W 644

A Primer in Economic Multipliers and Impact Analysis Using Input-Output Models

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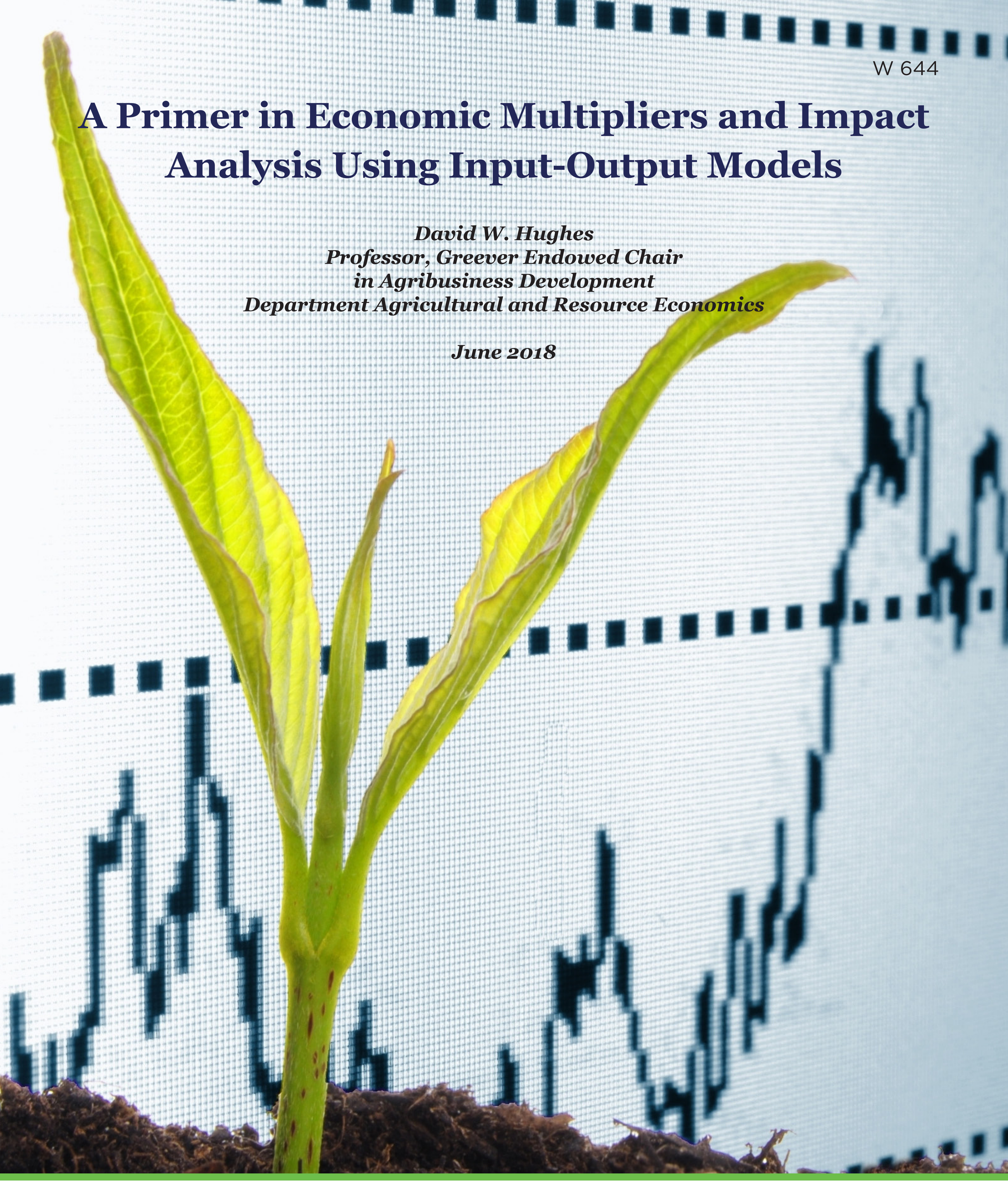

