CLIMATE CHANGE, IRRIGATION ADJUSTMENTS, AND ITS ECONOMIC IMPACTS:

EXPANSION OF IRRIGATED AGRICULTURE IN GEORGIA

by

CHANGKEUN PARK

(Under the Direction of Jeffrey D. Mullen)

ABSTRACT

As an adaptation strategy for coping with climate change, the expansion of supplemental irrigated agriculture can be appropriate for the southeast region. In this dissertation, economic and employment impacts for the expansion of irrigated agriculture are estimated by applying the supply-driven Georgia multiregional input-output (MRIO) model. For the analysis, non-irrigated cultivable acreage of cotton, peanuts, corn, and soybeans in 42 counties of southwest Georgia are assumed 100% converted into irrigated acreage. With this assumption, the difference in total net returns of production between the non-irrigation and irrigation method is calculated as input data of the supply-driven Georgia MRIO model. Applying the difference in total net returns of each county by each crop to the supply-driven Georgia MRIO model, the economic impact and employment impact of increasing agricultural production due to the conversion of non-irrigated acreage is estimated for 159 counties and 21 industry sectors. Based on the information of a 95% confidence interval for each crop's average price, the lower and upper bounds of estimated results are also presented.

INDEX WORDS: Climate change, economic impact, irrigated agriculture, supply-driven MRIO model, total net returns

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A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial

Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2014

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August 2014

ACKNOWLEDGEMENTS

First of all, I really want to express deepest appreciation to Dr. Jeffrey Mullen, my advisor professor, for his patience and support needed to finish my degree. I also would like to express gratitude to Dr. Houston and Dr. Kriesel for their advice as committee members.

Especially, I appreciated to my parents, brother, and my family for their supports and patience that makes my graduation possible.

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CHAPTER 1

INTRODUCTION

1.1 IRRIGATED AGRICULTURE IN THE U.S. AND GEORGIA

Irrigated agriculture has played an important role in water allocation as well as the market value of agricultural production in the U.S. According to the U.S. Geological Survey's (USGS) water use estimates for major water demand sectors of the U.S. reported every 5 years, water withdrawals for irrigated agriculture were estimated at 144 million acre-feet per year and accounted for 31% of the total U.S. water withdrawals (37 % of the total U.S. freshwater withdrawals) in 2005. Moreover, irrigated agriculture amounted to almost 90% of U.S. consumptive water use, the portion of water withdrawn that is lost to the local environment by evaporation, crop transpiration, incorporation into products or crops, consumption by humans or livestock, or otherwise removed from the immediate water environment (Kenny et al., 2009; Schaible and Aillery, 2012). In the case of Georgia, the 2008 Farm and Ranch Irrigation Survey (a follow-up to the 2007 Census of Agriculture) reported that 0.88 million acre-feet of water was applied by irrigation on 3,584 farms (1,007,763 acres of irrigated cropland) in 2008.

According to Table 1, the market value of agricultural products sold for all U.S. farms was $394.6 billion in 2012, an increase of 32.8% from the value of 2007 ($297.2 billion). Irrigated farms, including any irrigated cropland, accounted for about 38.6% of the agricultural production value ($152.4 billion) for all U.S. farms in 2012. The ratio was 39.9% and the market value of agricultural products sold from irrigated farms was $118.5 billion in 2007. Agricultural products consist of two sub-categories: crops (including nursery and greenhouse crops) and livestock and poultry (and their products). The market value of crops production for irrigated farms was $106.3 billion and represented 69.8% of the agricultural production value for U.S. irrigated farms in 2012, even though the crops production value for irrigated farms accounted for only 50% of the crops production value for all farms. However, the value of livestock and poultry production for non-irrigated farms took up 56.2% of the agricultural production value for non-irrigated farms in 2012. From these statistics, we can infer that irrigation contributes to the production of livestock and poultry through irrigated crop production used as animal forage and feed. Moreover, non-irrigated farms usually depend more on the production of livestock and poultry than the production of crops.

Table 1. Basic information for irrigated and non-irrigated farms in the U.S.

Farm Characteristics	All farms		Irrigated farms		Non-irrigated farms	
	2012	2007	2012	2007	2012	2007
Agricultural production value	394,644,481	297,220,491	152,421,721	118,510,873	242,222,760	178,709,618
Average per farm value	187,097	134,807	514,412	393,687	133,603	93,872
Crops value	212,397,074	143,657,928	106,281,346	78,297,158	106,115,728	65,360,770
Livestock and Poultry value	182,247,407	153,562,563	46,140,375	40,213,715	136,107,032	113,348,848
Farms	2,109,303	2,204,792	296,303	301,028	1,813,000	1,903,764
Land in farms	914,527,657	922,095,840	221,096,951	231,003,205	693,430,706	691,092,635
Irrigated land	55,822,231	56,599,305	55,822,231	56,599,305	0	0
Harvested cropland	314,964,600	309,607,601	52,092,384	51,537,104	226,553,572	223,078,210
Pastureland and other land	428,112,127	444,603,270	3,729,847	5,062,201	327,633,053	331,361,945

Source: USDA/NASS, 2012 Census of Agriculture – United States data.
Unit: 1. Agricultural production, Crops, and Livestock and Poultry: thousand dollars

2. Average per farm: dollar
3. Farms: number
4. Land in farms, Irrigated land, Harvested cropland, and Pastureland and other land: acres

The significance of irrigation to U.S. agriculture is all the more conspicuous when we compare the average per farm value of agricultural products sold. The 2007 average per farm value of irrigated farms ($393,687) was 2.9 times higher than that of all farms ($134,807) and 4.2 times higher than the value of non-irrigated farms ($93,872). These ratios declined in 2012; the average per farm value of irrigated farms ($514,412) was 2.7 and 3.9 times higher than that of all farms ($187,097) and that of non-irrigated farms ($133,603), respectively. While the size of land in farms and pastureland decreased in 2012 (except in the case of non-irrigated farms), the size of harvested cropland expanded in 2012 compared to 2007. In 2012, 7.5% of all harvested cropland and pastureland (743 million acres) was irrigated across the U.S. Of the 55.8 million acres of irrigated land, 52.1 million acres (93.4%) were harvested cropland in 2012, a 1.2% increase from the 2007 harvested cropland. Irrigated pastureland was 3.7 million acres in 2012, a 27.5% decrease from 2007 (USDA/NASS, 2014a).

In Georgia, the value of agricultural products sold from irrigated farms was $2.2 billion in 2007, accounting for 31.4% of the agricultural production value for all farms ($7.1 billion). In 2012, the market value of agricultural products sold from irrigated farms represented 37.4% ($3.5 billion) of the agricultural production value for all farms ($9.3 billion). The average per farm value of irrigated farms ($390,920) was 2.6 and 3.4 times the average per farm value for all farms ($148,662) and for non-irrigated farms ($115,793), respectively, in 2007. This relationship was enhanced in 2012; the average per farm value of irrigated farms ($661,015) was 3 and 4.2 times higher than that of all farms ($219,020) and non-irrigated farms ($156,589), respectively.

Through the fact that 2012 ratios of irrigated agriculture in Georgia increased from 2007, it can be shown that the importance of irrigated agriculture in Georgia intensified in 2012. The size of pastureland for all cases was decreased in 2012; however, the size of harvested cropland was increased from 2007. The harvested cropland on irrigated farms was 1.1 million acres in 2012 and 1.13 times higher than that of 2007 (0.99 million acres). Almost 31% of the harvested cropland was irrigated in 2012 and the ratio was 29% in 2007. In the case of pastureland, only 0.7% and 1.6% was irrigated in 2012 and 2007, respectively. This information is summarized in Table 2 (USDA/NASS, 2014b; Schaible and Aillery, 2012).

Table 2. Basic information for irrigated and non-irrigated farms in Georgia

Farm Characteristics	All farms		Irrigated farms		Non-irrigated farms	
	2012	2007	2012	2007	2012	2007
Agricultural production value	9,255,125	7,112,866	3,457,110	2,234,500	5,798,015	4,878,366
Average per farm value	219,020	148,662	661,015	390,920	156,589	115,793
Crops value	3,670,455	2,142,270	2,818,881	1,655,862	851,574	486,408
Livestock and Poultry value	5,584,670	4,970,596	638,230	578,638	4,946,441	4,391,958
Farms	42,257	47,846	5,230	5,716	37,027	42,130
Land in farms	9,620,836	10,150,539	3,413,743	3,439,646	6,207,093	6,710,893
Irrigated land	1,125,355	1,017,773	1,125,355	1,017,773	0	0
Harvested cropland	3,609,788	3,390,437	1,112,359	987,160	1,403,404	1,401,079
Pastureland and other land	1,504,400	1,929,413	12,996	30,613	1,305,028	1,655,594

Source: USDA/NASS, 2012 Census of Agriculture – State Data (Georgia).

Unit: 1. Agricultural production, Crops, and Livestock and Poultry: thousand dollars

2. Average per farm: dollar

3. Farms: number

4. Land in farms, Irrigated land, Harvested cropland, and Pastureland and other land: acre

1.2 IRRIGATED AGRICULTURE IN THE WESTERN UNITED STATES

Irrigation is an especially crucial issue for agriculture in the western United States. On irrigated farms in the 17 western states, about 73% of the harvested cropland and 94% of the pastureland was irrigated in 2007. These ratios reduced to 71% and 92% in 2012, respectively. The 17 leading western states in irrigated agriculture include Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming. Among these states, Nebraska had 22.2% of the harvested cropland on irrigated farms for this region in 2012. California ranked the second largest harvested cropland at 19.9% and Texas followed with 11.3% of harvested cropland.

Although Colorado, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, Oregon, Texas, Washington, and Wyoming experienced decreased harvested cropland on irrigated farms in 2012, the size of harvested cropland on irrigated farms increased in Arizona, California, Idaho, Kansas, Nevada, South Dakota, and Utah, as shown in Figure 1. For these states, most of the water demand from both surface water and groundwater sources is concentrated on irrigated agriculture. Irrigated farms in this region used about 122 million acre-feet of water per year in 2005, and this amount represented 64% of total water withdrawals, 58% of surface water withdrawals, and 79% of groundwater withdrawals.

As the irrigation method, Nebraska, Texas, and California used sprinkler and micro-irrigation systems. Micro-irrigation is the slow application of water to small areas adjacent to the roots of plants, either on the soil surface or directly onto the root zone, through emitters placed along a water delivery line. In 2005, Arizona and Idaho application rates of irrigation systems were high; California, Montana, Kansas, and Nevada typically used large amounts of water for irrigation declined considerably the application rates from 2000 to 2005 (Kenny et al., 2009; Schaible and Aillery, 2012; Ingram et al., 2013).

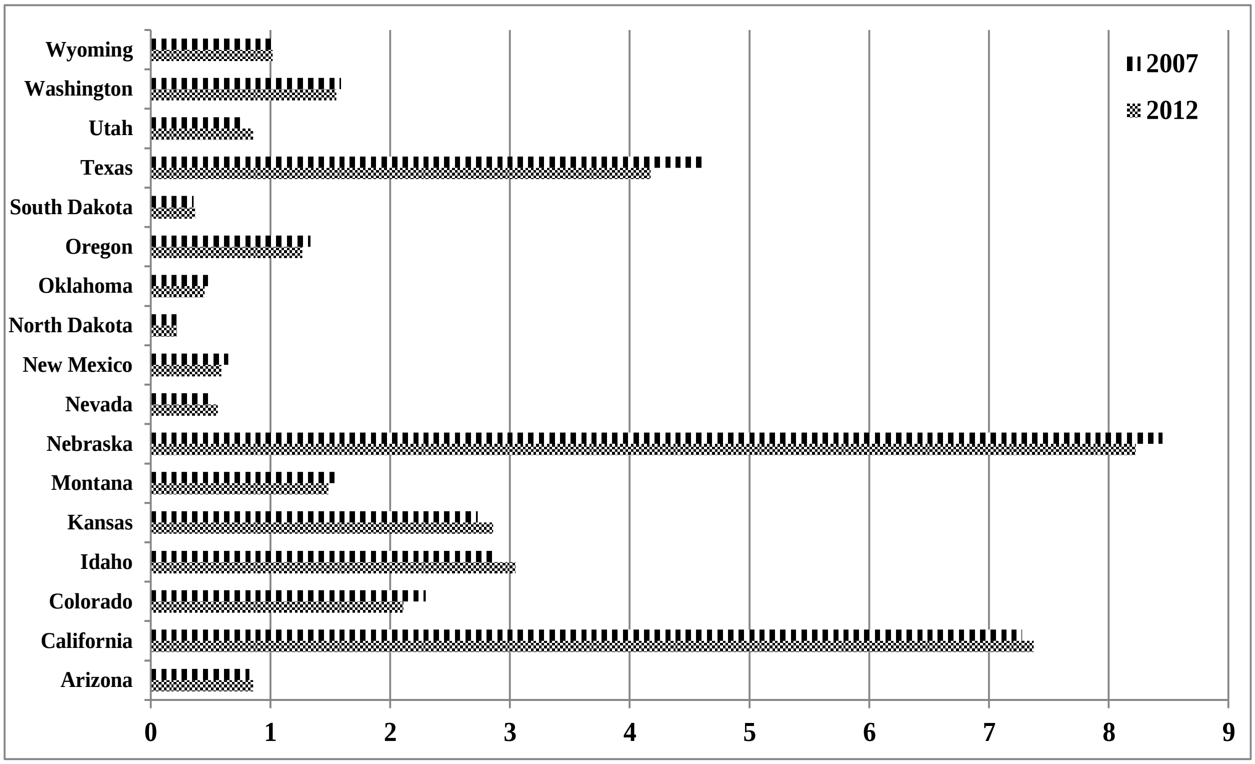

Figure 1. Harvested cropland for irrigated farms in the 17 western states
Source: USDA/NASS, 2012 Census of Agriculture – State Data
Unit: million acres

The agricultural production value for irrigated farms in the 17 states was $83 billion in 2007 and represented 60.4% of the total agricultural production value for all farms in the region. In 2010, the total agricultural production value for this region was about $162 billion, and almost 64% of this value came from irrigated agriculture. The agricultural production value for irrigated farms was $107 billion in 2012; however, the ratio to the value for all farms reduced to 58.7%. In 2012, California accounted for 34.9% of the agricultural production value for irrigated farms in the 17 states and Nebraska and Texas followed at 15.5% and 10%, respectively. The agricultural production value of Nebraska increased by 2.4% in 2012 compared to its share in 2007 (see Figure 2; Olsen 2012).

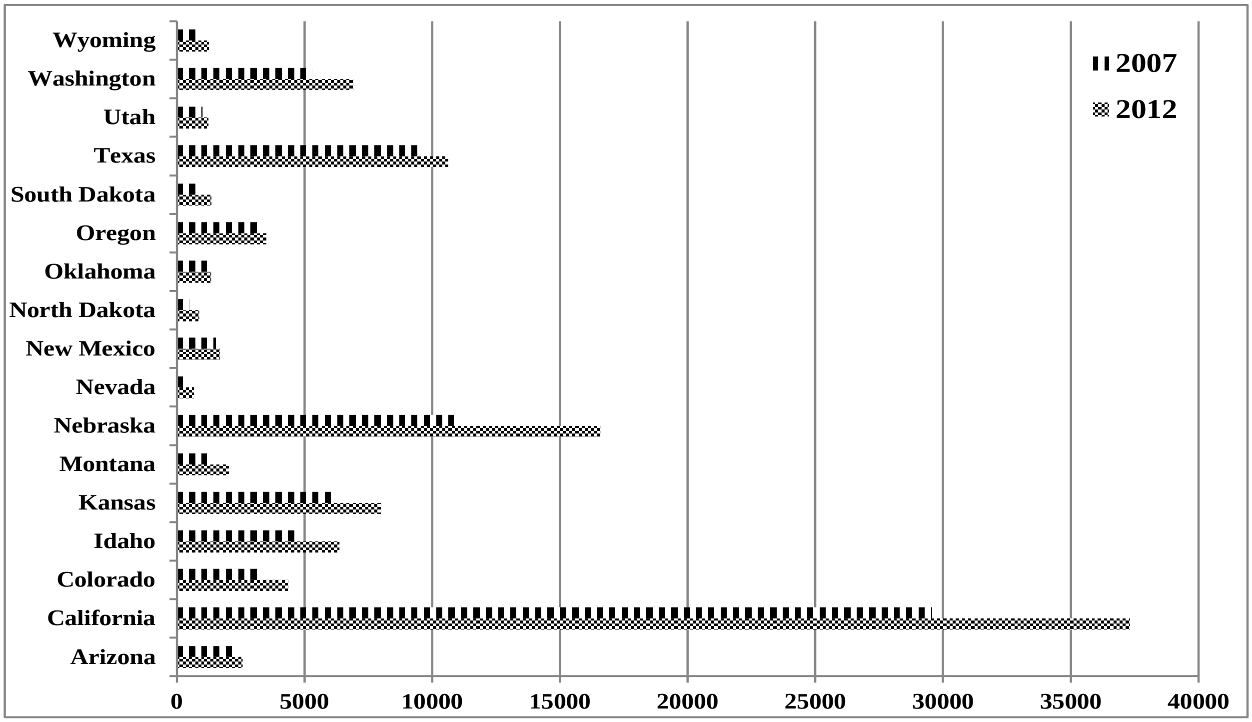

Figure 2. Agricultural production value for irrigated farms in the 17 western states
Source: USDA/NASS, 2012 Census of Agriculture – State Data
Unit: million dollars

According to Figure 3, the 2012 average per farm value of agricultural production increased greatly in the following states: North Dakota (90.7%), Montana (57%), South Dakota (52.2%), and Wyoming (50.2%). Among the 17 western states, Kansas has the highest share of average per farm value in 2012, at 14.5%. South Dakota (13.4%) and Nebraska (10.9%) followed. The 2012 average per farm value was relatively high in Nebraska, North Dakota, and Kansas, even though the agricultural production value was low in those states. Except for Arizona and New Mexico, the other states' average per farm value for irrigated farms was gretater in 2012.

