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# Wisconsin and the Agricultural Economy

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# Wisconsin and the Agricultural Economy

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## Wisconsin and the Agricultural Economy

From a historical perspective, agriculture, broadly defined to include both on farm production of raw commodities and value added processing, has been an integral part of the backbone of the Wisconsin economy. Self described as the Dairy State the national image of the Wisconsin economy remains one of dairy farming and the production of cheese. Many Wisconsinites proudly wear the label of being a "cheese head." But is this a reflection of today's Wisconsin economy or is it a more of a nostalgic view of historical Wisconsin?

Currently, Wisconsin accounts for about 45 percent of all butter and 30 percent of all cheese production in the U.S. The vast majority of milk produced on Wisconsin dairy farms is used in butter, cheese and other value added dairy products. In addition, Wisconsin is the national leader in several specialty crops including cranberries, ginseng and many vegetables. At the same time Wisconsin is a leader in the production of machinery for the paper industry, accounting for about 35 percent of national production, as well as paper production, about 20 percent of U.S. production. Wisconsin also accounts for about a third of national production of motorcycles and bicycles.

How do we decipher all the various and sometimes contradictory pieces to this complex puzzle? The intent of this applied research project is to shed some light on this puzzle and offer some insights into the central question concerning the importance of agriculture to the Wisconsin economy. The method used here centers on the construction and use of a regional economic modeling approach called input-output (IO) analysis. By constructing a regional input-output model of the Wisconsin economy we can measure the absolute and relative size of any particular industry. We can also trace though the linkages of the industry and document how it impacts other industries and hence the whole of the economy. This is widely referred to as multiplier analysis.

Before an economic impact assessment can be undertaken, it is necessary to define the industry under consideration. Unfortunately, there is no theoretical construct to help form this definition and hence be deemed somewhat arbitrary. Some agricultural advocates define agriculture as any industry contained in the food and fiber industry in the broadest sense. For example, all persons employed in grocery stores and restaurants should be classified as agriculture because they are working with food productions. This broad definition would also include all persons employed in clothing production and retailing because clothing is mostly made of agricultural products including cotton, wool and leather. In the extreme this definition would include part of the automobile industry to the extent that car and truck interiors are often made of leather. This definition is unacceptable for this study because it in effect describes the linkages of agriculture through the rest of the economy in an ad hoc manner.

Others view agriculture narrowly as only on-farm production and any value added processing that takes place beyond the farm gate is part of nondurable manufacturing. For this study this definition of agriculture is too narrow because it does not adequately reflect the vertical integration that has been occurring in agriculture where processors and producers are increasingly one in the same. This is partially a reflection of the industrialization of major parts of agriculture but also the growing number of farmers that are trying to capture more of the value added dollar. In Wisconsin, this is perhaps most evident by the number of cooperatives that are expanding into value added processing.

For this study agriculture is defined as being composed of three parts: on-farm production, value added processing and horticulture. On-farm production includes dairy farms, crop farms, and specialty farms including cranberry, ginseng and other specialty crops. Value added processing would include cheese production, poultry processing, breweries, and bakeries to name a few. Given our rapidly urbanizing society, horticulture is a growing part of the Wisconsin agricultural industry. Horticulture includes greenhouses, nurseries and to a limited extent landscaping businesses. Seven specific analyzes are offered: 1) on-farm dairy production, 2) dairy processing, 3) all dairy, which includes on-farm dairy production and dairy processing, 4) all on-farm production, 5) all agricultural processing, 6) horticulture, and 7) all agriculture, which includes all on-farm production, all agricultural processing and horticulture.

This study is composed of three parts beyond these introductory remarks. First a detailed discussion of IO analysis is represented along with a review of the strengths and weaknesses of the approach. A historical review of three common economic measures, income, employment and gross state product, with a focus on agriculture is presented. In the final section the results of the impact analysis is presented using three measures of economic activity including total industrial output (TIO) or industry sales, total income and employment.

## Basics of Input-Output Modeling

A simple non-technical discussion of the formulation of input-output (IO) modeling is presented in this section. Similar descriptive treatments are readily available, including Shaffer, Deller and Marcouiller (2004) while more advanced discussions of input-output include 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).[1] The simplest way to express this interaction is a regional *transactions table* (Table 1). The transactions table shows the flows 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.

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).[2] 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

[1] A "region" is defined here as a functioning economic area. This could be as large as multiple states such as the Great Lakes states or as small as a specific county. For this study we are interested in the region defined as Wisconsin.

[2] Note that government has not been entered into the table. If government were to be introduced, payments would be in the form of taxes.

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.

Table 1. Illustrative Transactions Table

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

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. Specifically, 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 2).

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.

| Table 2. Illustrative Direct Requirements Table | | | |
|---|---|---|---|
| | Purchasing Sectors (Demand) | | |
| Processing Sectors (Sellers) | 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 | 0.32 | 0.51 | 0.72 |
| Imports | 0.28 | 0.24 | 0.17 |
| Inputs | 1.00 | 1.00 | 1.00 |

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 regardless of input prices or production levels.

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 in 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 3). 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.

An additional, useful 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.[3] The higher these proportions are the more open the economy. By definition, as imports increase the values of the direct requirement coefficients will 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.

Table 3. Illustrative Total Requirements Table

| | Purchasing Sectors (Demand) | | |
|---|---|---|---|
| Processing Sectors (Sellers) | Agr | Mfg | Serv |
| Agr | 1.28 | 0.17 | 0.06 |
| Mfg | 0.12 | 1.11 | 0.07 |
| Serv | 0.16 | 0.07 | 1.03 |
| Total | 1.56 | 1.35 | 1.16 |

***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.[4] The total requirements table can

[3] As described above, the openness of the economy can also be discussed in terms of leakages; greater leakages translate into a more open economy.

[4] Economic impact analysis is an attempt to model the impacts that an economic change has on

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.

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 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.

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regions. 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.

But 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 perhaps 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 spillover 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 an appendix to this text (Appendix A).

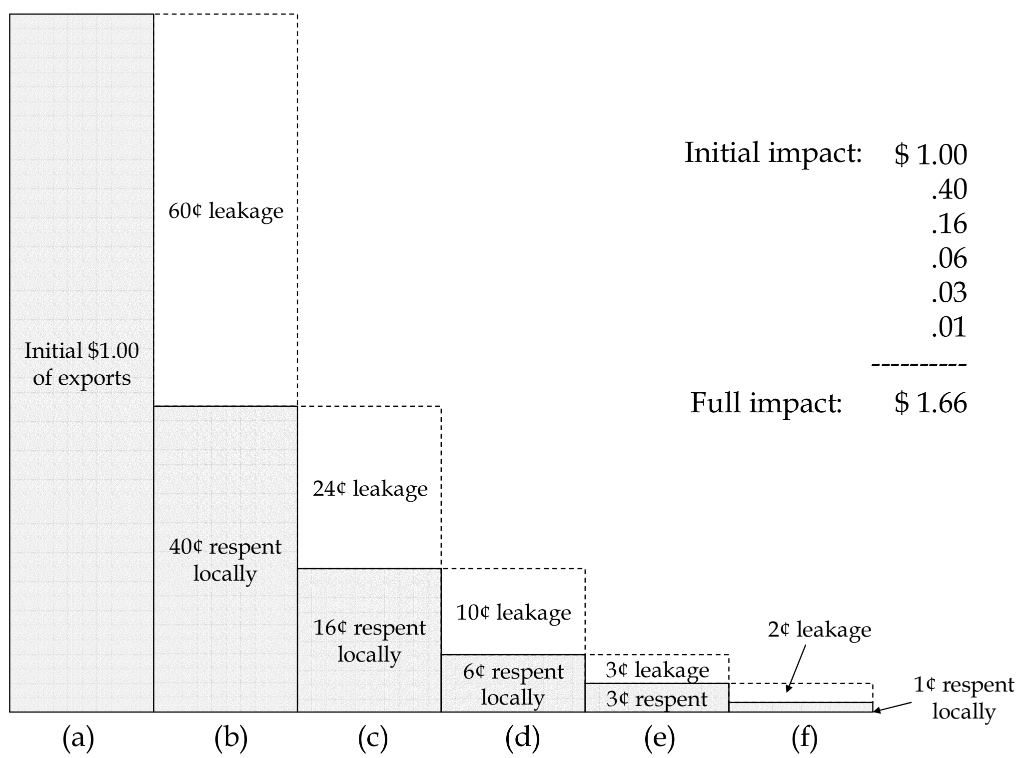


Figure 1. Multipliers and the round-by-round impacts estimated using input-output analysis

### ***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 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 and also 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) and also 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 generating an additional round of impacts. This second round 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.

