Economic and Fiscal Impacts of BioAlabama

by

Samuel Addy, Ph.D., *Associate Dean for Economic Development Outreach & Senior Research Economist*
Ahmad Ijaz, *Executive Director & Director of Economic Forecasting*
Viktoria Riiman, *Socioeconomic Analyst III*

Center for Business and Economic Research
Culverhouse College of Business
The University of Alabama
Box 870221, Tuscaloosa, AL 35487-0221
Tel: (205) 348-6191   Fax: (205) 348-2951   http://cber.cba.ua.edu

April 2018

THE UNIVERSITY OF
ALABAMA® | Culverhouse
College of Business
Center for Business and Economic Research

Contents

Executive Summary

- This report presents the economic and fiscal impacts of industries of focus for BioAlabama on economy of the State of Alabama. BioAlabama is the state partner of the life sciences trade organization Biotechnology Industry Organization (BIO). The focus is on 780 companies in 15 industries that had 17,871 employees as of the first quarter of 2018. Annualized impacts are presented assuming that these industries maintain that employment level through the year. To achieve this, the 780 companies will have total expenditures of $3.8 billion which includes a $1.2 billion payroll that translates into $67,664 per worker in annual wages.

- The economic impacts presented in this report focus on output, value-added, earnings (wages and salaries), and employment. Output refers to total or gross business activity and contains value-added, which is the contribution to gross domestic product (GDP) or the value of goods and services produced on a value-added basis. Earnings impacts are part of value-added and are the wages and salaries of the workers recognized by the employment impact. Fiscal impacts focus on income and sales taxes that are derived from the earnings impact and are conservative because several other taxes and fees (e.g., property, utility, car tags and fees, rental/leasing, cigarettes and tobacco, insurance premiums, and Birmingham City occupational) are not estimated.

- The annualized economic impacts of BioAlabama industries on the state are $7.3 billion in output which includes a $3.9 billion value-added or contribution to GDP of which $2.3 billion is earnings for 47,980 jobs (17,871 direct paying on average $67,664 and 30,109 indirect paying on average $35,283). The earnings impact generates $161.4 million in tax revenues comprising: $74.7 million in state income, $38.5 million state sales, and $48.2 million local sales taxes.[*]

- The impacts, productivity, and high wages of BioAlabama industries indicate that investing in bioscience is prudent and must remain an essential part of the state's economic development strategy.

---

[*] The Regional Input-Output software, RIMS II, developed by the U.S. Department of Commerce's Bureau of Economic Analysis is used to estimate the impacts.

Economic and Fiscal Impacts of BioAlabama

Introduction

This report presents the economic and fiscal impacts of industries of focus for BioAlabama on the economy of the State of Alabama. BioAlabama, the state partner of the life sciences trade organization Biotechnology Industry Organization (BIO), requested the study. Table 1 shows the industries of focus for BioAlabama, their specific primary North American Industry Classification System (NAICS) codes, employment, and number of companies as of the first quarter of 2018. There were 780 companies with 17,871 employees in 13 out of 15 specified industries under three life science industry groups.

Table 1. Employment and Number of Companies in BioAlabama Industries

Primary NAICS	Description	Number of Employees	Number of Companies
	Drugs and Pharmaceuticals		
325411	Medicinal and Botanical Manufacturing	376	14
325412	Pharmaceutical Preparation Manufacturing	1,108	62
325413	In-Vitro Diagnostic Substance Manufacturing	N.A.	N.A.
325414	Biological Product (except Diagnostic) Manufacturing	117	25
	Medical Devices and Equipment		
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing	295	25
334516	Analytical Laboratory Instrument Manufacturing	138	12
334517	Irradiation Apparatus Manufacturing	19	3
339112	Surgical and Medical Instrument Manufacturing	922	40
339113	Surgical Appliance and Supplies Manufacturing	1,301	49
339114	Dental Equipment and Supplies Manufacturing	196	19
	Research Testing and Medical Laboratories		
541380	Testing Laboratories	1,123	108
621511	Medical Laboratories	3,841	147
541713	Research and Development in Nanotechnology	N.A.	N.A.
541714	Research and Development in Biotechnology (except Nanobiotechnology)	120	22
541715	Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)	8,315	254
	Total	**17,871**	**780**

Note: N.A. – not available.

