considerations in Dam Safety Analysis” (1987).

3. RED Concepts

3.1 What do the primary RED impacts to a study area look like?

Before discussing the impacts of Corps projects, let's apply a more basic example of a change in the local/regional economy. Imagine yourself living in beautiful downtown Humdrum, a city with an average population, with average employment, average poverty levels and average income. Let's assume that an automobile manufacturer, Duryea Motors, decides to build a new assembly plant near Humdrum. What would be the regional/local impacts to the area, i.e., the impact this construction would have on the area's employment and income?

First, there are the direct impacts to the area's employment and income simply based on the goods and services necessary to complete construction of the plant. In all probability an Architectural and Engineering (A/E) firm will be contracted to design and manage construction of the facility. The A/E firm will sub-contract site work to one regional firm; concrete and foundation work to another regional firm, plumbing, electrical, HVAC, steel work, equipment procurement and furnishings will all be contracted to other regional firms. At the same time, firms supporting the automobile producer with raw materials will be engaged[6]. The increases in production for all companies engaged in plant construction or which supply raw materials for production are all captured in the **"direct effects"** category. Impacts described to this point are termed direct effects; these are impacts which can be directly attributed to the original source of new funds.

Other regional companies which supply materials or services to companies engaged in plant construction or to suppliers to the Duryea plant will also see an increase in their revenues above levels prior to the advent of the new plant. These "second line" companies do not directly supply materials to the automobile manufacturing plant, but supply materials or goods to those companies which do. There will be a need for additional equipment to produce the raw materials in automobiles as well as for the equipment used in building automobiles. These secondary effects are termed **"indirect effects"**; these are transactions which occur between industries in support of directly affected industries.

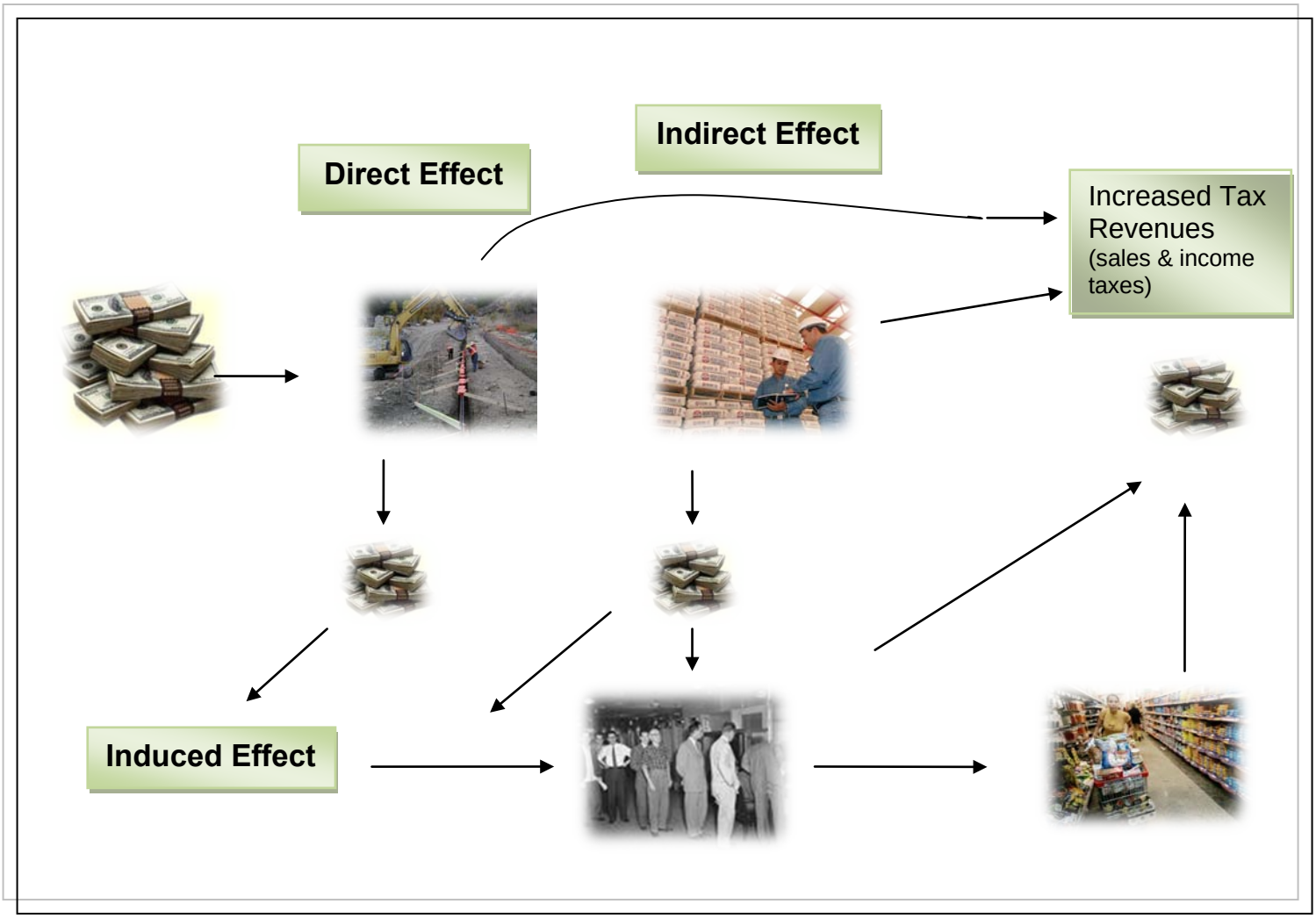
A final category of impacts results from changes in local spending patterns as the directly and indirectly affected firms receive the sudden influx of monies. The automobile plant will most likely hire workers, many of whom may commute from areas outside the project area, or whom were previously unemployed. This translates into an increase in disposable income. As a worker's income increases, that worker will spend some portion of that increase on additional meals in restaurants, local retail stores, car dealerships, dry cleaning, or to upgrade their house. Such increases in spending are known as **"induced effects"**.

[6] In rare occasions, construction assistance or materials may be supplied by foreign firms. For these reasons, it is most appropriate to consult with policy reviewers at HQUSACE.

It should be noted these local/regional impacts can also include the additional tax receipts generated from the plant in the form of sales/corporate taxes (minus subsidies) as well as its employees in the form of income and sales taxes.

The same concept can be applied to Corps projects. An injection of federal funds aimed at addressing a particular water resource problem enters a region. The project itself helps realize the federal objective by providing NED benefits (reduced flood damages, improved navigational efficiencies, etc.). At the same time, the injection of federal funds provides direct, indirect and induced spending throughout the local/regional economy (Figure 10).

Figure 10: Injection of Monies into the Local Economy & Subsequent Spillover Impacts



3.2 RED and "The Multiplier Effect"

In economics, the **multiplier effect** refers to the idea that an increase in spending can lead to even greater increase in income and consumption, as monies circulate or **multiply** through the economy.

Economist John Maynard Keynes, whose government intervention proposals first brought the multiplier effect to light, wrote:

"If the Treasury were to fill old bottles with banknotes, bury them at suitable depths in disused coal mines which are then filled up to the surface with town rubbish, and leave it to private enterprise on well-tried principles of laissez-faire to dig the notes up again (the right to do so being obtained, of course by tendering for leases of the note-bearing territory), there need be no more unemployment and with the help of the repercussions, the real income of the community, and its capital wealth also, would probably become a good deal greater than it actually is." (Heilbroner, 1999)

If, for example, a company spends $1 million to build a factory, it will employ construction workers and their suppliers as well as those that work in the factory. The workers and suppliers will receive wages which they will spend at restaurants, laundromats, auto repair shops and other stores and services in the factory's vicinity.

The builders, suppliers, and restaurateurs will then have higher disposable income; as a result, they will purchase appliances, do home repairs and otherwise put money back into the economy. Assuming that all of these workers and suppliers spend $2 million dollars combined, the multiplier would be 2.0, since there was an initial $1 million input which created a $2 million output because it was spent twice.

It should be noted that the extent of the multiplier effect is dependent upon how consumers respond to the additional income. If consumers decide to save the additional money, the multiplier would be lower. If they decide to spend it all, the multiplier would be higher.

The multiplier has been used as an argument for government spending or taxation relief to stimulate aggregate demand. Some notable examples are shown in Figure 11.

Figure 11: Real-World Cases in which Multipliers were Considered and Applied

*The Olympic Games are often cited as catalysts for regional economic growth. The arrival of tourists from across the globe plus the worldwide exposure of the host cities can create thousands of jobs and higher incomes to the areas, even in the short duration of two weeks. The benefits, however, are difficult to forecast since many other variables (aggregate demand, in-place infrastructure) play a role in the area's economic multipliers.

* The Department of Defense Base Realignment and Closure (BRAC) is watched very closely by communities, particularly rural ones. It is often believed that when bases close, so goes the military presence and monies. Grocers, pubs and barbers also inevitably suffer. The shortage of jobs and monies has also been reported to raise crime rates, but the degree to which is questionable. Communities are discovering that the long term impacts are not as severe as previously thought, however. In addition, some communities such as Bowie, Maryland may actually benefit from a proposed realignment.

* In the State of Alaska, oil companies work with the State Department of Labor to develop training programs in advance of project construction so that native Alaskans can be eligible to fill sorely-needed positions. The state has targeted companies with significant non-resident employment in an attempt to stop some of the leakage from workers coming to the state and sending their paychecks to their home state.

* Various Administrations have adopted Stimulus Packages (construction jobs, tax credits) as means of stimulating a stagnant economy. The American Recovery & Reinvestment Act of 2009 involved a $787B spending on various "shovel ready" construction projects. As a means of targeting regions of the country and for prioritizing projects, decision-makers examined the multiplier effects for various regions and industries.

3.3 Multiplier Effect of Corps Projects

RED impacts to income and employment are a direct result of the expenditure stream of a Corps project; starting with outlays for construction costs and ending with the last expenditure for operations and maintenance or project monitoring. Placement of a Corps project in a given area represents a new source or injection of revenue into the regional economy. Like all infusions into an economy, the effects of that injection are not limited to the initial expenditures, or in the case of Corps projects, the ongoing stream of expenditures for operations and maintenance but constitute a 'ripple' effect through the economy.

Corps projects provide federal monies to the local economy as funds are expended on goods and services necessary to support the project's construction. Expenditures include the physical materials, but also the salaries of those working on the project. In effect, the money gets spent a second time, once by the government and once by the provider of goods and services to the government. It is expended a third time and a fourth time, each time what is received as payment for goods and services or received as wages, some of which is saved, but more is spent again. Eventually the rounds of this new injection will peter out as all the effects are identified.

For a recent Corps project in Riverside County (see case study), the induced output multiplier for the construction category "Highway, Street, Bridge and Tunnel Construction" was determined to be **0.36**. This means that for every dollar spent on this type of construction activity, an additional **$0.36 dollars** of output is generated as those employees earning money working on the construction project respend their wages in other sectors of the economy[7], which then generates additional rounds of spending.

3.4 The "Nuts and Bolts" of Multipliers

Recall our Duryea auto plant. Let's say that you are working for the City of Humdrum and would like to estimate the impact of Duryea's new plant on the local economy. Let's assume that all the planning, site selection, design of the facility, financing, etc. has already been completed. The total cost to construct the plant is estimated to be $100 million while its construction will take place over a period of four years. Assume that on March 1st of the current year, a ground breaking takes place and construction begins. Further assume that 75 percent of the contracts for plant construction are awarded to firms located in the city of Humdrum.

What would be the impact on the local economy from construction of this facility? By assuming 75 percent of the contracts and a $100 million price tag, the first round of spending should inject $75 million into the local economy on other things. Let us then assume that each successive round of spending results in 75 percent of the outlay remaining in the study area, and the remaining 25 percent of the injection will be saved or "leaked to" outside the study area. The second round of spending equals $75 million multiplied by 75 percent ($75,000,000 X 0.75) = $56,250,000 to be spent on other things. This decreasing cycle will continue until the impact of

[7] A construction worker could spend his money on a haircut. The same could be said for the utility worker who helps supply the extra electricity brought on by the project.

the initial expenditure cannot be measured. If you extended our theoretical example far enough out, it appears that the rounds will peter out during the 79th cycling! It is during that round that the additional amount added to the area economy equals a mere one cent!

A more manageable way of calculating the multipliers (Chapter 6 of this handbook describes tools which perform these calculations) is to stop measuring this recurring effect when the sum total of the impact for a cycle equals 85 percent of the cumulative total impacts of an endless permutation of the model cycle. Figure 12 shows that point to be reached somewhere between the sixth and seventh cycle.

$$\lim_{t\to\infty} \sum \alpha_t i = \mathrm{X}$$

where: t = number of permutations
α = beginning cycle addition
i = percentage of expenditures expended inside the economic unit
X = cumulative total

The limit described in the equation tends to $400,000,000 as *t* reaches infinity. The 85th percentile is reached between the sixth and seventh cycling. The sum total of the impact of the initial $100 million dollar investment on the economy at the 85th percentile is somewhere between $328.8 million and $346.6 million. Interpolating between the two data points, results in $339.5 million for the 85th percentile. The multiplier is 3.4. If we extend the analysis to the last penny created, the sum total impact would approach $400 million, giving us a multiplier of 4.0.

Figure 12 – Multiplier Analysis

Cycle	Amount spent per cycle	Cumulative Total	Cumulative Percentage
1	$100,000,000	$100,000,000	
2	$75,000,000	$175,000,000	44%
3	$56,250,000	$231,250,000	58%
4	$42,187,500	$273,437,500	68%
5	$31,640,625	$305,078,125	76%
6	$23,730,469	**$328,808,594**	**82%**
7	$17,797,852	**$346,606,445**	**87%**
…	…	…	…

3.4.1 Assumptions of Multiplier Analysis

A basic assumption of multiplier analysis is that there are underemployed or unemployed resources within the local economy. If an area is already at full employment, local employers would need to raise their wages to convince workers to leave their jobs. To cover the higher wages, companies would be forced to raise prices of their products. In fairness, the RED analyst should validate whether the area or specific industries are fully employed. For example, the roofing industry in New Orleans experienced a sharp mark-up in wages due to the fact that the labor pool was overly committed to repairing the hundreds of thousands of roofs in the wake of Hurricane Katrina.

A second assumption of the multiplier effect is that some of the income generated at each cycling is removed or “leaks” out of the regional economy in the form of savings. For each additional dollar earned, the consumer will spend a portion of that dollar and will save a portion of that dollar. Without this leakage to spending (savings) the consumer will spend all of his additional income adding an exponential mechanism to the cycling rather than a decreasing mechanism as exhibited in Figure 11.

