How to Measure Economic Impacts of Business Activity

A summary of how estimates of impacts from small business activities are generated

How to Measure Economic Impacts of Business Activity

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Basic Theory Behind Economic Impact Estimation

What are impacts and how do we determine them?

Multipliers

- Final consumption (or final demand) drives input-output models.
- Industries respond to meet demands directly or indirectly by supplying goods and services to industries down the supply chain.
- Each industry that produces goods and services generates demands for other goods and services and so on, round by round.
- Multipliers describe these iterations.

Multipliers

- There are three different multipliers developed for predictive modeling: the Type I, the Type II, and the Type SAM.
- To get these, we first start with the Technology Matrix ➔ A
- The columns of the A Matrix are coefficients of the production function.
- A production function shows where an industry spends, and in what proportions, to generate each dollar of output.

Let's Start with the Two-Industry Model

- A hypothetical economy with only two industries, electric company *E* and water company *W*.
- Output for both companies is measured in dollars.

Two-Industry Model Input-Output (I-O) Model

- The electric company uses both electricity and water (input) in the production of electricity (output).
- The water company uses both electricity and water (input) in the production of water (output).

Key Assumptions of an Input-Output (I-O) Model

- Constant Returns to Scale (If additional output is required, all inputs increase proportionately.)
- No Supply Constraints (Supplies are unlimited)
- Fixed Commodity Input Structure (Price changes do not cause a firm to buy substitute goods.)
- Homogeneous Sector Output (Proportions of all commodities produced by an industry remain the same)
- Industry Technology Assumption (An industry uses the same technology to produce all of its products)

Two-Industry Model

- The production of each dollar's worth of electricity requires $0.30 worth of electricity and $0.10 worth of water.
- The production of each dollar's worth of water requires $0.20 worth of electricity and $0.40 worth of water.
- The final demand from the outside sector (the demand from all other users of electricity and water) is ➔
- d_1 = $12 million for electricity and d_2 = $8 million for water
- How much electricity and water must be produced to meet this final demand?

Two-Industry Model

- Electricity req'd to produce electricity
  + Electricity req'd to produce water
  = $5.2 million of electricity = 0.3(12) + 0.2(8) = 5.2

- Water req'd to produce electricity
  + Water req'd to produce water
  = $4.4 million of water = 0.1(12) + 0.4(8) = 4.4

Two-Industry Model

- System of Equations
- 0.3(12) + 0.2(8) = $5.2 million
- 0.1(12) + 0.4(8) = $4.4 million

BASIC INPUT-OUTPUT PROBLEM

- Given the internal demands for each industry's output, determine output levels for the various industries that will meet a given final (outside) level of demand as well as the internal demand.

BASIC INPUT-OUTPUT PROBLEM

- Independent Variables:
- x_1 = total output from electric company
- x_2 = total output from water company

BASIC INPUT-OUTPUT PROBLEM

- Independent Variables:
- $0.3x_1 + 0.2x_2$ ➔ internal demand for electricity
- $0.1x_1 + 0.4x_2$ ➔ internal demand for water

REVIEW OF BASIC MATRIX ALGEBRA

- **DON'T WORRY: EXCEL WILL DO ALL THIS FOR US!**
- Matrix Dimensions (row x columns)
- Matrix Addition
- Matrix Multiplication
- Identity Matrix
- Matrix Inverse

BASIC INPUT-OUTPUT PROBLEM

- Independent Variables:
- $0.3x_1 + 0.2x_2$ ➔ internal demand for electricity
- $0.1x_1 + 0.4x_2$ ➔ internal demand for water
- Matrix Product ➔

BASIC INPUT-OUTPUT PROBLEM – Building the Matrix Eq.

- Internal Demand for electricity: $0.3x_1 + 0.2x_2$
- Internal Demand for water: $0.1x_1 + 0.4x_2$
- $\begin{bmatrix} 0.3 & 0.2 \\ 0.1 & 0.4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$

BASIC INPUT-OUTPUT PROBLEM

- System of Equations (College Algebra):
- Total Output = Internal Demand + Final Demand
- Output of electricity: $x_1 = 0.3x_1 + 0.2x_2 + d_1$
- Output of water: $x_2 = 0.1x_1 + 0.4x_2 + d_2$

BASIC INPUT-OUTPUT PROBLEM - Matrix Form

- Output of electricity: $x_1 = 0.3x_1 + 0.2x_2 + d_1$
- Output of water: $x_2 = 0.1x_1 + 0.4x_2 + d_2$
- $$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0.3 & 0.2 \\ 0.1 & 0.4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} d_1 \\ d_2 \end{bmatrix}$$

