Economic Impacts from Agricultural Production in Arizona

Jorgen R. Mortensen

Department of Agricultural and Resource Economics
The Cardon Endowment for Agricultural Economics and Policy
The College of Agriculture and Life Sciences
The University of Arizona

July 2004

Table of Contents

Illustrations

Figures

Tables

Acknowledgments

This study was primarily funded by a grant from the Arizona Department of Agriculture. Contributions were also made by the Arizona Farm Bureau, Arizona Cotton Growers, Arizona Cattle Growers, Agri-Business Council, Arizona Nursery Association, Western Growers Association, Arizona Agricultural Aviation Association, and the Yuma Fresh Vegetable Association. Additional resources were provided by the Department of Agricultural and Resource Economics and the Cardon Chair Endowment for Agricultural Economics and Policy at the University of Arizona. Thanks go to Alan Ker who reviewed this publication and provided many valuable suggestions, and to Bruce Beattie for his never failing willingness to advise and exchange views on all involved issues, and for his comments and suggestions to drafts of the report. Thanks also to Dean Lueck and to Alberta Charney for good guidance. Doug Olson, Minnesota IMPLAN Group, gave precise and helpful replies to many muddled questions about proper use of the model software. Special thanks to Nancy Bannister for keeping watch on the linguistic correctness and for skillful design and layout of this report. The final contents of this report and any errors, mistakes, or omissions are the responsibility of the author.

Executive Summary

For many years, productivity increases in agriculture have been achieved through technological innovations that increasingly require input from related industries in the form of new machinery and equipment, processed feed, and many other goods and services needed for the operation of modern and competitive agriculture. In this impact analysis, the term primary agriculture or simply agriculture comprises ranches; feedlots; dairies; other cattle farms; pig, poultry, and other livestock farms (including equine and apiculture); farms with food, fiber, seed, and feed crops; farms with tree nuts, fruit, and berries; greenhouse and nursery operations; and farms with aquaculture (fish).

Concurrent economic growth and higher real incomes have left their mark on all sectors of the Arizona economy. Industries that pack and process agricultural products have been called upon to provide ready-to-cook and ready-to-eat food and other conveniences to meet consumers' changing needs. Suppliers of inputs and services have expanded their sales to agriculture. Supply and processing industries with agriculture as the basis for their activities have therefore come to play an increasing role in the agricultural economy in Arizona.

This study examines the economic impact of the entire agribusiness system, defined as the primary agricultural sector plus the closely related industries that depend on agricultural activity in Arizona. Grocery stores, eating places, and others which serve consumers are not considered part of agribusiness as their activity tends to be independent of the geographical origin of the farm and ranch products.

Apart from the direct economic activity spreading from agriculture to closely related industries within agribusiness this study measures the indirect impacts that arise when agribusiness firms acquire gas, electricity, transportation services, warehousing, and many other goods and services from other sectors in the Arizona economy. Beyond those economic ripple effects, additional induced impacts occur due to spending of incomes earned by people employed in agribusiness activities.

The indirect ripple effects and the induced impacts, in addition to the direct activity in agribusiness, added up to 6.6 billion dollars of total output value in 2000. Total output in agribusiness was 4.5 billion dollars, indirect ripple effects accounted for 0.9 billion dollars, while the induced consumption impact represented 1.2 billion dollars. The total output impact is 47 percent higher than the direct output value in agribusiness—the total output multiplier for agribusiness is 1.47.

In terms of value added, agribusiness's total economic impact was 3.0 billion dollars in 2000, of which 1.7 billion dollars was direct agribusiness activity. Value added is a better basis than total output for evaluation of activity in the economy because it avoids double counting outputs that are used as inputs in production by other industries. Indirect ripple effects add 0.5 billion dollars (32 percent) to direct value added in agribusiness, while induced impacts add 49 percent. The total indirect and induced value added impact is 81 percent of the activity in agribusiness. The value added multiplier is 1.81—considerably higher than the output multiplier of 1.47.

The total job impact was 72,900 in 2000, of which 8,300 jobs were caused by ripple effects from agribusiness, while 16,900 jobs were generated by spending of incomes earned in agribusiness industries. There were 20,600 jobs in agriculture. In other words, for every job in primary agriculture, more than two and a half jobs in the rest of the economy were dependent on agricultural production.

Introduction

Years ago, when cattle, cotton, and citrus were dominant in the Arizona economy together with copper, they appropriately acquired the nickname the "Big Cs." Later, climate entered the C-list because of its importance for increasing tourism and the influx of people moving to Arizona. Significant economic changes have taken place since the middle of last century, a period marked by strong economic growth. Increasing real incomes and economic welfare in Arizona, as in the rest of the industrialized world, have shifted consumers' demand for non-agricultural commodities and services. Basic needs such as food take up a declining share of consumers' expenditures. Data in table 1 illustrate this general development for major consumption groups over the last two decades. The data are for the United States as a whole, but the same pattern is found in all states, including Arizona, and it has left clear tracks in the form of varying development in employment and economic activity within different trades and industries.

Historical Context of U.S. and Arizona Agriculture

Agriculture has expanded less than most other business sectors. Specifically, service trades have increased their share of total economic activity. Enjoyable climate and natural wonders have accentuated expansion of the service industry in Arizona due to its popularity as a destination for tourism and new settlers from out-of-state, many of them retirees.

Since the early 1980s, Arizona's population has doubled against a nationwide increase of only 21 percent. Population growth—in absolute as well as relative terms—has been strongest in urbanized areas, but all counties in Arizona (rural and urban), except Greenlee, had growth rates well above the U.S. average. Arizona industries, including agriculture, have enjoyed the advantage of a stronger expansion of local demand than the rest of the country. Arizona's agricultural employment has been relatively stable over the period (table 2) compared with a 30 percent decrease for the United States. However, agriculture's percentage share of total employment was more than halved because the total number of jobs in Arizona more than doubled. Less than one percent of all jobs in Arizona are now

Table 1. U.S. Personal Consumption Expenditures, Billion Dollars

	3-year average, billion dollars			Percentage	
	1979/81	1999/01	Change	1979/81	1999/01
Food, drinks, and tobacco[1]	376	999	623	21.3	14.9
Clothing and personal care	159	484	325	9.0	7.2
Housing	258	1,010	752	14.6	15.1
Household operation	233	711	478	13.2	10.6
Medical care and health insurance	213	1,224	1,011	12.1	18.3
Financial and legal services, etc.	94	523	429	5.4	7.8
Transportation[2]	241	837	597	13.7	12.5
Recreation	119	578	459	6.8	8.6
Education	34	164	130	1.9	2.4
Travels and other	37	160	122	2.1	2.4
Total	**1,763**	**6,689**	**4,926**	**100.0**	**100.0**

1. Exclusive of tobacco and alcoholic beverages, food's shares are 17.6 and 12.2 percent, respectively.
2. User operated transportation amounts to 90–95 percent of total transportation expenditures.
Source: Based on National Economic Accounts, Bureau of Economic Analysis (BEA), U.S. Department of Commerce.

Table 2. Arizona Employment by Industry, 1,000 Full-Time and Part-Time Jobs

	3-year average, thousand jobs[1]			Percentage	
	1979/81	1999/01	Change	1979/81	1999/01
Agriculture	20.5	19.8	-0.7	1.6	0.7
Labor provided by farm family	7.4	7.6	0.1	0.6	0.3
Agriculture-related industries[1]	26.4	60.1	33.7	2.1	2.1
Agriculture and related industries	**49.9**	**79.9**	**32.9**	**3.7**	**2.8**
Mining	23.8	13.2	-10.7	1.9	0.5
Construction	92.3	201.1	108.9	7.2	7.2
Manufacturing[2]	147.1	210.7	63.6	11.5	7.5
Transportation, communication, utilities	54.4	124.5	70.1	4.2	4.4
Wholesale	53.0	121.2	68.2	4.1	4.3
Retail sales	226.4	484.6	258.2	17.7	17.3
Financing, insurance, real estate	117.3	280.3	163.0	9.2	10.0
Services	291.7	918.0	626.3	22.8	32.7
Government	228.2	371.2	143.0	17.8	13.2
Total	**1,281.0**	**2,804.6**	**1,523.5**	**100.0**	**100.0**

1. BEA's sector delineation does not exactly match that used in this report's input-output calculation.
2. Food and textile mill products moved from manufacturing to farm-related industries.
Source: Based on BEA, U.S. Department of Commerce.

found in agriculture. However, processing, supply, and service industries that are directly dependent on primary agricultural activity have maintained a constant share of 2.1 percent, representing an absolute increase from 26,000 to 60,000 jobs since 1980 according to the Bureau of Economic Analysis (BEA). Of a total 1.5 million new Arizona jobs, about 40 percent were created in the service sector, which has had the largest share increase of total employment.

A similar pattern emerges when comparing gross state product (GSP) among different sectors of the economy (table 3). An industry's GSP is the value added by labor and property assets engaged in production. The concept is similar to gross domestic product (GDP) that applies at the national level. Simplified, it is the value of total production output minus the value of inputs (goods and services) acquired from other industries in the state or from other states/countries. GSP therefore represents income earned by the basic production factors (that is, compensation of employees, remuneration of proprietors and property assets, and property taxes). On average for 1999–2001, annual GSP amounted to 1.2 billion dollars in farming and ranching and 2 billion dollars in farm-related industries representing 0.8 and 1.3 percent, respectively, of GSP in Arizona as a whole. These shares—especially for farming and ranching—declined over the last two decades. Again, services showed the largest expansion in both absolute and relative terms and that sector is now the largest in the traditional statistical grouping of Arizona's industries and trades.