3.5 Input-Output (I/O) Analysis

The primary analysis used in examining injections into an economy is **input – output (I/O) analysis**. I/O analysis is based on the notion that there is a fundamental relationship between the volume of output of an industry and the volume of the various inputs used to produce that output. Industries are often grouped into production, distribution, transportation, and consumption or they can be defined as narrowly as is necessary.

The **input-output model** of economics uses a matrix representation of a region's economy to predict the effect of changes in one industry on others and by consumers, government, and foreign suppliers on the economy. Wassily Leontief (1905-1999) received the Nobel Prize in Economics for his development of this type of economic model.

More specifically, input-output analysis measures the inter-dependence among industries and workers in an economy. The greater the inter-dependence among industry sectors, the larger the multiplier effect on the economy (and jobs) if a local industry receives new sales receipts from outside the region or from the government. Changes to monies drive the input-output model to project new levels of sales, employment, and personal income for each industry (Galbraith, 1999).

Leontief was a very strong advocate for using quantitative data in the study of economics. Throughout his life Leontief campaigned against "theoretical assumptions and non-observed facts". According to Leontief, most economists were reluctant to "get their hands dirty" by collecting raw empirical data. To that end, Leontief pushed to make quantitative data more accessible, and more indispensable, to the study of economics.

At a 1973 press conference shortly after the Nobel Prize announcement, Leontief gave an understandable example of how input-output analysis works: "When you make bread, you need eggs, flour, and milk. And if you want more bread, you must use more eggs. There are cooking recipes for all the industries in the economy." And hence, one industry's output is another's input, and the chain continues. Time Magazine publicized the event proclaiming “Government economists now compile a huge statistical grid showing how much each economic sector buys and sells from every other major sector. Using the chart, they can, for example, calculate how much a decision to slow the building of barracks will reduce the sales not only of the paint industry but also of the chemical firms from which it gets its pigment. Also, planners can decide what changes in the tax structure might increase employment in the shipping industry or promote the construction of boxcars.” (Time,1973).

One of the first applications of input-output analysis was when the U.S. Bureau of Labor Statistics (BLS) attempted to construct a national input-output table following the Second World

War. The effort culminated in the 1947 publication of a 50-sector table of inter-industry relations followed shortly thereafter by a 200-sector table with more highly-detailed industrial and sectored classifications. The table provided reputable projections of postwar employment growth in various industries along with policy recommendations should the economy fall short of full employment.

The tools discussed in Chapter 6 are based on this I/O framework. The basic operation of an I/O framework is discussed in the following section. Don't be daunted by the mathematics—it is much simpler than it looks!

3.5.1 The I/O Framework

Every entity, from the largest firm to the common household, can be thought of as a model of production. Every entity **consumes** goods and services that are provided by the economic market, and then uses those goods and services to **produce** other goods and services to be sold in the economic market. This circular flow is familiar to any student of economics. Think of the economy as one large corporation. Income earned through the purchase of a corporation's output is ultimately returned to the purchaser via the labor market as the wages and salaries of the corporation's employees. This income to the employee is eventually returned to the corporation when the employee purchases a product or service. Building on this, the five sector circular flow of income model lays out the inter-dependencies of the economy at large (Figure 13).

- The Financial Sector consists primarily of banks who engage in the lending and borrowing of money. The savings from households gets re-injected as investment (I) into the business/firms sector. Should households decide to save their money, the amount disappears from the circulation since the saved money would not be respent in the economy.

- The Government Sector, which consists of the economic activities of local, state and the federal government, collects revenues through Taxes (T) on households and firms. Government spending (G) represents an injection (put towards collective services or welfare payments to the community) whereas the taxes represent leakages of the current income which reduces the overall expenditures on current goods and services.

- The Overseas Sector represents the movement of imports and exports. The main leakage from this sector are imports (M), which represent spending by residents into the rest of the world. The main injection provided by this sector is the exports of goods and services which generate income for the exporters from overseas residents. The state of equilibrium occurs when the total leakages are equal to the total injections that occur in the economy. This can be shown as:

Savings (S) + Taxes (T) + Imports (M) = Investment (I) + Government Spending (G) + Exports (E)

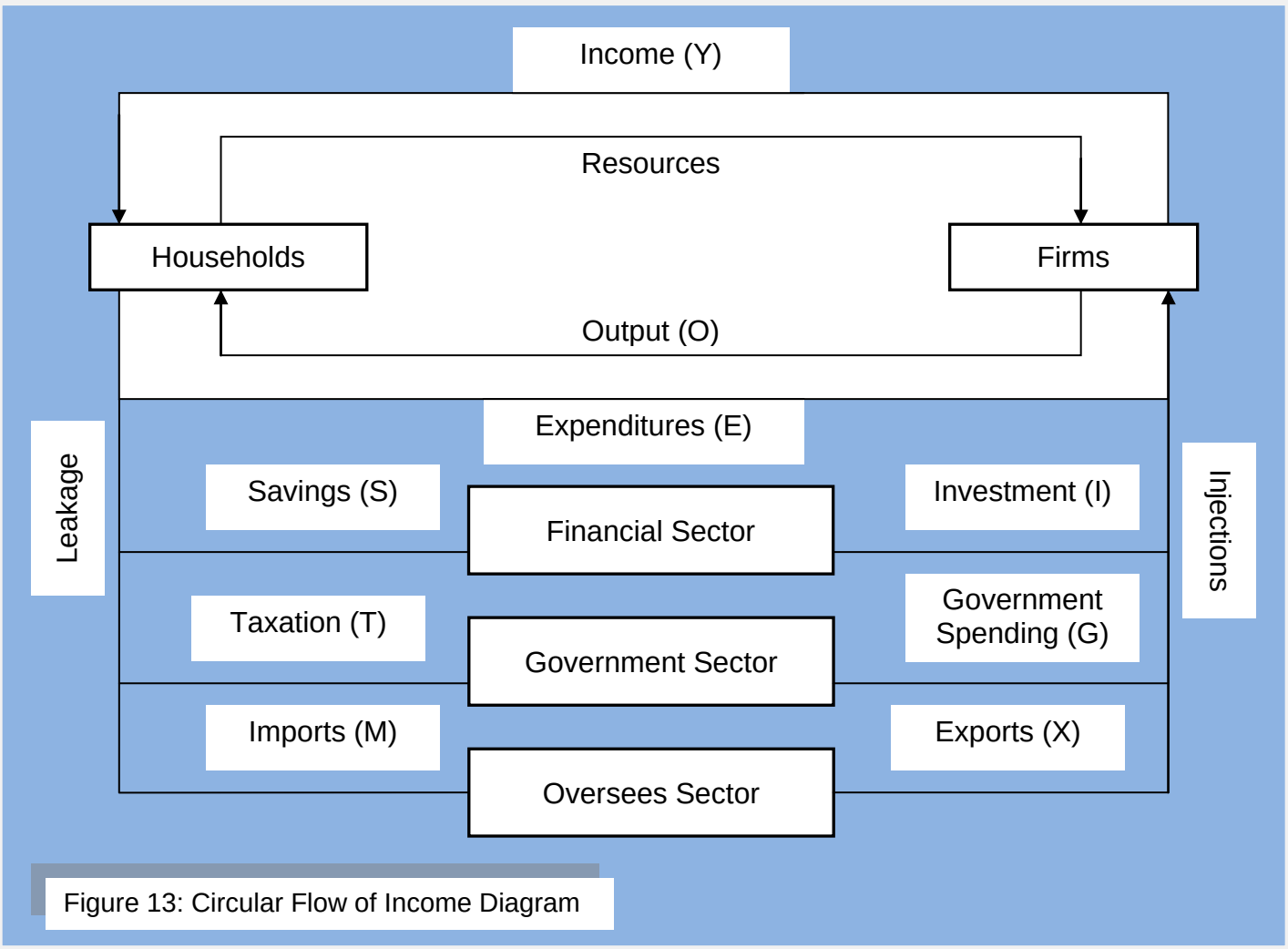


Figure 13: Circular Flow of Income Diagram

3.5.2 Performing Input-Output Analysis

Inputs = Outputs, thus I-O Analysis

In order to perform an input-output analysis, we must first become familiar with the relationships among the industries in the economy. This following example, drawn from Chapter 6 of the Fifth Edition of Urban Economics (McGraw-Hill/Irwin, 2003) explains the workings of an input-output analysis. Suppose a city produces and consumes just three goods: computers, electrical wire, and local consumer goods. Computers and wire products are produced for both export to outside regions and for local consumption. By definition, local merchants (restaurants, dry cleaners, grocery stores) produce goods for local consumption. Figure 14 shows the transactions in the city's economy. The first column of numbers shows the input usage of firms in the computer industry. To produce $2,000 worth of computers, the computer firms buy $400 of electrical wire, $1,000 of labor from city residents, and $600 of imported inputs (raw materials and intermediate inputs). The next column shows the input usage of wire producers, who use computers, labor, and imported inputs to produce $1,000 of wire. The third column shows the input usage of local merchants, who use computers, labor,

and imports to produce $2,500 of output. The household column shows how households divide their total income ($3,600) between computers ($180), local goods, ($2,500), and imports ($920). The export column shows the exports of computers ($1,370) and wire ($600). The total column shows the sum of the items in each row. Note that the figures in the total column match the figures in the total row.

Figure 14: Transactions Table from Input-Output Study

Inputs	Computer Firms	Wire Producers	Local Merchants	Households	Exports	Total
Computers	$0	$300	$150	$180	$1,370	$2,000
Wire	$400	$0	$0	$0	$600	$1,000
Local	$0	$0	$0	$2,500	--	$2,500
Labor	$1,000	$600	$2,000	$0	$0	$3,600
Imports	$600	$100	$350	$920	--	$1,970
Total	$2,000	$1,000	$2,500	$3,600	$1,970	

Figure 15, which is derived from Figure 14, provides a summary of the interactions between firms and households. The first column of numbers shows the input coefficients for the computer industry: for every dollar worth of computer production, the computer industry uses 20 cents worth of input from the wire industry ($400/$2000), 50 cents worth of labor ($1000/$2000), and 30 cents worth of imported materials (e.g., silicon chips and plastic). The second and third columns show the input coefficients for wire producers and local merchants. The fourth column shows that households spend 5 percent of their income on home computers, 69 percent on local goods, and 26 percent on imports.

Figure 15: Input Coefficients Table

	Producers			
Inputs	**Computer Firms**	**Wire Producers**	**Local Merchants**	**Households**
Computers	0.00	0.30	0.06	0.05
Wire	0.20	0.00	0.00	0.00
Local	0.00	0.00	0.00	0.69
Labor/Wages	0.50	0.60	0.80	0.00
Imports	0.30	0.10	0.14	0.26
Total	1.00	1.00	1.00	1.00

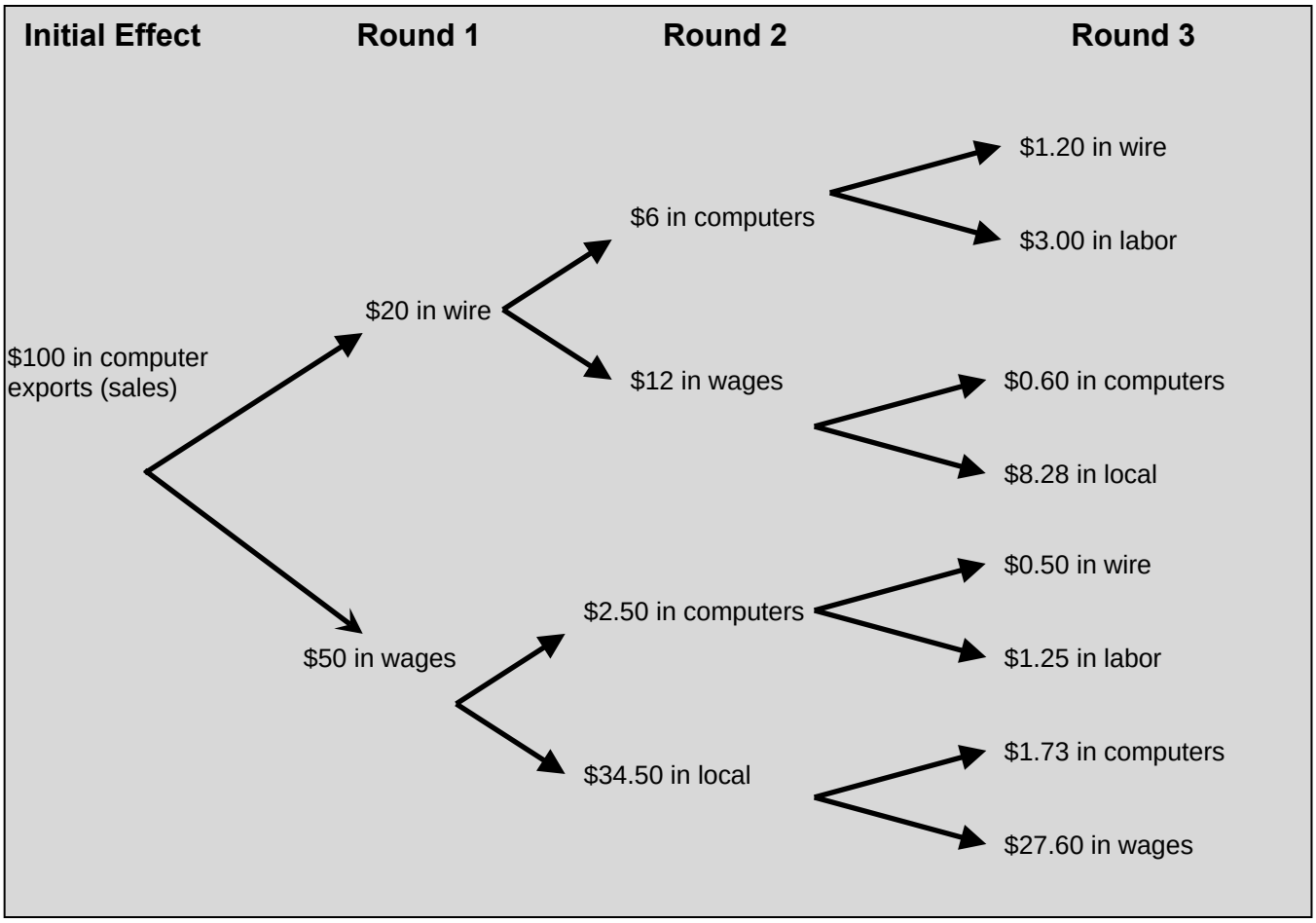
The information in Figure 15 can be used to estimate the multiplier effects of an increase in computer exports. Suppose that computer exports increase by $100, (or alternatively, an “injection” of Federal funding). The increase in computer sales will increase local spending, precipitating a series of spending rounds. The first three spending rounds are shown in Figure 16.