Source: Dun & Bradstreet Hoovers; BioAlabama; and Center for Business and Economic Research, The University of Alabama.

The impacts are presented on an annualized basis assuming that the 780 companies maintain the 17,871 employment level for a year. To be able to do this, the companies must spend a total of $3.8 billion for the year. This spending will provide jobs and business opportunities in various sectors of the state economy in addition to those of the BioAlabama industries themselves impacting output (gross business activity) and gross domestic product (GDP) and also generate tax revenues. The methodology is detailed in the Appendix.

Economic and Fiscal Impacts

The four major economic impacts of output, value-added, earnings (wages and salaries only), and employment as well as the associated fiscal impacts as driven and facilitated by BioAlabama industries' activities and expenses are the focus here. Output refers to total or gross business activity (often measured by revenues, sales, or transactions). This overall business activity impact includes value-added, which is the contribution to GDP or the value of goods and services produced on a value-added basis, as well as business-to-business dealings that are also called intermediate transactions. Earnings impacts are part of value-added and are the wages and salaries for employment impact jobs. Fiscal impacts focus on income and sales taxes that are derived from the earnings impact using tax rates published by the Alabama Department of Revenue (ADOR). The fiscal impacts are conservative because several other taxes and fees (e.g., property, utility, car tags and fees, rental/leasing, cigarettes and tobacco, insurance premiums, and Birmingham City occupational) are not estimated.

To determine the economic and fiscal impacts, two types of impacts are estimated. The first, household impacts, deals with the economic and fiscal impacts of the spending behavior of workers and determines employment and earnings impacts. Expenditure impacts, the second type, account for output and value-added impacts. Multipliers from the Regional Input-Output software, RIMS II, developed by the United States Department of Commerce's Bureau of Economic Analysis (BEA) are used. The impact model developed for the analysis combines relevant BEA RIMS II multipliers with economic structure and fiscal impact components that are specific to Alabama.

As noted above, annualized impacts are presented assuming that the state's BioAlabama industries maintain their 17,871 employment level for a year. Doing this will require total spending of $3.8 billion by these industries for the year, including a $1.2 billion payroll. This payroll translates into annual wages of $64,509 per worker which is 46 percent more than the $44,138 average salary or wages for an Alabama worker in 2016. Annualized economic and fiscal impacts are determined for each industry. These are then aggregated to determine the impacts for the entire BioAlabama industries group. Table 2 shows the aggregated annualized impacts and Table 3 shows annualized impacts of individual BioAlabama industries.

Annualized economic impacts of the BioAlabama industries group on the state are $7.3 billion in output which includes a $3.9 billion value-added or contribution to GDP of which $2.3 billion is earnings for 47,980 direct and indirect jobs. The earnings impact is for 17,871 direct BioAlabama industry jobs paying an average of $67,664 and 30,109 indirect other industries' jobs with average pay of $35,283. The earnings impact generates $161.4 million in tax revenues comprising $74.7 million state income tax, $38.5 million state sales tax, and $48.2 million local sales tax.

Table 2. Annualized Economic and Fiscal Impacts of BioAlabama

Input Data	Alabama
Employment	17,871
Economic Impacts	
Payroll amount	$1,209,216,788
Non-payroll expenditures	$2,636,807,618
Total expenditures	$3,846,024,406
Output (gross business activity)	$7,287,013,584
Contribution to GDP	$3,892,843,242
Earnings (direct wages and salaries)	$1,209,216,788
Earnings (indirect wages and salaries)	$1,062,359,451
Earnings (total wages and salaries)	$2,271,576,239
Employment (direct jobs)	17,871
Employment (indirect jobs)	30,109
Employment (total jobs)	47,980
Fiscal Impacts	
State individual income tax	$74,681,703
State sales tax	$38,525,933
Local sales tax	$48,157,416
Total income and sales taxes	$161,365,053
Direct jobs average earnings	$67,664
Indirect jobs average earnings	$35,283

Note: Rounding errors may be present.