The declining share of farm employment in relation to farm-related industries as shown in table 2 is consistent with a greater rate of labor productivity increase in primary agriculture relative to other industries. A study by Ball, Butault, and Nehring established that Arizona farm output per employee rose by an annual 3.1 percent between 1979/1981 and 1996. For the same period, Elitzak showed that U.S. labor productivity declined in both the meatpacking and bakery industries. These and the following U.S. data also represent the trend in Arizona. For fats and oil processing and grain mill products there was an increase of about 1 percent per

Table 3. Arizona Annual Gross State Product by Industry, Million Dollars

	3-year average, million dollars			Percentage	
	1979/81	1999/01	Change	1979/81	1999/01
Agriculture	790	1,220	430	2.6	0.8
Agriculture-related industries[1]	409	2,024	1,615	1.4	1.3
Agriculture and related industries	**1,199**	**3,244**	**2,045**	**4.0**	**2.1**
Mining	1,054	1,207	153	3.5	0.8
Construction	2,532	9,146	6,615	8.4	6.0
Manufacturing[1]	4,050	20,818	16,768	13.4	13.6
Transportation, communication, utilities	2,826	10,866	8,040	9.3	7.1
Wholesale	1,756	10,239	8,483	5.8	6.7
Retail sales	3,281	16,401	13,120	10.8	10.7
Financing, insurance, real estate	4,851	29,131	24,280	16.0	19.1
Services	4,193	33,325	29,132	13.8	21.8
Government	4,550	18,540	13,990	15.0	12.1
Total	**30,291**	**152,918**	**122,626**	**100.0**	**100.0**

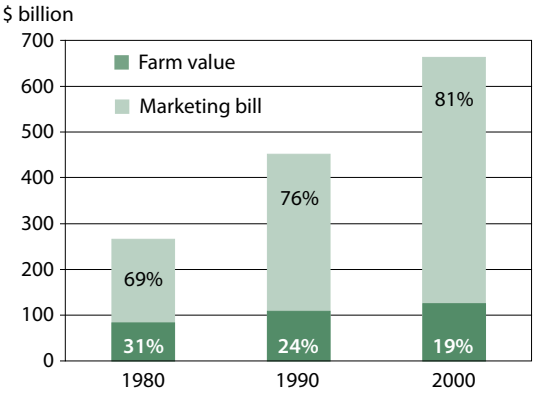
1. Food and textile mill products moved from manufacturing to farm-related industries.
Source: Based on BEA, U.S. Department of Commerce.

year, while per-employee output of processed dairy products and fruit and vegetable preserves rose by an annual average of 1.7 percent. Labor productivity change was negative for retail stores and eating and drinking establishments. Elitzak notes that these results may not fully account for product quality improvements taking place in processing, packaging, and retailing in the form of more conveniences such as ready-to-cook or ready-to-eat food. He warns that his calculation approach may entail a certain underestimation of true rates of productivity gain. This is probably a pertinent issue for long-term studies, including earlier decades when increasing demand for built-in "domestic aid" in food products began. Such distortions are believed to be less of a problem in comparisons among more recent periods.

The ratio of consumer expenditures on food (including costs of eating out) to the farm value of the supplied foodstuffs has continuously risen. Farmers' share of the food dollar fell from 31 cents in 1980 to 19 cents in 2000 (see figure 1). Correspondingly, the spread (or the marketing bill) went up from 69 cents in 1980 to 81 cents in 2000. The marketing bill includes wholesale and retail costs in addition to processing and packaging costs in directly farm-related industries. An increase in consumers' convenience demand has widened the spread between farm value and consumer outlay. The spread has also been influenced by away-from-home eating, which in 2000 represented more than 40 percent of personal food expenditures compared to 32 percent in 1980.

The greater productivity gain for farm-level production compared to that in food processing and distribution has also contributed to the widening of the retail-farm spread. Productivity gain counteracts price increases for production factors. Stronger annual productivity gain in farming therefore entails the possibility of slower increase in per-unit-costs of production

Figure 1. Total U.S. Food Spending, Marketing Bill and Farm Value
Percentages are shares of the consumer dollar.



Source: Based on data from Economic Research Service, USDA.

on farms than at subsequent stages of the food supply chain. The farmer's share of the consumer dollar goes down while costs incurred on food's path from farm to consumer's table represent an increasing share.

Tables 2 and 3 showed that agriculture—taken in isolation—represents a modest and declining share of total employment and economic activity in Arizona. But the data also indicate the growing role for agriculturally related businesses, as farmers increasingly become dependent on others to supply necessary production factors and services and to process and market farm products in accordance with consumers' preferences. Agricultural production is the platform for activity in this entire agribusiness complex of firms. Further, agricultural production exerts significant indirect economic impacts in other sectors through economic transactions with agribusiness firms. Finally, additional economic activity is induced because personal income generated in the agribusiness industry is the source of personal spending in a large number of households. This is crucial in relation to maintaining population, schools, other public services, etc., in rural districts and small towns.

Agriculture also plays an important societal role via the use and management of land and other natural resources. Besides the aesthetic influence on open landscape scenery—generally regarded as positive—effects on natural habitats for plants and wildlife attract increasing interest in relation to both use of rangeland and intensive crop production. For the latter, the allocation of water resources and use of fertilizers and chemicals are subjects of scrutiny as is the disposal of animal waste from large-scale feedlots and dairy operations.

In a dynamic society with rapid changes in technology and consumer preferences, agriculture must continuously adjust production and production methods. Due to strong reliance on the development and use of natural resources, agriculture will remain at the center of keen public and political deliberations over protection of the environment. Economic and environmental interests may conflict and it is important that the best possible information is available when far-reaching environmental policy measures are considered. Agriculture's total economic influence is an important part of such an information base.

Outline of Report

The purpose of this report is to provide information and a better understanding of agriculture's economic role. The following two sections establish some key statistical facts to sketch a profile of Arizona agriculture. In the last part of the report, results of further analysis contribute to drawing the full picture of agriculture's impact on the Arizona economy. Account is taken of the direct effects not only in agriculture but also in its closely related supply and processing industries. Indirect impacts on other economic sectors through transactions with primary agriculture and other agribusiness firms are added. This study also captures the induced economic effect of expenditures based on household incomes generated within the agricultural food and fiber industry. Based on the economic linkages in agribusiness among agriculture and directly related firms, and between agribusiness and other sectors of the economy, including households, it is possible to quantify the extent of economic ripples, or multiplier effects, that are associated with agricultural production. These calculations of agriculture's total economic impact are integrated in a comprehensive inter-industry input-output model for the entire Arizona economy.

Profile of Agriculture in Arizona

Land in farms and ranches occupies 27 million acres or 37 percent of Arizona's total area (table 4). With 7,300 farms and ranches, the average area per farm is 3,630 acres, which is 8 times the U.S. average. The main reason for the difference is the predominance of large cattle ranches in Arizona. According to the *1997 Census of Agriculture,* 37 percent of all farm units were classified as ranches. Ranches operated 92 percent of all "land in farms" (most of it pasture and range land) and had an average size of over 10,000 acres. That is about tenfold the average area of traditional field crop farms (table 5). Livestock farms, other than ranches, comprised

Table 4. Farms and Land in Farms, 1982–2002

	Arizona			U.S.
	Number of farms and ranches[1]	Land in farms[2] 1,000 acres	Acres per farm	Acres per farm
1982	8,000	37,500	4,688	440
1992	7,500	35,600	4,747	491
1993	7,800	28,300	3,628	440
2002	7,300	26,500	3,630	440

1. Farms with more than $1,000 annual sales.
2. Land owned and rented. Excludes grazing land under government permits on a per-head basis, about five million acres in 1997 according to the agricultural census After 1992, land under conservation programs and significant areas of woodland and wasteland held for non-agricultural purposes are not included, thus impairing the comparability with earlier years.

Sources: National Agricultural Statistics Services (NASS), USDA, and *2002 Arizona Agricultural Statistics Bulletin.*

Table 5. Use of Land by Type of Farm in Arizona, 1997

Type, NAICS[1] classification	Number of farms[2]	1,000 acres in farms	Acres per farm
Cattle ranches	2,242	24,628	10,985
Feedlots	100	61	612
Dairy	114	23	202
Pigs and poultry	128	11	89
Other livestock and aquaculture	1,230	200	163
All livestock farms	**3,814**	**24,924**	**6,535**
Oilseed and grain	182	206	1,130
Vegetables and melons	210	391	1,862
Fruit and tree nuts	634	98	155
Greenhouse, nursery, flowers	259	24	92
Cotton	463	591	1,276
Hay and other crops	573	633	1,105
All crop farms	**2,321**	**1,943**	**837**
All farms	**6,135**	**26,867**	**4,379**

1. North American Industry Classification System.
2. The number is lower than in table 4, mainly because not all operators on Indian reservations are counted individually in the census.

Source: *1997 Arizona Census of Agriculture,* NASS, USDA.

Table 6. Acres and Estimated Value Added (VA), Average per Farm, and Percentage of Total for Selected Farm Types, 1997

	Average per farm		Percentage of total		
	Acres	VA $1000	Farms	Acres	VA
Livestock	**6,535**	**43**	**62.2**	**92.8**	**18.5**
Ranches	10,985	17	36.5	91.7	4.3
Feedlots	612	377	1.6	0.2	4.3
Dairy farms	202	793	1.9	0.1	10.3
Crops, etc.	**837**	**308**	**37.8**	**7.2**	**81.4**
Vegetables	1,862	1,311	3.5	1.5	31.4
Greenhouse, nursery, flowers	92	370	4.2	0.1	10.9
Cotton	**1,276**	**309**	**7.5**	**2.2**	**16.3**

Source: Based on *1997 Arizona Census of Agriculture,* NASS, USDA; VA calculated as value of products minus all cash expenses except for wages, interest, rent, and property taxes.

1 percent of total farmland. Farms with various types of plant production farmed the remaining 7 percent of the area. Ranching is thus stretched over the entire Arizona landscape.