- Round 1: The increase in computer sales increases wire production by $20.00. The input coefficient of 0.20 (found in the “Computer Firms” column, “Wire” row) is multiplied by $100.00. Similarly, the increase in computer sales increases labor/wages by $50.00. The input coefficient of 0.50 (found in the “Computer Firms” column, “Labor/Wages” row) is multiplied by $100.00.

- Round 2: The $20 increase in wire production increases computer sales by an additional $6.00 (0.30 X $20) and wages by an additional $12.00 (0.60 X $20).

- Round 3: The increases in computer sales, wages, and local sales cause additional increases in wire sales, wages, computer sales, and local consumption.

Figure 16: The Multiplier Process



Because of the multiplier process, an increase in computer exports increases spending on all three goods. The spending and re-spending of income continues forever, but every spending round is smaller than the previous one. The multiplier process eventually peters out because both producers and consumers either spend some of their budgets on goods outside the study area or save the remainder. As shown in the fifth row of Figure

15, the Input Coefficient Table, (Imports), there is a leakage[8] of 30 percent in computer production ($600/$2,000), 10 percent in wire production ($100/$1,000), 14 percent in local goods production ($350/$2,500), and 26 percent from consumers ($920/$3,600). These leakages weaken the multiplier process, causing each spending round to be smaller than the previous round.

The input coefficients from Figure 15 can be used to compute spending multipliers for the two export industries shown in Figure 17. These multipliers encompass the direct, indirect and induced economic effects. For a description of the techniques used to derive the spending multipliers, see the appendix. Fortunately, high-speed computers do the laborious calculations for you.

The first column shows the multiplier effects of a $1 increase in computer exports. Total computer sales increase by $1.23 (1 x 1.23); wire production increases by $0.25 (1 x 0.25); and local sales increase by $1.17. The total multiplier effect is the sum of the effects on the three industries: a $1 increase in computer sales increases total sales by $2.65. Because the wire industry has a smaller import leakage (10 percent compared to 30 percent for the computer industry), it has a larger multiplier (3.04 versus 2.65).

Figure 17: Multipliers

	Added Sales per Dollar of Additional Export Sales of	
	Computers	Wire
Computers	1.23	0.52
Wire	0.25	1.10
Local	1.17	1.42
Total	2.65	3.04

In practice, the magnitudes of multipliers vary depending on the technology of the industry in which spending occurs and the size of the area economy –which affects the portion of these impacts that remain in the local economy and the portion that "leaks out" to outside areas. The multiplier values for most industries are generally around 2.5 - 3.5 for national impacts, 2.0 - 2.5 for state impacts and 1.5 - 2.0 for local area (large cities) impacts. Also, when regarding RED, one could use several multipliers, one for income, and another for jobs, etc., to estimate RED effects. The I/O analysis can also allow one to examine the multiplier effects to several industrial sectors.

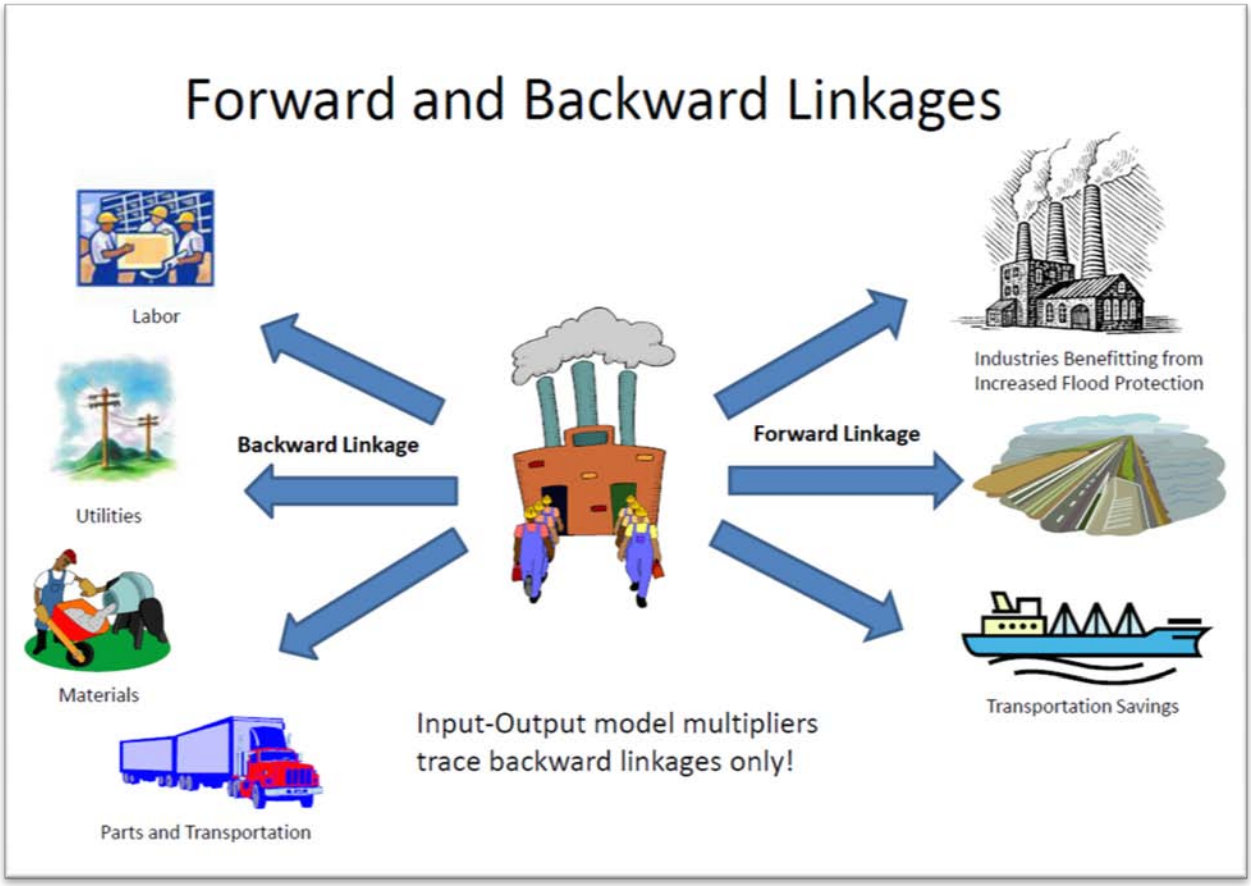
3.6 Cautions in Applying Multipliers to I/O Analysis

I/O analysts should avoid using the same multiplier from one study to the next. Borrowing multipliers from other regions or applying a multiplier for a larger region (such as state or region) to a smaller region has been one of the most common abuses of economic multipliers and can lead to significant errors in regional impacts (Beattie and Leones, 1993)[9]. Even for the same

[8] In macroeconomic theory, “leakages” are defined as income spent for products outside of the regional economy.
[9] Beattie and Leones warns against using the ‘all purpose’ or ‘standard’ multiplier. “These are multipliers that people pull out of the air because they don’t have access to multipliers estimated using a full-blown model or

economic activity, multipliers still vary across regions, sectors, and time periods. In addition, I/O models provide annual snapshots of data, so it may create challenges for projects having expenditures spread out over very long time horizons. Finally, I/O models assume a linear technology or recipe which will not capture changes in the recipe due to changes in relative prices.

In RED lingo, effects are often categorized as "backward" and "forward" linkages. Backward linkages describe the linkage between industries and suppliers and can be expressed as computed multipliers in an I/O model. Forward linkages are generally not reflected in the input-output multipliers and require more thought. In a recent Cornell study, child care was found to provide income and employment to businesses linked to it (a "backward linkage"); but it also created the capacity to support working parents (a "forward linkage") who in turn pay taxes, and increase the productivity of the region. In Corps settings, it is often easier to estimate the backward linkages associated with a project's construction. Estimating the impacts to the region based on project benefits, e.g., the increased transportation efficiencies may require detailed surveys of business owners along with examinations of effects in other regions.



because they don't know any better. The most common ones we hear are output multipliers of 3 or 3.5. These are large for state economies and even more so for county and city economies."

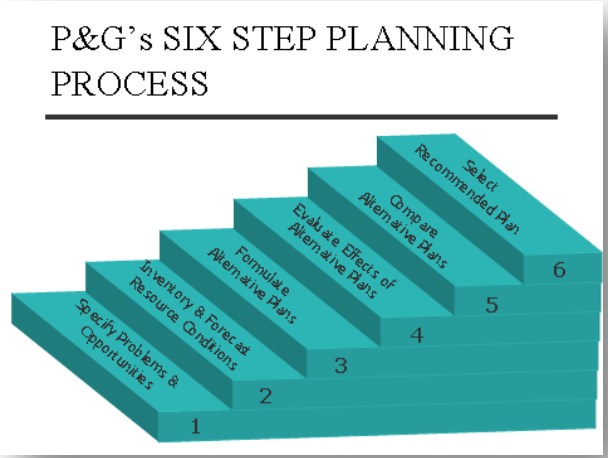
3.7 Summary and Look Ahead

By now, you should have a brief understanding of the “nuts and bolts” of RED analysis. While the mathematics and economic theory can be daunting to those with little experience with it, there is an abundance of software that provides easy-to-follow directions and results. The goal here is to explain the local and regional impacts of federal investments and not to get bogged down with the details.

It is important to know that RED impacts of a study area often differ from those in a traditional NED analysis. In many cases, these effects ripple through a series of businesses and communities. The direct, indirect, and induced RED impacts can be estimated through the application of Input-Output Analysis. The degrees of impact are generally measured by the multipliers.

The next chapter will walk the planner through the Corps’ 6-step planning process and how RED fits into each step.

4. Performing RED Analysis within the Corps' Planning Process



Six-step planning diagram frequently cited within the Corps of Engineers

This section describes the types of RED effects, information and recommended procedures for each step of the Corps' six-step planning process. More details on the six-step planning process can be obtained in the Planning Primer and Planning Manual (Orth and Yoe 1997). The main thing to remember is that planning may have six steps, but it is not a nice, neat sequential process, but a series of iterations. RED is no different to the process.

Step 1: Identifying Problems and Opportunities

Questions to Ask During Step 1 of the Planning Process

- What are the project objectives?
- Where is the location of the economic impact?
- How would the non-federal sponsor define the boundary since they may be interested in publicizing the impacts and estimating additional tax revenues?
- What potential RED metrics would the PDT need to consider?
- What time-frame would the PDT consider?

During this initial yet critical step, the planner should attempt to understand the economic landscape of the region and begin to develop a baseline of economic conditions in the study area. Employment, population, income and types of businesses are just some of the variables that comprise an economic baseline. The US Census Bureau's website houses detailed city and county population data. The Department of Labor's Bureau of Labor Statistics provides detailed industry data on employment, hours, and worker's earnings for counties, Metropolitan Statistical Areas (MSAs), states, and the nation. County data is often published quarterly; MSA, state and national data is often published monthly. The Department of Commerce's Bureau of Economic Analysis provides quarterly data on State and MSA Gross Domestic Product as well as state and local personal income.

Perhaps the most critical task to be undertaken during Step 1 is defining the area of impact or ***functional economic area***. Most RED analysis software packages rely on county-based income and employment data to calculate beneficial or detrimental impacts. At a minimum, the study area should be large enough, e.g., a county or a few counties, in order to effectively link

the claimed impacts to the source project. If, however, the study area is extremely large, as may be the case with watershed studies, project effects may be masked by extraneous economic activities. In some areas such as Alaska, project effects could reasonably leak to the lower 48 states or Canada due to the large number of transient workers. For projects that have multi-jurisdictional issues such as a lock and dam on a river bordering two states, the sponsors of both states will be very interested in knowing the economic impacts affecting each of their jurisdictions. Thus, a powerful multi-regional input-output model may be needed. The size of the multiplier for a given region depends heavily on how the study region is defined.

The study area of the RED analysis is often different that the one considered during NED or NER analysis. Because RED impacts can ripple through an economic system, the planner will often need to explore several counties that comprise the metropolitan region. The RED analysis should include a section describing the links between the "home" county where construction is being planned and the "child" counties having no part of the construction footprint, but where additional benefits of construction or O&M could be claimed.

Finally, during Step 1, the planner should work closely with the local sponsor in gathering their input and deciding which RED parameters (income, employment, output etc.) would be best suited for their particular study. The sponsor may highlight specific businesses that could potentially shut down if no federal action were to be taken.

Step 2: Inventorying and Forecasting Conditions

Questions to Ask During Step 2 of the Planning Process

- How will conditions in the study area change over the period of analysis?
- Which RED metrics would best convey the planning story?
- What types of businesses may be impacted by a project?
- Which RED model would be most appropriate for the particular study?

By now, the planning team would have sought stakeholder input and performed a baseline assessment of the key economic variables in the study area. At this stage, an appropriate impact area for the RED analysis should be pretty much hammered down while the industries potentially impacted by project improvements should be identified. When defining the economic area, the analyst needs to consider: initial impact site, residential location of the labor force (commuters), travel corridors, location of supporting industries and services and location of consumers.

Much of the data used in the inventory would serve a useful purpose in the generating forecasts. Some forecasts such as population and income are relatively easy to find. Economic forecasts over a long period or for specific industries are often more challenging and expensive. In a world of limited budgets, the key is to collect the data needed, not the data available. An information-gathering strategy can help you identify what is needed and where to get it. Hopefully by engaging with the stakeholders early on, the team will decide on the level of effort and amount of detail required in the economic forecast. By the end of Step 2, the team should also have a good sense of how vulnerable and resilient a community is to external events. Severe or long-term flooding, for example, could have substantial impacts on the local and regional economies and should be accounted for under the "without project" condition.

Step 3: Formulating Alternative Plans

Questions to Ask During Step 3 of the Planning Process

- Which kinds of measures directly and indirectly address the local and regional economies?
- How important should the RED account be to the overall decision?
- Will a project's construction result in temporary closures of businesses or recreation facilities?
- Will a project be completed right away or in phases?

This is the point in the planning process "where plans come from." Plan formulation is defined as the process of building plans that meet planning objectives and avoid planning constraints. If the team determines the RED to be a significant driver in the overall decision, then plans ought to address the local and regional economic needs raised in the previous two steps. After

performing the baseline assessment, for instance, the team may discover their study area to be plagued with high and persistent unemployment. Potential management measures could consider economic incentives, perhaps in the form of more labor-intensive construction components, so that RED benefits and not simply NED benefits could be realized. However, planners need to remember that the NED plan may not end up being the plan providing the greatest RED benefits (perhaps that particular plan could be considered a Locally-Preferred Plan) Also, the RED impacts may vary based on the timing and location of a project, so that information may be useful.

