The Contribution of Agriculture to the Wisconsin Economy: An Update for 2017

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Executive Summary

This study provides an update of the Contribution of Agriculture to the Wisconsin Economy undertaken by Deller (2014) using data for 2017, the most current available. Despite currently weak commodity prices, particularly within dairy, agriculture (defined to include on-farm activities, food processing, forestry and horticulture) remains an important part of the Wisconsin economy. In 2017, all of agriculture contributed $104.8 billion to industrial sales (revenues), up from $88.3 billion in 2012, 437,700 jobs, an increase of about 24,000 jobs from 2012, $22.5 billion in labor income (wages, salaries and proprietor addition, the economic activity associated with agriculture generated some $2.9 billion to state and local government revenues. While part of this increase in the three monetary measures (sales, labor and total income) can be attributed to inflation (6.7% between 2012 and 2017) the increases in the contribution of agriculture are greater than the rate of inflation (15.7% for industry sales, 17.2% for labor income, and 20.0% for total income).

- "All agriculture", combined on-farm and food processing, contributes $104.8 billion to industrial revenues (16.4% of the state total), 435,700 jobs (11.8%), $22.5 billion to labor income (11.3%),and $37.6 billion to total income (11.6%).

- On-farm activity contributes $22.0 billion to industrial sales or revenue (3.5% of the state total), 154,000 jobs (4.1%), $5.8 billion to labor income (2.9%), and $9.8 billion to total income(3.0%).

- Food processing activity contributes $82.7 billion to industrial sales (13.0% of the state total), 282,000 jobs (7.6%), $22.5 billion to labor income (8.4%), and $37.6 billion to total income(8.6%).

- Dairy, combining both on-farm and dairy processing, contributes $45.6 billion to industrial revenues (7.1% of the state total), 157,100 jobs (4.2%), $9.0 billion to labor income (4.5%) and $15.1 billion to total income (4.7%). Dairy processing accounts for roughly two-thirds of this contribution.

- The economic activity supported by agriculture results in state and local government tax revenues of $2.9 billion, which is roughly 7.4% of "own source revenues".

- The bulk of the growth in the contribution of agriculture to the Wisconsin economy between 2012 and 2017 is growth in the food processing sectors.

- Foreign exports of agricultural products (on-farm and processing) accounts for $4.9 billion in industry revenue (0.8% of Wisconsin total), 21,539 jobs (0.6%), about $1.1 billion in labor income (0.5%) and $1.8 billion in total income (0.6%). Additionally the economic activity generated by agricultural foreign exports creates $129.7 million in state and local tax revenues.

Introduction

The status of agriculture in Wisconsin has received significant attention in 2019. Media headlines, such as "State leads nation in farm bankruptcies again, dairy farm closings hit record high in 2018" (Wisconsin State Journal, February 24, 2019), has raised significant concerns about the health of the agricultural industry and its role in the Wisconsin economy. Is the role of agriculture in Wisconsin on the decline as other sectors of the economy, such as tourism/recreation, health care, or information technologies, become more important? Is the growth of markets for alternative forms of agriculture, such as specialty products like hops and breweries or production aimed at local foods markets, becoming a source of strength while the markets for more traditional agricultural commodity products are weakening? To what extent is Wisconsin agriculture dependent upon foreign markets and are trade conflicts harming Wisconsin agriculture? To help shed light on the role of agriculture in the Wisconsin economy this study is aimed at updating prior work (Deller 2004; Deller and Williams 2009; Deller 2014) on the contribution of agriculture to the Wisconsin economy.[1]

For this study, agriculture is composed of two parts: (1) on-farm production and (2) food processing. In Wisconsin these two parts of agriculture can be thought of as two sides to the same coin. For example, Wisconsin proudly refers to itself as "America's Dairyland" and cheese is a major component of that image. Indeed, the vast majority (about 90 percent) of milk produced by Wisconsin dairy farmers goes into cheese production. In addition, consumers have been shifting away from preparing meals at home to more convenience foods (Scholliers 2015), whether this is in the form of restaurants or take-home prepared foods, the role of food processing as part of agriculture is growing. For this study on-farm production and food processing are analyzed separately and combined. Because of the unique importance of dairy to Wisconsin agriculture, the dairy industry is also analyzed independently. Finally, included in the working definition of on-farm activity is forestry, horticulture and to a lesser extent seafood.[2]

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Beyond these short introductory comments the study is composed of five additional sections and several technical appendices. The next section explores historical trends in Wisconsin agriculture with a focus on broad measures of economic activity. In the following section the methods for the contribution analysis, specifically input-output analysis, are overviewed. A more detailed technical appendix is provided as a point of reference. The results of the contribution analysis are then presented and discussed. In addition to statewide contribution analysis, separate analysis is conducted for each of the nine sub-state regions (defined as the National Agriculture Statistical Services reporting districts) using regionally specific economic models. The study closes with a simple summary of the study and a short discussion of some of the limitations to the analysis.

[1] This represents a continuation of studies undertaken every five years (Deller 2004; Deller and Williams 2009; Deller 2014) to coincide with the release of the USDA Census of Agriculture, which itself is undertake every five years. The most recently released Census of Agriculture is for 2017.

[2] Sectors that are not included in the definition of agriculture include biofuels (e.g., ethanol), and wood processing industries beyond direct forestry and logging (e.g., paper, wooden furniture). Forestry is included in the definition of on-farm agriculture to reflect in most cases trees can be viewed as a crop with a long growing period.

Historical Patterns

The accelerating rate of Wisconsin farm bankruptcies has spurred interest in the financial health of farms not only in Wisconsin but across the U.S. While there are many ways to measure the financial health of farms (or any business), such as debt to asset ratios, a common measure is to track net farm income over long periods of time to look for patterns. Using IRS Form F data[3] the rate of growth in net farm income (adjusted to 2007 dollars) for Wisconsin, the Great Lakes States and the United States is plotted in Figure 1A. The growth index starts in 1969 and goes through 2017, the most current year of available data. There are three general observations: (1) growth in net farm income has been flat for 40 years, (2) the inherent instability in net farm income is readily apparent, and (3) most "down" years are followed by an "up" year.

Figure 1A: Net Farm Income (Revenues-Expenses) Growth Index
(Real 2017 Dollars)

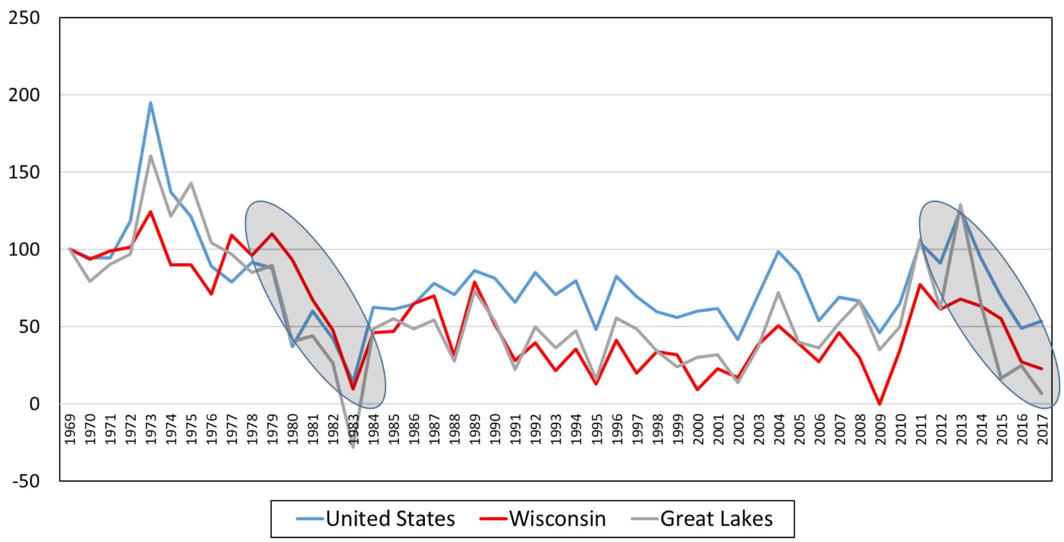
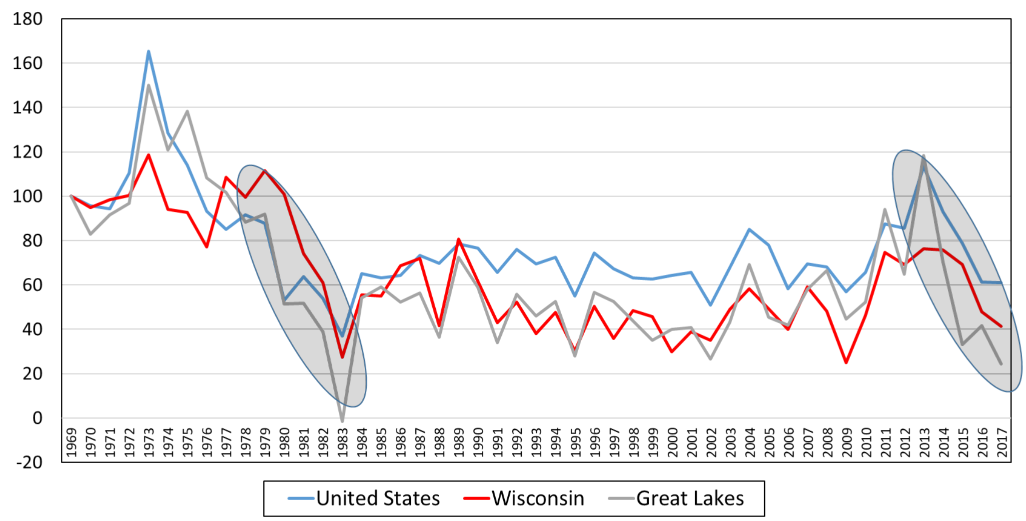


Figure 1B: Farm Earnings Growth Index
(Real 2017 Dollars)

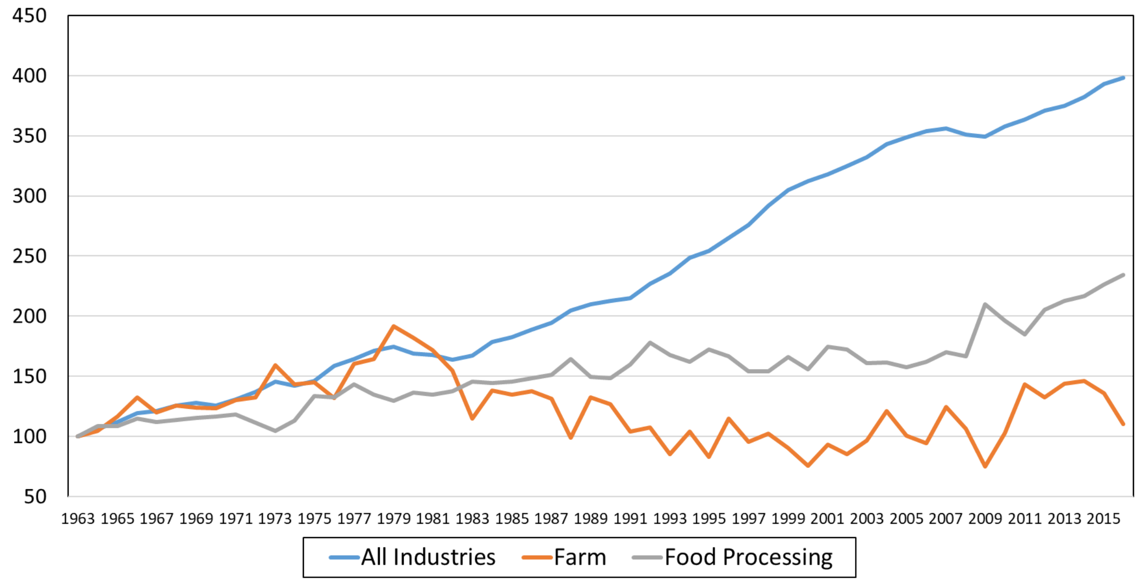


[3] These data are available from the USDA ERS Farm Income and Wealth Statistics program as well as the BEA Regional Economic Information System (BEA REIS). The USDA data is drawn from the ARMS survey and the BEA REIS data is drawn primarily from IRS data. While there are technical differences across the two sources in definitions and measurements, at the level of trend analysis reported here the differences are minimal. This study is based on the BEA REIS data.

The Successive "down" years is the primary cause for current fiscal stress facing many Wisconsin farms.

This latter point is particularly important for understanding the current condition of farming in Wisconsin. Given the tendency of "down" years to be followed by a recovery year, most farmers are positioned to plan for and adapt to what are generally year to year swings in net farm income. But there are two periods of sustained "down" years, the period leading to the farm crisis of the early 1980s and most recently (for Wisconsin, 2013 to 2017). The successive "down" years is the primary cause for the current fiscal stress facing many Wisconsin farms. Without an "up" year to rebuild assets (e.g., cash reserves) farmers are forced into dramatically reducing income to the farm household/family and/or accept higher levels of debt. The reduction in earnings flowing to the farmer (family/household) and workers (Figure 1B) creates an unsustainable fiscal situation for the farm family and the rising of farm debt can overleverage the farm enterprise.

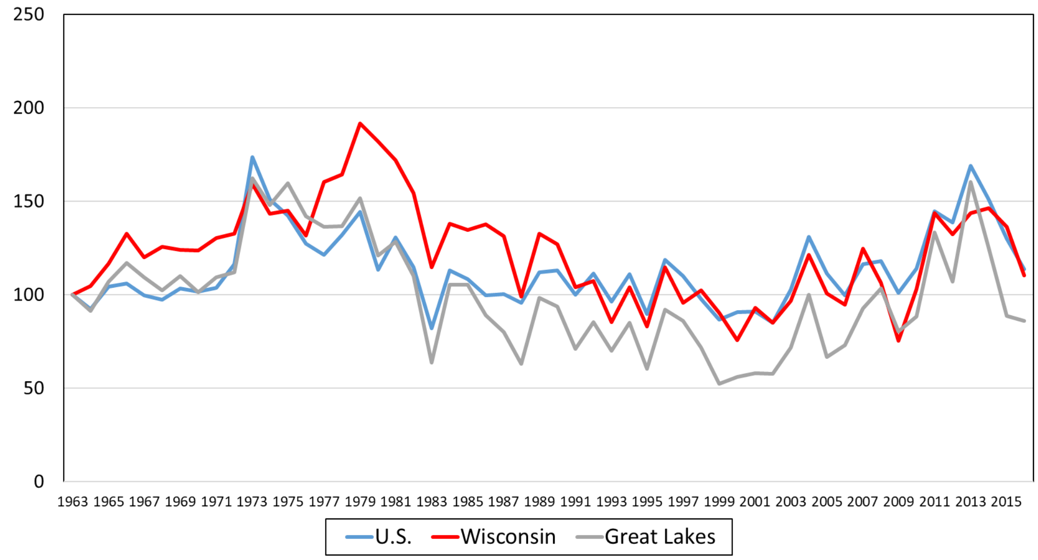
Figure 2A: Wisconsin Gross State Product Growth Index
(Real 2016 Dollars)



While farm income (net earnings to the farm business and earnings to the farmer) is an important measure of the health of the agricultural economy, it is only one and focuses on-farm production and not the broader agricultural economy, particularly food processing. To gain a finer insight into the agricultural economy consider agriculture's direct contribution (no multiplier effect is considered here) to gross state product (Figure 2A). These data begin in 1963 and run to 2016 (the most recent year available) and are adjusted to reflect prices in 2016 dollars. When looking at the growth rate of gross state product for all of Wisconsin and both farming and food processing, the lack of growth in the farming sector over this half century period is evident and complements the patterns in farm income (Figures 1A and 1B). When compared to the whole of the Wisconsin economy, which grew some 298% from 1963 to 2016, farm production is only 10.3% higher today than it was in 1963. Again the year to year instability in farming contribution to gross state product is evident. And the sustained downturn of the farm crisis of the early 1980s is not as evident over the past few years in Wisconsin. This is a simple indicator that the current stress in farming is not as severe as the early 1980s. When we compare Wisconsin's farming contribution to gross state product to the national average and the Great Lakes States (Figure 2B) we find that Wisconsin is largely following national and regional trends.

