REGIONALIZING COTTON COST FUNCTIONS IN IMPLAN

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Abstract

IMPLAN, one of the most popular tools for estimated economic contributions, assumes that all regions of the U.S. have the same cost function for cotton production. In reality, there are multiple production methods (e.g., dryland and irrigated production) with very different cost functions within even a single region. This study uses Extension crop budgets to modify the default IMPLAN cotton sector to represent irrigated and dryland production functions in two Texas regions—the High Plains and the Coastal Bend. Crop budgets typically allocate expenditures across fewer industry sectors than does IMPLAN so budget data were entered into the IMPLAN cotton sector, which was then rebalanced to redistribute expenditures across all industries in the national production function. Cotton output multipliers varied by up to 15 percent from the default multiplier for the state of Texas. Texas Value Added multipliers varied by up to 35 percent, Labor Income by up to 33 percent, and Employment by up to 19 percent. Economists in other cotton-producing regions can readily adopt this methodology to modify regional cost functions.

Introduction

Cotton is an important crop throughout the U.S. South. In fact, cotton in the most important crop and second most important agricultural commodity in Texas (following beef cattle), based on cash receipts and total contribution to gross state product (McCorkle et al. 2014). Cotton production results in economic contributions throughout the entire economy as farm purchase production inputs and as farmers and suppliers' employees purchase goods and services. However, most economic contribution studies assume that cotton has the same cost function, whether produced on the Texas High Plains or the Mississippi Delta. In reality, growing conditions, production methods (e.g., dryland and irrigated), and therefore costs functions vary across sub- regions even within a single state. This study uses Extension crop budgets to modify the default IMPLAN cotton sector to represent irrigated and dryland production functions in two Texas regions—the High Plains and the Coastal Bend. These two regions represent the bulk of Texas cotton production (Figure 1). The Southern High Plains represents more than 40 percent of Texas cotton sales.

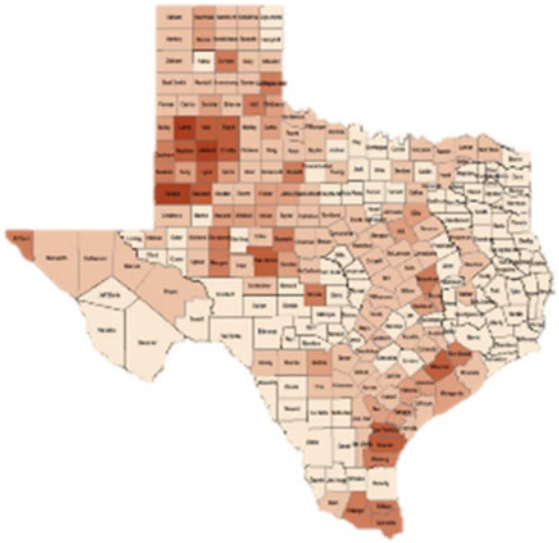

Figure 1. Total Cotton Cash Receipts for Counties in Texas, 2014.

Of the 526 IMPLAN industries, only the 14 production agriculture sectors display the same production function for all geographies. In fact, *all* regional (state and county) IMPLAN production functions are based on national data because some data sources are available only at the national level. However, in non-agricultural industries, covered wage and employment (CEW) data are used to modify the national benchmark production function to reflect the value added share of final demand sales at the regional level. Once the share of sales that pay value added (wages, proprietor income, other property income and indirect businesses taxes) is identified, absorption coefficients are proportionately reallocated with the residual total absorption value (the value of intermediate purchases). Thus, the absolute value of the absorption coefficients differs between regions, but the purchased inputs retains the same proportions to each other (Liu and Warner 2009; Minnesota IMPLAN Group 2004). The National Agricultural Statistics Service data used to estimate production agriculture does not correspond to CEW data so each ag sector's proportion of value added and gross absorption remain constant across geographies.

Although Texas and Mississippi are subject to the same IMPLAN production function based on benchmark I-O tables, the two states have different cotton multipliers. Similarly, within Texas, cotton multipliers differ between Crosby County in the panhandle and Calhoun County along the Gulf Coast. This is because IMPLAN geographies differ in how much of each commodity is produced (available) locally, how much of each commodity is used locally, which local industries or institutions produce the commodity, and how much of it each produces. In other words, IMPLAN has a consistent accounting of the production of each local economy and uses this accounting to establish linkages in the economy and calculate multipliers.