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Introduction

This publication is written as a companion document for the set of county-level agricultural economic impact documents constructed for each Tennessee county. It is designed to provide a basic understanding of economic multiplier-based impact analyses through input-output models. As such, explanations focus on how such models replicate spending in local economies, with a minimal amount of technical detail. Topics include the concept of a multiplier; the input-output (I-O) model; the A Table; the Multiplier Table; changes in the I-O Model and difference in local spending patterns; how I-O multipliers actually work; impact analysis with the I-O Model; accounting for households spending in the I-O Model; and summary and conclusions.

Concept of a Multiplier

What is an economic multiplier? As applied to a local community, a multiplier is a measure of how dollars interjected into a community are respent, thereby leading to additional economic activity. Or, for one dollar of economic activity, the output multiplier measures the combined effect of a $1 change in its sales on the output of all local industries (Hughes, 2003). In this regard, we need to think of the community as a closed economy system, with dollars and resources flowing between entities in the community and between those same entities and the outside world. The concept of a multiplier can be examined as round-by-round spending as shown in Figure 1 and Figure 2. A dollar comes into your community based on something that has been sold to the outside world (e.g., soybeans) and that dollar leads to additional local spending. For example, to produce a dollar's worth of soybeans, farmers must purchase local inputs, pay themselves, make investments, and, perhaps, buy local labor. (Economists call such activity backward linkages.) Purchases that are local also lead to further respending in the community, while purchases on inputs from elsewhere are leakages (money not respent locally). In Figure 1, these are shown as rounds of spending. For round one, the part of spending by the farmers that is local is represented as the portion of the dollar bill, while the part spent on inputs from outside the community is the missing part of that first dollar bill. The remaining local spending from round one, in turn, leads to additional spending — round two — with some of that spending staying local (the remaining part of the dollar bill in round two). Likewise, we have a similar situation for round three, based on round two local spending as the starting point. For each round of spending, the amount respent becomes smaller and smaller, due to leakages at each round, until it dwindles to zero. Adding all of the rounds of local spending provides the economic multiplier (Figure 2).

> For one dollar of economic activity, the output multiplier measures the combined effect of a $1 change in its sales on the output of all local industries.

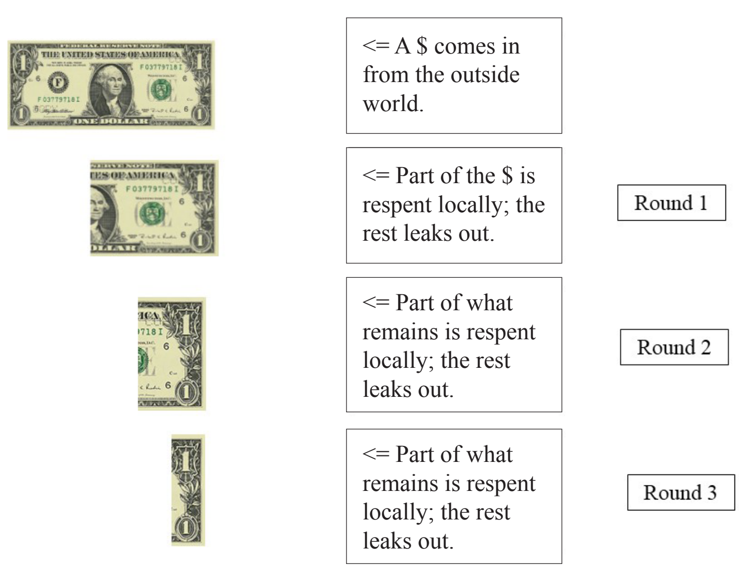

Figure 1. A Portion Of the Dollars Coming Into Your Community From the Outside World Is Respent Locally.