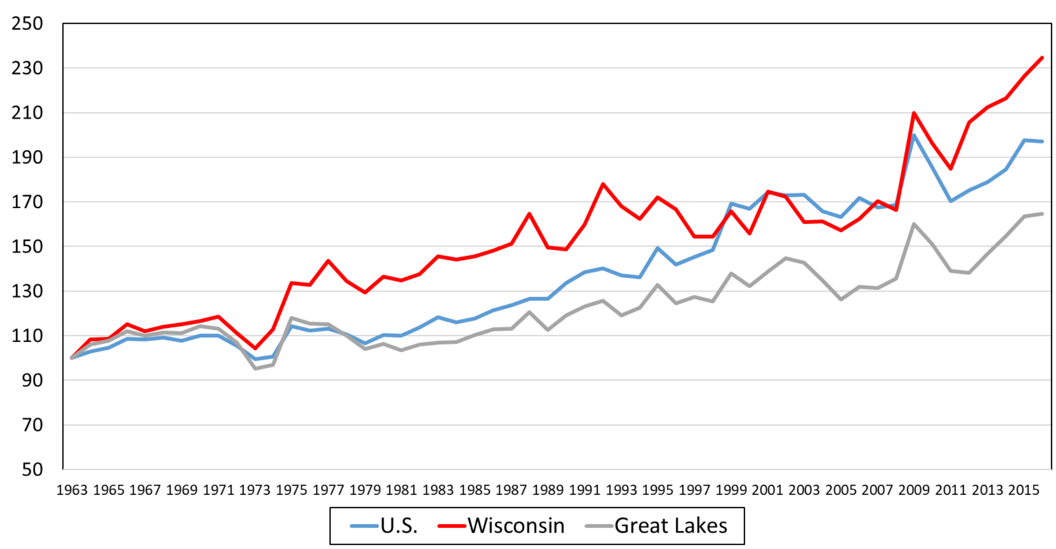
Wisconsin food processing is an integral component of the larger agricultural economy. Prior agricultural contribution studies (Deller 2004; Deller and Williams 2009; Deller 2014) have found that food processing can account for two-thirds of the total contribution. In terms of gross state product, food processing has gone through two periods of sustained growth, the first being modest growth from the early 1970s through the early 1990s, and the second being more recently, 2005 to today (Figure 2A). Since the end of the Great Recession, Wisconsin's food processing sector, measured in terms of gross state product, has seen its largest growth in several decades. This is partially a reflection of national trends (Figure 2C), but the most recent growth (2011 to today) is particularly strong in Wisconsin. The growth in food processing is reflective of changing consumer preferences for prepared meals. For the contribution analysis presented below, this strong upward movement in food processing helps explain the changes in overall impacts from 2012 to 2017.

Figure 2B: Farm Gross Domestic/State Product Growth Index (Real 2016 Dollars)

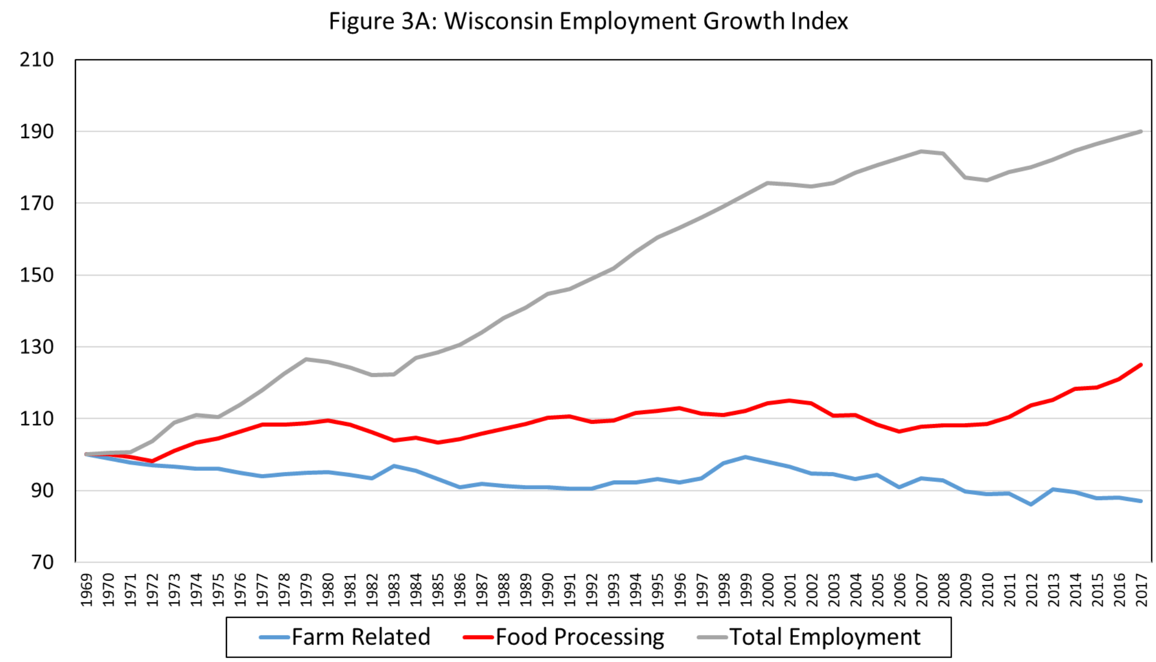


...since the end of the Great Recession Wisconsin's food processing sector, measured in terms of gross state product, has seen its largest growth in several decades.

Figure 2C: Food Processing Gross Domestic/State Product Growth Index (Real 2016 Dollars)



The third measure of economic activity used in this trend analysis is employment (Figure 3A).



Here the pattern observed in gross state product is mirrored in the employment data with somewhat lower levels of volatility. For Wisconsin the downward trend in farm employment is evident with slight upticks in particularly good years. When compared to the national average (U.S.) and the other Great Lakes States, however, Wisconsin's farm employment appears to be much more stable. Note that for the U.S. and the Great Lakes States there was a significant decline in farm employment in the decade of the 2000s. While the U.S. has seen a slight increase in farm employment since 2005, it appears to have plateaued in the past few years.

Similarly, after the significant decline in farm employment, the Great Lakes States region has largely stabilized with little change. Thus the farm employment patterns in Wisconsin are slowly trending downward (about 13% less farm employment in 2017 compared to 1969) that downward trend appears to have somewhat stabilized: neither growing nor declining at high rates. The likely explanation is a combination of growth in more labor intensive specialty crops (e.g., hops) which may be associated with growth in the markets for locally sourced foods and the growth in hired help in larger dairy operations.

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Perhaps the more interesting employment pattern is in food processing. Somewhat surprisingly, there is little evidence of the Great Recession impacting food processing employment and there has been strong growth particularly since 2010 (Figure 3A). Employment in food processing is about 25% higher in 2017 than it was in 1969 with most of that growth occurring in the past decade or less. Indeed, the growth rate of employment in Wisconsin food processing since 2010 has been greater than the overall growth rate in total employment. This trend, however, appears to be a national trend (Figure 3C) and is consistent with the strong growth in gross state product derived from food processing (Figure 2C).

Figure 3B: Farm Production Related Employment Growth Index

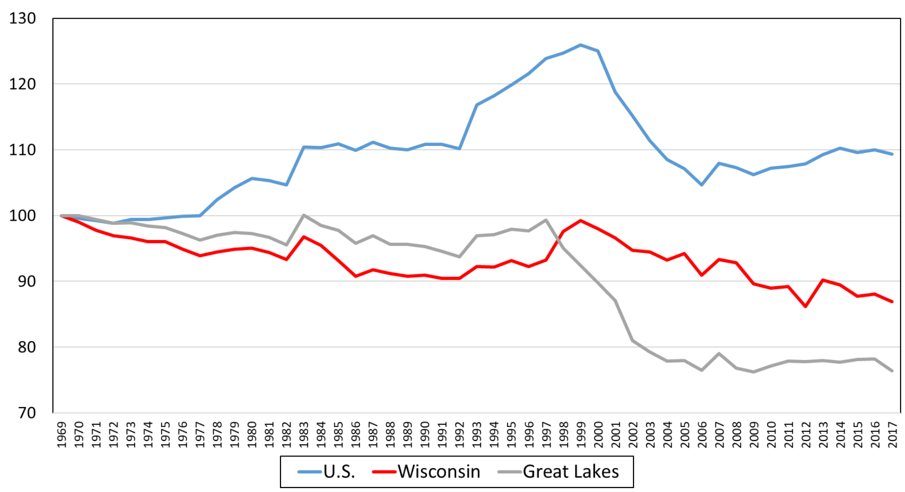
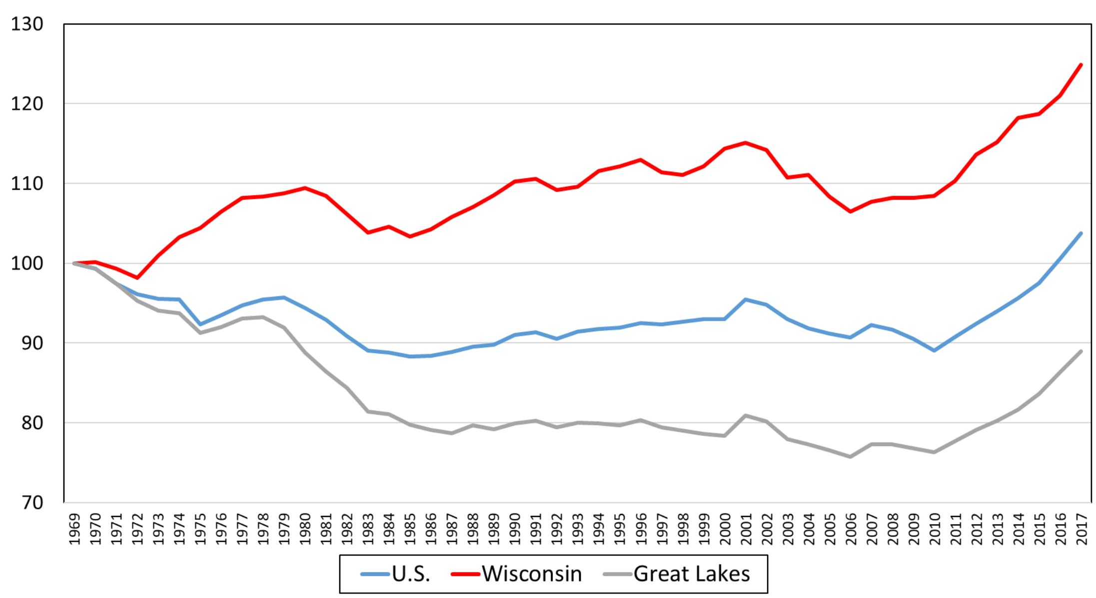


Figure 3C: Food Processing Employment Growth Index



Given the recent growth of food processing in Wisconsin, we gain additional insights into the nature of the industry by exploring the distribution of firms by type over time. Using data available through the County Business Patterns there are 944 businesses in 2016 that identify themselves as in the food processing industry, a decline of 22 firms from 2000. The two subsectors with the largest number of firms include dairy processing (228 firms in 2016) and bakeries (206 firms in 2016) (Figure 4A). Like most businesses in Wisconsin, the majority of food processors could be classified as "small businesses": about one in five have fewer than five employees and just over half have less than 20 employees while only 18% have 100 or more employees (Figure 4B). Comparing the distribution of food processing firms by size from 2000 to 2016, however, there is some evidence of a small movement from the industry being dominated by smaller firms to slightly larger firms.

