An Assessment of the Economic Impacts of the Pennsylvania Dairy Industry[1]

Steven Deller, Mark Stephenson and Chuck Nicholson[2]

Executive Summary

To assess the contribution of dairy to the Pennsylvania state economy we use input-output analysis to construct a set of economic multipliers custom to the Pennsylvania economy and six sub-regions. To undertake this analysis, we use the economic modeling system IMPLAN and the base year data for 2015.

The key findings are:

- The state's dairy industry is a major contributor to overall economic activity, generating an estimated 52,000 jobs and $14.7 billion in economic activity in 2015;
- The Southeast, South-Central and Western regions contribute about 80% of total employment and income generated by the dairy industry;
- The Southeastern region contributes nearly half of the Labor Income (wages, salaries and proprietor income), in part reflecting the nature of farming operations in that part of the state;
- Both the farm and processing sectors are important contributors to employment and income, with farms contributing about 46% of employment and 36% of total economic activity.

Overview and Study Objectives

To assess the contribution of dairy to the Pennsylvania state economy we use input-output analysis to construct a set of economic multipliers custom to the Pennsylvania economy and six sub-regions. To implement this analysis empirically, we use the economic modeling system IMPLAN and the base year data for 2015.

A Simple Review of Methods and Definitions of Terms

As discussed in more detail in Appendix A, the power of input-output analysis is in the ability to use the tool to track how small changes in one part of the economy resonate throughout the entire economy. For example, the expansion of dairy farms in the local economy introduces new or additional levels of spending in the local economy. This new spending causes a ripple, or multiplier effect, throughout the economy. Using input-output analysis, we can track and measure this ripple effect.

---

[1] The analyses described in this document are one component of the *Study to Support Growth and Competitiveness of the Pennsylvania Dairy Industry*, which has been funded by the Pennsylvania Department of Agriculture and the Center for Dairy Excellence.
[2] The authors are, respectively, Professor, Department of Agricultural and Applied Economics, Director of Dairy Policy Analysis, University of Wisconsin, Madison, and Adjunct Associate Professor, Cornell University.

To continue with the dairy farms example, the impact of an expansion of dairy farms is composed of three parts: the *direct*, *indirect,* and *induced*. The *direct* or *initial* effect captures the event that caused the initial change in the economy: for example, a new dairy beginning its operations or an existing dairy expanding operation. The dairy farm contributes directly to the local economy by selling farm products, paying employees' wages and salaries (generating income) and proprietor income to the farmer. Our new dairy farm has two types of expenditures that can be used to better understand the second two parts of the impact or multiplier. The first are business-to-business transactions, such as the purchase of feed from other farms or feed suppliers, fertilizer, seed and chemicals, veterinary services, trucking services to haul milk and livestock, electric and other utilities, insurance, interest and other financial services, land rent, farm and equipment repairs and maintenance, and many others. These business-to-business transactions are captured in the model through the *indirect* effect. In this situation, a grain farmer uses the proceeds from feed sales to dairy farmers to pay his or her own farm's operating expenses, make investments, or buy new equipment.

The second type of expenditure dairy farms introduce into the local economy are wages and salaries paid to employees as well as to the farmer themselves. Spending this income in the local economy is captured by the *induced* effect. Dairy farmers and their employees spend their income at local grocery stores, movie theaters, restaurants and other retail outlets. The theater owner, then, could use part of the money spent on tickets by dairy farmers to pay theater employees, and the cycle continues.

The combination of the *direct*, *indirect* and *induced* tells us what the complete impact or contribution of any particular industry has on the whole of the economy. By looking at the *indirect* and *induced* impacts, we can gain insights into how the industry of interest is connected or linked into the local economy. For example, industries that tend to be labor intensive and offer high wages tend to have larger *induced* effects on the local economy. Industries that are more capital intensive or offer lower wages tend to have larger *indirect* effects. We can also gain additional insights into the make-up of the local economy by examining the relative size of the multiplier effects. Smaller economies tend to have smaller multiplier or ripple effects than larger economies. This is because the "leakages" out of the local economy occurs faster in smaller economies. Larger economies have greater opportunities to keep those dollars within the local economy for a longer period of time, hence larger multiplier effects. Some smaller, more rural communities that have pursued tourism development have used multiplier analysis to better understand that simply bringing more tourists to the community is not sufficient: there must be someplace for those tourists to spend their money.