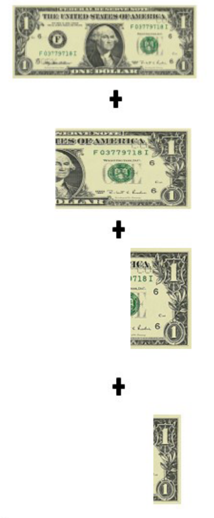

Figure 2. Adding Up the Rounds of Spending.

Likewise, the same process is shown in Figure 3 but with actual numbers and several more rounds of spending. In this figure, the exports are any sales outside the local economy; the leakage rate to the outside world is 60 percent; and the respending rate is 40 percent for each round of spending. Accordingly, the dollar leads to 40 cents being respent in the local economy in round one, with 60 cents spent on inputs from the outside world, a leakage for the local economy. The remaining local 40 cents forms the starting point for round two; 40 percent of the 40 cents is respent in the local economy (i.e., 40 cents *.4 = 16 cents), while the remaining 24 cents (60 percent) is spent on inputs from the outside world. The 16 cents, in turn, sets off the process leading to the round three impact of 6 cents and so on. The process continues on until there is no local money left to be respent. Adding all of the rounds of spending together, we get a multiplier of $1.66.

Next, we consider the input-output model that replicates this same multiplier process but in a much more detailed fashion.

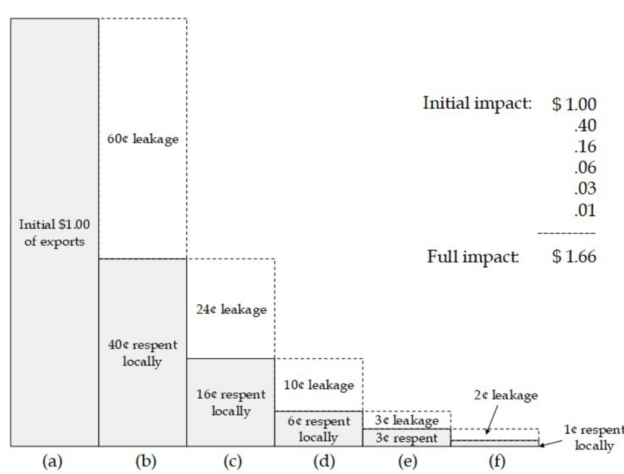

Figure 3. A Picture of the Multiplier Process.

The I-O Model

Input-output (I-O) models provide a detailed picture of the flow of products and resources within a given economy and between that economy and the outside world. Better yet, such models can be used to estimate economic multipliers for specific industries. The multipliers, in turn, form the basis for economic impact analysis, where the contribution of specific industries to a local economy or the effects of a given policy, event or investment can be estimated in terms of local jobs and local income. The ***key takeaways*** for this section are as follows:

1. You should be able to understand how I-O models replicate linkages in a local economy.
2. The strength of local linkages determines the size of the output multiplier and, as discussed in a later section, the size of economic impacts.
3. You will see how changing these local spending patterns influences the size of the output multiplier and economic impacts.

Input-output (I-O) models provide a detailed picture of the flow of products and resources within a given economy and between that economy and the outside world. Such models can be used to estimate economic multipliers for specific industries.

A hypothetical input-output model for a two-industry economy is provided in Figure 4. This spreadsheet shows the two local industries buying inputs (down the column) and selling output (across the row). Note that the table is balanced in that spending is exactly matched by revenues. (Profits are accounted for as part of value added.) Examining this rather simplistic economy, we see that local agriculture purchases $150 worth of inputs from local agriculture and $200 worth of inputs from local manufacturing. It spends $400 on value added — a combination of payment to workers and returns to capital and likewise as gross regional product — and spends $250 on imports of goods and services from outside of the local economy. Looking across the row for agriculture, we see sales of $150 to local agriculture, sales of $500 to local manufacturing, $100 in sales to local households, and $250 in sales outside the local economy for total revenue of $1,000. The values in the manufacture column and row have the same type of interpretation.

