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The estimated economic impacts of biotechnical firms in Hillsborough County, Florida : an analysis performed by Center for Economic Development Research, College of Business Administration, University of South Florida

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The Estimated Economic Impacts of Biotechnical Firms in Hillsborough County, Florida

An Analysis Performed by

CENTER FOR ECONOMIC DEVELOPMENT RESEARCH
College of Business Administration



1101 Channelside Dr., 2nd Floor N., Tampa, Florida 33602
Office: (813) 905-5854 or Fax: (813) 905-5856

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Preface

This study was commissioned by the Corporate Business Development section of the Hillsborough County Economic Development Department and performed by the Center for Economic Development Research, College of Business Administration, University of South Florida. The purpose of the report is to quantify the estimated economic impact to Hillsborough County by two types of biotechnical firms moving into the county. The Center for Economic Development Research provides information and conducts research on issues related to economic growth and development in the Nation, in the state of Florida, and particularly in the central Florida region. The Center serves the faculty, staff, and students of the College of Business Administration, the University, and individuals and organizations in the Tampa Bay region and statewide. Activities of the Center for Economic Development Research are designed to further the objectives of the University and specifically the objectives of the College of Business Administration.

Robert Anderson, Dean, College of Business Administration (COBA), USF
Dennis G. Colie, Director, Center for Economic Development Research (CEDR), COBA, USF,
Economist and Principal Investigator
Alex A. McPherson, Research Associate, CEDR, COBA, USF
May 9, 2005 (Revised)

Executive Summary

This study quantifies the economic impact in Hillsborough County of two types of biotechnical firms. The Hillsborough County Economic Development Department (HCEDD) provided the parameters of the hypothetical firms for the study. If these firms could be attracted to the county, there would be a gain of jobs, labor income, and production within the county. Specifically, we examine the quantifiable economic impact of capital investment and operations by the two types of firms – a small medical device manufacturing firm and a large biotechnical pharmaceutical firm. The impact is measured by employment, labor income, and output. These are three measurements of the same phenomenon just like weight, density, and shape are all ways to measure a solid.

The parameters for the small medical device manufacturing firm are 35 workers in North American Industrial Classification System (NAICS) Industry 339112 (Surgical and Medical Instrument Manufacturing). The workers in this firm will earn a total of \$1,865,000 per year in labor income. The work facility costs \$11,300,000 to build and another \$3,000,000 to equip. Another parameter specifies that there will be 12 new small medical device manufacturing firms.

The parameters for the single large biotechnical pharmaceutical firm are 910 workers in NAICS Industry 325412 (Pharmaceutical Preparation Manufacturing). The workers in this firm will earn a total of \$46,600,000 per year in labor income. The work facility costs \$111,000,000 to build and another \$34,500,000 to equip.

We estimate the total economic impact of the firms in Hillsborough County for a construction phase (non-recurring) and for an operations phase (recurring year over year).

During the construction phase, the twelve small medical device manufacturing firms generate jobs for about 3,530 workers who earn \$129.0 million in labor income and produce output valued at \$302.8 million. Or, the one large biotechnical pharmaceutical firm would generate jobs for about 2,950 workers who earn \$108.7 million in labor income and produce output valued at \$255.7 million.

For the operations phase, we estimate the economic impact of the firms and calculate multipliers. A multiplier indicates the proportional increase in a measurement of impact given a direct level of change introduced in an economy. For example, an Employment multiplier of 2.0 means that for each job a new firm brings, another job is created elsewhere in the economy so that the total increase is two jobs for every one job at the new firm. The greater the multiplier, the bigger a new firm's "bang" on the economy.

We calculate Employment, Labor Income, and Output multipliers. For the small medical device manufacturing firm, the multipliers are 2.066, 1.724 and 1.518, respectively. For the large biotechnical pharmaceutical firm, the multipliers are 1.066, 1.051 and 1.019, respectively.

We also estimate the absolute values of the annual economic impacts of the two types of firms. During the operations phase, a small medical device manufacturing firm generates jobs for about 72 workers who earn \$3.2 million in labor income and produce output valued at \$10.9 million. (Proportionally, twelve of these small firms generate jobs for about 870 workers who earn \$38.6 million in labor income and produce output valued at \$129.4 million.) Or, the one large biotechnical pharmaceutical firm would generate jobs for about 970 workers who earn \$49.0 million in labor income and produce output valued at \$370.1 million.