For this study, we use four measures of economic activity: employment, labor income, total income, and industrial revenues/sales. Employment here is simply the total number jobs and is *not* a full-time equivalent. For example, two part-time jobs created in the any sector is considered two jobs while one full-time job in any sector is considered one job. Labor income is the return to labor and includes wages, salaries and proprietor income. As noted in the trend analysis above, most labor income comes in the form of wages and salaries. Within agriculture, though, many farmers take income in the form of proprietor income. This proprietor income is the farmer's return on their labor input into the farm. Total income includes labor income and other sources of income such as dividends, interest and rental payments as well as transfer payments such as social security payments. For our purposes, total income is akin to gross domestic product, explored in the trend analysis. Industry sales or revenues are simply total revenues flowing to an industry.

Consider a dairy farmer that has $1 million in sales/revenues, two hired workers who are each paid $25,000. The farmer has structured the business to draw a $50,000 salary. Also suppose that the farm turns a $10,000 "profit" which the farmer takes as proprietor income. In this example, industry sales/revenue is $1 million, employment is three (two workers plus the farmer) and labor income is $110,000. Suppose that this farmer has crop acreage that is rented to a neighboring farmer for which the farmer receives $5,000 in rental income. Here, total income would be $115,000.

Structure of this Study

To better understand the effects of the dairy industry in different parts of the state, we have delineated six multi-country groupings (Table 1), in addition to assessing the impact statewide. These regions were selected to represent differences in topography, climate, other geographical characteristics and road access. This analysis uses input-output analysis to construct a set of economic multipliers custom to the Pennsylvania economy and six sub-regions. To undertake this analysis, we use the economic modeling system IMPLAN (http://www.implan.com) and data for 2015[3].

Table 1 Multiple-County Regions for Economic Multiplier Impact Analysis

Eastern	Southeast	South Central	Central	Western	Northern Tier
Carbon	Berks	Adams	Bedford	Allegheny	Bradford
Columbia	Bucks	Cumberland	Blair	Armstrong	Elk
Lackawanna	Chester	Dauphin	Cambria	Beaver	Forest
Luzerne	Delaware	Franklin	Cameron	Butler	Lycoming
Monroe	Lancaster	Perry	Centre	Clarion	McKean
Montour	Lebanon	York	Clearfield	Crawford	Potter
Northumber-land	Lehigh	Fulton	Clinton	Erie	Sullivan
Pike	Montgomery	Juniata	Jefferson	Fayette	Susquehanna
Schuylkill	Northampton	Mifflin	Huntington	Greene	Tioga
Wayne	Philadelphia		Indiana	Lawrence	Warren
			Somerset	Mercer	Wyoming
			Snyder	Venango	
			Union	Washington	
				Westmoreland	

Note: These groupings were developed with the assistance of Alan Zepp of the Center for Dairy Excellence

[3] As noted in the Phase I report for the Study to Support Growth and Competitiveness of the Pennsylvania Dairy Industry, a similar type of analysis of dairy processing (but not farm-level) impacts was sponsored by IDFA using data for 2014, with results reported by Congressional District rather than economic production regions.

Results of the Impact Analysis

The analysis confirms the importance of the Pennsylvania dairy industry to the state's economy, with a total employment of more than 52,000 jobs and economic activity valued at nearly $14.7 billion in 2015 (Table 2). About 40% of the employment and economic activity occur in the Southeastern part of the state, with the South-Central and Western regions comprising and additional 40%. Thus, these three regions of the state contribute about 80% of the employment and economic activity attributed to dairying. However, the share of labor income (wages, salaries and proprietor income) is even larger in the Southeastern region (45%), which likely reflects the structure of farms in the southeastern part of the state.

The analysis indicates that the farm-level contribution comprises about 25,000 jobs and $5.3 billion in total economic activity (Table 3), whereas post-farm dairy-processing activities account for 28,000 jobs and $9.4 billion in economic activity. These results underscore the importance of both farm and post-farm businesses to the state's economy. Detailed results by region are presented in Tables 4 through 9.