We can construct an "A Table" from the I-O Table. The A Table shows detailed purchases per dollar of sales by the purchasing (column) industry from the various local selling industries. ***The A Table is the tool used to estimate our economic multipliers and conduct impact analyses.*** This is accomplished by focusing on the industries-to-industries part of the I-O Model or table. For each column entry in that part of the table, we divide the entry in each row by the column value, simply translating into per-dollar of sales. (Mathematically, this is called column normalizing.) Or, as shown in Figure 5, the 150 is divided by 1,000 (agriculture buying from local agriculture), and the 200 is divided by the 1,000 (agriculture buying from local manufacture). We also do a similar set of calculations for the manufacture column, as shown in Figure 5.

Value added is a combination of payment to workers and returns to capital.

- A "Spreadsheet" of the Economy
- Down the Columns Is Demand or Buyers
- Across the Rows Is Supply Or Sellers
- Supply Equals Demand

Industry-By-Industry Transaction Table

	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			

Figure 4. An Input-Output Model.

Industry-By-Industry Transaction Table

Industries	*Agriculture*	*Manufacture*
Agriculture	150	500
Manufacture	200	100
Labor Payments	400	700
Imports	250	700
Sum of Spending	1,000	2,000

		Agriculture	Manufacture	
Agriculture	150/1,000=	0.15	0.25	=500/2,000
Manufacture	200/1,000=	0.20	0.05	=100/2,000

*Divide the entry in each row by the column value (simply translating into per $1 of sales).

Figure 5. A Matrix Construction (Industry-By-Industry Part of the Table).

This action translates the numbers in a per dollar of output or revenue value; that is, as shown in Figure 6, the 0.15 means that the agriculture one column spends 15 cents on purchases from local agriculture one per dollar of output and that it spends 20 cents per dollar of output in purchases from local manufacture. Similarly, looking at the second column, industry two spends 25 cents per dollar of output on purchases from local agriculture and 5 cents per dollar on purchases from manufacture.

		Agriculture	Manufacture	
Agriculture	150/1,000=	0.15	0.25	=500/2,000
Manufacture	200/1,000=	0.20	0.05	=100/2,000

For every $ of sales, local agriculture buys 15 cents of inputs from local agriculture.
For every $ of sales, local agriculture buys 20 cents of inputs from local manufacturing.

For every $ of sales, local manufacturing buys 25 cents of inputs from local agriculture.
For every $ of sales, local manufacturing buys 5 cents of inputs from local manufacturing.

Figure 6. A Matrix (Showing $1 of Industry Spending on Local Inputs Or Percentage Spent on Local Inputs).

The A Table is used to generate the Multiplier Table, as shown in Figure 7.[1] This table shows the total multiplier process, just like summing the changes in the dollar process that we looked at in Figure 1 and Figure 2 but with industry detail.

1 Mathematically, the multiplier table is called the Leontief Inverse (named for Wassily Leontief, the father of the I-O model). For more details, see Miller and Blair (2009).

This table shows the total multiplier process (just like summing the changes in the $ process that we examined already but with industry detail).

	Agriculture	Manufacture
Agriculture	1.25	0.33
Manufacture	0.26	1.12
Total	1.51	1.45

- The multiplier table shows the final outcome of the round-by-round spending in a ***detailed*** manner.
- So, now 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 we had a model with hundreds of industries, we would have hundreds of rows and hundreds of columns, one for each industry, but the interpretation is the same.

Figure 7. The Multiplier Table.

Now, let's interpret the values in the Multiplier Table (Figure 7). Like the A Table, the values are per $1 of sales for the column industry in question. But, unlike the A Table, the Multiplier Table shows all of the impacts of a dollar's worth of spending for the industry in question. That is, it replicates the economic multiplier process we discussed earlier but in a much more detailed fashion. So, looking at the industry one column, one dollar of sales by agriculture ultimately results in $1.25 in output for agriculture — the original $1 plus 25 cents in multiple type impacts. The same one dollar of sale by agriculture ultimately results in a 26 cent increase in output by local manufacture. Summing the two values, the output multiplier on the local economy for agriculture is $1.51, or a $1 increase in output by agriculture should ultimately lead to an increase of approximately $1.51 in output in the local economy. The values in the manufacture column have similar interpretations.