I. Introduction

This study quantifies the economic impact in Hillsborough County of two types of biotechnical firms. If these firms could be attracted to the county, there would be a gain of jobs, labor income, and production within the county. This study estimates these impacts if the firms opened for business and all their employees lived in the county.

Specifically, we examine the quantifiable economic effects of capital investment and operations by two types of biotechnical firms – a small medical device manufacturing firm and a large biotechnical pharmaceutical firm. Because of the circulation of funds within the county's economy, the overall impact of the economic activities is a multiple of the initial, or first round, of production. That is, there are links among the various commercial elements of Hillsborough County's economy. Through these links, second and subsequent rounds of production occur following the initial productivity by a new firm.

In Section II, we describe the parameters for the two types of firms. The Hillsborough County Economic Development Department (HCEDD) provided the parameters to CEDR. We consider all employment as continuous, so that our quantifiable estimate of the firms' operations may be measured and understood as an annual occurrence. That is, as long as the firms' doors remain open, the quantifiable impact will continue year to year.

We analyze each of the parameters using the IMPLAN Professional™ Impact Analysis Software (IMPLAN™), a widely accepted application of input-output analysis that relies on historical data for making estimates of impact. We use Type II multipliers for the analysis. A description of the IMPLAN™ model, including multipliers, is in Appendix A.

We explain the estimated economic impact to the county attributable to the small medical device manufacturing firm in Section III, and the estimated economic impact to the county attributable to the large biotechnical pharmaceutical firm in Section IV of this report. The impact is measured by employment, labor income, and output. These are three measurements of the same phenomenon just like weight, density, and shape are ways to measure a solid. The impact on employment is measured in terms of jobs. Labor income, which is aggregated from all sources, including employment income and proprietors' income, is denominated in 2002 dollars. Output, akin to sales, is also measured in 2002 dollars.

The measures of economic impact include the direct, indirect, and induced effects. For example, when a firm purchases locally produced milk, the dairy, in turn, must spend a portion of the funds received from the firm to hire workers, buy milking machines, and pay for veterinary services. The first round, or initial, spending produces a direct effect on the county's economy. The effects of subsequent spending by businesses, such as the purchase of milking machines and veterinary services, are called the indirect effects. And, workers' spending, which becomes possible due to their incomes motivated by direct and indirect expenditures, leads to induced effects. So it goes, round by round, with the initial spending by the firm having a multiple effect on employment, labor income, and output within the county.

These rounds of spending continue within the county until the initial expenditures that were made by the firm “leak” out of the county’s economy. Leaks occur due to taxes, savings, and spending for goods and services produced outside of Hillsborough County.

We present a summary of quantifiable impacts in Section V.

II. Parameters for Analysis

We show the parameters for each of the hypothetical firms as provided by the HCEDD in **Table 1**, next page.

The parameters for the small medical device manufacturing firm are 35 workers in North American Industrial Classification System (NAICS) Industry 339112 (Surgical and Medical Instrument Manufacturing).¹ The workers in this firm will earn a total of \$1,865,000 per year in labor income. The work facility costs \$11,300,000 to build and another \$3,000,000 to equip. A parameter specifies that there will be 12 new small medical device manufacturing firms.

The parameters for the single large biotechnical pharmaceutical firm are 910 workers in NAICS Industry 325412 (Pharmaceutical Preparation Manufacturing). The workers in this firm will earn a total of \$46,600,000 per year in labor income. The work facility costs \$111,000,000 to build and another \$34,500,000 to equip.

¹ The North American Industry Classification System (NAICS) has replaced the Standard Industry Classification (SIC) system. NAICS was developed jointly by the U.S., Canada, and Mexico to provide new comparability in statistics about business activity across North America.