Table 2. Summary of Total Economic Impacts (Direct, Indirect and Induced) of Dairy Farming and Processing in Pennsylvania, By State Region

Region	Employment	Labor Income ($ mil)	Total Income ($ mil)	Total Industrial Sales ($ mil)
Eastern	2,298	117	188	581
Southeast	20,161	1,563	2,382	5,782
South Central	10,640	658	970	2,909
Central	6,422	366	551	1,521
Western	10,726	548	906	2,666
Northern Tier	2,509	123	212	728
Total	52,573	3,487	5,446	14,650

Table 3. Direct, Indirect and Induced Effects of Dairy Farm and Dairy Processing Activity in Pennsylvania, 2015

State (Penn)	Direct	Indirect	Induced	Total
All Dairy				
Employment	14,324	21,609	16,641	52,573
Labor Income (MM$)	1,222.4	1,422.9	841.3	3,486.5
Total Income (MM$)	1,820.1	2,213.4	1,412.6	5,446.1
Total Industrial Sales (MM$)	7,941.6	4,296.9	2,411.6	14,650.1
Dairy Farm				
Employment	9,109	7,637	7,540	24,286
Labor Income (MM$)	856.0	371.1	380.4	1,607.6
Total Income (MM$)	1,225.8	613.4	639.3	2,478.4
Total Industrial Sales (MM$)	2,780.5	1,394.7	1,092.2	5,267.4
Dairy Processing				
Employment	5,215	13,971	9,101	28,287
Labor Income (MM$)	366.4	1,051.8	460.8	1,879.0
Total Income (MM$)	594.3	1,600.0	773.3	2,967.7
Total Industrial Sales (MM$)	5,161.1	2,902.2	1,319.3	9,382.6

Note: The reported values are those for all Pennsylvania counties.

Table 4. Direct, Indirect and Induced Effects of Dairy Farm and Dairy Processing Activity in the Eastern Region Pennsylvania, 2015

Eastern Penn Region	Direct	Indirect	Induced	Total
All Dairy				
Employment	651	1,105	541	2,298
Labor Income (MM$)	40.9	54.0	21.7	116.5
Total Income (MM$)	66.8	83.5	37.4	187.8
Total Industrial Sales (MM$)	339.4	173.3	68.4	581.1
Dairy Farm				
Employment	371	262	177	810
Labor Income (MM$)	23.7	7.1	7.1	37.9
Total Income (MM$)	39.4	11.9	12.2	63.5
Total Industrial Sales (MM$)	89.3	29.3	22.3	140.9
Dairy Processing				
Employment	280	843	365	1,488
Labor Income (MM$)	17.1	46.9	14.6	78.7
Total Income (MM$)	27.4	71.7	25.2	124.3
Total Industrial Sales (MM$)	250.0	144.0	46.1	440.1

Note: The reported values are those for Carbon, Columbia, Lackawanna, Luzerne, Monroe, Montour, Northumberland, Pike, Schuylkill and Wayne counties.

Table 5. Direct, Indirect and Induced Effects of Dairy Farm and Dairy Processing Activity in the Southeastern Region Pennsylvania, 2015

Southeastern Penn Region	Direct	Indirect	Induced	Total
All Dairy				
Employment	4,565	8,867	6,729	20,161
Labor Income (MM$)	484.7	706.0	371.9	1,562.6
Total Income (MM$)	668.3	1,092.9	620.7	2,382.0
Total Industrial Sales (MM$)	2,824.1	1,933.9	1,024.0	5,781.9
Dairy Farm				
Employment	2,777	2,161	2,740	7,678
Labor Income (MM$)	347.4	140.4	151.1	638.9
Total Income (MM$)	446.6	229.8	252.3	928.7
Total Industrial Sales (MM$)	1,013.1	465.6	415.9	1,894.6
Dairy Processing				
Employment	1,788	6,706	3,989	12,483
Labor Income (MM$)	137.2	565.7	220.9	923.8
Total Income (MM$)	221.7	863.1	368.4	1,453.3
Total Industrial Sales (MM$)	1,811.0	1,468.3	608.1	3,887.4

Note: The reported values are those for Berks, Bucks, Chester, Delaware, Lancaster, Lebanon, Lehigh, Montgomery, Northampton, Philadelphia counties.