### ***A More Formal Presentation***

To more formally think about input-output relationships, specify $X_i$ as total output of sector i in value (monetary) terms, $Y_i$ as total final demand for sector i's product, and $z_{ij}$ as the interindustry demands from sector i (intermediate input) to sector j (intermediate demand). Thus, demand for each industry can be written as:

$$X_i = z_{i1} + z_{i2} + z_{i3} + \dots + z_{in} + Y_i \tag{1}$$

In the IO structure, production takes place under very strict linear conditions. Specifically, IO analysis assumes that inter-industry flows from i to j are wholly dependent on the output of j. This leads to a set of production relationships that are generally referred to as "technical coefficients." Specified mathematically, these technical coefficients are defined as:

$$a_{ij} = \frac{z_{ij}}{X_j} \tag{2}$$

where $a_{ij}$ is the technical coefficient that translates value in dollar units into a proportion. Returning to our illustrative Direct Requirement Table (Table 2) $a_{ij}$ represents the elements of the table. A technical coefficient implies that production takes place under rather strict conditions of constant input to output ratios. This is our fixed proportion production technology discussed above.

Leontief's predictive form of IO analysis relates change in total output to the macroeconomic components of demand (intermediate and final). Basically he stated that if we can estimate changes in final demand, we can predict how an economy will react as measured in change in output. To understand his logic, we return to our original specification of output found in equation 1 and reorganize the technical coefficient found in 2 into the following:

$$z_{ij} = a_{ij} x_j \tag{3}$$

Substituting equation 3 into equation 1, we arrive at the following statement for sectoral output in a simple 2 sector model:

$$\begin{aligned} x_1 &= a_{11}x_1 + a_{12}x_2 + y_1 \quad &\text{(sector 1)} \\ x_2 &= a_{21}x_1 + a_{22}x_2 + y_2 \quad &\text{(sector 2)} \end{aligned} \tag{4}$$

This set of equations can be rearranged to be represented as follows:

$$\begin{aligned} x_1 - a_{11}x_1 - a_{12}x_2 &= y_1 \quad &\text{(sector 1)} \\ x_2 - a_{21}x_1 - a_{22}x_2 &= y_2 \quad &\text{(sector 2)} \end{aligned} \tag{5}$$

Further reorganization can represent these relationships alternatively as:

$$\begin{aligned} (1 - a_{11})x_1 - a_{12}x_2 &= y_1 \quad &\text{(sector 1)} \\ -a_{21}x_1 + (1 - a_{22})x_2 &= y_2 \quad &\text{(sector 2)} \end{aligned} \tag{6}$$

The astute reader will realize that when we extend this simple model into more than a couple of sectors, our scalar representation gets rather complex and computationally challenging. Our discussion will be greatly simplified if we move to matrix notation. Recognize that the equations for the two sectors found in 6 can be rewritten in matrix form in the following manner:

$$\begin{bmatrix} 1 - a_{11} & -a_{12} \\ -a_{21} & 1 - a_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} \tag{7}$$

and that the first array can be rewritten in the following manner:

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \tag{8}$$

which, when written in matrix notation, can be represented as *(I-A)*.

In matrix notation, Leontief's contribution walked through the following rearrangements (equations 9 to 11) to set up the predictive IO form, eventually found in equations 12 and 13. Each equation is presented in matrix form with the analogous scalar form identified from above.

$$X = AX + Y \quad \text{(analogous to 4)} \tag{9}$$

$$X - AX = Y \quad \text{(analogous to 5)} \tag{10}$$

$$(I - A)X = Y \quad \text{(analogous to 7)} \tag{11}$$

Dividing *(I-A)* by both sides results in Leontief's prime contribution. In matrix form, the quotient operation is represented as an inverse. Giving deference to its originator, this particular inverse is often referred to as the *Leontief* inverse and is a formal presentation of the total requirements table:

$$X = (I - A)^{-1} Y \tag{12}$$

Now we are able to predict change in a region's economic output (X) by specifying changes in demand (Y). Formally, the IO predictive form is given as follows:

$$\Delta X = (I - A)^{-1} \Delta Y \tag{13}$$

This set of relationships can be restated in words, which is sometimes helpful to the student learning this for the first time. The story goes as follows. A region's economic output for each of many sectors is produced with a unique set of inputs. In other words, output ($X_i$) is produced using intermediate purchased inputs and primary factors. These are fixed and reflective of the year in which the tableau was constructed. The amount of input purchased by a sector is determined solely by its level of output which is reflected within its technical coefficient. An example might be that the amount of milk required by a cheese manufacturer and purchased from local dairy farmers is determined by how much cheese the firm produces.

***Limiting Assumptions***

This cursory review of input-output modeling has employed the simplest form of the IO model. The most direct simplification is the explicit removal of the household sector from the total requirements table. By removing households, the *induced* impact on final demand of increases in value-added, or income, is ignored. Hence, the output multipliers reported in Table 3 are an underestimate of the total impact of a one-time change in final demand. That is, if households were included as a sector in the total requirements table, a new set of multipliers, which would be larger than those reported in Table 3, could be obtained.

Other simplifying assumptions include, but are not limited to, the use of `super-sectors'. This example IO model explicitly uses only three sectors (agriculture, manufacturing, and services), yet the national IO model has 528 sectors. While working with a smaller number of sectors may make the modeling process easier and subsequent analysis more tractable, valuable information is lost. The small number of sectors in the model above was used only to stimulate the discussion of IO techniques and procedures.

Despite the simplicity of the example region, the values of input-output modeling as a policy tool are evident. Input-output modeling provides policy makers with a descriptive as well as an analytical tool, allowing the assessment of changes within the economy. Through the use of the total requirements table, economic impact analysis becomes a fairly direct exercise. While policy makers often turn directly to the model's multipliers, the IO model presents a vast array of economic information, ranging from the description of a sector's importance in the economy to the identification of areas for potential development (e.g., sectors exhibiting high imports).

More technical limitations to IO become apparent when the assumptions of IO are laid out, these include:

a. The output of each sector is produced with a unique set of inputs (i.e., there is no substitution between inputs).

b. The amount of input purchased by a sector is determined solely by its level of output (i.e., there are no price effects, changes in technology, or economies of scale).

c. There are no external economies of scale (i.e., there are no agglomeration economies, or new industries are included in an additive manner).

d. The in-state and out-of-state distribution of purchases and sales is fixed.

e. There are no constraints on resources (i.e., supply is infinite and perfectly elastic).

f. Local resources are efficiently employed (no under employment of resources).

Despite these strong assumptions, IO remains one of the most widely used methods for assessing economic impacts. It is important, however, that as one interprets the results of the analysis presented here the reader must keep in mind that the estimates are the result of an economic model and as such, some restrictive assumptions were required.

## Historical Patterns for Wisconsin[5]

To gain insights into the importance of agriculture to the Wisconsin economy it is useful to examine historical trends as well as a detail examination of a "snap-shot" in time. This analysis allows us not only to examine growth patterns in agriculture itself, but also compare those growth patterns relative to the overall economy. Three measures of economic performance are used: employment, income and gross state product. In addition to data for Wisconsin, comparisons are made to the U.S. and Great Lakes economies. Looking at growth patterns in isolation, without a benchmark for comparison, it is impossible to tell if the observed pattern is strong, weak or on par with expectations. Growth indices are constructed and reported to facilitate comparisons across economies and measures. When examining these indices, one should look for three things: positive or negative growth trends; relative magnitudes of growth; and finally stability of the indices from one period to the next.