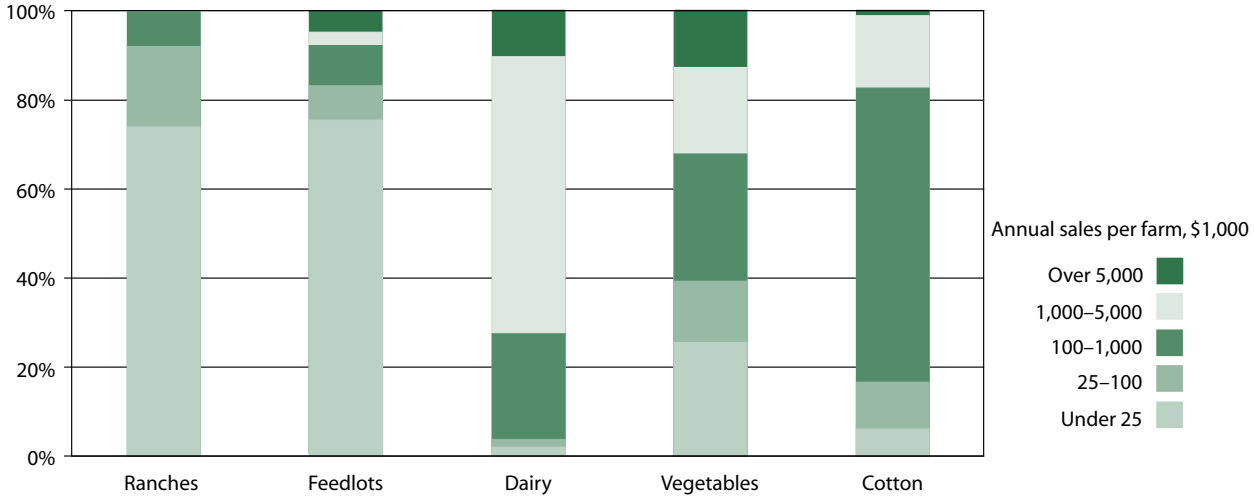
Land area alone does not reflect the general importance of the various farm types identified in table 5. Land productivity differs, and ranching represents a less intensive use of land than do other farm types, such as other livestock production and high-yielding irrigated crop farming. Value added is a useful common economic denominator that enables a more balanced comparison of size among different farm types. It reflects value added by a production process owing to the combination of labor and property assets, including but not limited to land, and renders a picture that is very different from the acreage comparison.

Value added in table 6 is approximated using information in the *1997 Census of Agriculture* on agricultural receipts and input expenditures. Ranches have 92 percent of total farmland but only 4 percent of total value added. Feedlots have the same share of value added but constitute less than 2 percent of all farms. On average, annual value added amounts to $17,000 for ranches, $377,000 for feedlots, and almost $800,000 for dairy farms. Crop farms also make up a much larger share of total value added than of total farmed acres, and on average their economic size is well above that of livestock operations.

Average farm size by farm type indicates some basic structural differences. However, averages fail to reveal that individual farms are widely dispersed around the averages within each group and that the distribution pattern differs significantly among farm categories. The 1997 census offers the possibility of illustrating the size distribution of individual operations within farm types using annual value of products sold per farm as a basis of comparison (figure 2).

Almost 75 percent of ranches had annual sales receipts under $25,000 and only 8 percent over $100,000. The average was $43,000 for all ranches. There are relatively few small dairy farms while more than 10 percent have an annual turnover of over 5 million dollars. About 75 percent of farms classified as feedlots have annual turnover under $25,000 just like ranches. Five percent of all feedlots had annual sales over 5 million dollars, which is half the rate in the dairy farm group. These figures seem to contradict the fact that on average, both feedlots and dairy farms sold products of roughly 2.5 million dollars in 1997. The explanation is that a handful of feedlots in the open-ended group over 5 million dollars are indeed very large units.

Figure 2. Percentage Distribution of Farms by Annual Sales Value per Farm



Source: Based on data from Economic Research Service, USDA.

Vegetable operations had average annual sales of 2 million dollars with a fairly even distribution comprising both many small and large units. A majority of cotton farms are found in the mid-sized groups. Their average annual sale comes to two thirds of a million dollars.

The varied farm size pattern among farm types entails differences with regard to market concentration. Based on the census data, it was estimated that 10 percent of ranches with the largest annual sales represent 75 percent of total sales from all ranches. The upper 10 percent of feedlots account for about 99 percent of total sales while the estimate for dairy with relatively few small farms is only 30 percent.

The pattern of organizational structure also varies among farm types (table 7). In 1997, sole proprietorships (individual or family, excluding partnerships and corporations) accounted for two-thirds of all farms and ranches. Individual ownership was very common for ranches and especially feedlots, while it was found at

Table 7. Percentage of Arizona Farms by Organization and Tenure, 1997

	Cattle ranches	Feedlots	Dairy farms	Vegetable and melon farms	Cotton farms	Greenhouses, nurseries, and flower farms	All farms
Organization:							
Individual or family	71	81	47	54	34	50	68
Partnership	14	8	23	20	52	11	17
Corporation	9	9	25	22	11	36	11
Cooperative, trust, institution	6	2	5	4	3	3	4
All farms	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Tenure:							
Full owner	73	83	60	45	36	67	70
Part owner/tenant	18	15	17	25	23	12	17
Tenant	8	2	24	31	41	21	14
All farms	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: *1997 Arizona Agricultural Census,* NASS, USDA.

Table 8. Expenses on Hired Labor by Selected Types of Farms, 1997

	Cattle ranches	Feedlots	Dairy farms	Vegetable & melon farms	Cotton farms	All farms
Total, million dollars	12.2	13.3	26.1	98.7	42.3	311.7
Per farm, thousand dollars	5.5	133.3	228.8	470.0	91.3	50.8

Source: *1997 Arizona Agricultural Census,* NASS, USDA.

only one-third of cotton farms and at about half of dairy farms, vegetable, greenhouse, nursery, and greenhouse operations. On the other hand, private partnership occurred most often on cotton farms. Corporate structure was found at more than one-third of greenhouse and nursery operations, at about one-fourth of dairy and vegetable farms, and roughly 10 percent of other farm types; most of them are held in family corporations. Cooperatives, trusts, and institutions owned 4 percent of all farms in 1997.

Organizational structure is matched by variations in the tenure form among the different farm types (see table 7). Full tenancy is more common for crop and dairy farms than for ranches and feedlots. On average for all farm types, 70 percent were under full ownership.

According to the 1997 census, the average expense for hired labor, including contract labor, was $50,800 for all farms (table 8). Ranches, representing 37 percent of all farms, only paid 4 percent of the total wage bill or the same as their share of total value added (see table 6). Compensation of hired labor averaged $5,500 for ranches, indicating that ranchers and their family members deliver the bulk of labor input. Vegetable operations, representing 6 percent of all farms in Arizona, accounted for 32 percent of total labor costs in 1997, again consistent with the share of value added. Labor cost on vegetable farms was close to half a million dollars. Based on the *2000 Arizona Agricultural Statistics Bulletin,* the hourly wage rate for farm work in the Mountain III Region (New Mexico and Arizona) was $6.61. Rough estimates using this rate indicate that the average vegetable farm provided 35 paid jobs, while dairy operations and feedlots typically had 17 and 10 hired workers, respectively. The estimated average for all farms is 3.8.

Income Formation in Arizona Agriculture

Tables 9, 10, and 11 display 1998–2002 statistics on total income formation in primary agriculture, the key sector for our impact analysis. The impact analysis has 2000 as its base year. The value of production increased to 3.3 billion dollars in 2002 from a level of 2.5–2.9 in the preceding four years (table 9). The increase of almost half a billion dollars came mainly from higher sales in the vegetable sector. Livestock output, which declined in 2002, fluctuated between 0.9 and 1.2 billion dollars over the 5-year period. Revenues from services, etc., which come to 0.3–0.4 billion dollars per year, include an imputed rental value of the farm dwellings. Inventory changes are included in total value of production but not shown separately in the table. Output data are gross figures calculated as the value of total production, part of which is used as a production input in other farming/livestock operations. For example, feed crops sold by farms (table 9) may end up as feed purchased by other Arizona farms (table 10).

The total value of inputs in farm production has been relatively stable around 1.2–1.4 billion dollars over the last three years, up about 130 million dollars from 1998 and 1999. This modest increase is mainly due to the purchase of livestock, which together with feed are the two largest single expenditure items. Table 11 summarizes revenues and expenditures. In addition, net transactions with the government—farm program payments minus taxes and fees—are included in the table. Combined, these elements determine gross value added (GVA). Note that property taxes, etc., are considered expenditures and not part of the GVA in the ERS tables. The ERS statistics are commodity oriented, which also gives rise to a certain deviation compared to the industry-oriented BEA statement of value added in table 3. GVA showed a substantial increase during the period, very much in line with output value, as input expenditures were relatively stable. Table 11 also shows net value added (NVA), which is GVA reduced by the evaluated consumption of real capital assets in the production process. Depreciation of building and farm implement values due to wear and aging reflect real capital consumption. NVA can be regarded as the remuneration of total input of labor and financial capital. When further deductions are made for wages to hired labor, rent, and interest payments on borrowed capital, we arrive at net farm income (NFI) at the bottom of table 11. NFI is the residual available for remuneration of farmers' and farm families' total input of labor and financial capital. Similar to GVA, both NVA and NFI showed substantial increases in 2001 and 2002, reflecting the output value changes.

A value-added concept similar to GVA is used as an important yardstick in the following analysis of agriculture's own direct impact and its indirect and induced ripple effects on the rest of the economy in Arizona. The value added approach eliminates double counting, which would occur if a simple summation of output values were taken to represent actual economic activity generated by the labor and capital resources invested in agriculture. Yet, the output value concept is of fundamental importance for the analysis since it is the only rational and feasible way to establish the linkages or economic transactions among the individual economic sectors.

