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IMPLAN Understates Agricultural Input-Output Multipliers: An Application to Potential Agricultural/Green Industry Drought Impacts in Colorado

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Synthesized input-output models are widely used by industry and government economists. The IMPLAN program is popular because it provides user access to the base data so that modifications can be made. The Washington survey-based model and IMPLAN for Washington State are compared, and differences in multipliers are traced to differences in final payments leakages. An adjustment technique for IMPLAN is demonstrated. An application is made to a Colorado potential drought impact analysis. More than 51,000 part- and full-time jobs and $1.6 billion of household income are at stake in the Colorado farm and "green industry" sectors.

Key Words: drought, economic impact, green industry, IMPLAN, input-output, irrigated agriculture

Synthesized input-output using IMPLAN provides quick and inexpensive multiplier estimates, but accuracy is less than is found in some survey-based models. Developed by the U.S. Forest Service (Alward and Palmer, 1981; Taylor et al., 1992), the commercial IMPLAN database and program are popular among government and industry economists (Minnesota IMPLAN Group, Inc., 1999). Advantages of IMPLAN include easy access to its underlying databases and to user assistance. IMPLAN also offers many more sectors than most survey-based models, which could greatly reduce aggregation bias.[1]

Noting cost, versatility, and the user-friendly program interface, the IMPLAN database was selected over other synthesized databases (Morrison and Smith, 1974; Radtke, Detering, and Brokken, 1985; Brucker, Hastings, and Latham, 1987, 1988; McKean et al., 1998). However, the IMPLAN program contains accounting

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[1] A shortcoming of IMPLAN is the aggregation of all types of electric generating plants (hydro, coal, gas, etc.) into a single sector. When IMPLAN attempts to balance the erroneous transactions among sectors, serious errors can result, especially for small region models. The power plant aggregation occurs in IMPLAN because power plants are not disaggregated in the national model.

conventions which misstate the leakages of spending from a region. We investigated the sensitivity of the multipliers to changes in IMPLAN accounting in order to create more accurate multipliers.[2]

Survey-Based versus Synthesized Multipliers

Many comparisons have been made between survey-based models and synthesized models (Schaffer and Chu, 1969; Morrison and Smith, 1974; Round, 1983; Sawyer and Miller, 1983; Radtke, Detering, and Brokken, 1985; Brucker, Hastings, and Latham, 1987, 1988; Rickman and Schwer, 1995). However, recent survey-based input-output models are scarce.

The Washington model is a survey-based model which has undergone updates over a long period of time (Bourque et al., 1967; Bourque and Conway, 1977; Bourque, 1987; Chase, Bourque, and Conway, 1993). Comparison of multipliers for Washington reveals a significant understatement by IMPLAN relative to the benchmark survey-based model. Columns 2 and 3 of table 1 present value-added multipliers for selected agricultural-related sectors from the 1987 survey-based Washington Input-Output Study and Washington IMPLAN. IMPLAN multipliers are often displayed as a range because IMPLAN offers many more sectors than the survey-based Washington model. (The variation in values of the IMPLAN multipliers reflects an advantage of the high level of disaggregation offered by IMPLAN.) Table 1 shows the understatement of the value-added multipliers generated by IMPLAN relative to the Washington survey-based model. The unadjusted IMPLAN Washington (and Colorado) value-added multipliers are much smaller than those found in the survey-based model. The consistent multiplier understatement by IMPLAN implies a major difference in accounting between the survey-based model and the synthesized model.

A source of error is in the IMPLAN treatment of final payments. Regionalization of the national final payments accounts requires data that are not readily available. Proprietor income is made endogenous, but the other property type income, which dominates final payments, is made totally exogenous when it should be partly endogenous. Overstatement of leakages in the farm as well the nonfarm sectors understates the size of the IMPLAN agricultural multipliers. Columns 4, 5, and 6 of table 1 show the increase in Colorado value-added multipliers as more components of final

[2] IMPLAN does not provide output (or for any other variable) multipliers based on changes in sales to final demand by households or proprietor income even though they are endogenous in the Type II or Social Accounting Matrix (SAM) models. Value-added multipliers created by IMPLAN show the ratio of direct, indirect (and induced for Type II or SAM) changes in value added divided by the direct change in value added that is required to increase a given industry's sales to final demand by $1 (excluding households and proprietor income). The available multipliers of this type include: total value added, employee compensation, proprietor's income, other property type income, indirect business tax, and output (sales transactions). The IMPLAN employment multipliers show direct, indirect (and induced) jobs created divided by the added direct jobs in a given industry which are required to increase that industry's sales to final demand by $1 (excluding households and proprietor income). IMPLAN also supplies multipliers for value added and all the other variables listed above calibrated directly in terms of the total effects on value added for an additional dollar of sales to final demand by a given industry (excluding households and proprietor income), but it reports these multipliers in a column labeled "Total" and does not refer to them as multipliers.