Consider first growth in personal income from 1958 to the first three months of 2003 (Figure 1). Up until about 1980 differences in personal income growth rates across the US, the Great Lake States and Wisconsin was relatively small. After 1980, however, growth rates appear to be noticeably different with Wisconsin growing at a faster rate than the Great Lakes States overall, but slower than the US aggregate. From the beginning of the period, personal income grew by 2,510 percent for the US, about 2,130 percent for Wisconsin, but only 1,790 percent for the Great Lake States. If we compare overall growth in personal income to growth in farm income and farm proprietor's income for Wisconsin, we get a very different picture (Figure 2). Although total personal income grew by 2,130 percent over the period examined, farm income grew only modestly and farm proprietor's income actually declined. Perhaps the most direct observation is production agriculture as major source of personal income has declined significantly over time. It is not necessarily the case that production agriculture has declined, but rather the rest of the state's economy has grown significantly.

If we focus more closely on farm income across the US, Great Lake States and Wisconsin the general levels of instability becomes even more apparent (Figure 3). Since the early 1970s, income from production agriculture has been increasingly unstable. Much of this instability comes from price volatility or variability. Dairy price volatility (variability), for example, has widen considerably since price supports have been reduced to a much lower level. Noticeable declines include 1983 and 1988 but for Wisconsin there was a remarkable increase in 2001 and the first quarter of 2003. If we look at the last three months of 2000, before the spike of 2001 and 2003, farm income grew by about 45 percent in both Wisconsin and the Great Lake States, but by 150 percent for the US overall. If we look at farm proprietor's income over the same 1958-2002 period

[5] For a more detailed discussion of the Wisconsin agricultural economy please see *Status of Wisconsin Agriculture, 2004* Department of Agricultural and Applied Economics, University of Wisconsin-Madison.

the same pattern of instability is evident, but more importantly there is a noticeable downward trend over the past ten years (Figure 4).

Looking at gross state product (GSP), a comprehensive measure of income, for the period 1977, the beginning year which state level GSP data are collected to the most current year 2001 a comparable story is revealed (Figure 5). In Wisconsin GSP grew by about 49 percent, and 59 percent for the US but only 37 percent for the Great Lake States. The recessions of the early 1980s, early 1990s and the most recent are clearly evident. But it is of particular interest to note that Wisconsin does not appear to have been affected by the recession of the early 1990s. Gross state product attributable to production agricultural declined by 20 percent in Wisconsin, 12 percent for the US and 26 percent for the Great Lake States (Figure 6). The farm crisis of the 1980s is particularly evident, but the rate of decline appears to have stabilized to a certain extent. Given the large increase in farm income revealed above (Figures 1 and 2) it may be reasonable to expect farm GSP in 2002 to have increased.

If we define agriculture differently and look at the food processing industry it becomes clear that the farm crisis that plagued production agriculture throughout the 1980s did not spill over into agricultural processing (Figure 7). From the beginning of the period (1977) GSP increase by 191 percent for the US, and 170 percent for Wisconsin and 142 percent for the larger region of the Great Lake States. The decline in production agriculture coupled with the growth in food processing is directly attributable to the changing food markets. Over the past 20-30 years the demand for processed or foods with greater value added has grown rapidly when compared for the growth in demand for farm commodity products. In other words, the growth in the food industry has not been in on-farm production, but rather value added processing.

Our final measure of economic activity for this historical descriptive analysis is employment. Tracking employment growth indices for the US, Wisconsin and the Great Lake States reveals again that neither Wisconsin nor the Great Lakes kept pace with overall growth for the US (Figure 8). Between 1977 and 2001, total employment in the US grew by 59 percent, almost 50 for Wisconsin and only 37 percent for the Great Lake States. The recessions of the early 1980s and 1990s as well as the current economic slow down are evident in the data. Again, Wisconsin's employment data reveal little of the recession of the early 1990s. Farm employment trends mirror the trends identified with the descriptive analysis of farm GSP where the farm crisis of the 1980s and stabilization beginning in 1997 is clearly evident (Figure 9). Between 1977 and 2001 farm employment declined by 20 for the US, and about 30 percent for Wisconsin and the Great Lake States. If we look at the number of farm proprieties (i.e., number of farm businesses), as opposed to farm employment, a similar pattern develops: number of farm proprieties declined by about 12 percent for the US, 20 percent for Wisconsin and 26 percent for the Great Lake States (Figure 10). Finally, by overlaying total employment growth with farm employment and farm proprietor's growth the declining importance of production agricultural as a source of employment in Wisconsin becomes apparent.

## Agricultural Impacts on the Wisconsin Economy

In order to assess the current or "snap shot" economic impacts of agriculture seven classifications of agriculture are considered: on farm dairy production; dairy processing; on farm dairy production and dairy processing combined; horticulture; all on farm production; all agricultural processing; and finally all agriculture which is a sum of horticulture, all on farm production and all agricultural processing. Although economic impact studies of dairy and farming in general have been previously undertaken, this study is unique in that it provides the first examination of horticulture as a sector within the larger agricultural industry. Horticulture is an important and growing component of Wisconsin's agricultural picture. As Wisconsin becomes wealthier and to an extent more urban the demand for horticultural products and services, including but not limited to landscaping, will expand.

For this analysis we employ the input-output modeling system entitled IMPLAN (Impact analysis for Planning). The IMPLAN system was originally developed by the US Forest Service in the 1980s in response to a federal mandate that requires the Forest Service to assess the economic impact of alternative uses of forested lands under the control of the Forest Service. Today the IMPLAN system is maintained by the Minnesota IMPLAN Group in Stillwater, Minnesota. In addition to the modeling system which allows users to build IO models and the next generation of social accounting matrices (SAMs) IMPLAN also provides detailed data bases. These data bases are county level allowing the user to build detailed county-level IO economic models. For this study we used the full Wisconsin model which contains 466 individual industries including 20 on-farm sectors and 38 agricultural processing industries. The data for this analysis are for calendar year 2000.

**Base Analysis**

Before reporting the results of the complete impact assessment it is useful to provide a simple "head count" analysis of Wisconsin's agricultural industries (Table 4). As described above, the economy is measured using three separate metrics: total industrial sales (TIO), employment and total income. From an economic accounting framework, total income here is akin to gross state product used in the historical analysis presented above. All data here represents a snapshot of the Wisconsin economy in 2000. Production agricultural (on farm, excluding horticulture) has total industrial sales of about $6.7 billion or about 2 percent of the Wisconsin total of $328.1 billion. There are also 97,528 jobs on farms, about 2.8 percent of Wisconsin's 3.4 million jobs, and $1.1 billion in total income, less than one percent of total income in Wisconsin. Because on farm agriculture accounts for 2.8 percent of jobs but only 0.7 percent of total income suggests that per job pay is relatively low.

Agricultural processing, before any multiplier analysis is conducted, directly contributes $21.2 billion to Wisconsin's economy, or about 6.5 percent of the State's total. Agricultural processing also directly contributes 68,219 jobs, or two percent of total employment and $5.2 billion in income, or about 3.1 percent of Wisconsin's total income level of $168.7 billion. Unlike production agriculture, the ratio of employment to income shares suggests that per job income is relatively high in agricultural processing. Horticulture, while growing in importance in Wisconsin's agricultural landscape, directly contributes only $712 million to total industrial sales, or 0.2 percent, 17,926 jobs or 0.5 percent of total employment and $424 million in total income or 0.3 percent of total income. In horticulture the typical job pays about $26,000 annually.

As evident from the simple analysis presented in Table 4, manufacturing (non-agricultural processing) accounts for 31.8 percent of Wisconsin's industrial output, 16.4 percent of total employment and 22.3 percent of total income. The service sector broadly defined to include such industries as health care, business and personal services and much of the tourism/recreation industry, accounts for 15.4 percent of industry output, 27.7 percent of employment or 950,000 jobs and 18.5 percent of total income. The service industry is unique in that there is a wide range of job types including medical doctors and lawyers to the cleaning staff at hotels. The trade sectors (retail and wholesale) account for 21.5 percent of all jobs and 16.2 percent of total income but only 11.9 percent of industrial sales. Unlike the services sector, the variation in job types, and hence income per job estimates, is much lower suggesting that income per job tends to be relative low in the trade sector. The financial, insurance and real estate sectors (FIRE) accounts for about the same level of industry output as the trade sector, but only 6.4 percent of total employment while accounting for 15.4 percent of total income. The large difference in percentages of employment and income in the financial, insurance and real estate sector indicates that the typical job in this sector is high paying. Transportation, communication and public utilities (TCPU) account for 146,000 jobs, or about 4.3 percent of all jobs in Wisconsin and 6.8 percent of total income. Construction completes the picture accounting for $24.9 billion in industry sales, or 7.6 percent of total industrial output, six percent of total employment and 5.8 percent of total income. Regardless of the metric used to measure economic activity, manufacturing dominates the Wisconsin economy.