Source: U.S. Department of Commerce, Bureau of Economic Analysis; Alabama Department of Revenue; Bio-Alabama; and Center for Business and Economic Research, The University of Alabama.

Conclusions

In the first quarter of 2018, there were 780 BioAlabama companies that employed 17,871 workers, about 0.9 percent of the state's nonagricultural employment of 2,079,876 recorded in January 2018. Maintaining this employment level for the year will result in economic impacts of $7.3 billion in output including $3.9 billion contribution to GDP (1.9 percent of the state's 2016 GDP, the latest available data) of which $2.3 billion is earnings for 47,980 direct and indirect jobs as well as fiscal impacts of $161.4 million in tax revenues ($74.7 million in state income, $38.5 million state sales, and $48.2 million in local sales taxes). Producing 1.9 percent of GDP with 0.9 percent of the workforce demonstrates that BioAlabama industries are very productive. Alabama should continue to keep biosciences as a focus in its economic development strategy since these industries provide high-wage jobs and are highly productive.

Table 3. Individual BioAlabama Industry Annualized Economic and Fiscal Impacts

	Medicinal and Botanical Manufacturing	Pharmaceutical Preparation Manufacturing	In-Vitro Diagnostic Substance Manufacturing	Biological Product (except Diagnostic) Manufacturing	Electromedical and Electrotherapeutic Apparatus Manufacturing
Input Data					
Employment	376	1,108	N.A.	117	295
Economic Impacts					
Payroll amount	$23,699,191	$64,436,119	N.A.	$7,190,909	$26,862,045
Non-payroll expenditures	$89,762,339	$254,200,409	N.A.	$41,081,954	$104,520,604
Total expenditures	$113,461,529	$318,636,528	N.A.	$48,272,863	$131,382,649
Output (gross business activity)	$192,192,485	$516,541,676	N.A.	$70,459,070	$222,522,793
Contribution to GDP	$103,749,223	$299,868,837	N.A.	$44,526,889	$121,029,697
Earnings (direct wages and salaries)	$23,699,191	$64,436,119	N.A.	$7,190,909	$26,862,045
Earnings (indirect wages and salaries)	$23,035,613	$60,118,899	N.A.	$6,653,748	$25,336,281
Earnings (total wages and salaries)	$46,734,804	$124,555,019	N.A.	$13,844,657	$52,198,327
Employment (direct jobs)	376	1,108	N.A.	117	295
Employment (indirect jobs)	595	1,549	N.A.	175	672
Employment (total jobs)	971	2,657	N.A.	292	967
Fiscal Impacts					
State individual income tax	$1,536,481	$4,094,946	N.A.	$455,165	$1,716,104
State sales tax	$792,622	$2,112,453	N.A.	$234,805	$885,284
Local sales tax	$990,778	$2,640,566	N.A.	$293,507	$1,106,605
Total income and sales taxes	$3,319,882	$8,847,965	N.A.	$983,477	$3,707,992
Direct jobs average annual earnings	$63,030	$58,155	N.A.	$61,461	$91,058
Indirect jobs average annual earnings	$38,702	$38,806	N.A.	$38,111	$37,679

Note: Rounding errors may be present. N.A. – not available

Source: U.S. Department of Commerce, Bureau of Economic Analysis; Alabama Department of Revenue; Bio-Alabama; and Center for Business and Economic Research, The University of Alabama.

Table 3. Individual BioAlabama Industry Annualized Economic and Fiscal Impacts (Continued)