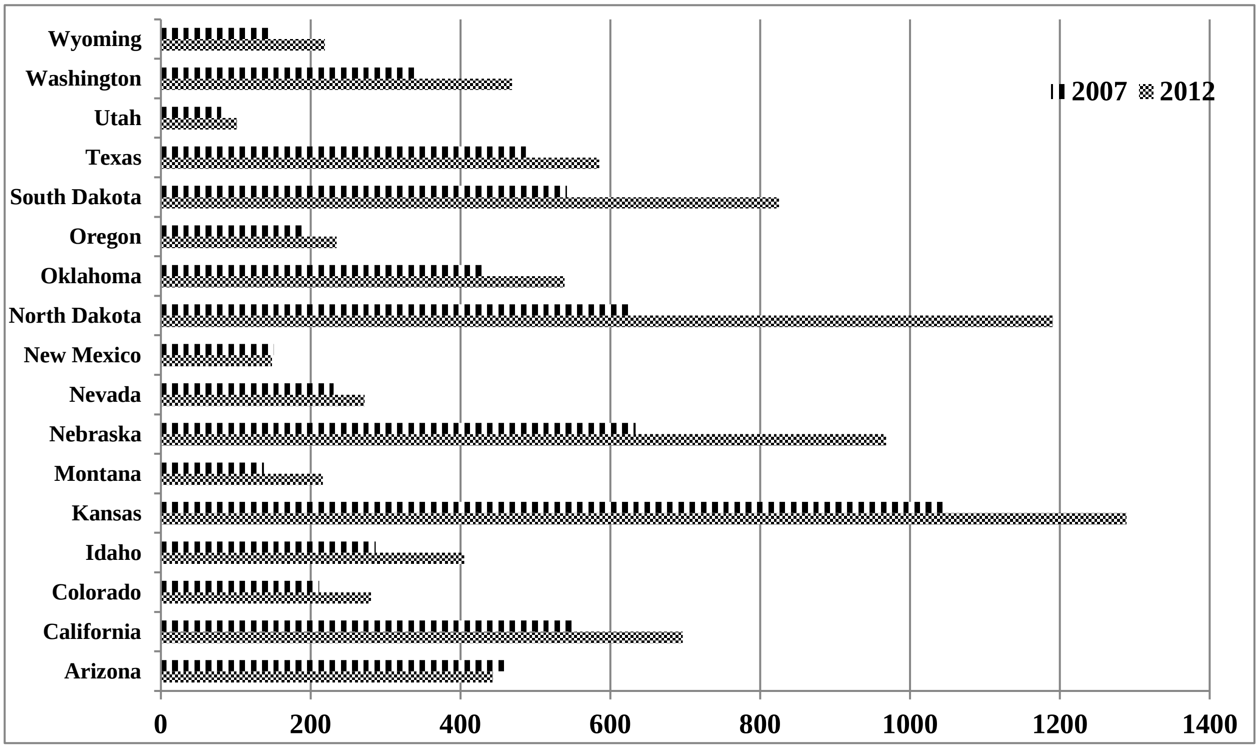

Figure 3. Average per farm value for irrigated farms in the 17 western states
Source: USDA/NASS, 2012 Census of Agriculture – State Data
Unit: thousand dollars

1.3 CLIMATE CHANGE AND IRRIGATED AGRICULTURE

During the last 50 years, government, industry, and environmental organization demands for water have increased significantly across the United States. Demands for surface and ground water needed to maintain natural ecosystems, population and economic growth, and expansion of the U.S. energy sector will continue to increase and bring new challenges for agricultural water use and conservation in the face of substantial evidence of the changes in global climate. Each sector will continuously compete for U.S. water resources and this competition is expected to strengthen during the foreseeable future. As sources of increasing water demands for the future, environmental flow requirements, energy sector expansion, climate change, and native water rights could be included (Schaible and Aillery, 2012; IPCC, 2007; U.S. CCSP, 2008).

In regard to climate change, Knowles et al. (2006) forecasted that annual precipitation will decline, particularly during the warmer summer months in many of the western states. More specifically, Kunkel et al. (2013a; 2013b; 2013c) simulated the U.S. future climate trend by climate models for two scenarios of the future path of greenhouse gas emissions. Washington, Oregon, and Idaho will experience a decrease in summer precipitation, even though there will be an increase in average annual precipitation (Kunkel et al., 2013c). The far southern regions of the southwest U.S. (California, Nevada, Utah, Colorado, Arizona, and New Mexico) will show the largest decrease in average annual precipitation, although the far northern areas will increase slightly (Kunkel et al., 2013b). The simulation results represented a decrease in summer precipitation for North Dakota, South Dakota, Montana, Wyoming, Nebraska, Kansas, Oklahoma, and Texas (Kunkel et al., 2013a).

Furthermore, simulation models of Kunkel et al. (2013a; 2013b; 2013c) indicated that annual temperature will increase during 2021 through 2099 under both high and low emissions scenarios in the 17 western states with relatively small spatial variations. Gradual increases of temperature will change the traditional source of freshwater supplies from winter snowpack to more frequent and intense early spring rain in the west (IPCC, 2007). Studies of Dettinger and Earman (2007) and Hall et al. (2008) pointed out that the amount of snowpack in mountains will decline due to the increase of temperature; therefore, water supply from storage in the the mountains will be reduced. According to Dettinger and Earman (2007), the decline of snowpack in mountains and altered runoff induced by climate change will affect crop evapotranspiration and lower river basin groundwater recharge. As these changes of climate are expected to alter both the quantity and timing of associated stream flows, water supplies for traditional peak irrigation water demands during the summer and fall growing seasons will reduce in the region. Given climate change projections, reduced water supplies could further restrain the allocation of water resources across much of the west and increased water demand from competitive user groups is expected to intensify additional constraints on water allocation (Schaible and Aillery, 2012).

Although the southeast region of the U.S. has much more precipitation and available water resources for agriculture than the arid west, modest irrigation amounts are needed to overcome seasonal and intra-seasonal rainfall variability and relatively poor water holding soils in most areas of the region. Considering its current and potential future climate condition, future agricultural growth may be a sustainable enterprise in the southeastern region. Therefore, a possible adaptation strategy for coping with climate change is needed in the southeast, and the expansion of supplemental irrigated agriculture can be an appropriate strategy. To meet sustainable food demand, not only at the local level, but also at the national level, some crop production moving from the west to the southeast (where water is more plentiful) will be a possible option to address climate change vulnerability and sustain irrigated agriculture in the southeast region.

If the production of some crops is moved to Georgia due to expected climate change, policy makers and stakeholders of irrigated agriculture will be interested in the issue of how to estimate the benefit of future allocation of water in agriculture. Based on the possibility of the production change of certain crops, this research explores the economic impacts of shifting irrigated agricultural production from the west to the southeast for the purpose of estimating added value of water allocation in the southeast’s agriculture. It will be a difficult task for future consideration regarding agricultural water allocations in the southeast and this research provides guidelines for examining the value of water allocation with a regional input-output (IO) model and for evaluating the effect and sustainability of expanding irrigated agriculture.

CHAPTER 2

LITERATURE REVIEW

Water transfer and/or reallocation issues have been of much interest in the southwestern region of the United States over several decades. Numerous studies focused on the evaluation of diverse water policies and water development projects and have been conducted on the regional economic impact analysis of water management at the state level (Seung et al., 1997; Seckler, 1971; Kelso et al., 1973; Hamilton et al., 1982; Hamilton and Pongtanakorn, 1983). Relating to the economic impact analysis of water-involved issues, two main approaches have been broadly adopted in the field: input-output (IO) and computable general equilibrium (CGE) approaches.

Among studies applying the CGE approach, Seung et al. (1997) estimated the economic impact of transferring water use from irrigated agriculture to recreational purposes at the Stillwater National Wildlife Refuge in Churchill County, Nevada. The study employed two alternative regional economic models and compared the results. The authors concluded that a regional CGE model provided a more conservative result than that of a supply-determined social accounting matrix (SDSAM) model. The SDSAM model employed overly restrictive assumptions, such as no factor substitution in production or commodity substitution in consumption and fixed prices including factor price. Considering water rights compensation, the reduction in agricultural production, and the increase in recreation-related expenditure effects, Seung et al. (1998) analyzed the economic impacts of water reallocation in the Walker River

Basin using a regional CGE model. They specified three different model variants depending on the assumptions about interregional factor mobility for the test of model sensitivity. The authors found that the effect of the reduction in agricultural production was greater than that of the combined effects of water rights compensation and the increase in recreation-related expenditures. The policy effect of each sector was also sensitive to alternative assumptions about the interregional factor mobility.

To evaluate the economic impacts of increasing irrigation in the Canterbury and Hawkes Bay regions, Kaye-Blake et al. (2010) employed the MONASH-NZ dynamic CGE model of the New Zealand economy to measure the increased irrigation impacts in three key ways: an increase in off-farm capital infrastructure costs, an increase in on-farm capital costs, and an increase in agricultural production. Using the newly developed version of the GTAP-W model, Calzadilla et al. (2008) analyzed the global effect of enhanced irrigation efficiency on crop production, water use, and welfare.

In the case of the IO approach, Kirsten and van Zyl (1990) compared several methodological alternatives for determining the impact of irrigation development, and they applied the IO model to calculate total output multipliers, income multipliers, and total employment multipliers for estimating the economic benefits of irrigation development as an empirical application. Based on the 1963 IO model of the Nebraska economy, Roesler et al. (1968) estimated the economic impact of a net increase in irrigated agriculture production with two separate impacts: the short-run impact of the additional crop production and the long-run impact due to investment activity in all sectors. With the estimated irrigated acreage in the Texas High Plains, Osborn (1973) estimated the total economic benefit using income and employment multipliers calculated from the IO model of the Texas High Plains region.

Based on the 1972 Washington State economy IO model, Findeis and Whittlesey (1984) measured the secondary impacts of irrigation development in Washington from following two aspects. First, they considered the effect of the increase in agricultural production only. Secondly, they applied the effect of higher electricity rates caused by irrigation development to the first condition. Under both assumptions of short-term and long-term output changes, they estimated the output, employment, labor income, and residual income impacts of irrigation expansion with each condition separately.

Moreover, Howe et al. (1990) analyzed the temporal pattern of water transfer from irrigated agriculture to urban areas with the Colorado Forecasting and Simulation Model (COFS). They found that the statewide negative impacts of historical agriculture-to-urban water transfer have been small relative to the costs of alternative ways of getting water for the urban areas. Similarly, Lee et al. (1987) and Whited (2010) estimated the economic impact of irrigation water transfer on Uvalde County, Texas, adopting the IO model with different measurement methods. While Lee et al. (1987) estimated the effect of projected future groundwater withdrawal rates by San Antonio on irrigated agriculture in Uvalde County, Whited (2010) focused on intermediate input changes specific to the actual crops production rather than a change in agricultural output. Other studies (Johnson and Kulshreshtha, 1982; Klein and Kulshreshtha, 1989; Kulshreshtha and Klein, 1989; Klein et al., 1989; Hamilton and Pongtanakorn, 1983; McKean and Spencer, 2003) also employed IO models or the marginal IO method to analyze the economic impact of irrigation development, irrigation water supply, and agricultural drought.

Besides IO and CGE approaches, Tiwari et al. (1999) provided a framework for environmental and economic decision-making processes in evaluating a lowland irrigated agriculture system using multi-criteria decision-making (MCDM) techniques. The MCDM included environmental and economic sustainability criteria. For the environmental sustainability criteria, land capability/suitability, energy input/output ratio, water requirements, and environmental costs are considered. The economic sustainability criteria are defined from three different perspectives: net present value from government viewpoints, net present value from farmers' viewpoints, and net present value from societal viewpoints. The results of this study showed that a shift to non-rice crops will generate more profit to farmers and fewer burdens to society differently from the traditional emphasis on rice cultivation as a means of enhancing incremental benefits of irrigated agriculture in dry season.

CHAPTER 3

RESEARCH MOTIVATION AND OBJECTIVES

3.1 RESEARCH MOTIVATION

Most of the previous studies adopting the IO approach used a demand-driven IO model or multipliers from a demand-driven IO model to estimate the economic impact of irrigated agriculture through accepting the change of agricultural production as the change of final demand. However, the total production change induced by the expansion of irrigated agriculture should be interpreted as a change of supply instead of a change of demand. Therefore, the estimation results adopting a demand-driven IO model for the impact analysis of a production change from irrigated agriculture could be incorrect, because a demand-driven IO model is not an appropriate model for the impact analysis.

The change of agricultural production could be categorized as the change of profits in agricultural sector from the economic structure. Since business sector profits are included in the value added sector, the impact of agricultural production change should be analyzed applying a supply-driven IO model instead of a demand-driven IO model. In this study, it is not the main issue which model (between the demand-driven IO model and the supply-driven IO model) can provide better estimates from the economic impact analysis derived by the agricultural production change. Instead, this study focuses on the issue of whether the application of the traditional demand-driven IO approach is appropriate or not for the impact analysis of the agricultural production change, and this viewpoint determined the motivation of this study. In order to determine the suitability of applying a demand-driven IO model for the evaluation of the effect of expanding irrigated agriculture, the following research question is posed: How does one evaluate the economic effect of increasing agricultural production caused by the expansion of irrigated agriculture?

3.2 RESEARCH OBJECTIVES

If the production of some of the crops in the west is moved to Georgia, agricultural supply in Georgia will increase and this impact cannot be measured exactly by the traditional demand-driven IO model. The demand-driven IO approach is an irrelevant approach for the case of supply change at this areal level of analysis. When we apply the supply-driven IO model, the impact analysis will provide relevant estimates for the agricultural production change in the end. This is the starting point of this research and the first objective is to develop a regional IO model for Georgia investigating the change of supply aspect for estimating the economic impact of increased agricultural production in Georgia. Estimation of the economic impact of increasing agricultural production can be accomplished with a supply-driven input-output (IO) model. Ghosh (1958) suggested a supply-driven model for estimating economic impact and Dietzenbacher (1997) interpreted the supply-driven IO model as a price model, similar to Leontief's price model. Despite some debate on the inoperability of the supply-driven IO model, Park (2007) represented the applicability of the supply-driven IO model when analyzing indirect impact from direct monetary losses.

The second research objective of this study is the estimation of the economic impact of increasing agricultural production induced by the conversion of non-irrigated cropland in Georgia using a supply-driven IO model. The results from this research will provide a guideline for estimating the value of water allocation into agriculture in Georgia.

CHAPTER 4

DATA

For a supply-driven input-output (IO) model, the 2009 Georgia multi-regional input-output (MRIO) model at the county level was constructed using the 2009 IMPLAN data. A supply-driven MRIO model for Georgia was then applied to analyze the economic impact of the crop production change induced by the conversion of non-irrigated cropland to irrigated cropland in Georgia.

As a study area, 42 counties in the southwestern region of Georgia were selected. Cotton, peanuts, corn, and soybeans are chosen as subject crops for the analysis. For a basic scenario of the analysis, all non-irrigated cultivable acreage of each subject crop in study area counties are assumed converted to irrigated acreage of cropland. That is, the scenario stands for 100% conversion from the non-irrigated production method to the irrigated production method.

As input data for the supply-driven Georgia MRIO model, the difference in total net returns of each crop between non-irrigated and irrigated production methods was calculated. For this purpose, the *2012 Census of Agriculture: Georgia State and County Data* and *Agricultural Prices* from the U.S. Department of Agriculture, National Agriculture Statistics Service were used. Based on selected counties of Georgia, each county's harvested acreage and irrigation acreage for "cotton all", "peanuts for nuts", "corn for grain", and "soybeans for beans" from Table 25 in the *2012 Census of Agriculture: Georgia State and County Data* was tabulated. The difference between harvested acreage and irrigation acreage is the size of cultivable acreage by conversion from non-irrigated production method to irrigated method.

Average price data on each crop for deriving the standard deviation of average price was calculated based on *Agricultural Prices* monthly reports from January, 2000 through February, 2014, which contain prices received by farmers for principal crops, livestock, and livestock products. The standard deviation of average price for each crop was used for the calculation of a 95% confidence interval of the difference in total net returns of each crop between both production methods.

Also compiled were the expected average price of each crop, the expected average yield per acre of each crop, and the total production cost of each crop, excluding land and management costs in South Georgia, for the conventional tillage from the *Summary of South Georgia Crop Enterprise Estimates, 2014*, provided by the UGA Extension Agricultural and Applied Economics. In Table 3, the expected average yield per acre of each crop and the total production cost of each crop excluding land and management costs in South Georgia are presented by both production methods.

Table 3. Expected average yield and Total production cost of each crop by production method

	Non-Irrigated				Irrigated			
	Cotton	Peanuts	Corn	Soybeans	Cotton	Peanuts	Corn	Soybeans
Expected Yield	750	3400	85	30	1200	4700	200	60
Unit	lb/acre	lb/acre	bushel/acre	bushel/acre	lb/acre	lb/acre	bushel/acre	bushel/acre
Total Cost ($/acre)	559	712	357	283	809	957	869	501

Source: Summary of South Georgia Crop Enterprise Estimates, 2014

The procedure calculating the difference in total net returns of each crop between non-irrigated production and irrigated production with the assumption of 100% conversion of non-irrigated cultivable acreage to irrigated acreage is shown in Equation 1:

$$IR_{ij} = (IY_i \times AP_i \times NA_{ij}) - (IC_i \times NA_{ij})$$

$$NR_{ij} = (NY_i \times AP_i \times NA_{ij}) - (NC_i \times NA_{ij})$$

$$DR_{ij} = IR_{ij} - NR_{ij} \quad (1)$$

where, IR = Total net return of irrigated production by each crop and county,

NR = Total net return of non-irrigated production by each crop and county,

DR = Difference in Total net returns by each crop and county,

IY = Expected average yield per acre of each crop by irrigated production,

AP = Expected average price of each crop,

IC = Total production cost of each crop by irrigated production,

NY = Expected average yield per acre of each crop by non-irrigated production,

NA = Non-irrigated acreage of each crop by each county (the difference between total harvested acreage and irrigated acreage),

NC = Total production cost of each crop by non-irrigated production,

i = cotton, peanuts, corn, soybeans, and

j = 42 counties in the southwest region of Georgia.

To indicate the reliability of an estimate, a 95% confidence interval was generated for the impact of increasing each crop's production. Based on the average crop price received by farmers from 2000 through 2014, the standard deviation of average crop price and a 95% confidence interval for average crop price were calculated. Using this 95% confidence interval for average crop price, the upper and lower bounds for the difference in total net returns for both production methods were calculated. The expected average price of each crop and its 95%

confidence interval are shown in Table 4. Based on this information, the calculated difference in total net returns of each crop and its 95% confidence interval are presented by each county in Table 5.