**Multiplier Impact Analysis**

As described above in detail it is possible to use input-output analysis to track through the linkages, and hence impact, of agriculture and its various components on the whole of the Wisconsin's economy. The results of the analysis are presented in two ways. First, a decomposition of the total impact into its respective parts (direct, indirect and induced) for each of the three metrics of the economy is provided in Table 5. Second, the distribution of the total impact across the various sectors of the economy are provided in Tables 6 through 12, one set of results for each definition of agriculture. Finally, a simple tax impact report is provided in Table 13. In the latter the level of taxes and other public revenues generated through the economic contribution of agriculture is computed. This would include taxes and fees paid directly by agricultural businesses and employees, but also taxes and fees generated through the multiplier affect.

Agricultural Impacts – Industry Output

Consider first the aggregate impact of all of agriculture on the Wisconsin economy: total industrial output is about $51.5 billion, total employment is about 420,000 jobs and total income is just over $16.8 billion. As reported in Table 5, the direct impact of agriculture on total industrial output is $28.6 billion, while the indirect is $17.6 billion and the induced impact is $5.3 billion. The "implicit" industrial output multiplier for all of agriculture is then 1.802. In other words, for every dollar of additional agricultural sales (i.e., industry output) an additional 80 cents of industrial sales will be generated in other parts of the Wisconsin economy. Given the break down between indirect and induced, the bulk of this multiplier impact is from business to business transactions (indirect) as opposed to wages and other income being spent by labor (induced).

By looking across the different definitions of agriculture a clearer picture can be gained as to how the components of agriculture contribute to the total impact.[6] On farm dairy operations have a total impact on industrial sales of slightly more than $4 billion while dairy processing, the bulk of which is cheese production, contributes $16.5 billion. The bulk of the multiplier impact is again through the indirect or business to business transactions. By combining all other types of farm enterprises with dairy farms, the impact on industrial sales is $10.6 billion. The impact of all agricultural processing is $39.8 billion again with the bulk of the multiplier affect attributed to indirect impacts. Horticulture could be considered still in its infancy and has an impact on industrial sales in Wisconsin accounting for $1.1 billion, which is about one quarter the size of on farm dairy production.

Agricultural Impacts - Employment

In terms of employment the direct impact is 183,600 jobs plus an indirect impact of about 163,000 jobs and about 73,000 jobs through the induced affect. The implicit employment multiplier is 2.289 suggesting that for every additional new job in agriculture about 1.3 additional jobs will be created. As with industry sales, the majority of the contribution of agriculture to the jobs metric of the Wisconsin economy comes from agricultural processing, with dairy processing accounting for 90,462 jobs while all of agricultural processing contributes 240,000 jobs. On farm dairy operations contribute 82,000 jobs and horticulture contributes almost 22,800 jobs. In nearly every case, the indirect impacts of agriculture are greater than the induced pointing to stronger inter-industry linkages and weaker wage or income linkages. The opposite is true with horticulture, however, where the induced impact is not quite double the indirect. This could be due to the importation of materials into the state or relative wages, salaries and profits.

[6] It is important to note that one can not add the impacts across the different components of agriculture to derive at a total. For example, adding dairy farm impacts with dairy processing will not sum up to total dairy impacts. The reason is that the impacts of dairy farming and dairy processing feed-back onto each other and to add the two separate analyses together would result in double counting. In cases where the individual components sum to the total as reported in Table 5 is purely coincidental.

Agricultural Impacts – Income (Gross State Product)

All of agriculture yields $16.8 billion in total income for the State of Wisconsin where $6.8 billion is direct affects, an additional $6.8 billion is from indirect impacts, and $3.2 billion are from induced impacts. The vast majority of this impact comes from agricultural processing. On farm dairying produces almost $1.1 billion while dairy processing yields $4.3 billion. Horticulture yields about $653 million. The implicit multipliers for total income (2.78 for all of agriculture) appear to be large across each of the agricultural sectors as defined for this study. These "large" multipliers should be interpreted with caution. In practice multipliers that are larger than "two" tend to indicate a potential error within the analysis. In the case of agriculture, however, the relatively low levels of direct or initial income associated with farming tends to suggest large multipliers.

Looking at the Sectoral Impacts of Agricultural

In addition to examining total impacts across direct, indirect and total impacts it is possible to decompose total impacts across different sectors of the economy. This decomposition is provided in Tables 6 through 12. For space considerations, only the aggregate grouping of all agriculture (Table 12) will be discussed here. The direct impacts are discussed in the agricultural and manufacturing (agricultural processing) sectors. The spillover, or multiplier affect, is felt in nearly every other sector of the Wisconsin economy ranging from construction and mining to government. The two sectors that are impacted the most are the broad categories of trade and services, where agriculture supports 54,600 and 57,300 jobs, respectively. By looking more closely within these broad categories the level of spillover becomes clearer. For example, agriculture, production, processing and horticulture support 1,050 in home furniture and furnishing stores, almost 900 jobs in beauty and barber shops, and 1,100 jobs in the banking sectors alone.

Agricultural creates a demand for government services to the level of about 2,000 jobs and $115 million in total income. But agriculture also generates tax revenues (Table 13). Looking at state and local tax revenue collection, agriculture and supported industries generated $574 million in property taxes, $473 million in sales taxes and $362 million in income taxes and once miscellaneous revenues are included agriculture generates $1,760 billion in state and local government revenues. It is important to note that these estimates do not include revenues devoted to public K-12 education and as such the computed level of $1.7 billion can be considered to be conservative.

## Conclusions

The intent of this applied research project has been to update and expand upon our understanding of the impact of agriculture on the Wisconsin economy. Using both historical data and a detail input-output model of the 2000 Wisconsin economy several conclusions can be drawn:

1. Wisconsin's economy has tended to perform stronger than the surrounding Great Lake States, but did not keep pace with the US economy.

2. Production, or on farm, agriculture is not a growth sector for the US or Wisconsin economy. As such, as the rest of the economy has grown, production agriculture accounts for a smaller share of the overall economy.

3. Farm income is extremely unstable.

4. Agricultural processing or value added agriculture is a growth sector for the US and Wisconsin.

5. Horticulture has a unique position within the broader agricultural industry and has a unique potential for growth, particularly in more urban markets.

6. Agriculture, and in particular agricultural processing, contributes 420,000 jobs to the Wisconsin economy, or 12.2 percent of all jobs, and $16.8 billion of total income, or about 10 percent of all income in Wisconsin.

7. Agriculture places demands on state and local governments, but also generates $1.7 billion in revenues for state and local governments, exclusive of revenues for public K-12 education.

A secondary goal of this effort has been to provide a primer on impact assessment and the use of input-output analysis. While widely accepted as a standard method for conducting impact assessment, IO analysis has several fundamental limitations. By gaining an appreciation for the strengths and weaknesses of IO analysis, a better understanding of the importance of agriculture to the Wisconsin economy can be gained.

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Miernyk, W.H. 1965. *The Elements of Input-Output Analysis.* New York: Random House.