	Analytical Laboratory Instrument Manufacturing	Irradiation Apparatus Manufacturing	Surgical and Medical Instrument Manufacturing	Surgical Appliance and Supplies Manufacturing	Dental Equipment and Supplies Manufacturing
Input Data					
Employment	138	19	922	1,301	196
Economic Impacts					
Payroll amount	$8,062,346	$1,077,279	$41,478,663	$54,722,627	$7,837,345
Non-payroll expenditures	$30,853,356	$3,930,201	$118,400,235	$211,218,991	$29,293,563
Total expenditures	$38,915,702	$5,007,480	$159,878,898	$265,941,618	$37,130,908
Output (gross business activity)	$68,857,443	$9,604,347	$285,831,493	$468,482,753	$66,542,300
Contribution to GDP	$35,028,023	$4,146,694	$158,471,963	$251,022,293	$32,329,881
Earnings (direct wages and salaries)	$8,062,346	$1,077,279	$41,478,663	$54,722,627	$7,837,345
Earnings (indirect wages and salaries)	$8,434,020	$1,263,217	$35,870,748	$57,770,677	$8,299,748
Earnings (total wages and salaries)	$16,496,366	$2,340,496	$77,349,411	$112,493,304	$16,137,093
Employment (direct jobs)	138	19	922	1,301	196
Employment (indirect jobs)	222	33	970	1,547	220
Employment (total jobs)	360	52	1,892	2,848	416
Fiscal Impacts					
State individual income tax	$542,344	$76,948	$2,542,986	$3,698,397	$530,533
State sales tax	$279,778	$39,695	$1,311,846	$1,907,886	$273,685
Local sales tax	$349,723	$49,619	$1,639,808	$2,384,858	$342,106
Total income and sales taxes	$1,171,846	$166,261	$5,494,639	$7,991,142	$1,146,324
Direct jobs average annual earnings	$58,423	$56,699	$44,988	$42,062	$39,986
Indirect jobs average annual earnings	$37,930	$38,812	$36,996	$37,346	$37,782

Note: Rounding errors may be present. N.A. – not available

Source: U.S. Department of Commerce, Bureau of Economic Analysis; Alabama Department of Revenue; Bio-Alabama; and Center for Business and Economic Research, The University of Alabama.

Table 3. Individual BioAlabama Industry Annualized Economic and Fiscal Impacts (Continued)

	Testing Laboratories	Medical Laboratories	Research and Development in Nanotechnology	Research and Development in Biotechnology (except Nanobiotechnology)	Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)
Input Data					
Employment	1,123	3,841	N.A.	120	8,315
Economic Impacts					
Payroll amount	$78,896,831	$196,380,464	N.A.	$9,938,205	$688,634,765
Non-payroll expenditures	$119,016,248	$235,430,337	N.A.	$19,904,200	$1,379,195,183
Total expenditures	$197,913,078	$431,810,800	N.A.	$29,842,405	$2,067,829,949
Output (gross business activity)	$403,960,384	$820,656,426	N.A.	$59,201,362	$4,102,161,052
Contribution to GDP	$219,663,725	$491,141,604	N.A.	$30,328,836	$2,101,535,577
Earnings (direct wages and salaries)	$78,896,831	$196,380,464	N.A.	$9,938,205	$688,634,765
Earnings (indirect wages and salaries)	$65,381,803	$118,495,972	N.A.	$9,271,351	$642,427,373
Earnings (total wages and salaries)	$144,278,634	$314,876,436	N.A.	$19,209,556	$1,331,062,138
Employment (direct jobs)	1,123	3,841	N.A.	120	8,315
Employment (indirect jobs)	1,930	3,519	N.A.	266	18,413
Employment (total jobs)	3,053	7,360	N.A.	386	26,728
Fiscal Impacts					
State individual income tax	$4,743,391	$10,352,067	N.A.	$631,545	$43,760,797
State sales tax	$2,446,966	$5,340,304	N.A.	$325,794	$22,574,814
Local sales tax	$3,058,707	$6,675,380	N.A.	$407,243	$28,218,517
Total income and sales taxes	$10,249,064	$22,367,751	N.A.	$1,364,582	$94,554,129
Direct jobs average annual earnings	$70,255	$51,127	N.A.	$82,818	$82,818
Indirect jobs average annual earnings	$33,883	$33,676	N.A.	$34,890	$34,890

Note: Rounding errors may be present. N.A. – not available

Source: U.S. Department of Commerce, Bureau of Economic Analysis; Alabama Department of Revenue; Bio-Alabama; and Center for Business and Economic Research, The University of Alabama.