Table 1. Comparison of Survey-Based Value-Added Multipliers and IMPLAN Value-Added Multipliers for Washington and Colorado (value added per dollar of sales to final demand)

[1]	[2]	[3]	[4]	[5]	[6]
Selected Industries	Benchmark Washington Survey-Based Value-Added Multipliers	Washington IMPLAN Value-Added Multipliers (Multiple Sectors)	Colorado IMPLAN Value-Added Multipliers (Multiple Sectors) All Final Payments Exogenous	Colorado IMPLAN Value-Added Multipliers (Multiple Sectors) Proprietor Income Endogenous (Standard Model)	Colorado IMPLAN Value-Added Multipliers (Multiple Sectors) Proprietor Income & Other Property Income Endogenous
Field & Seed Crops	1.48	0.85–1.05	1.01–1.03	1.04–1.07	1.37–1.43
Vegetables & Fruits	1.82	1.09–1.18	1.07–1.25	1.12–1.28	1.41–1.41
Livestock & Products	1.56	0.48–0.74	0.58–1.15	0.61–1.21	0.72–1.35
Other Agriculture	1.70	0.71–1.08	0.64–1.23	0.65–1.26	0.76–1.43
Meat Products Mfg.	0.76	0.51–0.77	0.61–0.73	0.62–0.76	0.65–0.79
Dairy Products Mfg.	1.55	0.60–0.71	0.56–0.69	0.58–0.71	0.62–0.80
Canning & Preserving	1.51	0.65–0.84	0.63–0.85	0.65–0.86	0.72–1.11
Grain Products	0.81	0.26–0.61	0.47–0.80	0.48–0.82	0.63–0.91
Beverages	1.53	0.44–1.06	0.52–0.77	0.53–0.78	0.58–0.86
Wholesale Trade	1.86	1.04	1.11	1.13	1.17
Restaurants	1.54	0.95	0.98	1.00	1.27
Rail Transport	1.32	1.00	1.08	1.10	1.16
Trucking	1.55	0.99	0.99	1.04	1.08
Transport Services	1.57	0.95	1.12	1.23	1.23
Finance, Insurance & RE	1.85	0.89–1.37	0.95–1.33	0.96–1.36	1.17–1.36
Other Business Services	1.72	1.07	0.97	1.02	1.06
Postal Services	1.88	1.25	1.29	1.31	1.31

payments are made endogenous. Only when employee compensation, proprietor income, and other property income are all made endogenous do the Colorado value-added multipliers approach the size of the benchmark survey-based Washington value-added multipliers.

Alternate Multiplier Types

Our objective was to create conventional Type II multipliers for the study region based partly on IMPLAN transactions-among-sectors data. Type II multipliers close the model with respect to households (induced effects), while Type I multipliers include the indirect but not the induced effects. Type II multipliers are more appropriate than Type III for recreation and resource-based regional analysis. Type III multipliers simulate the induced effect (household spending) by projecting household formation based on the direct and indirect job impacts. The number of new households is multiplied by average household income to determine the amount of income to recirculate as induced effects. The resulting Type III multipliers are biased upward for tourism, farming, forestry, and other sectors having below-average income and many part-time jobs (Charney and Leones, 1997; Stynes, Chang, and Propst, 1998). The Windows version of IMPLAN offers Type I, Type II, Type III, and SAM multipliers, but IMPLAN Type II and SAM multipliers tend to be small in comparison to benchmark multipliers calculated from survey-based models. The modifications discussed below ameliorate this problem.

For this study, Type II multipliers were chosen over SAM multipliers *only* because the benchmark Washington survey-based multipliers were Type II. The user may prefer to use SAM multipliers, and this analysis applies equally to IMPLAN Type II and SAM multipliers. SAM multipliers, which include induced effects, are smaller than Type II multipliers because the SAM model includes more leakages. However, the SAM model allows the user to close the model with respect to "institutions" such as state and local government if desired [see the *IMPLAN Pro User's Guide*, pp. 15–16 (Minnesota IMPLAN Group, Inc., 1999)]. If this option is used to make state and local government endogenous in the Colorado model, then some of the SAM multipliers exceed the values of the Type II multipliers.