Table 6. Direct, Indirect and Induced Effects of Dairy Farm and Dairy Processing Activity in the South-Central Region Pennsylvania, 2015

Southcentral Penn Region	Direct	Indirect	Induced	Total
All Dairy				
Employment	3,346	4,225	3,070	10,640
Labor Income (MM$)	297.6	224.9	134.9	657.5
Total Income (MM$)	423.3	318.1	229.0	970.3
Total Industrial Sales (MM$)	1,857.5	652.6	399.2	2,909.3
Dairy Farm				
Employment	2,153	1,272	1,524	4,949
Labor Income (MM$)	212.3	47.2	66.9	326.3
Total Income (MM$)	284.9	72.5	113.7	471.1
Total Industrial Sales (MM$)	646.3	176.1	198.0	1,020.4
Dairy Processing				
Employment	1,193	2,953	1,545	5,691
Labor Income (MM$)	85.3	177.8	68.1	331.2
Total Income (MM$)	138.3	245.6	115.3	499.2
Total Industrial Sales (MM$)	1,211.2	476.6	201.1	1,888.9

Note: The reported values are those for Adams, Cumberland, Dauphin, Franklin, Perry, York, Fulton, Juniata and Mifflin counties.

Table 7. Direct, Indirect and Induced Effects of Dairy Farm and Dairy Processing Activity in the Central Region Pennsylvania, 2015

Central Penn Region	Direct	Indirect	Induced	Total
All Dairy				
Employment	2,213	2,577	1,632	6,422
Labor Income (MM$)	194.6	108.1	63.0	365.7
Total Income (MM$)	293.0	149.1	109.2	551.2
Total Industrial Sales (MM$)	976.4	345.6	199.0	1521.1
Dairy Farm				
Employment	1,750.0	1,341.4	1,105.7	4,197.0
Labor Income (MM$)	166.9	36.7	42.7	246.3
Total Income (MM$)	247.5	56.7	74.0	378.2
Total Industrial Sales (MM$)	561.4	149.3	134.8	845.6
Dairy Processing				
Employment	463.0	1,235.6	526.3	2,224.9
Labor Income (MM$)	27.7	71.4	20.4	119.4
Total Income (MM$)	45.5	92.4	35.2	173.1
Total Industrial Sales (MM$)	415.0	196.3	64.2	675.5

Note: The reported values are those for Bedford, Blair, Cambria, Cameron, Centre, Clearfield, Clinton, Jefferson, Huntington, Indiana, Somerset, Snyder and Union counties.

Table 8. Direct, Indirect and Induced Effects of Dairy Farm and Dairy Processing Activity in the Western Region Pennsylvania, 2015

Western Penn Region	Direct	Indirect	Induced	Total
All Dairy				
Employment	3,579	4,494	2,653	10,726
Labor Income (MM$)	183.5	237.0	127.2	547.7
Total Income (MM$)	337.4	354.0	215.0	906.4
Total Industrial Sales (MM$)	1,615.5	681.0	368.9	2,665.5
Dairy Farm				
Employment	2,378.0	1,731.6	893.2	5,002.8
Labor Income (MM$)	104.4	37.7	42.7	184.8
Total Income (MM$)	209.0	64.9	72.3	346.3
Total Industrial Sales (MM$)	474.2	142.8	124.0	741.0
Dairy Processing				
Employment	1,201.0	2,762.5	1,759.9	5,723.4
Labor Income (MM$)	79.2	199.4	84.5	363.0
Total Income (MM$)	128.3	289.0	142.7	560.1
Total Industrial Sales (MM$)	1,141.3	538.2	245.0	1,924.5

Note: The reported values are those for Allegheny, Armstrong, Beaver, Butler, Clarion, Crawford, Erie, Fayette, Greene, Lawrence, Mercer, Venango, Washington and Westmoreland counties.

Table 9. Direct, Indirect and Induced Effects of Dairy Farm and Dairy Processing Activity in the Northern Tier Region Pennsylvania, 2015

Northern Tier Penn Region	Direct	Indirect	Induced	Total
All Dairy				
Employment	1,074	946	489	2,509
Labor Income (MM$)	70.1	34.5	18.3	122.9
Total Income (MM$)	125.6	54.0	32.1	211.7
Total Industrial Sales (MM$)	542.4	125.9	59.3	727.7
Dairy Farm				
Employment	784	485	294	1,563
Labor Income (MM$)	50.3	12.4	11.0	73.6
Total Income (MM$)	92.5	20.3	19.3	132.1
Total Industrial Sales (MM$)	209.9	50.1	35.6	295.6
Dairy Processing				
Employment	290	461	195	947
Labor Income (MM$)	19.8	22.1	7.3	49.3
Total Income (MM$)	33.0	33.8	12.8	79.6
Total Industrial Sales (MM$)	332.5	75.8	23.7	432.0

Note: The reported values are those for Bradford, Elk, Forest, Lycoming, McKean, Potter, Sullivan, Susquehanna, Tioga, Warren and Wyoming counties.