Figure 4A: Number of Food Processing Firms in Wisconsin 2000 Compared to 2016

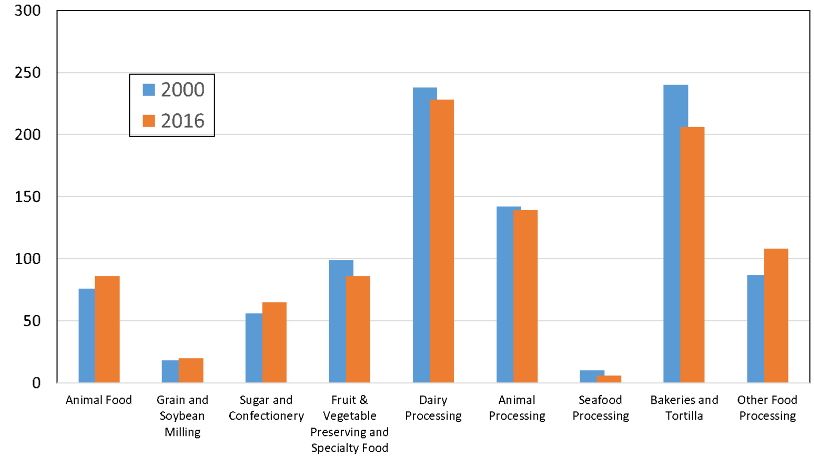
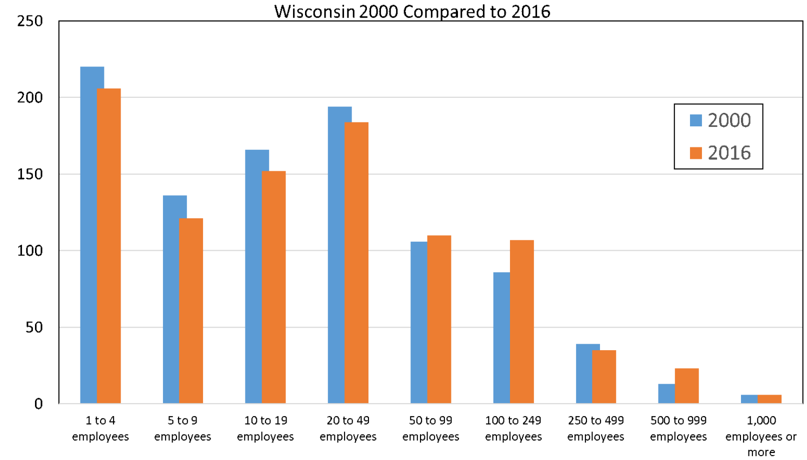


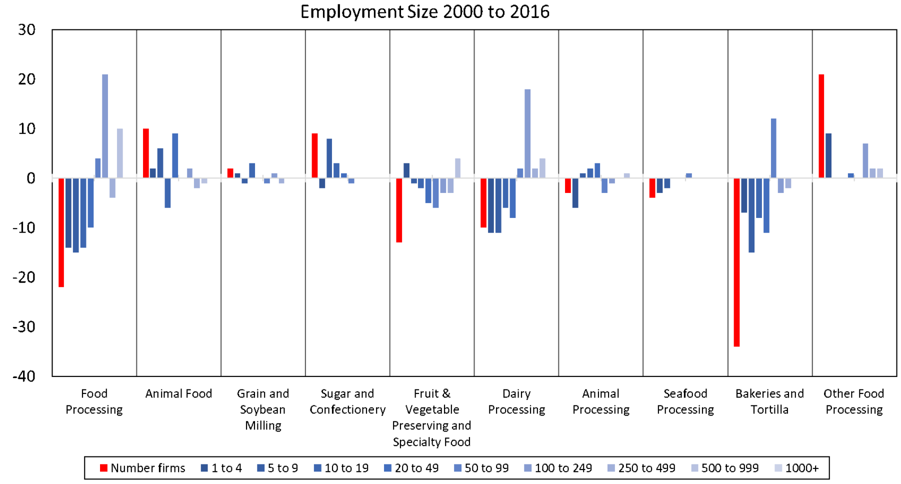
Figure 4B: Number of Food Processing Firms in Wisconsin by Employment Size Wisconsin 2000 Compared to 2016

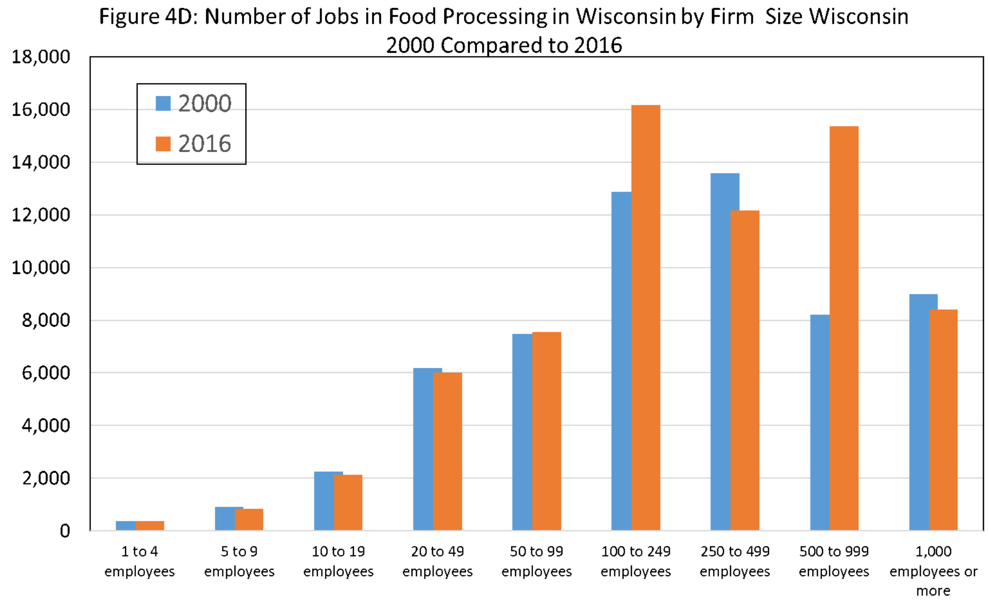


Like most businesses in Wisconsin, the majority of food processors could be classified as "small businesses": about one in five have fewer than five employees and just over half has less than 20 employees while only 18% have 100 or more employees.

This is most evident in dairy processing and bakeries (Figure 4C). Given the dominance of these two sectors to food processing in general, it is these two industry trends that are driving the aggregate patterns. For companies that make animal food (feed for livestock and pet foods) and confectionary oriented businesses, the trend appears to be toward smaller firms.

Figure 4C: Change in the Number of Food Processing Firms in Wisconsin by Employment Size 2000 to 2016





Examining the distribution of total employment across food processing firms by employment size, a slightly different picture of the industry is provided (Figure 4D). Although firms with less than 20 employees accounts for just over half of all food processing businesses, they account for just less than 5% of total employment in the industry. Similarly, businesses with less than 100 employees account for eight in ten food processing businesses, they account for just over one in four jobs in the industry. The small handful of "large" firms (more than 100 employees) account for 75% of all employment in the industry. These large firms tend to be concentrated in dairy processing, meat and poultry processing and fruit and vegetable processing and specialty food processing. Clearly food processing in Wisconsin is diversified not only in product lines but also in size of businesses.

The patterns that are revealed here tell a very distinct story about the Wisconsin agricultural economy. First, farming remains a very unstable industry and prolonged periods of weak commodity prices is resulting in a particularly high period of economic stress. This is evident by the sustained downward trends in net farm earnings and the increasing number of farm bankruptcies. At the same time, food processing is going through a period of strong growth. Much like on-farm activity, food processing is diversified not only in terms of product mix but also in firm sizes. Other than a relatively small handful of very large (determined by employment) firms, most food processors in Wisconsin tend to be small. What this analysis cannot answer is if weakening on-farm activity is threatening the viability of Wisconsin food processors. Clearly, the two are interdependent and could be described as two sides to the same coin.

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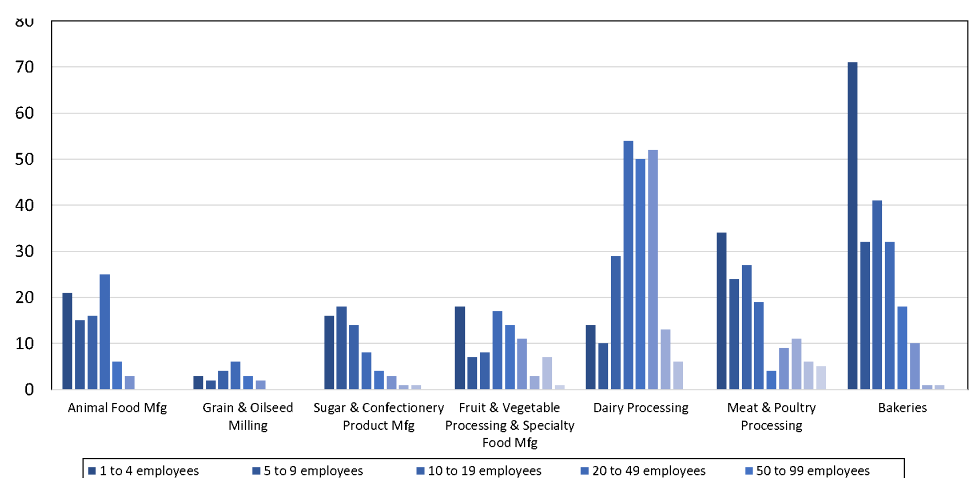


A Simple Review of Methods and Definitions of Terms

The focal point of this analysis is the contribution of agriculture to the Wisconsin economy. While the analysis of historical trends provides a foundation for a more in-depth analysis, it cannot adequately address the question of the exact economic contribution of agriculture to Wisconsin. To undertake this more in-depth analysis, a model of the Wisconsin economy must be constructed to identify how agriculture is woven into the larger economy. To do this a series of input-output models of the overall Wisconsin economy is constructed: one model for Wisconsin in aggregate and nine sub-state models reflecting the National Agricultural Statistical Services (NASS) reporting regions.

An input-output model can be thought of as a "spreadsheet" of the economy with buyers (demand) within the economy across the columns of the spreadsheet and sellers (supply) down the rows. The intersection of any one column and row represents the flow of money from the buyer to the seller. The column total is total demand (spending) of the buyer and the row total is total supply (revenue or sales) of the seller. As discussed in more detail in Appendix B, 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.

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 could then 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.

For this study, we use four measures of economic activity: employment, labor income, total income, and industrial revenues/sales. Employment here is simply jobs and is not a full-time equivalent. For example, two part-time jobs created in 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.

The analysis uses three broad definitions of agriculture: on-farm activity, food processing, and "all agriculture" which is both on-farm and food processing combined. Included in on-farm activity are forestry related activities as well as horticulture

The analysis uses three broad definitions of agriculture: on-farm activity, food processing, and "all agriculture" which is both on-farm and food processing combined. Included in on-farm activity are forestry related activities as well as horticulture. A parallel analysis is run for the dairy sector, again looking at on-farm dairy, and "all dairy", which is dairy processing and both dairy farm and processing combined. Note that dairy (both on-farm and processing) is included in all on-farm and processing activity. So the dairy analysis is a subset contained within all agriculture. We take a broad definition of on-farm activity to include crop and livestock farming, horticulture (and floriculture), forestry (including logging) and commercial fishing. Included with on-farm activity are direct farm support services such as farm management companies, planting and harvesting services, and custom testing services to name a few examples. Food processing ranges from the production of animal feed (livestock and pets), to cheese, to bakeries and breweries and distilleries. Thus, this analysis represents a comprehensive view of agriculture. The analysis is conducted for the state as a whole and for each of the nine sub-state regions as defined by the National Agricultural Statistical Services. Finally, given the current interest in international trade a separate analysis is conducted to explore the contribution of agricultural exports (again on-farm and food processing exports) to the Wisconsin economy.

Results of Contribution Analysis

Overall, all of agriculture contributes $104.8 billion dollars to the Wisconsin economy using industrial sales (or revenue) as the economic metric. A broad summary of the results are provided in Table 1. Slightly more than three quarters of that contribution comes from food processing which is consistent with prior studies of the contribution of agriculture to the Wisconsin economy. About 43.5% of the total contribution to industrial sales comes from dairy, which is largely driven by dairy processing. In Wisconsin, the vast majority of the dairy processing comes in the form of cheese. In terms of on-farm

Table 1: Total Contribution of Agriculture to the Wisconsin Economy (2017)

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)	State & Local Govt Revenue (MM$)
On-Farm	22,092.7	153,280	5,795.1	9,817.3	552.5
Food Processing	82,670.1	282,436	16,664.3	27,822.3	2,384.7
All Agriculture	104,762.8	435,717	22,459.3	37,639.6	2,937.2
Dairy Farm	10,121.4	48,581	2,433.4	4,140.2	228.3
Dairy Processing	35,441.4	108,539	6,577.2	10,938.2	986.4
All Dairy	45,562.8	157,120	9,010.6	15,078.5	1,214.7

contributions dairy farming accounts for slightly less (45.8%) of all on-farm contributions. The share of the Wisconsin economy that is attributable to agriculture is about 16.4% for all farming, and 7.1% for all dairy. Again, these are driven largely by food and dairy processing (13.0% and 5.6% respectively). Returning to the historical trend analysis, it is the growth in the food processing sectors that is largely driving the increase in industrial sales ($88.3 billion in 2012 to $104.8 billion in 2017).

Industry sales, or revenues, is but one measure of how agriculture contributes to the Wisconsin economy. Other measures include employment, labor income (wages, salaries and proprietor income) and total income (all sources of income as can be thought as akin gross state product). Note that employment is not full-time-equivalent: a job is a job. All of agriculture (farming and food processing), supports 435,700 jobs (11.8% of all jobs in Wisconsin), and $22.4 billion in labor income (11.3%), and $37.6 billion in total income (11.6%). As with industrial sales or revenue, the bulk of employment and income contributions come from food processing. Dairy, farm and processing, accounts for 36.1% of the total agricultural contribution to employment, 40.1% of both labor and total income. The economic activity generated by agriculture is also linked to revenues (taxes, fees, charges, etc.) flowing to state and local governments. The revenues generated that flow to the federal government are not considered in this analysis. All of agriculture accounts for $2.9 billion in state and local government revenues, which is approximately 7.4% of total revenues.[4]

Table 2: Total Contribution of Agriculture to Wisconsin: Share of State Economy (2017)

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)	State & Local Govt Revenue (MM$)
On-Farm	3.5%	4.1%	2.9%	3.0%	1.4%
Food Processing	13.0%	7.6%	8.4%	8.6%	6.0%
All Agriculture	16.4%	11.8%	11.3%	11.6%	7.4%
Dairy Farm	1.6%	1.3%	1.2%	1.3%	0.6%
Dairy Processing	5.6%	2.9%	3.3%	3.4%	2.5%
All Dairy	7.1%	4.2%	4.5%	4.7%	3.0%

It is possible to draw two conclusions from this state level analysis. First, the growth in the contribution of agriculture is largely driven by growth in the non-dairy related food processing sectors. Second, given weak commodity prices, the contribution of dairy, particularly on-farm dairy operations, is more modest than in previous studies...

Returning to the historical trend analysis, it is possible to draw two conclusions from this state level analysis. First, the growth in the contribution of agriculture is largely driven by growth in the non-dairy related food processing sectors. Second, given weak commodity prices, the contribution of dairy, particularly on-farm dairy operations, is more modest than in previous studies of the contribution of agriculture to the Wisconsin economy. This is not to say that dairy is weakening but rather other non-dairy related parts of Wisconsin agriculture are growing, particularly processing, and dairy is facing depressed commodity prices.

Agricultural activity, whether it be on-farm activity or food processing, is not evenly distributed across Wisconsin. Prior analysis (e.g., Deller 2004; Deller and Williams 2009; Deller 2014) reveals that some parts of Wisconsin are much more highly dependent on agriculture for economic activity than other parts. To gain further insights into this regional variation separate economic models (input-output) were generated for nine sub-regions of the state as defined by the National

[4] Care must be taken with the share of total revenues flowing to state and local government attributable to agriculture as there are subtle accounting differences within the economic modeling system that make these rough estimates.

Agricultural Statistical Agency (see the maps in the appendix for a definition of these regions). The total economic contributions are provided in Table 3, the shares of total regional economic activity attributed to agriculture are provided in Table 4, and the state and local government revenues generated are provided in Table 5. Note that a series of maps providing a visualization of the data in Table 4 (shares of total activity) are provided in an appendix along with the detailed analysis.