Table 9. Crop and Livestock Production in Arizona, Thousand Dollars 1998–2002

	1998	1999	2000	2001	2002
Value of crop production	**1,357,211**	**1,223,934**	**1,273,646**	**1,385,395**	**1,892,913**
Food grains	42,650	19,791	21,080	23,029	28,87
Feed crops	104,267	102,549	111,469	165,862	138,995
Cotton	291,154	195,723	114,863	136,654	146,739
Oil crops	3,206	2,003	1,755	819	673
Fruits and tree nuts	112,237	117,066	98,902	67,376	94,478
Vegetables	736,941	646,679	711,197	883,588	1,350,730
All other crops	134,106	134,306	120,486	131,868	142,652
Home consumption	525	525	518	518	532
Value of livestock production	**915,548**	**1,016,765**	**1,061,681**	**1,205,857**	**1,081,627**
Meat animals	482,216	546,956	671,088	704,414	655,425
Dairy products	389,528	399,766	359,261	449,967	399,789
Poultry and eggs	4,335	9,477	11,193	13,537	14,127
Miscellaneous livestock	44,745	34,450	28,874	23,850	24,715
Home consumption	3,334	3,164	3,628	3,603	2,394
Revenues from services, etc.	**279,417**	**305,704**	**286,489**	**306,819**	**365,095**
Machine hire, custom work	28,001	17,095	16,132	20,869	22,812
Forest products sold	8,225	5,459	5,908	4,352	3,844
Other farm income	99,852	137,613	94,049	107,783	173,384
Imputed rental value dwelling	143,339	145,537	170,400	173,815	165,055
Value of production[1]	**2,552,176**	**2,546,403**	**2,621,816**	**2,898,072**	**3,339,635**

1. Including inventory changes.
Source: ERS, USDA.

Table 10. Value of Inputs Used in Arizona Agriculture, Thousand Dollars 1998–2002

	1998	1999	2000	2001	2002
Farm origin	**414,307**	**461,344**	**546,045**	**537,745**	**512,431**
Feed purchased	203,731	190,189	203,486	186,499	201,347
Livestock and poultry	161,289	216,940	289,048	299,143	253,348
Seed purchased	49,287	54,215	53,511	52,103	57,736
Manufactured inputs	**238,678**	**229,051**	**247,639**	**242,622**	**238,952**
Fertilizers and lime	77,055	70,865	67,289	67,958	66,805
Pesticides	79,868	75,330	78,053	74,423	74,423
Petroleum fuel and oils	48,878	49,554	70,202	64,677	60,587
Electricity	32,877	33,302	32,095	35,564	37,137
Other purchased inputs	**569,145**	**546,998**	**590,056**	**566,117**	**612,695**
Repair and maintenance	76,658	80,748	90,340	82,653	83,840
Machine hire, custom work	96,353	94,465	98,767	95,805	81,140
Marketing, storage, transport	77,518	68,692	76,018	66,728	96,426
Contract labor	47,107	47,668	61,463	49,596	46,328
Miscellaneous expenses	271,509	255,425	263,468	271,335	304,961
Value of inputs	**1,222,130**	**1,237,393**	**1,383,740**	**1,346,484**	**1,364,078**

Source: ERS, USDA.

Table 11. Value Added and Net Farm Income, Thousand Dollars 1998–2002

	1998	1999	2000	2001	2002
Production value	**2,552,176**	**2,546,403**	**2,621,816**	**2,898,072**	**3,339,635**
Inputs (–)	**1,222,130**	**1,237,393**	**1,383,740**	**1,346,484**	**1,364,078**
Net government transactions (+)	**36,947**	**67,189**	**64,740**	**58,112**	**27,163**
Direct government payments	78,784	107,899	107,066	99,254	68,926
Registration, licensing fee	3,153	2,526	3,264	2,958	2,262
Property taxes	38,684	38,184	39,062	38,184	39,501
Gross value added	**1,366,993**	**1,376,199**	**1,302,816**	**1,609,699**	**2,002,720**
Depreciation (–)	**130,799**	**133,766**	**139,948**	**145,338**	**149,616**
Net value added	**1,236,194**	**1,242,433**	**1,162,868**	**1,464,361**	**1,853,104**
Payment to stakeholders (–)	**345,612**	**360,193**	**385,372**	**371,855**	**390,868**
Employee compensation	302,069	310,048	338,272	340,055	352,708
Net rent and interest	43,543	50,145	47,100	31,800	38,160
Net farm income	**890,582**	**882,240**	**777,496**	**1,092,506**	**1,462,236**

Source: ERS, USDA.

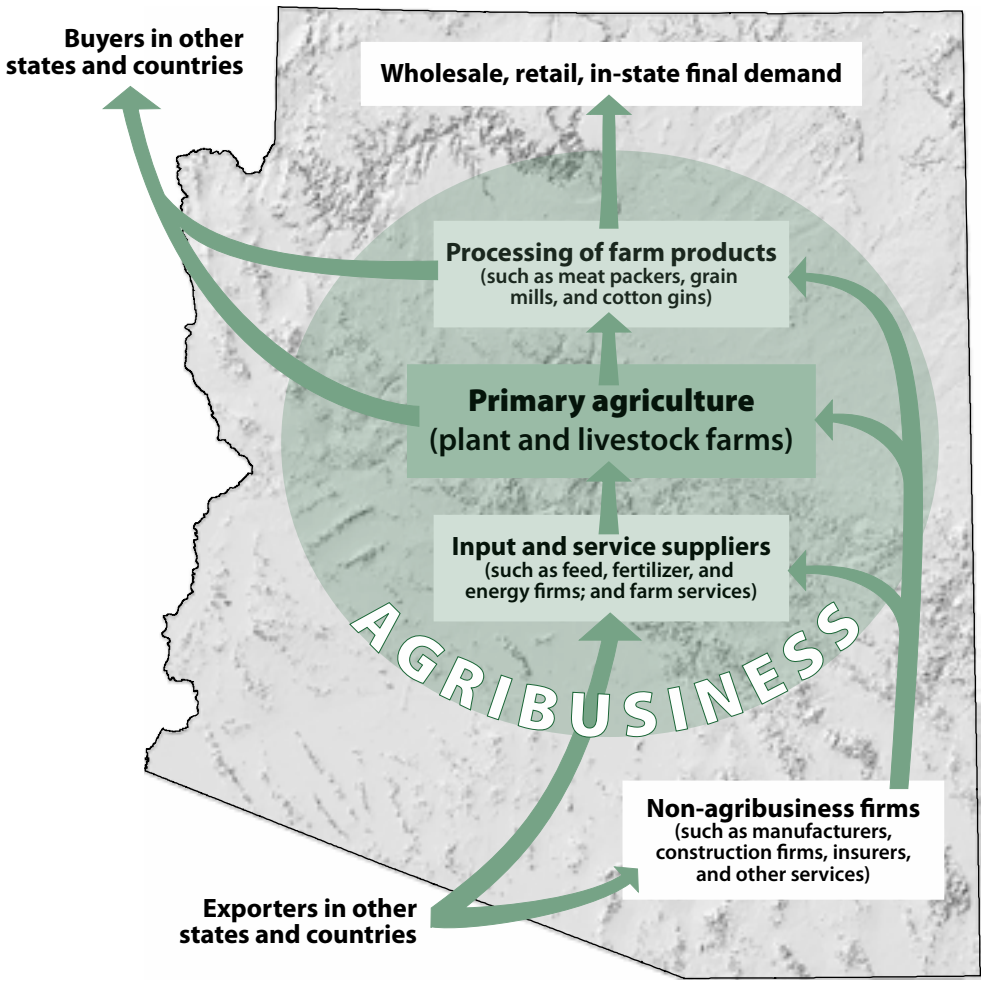
Total Economic Impact of Agricultural Production in Arizona

Specialization and division of labor characterize industries involved in today's supply of food, fiber, and other farm products for final consumption. Therefore, a full picture of the economic activity and employment associated with food supply requires examination not only of primary agriculture, but also of other directly and indirectly related sectors in the Arizona economy. The economic linkages among all sectors can be established using an input-output table that accounts for all inter-industry transactions. That is, an input-output table shows how much every industry buys from each of all other industries and to whom an industry sells its products—be it other industries or final consumers. The arrows in the stylized graph in figure 3 show the flow of goods and services in the total food and fiber supply system. Monetary payments, in the opposite direction, are the economic transactions that are recorded in the input-output table comprising all the sectors of the economy. The real world is significantly more complicated than what is shown in figure 3. For example, the schematic does not show that non-agribusiness firms, which supply agribusiness with goods and services, need some products from the agribusiness sector to carry out their activities. The schematic should therefore show many crisscrossing arrows to reflect real life. In any case, the sketch provides an outline of some general principles of input-output modeling and the practical procedures that are applied in order to capture the total economic impact associated with activity in a segment of the economy. A simple example is used to illustrate the input-output representation of the economy in Appendix A.

In the example, the inter-industry transactions represent the descriptive input-output table (table A1). This provides the basis for prediction of how activities in one or more sectors send rounds of ripples through other sectors of the economy via transaction linkages. Estimates of economic impacts can now be derived. One example could concern assessment of the total economic impact of a $10,000 increase in final demand for a specific commodity, say bottled milk. Another purpose might be to assess the impacts of a proposed new factory, for example in the computer industry. A third might pertain to establishing the economic importance of all production in a sector, for example copper mining. Yet another project could deal with a conglomerate of individual, but functionally closely related sectors. The purpose reported here is of the latter type and is concerned with the total economic effects of activities within what is termed agribusiness (primary agriculture plus closely related industries). An input-output model can capture these effects and is thus an appropriate tool for this study, the aim of which is to assess total direct and derived economic impacts associated with agricultural production in Arizona.

The analysis was conducted using the model software package IMPLAN Professional® Version 2.0, including base-year-2000 structural tables, from the Minnesota IMPLAN Group (MIG). Based on the Standard Industrial Classification (SIC), IMPLAN specifies 528 individual industries using the basic structure of the 1997 benchmark table for the economy from the Bureau of Economic Analysis (BEA). In the 2000 Arizona input-output table, 65–70 sectors appear with negligible or zero activity, thus leaving a table with 460 rows and 460 columns in which each entry shows how each of the 460 sectors buys from the other 459 (hence the name transaction matrix). Based on this descriptive image of the economy, multipliers can be established for all individual sectors allowing for prediction of the derived monetary impact that each sector exerts on the rest of the economy in addition to its own directly measured economic activity. Appendix A outlines some general principles for calculation of economic multipliers and impacts.