Step 4: Evaluating Alternative Plans

Questions to Ask During Step 4 of the Planning Process

- How does each measure address the local and regional economic conditions?
- What are the pros and cons of each alternative from an RED context?
- What are the spillover RED benefits for each project alternative?
- What assumptions would you make regarding how monies will enter/leave study area?

The purpose of evaluation is to find the value or worth of something. All measures and plans require some evaluation and obviously the best alternatives require the most detailed evaluation. As stated in the *Planning Manual*, evaluation is a two-part process*:* **assessment** *(quantification) and* **appraisal** *(judgment)*. Evaluation, like all other planning steps, is also an iterative process. It begins with the first screening of measures and plans and its detail and rigor increases as planning moves closer to a final decision. At this stage, the planning team should have a greater sense of the RED effects that a particular project would provide, however detailed RED statistics may still be unavailable at this point.

Step 5: Comparing Alternative Plans

Questions to Ask During Step 5 of the Planning Process

- What are the tradeoffs in RED from one alternative to another?
- Will non-federal sponsor consider a Locally-Preferred Plan (for an alternative different from the NED/NER)?

During Step 5, information on plan effects is displayed and used to establish which plan is preferred and why. All relevant information should be considered when comparing plans. The primary purpose of displaying and discussing the information and rationale for arriving at a preferred plan will be to communicate with decision makers who will actually select the recommended plan in the next step. When comparing alternatives, the P&G (Paragraph 1.6.2(c)) suggests applying the four evaluation criteria -- completeness, effectiveness, efficiency and acceptability. **A complete** alternative is one in which all the necessary implementation investments or other actions have been accounted for, either by Federal or non-Federal entities in the planning process. An **effective** plan makes a significant contribution to the solution of some problems. **Efficiency** is the extent to which an alternative plan is the most cost effective

means of alleviating the specified problems and realizing the specified opportunities. **Acceptability** is the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies." It is important to recognize that these criteria are not to be exclusively defined as "go "and "no go", but expressed as a range as presented in Figure 18. A PDT could also establish minimum standards for each of the criteria early in the screening process.

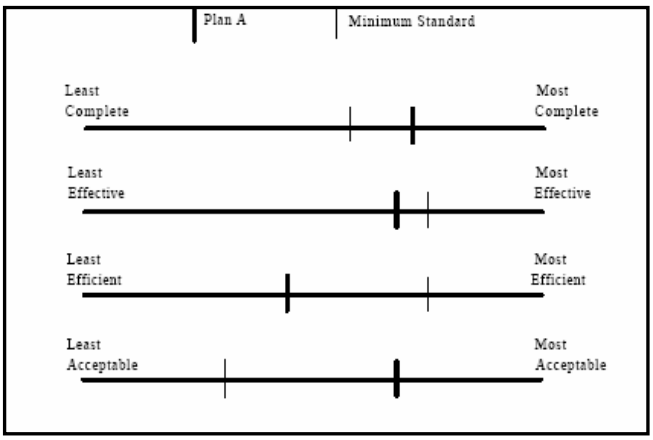


Figure 18: Source "Planning Manual"

One strategy in comparing plans is to assemble all the relevant details about plan effects, as presented in Figure 19. Changes in employment, income and tax revenues are just some of the metrics that can be employed when comparing alternatives in an RED context. Of course, some models can produce very detailed information on the RED effects; the PDT should agree on the level of detail appropriate for each study. Some RED effects, such as the estimated spillover benefits following a project's construction, may not be available until the detailed cost estimates are completed. Other RED effects, such as a flood's impacts on local businesses could be available sooner.

Figure 19-- Summary Comparison of Effects of Plans

	Plan A		Plan B	
Effects	**Pros**	**Cons**	**Pros**	**Cons**
NED	$1.5 M in average annual NED benefits in reduced flood damages	$1 M in average annual cost	$1.7 M average annual NED benefits in reduced flood damages	$1.5 M average annual cost
EQ	Preserves 500 acres of riverine habitat	Loss of 5 acres of wetlands	Preserves 600 acres of riverine habitat	Loss of 5 acres of wetlands
RED	**Local business income increases by 30%; 5,000 additional jobs created**	**1% increase in local taxes**	**Local business income increases 35%; 6,000 additional jobs created**	**1.5% increase in local taxes**
OSE	Provides the opportunity for continued growth and development of community having robust civic infrastructure and diverse and vibrant neighborhoods	Increased tax burden on all, but greater impact on the community's working poor	Provides the opportunity for continued growth and development of community having robust civic infrastructure and diverse and vibrant neighborhoods, plus a more economically resilient business community, and slightly more recreational access to the river for the community	Increased tax burden on all, but greater impact on the community's working poor

During Step 5, the planning team could collectively decide to assign preferences to the effects associated with each plan and see how each plan performs under various weights or via multi-criteria decision methods. The team may also refine the alternatives or identify the tradeoffs

between alternatives, such as the NED and LPP. Of course, this valuation process is largely dependent on the input of sponsors, stakeholders, outside agencies and others. It is important to recognize how the accounts relate to each other. For example, a project alternative may help to prevent a manufacturer from leaving a distressed area. From an NED perspective, there is no difference in the benefits to the nation. The manufacturer would still be able to produce its wares in the same region. But from a regional perspective (RED), the manufacturer's location will be of great importance because of the jobs, income, and tax revenues produced. And, if the area is already suffering from depressed income and unemployment, creating or preserving employment can be a significant RED (as well as an OSE) concern[10].

Step 6: Selecting a Plan

Questions to Ask During Step 6 of the Planning Process

- What is the NED Plan, National Ecosystem Restoration (NER) Plan or Combined NED/NER Plan and how significant is RED within that plan?
- Is the non-federal sponsor endorsing a plan different from the NED, NER, or NED/NER Plan?
- What are the summary RED statistics?
- How does the RED impact the locally-preferred plan?

In this step, the decision maker(s) selects the recommended plan. The Federal objective requires the Corps to identify the NED, or as in the case of ecosystem studies, the National Ecosystem Restoration (NER) plan. However, exceptions to the NED, NER, or Combined NED/NER plans can be recommended. The rationale for making the choice of recommended plan should be explained, making pertinent comparisons of effects with the without project, No Action and other plans. A water resource project may provide greater RED benefits than those of the NED plan. As a result, the non-federal sponsor may promote this project as a locally-preferred plan (LPP). Recommending the LPP has unique cost sharing implications and requires exemptions from the ASA(CW).

Step 7: Compute Detailed RED Statistics for Recommended Plan Reformulate?

Finally, for this additional task, planners should compute additional RED statistics for the recommended plan, if they have not already. For construction-related benefits, you may need to categorize and stratify the construction costs in order to accurately determine the benefits by industry. Depending on the relative importance of the RED account in the overall decision, the PDT could decide to refine the recommend plan by adjusting portions of the project to accommodate the regional economic needs of the study area. However, this could result in a deviation from NED requirements, causing the once NED to become a locally-preferred plan, along with its cost sharing implications.

[10] Again, in rare cases, a Corps project can provide claimable NED benefits to a region experiencing severe and chronic unemployment.

4.1 Special Considerations for RED Analysis

4.1.1 Classification of NED vs. RED Effects

The Federal objective in water resources planning is National Economic Development. Under this objective, society consists of all U.S. residents. This is a matter of perspective and national policy, not economics. If a Federal project induces a firm to leave one state to locate in the newly-protected floodplain of another state, the increase in regional income for the project area may well be a benefit to that area (and often presumed to be included among project benefits). If, however, such effects are included as benefits, we must also consider the loss of income in the state that loses the firm as a project cost. This is necessary to be consistent with a project to all U.S. residents. In most cases, the project area's gain is another area's loss and the two effects represent a transfer of income that cancels out any net change. The same scenario applies to navigation projects which may enable one port to lure traffic from another port. Corps guidance in navigation project evaluation is to include only net increases in traffic as project benefits. This is a policy consistent with the objective of National Economic Development.

At the regional, state of local levels, the operational definition of society is different, because the perspective is different.

4.1.2 Use of Otherwise Unemployed or Underemployed Labor Resources

The economic effects of the direct use of otherwise unemployed or underemployed labor resources during project construction or installation may, under certain conditions, be included as an NED benefit. NED benefits from this category apply only to areas having severe and persistent unemployment. ER100, Appendix D lists the eligibility requirements (unemployment needs to be at a particular level over a specified length of time, etc). Moreover, the level of claimable project benefits depends on the work requirements, occupational availability and types of construction. Conceptually, if you build a project in a chronically unemployed region, the opportunity cost to the nation of using that labor is zero; thus you can subtract it from the project implementation cost that use to compute net benefits. On the RED side, one can estimate the number of jobs added with the assumption that they are filled by workers already living in the area or others temporarily moving into the area.

There have been sporadic exceptions to the NED rule for Federal decision-making with regard to the evaluation of public expenditures. For example, most Appalachian counties during the 1960's were plagued with low per capita income, high and persistent unemployment, declining population, low levels of educational attainment and above-average malnutrition rates. The Appalachian Regional Development Act, passed by Congress in 1965, aimed at improving the region's access to the rest of the nation's economy by investing in capital intensive projects as well as health programs and vocational educational facilities (Miernyk, 1982). Section 2038 of WRDA 2007 contains language allowing the Corps to in help economically disadvantaged communities located in remote areas and dependent on water transportation for subsistence. Those particular navigation projects do not require project justification solely on the basis of NED.

Historically, only a handful of civil works projects have been justified on the basis of employing workers who would have been otherwise unemployed or underemployed. The guidance

also cautions about applying other methods of estimating benefits associated with the use of unemployed labor resources during project construction. The *Report of Survey of Corps of Engineers Construction Workforce* (IWR Research Report 81-R05) introduces several techniques, including the one provided in ER100. The report also states that if the technique deviates from the one provided in ER100, that technique should only be used to demonstrate how sensitive the results are to the different benefit measurement methods. Furthermore, "unemployment NED benefits shall not be used to economically justify projects. Net benefits should be positive when using traditional benefit categories.

4.1.3 Temporal Effects

Planners should be cognizant of the temporal impacts of projects. For example, construction-related impacts usually occur earlier and over a shorter period of time than do operations and maintenance. Likewise, areas with projects providing transportation cost savings (or other efficiencies) may experience RED impacts later on. Many models may need to be refined to address temporal effects.

4.2 Summary and Look Ahead

By now the planner should be aware that the RED analysis need not begin only after a final alternative is recommended. Indeed, as we have seen, critical baseline information on the local and regional economy can be collected early in the 6-step planning process and such information may actually influence the types of measures being formulated. The degree to which RED influences projects and project recommendation, especially given the rules on NED/NER, is still being discussed. In the next chapter, we will discuss how RED can be applied for each of the Corps' project purposes.

5. RED Considerations by Type of Project

This chapter discusses the particulars for each type of project improvement as they relate to the RED account. Individual sections are given for deep draft navigation, inland navigation, flood and coastal storm risk management, ecosystem restoration, and others.

5.1 Deep-Draft Navigation

NED benefits of deep draft navigation projects are often realized from reductions in transportation costs, made possible by larger vessels, increased vessel efficiencies, reduced transit times or reduced vessel damages. Specifically, navigation projects may involve deepening or widening of ship channels, building or modifying jetties or breakwaters, and dredged material management. Non-structural alternatives such as rescheduling, employing tug escorts, and changing intermodal practices, are implemented less frequently, but remain important nonetheless. Finally, the Corps has several authorities aimed at improving safety for vessels, which include the removal of debris and obstructions, as well as snagging and clearing[11].

When determining the RED gains to a Port's growth, the planner should carefully separate the growth as a result of the project with the "without-project" growth. It is likely that there will be some RED growth at the port even without project improvements.

A vessel calling on a deep-draft port may call on several other ports besides that which is being studied, but the main study area is generally confined to the port and its hinterlands. When undertaking a deep-draft navigation project, the planner should collect information on port traffic, port-related employment, and revenues as a baseline. Once the alternatives are formulated, the planner should then attempt to estimate the gains in cargo traffic, employment and revenues as a direct result of the project. For example, a deepening project may enable a new fleet of containership vessels to enter the port where they had been unable to enter previously. In many cases, a deep-draft project will provide two rounds of RED benefits; first, as a result of the federal investment towards its construction and maintenance ("backward linkage") and second, as a result of the induced growth from other ports ("forward linkage"). The recent Oakland Harbor Deepening Project, for example, is expected to generate more than 6,000 permanent jobs, an additional $1.9 billion in annual business activity and $62 million in increased local taxes for the San Francisco Bay Area. Occasionally dredging projects may employ laborers from outside the region in the same vein as workers on oil rigs. In these cases, the induced effects of income and employment may be low due to the high leakages out of the study area. Finally, the PDT should be cognizant of the potential negative RED impacts a project in one region could have on the competing port in another region.

[11] There are a number of deep draft ports that are home to large cruise ships, which provide both commercial and recreation benefits.

Potential RED Effects to Deep Draft Navigation

RED Factor	Potential RED Effects
Income	Construction and maintenance of the project itself could provide additional income to local workers; A project expansion could also induce cargo growth provide additional income for the Port and local community.
Tax Revenues	Increased federal and state taxes for workers on the project. If a project allows a Port to expand beyond its previous limit, the induced cargo traffic could result in additional tax revenues (sales and income).
Employment	Short-term increase in construction employment. Potential long-term employment gains commensurate with O & M If the project allows a Port to expand, then new jobs associated with movement of additional goods could be created.

It should be noted that projects involving dredging could provide additional RED benefits associated with the beneficial reuse of dredged material, either by placement on beaches (increasing beach revenues) or other ecosystem purposes (e.g., increased recreation-related revenues[12]).

Finally, projects classified under the Special Navigation Programs and Aids to Navigation Program are usually small and so the value of the funds injected and relative impact to the local economy is nominal. It may not be worth the effort to investigate the RED impacts under these circumstances.

5.2 Inland Navigation

Inland navigation is similar to deep draft navigation in that reductions in transportation costs comprise the main source of NED benefits. However, the savings (NED benefits) are often applied to the entire navigation system and not simply one leg of an entire voyage. Savings can be calculated as fewer or shorter trip delays (e.g. reduction in lock congestions), reduction in costs associated with the use of larger or longer tows, and reduction in costs due to more efficient use of barges. Such savings are expressed as in NED terms.