Table 3: Total Contribution of Agriculture to the Wisconsin Economy by NASS Reporting Regions (2017)

	South East	East Central	North East	North Central	Central	North West	West Central	South West	South Central
Industry Sales (MM$)									
On-Farm	1,091.0	4,104.2	1,005.5	1,851.1	1,602.9	1,283.4	2,587.5	2,277.4	3,210.4
Food Processing	15,001.2	19,911.0	1,488.0	5,364.2	4,553.0	3,454.7	7,365.4	3,791.8	12,515.4
All Agriculture	16,092.2	24,015.2	2,493.5	7,215.3	6,155.9	4,738.1	9,952.8	6,069.2	15,725.8
Dairy Farm	330.0	2,608.6	493.5	1,031.9	485.0	523.5	980.6	973.4	1,257.6
Dairy Processing	1,575.7	8,763.0	1,255.2	3,626.4	1,671.1	1,269.7	4,128.2	3,329.7	4,379.0
All Dairy	1,905.7	11,371.5	1,748.7	4,658.3	2,156.1	1,793.2	5,108.9	4,303.1	5,636.7
Employment									
On-Farm	8,155	23,595	7,824	13,971	12,750	11,298	19,910	19,198	23,270
Food Processing	54,232	63,700	4,033	14,884	12,641	10,629	21,820	9,049	37,826
All Agriculture	62,387	87,295	11,858	28,855	25,391	21,927	41,730	28,246	61,096
Dairy Farm	1,630	11,572	2,632	5,204	2,393	3,081	4,949	5,213	6,524
Dairy Processing	3,492	24,536	3,147	9,036	3,549	3,139	10,441	7,679	12,329
All Dairy	5,122	36,108	5,779	14,239	5,943	6,219	15,390	12,892	18,853
Labor Income (MM$)									
On-Farm	292.3	1,101.2	327.5	515.6	446.4	280.9	432.6	635.0	878.7
Food Processing	3,423.3	3,936.4	203.0	776.8	660.0	511.2	1,223.6	472.9	2,306.6
All Agriculture	3,715.6	5,037.6	530.6	1,292.4	1,106.3	792.1	1,656.2	1,107.9	3,185.3
Dairy Farm	71.1	669.1	144.9	246.2	102.2	90.6	140.4	260.4	320.9
Dairy Processing	147.8	1,513.6	165.8	491.9	189.5	155.5	598.3	408.8	771.3
All Dairy	218.9	2,182.7	310.7	738.0	291.8	246.1	738.7	669.2	1,092.2
Total Income (MM$)									
On-Farm	526.8	1,717.1	444.0	819.6	785.1	540.6	1,057.0	922.6	1,419.4
Food Processing	5,859.1	6,299.4	332.3	2,184.9	1,098.5	811.6	2,102.2	824.1	4,006.7
All Agriculture	6,385.8	8,016.5	776.3	1,365.3	1,883.6	1,352.2	3,159.1	1,746.7	5,426.1
Dairy Farm	141.7	1,039.8	196.1	410.0	184.1	200.4	383.7	381.5	529.9
Dairy Processing	380.2	2,475.1	274.7	904.6	317.5	251.3	1,016.0	703.9	1,259.7
All Dairy	521.9	3,514.9	470.8	1,314.6	501.7	451.7	1,399.7	1,085.4	1,789.6

Table 4: Total Contribution of Agriculture to Wisconsin: Share of State Economy by NASS Reporting Regions (2017)

	South East	East Central	North East	North Central	Central	North West	West Central	South West	South Central
Industry Sales (MM$)									
On-Farm	0.5%	3.2%	8.5%	5.6%	5.7%	5.2%	5.1%	10.5%	2.8%
Food Processing	6.7%	15.4%	12.5%	16.2%	16.3%	14.1%	14.5%	17.4%	10.9%
All Agriculture	7.2%	18.6%	21.0%	21.8%	22.0%	19.3%	19.6%	27.9%	13.7%
Dairy Farm	0.1%	2.0%	4.2%	3.1%	1.7%	2.1%	1.9%	4.5%	1.1%
Dairy Processing	0.7%	6.8%	10.6%	10.9%	6.0%	5.2%	8.1%	15.3%	3.8%
All Dairy	0.9%	8.8%	14.7%	14.1%	7.7%	7.3%	10.0%	19.8%	4.9%
Employment									
On-Farm	0.6%	3.4%	10.1%	7.2%	7.7%	7.5%	6.1%	14.0%	3.5%
Food Processing	4.2%	9.3%	5.2%	7.7%	7.7%	7.0%	6.7%	6.6%	5.6%
All Agriculture	4.8%	12.7%	15.3%	15.0%	15.4%	14.5%	12.8%	20.6%	9.1%
Dairy Farm	0.1%	1.7%	3.4%	2.7%	1.4%	2.0%	1.5%	3.8%	1.0%
Dairy Processing	0.3%	3.6%	4.1%	4.7%	2.1%	2.1%	3.2%	5.6%	1.8%
All Dairy	0.4%	5.3%	7.5%	7.4%	3.6%	4.1%	4.7%	9.4%	2.8%
Labor Income (MM$)									
On-Farm	0.4%	3.0%	10.0%	5.6%	5.7%	4.4%	2.8%	10.9%	2.3%
Food Processing	4.5%	10.6%	6.2%	8.5%	8.5%	8.1%	7.9%	8.1%	6.1%
All Agriculture	4.9%	13.6%	16.2%	14.1%	14.2%	12.5%	10.7%	19.0%	8.4%
Dairy Farm	0.1%	1.8%	4.4%	2.7%	1.3%	1.4%	0.9%	4.5%	0.8%
Dairy Processing	0.2%	4.1%	5.0%	5.4%	2.4%	2.5%	3.9%	7.0%	2.0%
All Dairy	0.3%	5.9%	9.5%	8.0%	3.7%	3.9%	4.8%	11.4%	2.9%
Total Income (MM$)									
On-Farm	0.4%	2.9%	8.7%	5.5%	6.1%	5.1%	4.2%	9.4%	2.3%
Food Processing	4.8%	10.5%	6.5%	14.6%	8.5%	7.7%	8.4%	8.4%	6.4%
All Agriculture	5.2%	13.4%	15.2%	9.1%	14.7%	12.8%	12.6%	17.8%	8.7%
Dairy Farm	0.1%	1.7%	3.8%	2.7%	1.4%	1.9%	1.5%	3.9%	0.8%
Dairy Processing	0.3%	4.1%	5.4%	6.0%	2.5%	2.4%	4.1%	7.2%	2.0%
All Dairy	0.4%	5.9%	9.2%	8.8%	3.9%	4.3%	5.6%	11.0%	2.9%

It is important to note that the sum of the contribution of agriculture across the nine sub-regions does not add to the state total.

Table 5: Agriculture's Contribution to State and Local Government Revenues for Wisconsin and NASS Reporting Regions (2017)

State & Local Govt Revenue (MM$)	South East	East Central	North East	North Central	Central	North West	West Central	South West	South Central
On-Farm	26.9	101.6	23.5	49.4	28.8	26.4	42.4	54.6	79.0
Food Processing	483.8	511.9	31.7	132.3	94.5	84.1	188.8	79.6	331.6
All Agriculture	510.7	613.5	55.3	181.7	123.3	110.5	231.1	134.3	410.6
Dairy Farm	7.3	56.9	9.4	22.6	7.8	8.6	15.9	19.3	28.2
Dairy Processing	46.4	212.6	25.5	87.6	27.2	25.1	90.6	64.6	108.8
All Dairy	53.7	269.5	35.0	110.3	35.0	33.7	106.5	83.8	137.0

It is important to note that the sum of the contribution of agriculture across the nine sub-regions does not add to the state total. The reason is because the economic models (input-output) is unique for each region of analysis and reflect the economic structure of each region. As such, the economic multipliers that provide a scalar measure that captures the connection of agriculture to the economy are uniquely different for each region. For example, the industrial revenue or sales multiplier for all of agriculture is the largest in the South East region of Wisconsin (1.650) and the smallest in the Central region (1.305) (Table 6).

Table 6: Total Contribution of Agricultural Foreign Exports to the Wisconsin Economy (2017)

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)	State & Local Govt Revenue (MM$)
Foreign Exports	4,933.3	21,539	1,084.6	1,803.1	129.7
Share of Wisconsir	0.8%	0.6%	0.5%	0.6%	

Generally the size of the multiplier is driven by the interconnections or density of relationships between economic agents (buyers/demand and sellers/supply) and the absolute size of the economy. Multipliers will be larger in regional economies that are themselves larger and more interconnected and smaller in more rural less densely populated areas and less interconnected. Thus, the unique nature of each sub-region dictates that the sum of the sub-regions will not add up to the state level analysis.

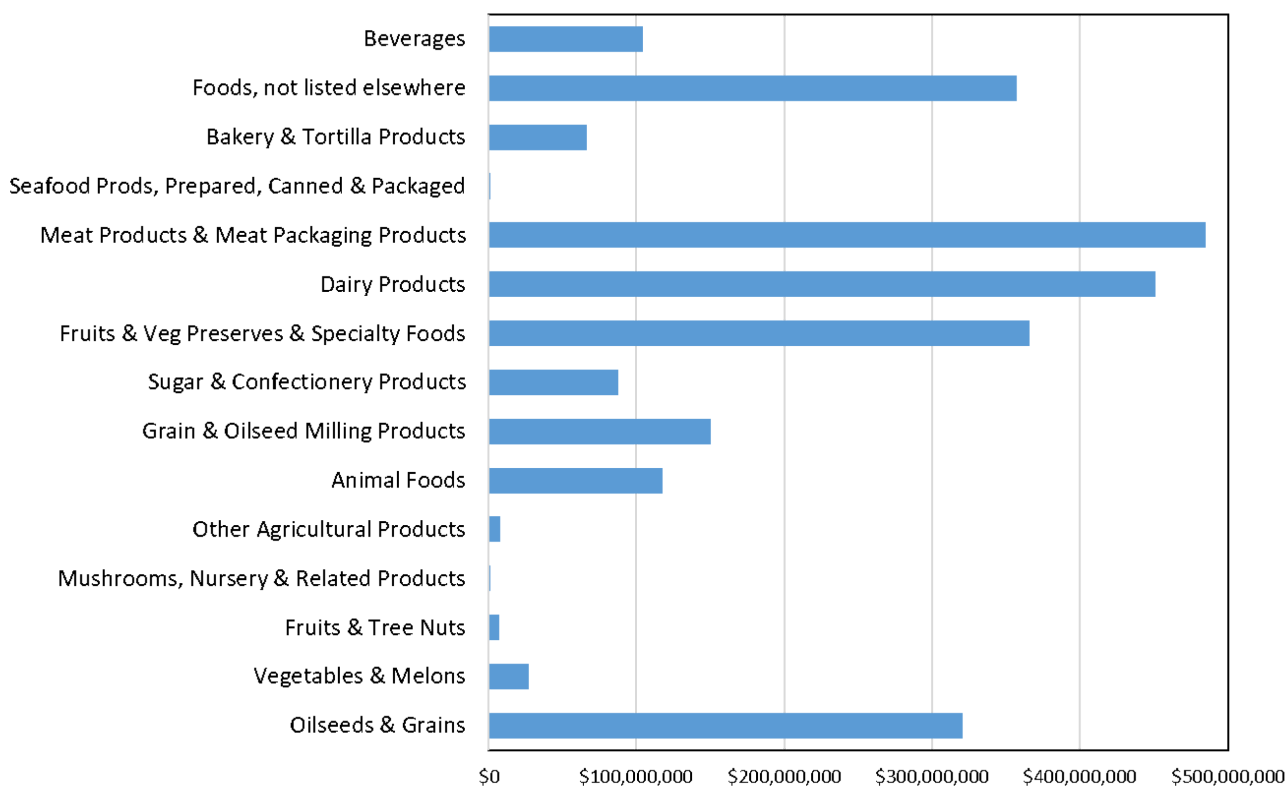
The region with the largest absolute contribution, using industry sales as the metric of the economy, is the East Central region at $24.0 billion (18.6% of region total) followed by the South East region with $16.1 billion (7.2%), and the South Central region with $15.7 billion (13.7%). But if we look at the relative contribution, the share of the region's total economic activity contributed to agriculture a different picture emerges. Again using industrial sales, agriculture accounts for 27.9% of the South West regional economy followed by the Central region at 22.0% and the North Central region at 21.8%. Similar variations across Wisconsin are observed when looking at just the dairy industry. The region with the largest contributions are East Central at $11.4 billion in industrial sales (8.8% of region total) followed by the South Central region at $5.6 billion (4.9%), and the West Central at $5.1 billion (10.0%). But in relative terms, the most dependent region on dairy activity (on-farm and processing) is South West Wisconsin at 27.9% and the lowest is South East Wisconsin at 7.2%.

This latter result on dairy contributions around the East Central and the South West regions points to the uniqueness or heterogeneity of regional economies across Wisconsin. East Central Wisconsin is dominated by the Fox Valley area (Green Bay to Fond du Lac) that has a significant amount of food processing activities. The relative concentration of this activity means that the total impact is large in absolute value, but given the overall size of the economy, it is a more modest share of the total. South West Wisconsin, however, is a much smaller economy thus a more modest total contribution estimate in absolute value, but given the relatively smaller size of the economy, agriculture accounts for a much larger share. Thus, from an interpretative perspective, the question of what is the more important measure of economic contribution, the overall size of the impact or the relative contribution to the regional economy, becomes a concern. One could argue that without the context of the absolute size of the economy the total contribution estimate is difficult to interpret. For South West Wisconsin agriculture, dairy in this case, is much more important to the regional economy than in East Central. For this reason, the summaries provided in the maps are share of the total economy attributed to agriculture and its different components.

...from an interpretative perspective, the question of what is the more important measure of economic contribution, the overall size of the impact or the relative contribution to the regional economy, becomes a concern.

This summary discussion has been limited to just industrial sales or revenue as the measure of economic activity, but there are three other measures including employment and two measures of income. A detailed review of the contribution of agriculture analysis is left to the reader as the volume of results prevents a succinct narrative. But a visual interpretation of the distribution of contributions by economic metric (revenue, employment, income) reveals that some parts of Wisconsin, particularly the South West and North East regions, are more highly dependent of agriculture than other parts of Wisconsin. This pattern also varies by whether one is considering on-farm activity or food processing. The latter tends to be more concentrated in more urban parts of Wisconsin while farming is distributed slightly more evenly across the state save for the very northern parts of the state.

Figure 5: Wisconsin Agricultural Foreign Exports



The final set of analysis explores the contribution of foreign export markets to the Wisconsin agricultural economy. One of the primary sources of growth for the agricultural industry has been foreign export markets, particular new markets that are opening in Asia. In 2018 Wisconsin exported just over $2.5 billion in agricultural (farm food processing) products with meat and meat packaging ($485 million) the largest single exported product followed by dairy products ($451 million) (Figure 5). The contribution of these agricultural products amounted to some $4.9 billion in industrial revenues or sales, 21,500 jobs, $1.1 billion in labor income, $1.8 billion in total income as well as $130 million in state and local government revenues. While each of these is less than one percent of Wisconsin's total economy, the uncertainty over current foreign trade policies is troublesome for Wisconsin agriculture.