Table 4. Expected average price and a 95% confidence interval for average price of each crop

	Cotton	Peanuts	Corn	Soybeans
Expected Average price	0.78	0.22	4.6	10.8
Lower bound of Average price	0.69	0.20	3.73	8.90
Upper bound of Average price	0.87	0.24	5.47	12.70
Unit	$/lb	$/lb	$/bu	$/bu

Source: 1. Summary of South Georgia Crop Enterprise Estimates, 2014
2. Agricultural Prices from January, 2000 through February, 2014

Table 5. A 95% of confidence interval for the difference in total net returns of each crop, by county, 2014

Counties	Cotton			Peanuts		
	Lower	Mean	Upper	Lower	Mean	Upper
Baker	0.31	0.54	0.77	0.10	0.32	0.75
Ben Hill	0.28	0.49	0.70	0.08	0.24	0.57
Berrien	1.35	2.33	3.31	0.18	0.55	1.27
Bleckley	0.13	0.23	0.32	0.02	0.06	0.14
Brooks	1.70	2.93	4.16	0.06	0.19	0.44
Calhoun	0.68	1.18	1.67	0.11	0.35	0.81
Clay	0.15	0.25	0.36	0.04	0.14	0.32
Colquitt	1.83	3.16	4.48	0.10	0.31	0.72
Cook	1.04	1.79	2.54	0.07	0.22	0.50
Crisp	1.81	3.12	4.42	0.11	0.36	0.83
Decatur	0.92	1.58	2.25	0.19	0.58	1.36
Dodge	0.36	0.63	0.89	0.01	0.03	0.07
Dooly	1.63	2.81	3.99	0.08	0.25	0.59
Dougherty	0.00	0.00	0.00	0.00	0.00	0.01
Early	1.18	2.03	2.89	0.16	0.50	1.16
Grady	1.10	1.90	2.69	0.06	0.20	0.47
Houston	0.15	0.25	0.36	0.02	0.07	0.16
Irwin	1.67	2.88	4.08	0.22	0.68	1.57
Lanier	0.44	0.76	1.08	0.02	0.06	0.15
Lee	0.46	0.79	1.12	0.07	0.21	0.49
Lowndes	0.22	0.39	0.55	0.03	0.08	0.19
Macon	0.25	0.44	0.62	0.01	0.03	0.06
Marion	0.01	0.01	0.02	0.00	0.01	0.03
Miller	0.72	1.24	1.75	0.07	0.22	0.51
Mitchell	1.22	2.10	2.98	0.09	0.28	0.66
Peach	0.04	0.07	0.10	0.00	0.00	0.01

Pulaski	0.58	1.01	1.43	0.02	0.08	0.18
Randolph	0.38	0.65	0.93	0.10	0.31	0.72
Schley	0.04	0.06	0.09	0.00	0.00	0.01
Seminole	0.57	0.98	1.39	0.07	0.21	0.49
Stewart	0.16	0.27	0.39	0.04	0.11	0.26
Sumter	0.77	1.32	1.88	0.05	0.16	0.37
Talbot	0.00	0.00	0.00	0.00	0.00	0.00
Taylor	0.02	0.04	0.06	0.00	0.00	0.00
Terrell	0.81	1.40	1.99	0.11	0.33	0.78
Thomas	2.08	3.58	5.08	0.09	0.29	0.66
Tift	0.86	1.49	2.11	0.06	0.19	0.45
Turner	0.81	1.40	1.99	0.07	0.22	0.52
Twiggs	0.29	0.50	0.72	0.00	0.00	0.00
Webster	0.47	0.82	1.16	0.03	0.09	0.22
Wilcox	1.53	2.63	3.74	0.09	0.29	0.67
Worth	2.81	4.84	6.87	0.27	0.84	1.94
Total	31.87	54.89	77.92	2.91	9.07	21.09

Counties	Corn			Soybeans		
	Lower	Mean	Upper	Lower	Mean	Upper
Baker	-0.18	0.04	0.26	0.01	0.03	0.05
Ben Hill	-0.09	0.02	0.13	0.00	0.01	0.01
Berrien	-0.23	0.05	0.32	0.03	0.07	0.11
Bleckley	-0.05	0.01	0.07	0.14	0.30	0.47
Brooks	-0.14	0.03	0.20	0.24	0.51	0.79
Calhoun	-0.29	0.06	0.41	0.02	0.03	0.05
Clay	-0.03	0.01	0.04	0.02	0.04	0.06
Colquitt	-0.08	0.02	0.11	0.03	0.05	0.08
Cook	-0.04	0.01	0.06	0.01	0.03	0.04

Crisp	-0.03	0.01	0.04	0.06	0.14	0.21
Decatur	-0.63	0.13	0.89	0.21	0.45	0.69
Dodge	-0.02	0.00	0.02	0.06	0.14	0.21
Dooly	-0.08	0.02	0.11	0.17	0.36	0.55
Dougherty	0.00	0.00	0.00	0.01	0.01	0.02
Early	-0.24	0.05	0.34	0.08	0.17	0.26
Grady	-0.34	0.07	0.49	0.08	0.18	0.28
Houston	-0.05	0.01	0.07	0.10	0.21	0.33
Irwin	-0.30	0.06	0.42	0.05	0.10	0.16
Lanier	-0.02	0.00	0.02	0.00	0.01	0.01
Lee	-0.22	0.04	0.31	0.12	0.25	0.39
Lowndes	-0.05	0.01	0.07	0.05	0.10	0.16
Macon	-0.11	0.02	0.16	0.22	0.48	0.74
Marion	-0.03	0.01	0.05	0.07	0.16	0.24
Miller	-0.14	0.03	0.19	0.07	0.16	0.24
Mitchell	-0.31	0.06	0.44	0.02	0.04	0.06
Peach	0.00	0.00	0.01	0.23	0.49	0.76
Pulaski	-0.05	0.01	0.07	0.06	0.13	0.20
Randolph	-0.16	0.03	0.22	0.13	0.28	0.43
Schley	-0.01	0.00	0.01	0.04	0.09	0.14
Seminole	-0.15	0.03	0.21	0.04	0.08	0.13
Stewart	0.00	0.00	0.01	0.02	0.05	0.08
Sumter	-0.34	0.07	0.48	0.14	0.31	0.48
Talbot	0.00	0.00	0.00	0.00	0.00	0.00
Taylor	-0.04	0.01	0.06	0.12	0.26	0.40
Terrell	-0.44	0.09	0.62	0.18	0.38	0.59
Thomas	-0.32	0.07	0.45	0.10	0.23	0.35
Tift	-0.05	0.01	0.07	0.00	0.01	0.01

Turner	-0.09	0.02	0.12	0.04	0.10	0.15
Twiggs	0.00	0.00	0.00	0.00	0.00	0.00
Webster	-0.03	0.01	0.04	0.03	0.07	0.10
Wilcox	-0.01	0.00	0.02	0.05	0.10	0.15
Worth	-0.17	0.04	0.25	0.02	0.04	0.06
Total	-5.58	1.14	7.86	3.09	6.66	10.23

Unit: million dollars

CHAPTER 5

METHODOLOGY

5.1 SINGLE-REGION INPUT-OUTPUT MODELS: SINGLE-REGION DEMAND-DRIVEN INPUT-OUTPUT MODEL

If we assume that a region's economy is composed of *n* industry sectors, the economy structure of a region can be simply summarized by the interindustry transactions table expanded to include final demand and value added sectors, as shown in Table 6. The final demand sector includes personal consumption and expenditure, private domestic investment, government purchases of goods and services, and net exports of goods and services. Furthermore, the value added sector comprises employee compensation, businesses profits, capital including interest payments and depreciation, rental payment, and government services such as those paid for by taxes (Miller and Blair, 2009).

Based on Table 6, the total output of sector *k*, $x_{k,}$ can be expressed as the summation of the transactions between sector *k* to all other sectors (z_{k1}, z_{k2}, …, z_{kn}) and the final demand for product of sector *k*, f_k, as shown in Equation 2:

$$x_k = z_{k1} + z_{k2} + \cdots + z_{kn} + f_k = \sum_{l=1}^{n} z_{kl} + f_k \qquad (2)$$

Table 6. Simple expanded transactions table of a regional economy

		Industry sectors				Final Demand	Total output
		1	2	$\cdots$	n		
Industry sectors	1	z_{11}	z_{12}	$\cdots$	z_{1n}	f_1	x_1
	2	z_{21}	z_{22}	$\cdots$	z_{2n}	f_2	x_2
	$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$	$\vdots$
	n	z_{n1}	z_{n2}	$\cdots$	z_{nn}	f_n	x_n
Value Added		v_1	v_2	$\cdots$	v_n		
Total input		x_1	x_2	$\cdots$	x_n		

In the same manner, *n* sectors' total output will be written as the following identities in Equation 3:

$$
\begin{aligned}
x_1 &= z_{11} + z_{12} + \cdots + z_{1n} + f_1 = \sum_{l=1}^{n} z_{1l} + f_1 \\
x_2 &= z_{21} + z_{22} + \cdots + z_{2n} + f_2 = \sum_{l=1}^{n} z_{2l} + f_2 \\
&\vdots \\
x_n &= z_{n1} + z_{n2} + \cdots + z_{nn} + f_n = \sum_{l=1}^{n} z_{nl} + f_n
\end{aligned} \tag{3}
$$

Since the term z_{kl} stands for the interindustry or intermediate sales from specific sector k to all other sectors l, the identities representing the distribution of each sector's sales in Equation 3 may be summarized as a matrix form in Equation 4:

$$\mathrm{X} = \mathrm{Zu} + \mathrm{F} \tag{4}$$

where, $\mathrm{X} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}$, $\mathrm{Z} = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ z_{n1} & z_{n2} & \cdots & z_{nn} \end{bmatrix}$, $\mathrm{u} = \begin{bmatrix} 1 \\ 1 \\ \vdots \\ 1 \end{bmatrix}$, and $\mathrm{F} = \begin{bmatrix} f_1 \\ f_2 \\ \vdots \\ f_n \end{bmatrix}$

In the demand-driven input output (IO) approach, the ratio of interindustry sales from sectors k to l (z_{kl}) to total output of sector l (x_l) determines a technical coefficient or direct input coefficient, and the technical coefficient of a region's economy can be expressed, as shown in Equation 5:

$$a_{kl} = \frac{z_{kl}}{x_l} \tag{5}$$

The technical coefficient represents a region's technology level and is assumed to be unchanging during a given period. Therefore, a_{kl} is used to measure the fixed relationship between output of each sector and its input. It could be interpreted that production in the IO approach operates under constant returns to scale, not economies of scale. Using a matrix form, it could be shown as:

$$\mathrm{A} = \mathrm{Z}\hat{\mathrm{X}}^{-1} \tag{6}$$

where, $A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$ and $\widehat{X}^{-1} = \begin{bmatrix} 1/x_1 & 0 & \cdots & 0 \\ 0 & 1/x_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 1/x_n \end{bmatrix}$

From Equation 6, we can derive the following relationship, $Z = AX$, and we can also express Equation 4 as the following:

$$X = AX + F, \quad X - AX = F,$$

$$(I - A)X = F, \quad X = (I - A)^{-1}F \tag{7}$$

In Equation 7, the inverse matrix $(I - A)^{-1}$ is usually called the Leontief inverse matrix or the total requirements matrix and this inverse matrix is used to measure the value of total output per unit of the final demand. Therefore, the change of total output (ΔX) would be derived through the Leontief inverse matrix when the change of final demand (ΔF) is given exogenously:

$$\Delta X = (I - A)^{-1}\Delta F \tag{8}$$

According to the fact that the Leontief inverse matrix relates the total output of each sector to a unit of product leaving the interindustry system at the end of the process, the l^{th} column sum of the Leontief inverse matrix measures the total output of all sectors generated from one unit final demand of l^{th} sector's output and this reflects the backward linkage of sector *l* (Reis and Rua, 2006).

5.2 SINGLE-REGION INPUT-OUTPUT MODELS: SINGLE-REGION SUPPLY-DRIVEN INPUT-OUTPUT MODEL

Similar to Equation 3, the structure of the economy consists of *n* sectors and can also be expressed with identities of the total input (x_l), transaction between sectors (z_{kl}), and value added sector (v_l):

$$
\begin{aligned}
x_1 &= z_{11} + z_{21} + \cdots + z_{n1} + v_1 = \sum_{k=1}^{n} z_{k1} + v_1 \\
x_2 &= z_{12} + z_{22} + \cdots + z_{n2} + v_2 = \sum_{k=1}^{n} z_{k2} + v_2 \\
&\vdots \\
x_n &= z_{1n} + z_{2n} + \cdots + z_{nn} + v_n = \sum_{k=1}^{n} z_{kn} + v_n
\end{aligned}
\tag{9}
$$

This transposes a column view of the economy structure to a row view and Equation 9 could be presented as a matrix form in Equation 10:

$$\mathrm{X}' = \mathrm{u}'\mathrm{Z} + \mathrm{V}' \tag{10}$$

where, $\mathrm{X}' = [x_1, x_2, \cdots, x_n]$, $\mathrm{u}' = [1,1,\cdots,1]$, and $\mathrm{V}' = [v_1, v_2, \cdots, v_n]$

For the construction of a supply-driven IO model, it is required to set up the relationship between interindustry sales from sector *k* to sector *l* (z_{kl}) and the total input of sector *k* (x_k) differently from the technical coefficients defined in Equation 6 for the demand-driven IO model.

The new relationship stands for an allocation coefficient or direct output coefficient and could be expressed as $b_{kl} = \frac{z_{kl}}{x_k}$. The direct output coefficient, b_{kl}, could be interpreted as the allocation of sector *k*'s total output to sectors *l* that purchase interindustry inputs from sector *k*. Dividing each row of the interindustry sales matrix Z by the total input of the sector associated with that row, the direct output coefficient matrix B can be derived as Equation 11:

$$\mathrm{B} = \hat{\mathrm{X}}^{-1}\mathrm{Z} \tag{11}$$

From $\mathrm{Z} = \hat{\mathrm{X}}\mathrm{B}$, Equation 10 can be rewritten and the Ghoshian inverse matrix $(\mathrm{I} - \mathrm{B})^{-1}$ is obtained through Equation 12 (Ghosh, 1958):

$$\mathrm{X}' = \mathrm{u}'\hat{\mathrm{X}}\mathrm{B} + \mathrm{V}' = \mathrm{X}'\mathrm{B} + \mathrm{V}', \qquad \mathrm{X}' - \mathrm{X}'\mathrm{B} = \mathrm{V}',$$
$$(\mathrm{I} - \mathrm{B})\mathrm{X}' = \mathrm{V}', \qquad \mathrm{X}' = V'(\mathrm{I} - \mathrm{B})^{-1} \tag{12}$$

The change of total output ($\Delta\mathrm{X}$) due to the exogenous change of value added sector ($\Delta\mathrm{V}$) would be estimated through the Ghoshian inverse matrix as shown in Equation 13:

$$\Delta\mathrm{X} = \Delta\mathrm{V}'(\mathrm{I} - \mathrm{B})^{-1} \tag{13}$$

Because the Ghoshian inverse matrix or output inverse matrix connects total output of each sector to the primary inputs entering the interindustry system at the beginning of the process, it is possible to measure the effect of a one unit change in primary inputs for sector *k* on the total output of sector *l*. Thus, k^{th} row sum of the Ghoshian inverse matrix represents the total output throughout all sectors induced by a unit change in primary inputs for sector *k*, and this row sum of the Ghoshian inverse matrix reflects the forward linkage of sector *k* (Reis and Rua, 2006; Augustinovics, 1970).

5.3 MANY-REGION INPUT-OUTPUT MODELS: THE INTERREGIONAL INPUT-OUTPUT (IRIO) MODEL

An essential issue in constructing a many-region input-output model is the estimation of the trade flows between regions. For the IO model consisting of many regions, both intra-regional and inter-regional data are required. Two types of models could be mentioned as a typical example of many-region input-output models: the interregional input-output (IRIO) model and the multiregional input-output (MRIO) model.

The IRIO model was introduced by Isard (1951) and advanced elaborately in the study of Isard et al. (1960). Considering the economy consists of two-regions, region *t* and *u*, the required data could be expressed as the following transactions matrices:

$$Z^{tt} = [z_{kl}^{tt}], Z^{uu} = [z_{kl}^{uu}], Z^{tu} = [z_{kl}^{tu}], \text{and } Z^{ut} = [z_{kl}^{ut}] \qquad (14)$$

Z^{tt} and Z^{uu} implied interindustry transactions from sectors *k* to *l* within same regions, *t* and *u*, respectively. Furthermore, Z^{tu} and Z^{ut} captured interindustry transactions from regions *t* to *u* and vice versa. Therefore, the former two matrices stand for intra-regional transactions matrices and the latter two matrices recorded inter-regional transactions. Let regions *t* and *u* have *m* industry sectors; we can collect the data presented in Table 7 by surveying the following two types of information from firms in each region. First, if we ask firms in both regions for the input amounts purchased from their region and the other region, we would accumulate the column data of Table 7. Also, for the row data of Table 7, we have to survey firms in each region on the amount they sell to each sector in their region and the other region (Miller and Blair, 2009).