Improvements generally involve locks and dams, basins or water areas for vessel maneuvering, passing, mooring or anchoring incidental to transit of the channels and locks. Although the NED benefits may be spread over several stops on a barge's voyage, RED impacts associated with project modifications tend to be closer to where the construction will take place.

When investigating the regional effects of inland navigation, the analyst would first identify the transportation efficiencies (cost reductions) generated by project improvements. This will in turn provide cost advantages for barge operators on the affected rivers or harbors. These cost advantages should be expected to be passed on to their customers (assuming that there is a

[12] Recreation-related benefits could appear in the form of NED (as a consumer's willingness to pay for a recreation resource) or RED (revenues or income made possible through the recreation resource).

"competitive" market system) and comprise an NED benefit. If large and long enough, these transportation efficiencies can ultimately spur increases to the local economy in the form of RED benefits[13]. If a coal company can deliver more coal given as the result of a more efficient navigation system, other industries which depend on the cheap coal may also benefit. Care must be taken in the model however, to link the navigation improvement directly to the benefiting industries (as well as the degree of impact).

Potential RED Effects to Inland Navigation

RED Factor	Potential RED Effects
Income	Construction and maintenance of the project itself could provide additional income to workers.
Business Revenues	A project expansion could also reduce congestion and bring additional cargo, revenues to the local community.
Tax Revenues	Increased federal and state taxes paid by workers on the project. If a project allows a Port to expand beyond its previous limit, the induced cargo traffic could result in additional tax revenues (sales and income).
Employment	Short-term increase in construction employment. Potential long-term employment gains commensurate with O & M. Potential increase in jobs associated with industries benefiting from improved waterway.

5.3 Flood Risk Management

The Corps of Engineers had been involved in various flood control activities throughout the 19th century, but it was not until the Flood Control Act of 1936 that first formalized flood control (now known as flood risk management) as a proper Federal activity. The Act also stipulated that for Federal involvement to be justified, ". . . the benefits to whomsoever they may accrue (must be) in excess of the estimated costs, and . . . the lives and social security of people (must be) otherwise adversely affected." Since the passage of the Flood Control Act of 1936, NED procedures were laid out and elaborated over time. Severe and persistent flooding can have devastating consequences to those living in floodplains as well as on the local economy.

The Great Mississippi Flood of 1993 was unprecedented in magnitude, extent, and impact. By the time the flooding finally subsided in October, the flood had inundated 20 million acres in nine states, damaged or destroyed approximately 50,000 homes, and forced around 54,000 people to be evacuated at some time during the event. The economic impact was staggering. The total cost of the flood was around $20 billion. Transportation was severely impacted. Barge traffic was halted on the Missouri and Mississippi Rivers for nearly two months. Railroad traffic came to a standstill in the Midwest. Ten commercial airports were flooded. Truck traffic either stopped or had to be rerouted due to closed bridges and flooded roadways. (NOAA, National Weather Service)

Structural solutions to flooding involve physical modifications which reduce the frequency of damaging levels of flood inundation. These include: dams with reservoirs, dry dams, channels,

[13] RED effects associated with construction are relatively close to the project site. RED effects associated with eventual efficiency improvements, however, tend to be spread further away from the project site; specifically, to where the producers of the goods shipped on the waterway are located and to where their consumers are located.

levees, floodwalls, diversion channels, pumps, ice-control structures, and bridge modifications. Non-structural solutions help reduce the flooding problem without significantly altering the nature or extent of the flooding, but by instead altering what may get damaged in the floodplain. Examples of non-structural solutions include flood proofing, relocating structures, flood warning systems and regulation of the floodplain. NED benefits are often well-documented and primarily include reductions in flood damages, which are based on replacement values of inventory and the probabilities of flooding in a particular floodplain.

The estimation of RED flood-related effects can be very complex. At a minimum, the RED analysis should include a qualitative description of the types of businesses at risk from flooding, particularly those that could have a significant adverse impact (output, employment, etc.) upon the community or regional economies if their operations should be disrupted by flooding and how this would be affected by the recommended project. A recent RED analysis for the Folsom Dam Modification Project (see case study) even evaluated the impacts spilling over from humanitarian aid, dewatering, debris removal, and levee repair, as these activities and projects spark additional economic development in spite of a devastating flood.

Potential RED Effects to Flood Risk Management

RED Factor	Potential RED Effects
Construction	Additional construction-related activity and resulting spillovers to suppliers.
Revenues	Increased local business revenues as a consequence of reduced flooding, particularly from catastrophic floods.
Tax Revenues	Increased income and sales taxes from the direct project and spillover industries.
Employment	Short-term increase in construction employment; With catastrophic floods, significant losses in local employment (apart from the debris and repair businesses, which may show temporary gains).
Population Distribution	Disadvantaged groups may benefit from the creation of a flood-free zone.
Increased Wealth	Potential increase in wealth for floodplain residents as less is spent on damaged property, repairs, etc. Potential increase in property values.

5.4 Coastal Storm Risk Management

Shore protection projects are designed to reduce damages caused by wind-generated and tide generated waves and currents along the Nation's ocean coasts. The mission was added to the Corps in 1956 when Congress authorized cost-shared Federal participation in shore protection and restoration of publicly-owned shore areas. Typical improvement types or projects are usually structural measures including beachfill, groins, seawalls, revetments, breakwaters, and bulkheads. However, nonstructural measures, such as property acquisition, relocations and evacuation are also considered as part of the alternative formulation process.

The RED impacts of a hurricane- storm damage reduction project are comprised of the construction-related effects and impacts of an increase in beach-related recreation near the

project site. If the project increases the attractiveness of the beach thereby increasing tourism, then it could be argued that additional tourist visits would increase commercial development and revenues to the existing hotels, restaurants and shops. The planner does need to carefully link the additional visits directly as a result of the project and ensure that the increased visitation would not have taken place in the "without-project" condition. Additionally, seasonal variation must be taken into account. Estimates of recreation RED benefits are usually much greater than NED estimates of recreation benefits. This occurs because the NED benefits from recreation are evaluated using a measure of individuals' willingness to pay (WTP) for the improved recreational experiences created by a nourished beach. Estimates of individuals' WTP for beach improvements are not measures of how much money people actually will spend when visiting the beach. The recreation expenditures that determine the RED benefits of recreation on a beach can be many times greater than the NED estimates based on measures of WTP (Robinson, 2004).

Occasionally, planners will be tasked with evaluating catastrophic impacts that hurricanes and strong coastal storms can bring. For those types of studies, RED impacts most certainly will be felt in terms of lost business revenues, jobs and property taxes and are encouraged to be quantified.

Potential RED Effects to Coastal Storm Risk Management

RED Factor	Potential RED Effects
Construction	Regional economic activity relating to construction of berms, groins, seawalls and periodic beach nourishment.
Employment	Gains in employment associated with project construction as well as the additional jobs associated with larger or more attractive beach With catastrophic coastal floods, significant losses in local employment (apart from the debris and repair businesses, which may show temporary gains).
Tax Revenues	Increased federal and state taxes for workers on the project as well as sales taxes from beach-related activities.
Recreation	RED benefits that are generated from beach-related recreation activities (beyond the traditional NED). Construction activities may affect recreational activity if recreational activities are closed to accommodate construction.

5.5 Ecosystem Restoration

As one of the Corps' newest Corps missions, ecosystem restoration was incorporated within the Civil Works program in response to the increasing national emphasis on environmental restoration and preservation. The objective of ecosystem restoration is to restore degraded ecosystem structure, function, and dynamic processes to a less degraded and more natural condition. Indicators of success would include the presence of a large variety of native plants and animals, the ability of the area to sustain larger numbers of certain indicator species or more biologically desirable species, and a more functional ecosystem.

Ecosystem improvements can run a wide gamut and include but are not limited to: use of dredged material to restore wetlands, restoring floodplain function by reconnecting oxbows to a main river channel, providing for more natural channel conditions including restoration of riparian vegetation, pools and riffles and adding structure, modification of obstructions to fish passage including dam removal, modifications to dams to improve dissolved oxygen levels or temperature downstream, removal of drainage structures and or levees to restore wetland hydrology, and restoring conditions conducive to native aquatic and riparian vegetation.

Ecosystem restoration outputs are rarely expressed in monetary terms. They are more likely to be defined in the form of environmental habitat units or impacts to various indicators. Nonetheless, there are economic impacts to restoring degraded habitat. Hedonic price models have demonstrated higher resale values and increased wealth of property owners (and subsequent property tax collections) for homes adjacent to restored wetlands. Likewise, environmental restoration projects continue to provide lucrative business for sightseeing and recreation-type industries.

In rare cases, environmental projects (e.g., EPA's Superfund-type projects) could displace existing businesses and reduce economic activity in a study area. Planners should be cognizant of this during the problem identification step of the planning process and be prepared to demonstrate the trade-offs between the environmental and economic outputs.

Potential RED Effects to Ecosystem Restoration

RED Factor	Potential RED Effects
Construction	Regional economic activity relating to construction of restoration features.
Increase Property Values	Potential increase in resale values for homes adjacent to newly-restored areas. Higher property values and increased property tax collections.
Tax Revenues	Increased federal and state taxes for workers on the project as well as sales taxes from recreational activities.
Recreation	RED benefits that are generated from recreational activities.

Recreation benefits of the restored ecosystem include such activities as bird watching, wildlife viewing, and other ecotourism activities. Recreation on impounded or increased water flows can include waterborne activities like canoeing, motor boating or fishing or landside activities like bank fishing. In addition, plan formulation of the final alternative may include the implementation of certain recreational facilities such as trails, picnic tables and bike trails. Given the vast amount of recreational potential suggested by an ecosystem restoration project, the potential impacts to the RED account are significant. However, care must be taken to ensure that the impacts are linked to the project, i.e., by determining the differences in the "with project" and "without project" conditions.

5.6 Other Project Purposes

5.6.1 Water Supply

Water supply effects may not be centered in the immediate project site. It is also possible that the creation of this new water source may alleviate pressure on other water sources in other areas. A more reliable water supply could benefit municipal and industrial (M & I) industries as well as agricultural industries.

Creating new water supplies (or improving existing ones) may induce construction of infrastructure in the communities which are the final users of the resource. The construction and ongoing employment of the water infrastructure can provide a boon to the local economy. Many water supply projects are 100 percent non-Federally funded, meaning that none of the construction monies flow from outside the region. It is argued that local funding could have been spent on something else if not invested in the water supply project and thus the RED effects may be minimal. One approach that has been discussed with the Omaha District is that various businesses may benefit from the new water supply (or reduced costs of water). If these impacts to businesses could be demonstrated, then the RED effects could be legitimized.

Potential RED Effects to Water Supply

RED Factor	Potential RED Effects from Water Supply
Construction	Regional economic activity relating to construction of water supply features.
Tax Revenues	Increased federal and state taxes for workers on the project as well as sales taxes from recreational activities.
Economic Output	Additional water could benefit local M & I and agricultural industries (outside of NED).
Recreation	Revenues generated from recreational activities dependent on water.

5.6.2 Hydropower

The RED analyst should make a concerted effort to engage the civil engineer and cost engineers in the RED computations. Many components of construction feed into the I-O models routinely used in RED analysis. The planner may not have the background to understand all of the nuances associated with the construction of a project, but the engineer can certainly help!

Hydropower projects can play a significant role in RED. Construction of a hydropower dam involves millions of labor hours, thousands of tons of equipment and millions of tons of material. However, today, nearly all Corps hydropower generation projects involve major rehabilitation of existing projects, not constructing new ones.

RED effects for hydropower generally apply to the injection of funds towards the rehabilitation and ongoing operation and maintenance of dams.

Initial amounts expended on construction or rehabilitation of components may include: refurbishment or addition to non-mechanical components such as the dam itself, water diversion, gates etc; replacement, refurbishment or expansion of mechanical components such as turbines, switchyards, etc; and finally the refurbishment, replacement or expansion of ancillary components such as transmission towers and lines.

Ongoing operations and maintenance will include not only the cost to operate and maintain physical components but the ongoing employment cost of electricity generation.

Other RED effects accrue if it is found that foregoing rehabilitation will increase the cost of production for area businesses and induce relocation of these businesses to points outside the study area.

Potential RED Effects to Hydropower

RED Factor	Potential RED Effects
Construction	Regional economic activity relating to rehabilitating dams.
Tax Revenues	Increased federal and state taxes for workers on the project as well as sales taxes from additional energy demand.
Economic Output/ Business Revenues	Additional power could potentially increase output of industries that rely on the hydropower as a source of energy.

5.6.3 Small Boat Harbors

In some parts of the U.S., small boat harbors provide significant income for local businesses and residents, namely from commercial fishing and its associated industries. Project improvements often involve breakwaters and jetties and are designed to improve the commercial navigation. RED benefits often focus on the number of jobs and business revenues, but not on the commercial fish landings. (This is often captured in the NED account).

The planner needs to be aware of state and local quotas on the amount of fish caught or harvested and avoid over-estimating the positive local impacts to project improvements.

Potential RED Effects to Small Boat Harbors

RED Factor	Potential RED Effects
Construction	Regional economic activity relating to construction.
Tax Revenues	Increased federal and state taxes for workers on the project as well as sales taxes from additional fish caught or harvested
Economic Output/ Business Revenues	Industries relating to commercial fishing can benefit indirectly through increased output.

5.6.4 Recreation

Recreation represents the most straightforward and widely-used application of RED analysis among the Corps' business lines. In fact, the bulk of the RED analyses performed within the Corps involved the Corps recreation sites and their economic-generated activities of visitor spending. In one study, "Economic Impacts of Recreation Activities at Oregon Coastal and River Ports", lays out the process of compiling data used to estimate recreation use and spending. They found that visitors' trip spending and annual and fixed boating expenses at the combined 18 Oregon ports supported a total of 1,700 jobs and generated $42 million in personal income.

In a 2003 Corps study, "Recreation Visitor Spending Profiles and Economic Benefit to Corps of Engineers Projects" the multipliers and detailed visitor spending on recreation at 16 Corps sites (from an initial list of 426) relied on sophisticated survey instruments (Figure 20). It was quite comprehensive and can help illustrate how to compile and identify the impacted industries.

Figure 20: Locations of the 16 Corps projects selected for the study

The following links provide additional details on economic impacts of recreation:

http://libweb.wes.army.mil/uhtbin/hyperion/EL-TR-03-12.pdf
ERDC/EL TR-03-12 "Economic Impacts of Recreational Activities at Oregon Coastal and River Ports"

ERDC/EL TR-03-21 Recreation Visitor Spending Profiles and Economic Benefit to Corps of Engineers projects

Potential RED Effects to Recreation

RED Factor	Potential RED Effects
Construction	Regional economic activity relating to construction.
Tax Revenues	Increased federal and state taxes for workers on the project.
Economic Output/ Business Revenues	Visitor spending on recreation-related activities.