Appendix A: Input-Output Modeling

Basics of Input-Output Modeling

We present a simple non-technical discussion of the formulation of input-output (IO) modeling in this section. An example of similar descriptive treatments would be Shaffer, Deller and Marcouiller (2004). An example of a more advanced discussion of input-output would be Miernyk (1965), and Miller and Blair (1985). As a descriptive tool, IO analysis represents a method for expressing the economy as a series of accounting transactions within and between the producing and consuming sectors. As an analytical tool, IO analysis expresses the economy as an interaction between the supply and demand for commodities. Given these interpretations, the IO model may be used to assess the impacts of alternative scenarios on the region's economy.

Transactions Table

A central concept of IO modeling is the interrelationship between the producing sectors of the region (e.g., manufacturing firms), the consuming sectors (e.g., households) and the rest of the world (i.e., regional imports and exports). The simplest way to express this interaction is through a regional transactions table (Table A1). The transactions table shows the flow of all goods and services produced (or purchased) by sectors in the region. The key to understanding this table is realizing that one firm's purchases are another firm's sales and that producing more of one output requires the production or purchase of more of the inputs needed to produce that product.

Table A1: Illustrative Transaction Table

	Purchasing Sectors (Buyers/Demand)			Final Demand		
Processing Sectors (Sellers/Supply)	**Agr**	**Mfg**	**Serv**	**HH (labor)**	**Exports**	**Output**
Agr	10	6	2	20	12	50
Mfg	4	4	3	24	14	49
Serv	6	2	1	34	10	53
HH (labor)	16	25	38	1	52	132
Imports	14	12	9	53	0	88
Inputs	50	49	53	132	88	372

The transactions table may be read from two perspectives: reading down a column gives the purchases by the sector named at the top of the column from each of the sectors named at the left. Reading across a row gives the sales of the sector named at the left of the row to those named at the top. In the illustrative transaction table for a fictitious regional economy (Table 1), reading down the first column shows that the agricultural firms buy $10 worth of their inputs from other agricultural firms. The sector also buys $4 worth of inputs from manufacturing firms and $6 worth from the service industry. Note that agricultural firms also made purchases from non-processing sectors of the economy, such as the household sector ($16) and imports from other regions ($14). Purchases from the household sector represent value added, or income to people in the form of wages and investment returns. In this example, agricultural firms purchased a total of $50 worth of inputs.

Reading across the first row shows that agriculture sold $10 worth of its output to agriculture, $6 worth to manufacturing, $2 worth to the service sector. The remaining $32 worth of agricultural output was sold to households or exported out of the region. In this case $20 worth of agricultural output was sold to households within the region and the remaining $12 was sold to firms or households outside the region. In the terminology of IO modeling, $18 (=$10+$6+$2) worth of agricultural output was sold for intermediate consumption, and the remaining $32 (=$20+$12) worth was sold to final demand. Note that the transactions table is balanced: total agricultural output (the sum of the row) is exactly equal to agricultural purchases (the sum of the column). In an economic sense, total outlays (column sum, $50) equal total income (row sum, $50), or supply exactly equals supply. This is true for each sector.

The transactions table is important because it provides a comprehensive picture of the region's economy. Not only does it show the total output of each sector, but it also shows the interdependencies between sectors. It also indicates the sectors from which the region's residents earn income as well as the degree of openness of the region through imports and exports. In this example, households' total income, or value added for the region is $132 (note total household income equals total household expenditure), and total regional imports is $88 (note regional imports equals regional exports). More open economies will have a larger percentage of total expenditures devoted to imports. As discussed below, the "openness" of the economy has a direct and important impact on the size of economic multipliers. Specifically, more open economies have a greater share of purchases, both intermediate and final consumption purchases, taking the form of imports. As new dollars are introduced (injected from exports) into the economy they leave the economy more rapidly through leakages (imports).

Direct Requirements Table

Important production relationships in the regional economy can be further examined if the patterns of expenditures made by a sector are stated in terms of proportions. This means that the proportions of all inputs needed to produce one dollar of output in a given sector can be used to identify linear production relationships. This is accomplished by dividing the dollar value of inputs purchased from each sector by total expenditures. Or, each transaction in a column is divided by the column sum. The resulting table is called the direct requirements table (Table A2).