Based on the information in Table 7, the direct input coefficients for regions *t* and *u* as well as the interregional direct input coefficients could be defined as:

$$a_{kl}^{tt} = \frac{z_{kl}^{tt}}{x_l^t},\ a_{kl}^{uu} = \frac{z_{kl}^{uu}}{x_l^u},\ a_{kl}^{tu} = \frac{z_{kl}^{tu}}{x_l^u},\ \text{and } a_{kl}^{ut} = \frac{z_{kl}^{ut}}{x_l^t} \tag{15}$$

Using similar notation in Equations 6 and 7, we can express the interregional input-output model with a matrix form in Equation 16:

$$\mathrm{X} = \mathrm{AX} + \mathrm{F}, \qquad \mathrm{X} = (\mathrm{I} - \mathrm{A})^{-1}\mathrm{F} \tag{16}$$

Where, $\mathrm{A} = \begin{bmatrix} A^{tt} & A^{tu} \\ A^{ut} & A^{uu} \end{bmatrix}$, $\mathrm{X} = \begin{bmatrix} X^{t} \\ X^{u} \end{bmatrix}$, $\mathrm{F} = \begin{bmatrix} F^{t} \\ F^{u} \end{bmatrix}$, $\mathrm{A}^{tt} = \begin{bmatrix} a_{11}^{tt} & a_{12}^{tt} \dots a_{1m}^{tt} \\ a_{21}^{tt} & a_{22}^{tt} \cdots a_{2m}^{tt} \\ \vdots & \vdots \ \ddots \ \vdots \\ a_{m1}^{tt} & a_{m2}^{tt} \cdots a_{mm}^{tt} \end{bmatrix}$,

$\mathrm{A}^{tu} = \begin{bmatrix} a_{11}^{tu} & a_{12}^{tu} \dots a_{1m}^{tu} \\ a_{21}^{tu} & a_{22}^{tu} \cdots a_{2m}^{tu} \\ \vdots & \vdots \ \ddots \ \vdots \\ a_{m1}^{tu} & a_{m2}^{tu} \cdots a_{mm}^{tu} \end{bmatrix}$, $\mathrm{A}^{ut} = \begin{bmatrix} a_{11}^{ut} & a_{12}^{ut} \dots a_{1m}^{ut} \\ a_{21}^{ut} & a_{22}^{ut} \cdots a_{2m}^{ut} \\ \vdots & \vdots \ \ddots \ \vdots \\ a_{m1}^{ut} & a_{m2}^{ut} \cdots a_{mm}^{ut} \end{bmatrix}$, $\mathrm{A}^{uu} = \begin{bmatrix} a_{11}^{uu} & a_{12}^{uu} \dots a_{1m}^{uu} \\ a_{21}^{uu} & a_{22}^{uu} \cdots a_{2m}^{uu} \\ \vdots & \vdots \ \ddots \ \vdots \\ a_{m1}^{uu} & a_{m2}^{uu} \cdots a_{mm}^{uu} \end{bmatrix}$,

$\mathrm{X}^{t} = \begin{bmatrix} x_1^t \\ x_2^t \\ \vdots \\ x_m^t \end{bmatrix}$, $\mathrm{X}^{u} = \begin{bmatrix} x_1^u \\ x_2^u \\ \vdots \\ x_m^u \end{bmatrix}$, $\mathrm{F}^{t} = \begin{bmatrix} f_1^t \\ f_2^t \\ \vdots \\ f_m^t \end{bmatrix}$, and $\mathrm{F}^{u} = \begin{bmatrix} f_1^u \\ f_2^u \\ \vdots \\ f_m^u \end{bmatrix}$.

Table 7. Simple expanded transactions table of the economy with two regions

		Region t				Region u				Final Demand	Total output
		1	2	$\cdots$	m	1	2	$\cdots$	m		
Region t	1	z_{11}^{tt}	z_{12}^{tt}	$\cdots$	z_{1m}^{tt}	z_{11}^{tu}	z_{12}^{tu}	$\cdots$	z_{1m}^{tu}	f_1^t	x_1^t
	2	z_{21}^{tt}	z_{22}^{tt}	$\cdots$	z_{2m}^{tt}	z_{21}^{tu}	z_{22}^{tu}	$\cdots$	z_{2m}^{tu}	f_2^t	x_2^t
	$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$	$\vdots$
	m	z_{m1}^{tt}	z_{m2}^{tt}	$\cdots$	z_{mm}^{tt}	z_{m1}^{tu}	z_{m2}^{tu}	$\cdots$	z_{mm}^{tu}	f_m^t	x_m^t
Region u	1	z_{11}^{ut}	z_{12}^{ut}	$\cdots$	z_{1m}^{ut}	z_{11}^{uu}	z_{12}^{uu}	$\cdots$	z_{1m}^{uu}	f_1^u	x_1^u
	2	z_{21}^{ut}	z_{22}^{ut}	$\cdots$	z_{2m}^{ut}	z_{21}^{uu}	z_{22}^{uu}	$\cdots$	z_{2m}^{uu}	f_2^u	x_2^u
	$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$	$\vdots$
	m	z_{m1}^{ut}	z_{m2}^{ut}	$\cdots$	z_{mm}^{ut}	z_{m1}^{uu}	z_{m2}^{uu}	$\cdots$	z_{mm}^{uu}	f_m^u	x_m^u
Value Added		v_1^t	v_2^t	$\cdots$	v_m^t	v_1^u	v_2^u	$\cdots$	v_m^u		
Total input		x_1^t	x_2^t	$\cdots$	x_m^t	x_1^u	x_2^u	$\cdots$	x_m^u		

Not only the direct input coefficients of regions *t* and *u*, but also interregional direct input coefficients are stable and unvarying during the given time. However, it is unlikely to get such a detailed and complete set of information in practice, when we consider time and costs to collect the survey data. As an alternative method, Chenery (1953) and Moses (1955) suggested the multi-regional input-output (MRIO) model, which is explained in the next section (the MRIO model is also labeled the “Chenery-Moses model”) (Miller and Blair, 2009).

5.4 MANY-REGION INPUT-OUTPUT MODELS: THE MULTIREGIONAL INPUT-OUTPUT (MRIO) MODEL

Contrasted with the IRIO model, the originating region's information of a given input is ignored in the direct input coefficients of regions *t* and *u* for the MRIO model. Only information on the transaction amount of input from sectors *k* to *l* is needed when the direct input coefficients are calculated in the MRIO model. Therefore, the direct input coefficients matrices for regions *t* and *u* could be expressed as $A^t = [a_{kl}^t]$ and $A^u = [a_{kl}^u]$. Moreover, the direct input coefficients for regions *t* and *u* are determined as $a_{kl}^t = \frac{z_{kl}^{*t}}{x_l^t}$ and $a_{kl}^u = \frac{z_{kl}^{*u}}{x_l^u}$, where * includes all the other originating regions. Consider the following expanded transactions table (Table 8) and interregional trade flows table (Table 9) representing the structure of the economy consisting of two regions (regions *t* and *u*) and *m* industry sectors.

Table 8. Simple expanded transactions table for a multiregional case with two regions

		Region *t*				Region *u*				Final Demand	Total output
		1	2	⋯	m	1	2	⋯	m		
Industry sectors	1	z_{11}^t	z_{12}^t	⋯	z_{1m}^t	z_{11}^u	z_{12}^u	⋯	z_{1m}^u	f_1^t	x_1^t
	2	z_{21}^t	z_{22}^t	⋯	z_{2m}^t	z_{21}^u	z_{22}^u	⋯	z_{2m}^u	f_2^t	x_2^t
	⋮	⋮	⋮	⋱	⋮	⋮	⋮	⋱	⋮	⋮	⋮
	m	z_{m1}^t	z_{m2}^t	⋯	z_{mm}^t	z_{m1}^u	z_{m2}^u	⋯	z_{mm}^u	f_m^t	x_m^t
Value Added		v_1^t	v_2^t	⋯	v_m^t	v_1^u	v_2^u	⋯	v_m^u		
Total input		x_1^t	x_2^t	⋯	x_m^t	x_1^u	x_2^u	⋯	x_m^u		

Table 9. Interregional trade flows of each sector for a multiregional case with two regions

	Sector 1		Sector 2		⋯	Sector *m*	
	Region *t*	Region *u*	Region *t*	Region *u*	⋯	Region *t*	Region *u*
Region *t*	z_1^{tt}	z_1^{tu}	z_2^{tt}	z_2^{tu}	⋯	z_m^{tt}	z_m^{tu}
Region *u*	z_1^{ut}	z_1^{uu}	z_2^{ut}	z_2^{uu}	⋯	z_m^{ut}	z_m^{uu}
sum	S_1^t	S_1^u	S_2^t	S_2^u	⋯	S_m^t	S_m^u

Each element in Table 9, for example z_k^{tu}, refers to the trade amount of sector *k* from region *t* to region *u* and in this case, all the destination industry sectors are included. Since trade flows estimation in the MRIO model is done by sector, the column sums in Table 9 represent the total trade flows of each industry sector from all the other regions into the given region. Thus, S_k^u

denotes the sum of trade flows of sector *k* from regions *t* and *u* into region *u*, irrespective of the destination industry sectors. Dividing each sector's trade flows by the total trade flows of each industry sector, the trade flows coefficient could be determined:

$$c_k^{tu} = \frac{z_k^{tu}}{S_k^u} \qquad (17)$$

Due to the number of industry sectors, the trade flows coefficient could be expressed as a (m x 1) column vector:

$$C^{tu} = \begin{bmatrix} c_1^{tu} \\ c_2^{tu} \\ \vdots \\ c_m^{tu} \end{bmatrix} \qquad (18)$$

Multiplying the direct input coefficients matrices of regions *t* and *u* by the diagonal matrices of the trade flows coefficient vector, we can estimate intra-regional and inter-regional direct input coefficients matrices, which are defined in the IRIO model:

$$A^{tt} = \hat{C}^{tt}A^t, \quad A^{tu} = \hat{C}^{tu}A^u, \quad A^{ut} = \hat{C}^{ut}A^t, \quad A^{uu} = \hat{C}^{uu}A^u \qquad (19)$$

where, $A^t = \begin{bmatrix} a_{11}^t & a_{12}^t & \dots & a_{1m}^t \\ a_{21}^t & a_{22}^t & \cdots & a_{2m}^t \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1}^t & a_{m2}^t & \cdots & a_{mm}^t \end{bmatrix}$, $A^u = \begin{bmatrix} a_{11}^u & a_{12}^u & \dots & a_{1m}^u \\ a_{21}^u & a_{22}^u & \cdots & a_{2m}^u \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1}^u & a_{m2}^u & \cdots & a_{mm}^u \end{bmatrix}$, $\hat{C}^{tt} = \begin{bmatrix} c_1^{tt} & 0 & \dots & 0 \\ 0 & c_2^{tt} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & c_m^{tt} \end{bmatrix}$,

$\hat{C}^{tu} = \begin{bmatrix} c_1^{tu} & 0 & \dots & 0 \\ 0 & c_2^{tu} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & c_m^{tu} \end{bmatrix}$, $\hat{C}^{ut} = \begin{bmatrix} c_1^{ut} & 0 & \dots & 0 \\ 0 & c_2^{ut} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & c_m^{ut} \end{bmatrix}$, and $\hat{C}^{uu} = \begin{bmatrix} c_1^{uu} & 0 & \dots & 0 \\ 0 & c_2^{uu} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & c_m^{uu} \end{bmatrix}$.

Based on Equations 16 and 19, the MRIO model could be defined as a matrix form:

$$(I - CA)X = CF, \qquad X = (I - CA)^{-1}CF \tag{20}$$

where, $A = \begin{bmatrix} A^t & 0 \\ 0 & A^u \end{bmatrix}$, $C = \begin{bmatrix} \hat{C}^{tt} & \hat{C}^{tu} \\ \hat{C}^{ut} & \hat{C}^{uu} \end{bmatrix}$, $X = \begin{bmatrix} X^t \\ X^u \end{bmatrix}$, and $F = \begin{bmatrix} F^t \\ F^u \end{bmatrix}$.

Major sources of trade flow data in the U.S. include the Commodity Flow Survey (CFS) and the Freight Analysis Framework (FAF). However, Erlbaum and Holguin-Veras (2005) pointed out several inherent problems in the CFS data with no trade flows under the aggregated metropolitan statistical level. Not only are trade flows of service sectors not available in the CFS and FAF data, but there are also no available data such as inter-industrial trade flows among counties. Although an estimating process for county-to-county trade flows of both commodity and service industry sectors are needed, the estimation of trade flows at the county level was impractical using the CFS and FAF data. Even though available data sources relevant to the estimation of trade flows for both state and county level are restricted in the field, Park (2006) reported an elaborate way to estimate trade flows of service sectors at the state level in the U.S. The Geographically Weighted Regression (GWR) methodology applied in the study of Park (2006) could be an operational framework for inter-county trade flows estimation of commodity sectors as well as industry sectors (Park et al., 2009a).

For the purpose of estimating interregional trade flows in the context of constructing a multiregional input-output model, two methods have been applied in the IMPLAN software: regional purchase coefficients (RPCs) and a National Trade Flows Model. Based on 1977 data and the MRIO approach done by Polenske (1970), Jack Faucett Associates, Inc. (1983) developed a MRIO model with 51 regions and 84 industry sectors. Using this MRIO model, Alward and Despotakis (1988) developed econometric equations to estimate regional purchase coefficients (RPCs) for estimating trade flows of commodities between counties. A regional purchase coefficient stands for the proportion of each dollar of local demand for a given commodity that is purchased from local producers. Recently, Thorvaldson et al. (2011) updated and improved econometric equations for the estimation of RPCs using more recent data and additional data not previously available. Alternatively, Lindall et al. (2005) developed a National Trade Flows Model for the inter-county trade flow estimates which adopted a doubly-constrained gravity model using county-level estimates of commodity supply and demand from the IMPLAN. The new trade flows model can provide not only a new set of regional purchase coefficients for a single region model, but it can also the basis for developing a multiregional social accounting matrix (SAM).

Aside from these approaches, Robinson and Liu (2006) evaluated two interregional trade flow estimating procedures: applying Location Quotients to estimate domestic exports and using the regional purchase coefficients to estimate domestic imports. They estimated the effects of both procedures on multiregional SAM multipliers. Furthermore, Canning and Wang (2005) developed and implemented a mathematical programming model to formulate constrained matrix-balancing problems. They estimated interregional and interindustry transaction flows in a national economic system based on an interregional accounting framework and initial information of interregional shipments. They also evaluated the performance of the model compared to real world data.

Several approaches for interregional trade flow estimation mentioned in the previous paragraphs have their own weak points. First, the RPCs method is only applicable to commodities for creating multipliers of each commodity and estimating the direct impact leakage.

For other types of transactions, such as construction and services, the RPCs could not cover the trade flows of these transactions between regions which the IMPLAN has adopted the alternative adjustment method for services sectors' trade flows estimation. In the case of a National Trade Flows Model, the trade flows between regions are proportional to the size of an economy and represent the inverse relationship to the distance or transaction cost of goods and services. Due to the structure of the gravity model, only the location of industries contributed to the trade relationship between regions. Therefore, the strategic location of a specific industry could not be reflected in the trade flow estimation under a doubly-constrained gravity model. Finally, the study of Hewings et al. (2001) used the location quotient to estimate industry trade coefficients using the employment data by the Illinois Department of Employment Security. Using only employment data to estimate trade coefficients is too restricted to reflect interregional trade relationships in the real world.

Compared to these approaches for estimating interregional trade flows, the GWR approach has a couple of relative advantages. First, the estimation of trade flows for service sectors is possible using the GWR approach. Second, the GWR approach could focus not only on distance between regions, but also on the other attributes of industry in the region, such as employment, commodity sectors total output, service sectors total output, locally supplied total output, and final demand. Therefore, it is possible in the GWR approach to capture more realistic trade relationships between regions than the above explained estimation methods. Because of these advantages in the estimation process of the GWR approach, the GWR approach to estimate the interregional trade flows is used in this study.

Combining the trade flows coefficients matrix estimated through the GWR approach and each county's IO tables, a multiregional input-output model could be constructed successfully along with the methodology suggested by Chenery (1953) and Moses (1955). The detailed process to construct a supply-driven multiregional input-output model for Georgia is expressed graphically in Figure 4.

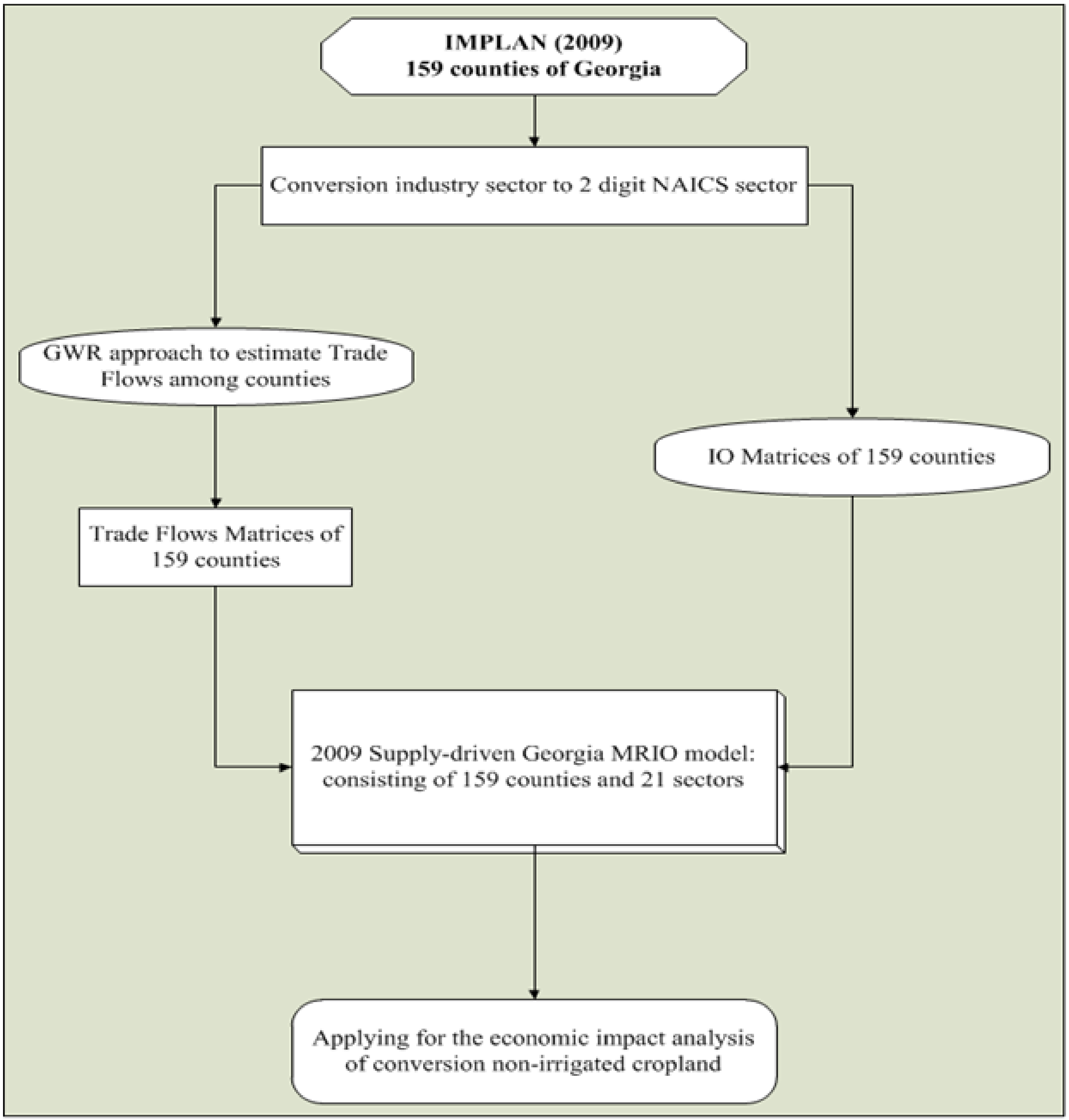

Figure 4 The process to construct the supply-driven Georgia MRIO model

5.5 GEOGRAPHICALLY WEIGHTED REGRESSIONS (GWR) APPROACH

Spatial heteroscadasticity means variation in relationships over space, and a different relationship will generally hold for every point in space. Among several approaches to model variation over space, geographically weighted regressions (GWR) is based on the non-parametric locally linear regression methods introduced by McMillen (1996) and McMillen and McDonald (1997). Applying the weighted least squares (WLS) method, the GWR approach used locally weighted regressions to adjust a spatial heteroscadiasticity based on a distance-weighted sub-sample of nearby observations (LeSage, 1999).