Conclusions

This study is intended to provide updates to the prior contribution of agriculture studies undertaken over the past several years (Deller 2004; Deller and Williams 2009; Deller 2014). Compared to the last analysis, which explored data for 2012, the economic contribution of agriculture has increased across all four measures of economic activity. On-farm activity, however, was not a major contributor to this increase and is likely a reflection of weak commodity prices in 2017. Dairy farm activity did see an increase in its contribution to the economy but not to the same extent as the increase in dairy processing. Indeed, the majority of the increase in the contribution of agriculture came through recent strong growth in food processing.

The challenge facing Wisconsin agriculture is that on-farm activity and food processing are "two sides to the same coin" and as one does better the other does better. The continued weak net farm income, a pattern that Wisconsin farmers have not experienced since the farm crisis of the early 1980s, may put the food processing industry at risk. While one could argue that a reduction in on-farm production might strengthen commodity prices and help remaining farmers strive to return to some acceptable level of fiscal health, such a reduction may place undue pressure of food processors. There is a clear balancing act between ensuring a healthy farm economy while continuing to promote growth in food processing.

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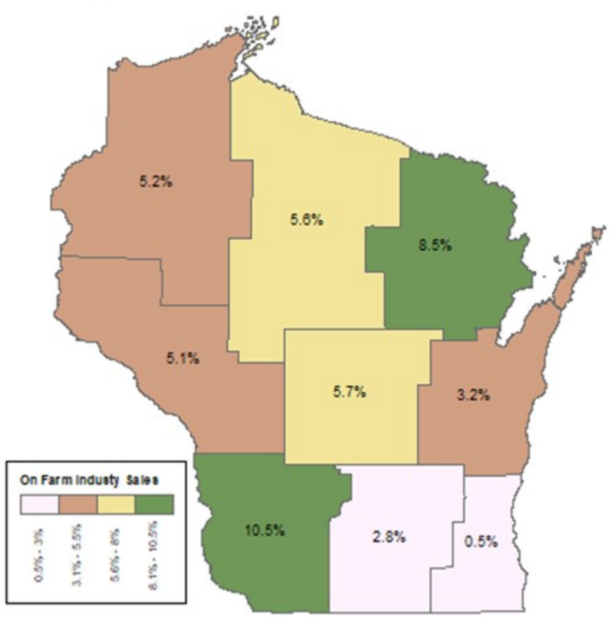
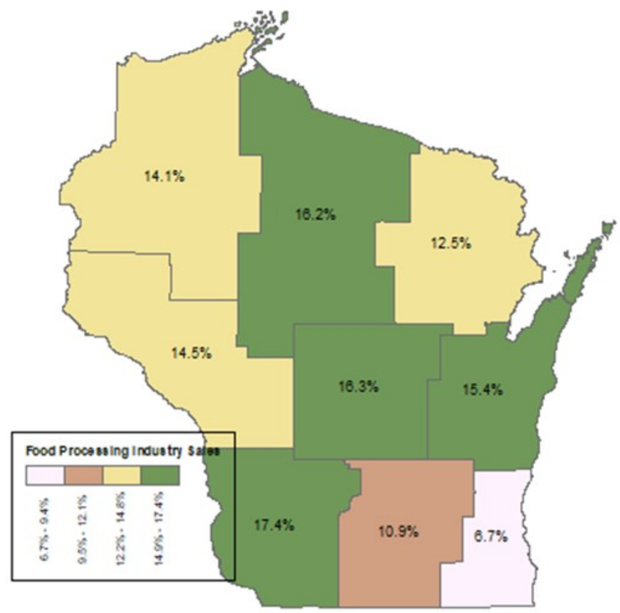
Appendix A: Detail Sub-State Analysis

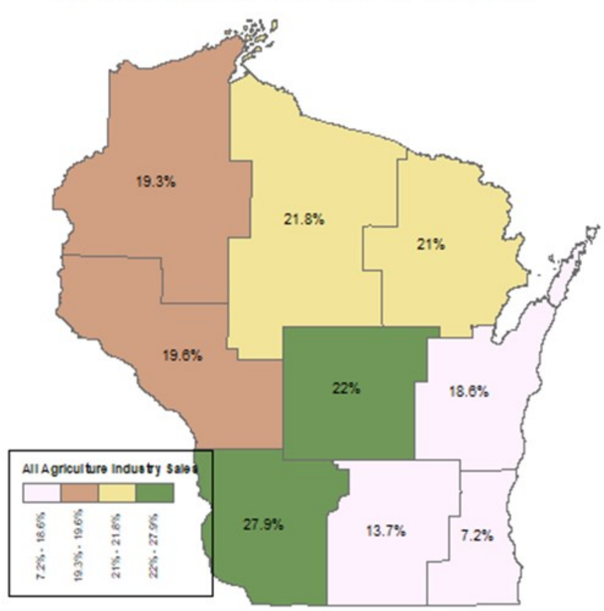
Map 1A: On Farm Contribution to Industrial Sales



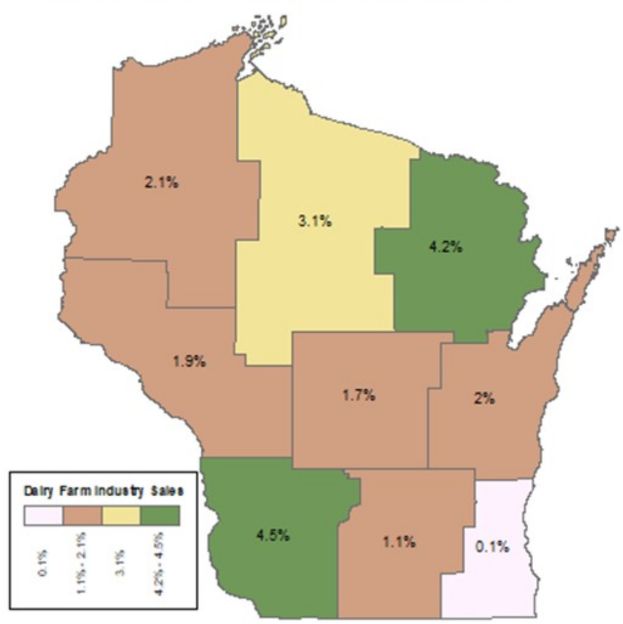
Map 1B: Food Processing Contribution to Industrial Sales



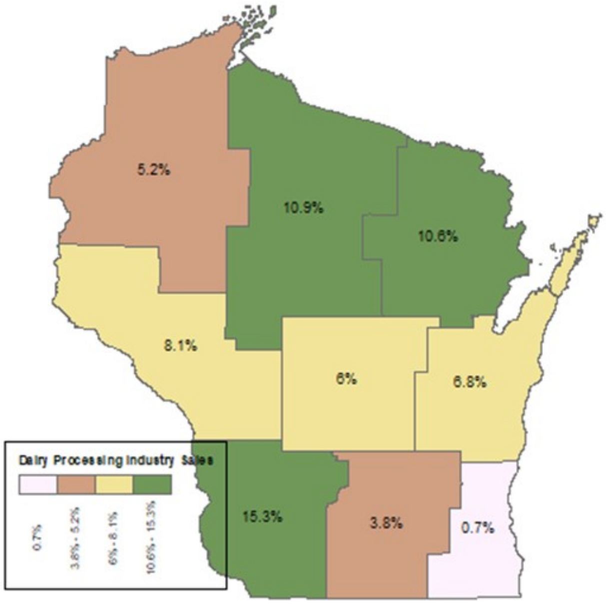
Map 1C: All Agriculture Contribution to Industrial Sales



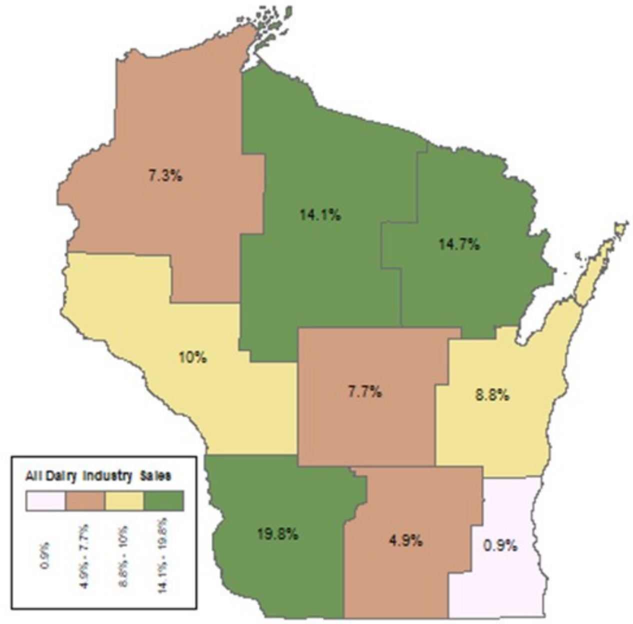
Map 1D: Dairy Farm Contribution to Industrial Sales



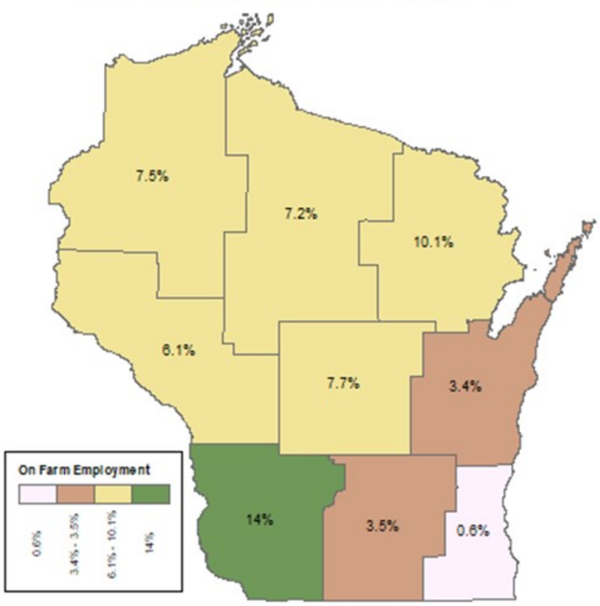
Map 1E: Dairy Processing Contribution to Industrial Sales



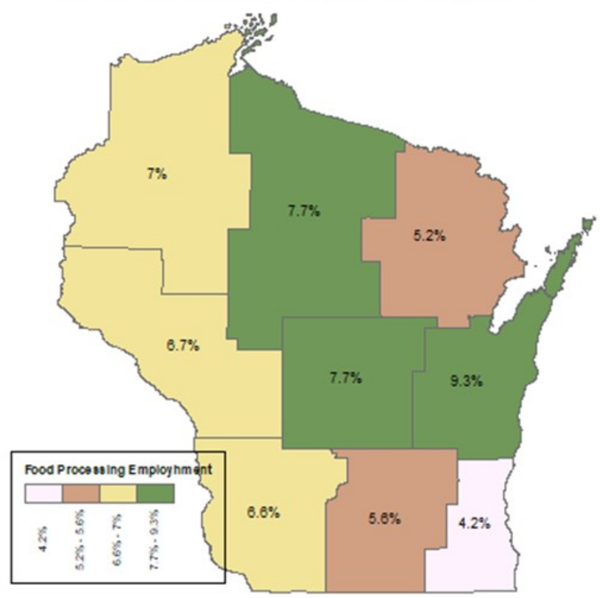
Map 1F: All Dairy Contribution to Industrial Sales



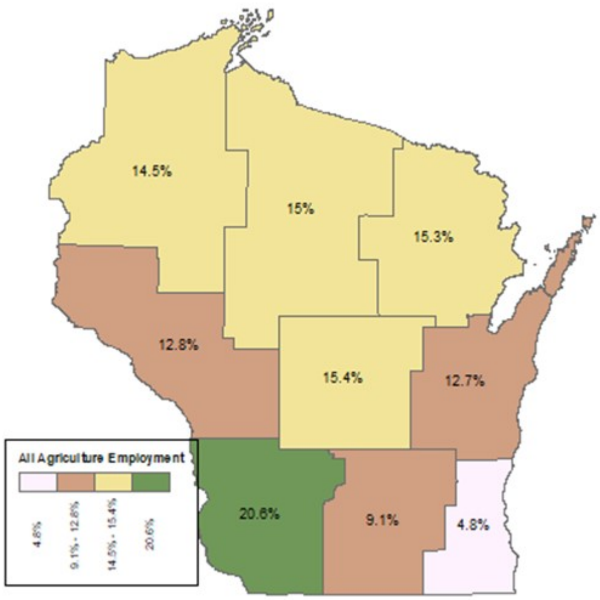
Map 2A: On Farm Contribution to Employment



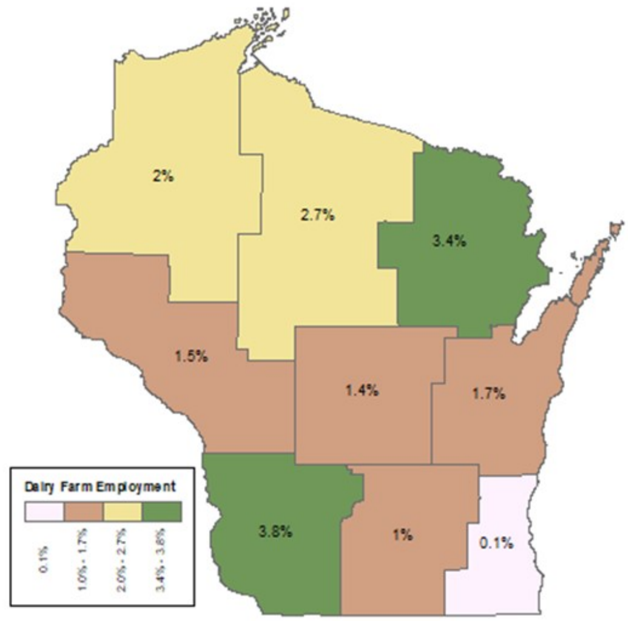
Map 2B: Food Processing Contribution to Employment