The direct requirements table, as opposed to the transactions table, can only be read down each column. Each cell represents the dollar amount of inputs required from the industry named at the left to produce one dollar's worth of output from the sector named at the top. Each column essentially represents a `production recipe' for a dollar's worth of output. Given this latter interpretation, the upper part of the table (above households) is often referred to as the matrix of technical coefficients. In this example, for every dollar of sales by the agricultural sector, 20 cents worth of additional output from itself, 8 cents of output from manufacturing, 12 cents of output from services, and 32 cents from households will be required.

In the example region, an additional dollar of output by the agricultural sector requires firms in agriculture to purchase a total of 40 cents from other firms located in the region. If a product or service required in the production process is not available from within the region, the product must be imported. In the agricultural sector, 28 cents worth of inputs are imported for each dollar of output. It is important to note that in IO analysis, this production formula, or technology (the column of direct requirement coefficients), is assumed to be constant and the same for all establishments within a sector. This assumption holds regardless of input prices or production levels.

Table A2: Illustrative Direct Requirements Table

	Purchasing Sectors (Buyers/Demand)		
Processing Sectors (Sellers/Supply)	Agr	Mfg	Serv
Agr	0.20	0.12	0.04
Mfg	0.08	0.08	0.06
Serv	0.12	0.04	0.02
HH (labor)	0.32	0.51	0.72
Imports	0.28	0.24	0.02
Inputs	1.00	1.00	1.00

Assuming the direct requirements table also represents spending patterns necessary for additional production, the effects of a change in final demand of the output on the other of sectors can be predicted. For example, assume that export demand for the region's agricultural products increases by $100,000. From Table 2, it can be seen that any new final demand for agriculture will require purchases from the other sectors in the economy. The amounts shown in the first column are multiplied by the change in final demand to give the following figures: $20,000 from agriculture, $8,000 from manufacturing, and $12,000 from services. These are called the direct effects and, in this example, they amount to a total impact on the economy of $140,000 (the initial change [$100,000] plus the total direct effects [$40,000]). For many studies of economic impact the direct and initial effects are treated as the same although there are subtle differences.
The strength of input-output modeling is that it does not stop at this point, but also measures the indirect effects of an increase in agricultural exports. In this example, the agricultural sector increased purchases of manufactured goods by $8,000. To supply agriculture's new need for manufacturing products, the manufacturing sector must increase production. To accomplish this, manufacturing firms must purchase additional inputs from the other regional sectors.

Continuing our $100,000 increase in export demand for a region's agricultural products, for every dollar increase in output, manufacturing must purchase an additional 12 cents of agricultural goods ($8,000 x .12 = $960), 8 cents from itself ($8,000 x .08 = $640), and 4 cents from the service sector ($8,000 x .04 = $320). Thus, the impact on the economy from an increase in agricultural exports will be more than the $140,000 identified previously. The total impact will be $140,000 plus the indirect effect on manufacturing totaling $1,920 ($960 + $640 + $320), or $141,920. A similar process examining the service sector increases the total impact yet again by $1,440 ([$12,000 x .04] + [$12,000 x .06] + [$12,000 x .02] = $1,440).

The cycle does not stop, however, after only two rounds of impacts. To supply the manufacturing sectors with the newly required inputs, agriculture must increase output again, leading to an increase in manufacturing and service sector outputs. This process continues until the additional increases drop to an insignificant amount. The total impact on the regional economy, then, is the sum of a series of direct and indirect impacts. Fortunately, the sum of these direct and indirect effects can be more efficiently calculated by mathematical methods. The methodology was developed by the Noble winning economist Wassily Leontief and is easily accomplished using computerized models.

Total Requirements Table

Typically, the result of the direct and indirect effects is presented as a total requirements table, or the Leontief inverse table (Table A3). Each cell in Table 3 indicates the dollar value of output from the sector named at the left that will be required in total (i.e., direct plus indirect) for a one dollar increase in final demand for the output from the sector named at the top of the column. For example, the element in the first row of the first column indicates the total dollar increase in output of agricultural production that results from a $1 increase in final demand for agricultural products is $1.28. Here the agricultural multiplier is 1.28: for every dollar of direct agricultural sales there will be an additional 28 cents of economic activity as measured by industry sales.