APPENDIX

Methodology - Model

The economic and fiscal impacts presented in this report are determined using a model that combines specific economic structure and fiscal components for Alabama with multipliers from the Regional Input-Output Modeling System (RIMS II), an input-output model developed and maintained by the U.S. Department of Commerce's Bureau of Economic Analysis (BEA). The economic impacts focus on output, value-added, earnings (wages and salaries), and employment. Output refers to total or gross business activity (often measured by revenues or sales or transactions) and contains value-added, which is the contribution to gross domestic product (GDP) or the value of goods and services produced on a value-added basis. Earnings impacts are part of value-added and are the wages and salaries of the workers recognized by the employment impact.

The four main types of multipliers—output, value-added, earnings, and employment—are defined as follows. Output multipliers represent the total dollar change in output that occurs in all industries for each additional dollar of output delivered to final demand (final consumption) by the industry under study. Similarly defined, value-added multipliers represent the total dollar change in value-added across all industries. Earnings multipliers represent the total dollar change in earnings of employees in all industries for each additional dollar of payroll (or each dollar of output delivered to final demand) by the industry whose economic impact is being estimated. Employment multipliers represent total change in the number of jobs in all industries for each direct job (or for each million dollars of output delivered to final demand) by the industry whose economic impact is being estimated. Multipliers that are used in this study are shown below for the identified industries.

Primary NAICS	Description	Final Demand				Direct Effect	
		Output	Earnings	Employ-ment	Value-added	Earnings	Employ-ment
325411	Medicinal and Botanical Manufacturing	1.6939	0.4119	8.5598	0.9144	1.9720	2.5830
325412	Pharmaceutical Preparation Manufacturing	1.6211	0.3909	8.3393	0.9411	1.9330	2.3982
325413	In-Vitro Diagnostic Substance Manufacturing	1.6887	0.4397	9.5411	0.9384	1.8965	2.3623
325414	Biological Product (except Diagnostic) Manufacturing	1.4596	0.2868	6.0404	0.9224	1.9253	2.4922
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing	1.6937	0.3973	7.3634	0.9212	1.9432	3.2794
334516	Analytical Laboratory Instrument Manufacturing	1.7694	0.4239	9.2600	0.9001	2.0461	2.6113
334517	Irradiation Apparatus Manufacturing	1.9180	0.4674	10.2940	0.8281	2.1726	2.7130
339112	Surgical and Medical Instrument Manufacturing	1.7878	0.4838	11.8313	0.9912	1.8648	2.0516
339113	Surgical Appliance and Supplies Manufacturing	1.7616	0.4230	10.7087	0.9439	2.0557	2.1890
339114	Dental Equipment and Supplies Manufacturing	1.7921	0.4346	11.1949	0.8707	2.0590	2.1208
541380	Testing Laboratories	2.0411	0.7290	15.4242	1.1099	1.8287	2.7183
621511	Medical Laboratories	1.9005	0.7292	17.0439	1.1374	1.6034	1.9161
541713	Research and Development in Nanotechnology	1.9838	0.6437	12.9255	1.0163	1.9329	3.2144
541714	Research and Development in Biotechnology (except Nanobiotechnology)	1.9838	0.6437	12.9255	1.0163	1.9329	3.2144
541715	Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)	1.9838	0.6437	12.9255	1.0163	1.9329	3.2144

Note: Final demand employment multipliers reflect jobs per million dollars of expenditure.   Source: U.S. Bureau of Economic Analysis.

Industries are by the North American Industrial Classification System (NAICS) codes at the 6-digit level. For some industries, multipliers at more aggregate levels are used due to data limitations as follows: 420000 for 423450, 424210, and 424910; 541300 for 541380; 621500 for 621511; and 541700 for 541713, 541714, and 541715. The Dun & Bradstreet Hoovers database was used as source for information on companies in Alabama's bio-industries. The number of employees at company sites was the one piece of information reported by virtually all the companies. As such employment by industry was taken as input for the model and used to determine required total expenditure by industry, which was then used to estimate the economic impacts.