An actual I-O Table with the results A Table and Multiplier Table can contain hundreds of industries. These tables are most often built with computer software programs such as IMPLAN (2000); however, the more sophisticated models operate in the same manner as our simple economy.

I-O and Difference in Local Spending Patterns

We can also look at the model in terms of leakages and multiplier effects in the local economy. Assume that instead of requiring a total of $0.35 in purchases from local industries, agriculture only requires a total of $0.175 on the dollar from local firms, with imports making up the difference (Figure 8). In other words, the 15 cents in our original A Table is now 7.5 cents, and the 20 cents in our original A Table is now 10 cents.

New A-Table (0.15 to .075 and 0.2 to .10).

	Agriculture	Manufacture
Agriculture	0.075	0.25
Manufacture	0.10	0.05

The New Multiplier Table Yields Smaller Values.

	Agriculture	Manufacture
Agriculture	1.11	0.29
Manufacture	0.12	1.08
Total	1.23	1.37

Figure 8. Local Agriculture Now Buys Less Locally.

Note the large reduction in the multiplier values. The multiplier for agriculture declines by $0.28 from its previous level, from 1.51 to 1.23 (Figure 8). Specifically, the impact on local agriculture declines by 14 cents, from 1.25 to 1.11, and the impact on local manufacture declines by 14 cents, from 0.26 to 0.12. The multiplier for manufacture also declines by 8 cents, even though its own spending patterns did not change. This result is because manufacture's multiplier is also based on agriculture's buying pattern, as well as its own.

The key takeaways are provided in Figure 9. The I-O Model and the resulting A Table should reflect buying and selling in the local economy (i.e., economic reality). The greater local buying means larger values in the A Table (for example, $0.15 on the dollar by local agriculture from local agriculture versus $.075) that drive the level of respending or the Multiplier Table. So, stronger local linkages lead to larger A Table values that lead to larger multipliers. Likewise, weaker local linkages lead to smaller A Table values that lead to smaller multipliers.

- The "A Table" should reflect buying and selling in the local economy (i.e., economic reality).
- The level of respending shown in the A Table drives the level of the multipliers.
- Stronger local linkages lead to larger A Table values that lead to larger multipliers.
  Or
- Weaker local linkages lead to smaller A Table values that lead to smaller multipliers.

Figure 9. Key Takeaways.

We now move to a discussion of impact analysis. See the Appendix for a better understanding of the process of going from the A Table to the Multiplier Table. You can still properly interpret economic multipliers and understand what such values mean without necessarily going through the appendix.

Impact Analysis

Impact analysis is the most important use of the Multiplier Table. Impact analysis looks at the effects of a positive or negative change in economic activity. Impact analysis is based on economic multipliers, which account for the total effect across the entire economy of the event under study. For example, impact analysis is often used to estimate the effects of a new local industry on jobs and incomes in all parts of the economy. It is also used to estimate policy or investment impacts and the total contribution of an industry to an economy.

To do impact analysis, we first determine the original change in output for the directly affected industry or set of industries. The change in Y is no longer $1, as in multiplier analysis, but rather a much larger positive or negative number resulting from a local economic "event." We can now look at an impact analysis example.

Assume that industry one has an expansion of $10 million in sales due to a new market for local agricultural products. What is the impact on the local economy? To calculate the impact, we multiply each value in the first industry (agriculture) column in the Multiplier Table from Figure 7 times the impact level or

1.25 *$10 million = $12.5 million (agriculture or industry 1 change).
0.26 *$10 million = $2.6 million (manufacturing or industry 2 change).
Sum = $15.1 million total change in output in the local economy.

What people are usually more interested in is the change in jobs, local income, and other, better measures of economic activity than output. Using jobs an example, we can use a jobs-to-output ratio for each industry.