Table A3: Illustrative Total Requirements Table

	Purchasing Sectors (Buyers/Demand)		
Processing Sectors (Sellers/Supply)	**Agr**	**Mfg**	**Serv**
Agr	**1.28**	**0.17**	**0.06**
Mfg	**0.12**	**1.11**	**0.07**
Serv	**0.16**	**0.07**	**1.03**
Inputs	**1.56**	**1.35**	**1.16**

An additional interpretation of the transactions table, as well as the direct requirements and total requirements tables, is the measure of economic linkages within the economy. For example, the element in the second row of the first column indicates the total increase in manufacturing output due to a dollar increase in the demand for agricultural products is 12 cents. This allows the analyst to not only estimate the total economic impact but also provide insights into which sectors will be impacted and to what level.

Highly linked regional economies tend to be more self-sufficient in production and rely less on outside sources for inputs. More open economies, however, are often faced with the requirement of importing production inputs into the region. The degree of openness can be obtained from the direct requirements table (Table 2) by reading across the imports row. The higher these proportions are, the more open the economy. As imports increase, the values of the direct requirement coefficients must, by definition, decline. It follows then that the values making up the total requirements table, or the multipliers, will be smaller. In other words, more open economies have smaller multipliers due to larger imports. The degree of linkage can be obtained by analyzing the values of the off- diagonal elements (those elements in the table with a value of less than one) in the total requirements table. Generally, larger values indicate a tightly linked economy, whereas smaller values indicate a looser or more open economy.

Input-Output Multipliers

Basics of Input-Output Multipliers

Through the discussion of the total requirements table, the notion of external changes in final demand rippling throughout the economy was introduced. The total requirements table can be used to compute the total impact a change in final demand for one sector will have on the entire economy. Specifically, the sum of each column shows the total increase in regional output resulting from a $1 increase in final demand for the column heading sector. Retaining the agricultural example, an increase of $1 in the demand for agricultural output will yield a total increase in regional output equal to $1.56 (Table 3). This figure represents the initial dollar increase plus 56 cents in direct and indirect effects. The column totals are often referred to as output multipliers.

The use of these multipliers for policy analysis can prove insightful. These multipliers can be used in preliminary policy analysis to estimate the economic impact of alternative policies or changes in the local economy. In addition, the multipliers can be used to identify the degree of structural interdependence between each sector and the rest of the economy. For example, in the illustrative region, a change in the agriculture sector would influence the local economy to the greatest extent, while changes in the service sector would produce the smallest change. The output multiplier described here is perhaps the simplest input-output multiplier available. The construction of the transactions table and its associated direct and total requirements tables creates a set of multipliers ranging from output to employment multipliers. Input-output analysis specifies this economic change, most commonly, as a change in final demand for some product. Economists sometimes might refer to this as the "exogenous shock" applied to the system. Simply stated, this is the manner in which we attempt to introduce an economic change.

The complete set includes:

Type Definition	
1. Output Multiplier	The output multiplier for industry *i* measures the sum of direct and indirect requirements from all sectors needed to deliver one additional dollar unit of output of *i* to final demand.
2. Income Multiplier	The income multiplier measures the total change in income throughout the economy from a dollar unit change in final demand for any given sector.
3. Employment Multiplier	The employment multiplier measures the total change in employment due to a one unit change in the employed labor force of a particular sector.

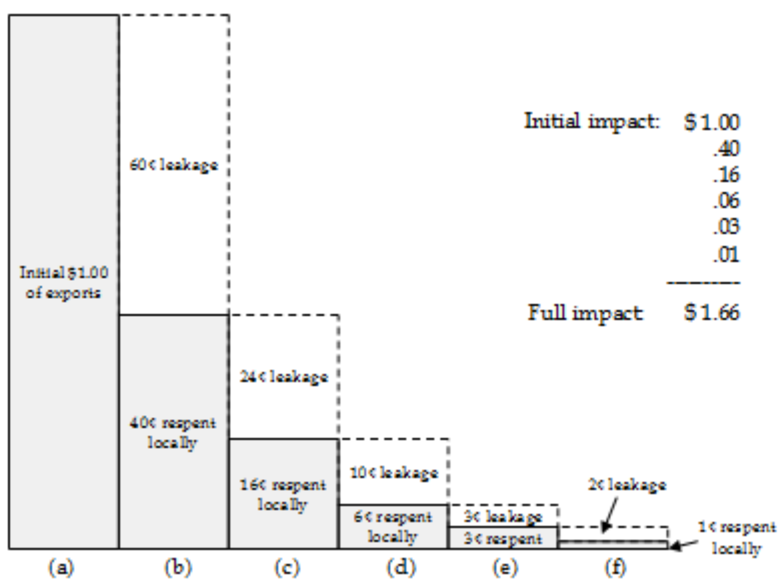
The income multiplier represents a change in total income (employee compensation plus proprietary income plus other property income plus indirect business taxes) for every dollar change in income for any given sector. The employment multiplier represents the total change in employment resulting from the change in employment in any given sector. Thus, we have three ways that we can describe the change in final demand.