Table 1
Parameters of Hypothetical Firms

Small Medical Device Manufacturing Firm

Model: Class III & IIb Medical Device
Activities: R & D, Manufacturing and Distribution

		Sq. Ft.	Employees	Avg. Unit Cost	Capital Investment	Wages
R & D	Class 100,000 + Support Space					
	Construction	10,000		\$ 350	\$ 3,500,000	
	Equipment	10,000		\$ 40	\$ 400,000	
	Ph.D. Researcher & Managers		2	\$ 85,000		\$ 170,000
	Researcher		4	\$ 60,000		\$ 240,000
	Research Asst.		4	\$ 35,000		\$ 140,000
Manufacturing	Class 10,000 + Support Space					
	Construction	20,000		\$ 300	\$ 6,000,000	
	Equipment	20,000		\$ 110	\$ 2,200,000	
	Process Engineers		22	\$ 55,000		\$ 1,210,000
Distribution	Warehouse + Quarantine					
	Construction	20,000		\$ 90	\$ 1,800,000	
	Equipment	20,000		\$ 20	\$ 400,000	
	Warehouse + Clerical		3	\$ 35,000		\$ 105,000
Totals		50,000	35		\$ 14,300,000	\$ 1,865,000

Large Biotechnical Pharmaceutical Firm

Model: Ethical Pharmaceutical
Activities: R & D, Manufacturing and Distribution

		Sq. Ft.	Employees	Avg. Unit Cost	Capital Investment	Wages
R & D	Class 100,000 + Support Space					
	Construction	100,000		\$ 350	\$ 35,000,000	
	Equipment	100,000		\$ 40	\$ 4,000,000	
	Ph.D. Researcher & Managers		50	\$ 85,000		\$ 4,250,000
	Researcher		250	\$ 60,000		\$ 15,000,000
	Research Asst.		250	\$ 35,000		\$ 8,750,000
Manufacturing	Class 10,000 + Support Space					
	Construction	250,000		\$ 250	\$ 62,500,000	
	Equipment	250,000		\$ 110	\$ 27,500,000	
	Process Engineers		300	\$ 55,000		\$ 16,500,000
Distribution	Warehouse + Quarantine					
	Construction	150,000		\$ 90	\$ 13,500,000	
	Equipment	150,000		\$ 20	\$ 3,000,000	
	Warehouse + Clerical		60	\$ 35,000		\$ 2,100,000
Totals		500,000	910		\$ 145,500,000	\$ 46,600,000

We analyze the construction of work facilities using IMPLANTM Industry 37, Manufacturing and Industrial Buildings, which is a part of NAICS Industry Sector 23, Construction.

Then, we analyze the equipment expenditure for each firm using IMPLANTM Industry 390, Wholesale Trade, which equates to NAICS Industry Sector 42, Wholesale Trade.

A small medical device manufacturing firm produces output categorized by NAICS Industry 339112, Surgical and Medical Instrument Manufacturing. We analyze output in this industry using IMPLANTM Industry 375, Surgical and Medical Instrument Manufacturing, which equates to the NAICS Industry 339112.

A large biotechnical pharmaceutical firm produces output categorized by NAICS Industry 325412, Pharmaceutical Preparation Manufacturing. We analyze output in this industry using IMPLANTM Industry 160, Pharmaceutical and Medical Manufacturing, which equates to the NAICS Industry 32541. NAICS Industry 32541 includes the following closely related industries: Medical and Botanical Manufacturing (NAICS Industry 325411), Pharmaceutical Preparation Manufacturing (NAICS Industry 325412), In-Vitro Diagnostic Substance Manufacturing (NAICS Industry 325413), and Biological Product, except Diagnostic, Manufacturing (NAICS Industry 325414).

III. Estimated Economic Impact of a Small Medical Device Manufacturing Firm

This section explains the estimated economic impact in Hillsborough County of operations and capital investment by a hypothetical small medical device manufacturing firm. In Section V, we multiply these results, which are for a single firm by 12, as specified in the parameters for analysis of twelve firms.

The construction phase of this project requires capital investment of \$11,300,000 for the work facility and \$3,000,000 for equipment. We present the results of analysis of the construction phase in **Table 2** for the work facility and **Table 3** for the equipment.

Table 2
Construction of \$11,300,000 Manufacturing and Industrial Building
in Hillsborough County, Florida
Results of IMPLAN Analysis

	Employment	Labor Income (2002\$)	Output (2002\$)
Direct	151.4	\$ 5,492,337	\$ 11,300,000
Indirect	30.6	1,225,949	2,996,589
Induced	71.0	2,229,002	6,301,624
Total	253.0	\$ 8,947,288	\$ 20,598,213

The construction of the \$11.3 million work facility will result in almost \$20.6 million of increased output generated in Hillsborough County during the year of the construction phase. The construction phase generates employment for about 253 workers who will earn over \$8.9 million in labor income.