If error term ε_i has a spatial heteroscadiasticity over space observation *i*, the regression model can be expressed as Equation 21:

$$\mathrm{y}_i = \sum_{k=1}^{K} \beta_k X + \varepsilon_i \tag{21}$$

where, i = spatial observation (e.g. state, county etc.),

y_i = a (n x 1) vector of dependent variables,

β_k = a (k x 1) vector of parameter estimated,

X = a (n x k) matrix of explanatory variables, and

ε_i = a (n x 1) vector of error term satisfied $\varepsilon_i \sim N(0, \sigma_i^2)$.

Assuming W_i represents a (n x n) diagonal matrix with distance-based weights for *i*, and therefore reflects the distance between space observation *i* and all other spatial observations, a geographically weighted regression model can be written in a matrix form:

$$\sqrt{W_i}y_i = \sqrt{W_i}X\beta_i + \sqrt{W_i}\varepsilon_i \tag{22}$$

For the distance-based weights W_i, Brundson et al. (1996) introduced "bandwidth" decay parameter θ using an exponential decay function to produce estimates that vary more or less rapidly over space. McMillen (1996) proposed the tri-cube function as the weight function. Park (2006) used the distance-based weights relying on a Gaussian standard normal density function $\emptyset$, as shown in Equation 23, and found that a Gaussian standard normal density function provided better estimates for trade flows. His finding is based on the fact that the "bandwidth" decay parameter θ, adjusting the distance-effects, is affected by various independent variables.

$$W_i = \emptyset\left(\frac{d_i}{\sigma\theta}\right) \tag{23}$$

Where, σ = the standard deviation of the distance vector d_i.

The distance vector included in Equation 23 is calculated in Equation 24:

$$d_i = \sqrt{(L_{xi} - L_{xj})^2 + (L_{yi} - L_{yj})^2} \tag{24}$$

where, L_{xi}, L_{xj}, L_{yi}, and L_{yj} = the latitude (x) and longitude (y) coordinate values of observations *i* and *j*.

Through a cross-validation procedure, the "bandwidth" decay parameter θ could be evaluated, and a new iteration approach was used to estimate the optimal decay parameter θ from a score function shown in Equation 25:

$$\sum_{k=1}^{K}[y_i - y^*_{\neq i}(\theta)]^2 \qquad (25)$$

where, $y^*_{\neq i}$ stands for the optimally fitted value of y_i omitted from observation *i*.

The decay parameter θ which minimizes the sum of the residuals is selected for the distance-based weights W_i through iterations. Therefore, the most optimally estimated $y^*_{\neq i}$ reflects all effects of the independent variables and spatial relationships with a fixed distance. Due to this selection process of the decay parameter, the weights matrix W_i can have estimates which represent characteristics of flexibility and tractability depending on independent variables, while other spatial autoregressive models have fixed weights.

In this study, the domestic imports of each county are used as the dependent variable for applying the GWR approach expressed in Equation 22. Domestic imports represent the trade amount within the boundary of the U.S. from all the other regions to the given region. For independent variables, employment, final demand, sum of commodity sectors output, sum of service sectors output, remaining output, and the latitude and longitude coordinate values of each county in Georgia are used. From the 2009 IMPLAN data, relevant data for dependent and independent variables was collected through the aggregation process for the conversion of industry sector to 2 digit NAICS sector.

Based on the distance-based weights matrix estimated from Equation 22, I calculated the trade flows of each industry sector between counties by multiplying the domestic imports into the weights matrix, which the diagonal elements exclude, and the results correspond to the element of Table 9, z_k^{tu}. The remaining output of each industry sector which represents the locally-supplied amount is used as the element z_k^{tt} from Table 9. Using these two trade flow data of each industry sector, the trade flows coefficients matrix C defined in Equation 20 is derived.

5.6 THE SUPPLY-DRIVEN GEORGIA MULTIREGIONAL INPUT-OUTPUT MODEL CONSTRUCTION

Applying the methodology that Chenery (1953) and Moses (1955) suggested for the MRIO model, the supply-driven Georgia MRIO model was formulated based on the procedure that Park et al. (2009b) used to construct an operational MRIO model at the U.S. state level. As the key requirement matrices for the MRIO model, trade flows and input-output matrices of given counties and industry sectors are used. When both matrices for 159 counties are prepared, the supply-driven Georgia MRIO model would be constructed by multiplying both matrices.

The final inverse coefficient matrix structure of the supply-driven Georgia MRIO model would be expected to have the matrix form seen in Figure 5. Because the 2009 IMPLAN data set has a different sector system (440 sectors, decreased from 509 sectors), 20 industry sectors consistent with two-digit NAICS sectors and another industry sector (which cannot be identified in the current NAICS sector system but is identified in the IMPLAN sector) were defined. Therefore, the inverse matrix has a (21 x 159) x (21 x 159) matrix form. The description of aggregated industry sectors of the supply-driven Georgia MRIO model can be found in Table 10.

		County 1			…	County158			County 159		
		I1	…	I21	…	I1	…	I21	I1	…	I21
County 1	I1				…						
	…				…						
	I21				…						
…	…	…	…	…	…	…	…	…	…	…	…
County 158	I1				…						
	…				…						
	I21				…						
County 159	I1				…						
	…				…						
	I21				…						

Figure 5. The structure of inversed Georgia supply-driven MRIO Coefficients Matrix

Table 10. The industry sector system of the Georgia supply-driven MRIO model

MRIO sectors	Two digit NAICS Code System	Sector Description
1	11	Total Farm
2	21	Natural Resources and Mining
3	22	Utilities
4	23	Construction
5	31	Manufacturing
6	42	Wholesale Trade
7	44	Retail Trade
8	48	Transportation and Warehousing
9	51	Information
10	52	Finance and Insurance
11	53	Real Estate and Rental and Leasing
12	54	Professional, Scientific and Technical Services
13	55	Management of Companies and Enterprises
14	56	Administrative and Support and Waste Services
15	61	Educational Services
16	62	Health Care and Social Assistance
17	71	Arts, Entertainment, and Recreation
18	72	Accommodation and Food Service
19	81	Other Services
20	92	Public Administration
21	93	Not an industry

Park (2007; 2008) and Park et al. (2008) elaborated a supply-driven MRIO model at the national level, including empirical tests. Based on this approach, Equation 26 is derived using the process explained in Equations 12 and 20. Also, Equation 26 shows the inverse supply-driven Georgia MRIO matrix as $(\mathrm{I} - \mathrm{GC})^{-1}$. Because Q is defined as a row vector of regional specific value added, the difference in total net returns of each crop will have an impact on other counties and industry sectors via Equation 26:

$$T^{I} = QC(I - GC)^{-1} \tag{26}$$

where, T^{I} = the total input row vector,

Q = a row vector of regional specific value added factors,

G = $(\hat{T}^{I})^{-1}Z$ stands for IO matrices and $\hat{T}^{I}$ is the block diagonal matrix of vector T^{I},

Z = the block diagonal matrix of interindustry transactions, and

C = the block diagonal matrix of interregional trade flows coefficients.

5.7 THE SUPPLY-DRIVEN GEORGIA MULTIREGIONAL INPUT-OUTPUT MODEL FOR EMPLOYMENT IMPACT ANALYSIS

Analyzing the employment impact of the difference in total net returns of each crop between both production methods, an employment coefficient term was added to Equation 26 and the following model was derived based on the equation from Miller and Blair (2009):

$$T^{E} = QCL(I - GC)^{-1} \tag{27}$$

where, T^{E} = the total employment row vector,

Q = a row vector of regional specific value added factors,

G = $(\hat{T}^{I})^{-1}Z$ stands for IO matrices and $\hat{T}^{I}$ is the block diagonal matrix of the total input row vector T^{I},

Z = the block diagonal matrix of interindustry transactions,

C = the block diagonal matrix of interregional trade flows coefficients, and

L = the block diagonal matrix of employment coefficients.

Dividing the employment in each sector by the total output of each sector, employment coefficients are determined in Equation 27. For example, a k^{th} industry's employment coefficient l_k is defined:

$$l_k = \frac{e_k}{x_k} \quad (28)$$

where, e_k = the employment in a k^{th} industry sector (number of job) and

x_k = the total output of a k^{th} industry sector (dollar).

Therefore, l_k represents the number of jobs which are needed to support one dollar's worth of k^{th} industry sector's output. The employment coefficient matrix L is derived by making a diagonal matrix of employment coefficients of each sector as shown in Equation 29 with a matrix form:

$$\mathrm{L} = \mathrm{E}\hat{\mathrm{X}}^{-1} \quad (29)$$

where, $\mathrm{L} = \mathrm{diag}(l_{kk})$,

$\mathrm{E} = \mathrm{diag}(e_{kk})$,

$\hat{\mathrm{X}}^{-1} = \mathrm{diag}(x_k)$, and

k = each industry sector (1, 2, ⋯ , 21).

Employment data also came from the 2009 IMPLAN data at the county level of Georgia.

CHAPTER 6

RESULTS

6.1 ECONOMIC IMPACT ANALYSIS RESULTS

With the assumption that non-irrigated cultivable acreage of cotton, peanuts, corn, and soybeans in 42 counties of southwest Georgia are 100% converted into irrigated acreage, the economic impact of increasing agricultural production due to the conversion of non-irrigated acreage is estimated. For this purpose, the difference in total net returns of each crop between the irrigated production method and non-irrigated production method is calculated.

Multiplying expected average yield per acre of each crop, expected average price of each crop, and non-irrigated acreage, the additional gross revenue of each crop is determined. The total net return of each crop is derived by subtracting each crop's total production cost, excluding land and management costs, from the gross revenue of each crop. This total net return of each crop is separately calculated for the irrigated production method and non-irrigated production method. Subtracting the total net return of each crop applying the non-irrigated production method from the total net return of each crop applying the irrigated production method, the difference in total net returns of each crop is finally calculated.

Applying the difference in total net returns of each county by each crop to Equation 26 as an exogenous change of value added vector Q, the economic impact of increasing agricultural production due to the conversion of non-irrigated acreage is estimated by 159 counties and 21 industry sectors. Based on the information of a 95% confidence interval for each crop's average price, the economic impact of each crop is also presented with the lower and upper bounds in the results tables. The estimated results of all crops are summarized by the top ten impacted counties and the top three impacted industry sectors; Table 11 shows the results for cotton, Table 12 the results for peanuts, Table 13 the results for corn, and Table 14 the results for soybeans. The full results are shown in Appendices 1 to 8.

In the results tables, "Direct impact" refers to the initial economic impact experienced in each sector in each county relating to the crop's production increase. Direct impacts of each crop are determined by multiplying the difference in total returns of each crop in Table 5 and trade flows coefficients matrix C, as shown in Equation 26. "Indirect impact" indicates the economic impact arising due to inter-industry linkages, and is estimated via the inversed coefficients matrix in the supply-driven Georgia MRIO model. A Type I multiplier describes the ratio of the sum of direct and indirect impacts relative to direct impact.

The impact of increasing crop production due to the conversion of non-irrigated cultivable acreage in 42 counties of Georgia positively affected the Georgia State economy. Table 11 summarizes the effects of the difference in total net returns of cotton between irrigated and non-irrigated production methods for the top ten impacted counties and top three impacted industry sectors in Georgia.

Table 11. Impact of increasing cotton production for selected counties and industry sectors

Counties	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
TH	1.07	0.05	1.12	1.85	0.08	1.92 (3.2)	2.62	0.11	2.73
IR	1.03	0.06	1.09	1.78	0.10	1.88 (3.1)	2.53	0.14	2.67
WO	1.01	0.04	1.05	1.74	0.06	1.81 (3.0)	2.47	0.09	2.57
ER	0.92	0.11	1.03	1.58	0.19	1.77 (2.9)	2.24	0.27	2.51
WI	0.96	0.06	1.02	1.66	0.11	1.76 (2.9)	2.35	0.15	2.50
GR	0.90	0.05	0.95	1.55	0.08	1.63 (2.7)	2.20	0.11	2.31
BO	0.89	0.04	0.93	1.54	0.07	1.60 (2.7)	2.18	0.09	2.27
CP	0.86	0.04	0.90	1.49	0.06	1.55 (2.6)	2.11	0.09	2.20
DR	0.84	0.06	0.90	1.44	0.10	1.54 (2.6)	2.04	0.15	2.19
CQ	0.84	0.04	0.89	1.45	0.08	1.53 (2.5)	2.06	0.11	2.17
Others	21.55	3.44	24.99	37.12	5.93	43.05 (71.7)	52.69	8.42	61.11
Total	30.87	3.98	34.85	53.19	6.85	60.04	75.50	9.73	85.23

Sector	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
1	30.87	1.87	32.75	53.19	3.22	56.41 (94.0)	75.50	4.58	80.08
5	0	2.03	2.03	0	3.50	3.50 (5.8)	0	4.97	4.97
4	0	0.02	0.02	0	0.03	0.03 (0.0)	0	0.04	0.04
Total	30.87	3.98	34.85	53.19	6.85	60.04	75.50	9.73	85.23
Type I multiplier									1.129

Note: 1. The value in parenthesis is the percentage of total impacts.
2. Others: 149 counties, excluding the top ten counties
3. Unit: million dollars

As the difference in total net returns of cotton between both production methods is calculated as $53 million due to the 100% conversion of non-irrigated acreage in selected counties of Georgia, the ten most affected counties were Thomas ($1.92 million, 3.2%), Irwin

($1.88 million, 3.1%), Worth ($1.81 million, 3%), Early ($1.77 million, 2.9%), Wilcox ($1.76 million, 2.9%), Grady ($1.63 million, 2.7%), Brooks ($1.6 million, 2.7%), Crisp ($1.55 million, 2.6%), Decatur ($1.54 million, 2.6%), and Colquitt ($1.53 million, 2.5%). Almost 30% of the total impact happened in the top ten counties. The total impact of the difference in total net returns of cotton production was $60 million and in the range of $35 million to $85 million.

In Table 11, the impact of the top three industry sectors for cotton production are shown together with the results of selected counties. The total economic gain of Sector 1 (Total Farm) was the greatest at $56 million and in the range of $33 million to $80 million and accounts for 94% of the total impact; Sectors 5 (Manufacturing) and 4 (Construction) followed with $3.5 million (5.8%) and $0.03 million (0.05%), respectively. Type I multiplier of the production change for cotton was 1.129.

Due to the conversion of non-irrigated acreage for peanuts production in 42 counties of Georgia, the difference in total net returns of peanuts between both production methods is estimated at $9 million. The most affected county for the change of peanuts production was Early ($0.4 million, 3.9%) and its impact was between $0.13 million and $0.93 million according to the range of the average price of peanuts; Irwin ($0.395 million, 3.9%), Decatur ($0.37 million, 3.7%), Worth ($0.3 million, 3%), Seminole ($0.25 million, 2.5%), Thomas ($0.248 million, 2.4%), Miller ($0.247 million, 2.4%), Berrien ($0.246 million, 2.4%), Grady ($0.242 million, 2.4%), and Baker ($0.24 million, 2.4%) followed. The other 149 counties (excluding the top ten impacted counties) accounted for 71% of the total impact of peanuts production change ($10.2 million) and the total impact was in the range of $3.28 million to $23.71 million (see Table 12).

Table 12. Impact of increasing peanuts production for selected counties and industry sectors

Counties	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
ER	0.12	0.01	0.13	0.36	0.04	0.40 (3.9)	0.84	0.10	0.93
IR	0.12	0.01	0.13	0.38	0.02	0.40 (3.9)	0.87	0.04	0.92
DR	0.11	0.01	0.12	0.35	0.02	0.37 (3.7)	0.81	0.05	0.87
WO	0.09	0.00	0.10	0.29	0.01	0.30 (3.0)	0.67	0.03	0.70
SE	0.07	0.01	0.08	0.22	0.04	0.25 (2.5)	0.50	0.08	0.59
TH	0.08	0.00	0.08	0.24	0.01	0.25 (2.4)	0.55	0.03	0.58
MI	0.07	0.00	0.08	0.23	0.02	0.25 (2.4)	0.54	0.04	0.57
BE	0.08	0.00	0.08	0.24	0.01	0.25 (2.4)	0.55	0.02	0.57
GR	0.07	0.00	0.08	0.23	0.01	0.24 (2.4)	0.53	0.03	0.56
BX	0.07	0.00	0.08	0.23	0.01	0.24 (2.4)	0.53	0.03	0.56
Others	2.00	0.33	2.33	6.24	1.02	7.26 (71.1)	14.50	2.36	16.86
Total	2.89	0.39	3.28	8.99	1.21	10.20	20.89	2.82	23.71

Sector	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
1	2.89	0.19	3.08	8.99	0.59	9.58 (93.9)	20.89	1.37	22.26
5	0.00	0.19	0.19	0.00	0.60	0.60 (5.9)	0.00	1.40	1.40
4	0.00	0.00	0.00	0.00	0.01	0.01 (0.1)	0.00	0.01	0.01
Total	2.89	0.39	3.28	8.99	1.21	10.20	20.89	2.82	23.71
Type I multiplier									1.135

Note: 1. The value in parenthesis is the percentage of total impacts.
2. Others: 149 counties, excluding the top ten counties
3. Unit: million dollars

As shown in Table 12, the economic impact of the production change for peanuts was highest in the following industry sectors: Sector 1 ($9.6 million, 93.9%), Sector 5 ($0.6 million, 5.9%), and Sector 4 ($0.006 million, 0.1%). The range of these sectors' impact was between

$3.08 million and $22.26 million, $0.19 million and $1.4 million, and $0.002 million and $0.013 million, respectively. The ratio of the sum of direct and indirect impacts relative to direct impact was 1.135 in the impact analysis for the peanuts production change.