Miller, R. and P.D. Blair. 1985. *Input-Output Analysis: Foundations and Extensions*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Figure 1. Growth Index of Personal Income

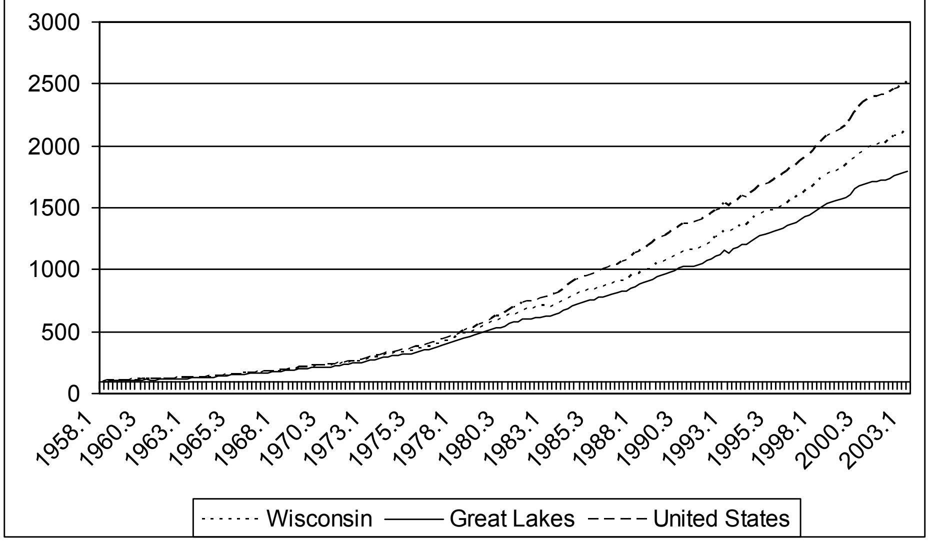


Figure 2. Growth Index of Wisconsin Personal and Farm Income

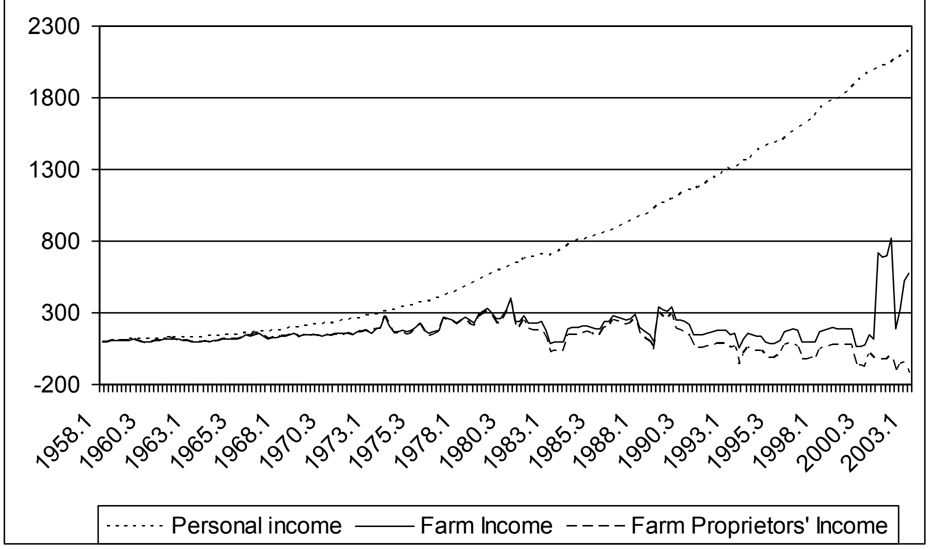

Figure 3. Growth Index of Farm Income

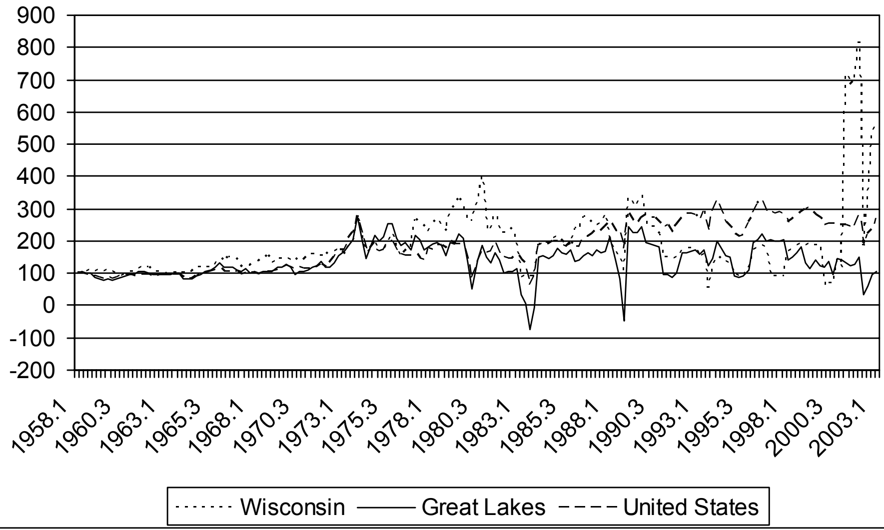


Figure 4. Growth Index of Farm Proprietors' Income: 1958-2002

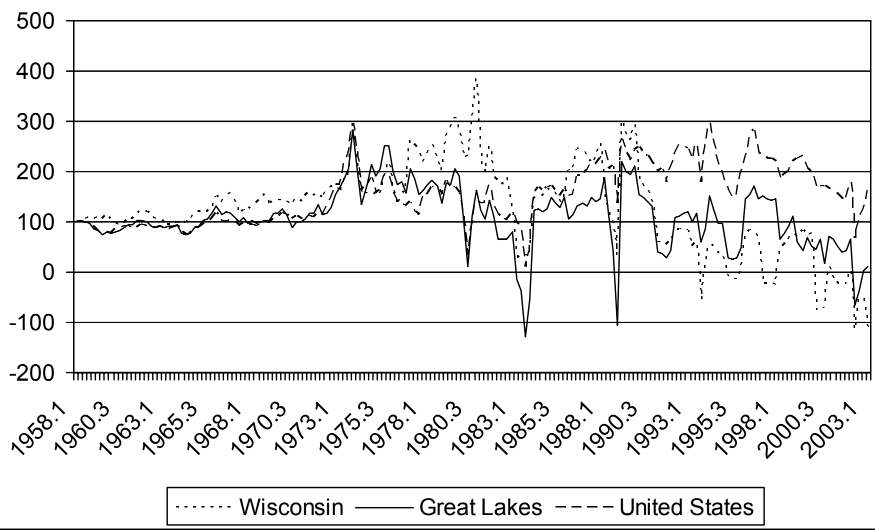

Figure 5. Growth Index of Gross State Product

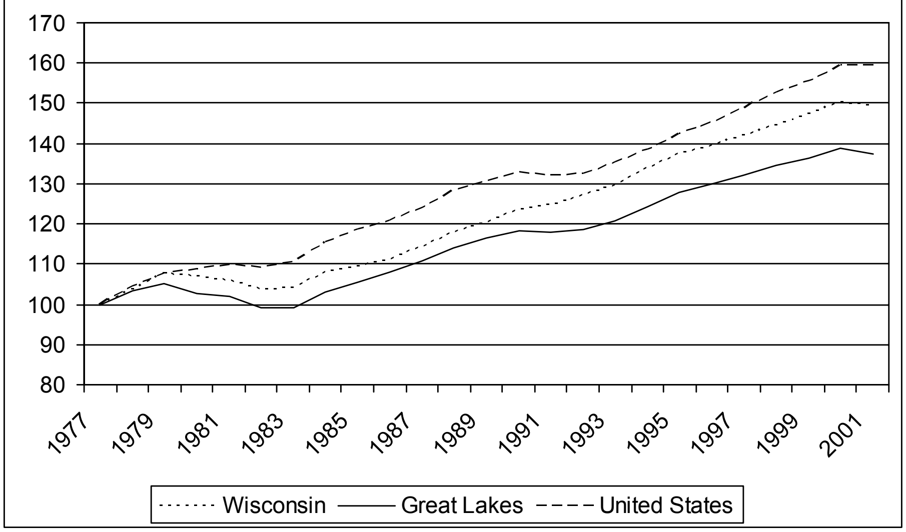


Figure 6. Growth Index of Farm Gross State Product

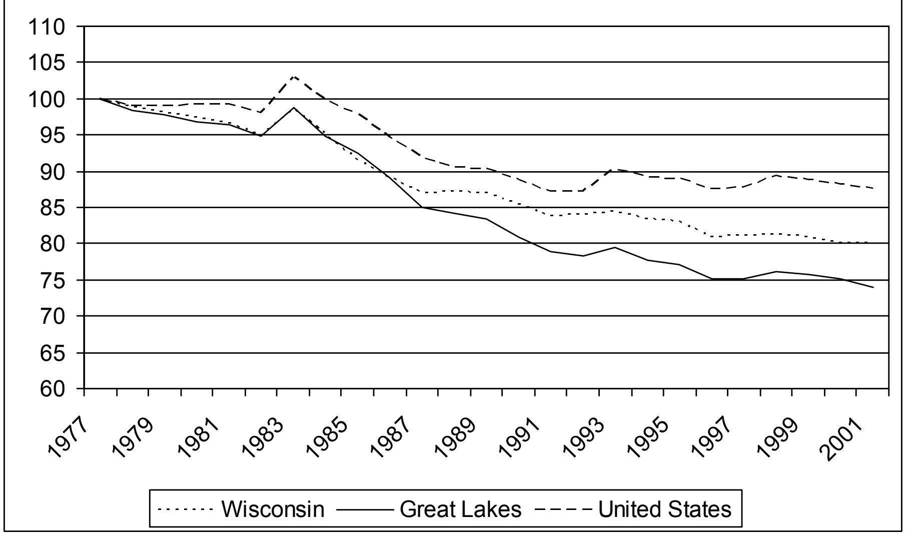


Figure 7. Growth Index of Food/Kindred Products GSP
360
310
260
210
160
110
60
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
Wisconsin
Great Lakes
United States


Figure 8. Growth Index of Employment
170
160
150
140
130
120
110
100
90
80
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
Wisconsin
Great Lakes
United States


Figure 9. Growth Index of Farm Employment
110
105
100
95
90
85
80
75
70
65
60
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
Wisconsin
Great Lakes
United States

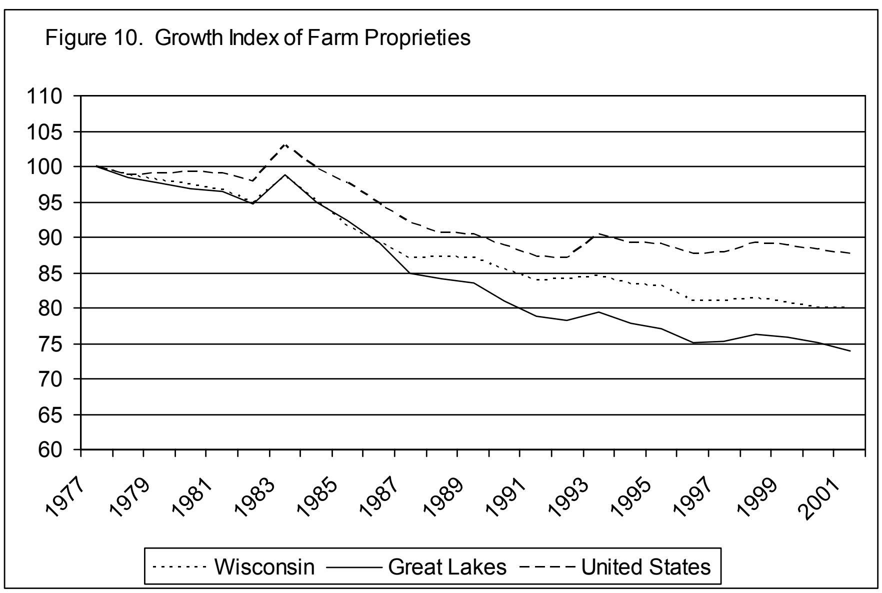
Figure 10. Growth Index of Farm Proprieties
110
105
100
95
90
85
80
75
70
65
60
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
Wisconsin
Great Lakes
United States

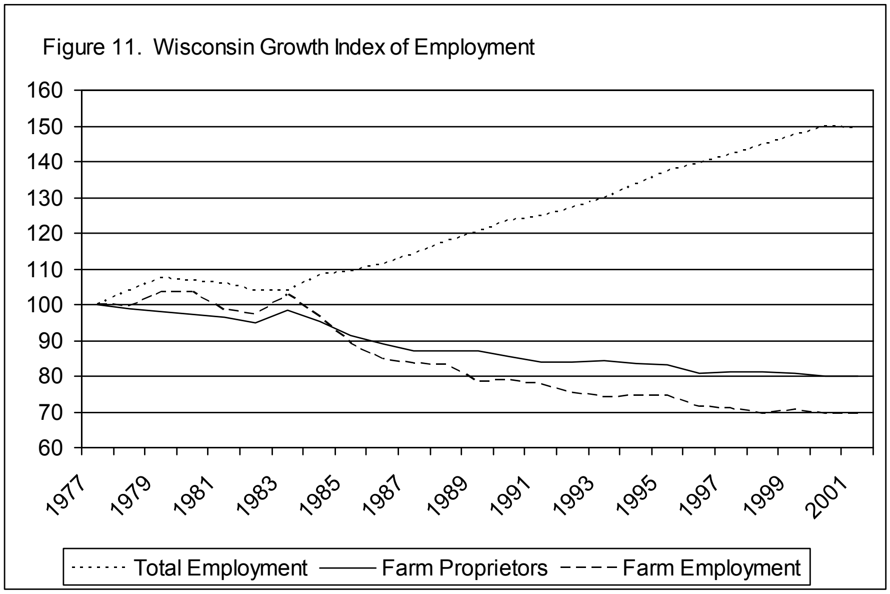


Table 4. Direct Economic Activity

| | Industry Output* | | | Employment | | Total Income* | |
|---|---|---|---|---|---|---|---|
| Agriculture | $ | 6,678 | 2.0% | 97,528 | 2.8% | $ 1,109 | 0.7% |
| Forestry and Fishing | $ | 469 | 0.1% | 11,908 | 0.3% | $ 248 | 0.1% |
| Horticulture | $ | 712 | 0.2% | 17,926 | 0.5% | $ 424 | 0.3% |
| Mining | $ | 538 | 0.2% | 3,470 | 0.1% | $ 309 | 0.2% |
| Construction | $ | 24,906 | 7.6% | 206,282 | 6.0% | $ 9,829 | 5.8% |
| Agricultural Processing | $ | 21,178 | 6.5% | 68,219 | 2.0% | $ 5,241 | 3.1% |