Local agriculture: hires 10 people per $ million of output
Local manufacturing: hires 20 people per $ million of output. What is the impact on jobs?

The impact on output multiplied by the appropriate jobs ratio:
$12.5 million *10 = 125 jobs in local agriculture
$2.6 million *20 = 52 jobs in local manufacturing
Sum = 177 jobs

We could do a similar set of calculations for local personal income (personal income per million dollars of output) or gross regional product per million dollars of output.[2,3]

2 Impact analysis provides very useful information, but people need to take care in interpreting results. For more information regarding the limitations of impact analysis, see Hughes (2003).
3 This discussion also raises the concept of various types of other multipliers besides output (i.e., the employment multiplier, income multiplier and value-added multiplier). For a discussion of such multipliers, see Miller (2017) or Miller and Blair (2009).

Accounting for Spending by Local Households (the Type II Multiplier)

At this point, we have only examined the respending impacts by firms and have not considered the important effects of local household spending. The process works the same way when we include payments to local workers by local businesses and the resulting local households spending, although the interpretation differs slightly. We must also consider the ***induced effect***, which is the multiplier effects due to household spending, versus the previously discussed ***indirect effect***.

> ***Induced Effect***
> The multiplier effects due to household spending.
>
> ***Indirect Effect***
> The multiplier effects due to purchases from other local industries.

We can include household spending by treating households like they were an industry: by adding payments to local households as another row and consumption by local households of local production as another column. That is, including the third row and the third column from the hypothetical I-O Model in our augmented A Table shown in Figure 10.

This leads to the new Multiplier Table in Figure 10:

		Industry		
		1	**2**	**3**
	1	**1.36**	**0.43**	0.18
Industry	2	**0.41**	**1.24**	0.24
	3	*0.80*	*0.71*	*1.35*
Total		?	?	?

Figure 10. Multiplier Table.

Note that we do not total the entire column in Figure 10. Why? Doing so would be mixing apples and oranges. The bold values are still output for businesses. The values in italics, the third row, measure household income (a factor of production) impacts. The last column is a measure of local consumption impacts, as a result of income changes.

So, to get our new output multiplier, we only sum the values in each column across all industries. Or, in our simple example:

1.36
+
0.41

1.77 = Multiplier Industry 1

0.43
+
1.24

1.67 = Multiplier Industry 2

Looking back at Figure 7, note that including the impact of household spending increased the multiplier for Industry 1 from $1.51 to $1.78 and increased the multiplier for Industry 2 from $1.45 to $1.68 (Figure 10). When the effects of household spending are included, a Type II Multiplier is generated (i.e., the indirect effect, plus induced effect, divided by the direct effect). When the effects of household spending are excluded, a Type I Multiplier (i.e., the indirect or purely industry-based multiplier effect divided by the direct effect) is generated.

> When the effects of household spending are excluded, a ***Type I Multiplier*** is generated (i.e., the indirect or purely industry-based multiplier effect divided by the direct effect).
>
> When the effects of household spending are included, a ***Type II Multiplier*** is generated (i.e., the indirect effect, plus induced effect, divided by the direct effect).

Summary and Conclusions

This publication provided a basic explanation of how input-output models 1) reflect the nature of local economies and 2) in turn, generate economic multipliers and impact analyses. In doing so, the concept of the multiplier was first introduced, followed by a discussion of the I-O Model and how it reflected the nature of linkages in local economies. The discussion then covered how I-O models generate output multipliers through the construction of the A Matrix. The use of such models in generating economic impact analyses (the multiplier-based effects of a given policy, industry or economic event) was discussed. We also examined how accounting for the impact of spending by local households increases economic impacts. The understanding of this process is important because many use economic impact analyses and multipliers in evaluating agricultural and other policy decisions. A basic understanding of such models helps eliminate misuse and, in general, improves our understanding of how local economies work.

Readers also need to be aware that multipliers and impact analyses, while useful, do not speak to feasibility or profitability and do not address resource limitations. As indicated earlier, see Hughes (2003) for more regarding the misuses of such models.