Consider, for example, a dairy farm that has $1 million in sales (industry output), pays labor $100,000 inclusive of wages, salaries and retained profits, and that employs three workers, including the farm proprietor. Suppose that demand for milk produced at these farm increases 10 percent, or $100,000 dollars. We could use the traditional output multiplier to determine what the total impact on output would be. Alternatively, to produce this additional output the farmer may find that they need to hire a part-time worker. We could use the employment multiplier to examine the impact of this new hire on total employment in the economy. In addition, the income paid to labor will increase by some amount and we can use the income multiplier to see what the total impact of this additional income will have on the larger economy.

How are these income and employment multipliers derived if the IO model only looks at the flow of industry expenditures (output)? In the strictest sense, the IO does not understand changes in employment or income, only changes in final demand (sales or output). To do this we use the fact that the IO model is a "fixed proportion" representation of the underlying production technologies. This is most clear by reexamining the direct requirements table (Table 2). For every dollar of output (sales) inputs are purchased in a fixed proportion according to the production technology described by the direct requirements table. For every dollar of output there is a fixed proportion of employment required as well as income paid. In our simple dairy farm example, for every dollar of output there are .000003 (= 1,000,000 ÷ 3) jobs and $.10 (= 1,000,000 ÷ 100,000) in income. We can use these fixed proportions to convert changes in output (sales) into changes in employment and income.

Graphically, we can illustrate the round-by-round relationships modeled using input-output analysis. This is found in Figure 1. The direct effect of change is shown in the far left-hand side of the figure (the first bar (a)). For simplification, the direct effect of a $1.00 change in the level of exports, the indirect effects will spill over into other sectors and create an additional 66 cents of activity. In this example, the simple output multiplier is 1.66. A variety of multipliers can be calculated using input-output analysis.

While multipliers may be used to assess the impact of changes on the economy, it is important to note that such a practice leads to limited impact information. A more complete analysis is not based on a single multiplier, but rather, on the complete total requirements table. A general discussion of the proper and inappropriate uses of multipliers is presented in the next appendix to this text.



Initial, Indirect and Induced Effects

The input-output model and resulting multipliers described up to this point presents only part of the story. In this construction of the total requirements table (Table 3) and the resulting multipliers, the production technology does not include labor. In the terminology of IO modeling, this is an “open” model. In this case, the multiplier captures only the initial effect (initial change in final demand or the initial shock) and the impact of industry to industry sales. This latter effect is called the indirect effect and results in a Type I multiplier. A more complete picture would include labor in the total requirements table. In the terminology of IO modeling, the model should be “closed” with respect to labor. If this is done, we have a different type of multiplier, specifically a Type II multiplier, which is composed of the initial and indirect effects as well as what is called the induced effects.

The Type II multiplier is a more comprehensive measure of economic impact because it captures industry to industry transactions (indirect) as well as the impact of labor spending income in the economy (induced effect). In the terminology of IO analysis, an “open” model where the induced effect is not captured, any labor or proprietor income that may be gained (positive shock) or lost (negative shock) is assumed to be lost to the economy. In our simple dairy farm example, any additional income (wages, salaries and profits) derived from the change in output (sales) is pocketed by labor and is not re-spent in the economy. This clearly is not the case: any additional income resulting from more labor being hired (or fired) will be spent in the economy thus generating an additional round of impacts. This second round of impacts is referred to as the induced impact.

Insights can be gained by comparing and contrasting the indirect and induced effects. For example, industries that are more labor intensive will tend to have larger induced impacts relative to indirect. In addition, industries that tend to pay higher wages and salaries will also tend to have larger induced effects. By decomposing the Type II multiplier into its induced and indirect effects, one can gain a better understanding of the industry under examination and its relationship to the larger economy.