| Manufacturing | $ | 104,332 | 31.8% | 564,039 | 16.4% | $ 37,579 | 22.3% |
| TCPU | $ | 21,280 | 6.5% | 146,213 | 4.3% | $ 11,539 | 6.8% |
| Trade | $ | 38,884 | 11.9% | 739,167 | 21.5% | $ 27,414 | 16.2% |
| FIRE | $ | 38,282 | 11.7% | 221,560 | 6.4% | $ 25,946 | 15.4% |
| Services | $ | 50,625 | 15.4% | 950,439 | 27.7% | $ 31,149 | 18.5% |
| Government | $ | 20,239 | 6.2% | 409,333 | 11.9% | $ 17,945 | 10.6% |
| Total | $ | 328,123 | | 3,436,085 | | $ 168,730 | |

* millions $

Table 5. Agricultural Impacts

| | Industry Output* | | | |
|---|---|---|---|---|
| | Direct | Indirect | Induced | Total |
| Dairy Farm | $ 2,690 | $ 1,075 | $ 369 | $ 4,134 |
| Dairy Processing | $ 7,775 | $ 7,246 | $ 1,468 | $ 16,489 |
| Dairy Combined | $ 10,465 | $ 8,322 | $ 1,837 | $ 20,623 |
| Horticulture | $ 712 | $ 156 | $ 225 | $ 1,093 |
| All Farm | $ 6,678 | $ 2,987 | $ 924 | $ 10,589 |
| All Processing | $ 21,172 | $ 14,464 | $ 4,159 | $ 39,795 |
| All Agriculture | $ 28,562 | $ 17,607 | $ 5,308 | $ 51,477 |
| | | | | |
| | Employment | | | |
| | Direct | Indirect | Induced | Total |
| Dairy Farm | 60,800 | 16,689 | 5,092 | 82,581 |
| Dairy Processing | 17,430 | 52,795 | 20,237 | 90,462 |
| Dairy Combined | 78,230 | 55,686 | 25,296 | 159,212 |
| Horticulture | 17,926 | 1,776 | 3,100 | 22,802 |
| All Farm | 144,622 | 26,009 | 12,665 | 183,296 |
| All Processing | 68,205 | 115,120 | 56,736 | 240,062 |
| All Agriculture | 183,661 | 163,376 | 73,304 | 420,341 |
| | | | | |
| | Total Income* | | | |
| | Direct | Indirect | Induced | Total |
| Dairy Farm | $ 355 | $ 514 | $ 225 | $ 1,095 |
| Dairy Processing | $ 1,348 | $ 2,099 | $ 894 | $ 4,341 |
| Dairy Combined | $ 1,703 | $ 2,256 | $ 1,118 | $ 5,077 |
| Horticulture | $ 424 | $ 91 | $ 137 | $ 653 |
| All Farm | $ 1,109 | $ 1,415 | $ 563 | $ 3,087 |
| All Processing | $ 5,241 | $ 4,772 | $ 2,498 | $ 12,511 |
| All Agriculture | $ 6,774 | $ 6,820 | $ 3,243 | $ 16,836 |