Figure 3. Linkages among Agribusiness Firms and Other Arizona Industries



Multipliers

Table 12 reports output and value-added multipliers for major sectors in Arizona's primary agriculture. Output multipliers are included in this table because output is the basic measure of transaction in an input-output table. The derived output multiplier is key to the calculation of other types of multipliers that provide a better basis for direct assessment of economic and employment impacts. Impact—or spillover—into the rest of the economy has two principal sources. One is mirrored by the indirect multiplier effect that is caused by backward linkages between the subject farm type, say dairy, and industries that provide goods and services to dairy farms. Further ripples due to these industries' backward linkages affect a still broader range of other sectors in the input-output table. The other source (the induced multiplier effect) reflects the economic impact from private consumption expenditures based on incomes earned by persons working on, for example, dairy farms. The sum of the two sources is shown as indirect-plus-induced multipliers in table 12.

It is important to note that indirect multiplier impacts do not (and should not) consider forward linkages to firms that buy products from the defined subject sector (for example, dairy farms) for further processing and distribution to final consumers. If we want to directly include activity in forward-linked industries (such as bottling firms, wholesale and retail), the model must be redefined by including

Table 12. Multipliers for Selected Types of Arizona Farms, 2000

Sector *(type of farm/ranch)*	Output multipliers		Value-added multipliers	
	Indirect	Indirect-plus-induced	Indirect	Indirect-plus-induced
Dairy	1.205	1.557	1.292	1.841
Range-fed cattle	1.467	1.877	1.568	2.268
Cattle feedlots	1.374	1.693	1.602	2.291
Cotton	1.377	1.776	1.438	1.963
Feed grains	1.285	1.653	1.285	1.718
Hay and pasture	1.309	1.677	1.329	1.787
Fruits	1.380	1.783	1.472	2.052
Vegetables	1.389	1.793	1.417	1.917

these additional industries as part of the subject sector. By doing so, the activity in the new industries will now be counted as part of the direct effect. The backward-linked economic impacts captured by the revised model will also include those stemming from the new industries.

Economic impacts corresponding to the multipliers are expressed in producer prices, that is prices at the level where the product exits the subject sector (for example, dairy farms). Value-added multipliers are derived by taking account of the ratio between value added and output for individual sectors in the input-output table. A similar procedure is applied to calculate multipliers with different bases, for example employment, by using the ratio between number of jobs and output in each sector.

Multiplier calculations take account of regional supply/demand balance for all commodities in extensive econometric analyses of production and trade flows, including exports and imports. Regional purchase coefficients (RPCs) are established by IMPLAN expressing the share of total demand in the area (Arizona) that is met by production inside the state. Like other basic data provided by IMPLAN, the coefficients can be adjusted to take account of additional information or to fit the relevant assumptions of a study project. Care must be taken to match project specifications with the right key coefficients. It is clear, for example, that a marginal change of activity that can be handled without hiring new employees would imply changes in household consumption that are different from a situation where additional hiring of employees must be assumed. Likewise, an increase in demand for a certain commodity that can be handled by existing firms in the pertinent sector would require additional new production factors inputs, which in volume and composition are very different compared to a situation where the additional demand entails establishment of a new firm. The flexibility within the IMPLAN software package enables adjustments that compensate for the basic rigid nature of input-output analyses. Once defined for a project, the structure locks the calculations in or limits the scope by implied assumptions such as constant returns to scale, no supply constraints, fixed input structure (no substitution) and same technology pertinent to both main and byproducts.

Continuing with the dairy sector as example, the value-added multiplier can be interpreted as follows: The indirect—also called Type I—multiplier of 1.292 means that an increase of $1 in value of sold milk from the farm will generate an additional $0.292 of added value in other backward-linked industries. The indirect-plus-induced multiplier of 1.841 shows that the spending of income generated by the $1 increase in milk production adds $0.549 in the form of induced

Table 13. Comparison of Some Total-Impact Value-Added Multipliers, 2000

Sector *(type of farm/ranch)*	SAM, including local and state government	SAM, excluding local and state government	Type II	Type III
Dairy	1.841	1.753	1.810	1.944
Range-fed cattle	2.268	2.098	2.166	3.326
Cattle feedlots	2.291	2.097	2.157	2.196
Cotton	1.963	1.812	1.866	2.226
Feed grains	1.718	1.556	1.587	2.164
Hay and pasture	1.787	1.623	1.657	3.321
Fruits	2.052	1.914	1.983	2.740
Vegetables	1.917	1.805	1.860	2.313

effect ($1.841 - $1.292). The total spillover from the $1 expansion of milk production is thus $0.841 in other sectors of the economy.

The indirect-plus-induced effect is often referred to as a Type II multiplier. In the present context it is more correct to use the term SAM multiplier, signifying that the household spending was derived from IMPLAN's Social Accounting Matrix. Calculation of SAM multipliers makes full use of social account information about transfers in the form of taxes, social security contributions, savings, etc. Households make consumption choices with only their disposable income but their taxes and savings data are retained in the model to capture further ripples induced by these transfers. The traditional Type II multiplier normalizes the household spending with the labor income, which yields slight differences compared to the SAM multiplier (table 13).

The SAM multiplier is flexible in the sense that one can select which final demand sectors to include in the multiplier calculation. In this study it was decided, apart from the induced household demand effect, to include effects from local and state government spending based on taxes levied on production and incomes generated by the production event that is examined. It is assumed that local and state government outlays are likely to remain in Arizona with full effect on the state economy. Generated federal government spending, etc., could also be included, which would add to the numerical multiplier values. This possibility was not exploited because the pertinent linkages to the Arizona economy are, at best, uncertain.

A SAM multiplier without the addition of local and state government spending effects is shown in table 13 for the comparison with other multiplier types. Type II multipliers are a little higher than the comparable SAM multipliers. A third variant of indirect-plus-induced multipliers (total-impact multipliers) is called Type III. It yields relatively high multipliers. In contrast to Type II and SAM, Type III assumes that induced effects through household spending are unrelated to wage levels in the impacted sectors but are instead directly related to the calculated number of jobs. Charney and Leones showed that only if wage levels in the examined sector and in its backward-related sectors are the same as those in the sectors subjected to induced effects, will Type II and Type III multipliers be identical. Otherwise, a relatively low-wage subject sector would, for example, result in Type III multipliers that are higher than Type II, representing an overestimation of induced impacts. This could be the case for most of the examined sectors in table 13. Type III was the multiplier used in the software chosen for the 1993 study of agriculture in the Arizona economy (Leones and Conklin). It was only after the 1993 study was published that the aforementioned problem with the Type III multipliers was

Table 14. Employment and Other Total-Impact Multipliers[1], 2000

Sector *(type of farm/ranch)*	Output	Value added	Employee compensation	Operator income	Employment (jobs)
Dairy	1.557	1.841	2.428	1.810	2.149
Range-fed cattle	1.877	2.268	2.820	2.162	1.786
Cattle feedlots	1.693	2.291	4.304	2.157	3.990
Cotton	1.776	1.963	2.578	1.866	3.499
Feed grains	1.653	1.718	5.814	1.587	1.832
Hay and pasture	1.677	1.787	7.010	1.657	1.339
Fruits	1.783	2.052	2.077	1.983	2.279
Vegetables	1.793	1.917	2.504	1.860	3.565

1. Type SAM multiplier, induced impact based on households and local and state government.

discovered and pointed out to the input-output modeling profession by Charney and Leones.

Table 14 shows some categories of total-impact multipliers that find use in many types of study projects. Besides output and value-added multipliers presented in table 12, columns have been added for employee compensation, operator income, and employment. The operator income multiplier is slightly lower than the value-added multiplier. The employee-compensation multiplier is generally higher than the value-added and operator-income multipliers. The employee-compensation multiplier shows a closer relation to the employment (job) multiplier. The variation vertically and horizontally in the table is due to many things. For example, the level of wages and total wage costs as a share of value added differ among both the farm sectors shown in the table and among those other sectors that are impacted by the economic ripples. Also, the ripples from the individual farm sectors may target different groups of sectors in the rest of the economy with varying cost structures.

Tables 15 and 16 illustrate the composition of multipliers to calculate the economic impact from dairy farm and cotton farm production, respectively. The first column shows the direct impact in the form of value added in the examined sector. Column 2, indirect impact, corresponds with the Type I multiplier in table 12. Column 3 shows the derived induced effect and column 4 sums the direct, indirect, and induced effects, thus corresponding with the total-impact SAM multiplier.

The direct activity at dairy farms of $150 million value added has a spillover in other sectors of $126 million distributed with $44 million in the form of indirect effects and $82 million value added as induced impact stemming from spending of personal incomes generated by dairy production. The indirect and induced impacts add 84 percent to the direct activity of $150 million at the dairy farms. About two-thirds of the spillover impact is concentrated on trade (wholesale and retail), finance, insurance and real estate, and services. For cotton in table 16, the indirect and induced impacts add 92 million dollars value added to the 96 million dollars direct activity of cotton farms, thus corresponding with a total-impact value added multiplier of 1.958. Two-thirds of the spillover pertains to services, trade, and the finance, insurance, and real estate sectors.