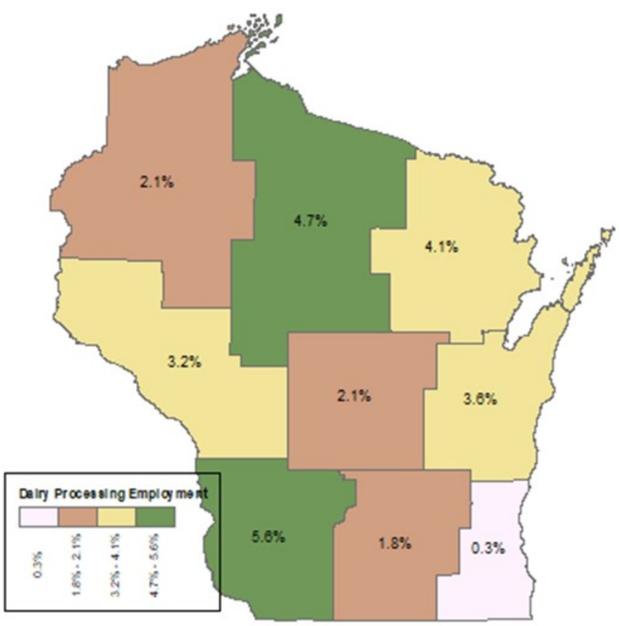
Map 2C: All Agriculture Contribution to Employment



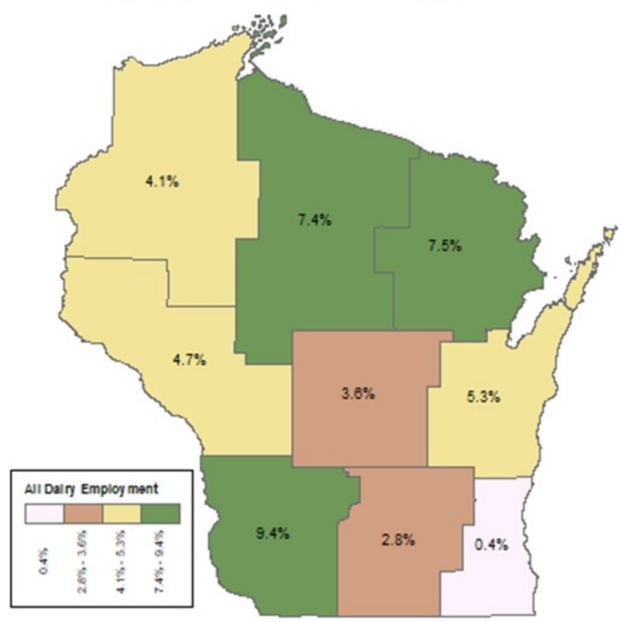
Map 2D: Dairy Farm Contribution to Employment



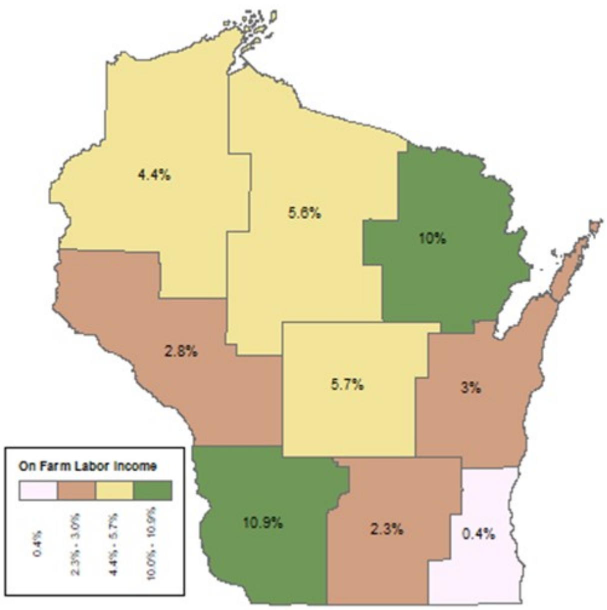
Map 2E: Dairy Processing Contribution to Employment



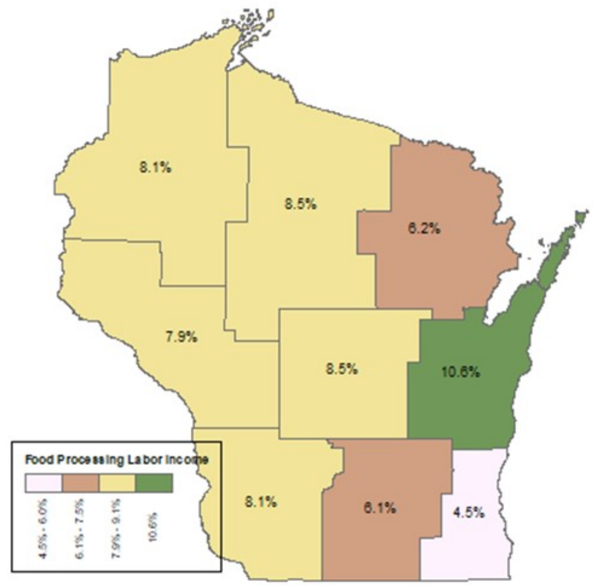
Map 2F: All Dairy Contribution to Employment



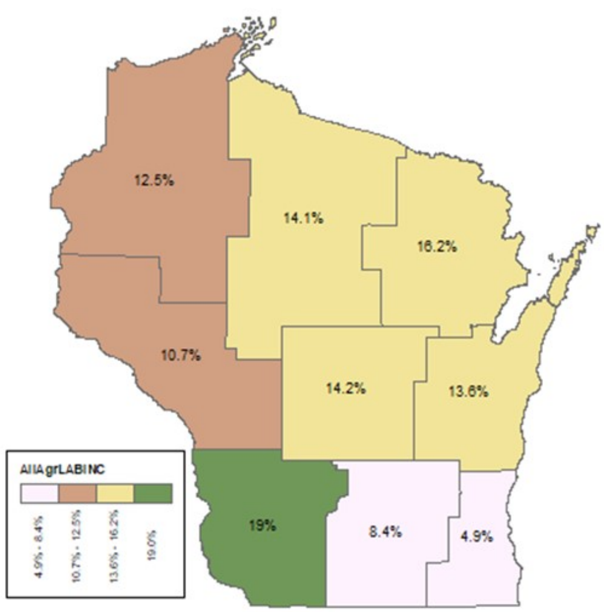
Map 3A: On Farm Contribution to Labor Income



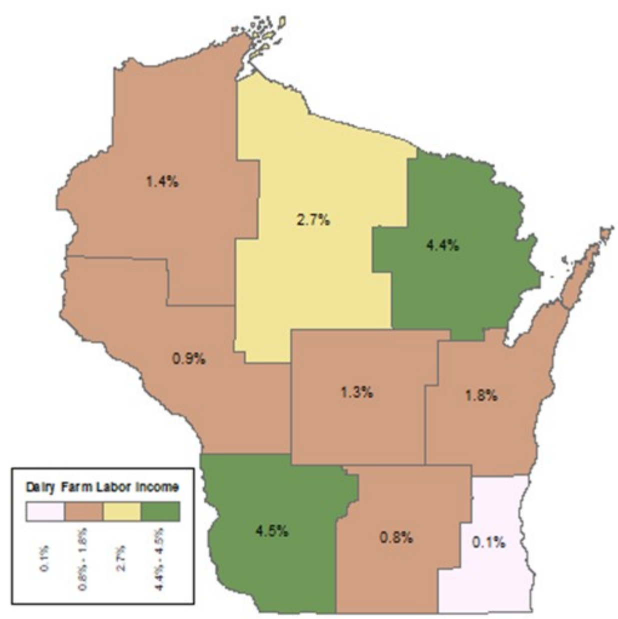
Map 3B: Food Processing Contribution to Labor Income



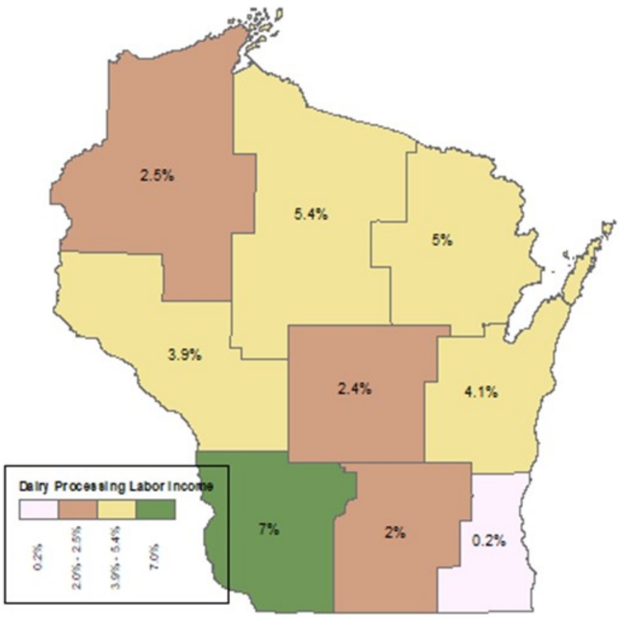
Map 3C: All Agriculture Contribution to Labor Income



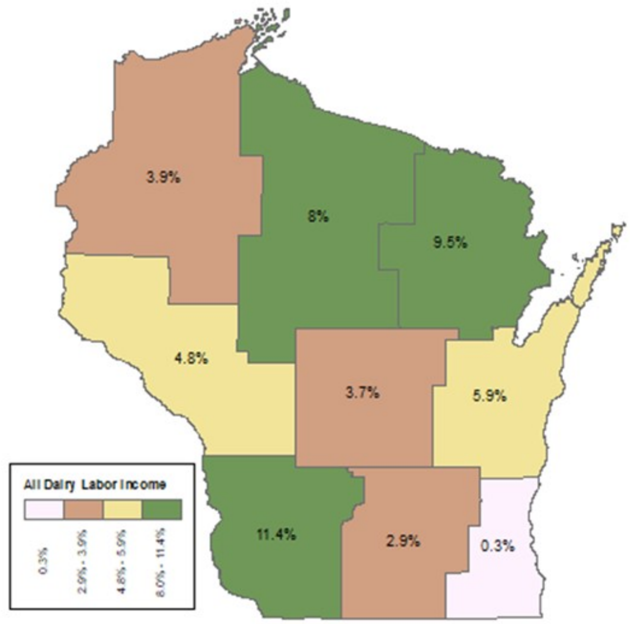
Map 3D: Dairy Farm Contribution to Labor Income



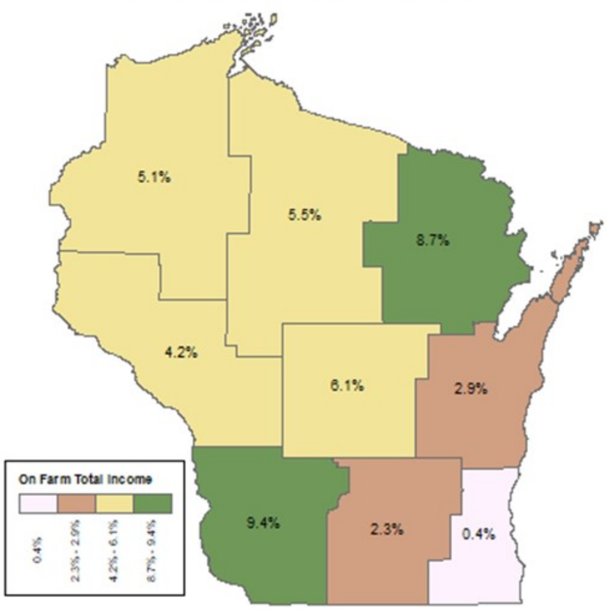
Map 3E: Dairy Processing Contribution to Labor Income



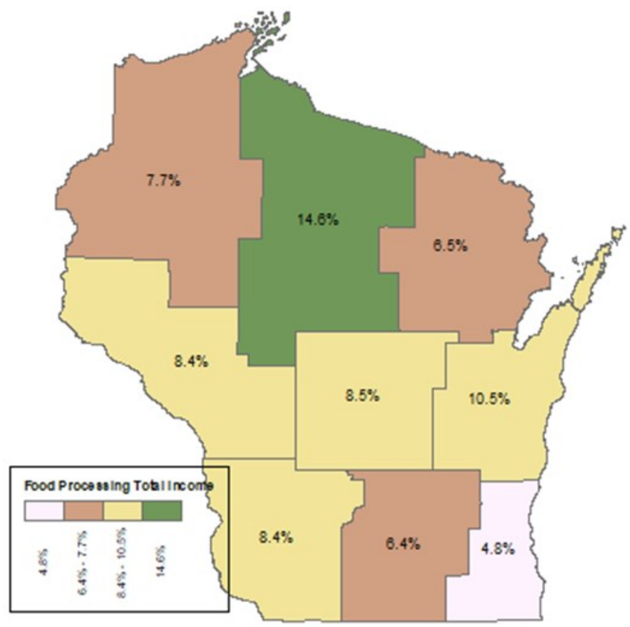
Map 3F: All Dairy Contribution to Labor Income



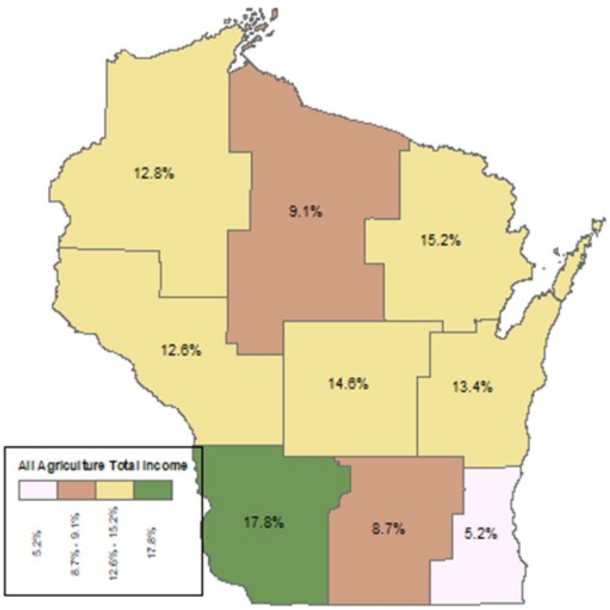
Map 4A: On Farm Contribution to Total Income



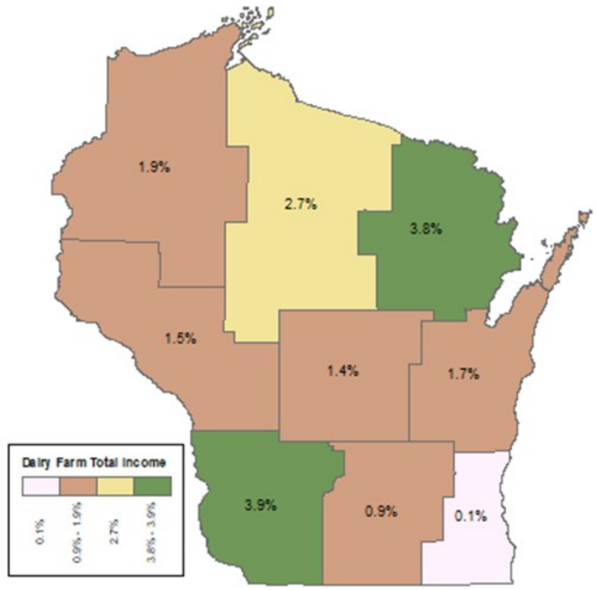
Map 4B: Food Processing Contribution to Total Income