BASIC INPUT-OUTPUT PROBLEM - Matrix Form

- Remember: d_1 = \$12 million for electricity and d_2 = \$8 million for water
- Output of electricity: $x_1 = 0.3x_1 + 0.2x_2 + 12$
- Output of water: $x_2 = 0.1x_1 + 0.4x_2 + 8$
- $$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0.3 & 0.2 \\ 0.1 & 0.4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 12 \\ 8 \end{bmatrix}$$

BASIC INPUT-OUTPUT PROBLEM (2 Industry) - Matrix Form

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0.3 & 0.2 \\ 0.1 & 0.4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 12 \\ 8 \end{bmatrix}$$

or $\boldsymbol{X = AX + D}$

BASIC INPUT-OUTPUT PROBLEM - Matrix Form

$$X = AX + D \qquad \textit{where}$$

$$D = \begin{bmatrix} d_1 \\ d_2 \end{bmatrix} = \textit{Final demand matrix}$$

$$X = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \textit{Output matrix}$$

$$A = \begin{bmatrix} 0.3 & 0.2 \\ 0.1 & 0.4 \end{bmatrix} = \textit{Technology matrix}$$

BASIC INPUT-OUTPUT PROBLEM – Technology Matrix

$$\text{Input} \quad \begin{matrix} E \\ W \end{matrix} \rightarrow \quad \mathbf{A} = \begin{matrix} E \\ \uparrow \end{matrix} \quad \begin{matrix} \\ W \end{matrix} \quad \begin{bmatrix} \begin{pmatrix} input\ from\ E \\ to\ produce\ \$1 \\ of\ electricity \end{pmatrix} & \begin{pmatrix} input\ from\ E \\ to\ produce\ \$1 \\ of\ water \end{pmatrix} \\ \begin{pmatrix} input\ from\ W \\ to\ produce\ \$1 \\ of\ electricity \end{pmatrix} & \begin{pmatrix} input\ from\ W \\ to\ produce \\ \$1\ of\ water \end{pmatrix} \end{bmatrix} = A$$

LEONTIEF ANALYSIS - Technology Matrix

Wassily Leontief (1905-1999) Wrote a paper in 1951 where he divided the U.S. Economy into 500 sectors

Leontief won the Nobel Prize in Economics in 1971 for this work

BASIC INPUT-OUTPUT PROBLEM

- $X = AX + D$
- $X - AX = D$
- $IX - AX = D$
- $(I - A)X = D$
- $X = (I - A)^{-1}D$ Assuming $I - A$ has an inverse

The INVERSE LEONTIEF

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

Assuming $I - A$ has an inverse

BASIC INPUT-OUTPUT PROBLEM – 2 Industry

TWO-INDUSTRY MODEL - USING EXCEL INPUT

IDENTITY MATRIX

$$\mathbf{I} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

TECHNOLOGY MATRIX

$$\mathbf{A} = \begin{bmatrix} 0.3 & 0.2 \\ 0.1 & 0.4 \end{bmatrix}$$

$\mathbf{I - A}$

$$\begin{bmatrix} 0.7 & -0.2 \\ -0.1 & 0.6 \end{bmatrix}$$

FINAL DEMAND MATRIX

$$\mathbf{D} = \begin{bmatrix} 12 \\ 8 \end{bmatrix}$$

BASIC INPUT-OUTPUT PROBLEM – 2 Industry

TWO-INDUSTRY MODEL - USING EXCEL to SOLVE

I-A

0.7	-0.2
-0.1	0.6

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

1.5	0.5
0.25	1.75

Using MINVERSE Function

INVERSE LEONTIEF

I-A

0.7	-0.2
-0.1	0.6

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

1.5	0.5
0.25	1.75

Product: (I - A) * (I-A)^-1

1.00	0.00
0.00	1.00

Using MMULT function

$(I-A)^{-1}$		**x**	**D**	**=**	**X**
1.5	0.5		12		22
0.25	1.75		8		17

Using MMULT Function

BASIC INPUT-OUTPUT PROBLEM – 2 Industry

	X	=	$(I-A)^{-1}$		x	D	
Output of Electricity	22		1.5	0.5		12	Final Demand for Electricity
Output of Water	17		0.25	1.75		8	Final Demand for Water

BASIC INPUT-OUTPUT PROBLEM – DEFINITIONS

- Direct Effects are the changes in the industries to which a final demand change was made
- Indirect Effects are the changes in inter-industry purchases as they respond to the new demands of the directly effected industries
- Type I multiplier measures the Direct and Indirect Effects of a change in economic activity.
- Type I multipliers capture *inter-industry* effects only, i.e. industries buying from other industries.