In the case of corn production change, $1.1 million of the difference in total net returns between both production methods has the greatest effect on Decatur ($0.07 million) and represents 3.9% of the total impact of corn production change. A 95% confidence interval for the impact on Decatur was estimated to be between -$0.33 million and $0.47 million. Grady ($0.05 million, 3.7%) and Early ($0.046 million, 3.7%) were ranked second and third with the range of -$0.22 million – $0.32 million and -$0.224 million – $0.316 million, respectively; Thomas ($0.04 million, 3.1%), Irwin ($0.037 million, 3%), Seminole ($0.036 million, 3%), Sumter ($0.036 million, 2.9%), Miller ($0.035 million, 2.9%), Calhoun ($0.03 million, 2.8%), and Baker ($0.033 million, 2.7%) followed. The impact of the top ten counties took up almost 33% of the total impact of corn production change ($1.23 million) and the impact of the top ten counties was in the range of -$2 million to $2.82 million (see Table 13).

Individual economic gain from the corn production change was greatest in Sector 1 at $1.16 million with 93.9% of the total impact; Sector 5 ($0.07 million, 5.6%) and Sector 4 ($0.001 million, 0.05%) were ranked second and third impacted industry sectors. A 95% confidence interval for the impact of these sectors was in the range of -$5.65 million to $7.97 million, -$0.34 million to $0.47 million, and -$0.003 million to $0.004 million, respectively. The Type I multiplier for the case of the corn production change was 1.128.

Table 13. Impact of increasing corn production for selected counties and industry sectors

Counties	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
DR	-0.32	-0.02	-0.33	0.06	0.00	0.07 (5.5)	0.44	0.02	0.47
GR	-0.21	-0.01	-0.22	0.04	0.00	0.05 (3.7)	0.30	0.01	0.32
ER	-0.20	-0.02	-0.22	0.04	0.00	0.05 (3.7)	0.28	0.03	0.32
TH	-0.18	-0.01	-0.19	0.04	0.00	0.04 (3.1)	0.25	0.01	0.27
IR	-0.17	-0.01	-0.18	0.04	0.00	0.04 (3.0)	0.24	0.01	0.26
SE	-0.15	-0.02	-0.18	0.03	0.01	0.04 (3.0)	0.21	0.03	0.25
SU	-0.17	-0.01	-0.18	0.03	0.00	0.04 (2.9)	0.24	0.01	0.25
MI	-0.16	-0.01	-0.17	0.03	0.00	0.04 (2.9)	0.23	0.01	0.24
CU	-0.16	-0.01	-0.17	0.03	0.00	0.03 (2.8)	0.22	0.01	0.23
BX	-0.15	-0.01	-0.16	0.03	0.00	0.03 (2.7)	0.21	0.01	0.22
Others	-3.45	-0.56	-4.00	0.71	0.11	0.82 (66.7)	4.86	0.78	5.64
Total	-5.32	-0.68	-6.00	1.09	0.14	1.23	7.50	0.96	8.46

Sector	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
1	-5.32	-0.33	-5.65	1.09	0.07	1.16 (94.2)	7.50	0.47	7.97
5	0.00	-0.34	-0.34	0.00	0.07	0.07 (5.6)	0.00	0.47	0.47
4	0.00	0.00	0.00	0.00	0.00	0.00 (0.0)	0.00	0.00	0.00
Total	-5.32	-0.68	-6.00	1.09	0.14	1.23	7.50	0.96	8.46
Type I multiplier									1.128

Note: 1. The value in parenthesis is the percentage of total impacts.
2. Others: 149 counties, excluding the top ten counties
3. Unit: million dollars
4. Negative sign stands for the economic losses.

When all of the non-irrigated cultivable acreage for soybeans production is assumed to be converted to irrigation acreage in 42 counties of Georgia, the total net benefit is estimated at $5.9

million. The total economic impact of the benefit induced by the soybeans production change was $7 million and the lower and upper bounds of the total impact were $3 million and $10 million, respectively. In addition, 27.1% of the total impact arose in the top ten counties with a range of $0.83 million to $2.77 million. The estimated results of these top ten impacted counties are shown in Table 14. The most affected county for the change of soybeans production was Decatur at $0.24 million, which accounted for 3.7% of the total impact, with $0.11 million as the lower bound and $0.37 million as the upper bound. Peach was the second most affected county at $0.21 million (3.1%) with range of $0.1 million to $0.32 million. Bleckley ($0.19 million, 2.9%), Sumter ($0.18 million, 2.7%), Randolph ($0.179 million, 2.7%), Macon ($0.17 million, 2.6%), Brooks ($0.169 million, 2.5%), Early ($0.16 million, 2.5%), Grady ($0.15 million, 2.2%), and Thomas ($0.14 million, 2.1%) followed.

In the case of the economic impact of the soybeans production change upon industry sectors as shown in Table 14, the economic benefit was sizable, with the following three industry sectors experiencing the greatest gains: Sector 1 ($6.26 million, 94.2%), Sector 5 ($ 0.37 million, 5.6%), and Sector 4 ($0.003 million, 0.05%). A 95% confidence interval for the impact of these three sectors was estimated at the range of $2.9 million to $9.61 million, $0.17 million to $0.57 million, and $0.002 million to $0.005 million, respectively. The ratio of the sum of direct and indirect impacts relative to direct impact was 1.126 in the impact analysis for the soybeans production change.

Table 14. Impact of increasing soybeans production for selected counties and industry sectors

Counties	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
DR	0.11	0.01	0.11	0.23	0.01	0.24 (3.7)	0.35	0.02	0.37
PE	0.09	0.00	0.10	0.20	0.01	0.21 (3.1)	0.30	0.02	0.32
BY	0.08	0.01	0.09	0.18	0.01	0.19 (2.9)	0.28	0.02	0.30
SU	0.08	0.00	0.08	0.17	0.01	0.18 (2.7)	0.26	0.01	0.28
RH	0.08	0.01	0.08	0.17	0.01	0.18 (2.7)	0.26	0.02	0.28
MA	0.08	0.00	0.08	0.16	0.01	0.17 (2.6)	0.25	0.01	0.26
BO	0.08	0.00	0.08	0.16	0.01	0.17 (2.5)	0.25	0.01	0.26
ER	0.07	0.01	0.08	0.15	0.02	0.16 (2.5)	0.22	0.03	0.25
GR	0.06	0.00	0.07	0.14	0.01	0.15 (2.2)	0.21	0.01	0.23
TH	0.06	0.00	0.07	0.14	0.01	0.14 (2.1)	0.21	0.01	0.22
Others	1.95	0.29	2.25	4.21	0.64	4.84 (72.9)	6.47	0.98	7.44
Total	2.74	0.34	3.08	5.90	0.74	6.64	9.07	1.14	10.21

Sector	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
1	2.74	0.16	2.90	5.90	0.35	6.26 (94.2)	9.07	0.55	9.61
5	0.00	0.17	0.17	0.00	0.37	0.37 (5.6)	0.00	0.57	0.57
4	0.00	0.00	0.00	0.00	0.00	0.00 (0.0)	0.00	0.00	0.00
Total	2.74	0.34	3.08	5.90	0.74	6.64	9.07	1.14	10.21
Type I multiplier									1.126

Note: 1. The value in parenthesis is the percentage of total impacts.
2. Others: 149 counties, excluding the top ten counties
3. Unit: million dollars

6.2 EMPLOYMENT IMPACT ANALYSIS RESULTS

The employment impact of each crop's production change occurring with a 100% irrigation conversion of each crop's non-irrigated acreage is summarized by the top ten impacted counties and the top three impacted industry sectors in Tables 15 through 18. The full employment impact of all counties and all industry sectors are presented in Appendices 9 to 12. A 95% confidence interval for the employment impact is also added in each table with the mean result. The effect of each crop's production change from the conversion of non-irrigated acreage is quantified through the calculation of the difference in total net returns of each crop between non-irrigated and irrigated production methods. This difference in total net returns of each crop was put into Equation 27 as input data for the employment impact analysis.

In Table 15, the employment impact of cotton production change for the top ten impacted counties and the top three impacted industry sectors is suggested with lower and upper bounds. The employment impact of a $53 million difference in total net returns of cotton production was estimated with 572 jobs added to the Georgia job market. The lower and upper bounds of the impact were 332 jobs and 812 jobs, respectively. The positive impact of cotton production change on the job market was the greatest in Cook, with 27 jobs (4.7%) – 16 jobs of lower bound and 38 jobs of upper bound; Tift (19 jobs, 3.3%), Grady (19 jobs, 3.3), Thomas (18 jobs, 3.1), Crisp (17 jobs, 2.9), Colquitt (16 jobs, 2.7), Lowndes (15 jobs, 2.6), Early (15 jobs, 2.6), Lanier (14 jobs, 2.4), and Mitchell (14 jobs, 2.4) followed. Employment increase in the other 149 counties (excluding the top ten impacted counties) was 400 jobs and represented 70% of the total employment impact.

The top three industry sectors experiencing employment increase from cotton production change were Sectors 1, 5, and 4; increased number of jobs for each sector was 536 jobs, 35 jobs, and 0.3 jobs, respectively. Moreover, the percentage ratio of each sector to the total impact was 93.7% for Sector 1, 6.1% for Sector 5, and 0.05% for Sector 4. A 95% confidence interval for the employment impact of each sector was 311 jobs – 761 jobs, 20 jobs – 49 jobs, and 0.2 jobs – 0.4 jobs, respectively.

Table 15. Employment impact of cotton production for selected counties and industry sectors

Counties	Lower	Mean	Upper
CX	16	27 (4.7)	38
TI	11	19 (3.3)	27
GR	11	19 (3.3)	27
TH	10	18 (3.1)	25
CP	10	17 (2.9)	24
CQ	9	16 (2.7)	22
LW	9	15 (2.6)	21
ER	9	15 (2.6)	21
LN	8	14 (2.4)	19
ML	8	14 (2.4)	19
Others	232	400 (70.0)	568
Total	332	572	812

Sector	Lower	Mean	Upper
1	311	536 (93.7)	761
5	20	35 (6.1)	49
4	0	0 (0.0)	0
Total	332	572	812

Note: 1. The value in parenthesis is the percentage of total impacts.
2. Others: 149 counties, excluding the top ten counties

3. Unit: number of jobs

The total employment impact of peanuts production change due to the conversion of non-irrigated acreage was an increase of 95 jobs, and this impact was in the range of a 30 job increase and 220 job increase. The top ten impacted counties' number of jobs increased from the peanuts production change impact was 27 jobs and accounted for 28.4 % of the total employment impact with the range of 8 jobs to 62 jobs. The most affected county of the employment increase from the difference in total net returns of peanuts production by $9 million was Cook (4 jobs, 4.2%); Early (3 jobs, 3.6%) and Tift (3 jobs, 3%) were ranked second and third impacted counties. Grady (3 jobs, 3%), Irwin (2 jobs, 2.6%), Berrien (2 jobs, 2.5%), Colquitt (2 jobs, 2.4%), Mitchell (2 jobs, 2.4%), Lowndes (2 jobs, 2.4%), and Crisp (2 jobs, 2.4%) followed (see Table 16).

In the case of the employment impact for each industry sector caused by the peanuts production change, as shown in Table 16, Sector 1 was estimated as the most affected industry sector with the increase of 89 jobs and took up 93.6 % of the total employment impact as shown in Table 14. The lower and upper bounds of Sector 1's employment increase was 29 jobs and 206 jobs, respectively. Sectors 5 and 4 followed with the range of the increase of 6 jobs (6.2%) to 0.05 jobs (0.1%).

Table 16. Employment impact of peanuts production for selected counties and industry sectors

Counties	Lower	Mean	Upper
CX	1	4 (4.2)	9
ER	1	3 (3.6)	8
TI	1	3 (3.0)	7
GR	1	3 (3.0)	7
IR	1	2 (2.6)	6
BE	1	2 (2.5)	5
CQ	1	2 (2.4)	5
ML	1	2 (2.4)	5
LW	1	2 (2.4)	5
CP	1	2 (2.4)	5
Others	22	68 (71.6)	158
Total	30	95	220

Sector	Lower	Mean	Upper
1	29	89 (93.6)	206
5	2	6 (6.2)	14
4	0	0 (0.1)	0
Total	30	95	220

Note: 1. The value in parenthesis is the percentage of total impacts.
2. Others: 149 counties, excluding the top ten counties
3. Unit: number of jobs

In Table 17, the employment impact of corn production change was summarized for the top ten impacted counties and top three impacted industry sectors. When $1.1 million of the difference in total net returns between the non-irrigated corn production method and irrigated corn production method is given, the employment impact of corn production change for the top ten impacted counties was projected as a 3 job increase in the job market. The total employment increase impact of corn production change was 11 jobs and a 95% confidence interval for the impact was the decrease of 55 jobs and the increase of 78 jobs in the job market. The increase of employment occasioned by the conversion of non-irrigated acreage for corn production was highest in Grady (1 job, 4.7%); Cook (3.4%), Early (3.4%), Sumter (3.3%), Thomas (3.1%), Lee (2.8%), Mitchell (2.8%), Decatur (2.8%), Calhoun (2.6%), and Tift (2.4%) followed. However, the number of jobs increased was smaller than one in nine counties.

The employment impact for the top three impacted industry sectors was highest in Sectors 1, 5, and 4 with an increase of 11 job, 1 job, and 0.005 job in the job market, respectively.

Table 17. Employment impact of corn production for selected counties and industry sectors

Counties	Lower	Mean	Upper
GR	-3	1 (4.7)	4
CX	-2	0 (3.4)	3
ER	-2	0 (3.4)	3
SU	-2	0 (3.3)	3
TH	-2	0 (3.1)	2
LE	-2	0 (2.8)	2
ML	-2	0 (2.8)	2
DR	-2	0 (2.8)	2
CU	-1	0 (2.6)	2
TI	-1	0 (2.4)	2
Others	-38	8 (68.8)	53
Total	-55	11	78

Sector	Lower	Mean	Upper
1	-52	11 (94.0)	73
5	-3	1 (5.8)	5
4	0	0 (0.0)	0
Total	-55	11	78

Note: 1. The value in parenthesis is the percentage of total impacts.
2. Others: 149 counties, excluding the top ten counties
3. Negative sign stands for the decrease of employment.
4. Unit: number of jobs

With $6 million of difference in total net returns of soybeans production, 65 jobs were added to the local job market for Georgia. The total employment impact of soybeans production change has a lower bound of a 30 job increase and an upper bound of a 100 job increase. The ten most affected counties experiencing employment increases were Peach (5 jobs, 7.4%), Sumter (2 jobs, 2.9%), Bleckley (2 jobs, 2.7%), Grady (2 jobs, 2.7%), Lee (2 jobs, 2.6%), Cook (2 jobs, 2.5%), Randolph (2 jobs, 2.4%), Dodge (1 job, 2.2%), Brooks (1 job, 2.1%), and Early (1 job, 2.1%). The employment increase in the other 149 counties (excluding the top ten impacted counties) was estimated at 46 jobs and accounted for 71% of the total employment impact with the lower bound of a 21 job increase and the upper bound of a 70 job increase in the Georgia job market (see Table 18).

The increase of employment caused by the production change of soybeans was the greatest in Sector 1 with an increase of 61 jobs and its 95% confidence interval was the range of a 28 job increase to a 94 job increase in the job market. Sector 5 followed with the increase of 4 jobs and took up 5.8% of the total employment increases.

Table 18. Employment impact of soybeans production for selected counties and industry sectors

Counties	Lower	Mean	Upper
PE	2	5 (7.4)	7
SU	1	2 (2.9)	3
BY	1	2 (2.7)	3
GR	1	2 (2.7)	3
LE	1	2 (2.6)	3
CX	1	2 (2.5)	2
RH	1	2 (2.4)	2
DG	1	1 (2.2)	2
BO	1	1 (2.1)	2
ER	1	1 (2.1)	2
Others	21	46 (70.6)	70
Total	30	65	100

Sector	Lower	Mean	Upper
1	28	61 (94.0)	94
5	2	4 (5.8)	6
4	0	0 (0.0)	0
Total	30	65	100

Note: 1. The value in parenthesis is the percentage of total impacts.
2. Others: 149 counties, excluding the top ten counties
3. Unit: number of job

CHAPTER 7

CONCLUSIONS

Climate change is an imperative issue globally, and an immediate adaptation strategy at a national as well as local levels to cope with the climate change effect is necessary for all stakeholders of diverse interests in society. Since agriculture is strongly sensitive and vulnerable to climate variability in addition to its change, climate factors, including CO_2 concentration in the atmosphere and changes in precipitation and temperatures, have affected the agricultural sector through various production mechanisms. The net effect of climate change on agricultural production will depend on the interaction of these climatic factors (Ingram et al., 2013). According to the study of Boote et al. (2011), sufficient understanding of the structure of natural systems and their operating processes in regards to climatic factors is a crucial issue to developing climate change adaptation strategies for the agricultural sector.

Through the interactions of climatic factors, such as increasing temperature and decreasing rainfall during crop growing seasons, which are expected in the western states, the timing and amount of water supply will negatively affect irrigated agriculture in the region. Reduced water supplies caused by the interaction of climate factors could further restrain the allocation of water resources in the western U.S. region. Moreover, increased water demand from competitive user groups in the region is expected to intensify, an additional constraint on water allocation.