The derived multipliers in the last line of the two tables for dairy and cotton are slightly smaller than those shown in tables 13 and 14. The differences occur because the estimates in tables 15 and 16 concern economic impact from the entire dairy and cotton sector activity, respectively. The zeroes in the first line indicate that indirect and induced impacts are already captured by the recorded total activity

Table 15. Dairy Farm Value-Added Impacts[1], Thousand Dollars 2000

	Direct	Indirect	Induced	Total
Dairy farms	150,093	0	0	150,093
Other agricultural sectors	0	2,383	260	2,643
Directly agricultural-related sectors	0	6,759	281	7,040
Mining	0	26	23	49
Construction	0	2,255	1,407	3,662
Manufacturing	0	966	1,930	2,896
Transportation, communication, utilities	0	7,624	5,007	12,631
Trade	0	13,124	19,421	32,545
Finance, insurance, real estate	0	5,523	20,217	25,741
Services	0	4,255	23,712	27,966
Government	0	859	10,094	10,953
Total Impact	**150,093**	**43,775**	**82,351**	**276,219**
Value-added multiplier	**1.000**	**0.292**	**0.549**	**1.840**

1. SAM-induced impact based on households and local and state government.

Table 16. Cotton Farm Value-Added Impacts[1], Thousand Dollars 2000

	Direct	Indirect	Induced	Total
Cotton farms	95,973	0	0	95,973
Other agricultural sectors	0	467	173	640
Directly agricultural-related sectors	0	11,684	155	11,840
Mining	0	17	13	30
Construction	0	1,951	991	2,942
Manufacturing	0	797	1,071	1,868
Transportation, communication, utilities	0	3,909	2,780	6,690
Trade	0	9,271	10,652	19,923
Finance, insurance, real estate	0	9,050	11,087	20,137
Services	0	4,101	13,069	17,170
Government	0	443	10,224	10,667
Total impact	**95,973**	**41,691**	**50,215**	**187,879**
Value-added multiplier	**1.000**	**0.434**	**0.523**	**1.958**

1. SAM-induced impact based on households and local and state government.

at primary dairy and cotton farms. The slightly higher multiplier figures in tables 13 and 14 could be an appropriate basis for a separate "marginal"-change analysis for each sector, whereas the estimation when playing with the entire sector as in tables 15 and 16 must be modified so as to avoid any double counting of economic impacts.

By the same token, one cannot simply add the total impact figures of tables 15 and 16 to get the combined total effect from dairy and cotton. This will be clear when considering that dairy exerts indirect and induced effects of more than $42,000 on cotton, and that cotton similarly has a $62,000 impact on the dairy calculation. But these amounts have already been included in the direct activity for cotton and dairy farms, respectively. This matter becomes clear if supposing that impact analyses were done for every single sector in Arizona's economy. Each sector would display a total multiplier of at least one, implying a derived impact

in addition to the direct activity in the sector itself. By adding total impact in all sectors the paradoxical result would be that Arizona's economy is larger than Arizona's economy! The issue of avoiding any double counting is pertinent and will be dealt with in the following assessment of economic impact from all the sectors that constitute agribusiness in Arizona.

Economic Impacts from Activity in the Agribusiness Sector

Delineation of agribusiness is the initial step for the impact calculations. 54 economic sectors were selected to constitute agribusiness in Arizona. There are 22 IMPLAN sectors representing primary agriculture, such as ranches, other livestock farms, and operations with food and fiber crops or other kinds of plant production. Aquaculture firms (fish), horticulture, and nurseries are among the 22 sectors. Forest industries are not, but forest products marketed as byproducts by the selected agricultural sectors will remain in the calculations. Equine activity on farms and apiculture are also included.

Supply, processing, and service industries that are closely linked with agriculture constitute the remaining 32 IMPLAN groups. The selection criterion was to include those sectors that likely would not exist—or at least be drastically smaller—if there were no primary farm and ranching activity in Arizona. The agribusiness list includes all major industries that pack or process livestock and plant products, as well as suppliers of means of production and services that are specific to primary agriculture. Appendix B shows which groups are included in agribusiness according to SIC.

Arizona firms that specialize in food distribution (transport, wholesale, and retail) are not considered part of agribusiness. Their activity depends on general Arizona demand for food and fiber products and it would remain more or less the same even if the basic agricultural product input originated from another geographical region than Arizona. This delineation of agribusiness is in close concert with the 1993 study (Leones and Conklin) but is less comprehensive than what is often referred to in general statistics as food industry, mainly because of the mentioned restricted definition of agriculture-related firms. The calculations will therefore display a ratio of agriculture-related activity to primary agricultural activity that is lower than, for example, that displayed in table 3 with data on Arizona GSP. Supply of goods and services to the agribusiness sector from other firms do not appear as direct activity but are captured as backward-linked indirect effects based on the input-output transaction table.

Summary results of the impact calculations are shown in table 17. Total output value has a pivotal role as a measure of transactions in the input-output modeling

Table 17. Economic and Employment Impact from Agribusiness Activity, 2000

	Billion dollars			Employment 1,000 jobs
	Output	Value added	Wages	
Primary agriculture	2.3	1.1	0.4	21
Agriculture-related sectors	2.2	0.6	0.3	27
Direct effect, agribusiness	**4.5**	**1.7**	**0.7**	**48**
Indirect effect	0.9	0.5	0.3	8
Induced effect	1.2	0.8	0.5	17
Total impact	**6.6**	**3.0**	**1.5**	**73**
Derived multiplier	**1.47**	**1.81**	**2.10**	**1.53**

of agribusiness. However, value added—expressing combined compensation to employed labor and property assets—yields a more rational basis for assessing and expressing agribusiness's economic impact. It avoids double counting by disregarding transactions (output) that do not represent sales for final consumption but rather input in the production process of other industries. The model for the whole agribusiness sector was adjusted to avoid double counting ripples that would otherwise show up and add to agribusiness's total activity, which has already been recorded as direct activity.

In 2000, value added within agribusiness was 1.7 billion dollars—1.1 in primary agriculture and 0.6 billion dollars in the directly related industries. The spillover to other sectors of the economy amounted to 1.3 billion dollars—0.5 billion as the indirect effect of linkages to other business sectors and 0.8 billion dollars induced by spending of generated incomes—corresponding with a value-added multiplier of 1.8 for agribusiness.

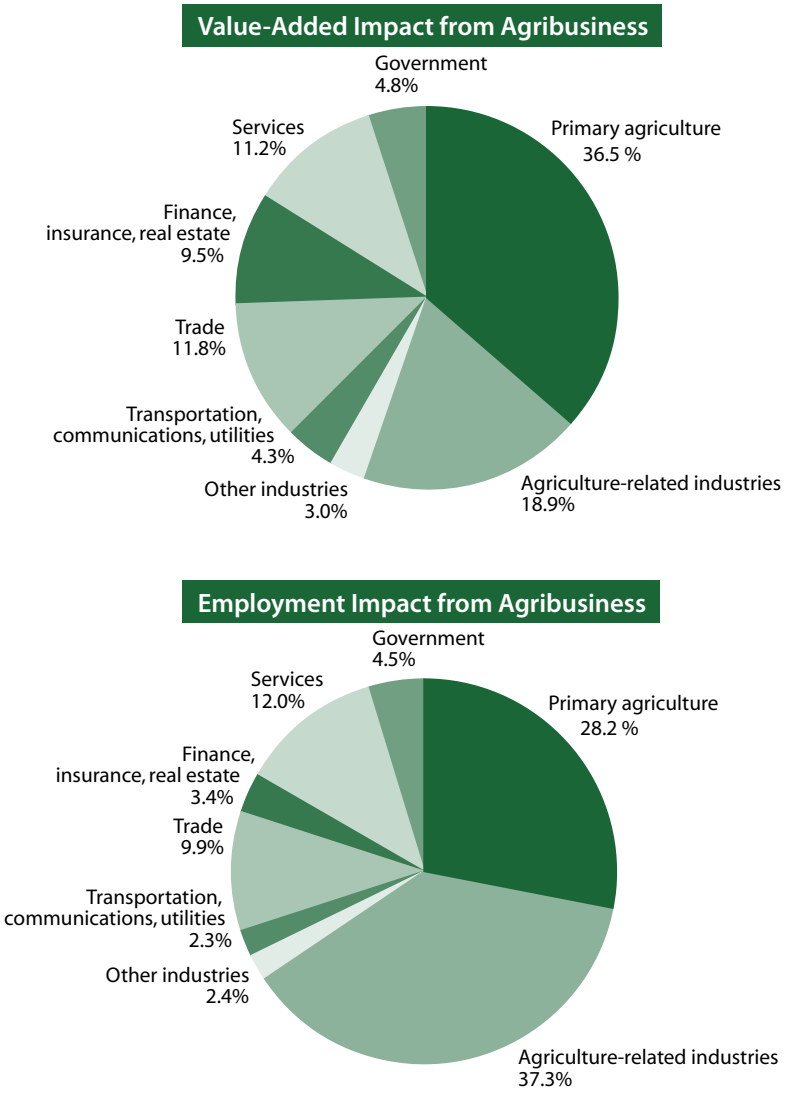
Agribusiness employed 48,000 persons—wage and salary employees plus self-employed farmers, etc.—of whom almost 21,000 were in primary agriculture and 27,000 in closely related industries. The total agribusiness activity gave rise to an additional 25,000 jobs in other sectors so that the derived employment multiplier was 1.5. In other words, every 100 jobs in primary agriculture enabled employment for 132 persons in other sectors of agribusiness and for an additional 122 persons in sectors outside agribusiness, all together 254 jobs. Employment in all sectors is in terms of persons employed, both full time and part time—standardization to full-time jobs was not pursued in this study. Variation in hourly wages among economic sectors and a relatively high share of self-employment in agriculture has the effect that the derived wages multiplier is significantly higher than the employment multiplier.

More details about the value-added impacts are shown in table 18. There are no calculated indirect and induced impacts for the agribusiness sector since the total value added is already captured as direct effect. Wholesale and retail trade accounted for one-third of agribusiness's indirect impact on other sectors, and significant indirect spillover was also recorded for services, finance, insurance and real estate, and transportation. These four sectors represent over 85 percent of the calculated total indirect effect, which amounts to 535 million dollars or 32 percent of the direct value added in agribusiness. That corresponds with a Type I multiplier for value added of 1.320.