BASIC INPUT-OUTPUT PROBLEM – Tweeking the final demand

Experiment to Convince Yourself the Leontief is Matrix of Multipliers

	X	=	**$(I-A)^{-1}$**	x	**D**	
Output of Electricity	1.5		1.5 0.5		1	Final Demand for Electricity
Output of Water	0.25		0.25 1.75		0	Final Demand for Water

Total

Dollar output of Electricity	1.5	results from a	1	dollar change in Final Demand for Electricity
Dollar output of Electricity	1.5	results from a	0	dollar change in Final Demand for Water
Dollar output of Water	0.25	results from a	1	dollar change in Final Demand for Electricity
Dollar output of Water	0.25	results from a	0	dollar change in Final Demand for Water

Experimentation with 1,0 and 0,1 column vectors for D confirms ==>

the Inverse Leontief is the matrix whose entries give Direct Effects

the Column Sums of Inv Leontief are the Direct + Indirect Effects = Type I Multipliers

BASIC INPUT-OUTPUT PROBLEM - MULTIPLIERS

- Technically, a Multiplier is unit-less because it is calculated as follows:
- Output Multiplier = Total Output / Direct Output
- GDP Multiplier = Total GDP / Direct GDP
- Employment Multiplier = Total Employment / Direct Employment

- From https://support.implan.com/hc/en-us/articles/115009674768-Explaining-the-Type-SAM-Multiplier

Economic Impacts Analysis in Summary

- Economic Impact Analysis using tools like IMPLAN utilize I-O Modeling to obtain multipliers.
- Initial effects determine Direct, Indirect, and Induced Effects on Output, Employment, Income, Value Added, and various Taxes.
- Multipliers help determine the magnitude of these effects.

BASIC INPUT-OUTPUT PROBLEM – MORE DEFINITIONS

- Induced Effects typically reflect changes in spending from households as income increases or decreases due to the changes in production
- Type II multipliers not only account for the direct and indirect effects associated with changes in production, but they also account for the induced impacts associated with increases in earnings.

IMPLAN, REMI, RIMS II

- Commercially Available Input-Output Modelling Systems
- RIMS II – Regional Input-Output System developed by the U.S. Bureau of Economic Analysis (introduced in 1970s) – Inexpensive
- IMPLAN – More sophisticated. Some cost.
- REMI – Most sophisticated and expensive.

BASIC INPUT-OUTPUT PROBLEM - IMPLAN MULTIPLIERS

IMPLAN Multiplier reports differentiate between

Effects, which are on a per-million-dollar basis (e.g., a Direct Employment effect of 7.5 indicates that 7.5 Direct jobs are needed for $1 million worth of production in that Industry), and

Multipliers, which are unit-less (e.g., an Employment Multiplier of 2.5 indicates that 1.5 additional Indirect and Induced jobs in a variety of Industries are needed for every Direct job in that Industry).

TYPE I MULTIPLIERS – A Spreadsheet of the Local Economy

	INDUSTRIES		***INSTITUTIONS***		
Industries	Agriculture	Manufacture	Households	Exports	**Sum of Revenues**
Agriculture	150	500	100	250	1,000
Manufacture	200	100	200	1,500	2,000
Value Added	400	700	**A Matrix**		
Imports	250	700			
Sum of Spending	1,000	2,000			

TYPE I MULTIPLIERS - A Spreadsheet of the Economy

- **A** =

150/1,000	500/2,000
200/1,000	200/2,000

0.15	0.25
0.20	0.05

It takes $0.20 of output from Manufacture to produce $1.00 of Agriculture

TYPE I MULTIPLIERS - A Spreadsheet of the Economy

- Form Leontief
- $(I-A)^{-1}=$

1.25	0.33
0.26	1.12

Type I Multipliers	1.51	1.45

TYPE I MULTIPLIERS – A Spreadsheet of the Economy

- Multipliers incorporate round by round spending
- If local agriculture sales increase by $1, that change will ultimately increase sales by local agriculture by $1.51 (including the original $1) and sales by local manufacturing by $0.26
- If hundreds of industries, then hundreds of rows and columns, one for each industry

TYPE II MULTIPLIERS – A Spreadsheet of the Economy

- We can include household spending by treating households like they are an industry: by adding payments to local households as another row and consumption by local production as another column
- That is, include the third row and third column in the augmented matrix $\mathbf{A}$.

TYPE II MULTIPLIERS – A Spreadsheet of the Local Economy

	INDUSTRIES		***INSTITUTIONS***		
Industries	Agriculture	Manufacture	Households	Exports	**Sum of Revenues**
Agriculture	150	500	100	250	1,000
Manufacture	200	100	200	1,500	2,000
Value Added	400	700			
Imports	250	700			
Sum of Spending	1,000	2,000			

A Matrix

TYPE II MULTIPLIERS – A Spreadsheet of the Economy

- Value Added is a combination of payment to workers and returns to capital.
- Down the Columns is Demand or Buyers.
- Across the Rows is Supply or Sellers.
- Supply Equals Demand.