Jablonksi et al. (2015) note that while IMPLAN agriculture sectors data are estimated consistently albeit from incomplete data sources. Thus,"…good regional measurements of the sector, if available, are probably superior" (p. 4). Lazarus, Platas, and Morse (2002) modified both productions functions and regional purchase coefficients for to distinguish distinct segments of the Minnesota swine industry and compare the estimated impacts of those segments using the default IMPLAN sector and their modified sectors. They note that modifying production functions (intermediate expenditure coefficients) results in larger changes in in estimated impacts, as compared to default production functions, than does changing regional purchase coefficients (the share of local purchases). At the same time, the effect of the regional purchase coefficient for feed grains on estimated results than do any other model modifications. Thus, regional purchase coefficients do matter, and should be updated if researchers have better information about local purchasing patterns. However, the local purchase shares of various inputs are usually unknown unless researchers survey industry participants.

Regional production functions are, however, much more accessible, thanks to state Extension systems. Extension agricultural economics departments across the country generate planning budgets at the state or sub-state levels for commonly-raised crops and livestock species. These budgets account for expected production levels, revenues and costs under various regional conditions and production systems. For example, the Texas A&M AgriLife Extension Service generated 24 separate cotton budgets for 2015, representing various districts, irrigation systems, planting patterns, and insect- and herbicide-resistance (Texas A&M AgriLife Extension Service 2015).

While Texas Extension budgets indicate two dozen or more cotton production functions across the state, the IMPLAN input-output model uses one production function across the entire United States, assuming that cotton grown in the Mississippi Delta is produced using the same inputs in the same ratio as cotton grown on the Texas High Plains. Of course, cotton is one crop among 528 IMPLAN sectors (IMPLAN 2014). It would be nearly impossible to account for various production functions for the same crop within states or even smaller geographies. In fact, many crops share a sector; sector 2, for example, encompasses all grain farming even though dryland wheat and irrigated corn clearly have different production functions. Fortunately, IMPLAN production functions are easy to modify, especially given that Extension budgets provide a ready data source.

Materials and Methods

This study considers a standard method by which to modify IMPLAN models to better represent regional production of cotton (or other crops for that matter) and compares the modified models to IMPLAN default production functions. Texas A&M AgriLife Extension budgets (2013) are used to modify the 2013 IMPLAN absorption coefficients. The 2013 budgets were selected because they match the latest data available from IMPLAN, reducing the potential for inflation-generated distortions. Three budgets were selected to represent cotton production in the state: dryland and

pivot-irrigated cotton in the Southern High Plains and dryland cotton along the central Gulf coast (Texas A&M AgriLife Extension Service 2015). These regions and production systems represent the bulk of Texas cotton.

Texas Extension budgets, like commodity budgets across the country, are produced by agricultural economists consulting with farmers about inputs and researching regional input prices, expected yields, and expected commodity prices. IMPLAN value added coefficients represent employee compensation, proprietor income, other property income, and taxes as a proportion of an industry's final demand sales; absorption coefficients represent expenditures for goods and services purchased from other industries. Because IMPLAN value added and absorption coefficients are based on expenditures per dollar of final demand sales, the expense for each input in the cotton budgets was divided by expected revenue, although the share rent value for High Plains dryland cotton was decreased to eliminate net losses and establish a breakeven scenario. Each item on the budget from cotton seed to proprietor income was matched to an IMPLAN sector and represents a proportion of revenue. Budgeted expenditures for each cropping system and the resultant coefficients are displayed in Table 1. The value of government payments is excluded because the ex-ante (pre-planting) budget assumes an at least marginally profitable cotton crop.

An IMPLAN model using default Texas data serves as the baseline. Three additional models represent the three modified production functions. A model was modified to represent a specific budget in three phases. A typical IMPLAN model allows indirect effects within the industry itself. For example, the default cotton industry spends 8 cents of every dollar on cotton, mostly in the form of seed. However, when measuring the contribution of an entire regional industry, it is inappropriate to allow indirect effects within that industry. If the entire industry is entered as a direct impact, there is no additional output for other industries to consume. Customizing trade flows to allow no local use of cotton industry production prevented industries from purchasing from the local cotton industry, which produces 94 percent of raw cotton commodity products. Two other industries, Support industries for agriculture and forestry and Other amusement and recreation, each produce a small amount of cotton commodities. We allowed these industries to continue trading within the local economy because they mostly produce other goods and services, which would have been curtailed if we had zeroed out their local use.

Second, study area data were customized to represent the local value added coefficient based on budget proprietor income, other property income, and wages. Because indirect taxes were not assessed in the regional budgets, the IMPLAN estimated tax share were subtracted from other property income. This was deemed appropriate because Texas does not have a state income tax, and property taxes naturally correspond to other property income, recognizing that the tax-paying landowner may not be the farmer. Furthermore, taxes, like other property income, are exogenous in IMPLAN while proprietor income is endogenous.