* millions $

Table 6. Dairy On Farm

| | Industry Output* | Employment | Total Income* |
|---|---|---|---|
| Agriculture (production) | $ 3,040 | 71,062 | $ 440.8 |
| Construction/Mining | $ 54 | 753 | $ 36.6 |
| Manufacturing | $ 129 | 567 | $ 41.0 |
| TCPU | $ 216 | 1,445 | $ 115.5 |
| Trade | $ 303 | 3,989 | $ 210.2 |
| FIRE | $ 195 | 1,349 | $ 132.9 |
| Services | $ 176 | 3,220 | $ 108.5 |
| Government | $ 22 | 196 | $ 9.1 |
| Total | $ 4,134 | 82,581 | $ 1,094.5 |
| Percent of Wisconsin Total | 1.3% | 2.4% | 0.7% |

* millions $

Table 7. Dairy Processing

| | Industry Output* | Employment | Total Income* |
|---|---|---|---|
| Agriculture (production) | $ 3,074 | 24,402 | $ 448.9 |
| Construction/Mining | $ 135 | 1,851 | $ 90.4 |
| Manufacturing | $ 9,750 | 20,683 | $ 1,554.7 |
| TCPU | $ 576 | 3,751 | $ 298.6 |
| Trade | $ 1,316 | 17,652 | $ 910.3 |
| FIRE | $ 659 | 4,321 | $ 443.7 |
| Services | $ 899 | 17,035 | $ 561.0 |
| Government | $ 78 | 767 | $ 33.5 |
| Total | $ 16,487 | 90,462 | $ 4,341.0 |
| Percent of Wisconsin Total | 5.0% | 2.6% | 2.6% |

* millions $

Table 8. All Dairy

| | Industry Output* | Employment | Total Income* |
|---|---|---|---|
| Agriculture (production) | $ 6,113 | 81,642 | $ 531.6 |
| Construction/Mining | $ 189 | 2,604 | $ 127.0 |
| Manufacturing | $ 9,879 | 21,241 | $ 1,594.9 |
| TCPU | $ 792 | 5,197 | $ 414.1 |
| Trade | $ 1,619 | 21,641 | $ 1,120.4 |
| FIRE | $ 854 | 5,671 | $ 576.6 |
| Services | $ 1,074 | 20,255 | $ 669.5 |
| Government | $ 100 | 963 | $ 42.7 |
| Total | $ 20,621 | 159,212 | $ 5,076.8 |
| Percent of Wisconsin Total | 6.3% | 4.6% | 3.0% |

* millions $

Table 9. All On-Farm

| | Industry Output* | Employment | Total Income* |
|---|---|---|---|
| Agriculture (production) | $ 7,389 | 150,759 | $ 1,206.0 |
| Construction/Mining | $ 168 | 2,320 | $ 113.2 |
| Manufacturing | $ 516 | 2,283 | $ 175.2 |
| TCPU | $ 518 | 3,495 | $ 268.2 |
| Trade | $ 779 | 10,212 | $ 540.6 |
| FIRE | $ 667 | 4,808 | $ 1,267.0 |
| Services | $ 488 | 8,871 | $ 299.2 |
| Government | $ 63 | 548 | $ 26.2 |
| Total | $ 10,588 | 183,296 | $ 3,895.6 |
| Percent of Wisconsin Total | 3.2% | 5.3% | 2.3% |

* millions $

Table 10. All Processing

| | Industry Output* | Employment | Total Income* |
|---|---|---|---|
| Agriculture (production) | $ 4,589 | 43,157 | $ 672.0 |
| Construction/Mining | $ 344 | 4,702 | $ 229.5 |
| Manufacturing | $ 25,706 | 78,216 | $ 5,866.5 |
| TCPU | $ 1,733 | 11,754 | $ 873.4 |
| Trade | $ 3,018 | 42,935 | $ 2,089.5 |
| FIRE | $ 1,705 | 7,372 | $ 1,150.3 |
| Services | $ 2,477 | 49,787 | $ 1,537.0 |
| Government | $ 216 | 2,138 | $ 93.0 |
| Total | $ 39,789 | 240,062 | $ 12,511.3 |
| Percent of Wisconsin Total | 12.1% | 7.0% | 7.4% |

* millions $

Table 11. Horticulture

| | Industry Output* | Employment | Total Income* |
|---|---|---|---|
| Agriculture (production) | $ 732 | 18,239 | $ 432.6 |
| Construction/Mining | $ 15 | 53 | $ 9.9 |
| Manufacturing | $ 38 | 190 | $ 12.1 |
| TCPU | $ 41 | 266 | $ 22.8 |
| Trade | $ 79 | 1,460 | $ 55.3 |
| FIRE | $ 76 | 499 | $ 51.9 |
| Services | $ 103 | 1,850 | $ 64.3 |
| Government | $ 8 | 60 | $ 3.4 |
| Total | $ 1,093 | 22,617 | $ 652.2 |
| Percent of Wisconsin Total | 0.3% | 0.7% | 0.4% |

* millions $

Table 12. All Agriculture

| | Industry Output* | Employment | Total Income* |
|---|---|---|---|
| Agriculture (production) | $ 12,710 | 178,528 | $ 2,410.6 |
| Construction/Mining | $ 527 | 7,226 | $ 352.7 |
| Manufacturing | $ 26,260 | 88,498 | $ 6,539.5 |
| TCPU | $ 2,292 | 15,516 | $ 1,164.4 |
| Trade | $ 3,877 | 54,606 | $ 2,685.4 |
| FIRE | $ 2,448 | 15,894 | $ 1,660.4 |
| Services | $ 3,069 | 57,294 | $ 1,900.5 |
| Government | $ 287 | 1,994 | $ 115.2 |
| Total | $ 51,470 | 419,556 | $ 16,828.8 |
| Percent of Wisconsin Total | 15.7% | 12.2% | 10.0% |

* millions $

Table 13. State/Local Govt (non-K/12)

| | |
|---|---|
| Corporate Profit Tax | $ 82 |
| Property Tax | $ 574 |
| Sales Tax | $ 473 |
| Income Tax | $ 362 |
| Fees/Charges/Other | $ 269 |
| Total | $ 1,760 |

millions $

## Appendix A: Misuses and Evaluation of Economic Multipliers[7]

Multipliers are often misused or misunderstood. Problems frequently encountered in applying multipliers to community change include: (1) using different multipliers interchangeably; (2) double counting; (3) pyramiding; and (4) confusing multipliers with other economic measurements, such as turnover and value added. Please note that if IMPLAN is used to generate the multipliers used in the analysis, many of the concerns outlined in this appendix are moot.

### Misuse of Multipliers

**(1) Interchanging Multipliers**. As mentioned earlier, multipliers can be estimated for changes in business output, household income, and employment. These different multipliers are sometimes mistakenly used interchangeably. This should not be done, as the sizes of the multipliers are different—and they measure totally different types of activity.