Table 3
Furnishing of \$3,000,000 of Equipment through
Wholesale Suppliers in Hillsborough County, Florida
Results of IMPLAN Analysis

	Employment	Labor Income (2002\$)	Output (2002\$)
Direct	20.0	\$ 1,101,578	\$ 2,724,300
Indirect	6.7	256,448	638,871
Induced	14.3	450,568	1,273,802
Total	41.0	\$ 1,808,594	\$ 4,636,973

We estimate that of the \$3.0 million investment in equipment, purchased through wholesalers, about \$2.7 million will be purchased in Hillsborough County. This generates an increase in output in Hillsborough County of over \$4.6 million. This is a one-time increase as a part of the construction phase. The equipment purchases generate about 41 jobs paying over \$1.8 million in labor income.

When the construction phase is complete, the small medical device manufacturing firm begins

operations. We show the economic impact of the operation of a single small medical device manufacturing firm in **Table 4**.

Table 4
 Operations of a Small Medical Device Manufacturing Firm
 in Hillsborough County, Florida
 Results of IMPLAN Analysis

	Employment	Labor Income (2002\$)	Output (2002\$)
Direct	35.0	\$ 1,865,000	\$ 7,105,351
Indirect	10.0	493,179	1,259,826
Induced	27.3	856,766	2,422,168
Total	72.3	\$ 3,214,945	\$ 10,787,345

The 35 workers employed by the firm are the direct effect. These workers annually earn almost \$1.9 million and produce output valued at more than \$7.1 million. Of the direct output produced by the 35 workers, almost \$4.8 million is purchased locally (Hillsborough County), while \$1.9 million is shipped to domestic trade destinations in the United States and the remaining \$0.4 million is shipped to foreign trade destinations. The indirect effect of local suppliers to the firm is 10 new jobs paying about \$493 thousand and producing sales more than \$1.2 million each year. The induced effect of workers' consumption expenditures on the local economy are 27 new jobs with income approximately \$857 thousand and sales around \$2.4 million each year.

IV. Estimated Economic Impact of a Large Biotechnical Pharmaceutical Firm

This section explains the estimated economic impact in Hillsborough County of operations and capital investment by a hypothetical large biotechnical pharmaceutical firm.

The construction phase of this project requires capital investment of \$111,000,000 for the work facility and \$34,500,000 for equipment. We present the results of analysis of the construction phase in **Table 5** for the work facility and **Table 6** for the equipment.

Table 5
Construction of \$111,000,000 Manufacturing and Industrial Building
in Hillsborough County, Florida
Results of IMPLAN Analysis

	Employment	Labor Income (2002\$)	Output (2002\$)
Direct	1487.5	\$ 53,951,268	\$ 111,000,000
Indirect	300.7	12,042,509	29,435,524
Induced	697.2	21,895,506	61,900,908
Total	2485.4	\$ 87,889,283	\$ 202,336,432

The construction of the \$111.0 million work facility will result in over \$202.3 million of increased output generated in Hillsborough County during the year of the construction phase. The construction phase generates employment of about 2,485 workers who will earn almost \$87.9 million in labor income.

Table 6
Furnishing of \$34,500,000 of Equipment through
Wholesale Suppliers in Hillsborough County, Florida
Results of IMPLAN Analysis

	Employment	Labor Income (2002\$)	Output (2002\$)
Direct	229.5	\$ 12,668,150	\$ 31,329,450
Indirect	76.6	2,949,152	7,347,014
Induced	165.0	5,181,528	14,648,726
Total	471.1	\$ 20,798,830	\$ 53,325,190

We estimate that of the \$34.5 million investment in equipment, purchased through wholesalers, about \$31.3 million will be purchased in Hillsborough County. This generates a one-time increase in output in Hillsborough County of almost \$53.3 million. The equipment purchase generates 471 jobs paying nearly \$20.8 million in labor income.

When the construction phase is complete, the large biotechnical pharmaceutical firm begins operations. We show the economic impact of the operations of the large biotechnical pharmaceutical firm in **Table 7**.