Third, industry production was customized by replacing some default absorption coefficients with values calculated from the regional budget. Extension budgets focus on major expenses and do not consider payments to all sectors of the economy. While Extension cotton budgets have 24 to 50 expenses (depending on the region and production method) represented by 12 IMPLAN sectors, the IMPLAN cotton cost function includes absorption coefficients for 99 sectors. For example, Extension crop budgets do not have a line for accounting services or computer equipment, but IMPLAN does. To estimate payments across the entire economy, the budget-driven coefficients were not held as fixed but rather were allowed to vary when the model rebalanced, which is an automated process in the IMPLAN model.

Table 1. Production Budgets for High Plains & Coastal Bend Regions of Texas, 2014

	District 2 – Dryland	District 2 – Irrigated	District 11 – Dryland
	Production Budget	Production Budget	Production Budget
INCOME			
Cotton Lint	$245.00	$700.00	$517.50
Cotton Seed	$75.00	$216.00	$150.00
TOTAL INCOME	**$320.00**	**$916.00**	**$667.50**
DIRECT EXPENSES			
Custom Services	$69.18	$173.57	$179.50
Herbicides	$28.00	$28.00	$27.19
Insecticides	$7.00	$13.00	$35.71
Seed	$54.60	$72.80	$72.55
Fertilizer	$31.50	$78.75	$82.05
Irrigation	$0.00	$108.00	$0.00
Other	$20.00	$30.00	$13.00
Growth Regulators	$0.00	$0.00	$1.92
Harvest Aid	$10.00	$25.00	$3.97
Operator Labor	$19.11	$18.69	$7.57
Hand Labor	$0.00	$8.09	$3.46
Diesel Fuel	$12.45	$12.58	$14.36
Gasoline	$5.62	$7.03	$0.00
Repair & Maintenance	$15.99	$54.38	$16.12
TOTAL DIRECT EXPENSES	**$273.45**	**$629.89**	**$457.40**
RETURNS ABOVE DIRECT EXPENSES	**$46.55**	**$286.11**	**$210.10**
FIXED EXPENSES	**$23.14**	**$73.50**	**$30.22**
TOTAL SPECIFIED EXPENSES	**$296.59**	**$703.39**	**$487.62**
RETURNS ABOVE SPECIFIED EXPENSES	**$23.41**	**$212.61**	**$179.88**
RESIDUAL ITEMS	**$23.41**	**$100.00**	**$83.88**
PROFIT	**$0.00**	**$112.61**	**$96.00**

Results and Discussion

Economic activity by the cotton industry (direct effects) ripples through the state economy as firms purchase inputs (indirect effects) and pay employees who also make regional purchases (induced effects). Money also leaks from the economy as firms and households purchase goods and services from other parts of the state, nation, and world. The total effects are the sum of direct, indirect, and induced effects. The ratios the total effects to the direct sales are multipliers for each of the outcomes: employment, labor income, total value added (contribution to gross regional product) and output (gross sales).

Cotton multipliers varied substantially when the default production function was modified to reflect regional cost functions (Table 2).[i] In terms of the output multiplier, which is widely reported in industry and media reports, the

default Texas multiplier was 1.82. The local use coefficient was set to zero to prevent the cotton industry from purchasing its own production, which is already fully accounted for when measuring total annual product, which dropped the Texas multiplier to 1.75.

Table 2. Multipliers for Regions and Modeling Phases

	Default	Zero-RPC	VA Only	Free Rebalance
Output Multipliers				
District 2 Dryland	1.82	1.75	2.04	2.07
District 2 Irrigated	1.82	1.75	1.98	2.09
District 11 Dryland	1.82	1.75	2.00	1.98
Value Added Multipliers				
District 2 Dryland	1.08	1.03	0.70	0.70
District 2 Irrigated	1.08	1.03	0.80	0.85
District 11 Dryland	1.08	1.03	0.84	0.83
Labor Income Multipliers				
District 2 Dryland	0.61	0.58	0.41	0.41
District 2 Irrigated	0.61	0.58	0.48	0.5
District 11 Dryland	0.61	0.58	0.55	0.55
Employment Multipliers				
District 2 Dryland	12.14	11.65	14.3	13.84
District 2 Irrigated	12.14	11.65	13.76	13.51
District 11 Dryland	12.14	11.65	13.9	14.43

Adjusting the value-added components to reflect the regional budgets resulted in the greatest change in the multipliers. In all three production scenarios, income was much smaller than estimated by IMPLAN on a national basis. Thus a larger proportion of Texas cotton sales were paid to supplying businesses (intermediate expenditures) than to households (wages, proprietor income, and other property incomes), and indirect or business-to-business spending results in greater multipliers than does spending directly by households. High Plains output multipliers after the value added adjustment were 1.98 for irrigated cotton to 2.04 for dryland, which was 17% larger than the dryland cotton output multiplier after accounting for local use. Similarly, value-added adjusted employment multipliers were 18-23% higher than in the local-use adjusted model; every million dollar sale of cotton results in more jobs because of a higher proportion of business-to-business sales, requiring more employees.