Understated Proprietor Leakages and Overstated Other Property Income Leakages

Although IMPLAN's accessability and data provide a strong base upon which to construct a region-specific interindustry model, the internal accounting conventions of the IMPLAN program overstate leakages. A critical part of the calibration of an input-output model separates local spending from leakages out of the local economy. (Synthesized input-output models cannot rely on the national model for calibration of final payments flows because leakages are much larger at the state or county level than at the national level.)

IMPLAN separates value added into: (*a*) employee compensation, (*b*) proprietor income, (*c*) other property income, and (*d*) indirect business taxes. Both employee compensation and proprietor income are assumed to be endogenous (retained in the local economy) by IMPLAN. Proprietor income consists of payment for work received by self-employed individuals. The inclusion of all proprietor income as endogenous by IMPLAN *could* overstate the multiplier effect because some proprietors providing services in the state live outside the state. Overstatement of endogenous employee compensation because of income leakages created by commuting is unlikely to be important for Colorado which has no major population centers near its borders. The assumption that all proprietor income is endogenous could be of major concern for other states or counties, however.

The major error in the IMPLAN accounting for Colorado is the complete exclusion of other property income from final payments in the more than 500 industries available in the model. Other property income consists of payments to households (including small business owners and farmer/ranchers) from interest, rents, royalties, dividends, and corporate profits. IMPLAN assumes that all of the other property income leaks from the region. This erroneous assumption significantly understates local income and spending and the multiplier effect. The understatement is particularly large for the farm sectors. Farms are highly capital intensive, and wages paid in the farm production sector tend to be much lower and more sporadic than in other sectors. Direct and indirect economic effects in agricultural production tend to be very small because the main nonlabor inputs are land, precipitation (and irrigation), and sunshine, none of which appear significantly in an input-output model. Thus, it is operator income and owner income (profit, rent, and other components of other property income) which create much of the multiplier effect in the farm sector through the induced effect.

An important reason for the understatement of IMPLAN farm multipliers is that IMPLAN removes all other property income from the spending stream and other property income makes up a large share of farm income. Making part of other property income endogenous greatly increases farm multipliers. Type II and SAM multiplier effects calculated by IMPLAN are significantly understated, while IMPLAN Type III multipliers are understated to a lesser extent because of their unique construction.

Adjustment to IMPLAN Final Payments Accounting

Leakages are incorporated in several places within the IMPLAN accounts. First, all other property income is removed from personal income. In Colorado this amounts to a loss of 31% of personal income. Second, personal income is adjusted using a user-accessible "ratio" which cuts down personal income to personal disposable income to account for income taxes. For the Colorado model in this study, the "ratio" is 0.747 so that 25.3% of income is leaked to taxes. Finally, the consumer spending "production function" includes leakages to savings and imports which amount to some 32.5% of consumer spending in Colorado. Thus, less than half of consumer income is spent in

Table 2. IMPLAN Type II Output, Jobs, and Personal Income Multipliers for Colorado