5.7 Summary and Look Ahead

There are numerous ways RED can be expressed and not merely the construction components of projects. Increased navigation efficiencies, reduced flood damages, and improved ecosystem outputs could result in spillover effects to the local and regional economies. In the subsequent chapter, we will examine and compare the tools frequently employed for RED analysis.

6. Catalogue of RED Assessment Tools

A variety of software programs are available to determine the RED impacts for each project. Depending on the level of effort, project purpose, precision requirements and the size of the study area, application will most likely vary.

6.1 IMPLAN Version 3.0

IMPLAN (IMPact Analysis for PLANning) was originally developed by the U.S. Forest Service in conjunction with Federal Emergency Management Agency (FEMA) and the Bureau of Land Management to assist in land and resource management planning and has been in use since 1979. Since 1993, IMPLAN has been developed under the exclusive license of the Minnesota IMPLAN Group, Inc. (MIG) and is widely used for economic analyses by clients in federal, state and local governments, universities, as well as the private sector.

IMPLAN is a computer-driven system of software and data commonly used to perform economic impact analysis and is largely an I-O based model. The economic data needed to construct the central input-output table is extracted from various sources generated by the Department of Commerce, the Bureau of Labor Statistics, and other federal and state agencies. Data is collected for 528 distinct industry sectors of the national economy, commonly known as North American Industry Classification (NAICS) (formerly Standard Industry Codes or SICs). Industry sectors are classified on the basis of the primary commodity or service produced. National data is de-aggregated to produce data sets for each county in the United States, allowing analysis at the county level and for geographic aggregations such as clusters of contiguous counties, states or groups of states. Figure 21 displays the inputs required to run an RED analysis in IMPLAN. Data includes industrial sector, cost, and employment. Adjustments can be made to account for business margins, years and leakages.

The IMPLAN software package allows the estimation of the multiplier effects of changes in final demand for one industry's output and the corresponding effect on all other industries within a local economic area. Analysts may choose from multipliers that capture only direct and indirect effects, multipliers which capture all three effects (direct, indirect and induced) and multipliers that capture the three effects noted above and further account for commuting, social security and income taxes, and savings by households. Data output consists of estimations of output, income and employment, and value added. The IMPLAN software itself is inexpensive, as are the fees for county-level data. State packages are slightly more expensive. Customized data is the most expensive, but still fairly reasonable. MIG also provides on-site training.

Events/Groups | Projects

Member of Group: **Plan 2d, 100-Year Protection Level**

Event Name	Sector	Value	Employment	Basis	Year	Deflator	Margin	% Local
Bridge and Road Relocation	39	374,000.	4	Industry	2007	1.049		100.0%
Subdrainage System Construction	40	1,657,500.	14	Industry	2007	1.049		100.0%
Channel Construction	41	8,087,461.	79	Industry	2007	1.049		100.0%
Mitigation	45	679,000.	8	Industry	2007	1.049		100.0%
Steel	203	2,012,460.	3	Commodity	2007	1.103		4.0%
A&E Services - As Built Drawings and PED	439	1,685,594.	16	Industry	2007	1.073		100.0%

Figure 21: Impact Entry Screen – IMPLAN, Riverside County

IMPLAN would be appropriate for most feasibility studies as much of the data is already readily available for quick RED analysis. It may not be applicable to larger, watershed-type studies or in places such as Alaska, with its large number of remote communities and where its counties (boroughs) may exceed thousands of square miles. For those cases, models which rely on national input-output tables may be more appropriate. There is also a risk of overestimating the economic multipliers using IMPLAN. Finally, while IMPLAN is very powerful and contains data for over 500 industries, only a handful of industries are applicable to the Corps.

Contact is through the Minnesota IMPLAN Group, Inc. website: www.implan.com.

6.2 Regional ECONomic System (RECONS)

The Corps of Engineers' Institute for Water Resources along with the Louis Berger Group has developed a regional economic impact modeling tool called RECONS (Regional ECONomic System) that provides estimates of regional and national job creation and retention and other economic measures. The expenditures made by the USACE for various services and products generate economic activity that can be measured in jobs, income, sales and gross regional product. RECONS automates calculations and generates estimates of economic measures associated with USACE's ARRA spending and annual Civil Work program spending.

RECONS was built by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE's project locations by the Minnesota IMPLAN Group. These multipliers were then imported to a database and RECONS matches various spending profiles to the matching industry sectors by location to produce economic impact estimates. RECONS will be used as a means to document the performance of direct investment spending of the USACE as directed by the American Recovery and Reinvestment Act (ARRA). RECONS also allow the USACE to evaluate project and program expenditures associated with the annual expenditure by the USACE. RECONS has been developed in both a desktop and on-line version (Figure 22).

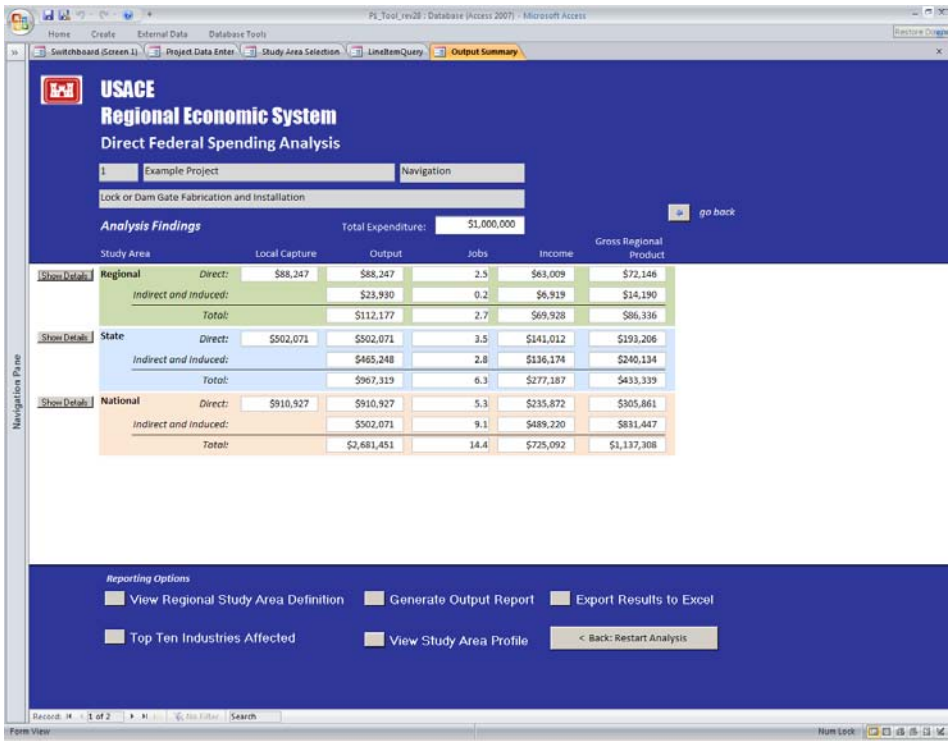


Figure 22: RECONS' Analysis Findings Summary Screen

6.3 Regional Input-Output Modeling System (RIMS II)

RIMS is the regional economic model of the Bureau of Economic Analysis. At its base, this model employs an input-output table similar to the one used by the IMPLAN model. As with IMPLAN, the RIMS II model's input-output table is derived from two sources: the Bureau of Economic Analysis's national I-O table which shows the input and output structure for 500 industry classifications and the BEA's regional economic accounts table, used to adjust the national I-O table to show a region's industrial structure and trading patterns.

RIMS multipliers are best suited for estimating the impacts of small changes on a regional economy. Utilizing RIMS II requires the user to provide geographically and industrially detailed information on the initial changes in output, earnings, or employment that are associated with the project under study. The multipliers can then be used to estimate the total impact of the project or program on regional output, earnings, and employment. RIMS II multipliers can be estimated for a region composed of one or more counties and for any industry, or group of industries, in the national I-O table. The accessibility of the main sources for RIMS II keeps the costs of estimating regional multipliers relatively low. The downside of RIMS II is its inflexibility and that it only produces industry-specific effects for one round of spending. Multipliers can be ordered for any region composed of one or more counties at a cost of $225 per region. For each region purchased, buyers will receive multipliers for all available RIMS II industries. Multipliers may also be ordered for any RIMS II industry at a cost of $50 per industry. For each industry purchased, buyers will receive multipliers for all states, the District of Columbia, and the nation.

www.bea.gov/regional/rims

6.4 Recreation Economic Assessment System (REAS)

REAS is a model specifically developed to estimate regional impacts of recreational visitor spending on area economies. REAS was developed by Michigan State University's Park, Recreation and Tourism Resources Department after which it was modified by ERDC for Corps use. It is designed to provide a simple, accurate method of applying appropriate multipliers to spending and visitation data.

REAS is spreadsheet based and free to all Corps employees. Model output includes direct effects, aggregate secondary effects and marginal effects. Output of the model includes direct effects of changes in sales, jobs, income and value added on 14 different categories. Output also includes a series of graphs useful for interpreting and presenting results.

REAS is especially useful for recreational and beach projects. It is corporately supported and maintained by the Corps of Engineers and is available on the Natural Resources Management Gateway:

http://corpslakes.usace.army.mil/employees/economic.

6.5 Money Generation Model 2 (MGM2)

MGM2 is a model specifically developed to estimate impacts of recreational visitor spending on local area economies. MGM2 was developed by Michigan State University's Park, Recreation and Tourism Resources Department. It is designed to provide a simple and reasonable method of applying appropriate multipliers to spending and visitation data. MGM2 is easy to use and utilizes national averages (which can be updated and modified) for many inputs. In a nutshell, it is a more general version of REAS.

MGM2 is spreadsheet based and free to all Corps employees. Model output includes direct and total economic effects. Output of the model includes direct effects of changes in sales, jobs, income and value added for 3 different categories: Day trips, motels, and camps. Output also includes a table listing various characteristics: recreation visits, visitor/Party nights in area, average spending per night, total visitor spending, and % of spending by category.

MGM2 is especially effective for recreational projects that utilize the travel cost method (revealed preference surveys as opposed to stated preference surveys). It is not corporately supported or maintained by the Corps of Engineers.

6.6 Economic Impact Forecasting System (EIFS II)

The US Army, along with a consortium of academic and professional economists, developed the Economic Impact Forecast System (EIFS) as a means of assessing economic impacts of actions or projects requiring National Environmental Policy Act (NEPA) documentation and to

measure their significance. In addition, the system has been frequently used to assess the impacts of the Base Realignment and Closure (BRAC) proposals.

The theoretical base of EIFS is economic base theory, which categorizes all local economic activities into basic or non-basic sectors. The basic sector is made up of local businesses that are entirely dependent upon external factors. For example, Boeing builds and sells large airplanes to companies and countries located throughout the world. Their business is dependent almost entirely upon non-local firms. The non-basic sector, in contrast, is composed of those firms that depend largely upon local business conditions. A local grocery store, for instance, sells its goods to local households, businesses, and individuals. Almost all local services (like drycleaners, restaurants, and drug stores) are identified as non-basic because they depend almost entirely on local factors.

The distinction between basic and non-basic sectors is important since the basic sector is the "engine" of the local economy. Economic base theory posits that the local economy is strongest when it develops those economic sectors that are not closely tied to the local economy. By developing firms that rely primarily on external markets, the local economy can insulate itself from economic downturns. In contrast, a local economy wholly dependent upon local factors will have great trouble responding to economic slumps.

The data in EIFS is national in scope and covers the approximately 3,700 counties, parishes, and independent cities that are recognized as reporting units by federal agencies. EIFS allows the user to define an economic region of influence (ROI) by simply identifying the counties to be analyzed. Once the ROI is defined, the system aggregates the data, calculates multipliers and other variables used, and prompts the user for input data.

EIFS models generate multipliers that are used to estimate the impacts resulting from changes in local expenditures or employment. This technique is especially useful for large-scale projects or for Environmental Assessments or Environmental Impact Statements, in which aggregate impacts are considered. The EIFS model can also be used to predict changes to the local economy's business sales volume, income, employment, and population.

An EIFS model was recently developed to examine the impacts of relocating tens of thousands of Department of Defense employees from the Pentagon to Fort Belvoir. The model indicated a net gain of about 22,000 jobs (military and civilian) to Fort Belvoir, but with a loss of some jobs due the proposed realignment. Implementation of the proposed realignment action would also require renovation of existing facilities and construction of new facilities to accommodate the increase in personnel and functions assigned to Fort Belvoir.

EIFS was initially maintained by the Army Construction Engineering Research Laboratory (CERL), the original developer of the system and was housed by the Mobile District. Today, a newer version, EIFS II, is maintained and operated privately by the firm R2 Construction (Webster, 2008) on the website nepaworkbench.com. Information concerning access to the NEPA Workbench: Economic Impact Forecast System (EIFS II) should be addressed to Ronald Webster at (404) 242-5923 or online at www.nepaworkbench.com.

6.7 REMI Policy Insight

REMI (Regional Economic Model, Inc.) Policy Insight is a regional economic software package used primarily to analyze impacts of newly implemented or recently changed policy. REMI is not dependent upon I-O analysis but combines several different kinds of analytical tools (including economic-base, input-output, and econometric models), allowing it to take advantage of each specific method's strengths and compensate for its weaknesses.

The model is calibrated to many sub-national areas for policy analysis and forecasting, and is available in single- and multi-area configurations. Each calibrated area (or region) has economic and demographic variables, as well as policy variables so that any policy that affects a local economy can be tested. REMI is data intensive and requires input for a wide range of variables. Like IMPLAN, the model is expensive to use but, like IMPLAN, the depth of data will increase accuracy.

Within the REMI program, the user can manipulate input variables to conduct sensitivity analysis. The user can manipulate the timing and degree of shocks to the economic system. User can analyze changes in resident and non-resident consumption patterns by category, changes in transportation savings costs, and changes in quality of life.

Outputs of the model include personal income in current dollars, detailed final demand and value added to gross regional product and changes in employment (labor force, participation rates, and changes in unemployment).

The REMI program was used extensively for the Louisiana Coastal Protection and Restoration Project given the need for sensitivity and the lack of available economic data in the aftermath of Hurricanes Katrina and Rita. It is considered to be the most expensive type of ready-made models (it costs approximately $30,000 simply to rent a REMI model) and requires a textbook knowledge of input-output analysis. State governments, investment firms, and universities are the most frequent clients.

www.remi.com

6.8 MARAD Port Kit

First developed in the 1970’s, the MARAD Port Kit is based on the US I-O model, a product of the US Bureau of Economic Analysis which describes the interactions of more than 500 defined economic sectors. Rutgers University Center for Urban Policy Research then modified the software for use by the port industry.