In the southeast U.S. region, modest irrigation amounts are needed to overcome seasonal and inter-annual rainfall variability and relatively poor water-holding soils in most areas of the region. Considering expected climate change in the western and southeastern regions and its impact on irrigated agriculture, a possible adaptation strategy for coping with climate change is needed in the southeast region. Several possible strategies, such as adaptation of variable-rate irrigation and micro-irrigation, have been suggested for the optimization of crop production in the southeast region (Ingram et al., 2013). In addition to these options, the expansion of irrigated agriculture can be an appropriate strategy for sustainability of productive agriculture in the region. For the sustainability of U.S. food demand as well as local demand, a shift of some crop production from the west to the southeast will likely be a foreseeable option concerning climate change vulnerability and sustainability of irrigated agriculture in the southeast region. Based on the assumption of certain crop production changes, this research explores the economic impacts of shifting irrigated agricultural production from the west (e.g. peanuts and corn in the west) to the southeast for the purpose of estimating the value of water allocation in the southeast's agriculture with a regional input-output (IO) model.

Most previous studies adopting the IO approach used traditional demand-driven IO models to estimate the economic impact of irrigated agriculture through accepting the change of agricultural production as the change of final demand. However, the total production change induced by the expansion of irrigated agriculture should be interpreted as a change of supply instead of a change of demand. Therefore, the motivation of this study is whether the application of the traditional demand-driven IO approach is appropriate or not for the impact analysis of agricultural production change. In order to determine the suitability of applying a demand-driven IO model for the evaluation of the effect of expanding irrigated agriculture, the following research question is posed: How does one evaluate the economic effect of increasing agricultural production caused by the expansion of irrigated agriculture?

To answer the research question, attention was given to the fact that agricultural production change could be categorized as the change of profits in the agricultural sector from an economic standpoint. Since the profits of business sectors include a value added element, the impact of an agricultural production change from additional irrigated agriculture should be analyzed applying a supply-driven IO model instead of a demand-driven IO model.

For the impact analysis of an agricultural production change due to the expansion of irrigated agriculture, non-irrigated cultivable acreage of cotton, peanuts, corn, and soybeans in 42 counties of southwest Georgia are assumed 100% converted into irrigated acreage. Estimating the economic impact of increasing agricultural production caused by the conversion of non-irrigated acreage, the difference in total net returns of each crop between the irrigated production method and non-irrigated production method is calculated.

Applying the difference in total net returns for each county by each crop to the supply-driven Georgia MRIO model, the economic impact and employment impact of increasing agricultural production due to the conversion of non-irrigated acreage is estimated for 159 counties and 21 industry sectors in Georgia. Based on the information of a 95% confidence interval for each crop's average price, the lower and upper bounds of estimated results are also presented.

The impact of increasing crop production due to the conversion of non-irrigated cultivable acreage in 42 counties of Georgia positively affected the Georgia State economy and job market. Among 159 counties of Georgia, Decatur, Early, Grady, and Thomas were in the group of the major affected counties for the economic impact of all crops production change;

Irwin was one of the most affected counties for the economic impact of cotton, peanuts, and corn production change. Baker, Brooks, Miller, Seminole, and Sumter also were among the most affected counties for the economic impact of crop production change. In the case of the employment impact, the increase of employment was high in Cook, Early, and Grady for all crop production change. The employment impacts of cotton, peanuts, and corn production change significantly affected the job markets of Mitchell and Tift. In addition to these counties, Colquitt, Crisp, Lee, Lowndes, Sumter, and Thomas experienced higher increases of employment due to the expansion of irrigated agriculture in Georgia. For the impact of all crop production change, the economic benefit and employment increase were the greatest in the total farm, manufacturing, and construction sectors.

As a possible adaptation strategy for climate change in Georgia, we can consider the expansion of irrigated agriculture for selected crops. Through the supply-driven Georgia multiregional input-output model, this study provides a meaningful outline to all relevant stakeholders for that option in the context of the regional economy as well as the local job market. Most previous studies presented results with total impacts or specific sector impact only. However, in this study, the economic and employment effects of crop production change caused by the conversion of non-irrigated acreages were suggested as a detailed value for each county and industry sector. For the reliability of estimates, a 95% confidence interval for economic and employment impacts were added.

As to methodology, a supply-driven IO model is more appropriate than a demand-driven IO model to analyze the economic impact of agricultural production change. Because agricultural production change should be recognized as supply change, not a demand change, application of traditional demand-driven IO models to the case of agricultural production change may be an unsuitable approach, not to mention generating biased results. Applying the GWR method to estimate interregional trade flows at the county level, the coefficient matrix can capture the distance information between regions as well as other specific inter-industry relationships between regions. Therefore, it is possible to construct a more accurate interregional and inter-industry trade flows coefficients matrix than the widely accepted trade flows estimation methods. Furthermore, this study applies a supply-driven IO model to empirical research and an empirical study using a supply-driven IO model is unusual.

With several advantages, this study also has few limitations. First, using an expected average yield of each crop could not reflect the yield difference between counties. Therefore, the possibility of generating biased estimates could exist in the estimation process. Instead of average yield of each crop, using a crop production simulation model could reduce such uncertainty in yield. Adopting diverse conditions of future climate factors and regional specific soil and growing conditions, the crop production simulation model will generate more realistic and regional specific yield information than just average yield. Second, farmers could be more interested in the issue relating to risk-reduction yield of irrigated agriculture than a 95% confidence interval of the impact. If these limitations are reflected in future studies, it could generate valuable research.

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APPENDICES

APPENDIX 1 Full economic impact of cotton production for counties

Counties	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
AP	0.12	0.02	0.14	0.21	0.04	0.25	0.29	0.06	0.35
AT	0.30	0.03	0.33	0.52	0.05	0.57	0.73	0.07	0.81
BC	0.20	0.03	0.23	0.34	0.05	0.39	0.49	0.07	0.55
BX	0.69	0.04	0.74	1.20	0.07	1.27	1.70	0.10	1.80
BL	0.08	0.02	0.10	0.13	0.03	0.17	0.19	0.05	0.24
BA	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
BW	0.01	0.01	0.02	0.01	0.02	0.04	0.02	0.03	0.05
BR	0.00	0.01	0.01	0.00	0.02	0.03	0.01	0.03	0.04
BH	0.37	0.05	0.43	0.64	0.09	0.73	0.91	0.13	1.04
BE	0.74	0.04	0.78	1.27	0.06	1.34	1.81	0.09	1.90
BI	0.17	0.03	0.20	0.29	0.04	0.34	0.42	0.06	0.48
BY	0.22	0.03	0.25	0.37	0.05	0.42	0.53	0.08	0.60
BT	0.09	0.02	0.11	0.15	0.04	0.19	0.21	0.06	0.27
BO	0.89	0.04	0.93	1.54	0.07	1.60	2.18	0.09	2.27
BN	0.02	0.02	0.04	0.04	0.03	0.08	0.06	0.05	0.11
BU	0.03	0.02	0.05	0.06	0.03	0.09	0.08	0.04	0.13
BK	0.01	0.02	0.03	0.02	0.03	0.05	0.03	0.04	0.07
BS	0.05	0.02	0.07	0.08	0.03	0.11	0.12	0.04	0.16
CU	0.64	0.04	0.68	1.10	0.07	1.17	1.57	0.10	1.66
CM	0.07	0.02	0.09	0.12	0.04	0.15	0.16	0.05	0.22
CZ	0.06	0.02	0.08	0.10	0.04	0.14	0.15	0.05	0.20
CL	0.02	0.01	0.03	0.03	0.02	0.05	0.04	0.03	0.07
CT	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
CR	0.10	0.03	0.12	0.17	0.05	0.21	0.24	0.07	0.30

CH	0.02	0.02	0.03	0.03	0.03	0.06	0.04	0.04	0.08
CE	0.26	0.03	0.30	0.46	0.05	0.51	0.65	0.07	0.72
CG	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
CK	0.00	0.01	0.02	0.00	0.02	0.03	0.01	0.03	0.04
CA	0.01	0.01	0.02	0.01	0.02	0.04	0.02	0.03	0.05
CY	0.31	0.05	0.36	0.54	0.08	0.62	0.76	0.12	0.88
CN	0.03	0.02	0.04	0.05	0.03	0.08	0.07	0.04	0.11
CI	0.19	0.04	0.22	0.33	0.06	0.39	0.46	0.09	0.55
CO	0.01	0.01	0.02	0.01	0.02	0.04	0.02	0.03	0.05
CF	0.26	0.04	0.30	0.45	0.06	0.51	0.64	0.09	0.73
CQ	0.84	0.04	0.89	1.45	0.08	1.53	2.06	0.11	2.17
CB	0.01	0.02	0.03	0.02	0.03	0.05	0.03	0.04	0.06
CX	0.73	0.04	0.76	1.25	0.06	1.32	1.78	0.09	1.87
CW	0.04	0.02	0.05	0.06	0.03	0.09	0.09	0.04	0.13
CD	0.18	0.02	0.21	0.32	0.04	0.36	0.45	0.06	0.51
CP	0.86	0.04	0.90	1.49	0.06	1.55	2.11	0.09	2.20
DD	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
DW	0.00	0.01	0.01	0.00	0.02	0.03	0.00	0.03	0.04
DR	0.84	0.06	0.90	1.44	0.10	1.54	2.04	0.15	2.19
DA	0.01	0.01	0.03	0.03	0.03	0.05	0.04	0.04	0.07
DG	0.36	0.05	0.41	0.62	0.08	0.71	0.88	0.12	1.00
DY	0.47	0.03	0.50	0.81	0.06	0.87	1.15	0.08	1.23
DU	0.59	0.04	0.62	1.01	0.07	1.08	1.43	0.09	1.53
DO	0.01	0.01	0.03	0.02	0.03	0.05	0.03	0.04	0.07
ER	0.92	0.11	1.03	1.58	0.19	1.77	2.24	0.27	2.51
EC	0.33	0.03	0.37	0.58	0.05	0.63	0.82	0.08	0.89
EF	0.02	0.02	0.03	0.03	0.03	0.06	0.04	0.04	0.08
EB	0.00	0.01	0.02	0.01	0.02	0.03	0.01	0.03	0.04
EM	0.08	0.02	0.10	0.14	0.04	0.17	0.19	0.05	0.24
EV	0.07	0.02	0.09	0.11	0.04	0.15	0.16	0.05	0.21
FN	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
FY	0.04	0.02	0.05	0.06	0.03	0.09	0.09	0.04	0.13
FL	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
FO	0.00	0.01	0.02	0.01	0.02	0.03	0.01	0.03	0.04
FK	0.00	0.01	0.01	0.00	0.02	0.03	0.00	0.03	0.04

FU	0.01	0.01	0.03	0.02	0.02	0.05	0.03	0.04	0.07
GI	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
GL	0.03	0.02	0.04	0.05	0.03	0.08	0.07	0.04	0.11
GN	0.06	0.02	0.08	0.10	0.04	0.15	0.15	0.06	0.21
GO	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
GR	0.90	0.05	0.95	1.55	0.08	1.63	2.20	0.11	2.31
GE	0.02	0.01	0.03	0.03	0.03	0.05	0.04	0.04	0.08
GW	0.01	0.01	0.02	0.01	0.02	0.04	0.02	0.03	0.05
HM	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
HL	0.00	0.01	0.01	0.00	0.02	0.02	0.01	0.03	0.03
HK	0.04	0.02	0.06	0.07	0.03	0.10	0.10	0.04	0.15
HR	0.01	0.01	0.02	0.01	0.02	0.04	0.02	0.03	0.05
HS	0.08	0.02	0.11	0.14	0.04	0.18	0.20	0.06	0.26
HA	0.00	0.01	0.01	0.00	0.02	0.03	0.00	0.03	0.04
HE	0.03	0.02	0.05	0.05	0.03	0.08	0.07	0.04	0.11
HY	0.04	0.02	0.05	0.07	0.03	0.09	0.09	0.04	0.13
HT	0.31	0.03	0.34	0.54	0.06	0.59	0.76	0.08	0.84
IR	1.03	0.06	1.09	1.78	0.10	1.88	2.53	0.14	2.67
JK	0.00	0.01	0.02	0.01	0.02	0.03	0.01	0.03	0.04
JA	0.05	0.02	0.07	0.09	0.03	0.12	0.13	0.04	0.17
JD	0.06	0.03	0.10	0.11	0.05	0.16	0.16	0.07	0.23
JF	0.03	0.02	0.05	0.05	0.03	0.08	0.07	0.04	0.11
JS	0.03	0.02	0.05	0.05	0.03	0.08	0.07	0.04	0.11
JH	0.08	0.02	0.10	0.13	0.04	0.17	0.18	0.05	0.24
JO	0.09	0.02	0.11	0.15	0.04	0.19	0.22	0.05	0.27
LR	0.09	0.02	0.11	0.16	0.03	0.20	0.23	0.05	0.28
LN	0.51	0.03	0.55	0.88	0.06	0.94	1.25	0.09	1.34
LS	0.19	0.03	0.23	0.34	0.05	0.39	0.48	0.08	0.55
LE	0.57	0.03	0.60	0.98	0.06	1.04	1.39	0.08	1.47
LI	0.03	0.02	0.05	0.06	0.03	0.09	0.08	0.05	0.13
LC	0.00	0.01	0.02	0.01	0.02	0.03	0.01	0.03	0.05
LG	0.05	0.02	0.07	0.09	0.04	0.12	0.13	0.05	0.18
LW	0.62	0.04	0.67	1.07	0.08	1.15	1.53	0.11	1.63
LU	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
MF	0.01	0.02	0.03	0.03	0.03	0.05	0.04	0.04	0.07

MC	0.04	0.02	0.05	0.06	0.03	0.09	0.09	0.05	0.13
MA	0.34	0.03	0.37	0.58	0.05	0.63	0.82	0.07	0.90
MD	0.00	0.01	0.02	0.01	0.02	0.03	0.01	0.03	0.04
MR	0.31	0.03	0.34	0.53	0.05	0.58	0.75	0.07	0.83
MW	0.06	0.02	0.07	0.10	0.03	0.13	0.14	0.05	0.18
MI	0.72	0.05	0.77	1.24	0.08	1.32	1.76	0.11	1.87
ML	0.77	0.05	0.82	1.33	0.09	1.42	1.89	0.12	2.01
MO	0.10	0.02	0.12	0.17	0.03	0.20	0.24	0.05	0.28
MY	0.10	0.03	0.12	0.17	0.04	0.21	0.24	0.06	0.30
MG	0.02	0.01	0.04	0.04	0.02	0.07	0.06	0.04	0.10
MU	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
ME	0.22	0.03	0.25	0.38	0.05	0.43	0.53	0.07	0.61
NE	0.03	0.02	0.05	0.05	0.03	0.08	0.08	0.04	0.11
OC	0.01	0.01	0.02	0.02	0.02	0.04	0.03	0.04	0.06
OG	0.01	0.01	0.02	0.01	0.02	0.04	0.02	0.04	0.06
PA	0.01	0.01	0.02	0.01	0.02	0.03	0.01	0.03	0.05
PE	0.21	0.03	0.23	0.36	0.05	0.40	0.51	0.07	0.57
PI	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
PR	0.13	0.02	0.15	0.22	0.04	0.27	0.32	0.06	0.38
PK	0.07	0.02	0.09	0.12	0.03	0.16	0.17	0.05	0.22
PO	0.00	0.01	0.02	0.01	0.02	0.03	0.01	0.03	0.04
PU	0.48	0.04	0.52	0.82	0.08	0.89	1.16	0.11	1.27
PM	0.05	0.02	0.06	0.08	0.03	0.11	0.11	0.04	0.15
QU	0.22	0.05	0.27	0.38	0.09	0.46	0.54	0.12	0.66
RA	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
RH	0.48	0.05	0.53	0.83	0.09	0.92	1.18	0.13	1.30
RI	0.01	0.02	0.03	0.02	0.03	0.05	0.03	0.04	0.07
RO	0.02	0.01	0.04	0.04	0.03	0.06	0.06	0.04	0.09
SH	0.31	0.03	0.33	0.53	0.05	0.57	0.75	0.07	0.82
SN	0.01	0.01	0.02	0.02	0.02	0.04	0.02	0.03	0.06
SE	0.60	0.10	0.70	1.04	0.18	1.21	1.47	0.25	1.72
SP	0.06	0.02	0.07	0.10	0.03	0.13	0.14	0.04	0.18
ST	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
SW	0.27	0.05	0.32	0.47	0.08	0.54	0.66	0.11	0.77
SU	0.58	0.04	0.62	0.99	0.07	1.06	1.41	0.10	1.51

TA	0.13	0.02	0.15	0.22	0.04	0.27	0.32	0.06	0.38
TL	0.02	0.02	0.04	0.03	0.03	0.06	0.05	0.04	0.09
TT	0.05	0.02	0.07	0.09	0.04	0.13	0.13	0.05	0.18
TR	0.21	0.03	0.24	0.36	0.04	0.41	0.52	0.06	0.58
TF	0.24	0.04	0.28	0.41	0.07	0.48	0.58	0.10	0.68
TE	0.58	0.04	0.62	1.00	0.06	1.06	1.42	0.09	1.51
TH	1.07	0.05	1.12	1.85	0.08	1.92	2.62	0.11	2.73
TI	0.70	0.04	0.73	1.20	0.06	1.27	1.71	0.09	1.80
TS	0.05	0.02	0.08	0.09	0.04	0.13	0.13	0.06	0.19
TO	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
TU	0.12	0.02	0.14	0.21	0.04	0.25	0.29	0.06	0.35
TR	0.06	0.02	0.08	0.11	0.03	0.14	0.15	0.05	0.20
TN	0.64	0.03	0.67	1.09	0.06	1.15	1.55	0.09	1.64
TW	0.24	0.03	0.27	0.41	0.05	0.46	0.59	0.07	0.66
UN	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
UP	0.13	0.02	0.15	0.22	0.04	0.26	0.32	0.05	0.37
WA	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
WN	0.01	0.01	0.03	0.02	0.02	0.05	0.03	0.03	0.07
WE	0.21	0.03	0.24	0.37	0.05	0.42	0.53	0.07	0.60
WR	0.02	0.02	0.04	0.04	0.03	0.07	0.06	0.04	0.10
WG	0.04	0.02	0.06	0.06	0.03	0.10	0.09	0.05	0.14
WY	0.09	0.02	0.12	0.16	0.04	0.20	0.23	0.06	0.28
WB	0.45	0.04	0.50	0.78	0.08	0.86	1.11	0.11	1.22
WL	0.13	0.03	0.16	0.23	0.05	0.28	0.33	0.07	0.40
WH	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
WD	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
WI	0.96	0.06	1.02	1.66	0.11	1.76	2.35	0.15	2.50
WS	0.01	0.01	0.02	0.01	0.02	0.03	0.01	0.03	0.05
WK	0.08	0.02	0.11	0.14	0.04	0.18	0.20	0.06	0.26
WO	1.01	0.04	1.05	1.74	0.06	1.81	2.47	0.09	2.57
Total	30.87	3.98	34.85	53.19	6.85	60.04	75.50	9.73	85.23