[1] Farm Sector	[2] Employee Compensation Endogenous	[3] Employee Compensation & Proprietor Income Endogenous (Standard IMPLAN)	[4] Employee Compensation, Proprietor Income, & Other Property Income Endogenous
	<! ! ! ! ! ! ! ! (Output / Jobs / Personal Income) ! ! ! ! ! ! ! !>		
Dairy Farm	1.37 / 8.41 / 0.21	1.52 /10.50 / 0.44	1.68 / 12.77 / 0.87
Poultry & Eggs	1.37 / 8.09 / 0.18	1.43 / 8.86 / 0.27	1.60 / 11.30 / 0.67
Ranch Fed Cattle	1.43 / 15.58 / 0.22	1.53 / 16.98 / 0.37	1.69 / 19.29 / 0.78
Range Fed Cattle	1.59 / 20.30 / 0.25	1.73 / 22.15 / 0.46	1.88 / 24.40 / 0.88
Cattle Feedlots	1.54 / 6.90 / 0.16	1.64 / 8.30 / 0.31	1.80 / 10.62 / 0.71
Sheep, Lambs & Goats	1.55 / 41.89 / 0.19	1.68 / 43.67 / 0.39	1.79 / 45.32 / 0.71
Hogs, Pigs & Swine	1.42 / 9.20 / 0.14	1.47 / 9.87 / 0.22	1.66 / 12.51 / 0.64
Other Meat Animal Products	1.51 / 14.64 / 0.21	1.59 / 15.72 / 0.33	1.75 / 18.03 / 0.74
Misc. Livestock	1.37 / 47.16 / 0.51	1.46 / 48.45 / 0.66	1.68 / 51.58 / 1.26
Food Grains	1.05 / 11.56 / 0.05	1.12 / 12.52 / 0.16	1.64 / 19.96 / 1.23
Feed Grains	1.03 / 5.83 / 0.03	1.10 / 6.75 / 0.13	1.62 / 14.08 / 1.18
Hay & Pasture	1.05 / 21.41 / 0.06	1.13 / 22.53 / 0.18	1.62 /29.46 / 1.18
Grass Seeds	1.04 / 37.28 / 0.04	1.10 / 38.21 / 0.15	1.71 / 46.72 / 1.36
Fruit	1.42 / 20.29 / 0.65	1.47 / 20.95 / 0.72	1.67 / 23.84 / 1.30
Vegetables	1.14 / 6.58 / 0.20	1.23 / 7.68 / 0.33	1.68 / 14.22 / 1.31
Sugar Crops	1.03 / 5.61 / 0.03	1.09 / 6.48 / 0.12	1.67 / 14.57 / 1.27
Misc. Crops	1.18 / 19.04 / 0.15	1.27 / 20.34 / 0.29	1.68 / 26.05 / 1.16
Oil Bearing Crops	1.06 / 8.22 / 0.08	1.12 / 9.14 / 0.18	1.63 / 16.23 / 1.21
Forest Products	1.07 / 10.49 / 0.09	1.10 / 10.99 / 0.14	1.69 / 19.31 / 1.33
Greenhouse & Nursery	1.39 / 16.16 / 0.59	1.43 / 16.75 / 0.66	1.71 / 20.72 / 1.37
Forestry Products	1.59 / 20.40 / 0.21	1.62 / 20.75 / 0.25	1.79 / 23.17 / 0.65
Ag, Forestry Services	1.65 / 52.07 / 0.56	1.73 / 53.28 / 0.70	1.75 / 53.45 / 0.90
Landscape & Horticultural Services	1.52 / 46.36 / 0.63	1.64 / 48.04 / 0.82	1.67 / 48.56 / 1.10

Notes: Multipliers for direct, indirect, and induced output and personal income are per dollar of sales to final demand; multipliers for jobs are per million dollars of sales to final demand.

Colorado in the standard IMPLAN model. (Also, each of the industry production functions includes leakages to savings, indirect business tax, and imports.)

Because local (in-state) operation and ownership exists for many firms and farms, the total leakage of other property income assumed by IMPLAN is greatly overstated. Part of other property income should be incorporated into the endogenous processing quadrant along with worker compensation and proprietor income. The effects on the output, employment, and personal income multipliers of changing the leakages of proprietor income and other property income are shown in table 2. The steps required to shift other property income or other components of final payments between exogenous and endogenous using IMPLAN are reported in the appendix.

Table 3. Share of Payroll from In-State Colorado Firms by Industry

Selected Industries	Payroll from In-State Firms (%)	Selected Industries	Payroll from In-State Firms (%)
Farms	86	Transportation	17
Nursery/Greenhouse	34	Wholesale	48
Forestry	25	Groceries	11
Ag Service	79	Restaurants	9
Landscape/Horticulture	70	Finance	32
Extraction	32	Lodging	22
Food Processing	8	Health Services	64
Textiles	45	Other Services	48
Wood Processing	49		

Endogenous business spending is payments made to residents of the state by firms operating and managed in the state. The share of Colorado payroll from firms in a given industry paid out from companies headquartered in Colorado provides an indicator of the share of other property income which is endogenous to Colorado for that industry. Confidential data from the Quarterly Unemployment Insurance Address File (ES-202) show employment and payroll for individual firms with their address and SIC code (Colorado Department of Labor and Employment, 1994). Computer sorts on this data file revealed the share of payroll paid out by local (in-state) headquarters. The payroll share paid from in-state headquarters varied from 86% in the farm sector and 79% in agricultural services to a low of 8% in the food processing sector and 9% in the restaurant sector.

Table 3 presents the payroll share ratios for major sectors in Colorado. Access to the confidential ES-202 data is not possible for IMPLAN or for most researchers. University faculty and certain state researchers are granted access to the confidential ES-202 data in a few states but not in others. The confidential detailed ES-202 data do not provide a general solution for adjusting the IMPLAN accounts because many persons (including IMPLAN) cannot gain access. However, the detailed ES-202 data strongly suggest that the total leakage of other property income assumed by IMPLAN is wrong.