On-going maritime activities modeled in the MARAD Port Kit include container, liquid and dry bulk, break-bulk, auto transport, cruise, project cargo, and passenger ferry operations. The model includes all sectors and inputs necessary to the operation of the port, including maritime construction and dredging. The software does not classify construction costs of the terminal itself or deepening activities associated with a project as direct impacts. The model classifies

direct economic impacts as those resulting from the movement of waterborne cargo and passengers through the terminals or the impact of vessels and landside infrastructure.

The software quantifies the economic value of deep-draft port activities by employment, income and tax revenue. It is also able to analyze hypothetical projects and perform sensitivity analysis. Use of this software package is appropriate for performing impact analysis for small to medium ports.

The model classifies resulting activity as output, income, gross state product and employment. Income and employment are self explanatory, output refers to the value of industry production, and gross state product refers to the value added to statewide output by the facility.

Copies of the model are available through the National Technical Information Service (NTIS) website (http://www.ntis.gov/fcpc/cpn8935.htm) or by calling their sales desk at 800-553-6847 (or 703-605-6000). Refer to NTIS order number PB2001-500021. The software is on one CD-ROM disk and requires Windows 95, 98, or NT to run. All documentation is on the disk.

Further information may be obtained from the Maritime Administration's Office of Ports and Domestic Shipping, 400 Seventh St., SW (Room 7201), Washington, DC 20590; tel.: (202) 366-4357; or via fax at (202) 366-6988 or Email: ports.marad@marad.dot.gov.

6.9 Rural Inland Waterways Economic Impact Kit

This model has its origins in the MARAD Port Kit and allows users to evaluate the economic impact of existing rural inland waterways ports and their linkage to the community’s industrial structures and transportation system. After first defining the study area and inputting the regional data by selecting a level of industrial codes, the model calculates the direct, indirect, and induced impacts in the various industries that are dependent on the inland waterways (Figure 23).

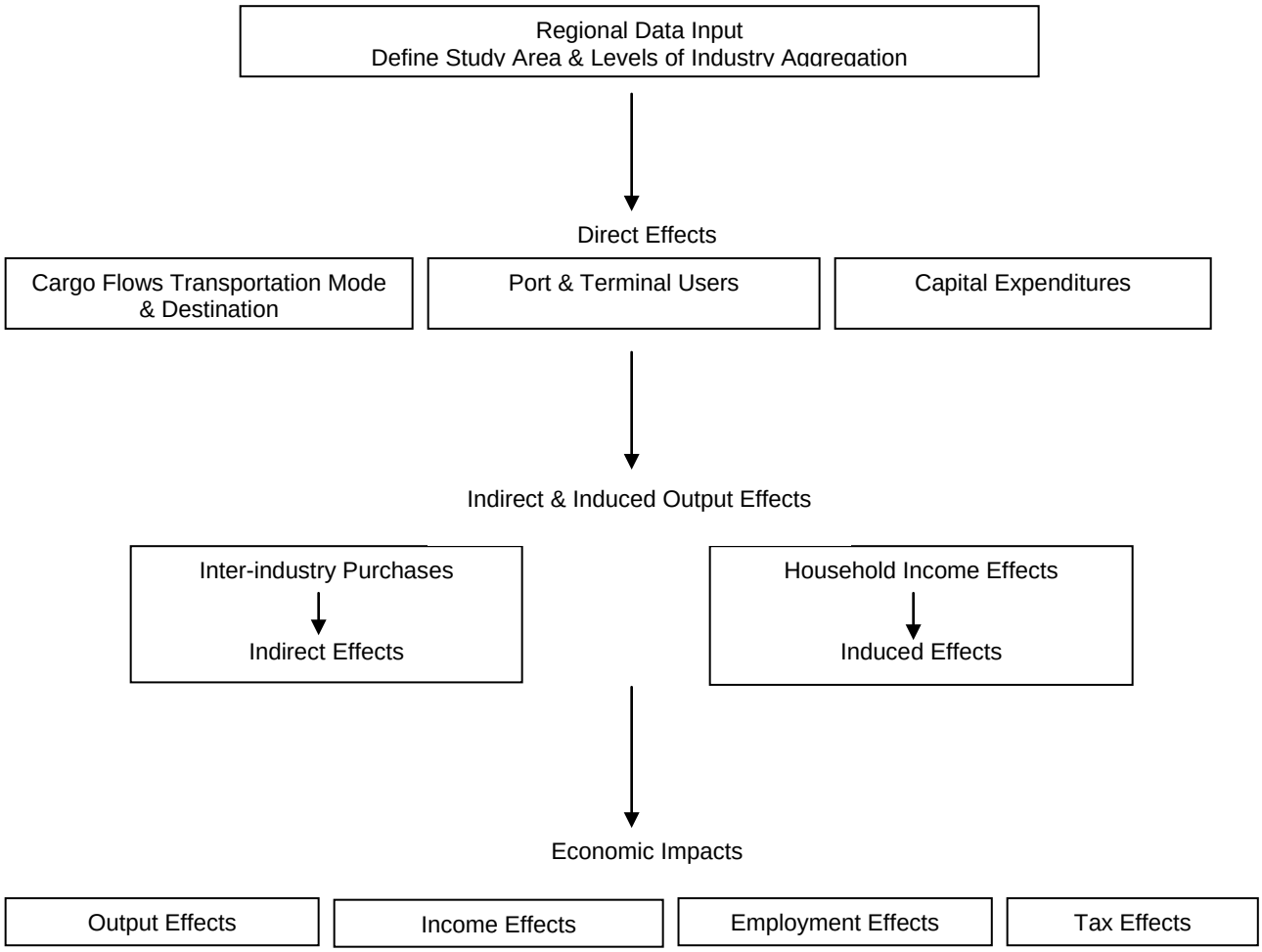


Figure 23: Rural Inland Waterways Economic Impact Kit

The model is similar to BEA's RIMS II model and was developed by the University of Arkansas' Institute for Economic Advancement. Two documents accompany the Rural Inland Waterways Kit: (1) a user's guide with step-by-step instructions of an economic impact analysis of the various activities at a port or terminal; and (2) an analysis manual which focuses on the details and processes as well as the data collection requirements, methodology issues, and the interpretation of the findings. Both can be accessed via the Department of Transportation's Bureau of Transportation Statistics. www.ntl.bts.gov

6.10 MRVIO (Multi-Regional Variable Input-Output) Model

In the 1950's the science of I-O Models was expanded to the Multi-Regional Variable Input-Output (MRVIO) Model, which is a more complex model that investigates the regional economic and other social impacts over multiple regions. One of its notable applications was done by the Institute for Water Resources during their investigation of the McClellan-Kerr Arkansas River System Study. The results demonstrated how much the inland waterway contributed to regional development, accounting for other factors such as Sunbelt movement, highway construction, cheaper land, and tax structures (global warming impacts to China, the impacts of electrical

outages, etc.) Other notable uses of the MRVIO model for RED analysis include:

- The McClellan-Kerr Arkansas River Navigation System
- The Coosa River Navigation Project
- The Deepening of Norfolk and Baltimore Harbors
- The Oklahoma Water Resources Plan
- The Alabama Public Investment Decision-Making Methodology
- The Apalachicola-Chattahoochee-Flint River Basin Navigation System
- Local Area Impacts of Drought from Exporting Alabama Coal through the Port of Mobile
- The Red River Navigation Project: Shreveport to Daingerfield
- Olmsted Lock and Dam Navigation Improvement Project: Regional and Local Impacts
- The Missouri River Water Allocation Impact Study
- National Level Economic Impacts of the Proposed Harbor Services User Fee

For more information, contact Chieng Liew, Professor of Economics, University of Central Oklahoma, 2325 Houston Ave., Norman, OK 73071 or Dennis P. Robinson, Community Policy Analysis Center, University of Missouri. The Corps of Engineers Inland Navigation Center of Expertise (Lakes & Rivers Division) is also familiar with the MRVIO model, having partnered with the Tennessee Valley Authority and the Oak Ridge National Lab for its efforts on the Ohio River Basin.

6.11 Econometric versus Input-Output Models

Econometric models often involve sophisticated computer programs that trace the total effects over time of ***changing economic conditions*** in a study area. They also use empirical data, rather than experimental data, to examine the relationships between variables (as well as their influences on each other). More specifically to RED analyses, econometric models can show the changes in total economic activity to changes in exports of different types of goods, or alternatively, changes in federal investment. Its regression can be based on a sample of observations, which may include a single region at many points in time; many regions at a single point in time; or in a few studies, pooled regions across time.

Econometric models do have limitations. For one thing, the resulting multipliers are averages over time or over regions; the multipliers are usually not localized enough for most Corps studies. As a result, the models are often viewed as less accurate.

Input-output models can provide a more detailed disaggregation than econometric models, but they are often more expensive since they require extremely detailed information on the sales between each pair of sectors for a given year. With forty-eight sectors, that amounts to some 2,304 (forty-eight times forty-eight) groups of data. Input-output models are limited in that they only provide a static snapshot of the economic conditions, in contrast to the ever-changing conditions of a study area.

Based on research, the input-output multipliers tend to have less average mean errors than the econometric-driven multipliers. However, for some sectors the two multipliers varied by as much as 50 percent depending on which model generated them. Nonetheless, econometric models

have been quite useful. For one of its shoreline studies, the Corps measured effects shoreline erosion had on the price of shoreline properties using the hedonic price approach. A hedonic price model is a way of estimating the price of a property given a set of characteristics and applying regression analysis. Their results found that the beach erosion rate is a significant variable in the transaction price of all houses for that particular community.

The PDT should carefully decide on which model to apply—econometric versus input-output model. Naturally, econometric models require the economist/planner to have considerable knowledge of statistics and econometrics (e.g., regression, ordinary least squares, F test, etc.)

6.12 Economic Base Model

The simplest and least expensive way to measure multipliers is something called the economic base model, which divides the economy into only two sectors: industries that mainly export and industries that mainly produce for local consumption. The multiplier represents the ratio of total economic activity to activity in the basic industries. This approach has fallen into disfavor because it is believed to be inaccurate. In particular, it is highly aggregative (there is only one exporting sector), and exports are poorly measured. In the real world, many industries produce partly for local consumption and partly for export. Still, some may find a “quick and dirty” use for it.

6.13 Additional Models

There are other models which can be used to generate RED effects. These include local forecasting models, infrastructure productivity models, Carlino-Mills models, and CGE models. In 2005, Drs. Dennis Robinson and Thomas Johnson developed a multi-regional multiplier analysis system, call the Socio-Economic Benefits Assessment System (SEBAS), for the U.S. Department of Agriculture’s Rural Development program. SEBAS is used by Rural Development to annually report to the President’s Office of Management and Budget on the effectiveness of Rural Development’s business and industry guaranteed loan and grant projects both locally and by metropolitan and non-metropolitan areas in each state. The REDYN model, developed by Regional Dynamics is thought to be a simplified version of REMI, but has yet to become well established in the field.

In addition, recent efforts at the University of Missouri have been undertaken to generate a county-level forecasting capability to be used with such regional economic impact models as IMPLAN, called the ShowMe Model—Johnson and Scott (2006) and Bhandari (2008). This model has been implemented in the form of an easy-to-use spreadsheet program. The ShowMe Model makes ten-year, county level forecasts of demographic changes (total population and age-specific categories), housing demand conditions (owner-occupied, renter-occupied, median house value, median monthly rent value), labor market conditions (male and female labor force, in-commuters, out-commuters, holders of second jobs, and unemployment), economic well-being indicators (median household income and population under the federal poverty level), and public finance impacts (assessed property values, retail sales, total and 5 types of public revenues, and total and 14 types of public expenditures).

6.13 Summary of RED Models

Model	Advantages	Disadvantages	Best Suited For
IMPLAN	Relatively inexpensive; Easy to use	Potential over-estimation of multipliers; Not suitable for catastrophic-disaster studies	Most feasibility-level studies
RECONS	Easy to use	Potential over-estimation of multipliers; Not suitable for catastrophic-disaster studies	Most feasibility-level studies
RIMS II	Relatively inexpensive	Not very flexible; Only provides sector-specific effects for one round of spending	"Quick and dirty" analyses requiring fewer RED details
REAS	Easy to use	Not universally applicable	Recreation and beach studies
MGM2	Easy to use	Not universally applicable	Recreation and beach studies
EIFS	Useful for estimating aggregate impacts (on income, employment and population)	Generally not appropriate for smaller studies	Environmental Impact Statements
REMI	Most flexible; Dynamic model, Shows detailed and accurate impacts for a large number of sectors and on a year-by-year basis	Very expensive; Requires a textbook knowledge of input-output analysis	Large, watershed studies requiring detailed information; Post-Katrina-like studies
MARAD Port Kit	Provide comprehensive statistics relating to income, employment and tax revenues	Does not measure the impact of deepening itself, only the impact of increased cargo and/or trade associated with deepening	Deep draft navigation studies
Rural Inland Waterways Economic Impact Kit	Interactive, Can provide meaningful navigation-based statistics	Not universally applicable	Primarily inland navigation studies
MRVIO Model	Comprehensive	Could be unwieldy at times	RED analysis for large regions or multiple states

7. Conclusions

By now, you should have seen that the regional economic development impacts are important to consider for all Corps project purposes and most types of planning studies. More often than not, these impacts will be categorized by the direct, indirect and induced consequences of federal investments which spill from the project footprint into surrounding areas. By performing an adequate baseline assessment of the local/regional economy and taking advantage of useful software, credible estimates of the RED impacts can be determined.

There may also be times when the “without project” condition contains severe consequences that can permanently impact the RED in a community or region (e.g., catastrophic or chronic storms). Subsequently, a project could reduce or eliminate these negative impacts.

The real question of merit RED models has to be based on relative grounds—for example, time and cost of the analysis, desirable characteristics of the model (public finance, jobs created, temporal effects, etc) or the type of impact analysis undertaken such as impacts of flood projects or impacts of efficiency changes due to transportation cost reductions. Each of the models has unique features that appeal to different situations.

One of the remaining challenges deals with applying the RED impacts to the formulation and overall evaluation of projects. While there has been disagreement on the relative importance of RED, it is widely agreed that RED effects deserved to be explored and shared with the project sponsors continually throughout the planning process.

Glossary of Economic Terms

Backward Linkage: Links an industry to its suppliers and the producers of household goods and services. For a construction project, a construction firm and companies providing materials represent a backward linkage.