Table 7
Operations of a Large Biotechnical Pharmaceutical Firm
in Hillsborough County, Florida
Results of IMPLAN Analysis

	Employment	Labor Income (2002\$)	Output (2002\$)
Direct	910.0	\$ 46,600,000	\$ 363,353,316
Indirect	31.8	1,487,908	4,223,993
Induced	28.7	902,311	2,550,928
Total	970.5	\$ 48,990,219	\$ 370,128,237

The 910 workers employed by the firm are the direct effect. These workers annually earn \$46.6 million and produce output valued at almost \$363.4 million. Of the direct output produced by the 910 workers, almost \$10.8 million is purchased locally (Hillsborough County), while about \$324.9 million is shipped to domestic trade destinations in the United States and the remaining \$27.7 million is shipped to foreign trade destinations. The indirect effect of local suppliers to the firm is about 32 new jobs paying almost \$1.5 million and producing sales over \$4.2 million each year. The induced effect of workers' consumption expenditures on the local economy are 29 new jobs with income approximately \$902 thousand and sales around \$2.5 million each year.

V. Summary of Quantifiable Impacts

This section summarizes the estimated economic impacts within Hillsborough County of capital investment and operations for two types of firms. We hypothesize twelve small medical device manufacturing firms or one large biotechnical pharmaceutical firm.

Besides recurring operations, the parameters for both firm types include constructing new work facilities and furnishing with new equipment prior to initiating operations. These activities are one-time capital investments. **Table 8** summarizes the capital investments for the twelve small medical device manufacturing firms.

Table 8
Non-Recurring Capital Investment Effects of
Construction and Equipment for
Twelve Small Medical Device Manufacturing Firms

	Employment	Labor Income (2002\$)	Output (2002\$)
Direct	2056.8	\$ 79,126,980	\$ 168,291,600
Indirect	447.6	17,788,764	43,625,520
Induced	1023.6	32,154,840	90,905,112
Total	3528.0	\$ 129,070,584	\$ 302,822,232

Similarly, **Table 9** summarizes the capital investments for a single large biotechnical pharmaceutical firm.

Table 9
Non-Recurring Capital Investment Effects of
Construction and Equipment for
One Large Biotechnical Pharmaceutical Firm

	Employment	Labor Income (2002\$)	Output (2002\$)
Direct	1717.0	\$ 66,619,418	\$ 142,329,450
Indirect	377.3	14,991,661	36,782,538
Induced	862.2	27,077,034	76,549,634
Total	2956.5	\$ 108,688,113	\$ 255,661,622

Table 10 shows the economic impacts of construction and equipment for twelve small medical device manufacturing firms or one large biotechnical pharmaceutical firm. For each of our three measures of economic impact, the twelve small firms have a greater effect than the single large firm.

Table 10
Comparison of Non-Recurring Capital Investment Effects
Twelve Small Medical Device Manufacturing Firms (NAICS 339112) and
One Large Biotechnical Pharmaceutical Firm (NAICS 32541)

	Twelve Small Employment	One Large Employment	Twelve Small Labor Income (2002\$)	One Large Labor Income (2002\$)	Twelve Small Output (2002\$)	One Large Output (2002\$)
Direct	2056.8	1717.0	\$ 79,126,980	\$ 66,619,418	\$ 168,291,600	\$ 142,329,450
Indirect	447.6	377.3	17,788,764	14,991,661	43,625,520	36,782,538
Induced	1023.6	862.2	32,154,840	27,077,034	90,905,112	76,549,634
Total	3528.0	2956.5	\$ 129,070,584	\$ 108,688,113	\$ 302,822,232	\$ 255,661,622

For the operation of each type of firm, we develop a multiplier that summarizes the direct, indirect, and induced impacts, which combine to produce its total effect. We calculate the multipliers by dividing a Total measurement of impact by the Direct effect for that measurement. For instance, we find the small medical device manufacturing firm’s Total Employment Multiplier of 2.066 by dividing Total Employment of 72.3 by the Direct Employment of 35.0. The interpretation of this multiplier is that for every job generated at the small medical device manufacturing firm, another 1.066 jobs, or a total of 2.066 jobs, are generated for Hillsborough County’s economy. We similarly interpret the Total Labor Income and Total Output multipliers.

Table 11 shows multipliers for the small medical device manufacturing firm.