A second indicator of the error created by assuming total leakage of other property income is shown by the ratio of the personal income and jobs multipliers. This multiplier ratio shows the direct, indirect, and induced personal income divided by the direct, indirect, and induced jobs. The projected income per job ratio at different levels of income leakage is compared to the Colorado average personal income for 2001, which is over $64,000 per worker, and the Colorado earnings per worker for 2001, which is over $47,000 (Bureau of Economic Analysis and Colorado Department of Labor and Employment, online). Although direct farm spending includes low-wage farm workers, it also should include proprietor income and much of other property income. The indirect and induced effects for the farm sectors are mainly on

Table 4. IMPLAN, Direct, Indirect, and Induced Income per Direct, Indirect, and Induced Job

[1] Farm Sector	[2] Employee Compensation Endogenous	[3] Employee Compensation & Proprietor Income Endogenous (Standard IMPLAN)	[4] Employee Compensation, Proprietor Income, & Other Property Income Endogenous	[5] Average of Columns 3 and 4
	<!!!!!!!!!!!!!!!!!!	($)	!!!!!!!!!!!!!!!!!!>	
Dairy Farm	24,970	41,905	68,128	55,017
Poultry & Eggs	22,250	30,474	59,292	44,883
Ranch Fed Cattle	14,121	21,790	40,435	31,113
Range Fed Cattle	12,315	20,767	36,066	28,417
Cattle Feedlots	23,188	37,349	66,855	52,102
Sheep, Lambs & Goats	4,536	8,931	15,666	12,299
Hogs, Pigs & Swine	15,217	22,290	51,159	36,725
Other Meat Animal Products	14,344	20,992	41,043	31,018
Misc. Livestock	10,814	13,622	24,428	19,025
Food Grains	4,325	12,780	61,623	37,202
Feed Grains	5,146	19,259	83,807	51,533
Hay & Pasture	2,802	7,989	40,054	24,022
Grass Seeds	1,073	3,926	29,110	16,518
Fruit	32,035	34,368	54,530	44,449
Vegetables	30,395	42,969	92,124	67,547
Sugar Crops	5,348	18,519	87,165	43,583
Misc. Crops	7,878	14,258	44,530	29,394
Oil Bearing Crops	9,732	19,694	74,553	47,124
Forest Products	8,580	12,739	68,876	40,808
Greenhouse & Nursery	36,510	39,403	66,120	52,762
Forestry Products	10,294	12,048	28,054	20,051
Ag, Forestry Services	10,755	13,138	16,838	14,988
Landscape & Horticultural Services	13,589	17,069	22,652	19,861

high-wage nonfarm workers. Thus, the range of $47,000 to $64,000 per worker/owner figure should be realistic for some farm sectors as well as for nonfarm sectors.

Table 4 shows the projected income per worker ratio for three leakage alternatives. The final column gives an average of projected income per worker when employee compensation and proprietor income are endogenous and when employee compensation, proprietor income, and other property income are endogenous. The income multipliers are much more sensitive to reductions in the leakage of other property income than are the employment multipliers (or the output multipliers). When only employee compensation is endogenous, the typical projected income per job ratio (see column 2, table 4) is very small, and is far below the $47,000–$64,000

benchmark range. Conversely, when employee compensation plus both proprietor income and other property income are endogenous (see column 4, table 4), the projected income per job ratio is above the benchmark range for a few sectors. The average values shown in column 5 of table 4 appear to vary around $40,000 income per job, which is still below the benchmark range. (In fact, when this technique is applied to the actual Colorado irrigated farm sales data, the ratio of direct, indirect, and induced income to direct, indirect, and induced jobs is $40,047.)

If critical data values are unknown, a common practice is to use a central tendency value rather than zero or the maximum value. Given the nature of the local firm payroll share data from the confidential ES-202 data file and the implication of the income multiplier/jobs multiplier ratios discussed above, our preferred option *for Colorado* is to use an average of the multipliers shown in column 3 of table 2 (employee compensation and proprietor income endogenous), and column 4 of table 2 (employee compensation, proprietor income, and other property income endogenous).

Potential Irrigation-Related Drought Effect in Colorado

The Current Situation

Drought conditions are in their fourth year in most areas of Colorado. Reservoir storage has protected agricultural producers in the past, but now most reservoirs are very low or entirely empty. Bids for rental water by firms selling domestic water have risen from $15 per acre foot to $350 per acre foot or more. Water utilities have been unable to rent adequate water even at these prices. Some farmers who own water rights would be better off to shut down and rent out their water. Farms which depend on rental water will be forced to shut down. Supplemental water from the Colorado Big Thompson system along the front range will shrink by two-thirds in 2003. Some canal systems in north central Colorado have indicated they can deliver only for a one-time period of about eight days—which is insufficient for any conventional Colorado crops.