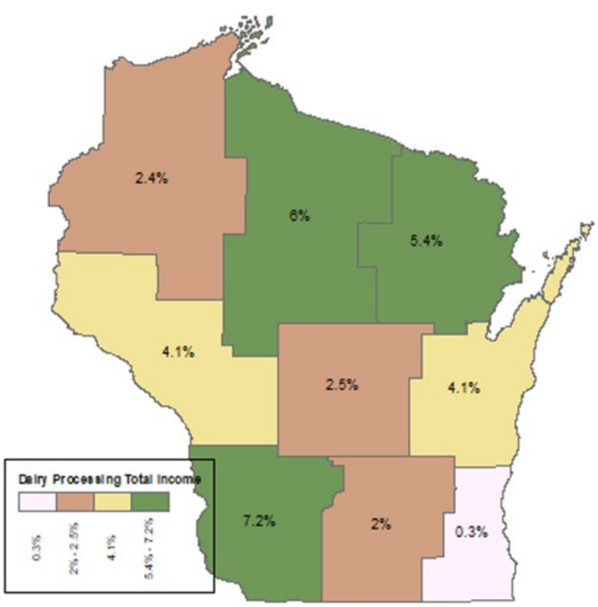
Map 4C: All Agriculture Contribution to Total Income



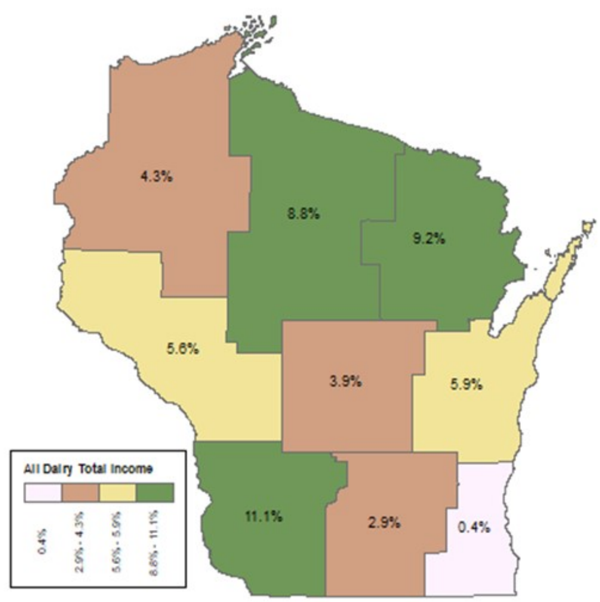
Map 4D: Dairy Farm Contribution to Total Income



Map 4E: Dairy Processing Contribution to Total Income



Map 4F: All Dairy Contribution to Total Income



Detailed Analysis: ***Wisconsin***

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)
On-Farm				
Direct	12,972.1	102,577	3,197.4	5,024.1
Indirect	4,870.4	19,485	1,203.1	2,324.4
Induced	4,250.2	31,217	1,394.6	2,468.8
Total	22,092.7	153,280	5,795.1	9,817.3
Multiplier	1.703	1.494	1.812	1.954
Food Processing				
Direct	49,675.3	77,846	5,179.3	9,292.0
Indirect	21,828.4	121,508	7,778.4	11,977.8
Induced	11,166.4	83,083	3,706.5	6,552.5
Total	82,670.1	282,436	16,664.3	27,822.3
Multiplier	1.664	3.628	3.217	2.994
All Agriculture				
Direct	62,647.3	180,423	8,376.7	14,316.1
Indirect	26,698.9	140,992	8,981.5	14,302.2
Induced	15,416.6	114,300	5,101.2	9,021.3
Total	104,762.8	435,717	22,459.3	37,639.6
Multiplier	1.672	2.415	2.681	2.629
Govt Rev (MM$)	On-Farm	Food Processing	All Agriculture	
Sales	142.5	784.2	926.7	
Property	169.4	921.6	1,091.0	
Income	156.9	405.6	562.4	
Other	83.8	273.4	357.1	
Total S&L	552.5	2,384.7	2,937.2	
Dairy Farm				
Direct Effect	5,554.4	19,103	1,098.8	1,892.9
Indirect Effect	2,971.8	17,742	810.8	1,320.3
Induced Effect	1,595.2	11,736	523.7	927.1
Total Effect	10,121.4	48,581	2,433.4	4,140.2
Multiplier	1.822	2.543	2.215	2.187
Dairy Processing				
Direct Effect	20,680.1	20,254	1,429.9	2,591.4
Indirect Effect	10,232.3	54,922	3,656.0	5,710.0
Induced Effect	4,529.0	33,362	1,491.4	2,636.8
Total Effect	35,441.4	108,539	6,577.2	10,938.2
Multiplier	1.714	5.359	4.600	4.221
All Dairy				
Direct Effect	26,234.5	39,357	2,528.7	4,484.3
Indirect Effect	13,204.1	72,664	4,466.8	7,030.3
Induced Effect	6,124.2	45,098	2,015.1	3,563.9
Total Effect	45,562.8	157,120	9,010.6	15,078.5
Multiplier	1.737	3.992	3.563	3.363
Gov Rev (MM$)	Dairy Farm	Dairy Processing	All Dairy	
Sales	62.2	328.2	390.4	
Property	73.7	385.5	459.2	
Income	58.6	161.8	220.5	
Other	33.9	110.8	144.6	
Total S&L	228.3	986.4	1,214.7	

Detailed Analysis: ***South East***

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)
On-Farm				
Direct	662.8	5,705	155.5	275.1
Indirect	212.2	916	62.0	121.2
Induced	216.0	1,532	74.8	130.5
Total	1,091.0	8,155	292.3	526.8
Multiplier	1.646	1.429	1.880	1.915
Food Processing				
Direct	9,088.8	18,860	1,254.2	2,388.6
Indirect	3,580.6	18,713	1,357.1	2,055.0
Induced	2,331.8	16,657	812.1	1,415.4
Total	15,001.2	54,232	3,423.3	5,859.1
Multiplier	1.651	2.875	2.730	2.453
All Agriculture				
Direct	9,751.7	24,565	1,409.7	2,663.7
Indirect	3,792.8	19,629	1,419.1	2,176.2
Induced	2,547.8	18,189	886.9	1,545.9
Total	16,092.2	62,387	3,715.6	6,385.8
Multiplier	1.650	2.540	2.636	2.397
Govt Rev (MM$)	On-Farm	Food Processing	All Agriculture	
Sales	6.2	146.4	152.5	
Property	8.4	196.4	204.7	
Income	7.8	82.4	90.1	
Other	4.6	58.7	63.3	
Total S&L	26.9	483.8	510.7	
Dairy Farm				
Direct Effect	198.5	693	27.2	67.7
Indirect Effect	83.5	596	27.3	45.1
Induced Effect	48.0	341	16.6	29.0
Total Effect	330.0	1,630	71.1	141.7
Multiplier	1.662	2.352	2.611	2.095
Dairy Processing				
Direct Effect	841.3	749	57.5	137.5
Indirect Effect	518.0	1,209	72.9	112.0
Induced Effect	216.4	1,532	74.9	130.6
Total Effect	1,575.7	3,492	147.8	380.2
Multiplier	1.873	4.662	2.572	2.765
All Dairy				
Direct Effect	1,039.8	1,442	84.7	205.2
Indirect Effect	601.5	1,805	100.2	157.1
Induced Effect	264.4	1,873	91.5	159.6
Total Effect	1,905.7	5,122	218.9	521.9
Multiplier	1.833	3.552	2.584	2.544
Gov Rev (MM$)	Dairy Farm	Dairy Processing	All Dairy	
Sales	1.8	14.2	16.0	
Property	2.5	19.1	21.5	
Income	1.7	7.5	9.3	
Other	1.2	5.6	6.9	
Total S&L	7.3	46.4	53.7	

Detailed Analysis: ***East Central***

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)
On-Farm				
Direct	2,544.7	14,603	664.3	926.7
Indirect	832.5	3,395	201.2	374.0
Induced	726.9	5,596	235.6	416.4
Total	4,104.2	23,595	1,101.2	1,717.1
Multiplier	1.613	1.616	1.658	1.853
Food Processing				
Direct	12,826.6	18,443	1,477.6	2,387.8
Indirect	4,701.4	26,765	1,681.0	2,539.4
Induced	2,383.0	18,491	777.8	1,372.2
Total	19,911.0	63,700	3,936.4	6,299.4
Multiplier	1.552	3.454	2.664	2.638
All Agriculture				
Direct	15,371.3	33,046	2,141.9	3,314.5
Indirect	5,533.9	30,160	1,882.2	2,913.4
Induced	3,109.9	24,087	1,013.4	1,788.5
Total	24,015.2	87,295	5,037.6	8,016.5
Multiplier	1.562	2.642	2.352	2.419
Govt Rev (MM$)	On-Farm	Food Processing	All Agriculture	
Sales	27.2	170.1	197.3	
Property	30.1	186.1	216.2	
Income	29.8	95.1	124.8	
Other	14.5	60.7	75.1	
Total S&L	101.6	511.9	613.5	
Dairy Farm				
Direct Effect	1,501.2	4,667	349.9	511.6
Indirect Effect	710.3	3,843	190.4	300.7
Induced Effect	397.0	3,062	128.8	227.5
Total Effect	2,608.6	11,572	669.1	1,039.8
Multiplier	1.738	2.480	1.912	2.032
Dairy Processing				
Direct Effect	5,793.4	5,911	488.6	815.2
Indirect Effect	2,033.7	11,407	720.7	1,123.5
Induced Effect	935.9	7,218	304.3	536.4
Total Effect	8,763.0	24,536	1,513.6	2,475.1
Multiplier	1.513	4	3.098	3.036
All Dairy				
Direct Effect	7,294.6	10,578	838.5	1,326.8
Indirect Effect	2,744.1	15,251	911.1	1,424.2
Induced Effect	1,332.9	10,279	433.1	763.9
Total Effect	11,371.5	36,108	2,182.7	3,514.9
Multiplier	1.559	3.413	2.603	2.649
Gov Rev (MM$)	Dairy Farm	Dairy Processing	All Dairy	
Sales	15.5	72.1	87.5	
Property	17.1	78.8	95.9	
Income	16.2	36.8	53.0	
Other	8.2	24.9	33.1	
Total S&L	56.9	212.6	269.5	

Detailed Analysis: ***North East***

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)
On-Farm				
Direct	771.9	5,941	263.4	322.6
Indirect	83.9	544	23.2	41.9
Induced	149.7	1,339	41.0	79.4
Total	1,005.5	7,824	327.5	444.0
Multiplier	1.303	1.317	1.243	1.376
Food Processing				
Direct	1,132.7	1,488	83.7	145.6
Indirect	275.7	1,828	97.3	144.3
Induced	79.6	716	22.0	42.4
Total	1,488.0	4,033	203.0	332.3
Multiplier	1.314	2.710	2.425	2.283
All Agriculture				
Direct	1,904.6	7,429	347.2	468.2
Indirect	359.6	2,373	120.5	186.3
Induced	229.3	2,055	62.9	121.8
Total	2,493.5	11,858	530.6	776.3
Multiplier	1.309	1.596	1.528	1.658
Govt Rev (MM$)				
Sales	4.8	10.2	15.0	
Property	6.5	13.6	20.1	
Income	9.0	4.7	13.7	
Other	3.2	3.3	6.5	
Total S&L	23.5	31.7	55.3	
Dairy Farm				
Direct Effect	360.4	1,251	96.2	122.8
Indirect Effect	76.0	869	33.0	43.0
Induced Effect	57.1	512	15.7	30.3
Total Effect	493.5	2,632	144.9	196.1
Multiplier	1.369	2.104	1.506	1.597
Dairy Processing				
Direct Effect	916.5	939	59.3	106.8
Indirect Effect	273.9	1,628	88.7	133.5
Induced Effect	64.8	581	17.8	34.4
Total Effect	1,255.2	3,147	165.8	274.7
Multiplier	1.370	3.352	2.798	2.573
All Dairy				
Direct Effect	1,276.9	2,190	155.4	229.6
Indirect Effect	349.9	2,497	121.7	176.5
Induced Effect	121.9	1,092	33.5	64.7
Total Effect	1,748.7	5,779	310.7	470.8
Multiplier	1.369	2.639	1.999	2.050

Gov Rev (MM$)	Dairy Farm	Dairy Processing	All Dairy
Sales	2.0	8.2	10.2
Property	2.7	10.9	13.6
Income	3.4	3.8	7.2
Other	1.3	2.7	4.0
Total S&L	9.4	25.5	35.0

Detailed Analysis: ***North Central***

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)
On-Farm				
Direct	1,292.6	10,259	355.7	525.1
Indirect	265.5	1,390	68.5	128.6
Induced	293.1	2,322	91.4	165.9
Total	1,851.1	13,971	515.6	819.6
Multiplier	1.432	1.362	1.450	1.561
Food Processing				
Direct	3,865.4	4,804	284.1	565.8
Indirect	1,090.8	6,832	364.8	568.2
Induced	408.1	3,248	127.9	231.3
Total	5,364.2	14,884	776.8	1,365.3
Multiplier	1.388	3.098	2.735	2.413
All Agriculture				
Direct	5,157.9	15,063	639.8	1,090.9
Indirect	1,356.2	8,221	433.3	696.8
Induced	701.2	5,570	219.3	397.1
Total	7,215.3	28,855	1,292.4	2,184.9
Multiplier	1.399	1.916	2.020	2.003
Govt Rev (MM$)				
Sales	13.9	48.7	62.6	
Property	15.2	52.3	67.5	
Income	13.9	18.5	32.3	
Other	6.4	12.9	19.4	
Total S&L	49.4	132.3	181.7	
Dairy Farm				
Direct Effect	684.5	2,327	140.9	233.3
Indirect Effect	220.4	1,868	65.6	104.8
Induced Effect	126.9	1,009	39.6	71.8
Total Effect	1,031.9	5,204	246.2	410.0
Multiplier	1.507	2.236	1.7	1.8
Dairy Processing				
Direct Effect	2,615.6	2,311	161.5	360.0
Indirect Effect	750.6	4,656	248.9	397.3
Induced Effect	260.2	2,069	81.5	147.3
Total Effect	3,626.4	9,036	491.9	904.6
Multiplier	1.386	3.910	3.0	2.5
All Dairy				
Direct Effect	3,300.2	4,638	302.4	593.3
Indirect Effect	971.0	6,524	314.5	502.1
Induced Effect	387.1	3,077	121.1	219.2
Total Effect	4,658.3	14,239	738.0	1,314.6
Multiplier	1.412	3.070	2.4	2.2
Gov Rev (MM$)	Dairy Farm	Dairy Processing	All Dairy	
Sales	6.5	32.4	38.9	
Property	7.1	34.7	41.8	
Income	6.0	11.7	17.7	
Other	3.1	8.8	11.9	
Total S&L	22.6	87.6	110.3	