Table 18. Value-Added Impact from Agribusiness, Million Dollars 2000

	Direct	Indirect	Induced	Total
Primary agriculture	1,101.6	0	0	1,101.6
Agriculture-related sectors	569.9	0	0	569.9
Agribusiness	**1,671.5**	**0**	**0**	**1,671.5**
Mining	0	0.5	0.2	0.7
Construction	0	29.2	15.1	44.3
Manufacturing	0	28.8	18.1	46.9
Transportation, communications, utilities	0	81.7	47.2	128.9
Trade	0	174.5	182.7	357.2
Finance, insurance, real estate	0	96.9	190.6	287.4
Services, etc.	0	114.2	224.0	338.2
Government	0	9.0	137.0	146.0
Total	**1,671.5**	**534.7**	**815.0**	**3,021.3**
Multiplier for agribusiness	**1.000**	**0.320**	**0.488**	**1.808**

Figure 4. Total Value-Added and Employment Impacts from Agribusiness by Sector



The consumption generated, induced value-added impact from agribusiness is 815 million dollars or 49 percent of the direct value-added activity. Three sectors—services; finance, insurance, and real estate; and trade—represent about 600 million dollars or three-fourths of total-induced impact, and a significant impact on the public sector is also recorded.

Indirect and induced impacts add up to over 1,300 million dollars, which is 80.8 percent of the direct value added in agribusiness. The total-impact value-added multiplier (the IMPLAN SAM multiplier) that counts direct, indirect, and induced effects is therefore 1.808 (= sum of 1,672, 535, and 815 million dollars divided by 1,672 million dollars). The distribution of total agribusiness impact by main economic sectors is shown in figure 4.

The employment impact from agribusiness is specified by sectors and types of impact in table 19. Distribution of total indirect impact displays some similarities to the pattern for value added, although with more weight on services. The total indirect employment impact in all sectors outside agribusiness is almost 8,300 jobs, which is 17.3 percent of employment in agribusiness, consistent with a Type I multiplier of 1.173.

Table 19. Employment Impact from Agribusiness, Jobs 2000

	Direct	Indirect	Induced	Total
Primary agriculture	20,573	0	0	20,573
Agriculture-related sectors	27,233	0	0	27,233
Agribusiness	**47,806**	**0**	**0**	**47,806**
Mining	0	7	3	10
Construction	0	644	314	958
Manufacturing	0	480	269	748
Transportation, communications, utilities	0	1,136	514	1,650
Trade	0	2,224	5,004	7,228
Finance, insurance, real estate	0	1,134	1,328	2,463
Services, etc.	0	2,550	6,214	8,764
Government	0	87	3,206	3,292
Total	**47,806**	**8,261**	**16,853**	**72,920**
Multiplier for agribusiness	**1.000**	**0.173**	**0.353**	**1.525**

Services, trade, and government together take about 85 percent of the total induced employment impact. Total induced employment was 16,853 jobs in 2000 or 35 percent of direct employment in agribusiness.

The sum of indirect and induced employment impacts is over 25,000 jobs. That is 52.5 percent of direct employment in agribusiness so that the total-impact employment multiplier is 1.525. A breakdown of total impact by sectors is shown in Figure 4.

Conclusions about Economic and Employment Impacts from Arizona Agribusiness

In 2000, production in Arizona agriculture had a value of more than 2.3 billion dollars. After accounting for necessary operation expenditures, value added in primary agriculture represented an economic activity of 1.1 billion dollars.

Many firms base their existence on supplying goods and services to agriculture just as the activity in many processing and packing industries is dependent on the input of plant products, live animals, and livestock products from agriculture. These agriculture-linked firms represented an additional 2.2 billion dollars of output and 0.6 billion dollars of value added in 2000.

The industry complex consisting of the firms in primary agriculture and in its dependent supply and processing industries is called agribusiness. Agribusiness represented an output value of 4.5 billion dollars in 2000 and its total value added came to 1.7 billion dollars.

Agribusiness provided direct employment for 48,000 employees and self-employed persons in 2000, 21,000 of whom were in primary agriculture. Employees in agribusiness received compensation of more than 700 million dollars.

Agribusiness activity sends ripples into many other Arizona economic sectors that deliver goods and services to firms in agribusiness. This indirect effect was captured in an input-output model of agribusiness's own economic activity and its impact on the rest of the Arizona economy. The indirect impact in other sectors was 0.9 billion dollars output and 0.5 billion dollars value added. That is a 20 percent addition to output value in agribusiness and a 32 percent one for value added. The indirect employment effect was over 8,000 persons or 17 percent of direct employment in agribusiness.

Further economic activity is induced by personal consumption with incomes based on the direct and indirect agricultural activity. The induced impact is 1.2 billion dollars in output and 0.8 billion dollars in value added—27 and 49 percent of the respective values in agribusiness. The induced employment impact is over 17,000 persons, which adds 35 percent to employment in agribusiness.

In 2000, indirect and induced impacts together added 2.1 billion dollars output (47 percent), 1.3 billion dollars value added (81 percent), and 25.000 jobs (53 percent) to the direct activity in agribusiness. The total impact from agricultural production in Arizona was therefore 6.6 billion dollars output, 3.0 billion dollars value added, and 73,000 jobs. The total multipliers were 1.47, 1.81, and 1.53 for output, value added, and employment, respectively.

NOTE: A similar study based on 1988–1990 data (Leones and Conklin) showed a 6.3 billion dollar output impact from agribusiness. Adjusted for inflation between 1988–90 and 2000 (base year for the present study) and assuming little change in total output volume, the impact found in the previous study could be stated as 7.9 billion 2000-dollars, which is considerably higher than the 6.6 billion dollars result of the present study. The difference is due to use in the previous study of the so-called Type III multiplier, which according to later research (Charney and Leones) led to overstated results. When corrected to the level of today's recommended calculation approach, an up-date of the 1988–90 study would yield a total output impact of 6.6 billion dollars, which is the same as found in the present study. There is also good correspondence between value added and employment estimates.

References

Arizona Agricultural Statistics Bulletin (annual). USDA, NASS Arizona Agricultural Statistics Service, The University of Arizona, and Arizona Department of Agriculture.

Ball, V.E., J-P. Butault, and R. Nehring. "U.S. Agriculture, 1960–96: A Multilateral Comparison of Total Factor Productivity." U.S. Department of Agriculture, Economic Research Service, Technical Bulletin Number 1895, May 2001.

Census of Agriculture, *Arizona State and County Data 1997,* Volume 1, Part 3, U.S. NASS, USDA.

Charney, A.H., and J. Leones. "IMPLAN's Induced Effects Identified through Multiplier Decomposition." *Journal of Regional Science,* 37(1997):503–517.

Charney, A.H., and M.J. Vest. "Modeling Practices and Their Ability to Assess Tax/Expenditure Economic Impacts." Paper to the AUBER Conference, New Orleans. The University of Arizona, October 1993.

Elitzak H. "Food Cost Review 1950–97." U.S. Department of Agriculture, Economic Research Service, Food and Rural Economics Division, Agricultural Economics Report No. 780, June 1999.

Hastings, S.E., and S.M. Brucker. "An Introduction to Regional Input-output Analysis." In D.M. Otto and T.G. Johnson, eds. *Microcomputer-Based Input-Output Modeling.* Boulder, CO: Westview Press, 1993, pp.1–27.

Leones, J.P., and N.C. Conklin. "Agriculture in the Arizona Economy." Arizona Department of Agriculture, Arizona State University, and The University of Arizona, April 1993.

Leontief, W. *Input Output Economics.* Second edition. New York: Oxford University Press, 1986.

Minnesota IMPLAN Group Inc. (MIG). Implan Professional® Version 2.0, Social Accounting and Impact Analysis Software. Second Edition. Stillwater, Minnesota, June 2000.

Online statistics and other information

U.S. Department of Agriculture, Economic Research Service (http://www.ers.usda.gov).

U.S. Department of Agriculture, National Agricultural Statistics Service (http://www.usda.gov.nass).

U.S. Department of Commerce, Bureau of Economic Analysis (http://www.bea.doc.gov).

U.S. Department of Commerce, Bureau of The Census (http://www.census.gov).

Appendix A—Example Showing Derivation of Multipliers

Transaction Table

The principles of multiplier calculation are illustrated in many textbooks, papers, and journal articles. The following fictional and very simplified example of an economic system with only three economic sectors of industries has received inspiration from, among others, the IMPLAN user guide, and Hastings and Brucker.

The data showing economic linkages among industries is normally referred to as the *transaction table* (shaded background in table A1). The Industry1-row shows that Industry1 sells $1 million worth of goods to be used as inputs in Industry1 itself, while $1 and $8 million worth of output is sold to Industry2 and Industry3, respectively. The rest of Industry1's $120 million total output is available for household consumption and consumption in other groups, such as public institutions. Corresponding information can be obtained by reading the lines for the other industries.

The column for Industry1 shows from where it acquires inputs that are needed to produce the $120 million worth of output. Industry1 buys goods and materials worth $35 million from itself and the two other industries, and so $85 million is available to labor and capital. The total outlay from Industry1 is $120 million—the same as its total output. This identity of course also holds for the other industries. Normalization of the outlay columns for all industries—dividing each item by the column total—allows for easier comparison of input composition, or *production function*, among industries (table A2). The array of coefficients are elements of what is often referred to as the ***A*** *matrix* so that, for example element a_{21} (0.042) is the share of all inputs that Industry1 acquires from Industry2. The element a_{52} (0.206) shows that use of real capital assets represents 20.6 percent of Industry2's total outlay. Roundings may cause the coefficients not to sum to the column total of 1.000.