Fiscal impacts are derived from the earnings impact and cover worker's income and sales taxes only; no company paid taxes are included due to data limitations. The fiscal impacts are conservative for this reason and also because several other taxes and fees (e.g., property, utility, car tags and fees, rental/leasing, cigarettes and tobacco, insurance premiums, and Birmingham City occupational) are not estimated. It is important to note that not all of the earnings impacts are sales or income taxable. Spending on sales taxable items constitute 42.4 percent of total earnings based on U.S. Bureau of Labor Statistics (BLS) data. State taxable income (net income) is about 65.8 percent of earnings and the applicable tax rate is essentially 5.0 percent; the first $500 and the next $2,500 are taxed at 2.0 percent and 4.0 percent, respectively, for single persons, head of family, and married persons filing separately while for married persons filing joint returns the first $1,000 and the next $5,000 are taxed at 2.0 percent and 4.0 percent, respectively, and excess net income is taxed at the 5.0 percent rate. Corporations pay at a 6.5 percent rate and corporate income tax averages about 15 percent of individual income tax. Sales tax rates used are 4.0 percent for the state and 5.0 percent for local (combined county and city) jurisdictions. The Alabama Department of Revenue (ADOR) publications show that local sales tax rates vary between 3.0 to 7.0 percent statewide, but are usually at 5.0 percent.

Methodology - Economic Impact Analysis

Economic impact analysis measures the effects of a specific economic activity or event on a specified geographic area. Examples include impacts of a proposed industrial plant, an existing industry, closing a military installation, or expansion of an existing industrial facility. Federal laws and state and local regulations sometimes require economic impact studies prior to the implementation of a particular policy or action (relocation of an economic activity, change in tax policy, changes in zoning ordinance, providing economic incentives, etc.). Impact studies are designed to provide information for taking actions or instituting policies that facilitate positive economic impacts and/or mitigate potential negative impacts. Economic impact analysis is therefore an important decision making tool which can enhance the quality of decisions made, as well as the decision making process in both public and private sectors. The analysis typically focuses

on one or more of the major economic indicators: output, value-added, employment, and income. The purpose of an impact study usually determines which socioeconomic variable(s) should be monitored. In this study, the primary focus is on all four major economic indicators and the consequent changes in income and sales tax revenues.

Economic impacts comprise direct and indirect types. Direct impacts are those that are most obvious and include the wages and salaries of the employees who work directly for a firm or industry, as well as all other expenditures of the firm or industry, including taxes and distributed profits. Indirect economic impacts, often referred to as the "ripple" or "multiplier" effects, occur because of the additional demands arising from new income and expenditures for inputs and products related to the activity under study. New income creates demand for consumer products and services and their associated indirect impacts are often called induced impacts. Indirect and induced impacts may spark demand for the output of the firm or industry under study. For example, BioAlabama companies create direct and indirect impacts on other industries through purchases of products and services for their own use and for their workers as consumers. These other industries and their workers in turn make purchases from other vendors in the area, and so forth. To meet this additional demand, the other industries and their workers may utilize BioAlabama companies' services and products. All of this results in development of the state economy. The total economic impacts of the activity being studied are the combined direct, indirect, and induced impacts. The ratio of the total economic impact to the direct impact is the multiplier that can be used to summarize the economic effects of the organization on the region(s) or area(s) of focus.

Economic relationships do not obey strict geographic boundaries; workers, their incomes, and industry purchases flow across these boundaries enabled by transportation and communication. Thus a portion of the indirect effects of purchases or expenditures may occur beyond the boundaries of the specified region. Such occurrences are called *leakages*, as opposed to *linkages* (supplier-purchaser relationships) within the region. In general, small geographic areas have smaller *absolute* economic impacts because leakages are highly likely. Large regions have larger absolute economic impacts, but smaller *relative* economic impacts. The closure of one plant within a state, for example, may have only a small relative impact even if the plant employs thousands of workers; the absolute impact could be very large. The important point is that the effect or size of the economic impact is influenced by the size of the study area. If the area is too broadly defined, the relative impact will be small. If narrowly defined, the relative impact will be large.