Estimating the Economic Contribution by Colorado Irrigated Agriculture

Unadjusted IMPLAN multipliers understate the true induced effects in the agricultural production sectors because of faulty accounting for other property income. Alternative adjusted multipliers are given in table 2. The multipliers are applied to Colorado irrigated agriculture outputs to show the impact for each irrigated crop if production was shut down. These estimates are the backward-linked impacts and exclude any forward-linked effects. The assumption is that cattle farms, feedlots, and food processing firms which depended on locally produced farm outputs would be able to import needed irrigated farm products. If that is not the case, this assumption could greatly understate total impacts.

Table 5. Total Economic Effects of Irrigated Agriculture for State of Colorado in 2001, Without and With Proprietor Income and Other Property Income Endogenous

[1] Colorado Irrigated Crops	[2] Direct, Indirect, & Induced Jobs (part- and full-time jobs)	[3] Direct, Indirect, & Induced Personal Income ($1,000s)	[4] Value of Irrigated Farm Production ($1,000s)
	Employee Compensation endogenous / Employee Compensation & Proprietor Income endogenous / Employee Compensation, Proprietor Income & Other Property Income endogenous		
Barley	137 / 159 / 331	705 / 3,053 / 27,721	23,492
Beans	224 /261 / 484	6,807 / 11,232 / 44,588	34,037
Corn for Grain	1,680 / 1,945 / 4,056	8,643 / 37,453 / 339,958	288,100
Corn for Silage	339 / 393 / 819	1,746 / 7,565 / 68,664	58,190
Alfalfa Hay	7,504 / 7,897 / 10,326	21,030 / 63,090 / 413,590	350,500
Other Hay & Pasture	6,461 / 6,799 / 8,890	18,105 / 54,316 / 356,074	301,758
Oats	18 / 21 / 43	176 / 401 / 3,643	3,087
Potatoes	1,424 / 1,662 / 3,078	43,290 / 71,428 / 283,547	216,448
Sorghum for Grain	26 / 30 / 62	132 / 571 / 5,183	4,392
Sorghum for Silage	24 / 28/ 57	122 / 530 / 4,814	4,080
Sugar Beets	194 / 224 / 504	1,038 / 4,153 / 43,957	34,612
Spring Wheat	92 / 100 / 159	399 / 1,276 / 9,809	7,975
Winter Wheat	267 / 289 / 461	1,155 / 3,696 / 28,413	23,100
Cabbage	57 / 66 / 122	1,723 / 2,842 / 11,283	8,613
Cantaloupe	40 / 46 / 85	1,196 / 1,974 / 7,836	5,982
Carrots	139 / 162 / 300	4,224 / 6,970 / 27,667	21,120
Sweet Corn	56 / 65 / 121	1,703 / 2,810 / 11,156	8,516
Lettuce	55 / 65 / 119	1,680 / 2,772 / 11,004	8,400
Onions	284 / 331 / 614	8,630 / 14,240 / 56,529	43,152
Spinach	17 / 19 / 36	504 / 832 / 3,301	2,520
Apples	94 / 97 / 110	2,997 / 3,319 / 5,993	4,610
Cherries	5 / 5 / 6	169 / 187 / 338	260
Peaches	191 / 198 / 225	6,143 / 6,804 / 12,285	9,450
Pears	19 / 20 / 23	618 / 684 / 1,235	950
TOTAL	19,364 / 20,883 / 31,075	$132,852 / $302,198 / $1,778,588	$1,463,344

Table 5 reports ranges for the impact of drought on irrigated agriculture in Colorado based on farm outputs in 2001 (Colorado Department of Agriculture and National Agricultural Statistics Service, 2002). The lower impact value excludes proprietor and other property income from internal trade flows, the intermediate value excludes other property income from internal trade flows, and the highest value includes both proprietor income and other property income.

The Potential Economic Impacts

Caution is imperative when projecting economic impacts of a major drought. Input-output models apply to a point in time rather than to dynamic change. The proportion of expenditure flows from an industry to each of its suppliers is assumed fixed. The model assumes a competitive market with constant returns to scale where inputs are available in any amounts at constant prices. Thus, the input-output model works best when applied to relatively small short-run changes. If the drought extends over a period of many years, new investment in water-saving devices and water storage facilities would require significant recalibration of the model. Even in the short run, a major drought implies large price changes for water and closely related goods and water rationing by monopolistic and public water suppliers. Many important changes in reaction to the drought are simply not amenable to economic forecasting models. Even price-endogenous general equilibrium models cannot accurately project the imposition of rationing or legislative decisions to invest in water storage and transport facilities and other infrastructure.