Letting x_i denote total output from Industry$_i$ and Y_i be final demand for products from Industry$_i$, the information in the two tables can be rewritten as a set of linear identities

$$x_1 = 0.008^*x_1 + 0.003^*x_2 + 0.018^*x_3 + Y_1$$
$$x_2 = 0.042^*x_1 + 0.041^*x_2 + 0.000^*x_3 + Y_2$$
$$x_3 = 0.242^*x_1 + 0.103^*x_2 + 0.071^*x_3 + Y_3$$

Table A1. Annual Transactions, Million Dollars—Fictive Example for Illustration

	Buying industry			Demand groups		Total industry output
	Industry1	Industry2	Industry3	Households	Others	
Selling industry						
Industry1	1	1	8	80	30	120
Industry2	5	14	0	270	51	340
Industry3	29	35	32	295	59	450
Total	35	50	40			
Value added						
Labor	20	220	340			
Capital	65	70	70			
Total VA	85	290	410			
Total industry outlay	120	340	450			

Solving for the Ys, the equations become

$$x_1 - 0.008*x_1 - 0.003*x_2 - 0.018*x_3 = Y_1$$
$$- 0.042*x_1 + x_2 - 0.041*x_2 - 0.000*x_3 = Y_2$$
$$- 0.242*x_1 - 0.103*x_2 + x3 - 0.071*x_3 = Y_1$$

Further rewriting yields

$$(1 - 0.008)*x_1 - 0.003*x_2 - 0.018*x_3 = Y_1$$
$$- 0.042*x_1 + (1 - 0.041)*x_2 - 0.000*x_3 = Y_2$$
$$- 0.242*x_1 - 0.103*x_2 + (1 - 0.071)*x_3 = Y_3$$

The system of equations can be expressed as matrices and the last rewrite reveals the existence of an identity matrix, which helps the further derivation of the multipliers.

I denotes the identity matrix
A is the coefficient matrix
X is the vector denoting the industries, and
Y is the final demand vector

$$\left|\begin{array}{ccc} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{array}\right| \; (I) \; - \left|\begin{array}{ccc} 0.008 & 0.003 & 0.018 \\ 0.042 & 0.041 & 0.000 \\ 0.242 & 0.103 & 0.071 \end{array}\right| \; (A) \; * \left|\begin{array}{c} x_1 \\ x_2 \\ x_3 \end{array}\right| \; (X) \; = \left|\begin{array}{c} Y_1 \\ Y_2 \\ Y_3 \end{array}\right| \; (Y)$$

The matrix equation in condensed form is

$$\mathbf{(I - A) * X = Y}$$

Solving this expression for **X** yields the predictive multiplier model

$$\mathbf{X = (I - A)^{-1} * Y}$$

$\mathbf{(I - A)^{-1}}$, the inverted **(I - A) matrix**, is also known as the "Leontief Inverse," which is the basis for establishing multipliers for individual industries.

$\mathbf{(I - A)^{-1}}$ Leontief Inverse

1.013	0.005	0.019
0.044	1.043	0.001
0.269	0.117	1.082

Type I Multipliers

Type I multipliers—direct economic activity in the examined industry plus spillover in other industries—are shown in table A3. For example, the Type I output multiplier for Industry1 is found as the sum of the elements in the Industry1-column of the Leontief Inverse, 1.326. This figure tells us that a one-dollar change (increase) of final consumption of Industry1's product requires a $1.013 increase of the total output in Industry1 with ripple effects into other industries amounting to $0.044 + $0.269. Similar interpretations can be made for Industry2 and Industry3.

These multipliers can be used to measure "marginal" impact, for example, of demand expansion or contraction for a certain commodity, of establishing a new production unit in a certain industry, and so on. A precondition is, of course, that average industry data in the transaction table also apply to

Table A2. Coefficients of Inputs by Industry—the A Matrix

	Industry1	Industry2	Industry3
Industry1	0.008	0.003	0.018
Industry2	0.042	0.041	0.000
Industry3	0.242	0.103	0.071
Labor	0.167	0.647	0.756
Capital	0.542	0.206	0.156
Total	**1.000**	**1.000**	**1.000**

Table A3. Calculated Type I Output Multipliers by Industry

	Industry1	Industry2	Industry3
Industry1	1.013	0.005	0.019
Industry2	0.044	1.043	0.001
Industry3	0.269	0.117	1.082
Type I output multiplier	**1.326**	**1.165**	**1.102**

Table A4. Derivation of Type I Value-Added Multiplier for Industry1

	Direct and indirect output impact	Value added per dollar of output	Direct and indirect value-added impact
Industry1	1.013	0.708	0.718
Industry2	0.044	0.853	0.038
Industry3	0.269	0.911	0.245
Value-added multiplier	**1.326**		**1.393**

marginal changes; if that is not the case, then data adjustments should be made before the model is run. If the total activity and its impacts are considered, for example in Industry1, the indirect effect of Industry1 on itself (represented by 0.013 out of 1.013 in table A3) is already included in the total direct impact as shown in the transaction matrix (table A1). In this case, the model must be adjusted to avoid the double counting of activity. A similar double counting problem must be solved when examining the combined impact from more than one industry.

Output is the only feasible basis for establishing the links—transactions between industries. The output approach implies the possibility of double counting activity that at the same time represents both output from one firm (for example feed cereals) and production input (feed) in another. A value-added concept may therefore be considered a better yardstick for measurement of impact, or one might want to illustrate the impact on an employment basis. Derivation of a value-added multiplier for Industry1 is illustrated in table A4.

The ratio between value added and output for each industry is multiplied by the Industry1-coefficients from the Leontief Inverse in table A3 to get the figures in column 4 of table A4. The value-added multiplier of 1.393 is then found as (0.718 + 0.038+0.245) / 0.718.

The procedure in Table A4 can be used to establish a job multiplier by calculating jobs per dollar of output for the individual industries.

Table A5. Calculated Type II Output Multipliers by Industry

	Industry1	Industry2	Industry3
Industry1	1.016	0.010	0.025
Industry2	0.090	1.130	0.095
Industry3	0.278	0.134	1.100
Household income	0.437	0.834	0.897
Type II output multiplier	**1.820**	**2.109**	**2.116**

Type II Multipliers—Inclusion of Induced Impact from Household Spending

The induced impact is an effect of private consumption spending of incomes generated on the basis of agribusiness activity. The first step in capturing the deduced impact is to expand the **(I - A)** coefficient matrix with a row for earned incomes based on the **A** matrix in table A2 and with a new "industry" column reflecting estimated coefficients for households' private expenditures:

	Industry 1	**Industry2**	**Industry3**	**(Household spending)**
	0.008	0.003	0.018	0.005
Expanded	0.042	0.041	0.000	0.100
A matrix	0.242	0.103	0.071	0.007
(Earned income)	0.167	0.647	0.756	0.000

The corresponding **(I - A)** becomes:

	0.992	-0.003	-0.018	-0.005
Expanded	-0.042	0.959	0.000	-0.100
(I - A)	-0.242	-0.103	0.929	-0.007
	-0.167	-0.647	-0.756	1.000

And the expanded Leontief Inverse is:

	1.016	0.010	0.025	0.006
Expanded	0.090	1.130	0.095	0.114
$\mathbf{(I - A)^{-1}}$	0.278	0.134	1.100	0.023
	0.437	0.834	0.897	1.092

The Type II output multipliers are calculated in Table A5 as the sum of the coefficients in the expanded Leontief Inverse. Type II multipliers are higher than Type I because they capture both the indirect and the induced impacts.

Appendix B—Delineation of Agribusiness

*Primary Agriculture and Agriculture-Related Industries**

IMPLAN sector	Corresponding Standard Industrial Classification (SIC) codes	
	Farms and ranches—primary agriculture—22 sectors	
1. Dairy	0241	Also part of 0191 0259 0291
2. Poultry and eggs	0251 0252 0253	Also part of 0191 0219 0259 0291
3. Ranch-fed cattle		Part of 0191 0212 0219 0259 0291
4. Range-fed cattle		Part of 0191 0212 0219 0259 0291
5. Cattle feedlots	0211	Also part of 0191 0219 0259 0291
6. Sheep, lambs and goats	0214	Also part of 0191 0219 0259 0291
7. Hogs, etc.	0213	Also part of 0191 0219 0259 0291
8. Other meat animals		Part of 0191 0212 0219 0259 0291
9. Miscellaneous livestock	0271 0272	Also part of 0191 0219 0259 0273 0279 0291
10. Cotton	0131	Also part of 0191 0219 0259 0291
11. Food grains	0111 0112	Also part of 0191 0219 0259 0291
12. Feed grains	0115	Also part of 0139 0191 0219 0259 0291
13. Hay and pasture		Part of 0139 0191 0219 0259 0291
14. Grass seeds		Part of 0139 0191 0219 0259 0291
16. Fruits	0171 0172 0174 0175	Also part of 0179 0191 0219 0259 0291
17. Tree nuts		Part of 0173 0179 0191 0219 0259 0291
18. Vegetables	0134 0161	Also part of 0119 0139 0191 0219 0259 0291
20. Miscellaneous crops		Part of 0119 0139 0191 0219 0259 0291
21. Oil bearing crops	0116	Also part of 0119 0139 0173 0219 0259 0291
22. Forest products	0810 0830 0970	Forest products from farms and ranches
23. Greenhouse, nursery	0182	Also part of 0181 0191 0219 0259 0291
25. Aquaculture (fish)	0910	

* Source: IMPLAN User Guide

IMPLAN sector	Corresponding Standard Industrial Classification (SIC) codes	
Agricultural-related supply, service, and processing industries—32 sectors		
26. Agricultural services	0710 0720 0750 0760 0254 0850 0920	Also part of 0279
58. Meat packing	2011	
59. Sausages, prepared meats	2013	
60. Poultry processing	2015	
63. Condensed milk	2023	
64. Ice cream, frozen desserts	2024	
65. Fluid milk	2026	
66. Canned specialties	2032	
67. Canned fruit and vegetables	2033	
68. Dehydrated food products	2034	
69. Pickles, etc.	2035	
70. Frozen fruit, juices, etc.	2037	
71. Frozen specialties	2038	
72. Flour, other mill products	2041	
75. Prepared flour	2045	
76. Wet corn milling	2046	
77. Pet food	2047	
78. Prepared feeds	2048	
85. Prepared nuts and seeds	2068	
86. Cotton seed oil mills	2074	
88. Vegetable oils	2076	
89. Animal fats and oils	2077	
93. Wineries	2084	
102. Macaroni products	2098	
103. Food preparation, other	2099	
108. Broadwoven fabrics	2210 2220 2230 2261	
116. Yarn mills, etc.	2269 2281 2282	
118. Thread mills	2284	
203. Fertilizer mixing	2875	
204. Agricultural chemicals	2879	
221. Leather tanning	3110	
309. Farm machinery, equipment	3523	