Table 11
Operations of a Small Medical Device Manufacturing Firm
in Hillsborough County, Florida
IMPLAN Multipliers

	Employment Multiplier	Labor Income Multiplier	Output Multiplier
Direct	1.000	1.000	1.000
Indirect	0.286	0.264	0.177
Induced	0.780	0.459	0.341
Total	2.066	1.723	1.518

Table 12 shows multipliers for the large biotechnical pharmaceutical firm.

Table 12
 Operations of a Large Biotechnical Pharmaceutical Firm
 in Hillsborough County, Florida
 IMPLAN Multipliers

	Employment Multiplier	Labor Income Multiplier	Output Multiplier
Direct	1.000	1.000	1.000
Indirect	0.035	0.032	0.012
Induced	0.032	0.019	0.007
Total	1.067	1.051	1.019

Table 13 compares the multipliers for the two types of biotechnical firms. For each of our three measures of economic impact a small medical device manufacturing firm has a greater multiplier effect than the large pharmaceutical firm.

Table 13
 Comparison of Operational Multipliers
 Small Medical Device Manufacturing Firm (NAICS 339112) and
 Large Biotechnical Pharmaceutical Firm (NAICS 32541)

	NAICS 339112 Employment Multiplier	NAICS 32541 Employment Multiplier	NAICS 339112 Labor Income Multiplier	NAICS 32541 Labor Income Multiplier	NAICS 339112 Output Multiplier	NAICS 32541 Output Multiplier
Direct	1.000	1.000	1.000	1.000	1.000	1.000
Indirect	0.286	0.035	0.264	0.032	0.177	0.012
Induced	0.780	0.032	0.459	0.019	0.341	0.007
Total	2.066	1.067	1.723	1.051	1.518	1.019

Table 14 compares the absolute values of recurring operations of the twelve small medical device manufacturing firms and the one large pharmaceutical firm. In Table 14, twelve small medical device manufacturing firms create fewer total jobs with less total income and produce less total output than one large pharmaceutical firm. However, the indirect and induced effects show a small medical device manufacturing firm generates greater commercial links with existing Hillsborough County firms than the one large pharmaceutical firm.

Table 14
Comparison of Operations
Twelve Small Medical Device Manufacturing Firm (NAICS 339112) and
One Large Biotechnical Pharmaceutical Firm (NAICS 32541)

	NAICS 339112	NAICS 32541	NAICS 339112	NAICS 32541	NAICS 339112	NAICS 32541
	Employment	Employment	Labor Income (2002\$)	Labor Income (2002\$)	Output (2002\$)	Output (2002\$)
Direct	420.0	910.0	\$ 22,380,000	\$ 46,600,000	\$ 85,264,212	\$ 363,353,316
Indirect	120.0	31.8	5,918,148	1,487,908	15,117,912	4,223,993
Induced	327.6	28.7	10,281,192	902,311	29,066,016	2,550,928
Total	867.6	970.5	\$ 38,579,340	\$ 48,990,219	\$ 129,448,140	\$ 370,128,237

Appendix A.

Regional Economic Development Impact Analysis

*The Center for Economic Development Research (CEDR), College of Business Administration, University of South Florida (USF), uses the **IMPLAN Professional**TM Social Accounting and Impact Analysis Software (an input-output model) for economic impact analyses. Data (year 2002 currently available) for each county in the state of Florida are available. County-wide data may be aggregated to focus on a region, such as the 7-county region - Hernando, Hillsborough, Manatee, Pasco, Pinellas, Polk and Sarasota - of special importance to the USF community. The following article briefly explains the economic impact analysis and the assumptions upon which the analysis is based.*

The Impact Analysis.

Economic impact analysis is based on conditional, predictive models of the form: If ...then... An input-output model is one type of model used in impact analysis. Other generally accepted models are the economic base model and the income-expenditure model. Compared with the input-output model, both the economic base and income-expenditure models are limited in application to small economic regions in which the interdependencies (sales/purchase relationships) between producing sectors are insignificant.