Forward Linkage: is the link between the industry producing a good or service and the consumers of that good of service. An industry's multipliers do not capture forward linkages. A wood furniture manufacturer is a forward linkage for a sawmill. The sawmill also exports and sells to households (both forward linkages).

Input-Output Analysis: is a means of examining relationships within an economy, both between businesses and between businesses and final consumers. It captures all monetary market transactions for consumption in a given time period. The resulting mathematical formulas allow examination of the effects of a change in one or several economic activities on an entire regional economy.

Value Added: a metric comprised of four components: (1) employee compensation; (2) proprietor income; (3) other property income; and (4) indirect business tax.

Impact analysis estimates the impact of dollars from outside the region ("new dollars") on the region's economy. Impact analysis typically includes only the spending of visitors from outside the region.

Significance analysis estimates the importance or significance of an industry or activity to a region and usually includes spending by both local residents and visitors from outside the region.

Input-output (I-O) models examine the flows of economic activity between sectors within a region. The model captures what each business or sector must purchase from every other sector in order to produce a dollar's worth of goods or services. Using such a model, flows of economic activity associated with any change in spending may be traced either forwards (e.g., spending generates employee wages, which induces further spending) or backwards (e.g., visitor purchases of meals leads restaurants to purchase additional inputs -- groceries, utilities, etc.). Multipliers for a region may be derived from an input-output model of the region's economy.

IMPLAN is a micro-computer-based, input-output modeling system. With IMPLAN, one can estimate I-O models of up to 528 sectors for any region consisting of one or more counties. IMPLAN includes procedures for generating multipliers and estimating impacts by applying final demand changes to the model. The current version of IMPLAN is IMPLAN Pro 2.0.

Final Demand (sometimes referred as final consumption) is the term for sales to final consumers (households or government). Sales between industries are termed intermediate

sales. Economic impact analysis generally estimates the regional economic impacts of final demand changes. Visitor spending at a recreation site is one type of final demand.

Direct effects are the changes in economic activity during the first round of spending or alternatively, the proportion of the expenditure in each industry that flows to material and service providers in the region.

Secondary effects are the changes in economic activity from subsequent rounds of respending of dollars as a result of a project. There are two types of secondary effects:

- **Indirect effects** are the changes in sales, income, or employment within the region in backward-linked industries supplying goods and services. Using tourism as an example, the increased sales in linen supply firms resulting from more motel sales is an indirect effect of visitor spending.

- **Induced effects** are the increased sales within the region from household spending of the income earned by the supporting industries. Employees on a Corps project and those in its supporting industries spend the income on housing, utilities, groceries, and other consumer goods and services. This generates sales, income, and employment throughout the region's economy.

Total effects are the sum of direct, indirect, and induced effects.

Multipliers capture the size of the secondary effects in a given region, generally as a ratio of the total change in economic activity in the region relative to the direct change. Multipliers may be expressed as ratios of sales, income or employment, or as ratios of total income or employment changes relative to direct sales. Multipliers express the degree of interdependency between sectors in a region's economy and therefore vary considerably across regions and sectors.

Capture rate is the percentage of spending that accrues to the region's economy as direct sales or final demand. All tourist spending on services within the region is captured; however, tourist purchases of goods are generally not all treated as final demand to the region. For imported goods bought at retail establishments, typically only the retail (and possibly wholesale) margins will accrue to the local economy.

Many of these definitions and more can be found in the following website:

http://corpslakes.usace.army.mil/employees/economic/economic.cfm

Appendix A -- Case Studies

Case studies forthcoming

Appendix B -- More Information on RED Analysis

Economic Base Theory

At its heart economic base theory seeks to explain the economic growth of symbiotic economic units by describing the relationship between imports and exports into and out of a city, town, state, or even a nation. Economics textbooks present the link between competitive advantage, trade and growth and explain that an economy can only move beyond its own production possibilities curve by engaging in trade with other nations. Therefore, special emphasis is placed on the acquisition of industries which manufacture products for consumers outside of the boundaries of the economic unit. Economic base theory classifies all industries as either a "base" industry, one in which a large portion of their output is consumed outside the boundaries of the economic unit or as a "non-base" industry.

The economic activity of each region must be subdivided into base and non-base sectors. This can be quite difficult since industry does not differentiate its consumers by location. One possible method is to survey area businesses and determine the relative local/non-local mix of their customer base. This is time consuming and expensive to enact and should be undertaken only when directed to do so. The EIFS (Economic Impact Forecast System) manual describes four alternatives to a direct survey approach: **assumption o f assignment ap proach, regression, minimum requirements, and location quotients**.

The **assumption o f assignment appr oach** is a straightforward and simplistic approach to industry assignment. Based on the analyst's knowledge of the product mix and market orientation of the company, the analyst will assign a certain percentage of output to each category based on subjective judgment. This methodology has its obvious shortcomings given biases when making subjective judgments. Consultation with an expert or panel of experts may help to alleviate some of these inherent shortcomings. To maximize their credibility and minimize bias, at least three subject matter experts are included and are often removed from the area of interest.

The **econometric or statistical approach** provides an estimation of base versus non-base activity by regressing local activity on national activity. Information on local activity broken down by industry is in most cases unattainable, so a proxy such as the over the year change in employment or income expressed as a percentage is often used. Time series data for the national economy is input as the independent variable and employment or income or the area of interest is obtained and input as the dependent variable. The result is a measure of the correlation between national trends in income or employment growth and the local or regional trend in employment or income. The resulting equation is fairly straight forward:

$$X = \beta Y + \varepsilon$$

It is assumed that the base/non-base ratio for the nation is a known quantity. If the value of β is equal to one the rate of change in the local mirrors that in the national economy and the national base/non-base ratio is utilized. If the value of β is less than one, then there is a corresponding decline in local base industries. If the value of β is greater than one then it is assumed that the base industries or exporting industries have grown. As with all other approaches this

methodology has its drawbacks. Boundaries of the area of interest are much more transparent and are easier to cross than national boundaries. It must be remembered that any production consumed outside the boundaries of the area of interest is classified within the confines of the model as an export. Inclusion of certain employment classifications like federal government installations or high concentrations of service or non-base sectors may bias the results of this methodology. The ability to de-aggregate employment data so as to remove certain sectors from consideration, military and inherently governmental activities that are not exported nationally but could be classified as exported locally, would alleviate some of this problem.

The **minimum requirements approach** is a bottom up approach; it compares the economic activity of the area of interest with the economic activity of a small and self sustained community, a "minimum requirement region". This approach identifies the economic activity carried out by the minimum requirement region as that minimum level of activity necessary to sustain that region. This approach necessitates several gross assumptions. Designation of a local minimum requirement region is a purely theoretical exercise, in reality such a community would be a net importer, having a large per capita demand for manufactured goods and exporting a small amount of raw materials. Even if such a theoretical community could be located the model would translate this assumed lack of imports to the larger area of interest. If the methodology assumes that each community is self-sustaining then no imports are needed.

The **location quotient** is similar to the econometric approach described above; this approach compares the regional concentration of industrial activity with that for the nation as a whole. The methodology assumes that the nation exports a negligible amount and produces all its basic needs. When comparing the output of the area of interest with that of the nation, a region having a greater concentration of its economic activity in that commodity than at the national level must not only be satisfying its local needs for the product, but producing for the consumption of areas outside its boundaries.

The location quotient is calculated in the following equation:

$$LQ_{ir} = \frac{E_{ir} / E_r}{E_i / E}$$

Where LQ_{ir} is the location quotient for industry '*i*' in region '*r*' and '*E*' is the relative employment for each industry and region combination.

E_{ir} = regional employment for industry '*i*' in region '*r*'
E_r = total regional employment for region '*r*'
E_i = national employment for industry '*i*'
E = total national employment.

If the location quotient is greater than one, the region is an exporter of those commodities because their region appears to be producing more than it needs to satiate domestic demand. If the location quotient is less than one, the region is an importer of those as domestic output is

not sufficient to satiate domestic demand. If the location quotient is equal to one then output exactly equals demand. The location quotient methodology in comparing the regional economy to the national economy assumes that all economies are similar; not only is the national and regional economy similar but the regional economy is similar to all other economies across the nation. Further the methodology assumes that local demand is satisfied by local production and that the nation imports nothing and exports very little.

Derivation of the Multiplier

Regional economic multipliers are largely derived from the Keynesian multiplier equation of the equilibrium condition, common to in macroeconomics theory. Consider the Keynesian aggregate demand model where equilibrium Y represents the aggregate expenditures in the economy:

$$Y = C + I + G + X_M \quad (1)$$

In equation (1), *C* is aggregate consumption, *I* represents business investment, *G* is government expenditures and X_M stands for net exports (exports minus imports or X – M). Government expenditure, denoted as *G,* equal government expenditures minus taxes or *G-T.* Government expenditure levels along with the level of investment and the level of exports in the economy are considered to be exogenously derived. All other variables are income dependent. Consumption and imports can be further defined as equations (2) and (3).

$$C = c_0 + cY \quad (2)$$

Where c_0 is the given level of consumption and *cY* ties the level of consumption to the level of income. If income levels start to rise, overall consumption will also rise; if income levels fall, overall consumption will fall as well. Likewise, the level of imports is tied to the level of income.

$$M = m_0 + mY \quad (3)$$

The level of taxation is dependent upon income levels as defined in equation (4) below.

$$T = t_0 + tY \quad (4)$$

For the purposes of this model, goods and services consumed are divided into domestic production and foreign production. This distinction between domestic and foreign production is not important and is made only so that the underlying model coincides with the aggregate level model.

Substituting equations (2), (3) and (4) into equation (1) yields equation (5).

$$Y = c_o + cY + I + X - m_0 - mY + G - t_0 - tY \quad (5)$$

Or,

$$Y = \frac{c_0 - m_0 - t_0 + I + X + G}{(1 - c + m - t)} \quad (6)$$

The export variable, 'X' is exogenously derived since its level is largely a function of outside economic variables such as exchange rates and the economies of other nations. While the level of government revenue, tax level, is dependent upon the level of income; expenditures by the government are assumed to approximate a constant or slightly increasing level of expenditure. As a result, the level of government expenditure is not dependent upon the level of income in an economy. It is generally assumed that the investment variable in equation (1) is the desired level of investment in the economy. Its level is therefore dependent upon the prevailing interest rate and is not dependent upon income level.

If we wish to find the rate of change in total income given a change in government expenditure you take the derivative of equation (7):

$$\frac{\partial Y}{\partial X} = \frac{1}{1 - c + m + t} \quad (7)$$

Definitively, the right hand side of this equation is the income multiplier. In this case it is the increase/decrease in income or output (employment) within the defined economic unit expressed as a proportion of the change in government expenditure. The denominator equals the marginal propensity to consume or '*c*' plus the percentage of that consumption which is satiated by an imported product plus the percentage of that additional income which must be paid out as taxes.

Interpretation of the results is fairly straightforward. Assume that the marginal propensity to consume is equal to .8; that of this proclivity to consume fully one quarter is satiated through the consumption of imported goods. Finally, assume that this additional income is taxed at eighteen percent. Equation (7) becomes:

$$\frac{1}{1 - .8 + .25 + .18} = \frac{1}{.63} = 1.587 \quad (8)$$

The multiplier is 1.587. This means an increase in government spending within the economic unit of $100 million would result in a total increase to area income or employment of approximately $158 million.

Derivation of Input Coefficients

The following section shows how input coefficients are derived. It isn't as daunting as it might appear. Derivation begins by defining the subject economy into *n* components or industries with the household or labor component designated as *n+1.* For mathematical manipulation, the output of each component industry, industry *i,* is designated as $x_{i,}$, and the amount of output of sector *i* absorbed by sector *j* is designated as $x_{ij.}$

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & x_{13} & x_{1n} \\ x_{21} & x_{22} & x_{23} & x_{2x} \\ \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{n2} & x_{n3} & x_{nn} \end{bmatrix} \quad (1)$$

Convert the representative economy described in Table 1 to matrix notation and designate the sum total of each column in the matrix as a column vector.

$$X_i = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_i \end{bmatrix} \quad (2)$$

The input coefficient equals the ratio of each element a_{ij} by the summation of that industries output b_i.

$$a_{ij} = \frac{x_{ij}}{b_i} \quad (3)$$

The resulting matrix is the matrix of input coefficients. Each input coefficient is equal to the level of input required of each input component industry, *i,* by the producing component industry, *j,* to produce a single dollar of its output.

$$A_i = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{1n} \\ a_{21} & a_{22} & a_{23} & a_{2x} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & a_{n3} & a_{nn} \end{bmatrix} \quad (4)$$

The flows of expenditures laid out in Table 2 have been converted into percentages, based on the total inputs needed by each of the major sectors: Row/Column 1 for construction, Row/Column 2 for retail, Row/Column 3 for manufacturing, and Row/Column 4 for household.

$$A_i = \begin{bmatrix} .029 & .286 & .400 & .465 \\ .233 & .071 & .050 & .419 \\ .039 & .514 & .240 & .419 \\ .350 & .429 & .160 & .047 \end{bmatrix} \quad (5)$$

Thus, to produce $1,000 worth of constructed space, the construction industry must consume $29 worth of its own output (.029), $233 of retail goods (.233), $39 worth of manufacturing output (0.039) and $350 worth of labor (.350).

More on the Leontief Inverse

The Leontief inverse is a very useful and powerful component in Input-Output analysis. Purchases for final use (final demand) drives input-output models. Industries respond to meet demands directly or indirectly by supplying goods and services to industries responding directly. Each industry that produces goods and services then generates demands for other goods and services and so on, round by round. These indirect purchases (or indirect effects) continue until leakages from the region (imports, savings, etc.) stop the cycle.

The indirect effects and the induced household spending effects can be mathematically derived as sets of multipliers. It is this derivation that makes up the Leontief inverse. The resulting sets of multipliers describe the change of output for each industry caused by a one dollar change in final demand for any given industry.

Through algebraic manipulation of a given production function, which shows where an industry spends, and in what proportions, to generate each dollar of output, we can develop a predictive multiplier model equation:

$X = (I-A)^{-1}*Y$

where:

X = Total industry output (also known as “vector output”)
I = Identity matrix
A = A matrix (each industry)
Y = Final Demand

This can also be interpreted as:
$\Delta X = (I-A)^{-1}*\Delta Y$

or Change in Total Industry Output = (I-A)-1* Change in Final Demand

The predictive model shows how output will change with a given change in final demand. The (I-A) inverse is the matrix of multipliers referred as the Leontief inverse.

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2011-RPT-01