Table 5 shows drought impacts on jobs and personal income by Colorado farm sector in 2001. Direct sales by the irrigated agriculture sector totaled some $1.46 billion. The estimated backward-linked part and full-time jobs created in Colorado by irrigated agriculture totaled (20,883 + 31,075)/2 = 25,979 in 2001 (using our preferred average multiplier effect discussed earlier). Colorado employment was about 2,200,000 (Colorado Department of Labor and Employment, Labor Market Information), so that backward-linked jobs associated with irrigated agriculture accounted for about 1.2% of Colorado employment. The estimated personal income created by Colorado irrigated agriculture was ($302,198,000 + $1,778,588,000)/2 = $1,040,399,000.

In addition to irrigated farms, the drought can seriously damage Colorado's "green industry." This sector is composed of greenhouse, nursery and turf production, landscape architecture, landscape and horticultural services, wholesale flowers and nursery stock, retail nurseries, lawn and garden supplies, retail florists, and golf courses. We estimated that this sector accounted for more than $1.37 billion of sales, 25,500 part- and full-time jobs, and $555 million in payroll in 1993 (Gray et al., 1997).[3]

The entire potential impact of irrigation shut down, including both irrigated agriculture and the "green industry," totaled some 51,479 full- and part-time jobs and, after adjustment to current dollars, household incomes of more than $1.6 billion. (The direct sales and employment impacts of irrigated agriculture and the "green industry" are virtually identical.) The potential total irrigation-related job impacts account for over 2.3% of Colorado employment. Added impacts will occur in the nonirrigated crop sectors in Colorado which experience reduced productivity because of the drought.

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[3] The "green industry" study by Gray et al. (1997) also adjusted the IMPLAN multipliers for overstated leakages of final payments.

Comparison of Impacts Based on Unadjusted IMPLAN Data versus the Adjusted Data

For comparison purposes, we estimated the employment impact of irrigation in Colorado using the unadjusted IMPLAN Type II multipliers for Colorado. As discussed above, the irrigation impacts were calculated using the midpoint multipliers which averaged the impacts excluding and including other property income in the spending stream. Replication of the calculations using the standard IMPLAN multipliers (all other property income exogenous) resulted in a significant reduction in estimated irrigated agriculture impacts. Instead of 25,979 part- and full-time jobs associated with irrigated agriculture, there are only 20,882 jobs when the conventional IMPLAN Type II multipliers are used (see table 5). The unwarranted profit leakages in IMPLAN resulted in multipliers which reduce the projected employment to about 80% of the estimate based on the adjusted multipliers. This result demonstrates the critical sensitivity of input-output employment projections to changes in the assumption about final payments leakages.

IMPLAN projections of personal income are more disturbing. Projected personal income falls from $1,040.4 million to only $302.2 million, a decline to 29% of the adjusted multiplier projection. The result is that average projected personal income per worker falls from $40,047 down to $14,472. This low value for the projected average earnings per worker is because IMPLAN has almost no indirect or induced spending by agriculture. Thus, the low-wage farm worker and farm services sector worker dominate IMPLAN farm projections. For example, the annual average wage for nonfarm workers in Colorado is 2.5 times the wage for farm service workers. (An identical ratio exists in Washington State.) The indirect inputs to the farm sector are the purchases made by the sectors which sell to farms. These indirect inputs are mainly in the higher-wage nonfarm sector. The induced inputs to the farm sector include sales made to farm owners and operators whose income is mainly farm profit, but this source of impacts is totally excluded by the standard IMPLAN accounts.

As noted earlier, the direct and indirect effects of agriculture are very small because the main inputs, other than labor, include land, precipitation (and irrigation), and sunshine, which are mostly not measured by input-output accounts. The Type I farm multipliers in IMPLAN are extremely small. For example, some Type I multipliers for farming in Colorado are: feed grains 1.0098, food grains 1.0123, hay 1.0154, oil bearing crops 1.0075, fruit 1.0073, and vegetables 1.0096. Given their extremely small indirect effects, the farm sectors are almost totally dependent on induced effects for their Type II multipliers. The induced spending by farm operators created when improper final payments leakages in IMPLAN are reduced creates new spending on the high-wage goods and services provided by the nonfarm sectors, resulting in higher farm multipliers. Correcting excess leakages of final payments in the nonfarm sectors further increases the farm multipliers.

Summary and Conclusions

Comparison of Washington survey-based Type II value-added multipliers and IMPLAN Type II value-added multipliers revealed that the IMPLAN multipliers were much smaller. The source of the discrepancy was traced to the total leakage of other property income assumed in the IMPLAN accounts. Examination of confidential firm employment data for Colorado showed that farm sectors and many other industries had a large share of in-state headquarters and in-state payroll. These data suggest that other property income for these sectors should not be completely excluded from endogenous income flows.