Interindustry relationships were first described in 1758 by the Frenchman Francois Quesnay, founder of the physiocratic or “natural order” philosophy of economic thought. The physiocrats depicted the flow of goods and money in a nation, and thus made the first attempt to describe the circular flow of wealth on a macroeconomic basis. Wassily Leontief was born in Russia in 1906 and first studied economic geography at the University of St. Petersburg before moving to Berlin and China. He came to the United States in 1931 and, after a brief 3-month stint at the National Bureau of Economic Research in New York, he was hired by Harvard University. At Harvard, Professor Leontief undertook a research project that encompassed a 42-industry input-output table showing how changes in one sector of the economy lead to changes in other sectors. From this research, he developed the concept of multipliers from input-output tables, and was subsequently awarded the Nobel prize in economics in 1973 for his development of input-output (I-O) economics.

The historical transactions data in the I-O model represent the sales and purchases between sectors that occurred over an estimation period. These data describe each sector’s “purchases” and “sales” linkages with the rest of the economy. For each productive sector the transaction data take into account all sales revenue and costs, with the difference between revenue and costs being profit, which is a part of value added. (Total value added to a product at each stage of its production is the sum of wages and salaries, rents, profits, interest, and dividends.) The historical transaction or descriptive data are used to create the *descriptive* model of information about local economic interactions called *regional economic* accounts. These accounts, or transaction tables, describe a local economy in terms of the flow of dollars from purchasers to producers within the defined region.

For example, an increase in government purchases (first round) of output from the “manufacturing” sector of a region may require the “manufacturing” industry, in order to expand output, to purchase (second round) factor inputs from other sectors of the regional economy. In turn, these other sectors may have to purchase (third round) inputs to deliver the supporting production of factors to the “manufacturing” sector. The rounds of spending will continue with each round becoming increasingly weaker in its impact because of leakages from the region attributable to imports, savings, and taxes.

The first round is called the direct effects of the change in final demand (consumption) in a sector(s) of the economy. The second and subsequent rounds are collectively referred to as the indirect effects of interindustry purchases (reduction in purchases) in response to direct effects.

The *open* I-O model just described does not take into account changes in spending in the region, in response to the direct effects, for household consumption. Changes in spending from households as income or population increases (decreases) due to changes in the level of production are called induced effects.

Induced effects are incorporated into the I-O descriptive model by forming a *closed* model. That is, transactions of the household sector are made endogenous to the model by treating households as a producing sector. The household sector sells its labor to the other producing sectors and purchases factor inputs, i.e. consumption expenditures, in order to maintain its labor.

There are two steps in impact analysis using the I-O model. First, the descriptive model is created; then, the predictive model is derived from the descriptive model. The descriptive model contains information about interindustry transactions called the *regional economic accounts*. The information describes the flow of dollars from purchasers to producers within the region.

In addition to the regional economic accounts, the descriptive I-O model includes the *social accounts*. Social accounting data include, for example, taxes paid by businesses and households to government, and transfer payments from government to businesses and households. Trade flows also are a part of the social accounts.

Trade flows describe the movement of goods and services between the region and the rest of the world, that is imports and exports. The analyst must choose between *regional purchase coefficients* (RPCs) or supply/demand pooling. RPCs are econometrically derived to predict local purchases based upon a region’s characteristics. In contrast, *supply/demand pooling* presumes everything that can be purchased locally, will be. Hence, it will lead to larger multipliers than RPCs, because the leakages for imports are less. (The analyst also decides if local purchase coefficients - LPCs - are to be applied to an event during impact analysis. If the LPCs were to be applied, the model’s RPCs are used to determine how much of the first-round expenditure is used to purchase local products and how much is for imported items. Otherwise, the RPCs are applied to second and subsequent rounds of spending only.)

The regional economic accounts and social accounts are used to build *multipliers*. The multipliers are the *predictive* I-O model. A set of multipliers are expected changes in output for each industry in the model given a one dollar change in final demand for any particular industry or commodity.

A multiplier measures the effects of a change in final demand(s) in a region. The change in economic activity is called the *impact*. The impact is essentially the expected or predicted consequence of a change in final demand(s) within the region due to a single event or a group of events. A group of related events may be referred to as a project.

A Type I multiplier measures the direct and indirect effects of a change in economic activity. It only captures interindustry effects within the region. In addition to the direct and indirect effects, a Type II multiplier captures the induced effects of changes in household income and expenditures. A Type III multiplier also captures direct, indirect, and induced effects. However, the Type III multiplier estimates the induced effects based upon changes in employment. It assumes the region is at full employment, then each job added or subtracted by the impact is associated with the region's average expenditures per person. A Type II multiplier is most commonly used in impact analyses.