Detailed Analysis: ***Central***

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)
On-Farm				
Direct	1,217.2	10,018	337.1	581.6
Indirect	162.7	885	43.0	79.9
Induced	223.0	1,846	66.2	123.7
Total	1,602.9	12,750	446.4	785.1
Multiplier	1.317	1.273	1.324	1.350
Food Processing				
Direct	3,500.8	5,618	309.8	531.1
Indirect	741.5	4,428	257.1	394.3
Induced	310.7	2,595	93.1	173.1
Total	4,553.0	12,641	660.0	1,098.5
Multiplier	1.301	2.250	2.130	2.068
All Agriculture				
Direct	4,718.0	15,636	646.9	1,112.7
Indirect	904.2	5,313	300.1	474.2
Induced	533.7	4,441	159.3	296.7
Total	6,155.9	25,391	1,106.3	1,883.6
Multiplier	1.305	1.624	1.710	1.693
Govt Rev (MM$)				
Sales	5.2	31.5	36.7	
Property	6.4	37.5	43.8	
Income	11.4	15.4	26.8	
Other	5.8	10.1	16.0	
Total S&L	28.8	94.5	123.3	
Dairy Farm				
Direct Effect	349.7	1,087	64.2	119.2
Indirect Effect	87.7	911	23.8	38.5
Induced Effect	47.6	395	14.2	26.4
Total Effect	485.0	2,393	102.2	184.1
Multiplier	1.387	2.202	1.592	1.545
Dairy Processing				
Direct Effect	1,303.0	1,197	66.6	120.9
Indirect Effect	278.7	1,609	96.3	147.1
Induced Effect	89.3	743	26.7	49.6
Total Effect	1,671.1	3,549	189.5	317.5
Multiplier	1.282	2.965	2.846	2.627
All Dairy				
Direct Effect	1,652.7	2,284	130.8	240.0
Indirect Effect	366.5	2,520	120.1	185.6
Induced Effect	136.9	1,138	40.8	76.0
Total Effect	2,156.1	5,943	291.8	501.7
Multiplier	1.305	2.602	2.230	2.090
Gov Rev (MM$)	Dairy Farm	Dairy Processing	All Dairy	
Sales	1.8	9.1	10.9	
Property	2.2	10.8	13.0	
Income	2.4	4.4	6.8	
Other	1.4	2.9	4.3	
Total S&L	7.8	27.2	35.0	

Detailed Analysis: ***Northwest***

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)
On-Farm				
Direct	975.3	9,144	203.3	391.2
Indirect	158.7	879	36.1	70.3
Induced	149.4	1,275	41.5	79.1
Total	1,283.4	11,298	280.9	540.6
Multiplier	1.316	1.236	1.382	1.382
Food Processing				
Direct	2,603.7	4,630	248.9	383.2
Indirect	614.2	3,957	196.0	302.3
Induced	236.9	2,042	66.3	126.1
Total	3,454.7	10,629	511.2	811.6
Multiplier	1.327	2.296	2.054	2.118
All Agriculture				
Direct	3,579.0	13,774	452.2	774.4
Indirect	772.9	4,836	232.1	372.6
Induced	386.2	3,317	107.8	205.1
Total	4,738.1	21,927	792.1	1,352.2
Multiplier	1.324	1.592	1.752	1.746
Govt Rev (MM$)				
Sales	6.3	29.3	35.6	
Property	7.7	34.9	42.6	
Income	7.8	12.1	19.9	
Other	4.6	7.8	12.4	
Total S&L	26.4	84.1	110.5	
Dairy Farm				
Direct Effect	379.7	1,553	48.1	129.4
Indirect Effect	102.7	1,175	31.1	49.2
Induced Effect	41.1	353	11.4	21.8
Total Effect	523.5	3,081	90.6	200.4
Multiplier	1.379	1.984	1.885	1.549
Dairy Processing				
Direct Effect	937.8	1,026	61.1	98.1
Indirect Effect	261.5	1,509	74.7	116.0
Induced Effect	70.4	603	19.6	37.3
Total Effect	1,269.7	3,139	155.5	251.3
Multiplier	1.354	3.059	2.544	2.563
All Dairy				
Direct Effect	1,317.6	2,579	109.2	227.5
Indirect Effect	364.2	2,684	105.9	165.2
Induced Effect	111.5	956	31.1	59.1
Total Effect	1,793.2	6,219	246.1	451.7
Multiplier	1.361	2.411	2.254	1.986
Gov Rev (MM$)	Dairy Farm	Dairy Processing	All Dairy	
Sales	2.2	8.8	11.0	
Property	2.6	10.4	13.1	
Income	2.1	3.6	5.7	
Other	1.6	2.4	4.0	
Total S&L	8.6	25.1	33.7	

Detailed Analysis: ***West Central***

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)
On-Farm				
Direct	1,893.7	15,597	231.9	681.4
Indirect	425.5	2,185	117.1	223.6
Induced	268.2	2,126	83.7	151.9
Total	2,587.5	19,910	432.6	1,057.0
Multiplier	1.366	1.276	1.866	1.551
Food Processing				
Direct	5,161.0	7,450	475.9	886.1
Indirect	1,522.8	8,928	534.2	828.3
Induced	681.6	5,442	213.5	387.7
Total	7,365.4	21,820	1,223.6	2,102.2
Multiplier	1.427	2.929	2.571	2.372
All Agriculture				
Direct	7,054.8	23,047	707.7	1,567.6
Indirect	1,948.3	11,112	651.3	1,051.9
Induced	949.8	7,568	297.2	539.6
Total	9,952.8	41,730	1,656.2	3,159.1
Multiplier	1.411	1.811	2.340	2.015
Govt Rev (MM$)				
Sales	10.1	66.0	76.0	
Property	11.3	73.0	84.2	
Income	11.5	28.9	40.5	
Other	9.5	20.9	30.4	
Total S&L	42.4	188.8	231.1	
Dairy Farm				
Direct Effect	683.3	2,415	54.8	232.9
Indirect Effect	220.1	1,920	61.5	107.1
Induced Effect	77.3	614	24.1	43.8
Total Effect	980.6	4,949	140.4	383.7
Multiplier	1.435	2.049	2.563	1.648
Dairy Processing				
Direct Effect	2,874.5	2,455	170.4	319.5
Indirect Effect	915.4	5,293	322.2	504.5
Induced Effect	338.4	2,693	105.8	192.0
Total Effect	4,128.2	10,441	598.3	1,016.0
Multiplier	1.436	4.253	3.511	3.180
All Dairy				
Direct Effect	3,557.8	4,870	225.2	552.3
Indirect Effect	1,135.4	7,213	383.7	611.6
Induced Effect	415.6	3,307	129.9	235.8
Total Effect	5,108.9	15,390	738.7	1,399.7
Multiplier	1.436	3.160	3.280	2.534
Gov Rev (MM$)	Dairy Farm	Dairy Processing	All Dairy	
Sales	4.4	31.4	35.8	
Property	4.8	34.8	39.6	
Income	3.3	14.3	17.6	
Other	3.4	10.1	13.5	
Total S&L	15.9	90.6	106.5	

Detailed Analysis: ***South West***

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)
On-Farm				
Direct	1,666.9	15,083	468.7	600.9
Indirect	277.0	1,413	69.8	136.7
Induced	333.6	2,702	96.5	185.0
Total	2,277.4	19,198	635.0	922.6
Multiplier	1.366	1.273	1.355	1.535
Food Processing				
Direct	2,906.6	3,227	177.0	343.2
Indirect	657.8	3,966	229.6	354.4
Induced	227.5	1,854	66.3	126.5
Total	3,791.8	9,049	472.9	824.1
Multiplier	1.305	2.804	2.671	2.401
All Agriculture				
Direct	4,573.4	18,310	645.7	944.1
Indirect	934.7	5,379	299.4	491.1
Induced	561.1	4,556	162.7	311.5
Total	6,069.2	28,246	1,107.9	1,746.7
Multiplier	1.327	1.543	1.716	1.850
Govt Rev (MM$)				
Sales	18.4	37.1	55.4	
Property	12.0	23.6	35.6	
Income	17.6	11.5	29.0	
Other	6.7	7.5	14.2	
Total S&L	54.6	79.6	134.3	
Dairy Farm				
Direct Effect	675.2	2,405	169.7	230.1
Indirect Effect	177.8	1,829	55.8	84.5
Induced Effect	120.4	980	34.9	66.9
Total Effect	973.4	5,213	260.4	381.5
Multiplier	1.442	2.168	1.535	1.658
Dairy Processing				
Direct Effect	2,551.9	2,570	148.3	280.5
Indirect Effect	579.5	3,494	202.8	313.3
Induced Effect	198.2	1,613	57.7	110.1
Total Effect	3,329.7	7,679	408.8	703.9
Multiplier	1.305	2.988	2.756	2.509
All Dairy				
Direct Effect	3,227.2	4,975	318.0	510.6
Indirect Effect	757.3	5,323	258.6	397.8
Induced Effect	318.7	2,593	92.6	177.0
Total Effect	4,303.1	12,892	669.2	1,085.4
Multiplier	1.333	2.591	2.104	2.126
Gov Rev (MM$)	Dairy Farm	Dairy Processing	All Dairy	
Sales	6.3	29.5	35.8	
Property	4.1	18.8	22.9	
Income	6.3	10.0	16.3	
Other	2.5	6.3	8.8	
Total S&L	19.3	64.6	83.8	

Detailed Analysis: ***South Central***

	Industry Sales (MM$)	Employment	Labor Income (MM$)	Total Income (MM$)
On-Farm				
Direct	1,945.8	16,216	516.8	718.2
Indirect	666.6	2,663	167.6	344.1
Induced	598.0	4,390	194.3	357.1
Total	3,210.4	23,270	878.7	1,419.4
Multiplier	1.650	1.435	1.700	1.976
Food Processing				
Direct	8,498.3	13,402	864.2	1,645.1
Indirect	2,672.1	14,489	1,002.4	1,554.7
Induced	1,345.0	9,932	439.9	806.9
Total	12,515.4	37,826	2,306.6	4,006.7
Multiplier	1.473	2.822	2.669	2.435
All Agriculture				
Direct	10,444.1	29,618	1,381.1	2,363.4
Indirect	3,338.7	17,152	1,170.0	1,898.7
Induced	1,943.1	14,322	634.2	1,164.0
Total	15,725.8	61,096	3,185.3	5,426.1
Multiplier	1.506	2.063	2.306	2.296
Govt Rev (MM$)				
Sales	19.6	110.7	130.3	
Property	23.0	128.3	151.4	
Income	24.5	54.0	78.6	
Other	11.9	38.5	50.4	
Total S&L	79.0	331.6	410.6	
Dairy Farm				
Direct Effect	721.9	2,706	147.9	246.0
Indirect Effect	351.2	2,461	113.1	173.7
Induced Effect	184.5	1,357	60.0	110.2
Total Effect	1,257.6	6,524	320.9	529.9
Multiplier	1.7	2.411	2.2	2.2
Dairy Processing				
Direct Effect	2,847.5	3,093	216.4	352.8
Indirect Effect	1,078.1	5,904	407.2	636.0
Induced Effect	453.4	3,331	147.6	270.9
Total Effect	4,379.0	12,329	771.3	1,259.7
Multiplier	1.538	3.986	3.564	3.571
All Dairy				
Direct Effect	3,569.4	5,799	364.3	598.8
Indirect Effect	1,429.3	8,365	520.3	809.7
Induced Effect	637.9	4,688	207.6	381.1
Total Effect	5,636.7	18,853	1,092.2	1,789.6
Multiplier	1.579	3.251	2.998	2.989
Gov Rev (MM$)	Dairy Farm	Dairy Processing	All Dairy	
Sales	7.6	36.4	44.0	
Property	8.9	42.2	51.1	
Income	7.6	18.1	25.7	
Other	4.2	12.0	16.3	
Total S&L	28.2	108.8	137.0	

Appendix B: 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 A1), 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 demand. 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).

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...

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).

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

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.

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 (the sum of employee compensation, proprietary income, other property income and 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.

Basics of Input-Output Multipliers, Cont'd

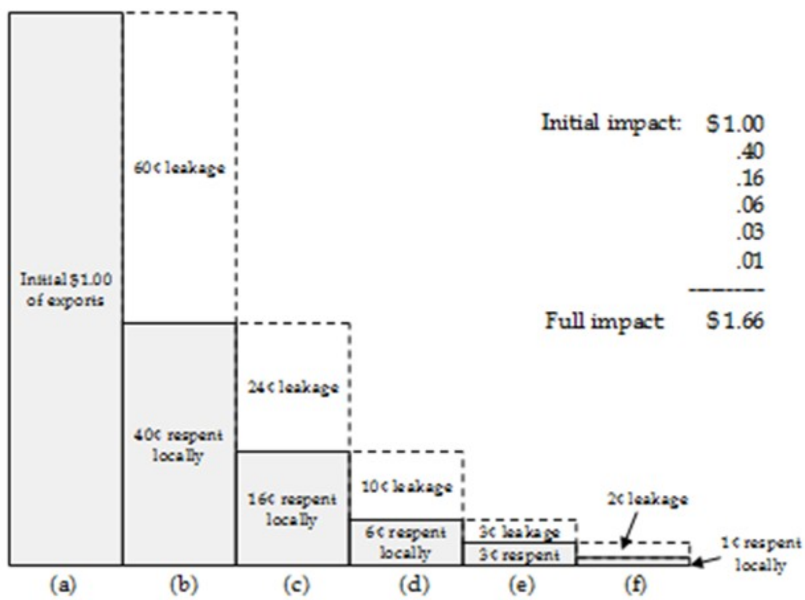
How are these income and employment multipliers derived if the IO model only looks at the flow of industry expenditures (output)? In the strictest sense, the IO does not understand changes in employment or income, only changes in final demand (sales or output). To do this we use the fact that the IO 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.

Appendix B: Misuses and Evaluation of Economic Multipliers

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 resolved.

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 because the sizes of the multipliers are different and because they measure completely 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 non-basic 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 was 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, the initial dollar "turns over" five times; however, only part of the initial dollar is re-spent each time it changes hands. Someone confusing turnover with a 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.

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. The test of accuracy for a multiple is captured in this question: 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 en route 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 also influence multiplier size. A densely populated area generally has more businesses. This means that a given dollar is able to circulate more times before leaking than would be the case in a less populated 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. It is often difficult to find a similar area where impact studies have been completed so that multipliers can be borrowed readily. An area's dollar flow patterns may be so unique, for example, that overlaying will not work.

(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 than in published or already-collected data. Primary data collection, though, 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?

As are most multipliers encountered by local decision makers, the multipliers discussed here are static in nature. 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.