The ratio of the IMPLAN personal income multiplier to the employment multiplier shows projected income per worker. The projected income per worker ratio was very small unless at least some of other property income was included in the endogenous spending streams. For Colorado, we found that averaging the multipliers for the case where employee compensation and proprietor income was endogenous and where employee compensation, proprietor income, and other property income was endogenous increased earnings per worker projections from less than $15,000 to about $40,000, which was still below the average for Colorado ($47,000). We have included an appendix describing the process by which IMPLAN can be adjusted to shift components of final payments between exogenous and endogenous.

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Appendix:
Adjusting IMPLAN Final Payments Flows

IMPLAN provides two different Type II multiplier estimates. The first Type II multiplier (SAM Income Ratio) uses the SAM model to determine the adjustment from personal income to personal disposable income. This adjustment ratio is automatically applied by IMPLAN to reduce personal consumption spending to account for the effects of income taxes. The second Type II multiplier (Specific Disposable Income) allows the user to set the disposable income/labor income ratio. If the user plans to adjust components of final

payments flows from exogenous to endogenous or vice versa, it is important to first determine and record the value of the disposable income/labor income ratio for the study region prior to making any changes in the model. This ratio will need to be reset by the user after the adjustments are made to final payments flows or else the built-in SAM adjustment process will offset most of the changes which the user made in the final payments.

To find the original value for the disposable income/labor income ratio, take the following steps:

(1) Open the desired IMPLAN model.

(2) From the main menu, click the "Construct Model" option.

(3) Click either Type II or SAM, and click on "No" for the question: "Do you want to reconstruct the multipliers?"

(4) Click "Advanced," and then click "Next" four times, which results in a menu showing various multiplier options. A rectangular box will appear which contains the disposable income/labor income ratio. The user should record this decimal fraction number so the ratio can be reset to this value after the components of final payments have been adjusted.

Note: The Specific Disposable Income ratio is discussed briefly in the *IMPLAN Pro User's Guide*, pp. 44–45 and p. 171 (Minnesota IMPLAN Group, Inc., 1999).

User modification of components of final payments (value added) is achieved by the following steps:

(1) From the main menu, click the "Edit" option.

(2) Move the cursor over the "Region Data" option and a window will appear to the left of it. Click "Study Area Data" from this window.

(3) A window with a list of the industry sectors will appear on the right side of the screen. Click on the first industry you wish to adjust, and some tables will now appear on the left side of the screen.

(4) The top table is "Value Added," and it shows values for employee compensation, proprietor income, other property income, and indirect business taxes. These values can be changed by the user as desired.

Keep in mind that the first two categories of final payments (i.e., employee compensation and proprietor income) are always endogenous in the IMPLAN model, while the other two accounts (i.e., other property income and indirect business taxes) are always exogenous in the IMPLAN model. Thus, to make all or part of other property income endogenous, the value in other property income can be reduced and the value in proprietor income can be increased by the same amount. If one wishes to make part or all of proprietor income exogenous, one can reduce the value in the proprietor income cell and increase the value in other property income by the same amount. Note that the changes entered take effect immediately and are automatically saved when entered. The adjustment process for final payments is discussed in the *IMPLAN Pro User's Guide* (p. 19). [If the user plans to aggregate the industry sectors in the model (see p. 32), it would save time to do that before making the many adjustments on the final payments sectors.]

After making the desired adjustments to components of final payments, reset the disposable income/labor income ratio to its original value by proceeding with the following steps:

(1) From the main menu, click the "Construct Model" option.
(2) Click either Type II or SAM, and click "No" for the question: "Do you want to reconstruct the multipliers?"
(3) Click "Advanced," and then click "Next" four times, which results in a menu showing various multiplier options. A rectangular box will appear which contains the disposable income/labor income ratio.
(4) Click "Specific Disposable Income" and the decimal fraction in the box will highlight.
(5) Change the decimal fraction to the original value recorded earlier in order to maintain the income tax leakage share at its original value. The value entered is automatically saved when entered.

The final sequence of steps is to construct the Type II multipliers:

(1) From the main menu, click "Construct Model."
(2) Click "Type II," and click "Yes" for the question: "Do you want to reconstruct the multipliers?"
(3) Click "Continue" and the multiplier construction will commence.
(4) When the program is finished, it will display "Model Construction Is Complete." "OK." Click "OK."
(5) Click "Close."

To see the estimated multiplier values:

(1) From the main menu, click "Reports."
(2) Click "Multipliers."
(3) Click the desired type of multiplier.
(4) Click "Print Preview" or "Print," as desired.
(5) Click "Continue."