Determining the Multiplier

Several methodological approaches are used in estimating economic impacts. These involve construction of econometric, economic base, computable general equilibrium (CGE), and input-output (I-O) models. Econometric and CGE models can be very costly and time-consuming to build. Economic base models require very detailed information that is sometimes not available. The other methodological approaches generate slightly smaller multipliers than I-O models because of assumptions on factors such as input substitution and optimization behavior by economic agents. The I-O modeling framework is used in this study. The technique generates multipliers for the economic activity of interest by focusing on economic interactions among all industries and all other economic transactions in the specified region. Interindustry relationships exist in two directions; backward (suppliers and other upstream linkages and leakages), and forward (distributors, retailers, customers, and other downstream linkages and leakages). The number and strength of these backward and forward linkages and leakages determine the multiplier effects of the industry. In general, products and services that require a small number of inputs and little additional processing (little value addition) will have smaller multiplier effects than complex products that require lots of inputs and extensive processing.

The nature of the product and technology largely determine the degree of interindustry linkages and leakages (and thus the overall impact), and the specific impact on a region depends upon the degree to which these interindustry relationships are localized. Technology determines inputs and economics determines the geographic source of supply and destination of products or services. Inputs purchased outside the study area constitute leakage of potential impact—activities of local firms that have no economic impact—and provide opportunities for "localizing" such impact. Identifying leakage can provide valuable planning information for economic development. An activity's maximum impact on a specific area is obtained when all interindustry linkages occur within the area. A system-wide view is required because different firms or activities have different linkages. The I-O technique permits the incorporation of such system-wide perspectives.

To estimate the economic impacts, linkages between the activity of interest and all related suppliers and clients or customers must be traced. This task is greatly facilitated by BEA's RIMS II, which provides multipliers for every state, region, county, and metropolitan area in the nation. The RIMS II I-O model provides data on each industry that reflect the value of inputs used per dollar of output in the production of that industry's output and is represented in a tabular format. Since the rows (outputs) are produced by specific industries, they are also columns (inputs) to other industries. I-O models are based on a table of transaction balances that ensures economy-wide accounting consistency. Total payments equal total receipts for each producing sector and aggregate final demand equals aggregate value-added. Demand for a particular input causes supply from its source

industry which in turn creates demand for the materials and services that are used to produce the particular input, and so on. The round-by-round effects decrease and converge; I-O methodology captures the total effect of the rounds of spending with the multiplier. RIMS II multipliers for an economy account for all linkages in and leakages from that economy.

Multipliers are determined mathematically from I-O tables that are constructed from observed and reported data for the economic area of interest. The economy is divided into a number of producing industries that sell and purchase goods and services to and from each other with *interindustry* flows that are key data. Sector goods and services are purchased by domestic consumers (households), international customers (exports), government (federal, state, and local), and for private investment purposes. These external to production purchases are for direct use and termed *final demand.* For an economy with n sectors, if X_i represents total output for sector i, Y_i represents final demand for sector i products, and z_{ij} represent interindustry flows (with j representing sectors as well), then

$$X_i = \sum_{j=1}^{n} z_{ij} + Y_i \qquad (1)$$

If a_{ij} represents the I-O technical coefficients where $a_{ij} = z_{ij} / X_j$ so that sectors use inputs in fixed proportions (the constant returns to scale Leontief production function) then the above equation becomes

$$X_i = \sum_{i=1}^{n} a_{ij} X_i + Y_i \qquad (2)$$

The standard formulation of the basic I-O model and its application, in matrix notation is:

Transactions balance: $X = AX + Y$ (3)

Solving for X: $X = (I - A)^{-1}Y$ (4)

For a change in Y: $\Delta X = (I - A)^{-1}\Delta Y$ (5)

where X is the gross output column vector, A is the matrix of fixed I-O coefficients, Y is the final demand column vector, and I is the identity matrix. This model enables determination of the output given changes in final demand levels (consumption, investment, government, or exports). The Leontief inverse, $(I - A)^{-1}$, provides the I-O multipliers used to determine impacts. The elements of the matrix are very useful and important. Each captures in a single number, an entire series of direct and indirect effects. Gross output requirements are translatable into employment coefficients in a diagonal matrix that is used together with the Leontief inverse to generate employment impacts. Similar manipulations generate value-added and income or earnings multipliers.