On the other hand, the District 2 dryland value added multiplier of 0.70 is 32% smaller and the labor income multiplier is 29% smaller than the respective multipliers after accounting for local use. As a higher share of cotton sales pays for inputs, the corresponding smaller share of farm income implies a smaller contribution to gross domestic product and labor income, which includes both wages and proprietor income. District 2 dryland cotton production and prices in 2014 resulted in a negative to barely breakeven scenario for farmers, and neither crop insurance nor government payments are included in this economic contribution model. More profitable dryland production conditions in District 11 resulted in value added and labor income multipliers that were only 18% and 5% lower than respective multipliers after accounting for local use.

The effect of editing the IMPLAN industry production coefficients to represent costs identified in the Extension budget was fairly modest. After accounting for the production coefficients, the final output multiplier for District 2 dryland cotton increased by only 1% and the District 11 out multiplier decreased by 1% relative to the value-added adjusted multipliers. Differences in value added, labor income, and employment multipliers were also quite small for these two production systems. The Irrigated District 2 cotton output multiplier increased by 5%, bolstered by higher use of energy and chemicals. Strong energy and chemical sectors within the region are fairly robust resulted in 6% larger value-added coefficients and 4% larger labor income coefficients relative to the value-added adjusted multipliers.

Compared to the default cotton output multiplier for Texas, statewide multipliers for the regional production systems were 9%-15% larger. Value added multipliers were 21%-35% lower. Labor income was 10%-33% lower. Employment multipliers were 11%-19% smaller. These differences result in significantly different calculations of the economic contribution of Texas Cotton.

Although cotton production in the two districts represents the vast majority of Texas cotton sales, cotton sales across the rest of the state were proportionately assigned to the three production functions to determine the contribution of all Texas cotton to the state economy. The $2.2 billion in direct cotton sales contributed an estimated $4.5 billion in output across the entire economy as well as 29,500 full- and part-time jobs in 2014 (Table 3). The state gained $1.8 billion in value added or "GDP", including $1.1 billion in labor income. Value added and labor income are components of output so these measures cannot be summed. Indirect effects represent firm-to-firm purchases, while induced effects represent household's purchases.

Table 3. Statewide Economic Impacts of Cotton Production in 2014

Impact Type	Output	Value Added	Labor Income	Employment
Direct Effect	$2,164,067,200	$504,502,700	$296,516,000	11,600
Indirect Effect	$1,616,522,400	$858,147,200	$533,356,200	12,700
Induced Effect	$728,916,500	$415,583,900	$238,585,200	5,200
Total Effect	$4,509,506,100	$1,778,233,800	$1,068,457,400	29,500

Summary

Texas cotton multipliers were highly sensitive to the modifications introduced by regional production functions. Statewide output multipliers were up to 15% larger than the Texas default cotton multiplier, but value added or GDP multipliers were up to 35% smaller even after eliminating local use of cotton to avoid overestimating the annual production total, an important step when accounting for all regional production of a commodity. The majority of the change in the multipliers was attributable to modifying the study area data to reflect the value-added components of employee compensation, proprietor income, and other property income. Texas Extension budgets do not include an estimate of taxes, but if such information is available for other states, it will provide the final component of value added.

These results suggest that input-output modelers should modify their models to reflect local production functions. Over millions of dollars in cash receipts, even relatively small deviations in multipliers result in large differences in economic contributions. However, if time or information is limited, simply modifying the value added components will produce a more accurate estimate of economic contributions as compared with the default multipliers.

The methods described in this paper do not include income from crop insurance or government payments. Farmers do not purchase inputs expecting crop losses; they purchase inputs with the expectation of breaking even or making a profit. When yields or prices are lower than expected, farm income is eroded, resulting in reduced value added and income multipliers. At the same time, a larger share of income spent on purchased inputs results in larger output multipliers. Because farm payments under the 2014 farm bill are likely to be made well after production, modifying input-output models to reflect regional cost functions will allow delayed payments to be modeled as supplemental income. However, farm payments are not intended to result in additional profit; most generally they will simply make up the difference of the expected income and will not need to be modeled. Farm payments attributed solely to income generate lower output multipliers than does cotton production.

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[i] Results reported are from IMPLAN models run with 2013 data on November 19, 2015 using data last downloaded August 20, 2015. Model dates are recorded because IMPLAN updates do result in different multipliers. For example, August 24 IMPLAN models showed output multipliers that were 5% smaller than the November 19 values.