Hopefully, this effort has piqued the interest of some readers regarding the use of I-O models in examining local economies. For individuals desiring more detailed information regarding such models, there are a number of other useful resources: the most comprehensive is likely the book *Input-Output Analysis: Foundations and Extensions* by Miller and Blair (2009).

References

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Appendix

How the I-O Multiplier Actually Works

The manner in which the multiplier operates in an I-O model is provided in Appendix, Figure 1. This process depicts how we go from the A Table to the final multipliers provided in our Multiplier Table. To do this, we need to breakdown several rounds of spending, just like we did with the dollar bill in Figure 1 and Figure 2. In Appendix, Figure 1, please note that because of space limitations, we have replaced Output Agriculture with the label X_{ag} and Output Manufacture with the label X_{mn}. Also, note that we have attached the Delta symbol to both variables to denote change in either Agriculture Output (ΔX_{ag}) or Manufacture Output (ΔX_{mn}) and the various rounds of spending.

Recall that the A Table shows the pattern of sales (down the column) or purchases (across the row) between the two industries — agriculture and manufacturing — in the local economy. Also, recall that the pattern is in terms of $1 of sales or output by the purchasing (column) industry. The initial change in sales starts the multiplier process. (Remember, the $1 change in demand for agricultural products [ΔY_{ag}] is the same as a $ 1 change in agricultural output ΔX_{ag}.) To support the $1 increase in output, as shown in the A Table, local agriculture must increase its purchases from local agriculture by 15 cents and its purchases from local manufacturing by 20 cents (Appendix, Figure 1). Together, both purchases are the first round of spending, as shown in Appendix, Table 1.

The first round of spending leads to additional spending or other rounds. Or, the 15 cent increase in sales for agriculture in round one necessitates additional spending on its part, as does the 20 cent increase in sales for manufacturing in round one. So, like in round one, these output increases must be supported by more local purchases; however, because both agriculture and manufacturing have increased their outputs, this set of second-round changes must be traced down their respective columns.

Looking at the agricultural (ag) column in Appendix, Figure 1, the first cell shows that 15 percent, or 15 cents on the dollar, of agricultural purchases come from local agriculture or that the 15 cent increase in agriculture output requires an additional .0225 increase in agricultural output (or **0.15** *0.15 = .0225, as shown in Appendix, Figure 1). Looking at the second cell in the agriculture column, 20 percent of agricultural purchases come from local manufacturing, or the 15 cent increase in agricultural output requires a .03 increase in output by local manufacturing (or **0.15** *0.20 = .03).

Now, looking at the manufacture (mn) column in the A Table, the first cell shows that 25 percent of manufacturing purchases come from local agriculture or that the 20 cent increase in manufacturing output requires an additional 5 cent increase in agricultural output (or .05 = **0.20** *0.25, as shown in Appendix, Figure 1). Looking at the second cell in the manufacture column, 5 percent of manufacture purchases come from local manufacturing, or the 20 cent increase in manufacture output requires a 1 cent increase in output by local manufacturing (or **0.20** *0.05= .01).

We now have four changes: two for agriculture and two for manufacturing. So, we simply sum the changes for agriculture to get the total second-round spending for agriculture (or .0225 + .05 = **.0725**). Likewise, we simply sum the changes for manufacturing to get the total second-round spending for manufacture or .03 + .01 = **.04**. Another way of looking at this process is to say that we are summing the changes across each row. So, we are done in terms of calculating the second round of spending, as shown in Appendix, Figure 1 and in Table 1.

Now, looking at Appendix, Figure 1, you will see the same type of calculations for round three but now using the round-two impacts as the starting point. Since the process works the same for round three as it does for round two, we will not look at this group of changes in detail.