Personal consumption expenditures (PCE) are spending by households and are strongly related to total personal income. Total personal income is income from all sources, including employment income and transfer payments that are based on place of residence. Because of commuting patterns, PCE in a region may not be strongly related to employment income in that location. Hence, the income based induced effects of the Type II multiplier are normally adjusted so that a regional average amount of transfer payments is associated with a change in employment income. Such multiplier is called a Social Accounting Matrices (SAM) Income multiplier. However, suppose that an increase (decrease) in employment income is not anticipated to be associated with a corresponding change in regional transfer payments. For instance, it may be believed that an increase in final demand will only generate low paying jobs. Then, it is likely that the under-employed will be hired and transfer payments will not increase in the region. Accordingly, a Specific Disposable Income may be applied to the Type II multipliers. That is, the change in household consumption expenditures is estimated by disposable income, which is defined as a specified (by the analyst) percentage of employment income.

A change in final demand may be applied to an industry or to a commodity. Industries are businesses producing goods and services; commodities are the goods and services being produced. An industry can make more than one commodity. An industry usually is named for the primary, by value, commodity it produces. Commodities produced by an industry, other than its primary commodity, are called secondary commodities or by-products. An industry applied change in final demand has a direct effect on the selected industry only. A commodity applied change in final demand directly affects all industries that produce the commodity, whether as a primary or secondary commodity. The analyst chooses between an industry or commodity applied change in final demand. The choice is appropriately based on the circumstance for the

change in final demand. The choice will affect the predicted impact.

As an alternative to estimating the economic impact of a change in final demand (“at the factory door”), the analyst may estimate the impact of a change in sales and employee payroll for a particular institution, e.g. state/local government education, or business sector. Then, a typical expenditure pattern for the institution or industry is generated to assess the economic impact of the change in sales and payroll. (If the event under study is believed to have an atypical expenditure pattern, this alternative approach is inappropriate. Instead the analyst should specify the expenditure pattern of the institution or industry in detail.) Using this alternative approach, the direct effect on final demand, i.e. output, in the region will be less than the change in sales. This happens because the model includes the institution’s or industry’s production function and final demand is an estimate of the value, in producer prices, of the factor inputs needed to generate the specified change in level of sales. The difference between the estimated change in final demand and the change in sales is total value added. Also, with this approach, the induced effects are interpreted as resulting from a change in household spending by the suppliers of the institution’s or industry’s factor inputs (first round) as well as subsequent rounds of interindustry sales/purchases.

Margins are used to convert purchaser prices to producer prices. Margins depend on the consumer. For example, households pay the full retail margins, but government may pay little or no retail margins because it has more buying power than individual households. Margins split a purchaser price into appropriate producer values, each value impacting a specific industry. For example, the purchaser price of a tire at an automotive retailer includes the producer price at the factory door plus transportation costs, the wholesaler’s markup, and the retailer’s markup. Unless edited by the analyst, margins used in impact analysis are national averages.

A deflator may be used to convert expenditures to the base year (estimation period) used to calculate predictive multipliers and to inflate the reports of impact analysis to the current year. Deflators are associated with commodities, and are also used to adjust margin values.

A predicted regional impact may be gauged in terms of output (a change in production measured in dollars), of employment (a change in employment measured by number of jobs), or of personal income (a change in income from all sources, including employment and transfer payments, for persons residing in the region).

I-O Model Assumptions.

The following are the fundamental assumptions of the I-O model. First, it is assumed that the proportions in which each sector purchases its inputs from all other sectors are invariant over the period of analysis. The implications of this assumption are unchanged technology, constant relative prices, no shift in the mix production activities within sectors, and no new significant firm has moved into or out of the region.

Second, the I-O model assumes linear production functions, that is a sector's inputs remain in proportion to its output. This implies that no industry enjoys economies of scale. Third, each sector of the regional economy is assumed to be homogeneous. An increase (decrease) in a sector's final demand will always have the same impact on the economy. And fourth, in the closed I-O model, it is assumed that the household sector's marginal propensity to consume equals its average propensity to consume.

Prepared by:
Dennis G. Colie, Ph.D.
Economist
E-mail: DCOLIE@coba.usf.edu