**(2) Double Counting**. Unless otherwise specified, the direct effect or initial change is included in all multiplier calculations. Consider, for example, a mining business multiplier of 2.20. The 2.20 represents 1.00 for the direct effect, and 1.20 for the indirect effects. The direct effect is thus accounted for by the multiplier and should not be added into the computation (double counted). A $440,000 total impact resulting from an increase of $200,000 in outside income (using the above 2.20 multiplier) includes $200,000 direct spending, plus $240,000 for the indirect effects. The multiplier effect is sometimes thought to refer *only* to the indirect effect. In this case, the initial impact is added to the multiplier effect, and is thereby counted twice—yielding an inflated estimate of change.

**(3) Pyramiding**. A more complicated error in using multipliers is pyramiding. This occurs when a multiplier for a nonbasic sector is used, in addition to the appropriate basic sector multiplier.

For example, sugar beet processing has been a major contributor to exports in many western rural counties. Assume the local sugar beet processing plant were closed, and local officials wanted to determine the economic effect of the closing, as well as the subsequent effect upon local farmers. The multiplier for the sugar beet processing sector includes the effect upon farms raising sugar beets, because the sugar beet crop is sold to local processors and not exported. Therefore, the processing multiplier should be used to measure the impact of changes in the sugar industry on the total economy. The impact estimate would be pyramided if the multiplier for farms, whose effects had already been counted, were added to processing.

Double counting and pyramiding are particularly serious errors because they result in greatly inflated impact estimates. If inflated estimates are used in making decisions about such things as school rooms or other new facilities, the results can be very expensive, indeed.

**(4) Turnover and Value Added**. Economic measurements incorrectly used for multipliers also result in misleading analysis. Two such examples are turnover and value added. Turnover refers to the number of times money changes hands within the community. In Figure 1, for example, the initial dollar "turns over" five times; however, only part of the initial dollar is respent each time it changes hands. Someone confusing turnover with multiplier might say the multiplier is 5, when the multiplier is actually only 1.66.

Value added reflects the portion of a product's total value or price that was provided within the local community. The value added would consider the value of a local raw product—like wheat delivered to the mill—and subtract that from the total wholesale value of the flour, then figure the ratio between the two. With cleaning losses, labor, bagging, milling, etc., the wholesale value may represent several times the value of the raw product and may be a fairly large number.

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[7] This material is based on the reported prepared by Eugene Lewis, Russ Youmans, George Goldman, and Garnet Premer, "Economic Multipliers: Can A Rural Community Use Them?" Western Rural Development Center, Oregon State University, Corvallis, OR. WREP 24, October, 1979.

**Evaluating Multipliers**

The determination of whether a multiplier is accurate can be a complicated procedure requiring time, extensive research, and the assistance of a trained economist. On the other hand, there are several questions that anyone who uses multipliers should ask. Essentially the test of accuracy for a multiple is: *How closely does that multiplier estimate economic relationships in the community (or region) being considered?*

**(1) Is the multiplier based on local data, or is it an overlay?** Often, multipliers are used that were not developed specifically from data for that area. These multipliers are *overlaid* onto the area on the assumption that they will adequately reflect relationships in the economy. An example would be using the mining multiplier from a county in northwestern Wyoming to estimate a mining impact in northeastern Nevada.

A multiplier is affected by the economy's *geographic location* in relation to major trade centers. Areas where the trade center is outside the local economy have smaller multipliers than similar areas containing trade centers. Geographic obstacles enroute to trade centers also affect a local economy. Multipliers for small plains towns are smaller than those for apparently comparable mountain towns, since plains residents usually do not face the same travel obstacles as mountain residents. More services will characteristically develop in the mountain area because of the difficulty in importing services; the larger services base will lead to a larger multiplier effect.

The *size* of the economy will influence multiplier size. A larger area generally has more businesses; thus, a given dollar is able to circulate more times before leaking than would be the case in a smaller area.

Two economies with similar population and geographic size may have quite different multipliers, depending on their respective economic structures. For example, if two areas have similar manufacturing plants, but one imports raw materials and the other buys materials locally, then the manufacturing multiplier for the two areas would be quite different.

The overlaying practice, when used appropriately, can save money and time—and produce very acceptable results. However, an area's dollar flow patterns may be so unique that overlaying will not work. Also, it is often difficult to find a similar area where impact studies have been completed so that multipliers can be borrowed readily. It is, however, worth checking.

**(2) Is the multiplier based on primary or secondary data?** Usually, there is more confidence in a multiplier estimated from data gathered in the community, as opposed to published or already-collected data.

Primary data collection is expensive and time consuming. Recent research has indicated that, in some cases, there is little difference between multipliers estimated by primary or secondary data. In fact, primary data multipliers are not necessarily better than secondary data multipliers. While the type of secondary data needed for estimating multipliers may be available from existing sources, the format and/or units of measurement may not permit some multipliers to be estimated. The resulting adjustments made to use the existing data may cause errors. If secondary data is used, it may be advisable to consult individuals familiar with the data regarding its use.

**(3) Aggregate versus disaggregate multipliers.** As mentioned earlier in this publication, disaggregate multipliers are much more specific and therefore generally more trustworthy than aggregate multipliers. The accuracy required, and the time and money available most likely will determine whether the model will be aggregate or disaggregate. In many cases, an aggregated rough estimate may be sufficient.

**(4) If you are dealing with an employment multiplier, is it based on number of jobs or full-time equivalent (FTE)?** Employment multipliers are often considered to be the most important multipliers used in impact analysis. This is because changes in employment can be transmitted to changes in population, which in turn affect social service needs and tax base requirements. Employment multipliers can be calculated on the basis of number of jobs or on FTE. One FTE equals one person working full-time for one year.

When multipliers are calculated on a number-of-jobs basis, comparisons between industries are difficult because of different definitions of part-time workers. For example, part-time work in one industry might be four hours per day, while in another it might be ten hours per week. If calculations were based on number of jobs, a comparison of multipliers would be misleading. The conversion of jobs to FTE also helps adjust for seasonal employment in industries such as agriculture, recreation, and forestry.

**(5) What is the base year on which the economic model was formulated?** Inflation can affect multipliers in two ways: (1) through changes in the prices of industry inputs, and (2) through changes in the purchasing patterns produced by inflation. Each input-output multiplier assumes that price relationships between sectors remain constant over time (at least for the period under consideration). In other words, the studies estimating multipliers assume that costs change proportionally: utility prices change at nearly the same rate as the cost of food, steel, and other commodities. If some prices change drastically in relation to others, then purchasing patterns and multipliers will likely change.

Marketing patterns change slowly, however, and while they must be considered, they usually do not present a major problem unless the multiplier is several years old. The rate of growth in the local area will influence the period of use for the multipliers.

**(6) What can a multiplier do?** The multipliers discussed here are static in nature, as are most multipliers encountered by local decision makers. Static means that a multiplier can be used in "if/then" situations; they do not project the future. For example, *if* a new mine that employs 500 people comes into the country, *then* the total employment increase would be the employment multiplier times 500. A static model cannot be used to make projections about the time needed for an impact to run its course, or about the distribution of the impact over time. Static multipliers only indicate that *if* X happens, *then* Y will eventually occur.

**(7) How large is the impact in relation to the size of the affected industry on which the multiplier is based?** Dramatic changes in an industry's scale will usually alter markets, service requirements, and other components of an industry's spending patterns. Assume a mining sector employment multiplier of 2.0 had been developed in a rural economy having 132 FTE. If a mine were proposed several years later with an estimated 300 FTE, the multiplier of 2.0 would probably not accurately reflect the change in employment because of the scale of the project relative to the industry existing when the multiplier was developed. In essence, the new industry would probably change the existing economic structure in the local area.

**(8) Who calculated the multiplier—and did the person or agency doing the calculation have a vested interest in the result?** Multipliers are calculated by people using statistics, and as such, there is always the opportunity to adjust the size of the multiplier intentionally. Before accepting the results of a given multiplier, take time to assess the origin of the data. Studies conducted by individuals or firms having a vested interest in the study's results deserve careful examination.

**(9) Is household income included as a sector similar to the business sectors in the local economic model?** The decision to include household income in the model depends upon whether or not the household sector is expected to react similarly to other sectors when the economy changes, or whether personal income is largely produced by outside forces. Discussion of this issue is too lengthy for this publication, but the important point is that multipliers from models that include household sectors are likely to be larger than those from models without household sectors.