TYPE II MULTIPLIERS – A Spreadsheet of the Economy

- Type I Multipliers

  = (Direct + Indirect Effect) / Direct Effect

- Type II Multipliers

  = (Direct + Indirect + Induced Effect)

  / Direct Effect

Type SAM Multiplier (IMPLAN)

- A Type SAM Multiplier (SAM stands for Social Accounting Matrix) is calculated by dividing the sum of the Direct Effects, Indirect Effects, and Induced Effects by the Direct Effects.
- The Induced Effects represent the spending of Labor Income by the employees working in the Indirectly-impacted Industries, under the assumption that the more income households earn, the more money those households spend.

Type SAM Multiplier (IMPLAN)

- IMPLAN (SAM Multiplier) does not assume that 100% of this Labor Income is spent, nor that it is spent locally.
- IMPLAN removes payroll taxes, personal income taxes, savings, in-commuter income, and non-local purchases before spending the rest locally.
- These leakages and expenditures are based on information in the SAM.

Economic Indicators - Obtainable from IMPLAN

- ***Employment*** includes total wage and salary employees as well as self-employed jobs in a region. It includes both full-time and part-time workers and is measured in annual average jobs.
-
- ***Labor income*** includes all forms of employment income, including employee compensation (wages and benefits) and proprietor income.
-
- ***Value-Added*** consists of four components.

1. Employee Compensation
2. Proprietor Income
3. Other Property Income
4. Indirect Business Tax

Economic Indicators - Obtainable from IMPLAN

- ***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.
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- ***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.

Economic Indicators - Obtainable from IMPLAN

- ***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.
- ***Total Industry Output*** (TIO) is the value of production by industry for a calendar year. Output can be measured either by the total value of final purchases, or by intermediate outlays plus value-added. Output can also be thought of as a value of sales plus or minus inventory.
- Output values used by IMPLAN as inputs are derived from a number of sources, including Bureau of Census economic censuses, BEA output estimates, and the BLS employment projections.

Output Snippet from a Study by Three Rivers Analytics

Impact Type	Employment (Jobs)	Labor Income	Total Value Added	Output
Direct Effect	7.0	$ 168,341	$ 236,913	$ 470,598
Indirect Effect	1.0	25,887	42,883	90,871
Induced Effect	0.8	23,448	52,604	91,095
Total Effect	8.8	$217,676	$332,400	$652,564

Output Snippet from a Study by Three Rivers Analytics

Sector	Description	Total Employment	Total Labor Income	Total Total Value Added	Total Output
413	Food services and drinking places	3.1	55,206.7	85,759.5	175,796.7
330	Retail Stores - Miscellaneous	2.1	32,608.7	69,590.2	90,948.3
411	Hotels and motels, including casino hotels	1.3	21,747.1	43,755.8	120,093.5
348	Radio and television broadcasting	0.4	54,621.2	26,110.4	72,364.8
403	Spectator sports companies	0.3	1,157.7	449.0	7,606.6
326	Retail Stores - Gasoline stations	0.3	10,372.0	19,926.7	27,428.5
382	Employment services	0.1	2,385.3	2,782.4	3,827.0
39	Maintenance and repair construction of nonresidential structures	0.1	1,658.3	1,824.8	4,553.8
360	Real estate establishments	0.1	409.3	5,817.6	8,661.9
329	Retail Stores - General merchandise	0.1	1,356.9	2,314.3	3,016.0

Output Snippet from a Study by Three Rivers Analytics

Institution Receipts	Transfer Type	Description	Employee Compensation	Tax on Production and Imports	Households	Corporations
12001	15007	Dividends				$20.00
12001	15014	Social Ins Tax- Employee Contribution	$208.00			
12001	15015	Social Ins Tax- Employer Contribution	$368.00			
12001	15020	Tax on Production and Imports: Sales Tax[1]		State = $10,170.48 City = $7,684.37 County= $3,164.15 Total = $21,019.00		

For Fun: Let's Model a Three-Industry Economy to get Type I Multipliers

- Three Sectors: Ag, Energy, Manufacturing
- Production of $1 of Ag requires input of $0.20 from Ag sector and $0.40 from Energy Sector
- Production of $1 of Energy requires input of $0.20 from Energy and $0.40 from Manufacture
- Production of $1 of Manuf requires $0.10 from Ag, $0.10 from Energy, and $0.30 from Manuf

For Fun: Let's Model a Three-Industry Economy to get Type I Multipliers (Time Permitting)

- Technology Matrix
- A =

0.2	0	0.1
0.4	0.2	0.1
0	0.4	0.3

Let's use Excel!

Thank You for letting me share with you today !

Email questions to: jacksonb@nsuok.edu