Still looking at Appendix, Table 1, we can proceed to add up all of the changes through round three. For agriculture, this includes the initial **$1** in sales by agriculture; the first-round agriculture increase in output (**.15**); the second-round increase in agriculture output (**.0725**); and the third-round output increase in agriculture (**.020875**). Together, these four changes equal **$1.243375**. For manufacture this includes the first-round increase in output (**.20**), the second-round increase in manufacture output (**.04**), and the third-round increase in manufacture output (**.0165**). Together, the three changes equal **$0.2565**. As indicated in Appendix, Figure 1, compare these changes to our first column in the Multiplier Table. Note that through three rounds of impact, the change in agriculture is getting close to the table value for agriculture, and the change in manufacture is getting close to the table value for manufacture. Or, the 1.243375 is close to the 1.25 (slightly less than a cent) and that the 0.2565 is close to the 0.26 (slightly less than half a cent). A fourth, fifth, and so on of additional rounds of spending would bring us even closer to the final values found in the first column of the Multiplier Table.

Our main points are as follows: 1) Tracing through the spending in the A Table in a round-by-round fashion shows how such a model captures the multiplier effects, as shown in the Multiplier Table; 2) While we only have a two-industry economy, the process works the same way for an economy with hundreds of industries; and 3) Reiterating from page eight, the values in the A Table are based on an I-O Table showing strength of linkages between local businesses (industries). The multipliers generated from the A Table reflect the strength of these internal linkages. If the values in the A Table become smaller, the multipliers decline in size. If the values in the A Table become larger, the multipliers increase in size.

Appendix. Figure 1. How Multipliers Operate in I-O

	X_{ag}	X_{mn}
X_{ag}	.15	.25
X_{mn}	.20	.05

= A Table (I-O Model)

Initial Change ($1 in sales of final demand): $\Delta Y_{ag} = \$1$

↓

$\Delta X_{ag} = \$1$

Round 1: $1 *0.15 = **0.15** ($\Delta X_{ag}$) $1 *0.20 = **0.20** ($\Delta X_{mn}$)

Then, trace round 1 change through to get round 2 change.

Round 2:
0.15 *0.15 = .0225 (ΔX_{ag})
0.15 *0.20 + .03 (ΔX_{mn})

Round 2:
0.20 *0.25 = .05 (ΔX_{ag})
0.20 *0.05 = .01 (ΔX_{mn})

Then, sum up the changes for X_{ag} and X_{mn} (ACROSS THE ROWS) to get the total change for round two:

Total ΔX_{ag} = .0225 + .05 = **.0725**

Total ΔX_{mn} = .03 + .01 = **.04**

Round 3: Trace through round two changes to get round three changes:

ΔX_{ag} (**.0725**) ΔX_{mn} (**.04**)

Round 3:

0.0725 *0.15 = .010875(ΔX_{ag}) **0.0725** *0.20= .0145(ΔX_{mn}) **0.04** *0.25 = .01(ΔX_{ag}) **0.04***0.05= .002(ΔX_{mn})

Sum up the changes for X_{ag} and X_{mn} to get the total change for round three:

Total ΔX_{ag} = .010875 + .01 = .020875

Total ΔX_{mn} = .0145 + .002 = .0165

Appendix. Table 1. How Tracing the Changes Through Approximates the Multiplier Table.

Round	ΔY_{ag}	ΔX_{ag}	ΔX_{mn}
Initial	$1	**$1.0**	
1		**.15**	**.20**
2		.0225 + .05 = **.0725**	.03 + .01 = **.04**
3		.010865 + .01 = **.020865**	.0145 + .002 = **.0165**
Total	$1	**$1.243365**	**$0.2565**

Note that the total change for X_{ag} and X_{mn} through round three is approaching the final values for X_{ag} and X_{mn}, with a $1 change in X_{ag}, as found in the Multiplier Table (the first column).

That is,

1.243365 is close to 1.25

0.2565 is close to 0.26

	X_{ag}	X_{mn}
X_{ag}	1.25	.33
X_{mn}	.26	1.12

= Multiplier Table

Additional rounds of spending would bring us even closer to the final values found in the first column of the Multiplier Table.

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