Unit: million dollars

APPENDIX 2 Full economic impact of cotton production for industry sectors

Sector	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
1	30.87	1.87	32.75	53.19	3.22	56.41	75.50	4.58	80.08
2	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
4	0.00	0.02	0.02	0.00	0.03	0.03	0.00	0.04	0.04
5	0.00	2.03	2.03	0.00	3.50	3.50	0.00	4.97	4.97
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
10	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.01
11	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.03	0.03
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	30.87	3.98	34.85	53.19	6.85	60.04	75.50	9.73	85.23

Unit: million dollars

APPENDIX 3 Full economic impact of peanuts production for counties

Counties	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
AP	0.01	0.00	0.01	0.03	0.01	0.04	0.08	0.02	0.09
AT	0.03	0.00	0.03	0.08	0.01	0.09	0.19	0.02	0.21
BC	0.02	0.00	0.02	0.05	0.01	0.06	0.13	0.02	0.14
BX	0.07	0.00	0.08	0.23	0.01	0.24	0.53	0.03	0.56
BL	0.01	0.00	0.01	0.02	0.01	0.02	0.04	0.01	0.06
BA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
BW	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01
BR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
BH	0.06	0.01	0.07	0.19	0.02	0.21	0.44	0.05	0.49
BE	0.08	0.00	0.08	0.24	0.01	0.25	0.55	0.02	0.57
BI	0.01	0.00	0.02	0.04	0.01	0.05	0.10	0.02	0.12
BY	0.02	0.00	0.02	0.07	0.01	0.08	0.16	0.02	0.18
BT	0.01	0.00	0.01	0.02	0.01	0.03	0.05	0.02	0.07
BO	0.06	0.00	0.07	0.19	0.01	0.21	0.45	0.03	0.48
BN	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.03
BU	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.01	0.04
BK	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
BS	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.01	0.04
CU	0.07	0.00	0.08	0.22	0.01	0.23	0.51	0.03	0.54
CM	0.01	0.00	0.01	0.02	0.01	0.02	0.04	0.01	0.06
CZ	0.01	0.00	0.01	0.02	0.01	0.02	0.04	0.01	0.05
CL	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02
CT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
CR	0.01	0.00	0.01	0.03	0.01	0.03	0.06	0.02	0.08
CH	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02
CE	0.03	0.00	0.03	0.09	0.01	0.10	0.20	0.02	0.23
CG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
CK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
CA	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01
CY	0.05	0.01	0.06	0.16	0.02	0.18	0.37	0.05	0.42
CN	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.01	0.03
CI	0.02	0.00	0.02	0.05	0.01	0.06	0.11	0.02	0.14

CO	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
CF	0.02	0.00	0.03	0.07	0.01	0.08	0.16	0.02	0.19
CQ	0.07	0.00	0.07	0.21	0.01	0.23	0.50	0.03	0.53
CB	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
CX	0.06	0.00	0.06	0.18	0.01	0.19	0.43	0.02	0.45
CW	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.01	0.04
CD	0.02	0.00	0.02	0.05	0.01	0.06	0.12	0.02	0.13
CP	0.06	0.00	0.07	0.20	0.01	0.21	0.47	0.02	0.49
DD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
DW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
DR	0.11	0.01	0.12	0.35	0.02	0.37	0.81	0.05	0.87
DA	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
DG	0.02	0.00	0.02	0.06	0.01	0.07	0.14	0.02	0.16
DY	0.04	0.00	0.04	0.12	0.01	0.13	0.29	0.02	0.31
DU	0.06	0.00	0.06	0.17	0.01	0.18	0.40	0.03	0.43
DO	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
ER	0.12	0.01	0.13	0.36	0.04	0.40	0.84	0.10	0.93
EC	0.03	0.00	0.03	0.09	0.01	0.09	0.20	0.02	0.22
EF	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02
EB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
EM	0.01	0.00	0.01	0.02	0.01	0.03	0.05	0.01	0.06
EV	0.01	0.00	0.01	0.02	0.01	0.03	0.04	0.01	0.06
FN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
FY	0.00	0.00	0.01	0.01	0.00	0.02	0.03	0.01	0.04
FL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
FO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
FK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
FU	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
GI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
GL	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.01	0.03
GN	0.01	0.00	0.01	0.02	0.01	0.02	0.04	0.02	0.05
GO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
GR	0.07	0.00	0.08	0.23	0.01	0.24	0.53	0.03	0.56
GE	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
GW	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01

HM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
HL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
HK	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.01	0.04
HR	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
HS	0.01	0.00	0.01	0.03	0.01	0.04	0.06	0.02	0.08
HA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
HE	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.01	0.04
HY	0.00	0.00	0.00	0.01	0.00	0.02	0.02	0.01	0.04
HT	0.03	0.00	0.03	0.08	0.01	0.09	0.19	0.02	0.21
IR	0.12	0.01	0.13	0.38	0.02	0.40	0.87	0.04	0.92
JK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
JA	0.00	0.00	0.01	0.01	0.00	0.02	0.03	0.01	0.04
JD	0.01	0.00	0.01	0.02	0.01	0.03	0.04	0.02	0.06
JF	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.01	0.03
JS	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.03
JH	0.01	0.00	0.01	0.02	0.01	0.03	0.05	0.01	0.06
JO	0.01	0.00	0.01	0.02	0.01	0.03	0.05	0.01	0.07
LR	0.01	0.00	0.01	0.03	0.01	0.03	0.06	0.01	0.07
LN	0.04	0.00	0.04	0.12	0.01	0.13	0.28	0.02	0.31
LS	0.02	0.00	0.02	0.05	0.01	0.06	0.12	0.02	0.14
LE	0.06	0.00	0.06	0.17	0.01	0.19	0.41	0.03	0.43
LI	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.01	0.04
LC	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01
LG	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.01	0.05
LW	0.05	0.00	0.06	0.16	0.01	0.18	0.38	0.03	0.41
LU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
MF	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
MC	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.01	0.04
MA	0.03	0.00	0.03	0.09	0.01	0.09	0.20	0.02	0.22
MD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
MR	0.03	0.00	0.03	0.09	0.01	0.10	0.22	0.02	0.24
MW	0.01	0.00	0.01	0.02	0.01	0.02	0.04	0.01	0.05
MI	0.07	0.00	0.08	0.23	0.02	0.25	0.54	0.04	0.57
ML	0.07	0.01	0.08	0.22	0.02	0.24	0.52	0.04	0.56
MO	0.01	0.00	0.01	0.03	0.01	0.03	0.06	0.01	0.07

MY	0.01	0.00	0.01	0.03	0.01	0.03	0.06	0.02	0.08
MG	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02
MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
ME	0.02	0.00	0.03	0.07	0.01	0.08	0.17	0.02	0.19
NE	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.01	0.03
OC	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
OG	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01
PA	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01
PE	0.02	0.00	0.02	0.05	0.01	0.06	0.12	0.02	0.14
PI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
PR	0.01	0.00	0.01	0.04	0.01	0.04	0.08	0.02	0.10
PK	0.01	0.00	0.01	0.02	0.01	0.03	0.05	0.01	0.06
PO	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01
PU	0.03	0.00	0.03	0.09	0.01	0.10	0.21	0.02	0.24
PM	0.00	0.00	0.01	0.01	0.00	0.02	0.03	0.01	0.04
QU	0.02	0.01	0.03	0.08	0.02	0.09	0.18	0.04	0.22
RA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
RH	0.07	0.01	0.08	0.22	0.02	0.24	0.51	0.05	0.55
RI	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
RO	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02
SH	0.03	0.00	0.03	0.09	0.01	0.10	0.20	0.02	0.22
SN	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
SE	0.07	0.01	0.08	0.22	0.04	0.25	0.50	0.08	0.59
SP	0.01	0.00	0.01	0.02	0.01	0.02	0.04	0.01	0.05
ST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
SW	0.04	0.01	0.04	0.12	0.02	0.14	0.28	0.04	0.32
SU	0.05	0.00	0.05	0.15	0.01	0.16	0.34	0.03	0.37
TA	0.01	0.00	0.02	0.04	0.01	0.05	0.09	0.02	0.11
TL	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
TT	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.01	0.05
TR	0.02	0.00	0.02	0.06	0.01	0.07	0.14	0.02	0.16
TF	0.02	0.00	0.02	0.06	0.01	0.07	0.15	0.03	0.17
TE	0.06	0.00	0.06	0.18	0.01	0.19	0.42	0.03	0.45
TH	0.08	0.00	0.08	0.24	0.01	0.25	0.55	0.03	0.58
TI	0.06	0.00	0.06	0.18	0.01	0.19	0.42	0.02	0.44

TS	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.02	0.05
TO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
TU	0.01	0.00	0.01	0.03	0.01	0.04	0.07	0.02	0.09
TR	0.01	0.00	0.01	0.02	0.01	0.03	0.05	0.01	0.06
TN	0.06	0.00	0.06	0.17	0.01	0.18	0.40	0.02	0.42
TW	0.01	0.00	0.02	0.04	0.01	0.05	0.10	0.02	0.11
UN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
UP	0.01	0.00	0.01	0.04	0.01	0.04	0.09	0.01	0.10
WA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
WN	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02
WE	0.02	0.00	0.02	0.06	0.01	0.07	0.13	0.02	0.15
WR	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02
WG	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.03
WY	0.01	0.00	0.01	0.03	0.01	0.03	0.06	0.02	0.08
WB	0.04	0.00	0.04	0.13	0.01	0.14	0.29	0.03	0.33
WL	0.01	0.00	0.01	0.04	0.01	0.04	0.08	0.02	0.10
WH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
WI	0.06	0.00	0.07	0.20	0.01	0.22	0.47	0.03	0.50
WS	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01
WK	0.01	0.00	0.01	0.02	0.01	0.03	0.05	0.01	0.06
WO	0.09	0.00	0.10	0.29	0.01	0.30	0.67	0.03	0.70
Total	2.89	0.39	3.28	8.99	1.21	10.20	20.89	2.82	23.71

Unit: million dollars

APPENDIX 4 Full economic impact of peanuts production for industry sectors

Sector	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
1	2.89	0.19	3.08	8.99	0.59	9.58	20.89	1.37	22.26
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01
5	0.00	0.19	0.19	0.00	0.60	0.60	0.00	1.40	1.40
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	2.89	0.39	3.28	8.99	1.21	10.20	20.89	2.82	23.71

Unit: million dollars

APPENDIX 5 Full economic impact of corn production for counties

Counties	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
AP	-0.01	0.00	-0.02	0.00	0.00	0.00	0.02	0.01	0.03
AT	-0.04	0.00	-0.04	0.01	0.00	0.01	0.05	0.01	0.06
BC	-0.02	0.00	-0.03	0.00	0.00	0.01	0.03	0.01	0.04
BX	-0.15	-0.01	-0.16	0.03	0.00	0.03	0.21	0.01	0.22
BL	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.02
BA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BH	-0.08	-0.01	-0.09	0.02	0.00	0.02	0.11	0.01	0.12
BE	-0.11	-0.01	-0.12	0.02	0.00	0.02	0.16	0.01	0.16
BI	-0.03	0.00	-0.03	0.01	0.00	0.01	0.04	0.01	0.04
BY	-0.04	-0.01	-0.05	0.01	0.00	0.01	0.06	0.01	0.07
BT	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.01	0.02
BO	-0.12	-0.01	-0.13	0.02	0.00	0.03	0.17	0.01	0.18
BN	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.01
BU	0.00	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
BK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
BS	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.02
CU	-0.16	-0.01	-0.17	0.03	0.00	0.03	0.22	0.01	0.23
CM	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.02
CZ	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
CL	0.00	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
CT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR	-0.01	0.00	-0.02	0.00	0.00	0.00	0.02	0.01	0.02
CH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
CE	-0.06	-0.01	-0.07	0.01	0.00	0.01	0.09	0.01	0.09
CG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CY	-0.07	-0.01	-0.08	0.01	0.00	0.02	0.10	0.01	0.12
CN	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
CI	-0.02	-0.01	-0.03	0.01	0.00	0.01	0.03	0.01	0.04

CO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
CF	-0.03	-0.01	-0.04	0.01	0.00	0.01	0.05	0.01	0.05
CQ	-0.12	-0.01	-0.12	0.02	0.00	0.03	0.17	0.01	0.18
CB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
CX	-0.09	-0.01	-0.09	0.02	0.00	0.02	0.12	0.01	0.13
CW	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.02
CD	-0.03	0.00	-0.03	0.01	0.00	0.01	0.04	0.01	0.05
CP	-0.07	-0.01	-0.07	0.01	0.00	0.02	0.10	0.01	0.11
DD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DR	-0.32	-0.02	-0.33	0.06	0.00	0.07	0.44	0.02	0.47
DA	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.01
DG	-0.03	-0.01	-0.03	0.01	0.00	0.01	0.04	0.01	0.05
DY	-0.07	-0.01	-0.08	0.01	0.00	0.02	0.10	0.01	0.11
DU	-0.11	-0.01	-0.12	0.02	0.00	0.02	0.15	0.01	0.16
DO	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.01
ER	-0.20	-0.02	-0.22	0.04	0.00	0.05	0.28	0.03	0.32
EC	-0.04	0.00	-0.05	0.01	0.00	0.01	0.06	0.01	0.07
EF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
EB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EM	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.02
EV	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.02
FN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FY	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.02
FL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FU	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.01
GI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GL	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.01
GN	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.01	0.02
GO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GR	-0.21	-0.01	-0.22	0.04	0.00	0.05	0.30	0.01	0.32
GE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
GW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01

HM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HK	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
HR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
HS	-0.02	0.00	-0.02	0.00	0.00	0.01	0.03	0.01	0.03
HA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HE	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
HY	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
HT	-0.05	-0.01	-0.05	0.01	0.00	0.01	0.07	0.01	0.07
IR	-0.17	-0.01	-0.18	0.04	0.00	0.04	0.24	0.01	0.26
JK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
JA	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.02
JD	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.01	0.02
JF	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.01
JS	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.01
JH	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.02
JO	-0.01	0.00	-0.02	0.00	0.00	0.00	0.02	0.00	0.02
LR	-0.02	0.00	-0.02	0.00	0.00	0.00	0.02	0.00	0.03
LN	-0.06	-0.01	-0.07	0.01	0.00	0.01	0.08	0.01	0.09
LS	-0.02	0.00	-0.03	0.00	0.00	0.01	0.03	0.01	0.04
LE	-0.12	-0.01	-0.13	0.02	0.00	0.03	0.17	0.01	0.18
LI	0.00	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
LC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LG	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
LW	-0.09	-0.01	-0.10	0.02	0.00	0.02	0.13	0.01	0.14
LU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
MC	0.00	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
MA	-0.07	-0.01	-0.08	0.01	0.00	0.02	0.10	0.01	0.11
MD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MR	-0.07	-0.01	-0.07	0.01	0.00	0.01	0.09	0.01	0.10
MW	-0.01	0.00	-0.02	0.00	0.00	0.00	0.02	0.00	0.02
MI	-0.16	-0.01	-0.17	0.03	0.00	0.04	0.23	0.01	0.24
ML	-0.15	-0.01	-0.16	0.03	0.00	0.03	0.21	0.01	0.22
MO	-0.02	0.00	-0.02	0.00	0.00	0.00	0.02	0.00	0.03

MY	-0.01	0.00	-0.02	0.00	0.00	0.00	0.02	0.01	0.02
MG	0.00	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ME	-0.05	-0.01	-0.06	0.01	0.00	0.01	0.07	0.01	0.08
NE	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
OC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
OG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
PE	-0.03	0.00	-0.04	0.01	0.00	0.01	0.04	0.01	0.05
PI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PR	-0.02	0.00	-0.02	0.00	0.00	0.00	0.02	0.01	0.03
PK	-0.01	0.00	-0.02	0.00	0.00	0.00	0.02	0.00	0.03
PO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PU	-0.05	-0.01	-0.06	0.01	0.00	0.01	0.07	0.01	0.08
PM	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
QU	-0.05	-0.01	-0.06	0.01	0.00	0.01	0.08	0.02	0.09
RA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RH	-0.13	-0.01	-0.14	0.03	0.00	0.03	0.19	0.02	0.20
RI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
RO	0.00	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
SH	-0.06	-0.01	-0.06	0.01	0.00	0.01	0.08	0.01	0.09
SN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SE	-0.15	-0.02	-0.18	0.03	0.01	0.04	0.21	0.03	0.25
SP	-0.01	0.00	-0.01	0.00	0.00	0.00	0.02	0.00	0.02
ST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SW	-0.05	-0.01	-0.05	0.01	0.00	0.01	0.07	0.01	0.08
SU	-0.17	-0.01	-0.18	0.03	0.00	0.04	0.24	0.01	0.25
TA	-0.03	0.00	-0.03	0.01	0.00	0.01	0.04	0.01	0.05
TL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
TT	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
TR	-0.05	0.00	-0.05	0.01	0.00	0.01	0.07	0.01	0.07
TF	-0.03	-0.01	-0.03	0.01	0.00	0.01	0.04	0.01	0.05
TE	-0.13	-0.01	-0.13	0.03	0.00	0.03	0.18	0.01	0.19
TH	-0.18	-0.01	-0.19	0.04	0.00	0.04	0.25	0.01	0.27
TI	-0.08	-0.01	-0.09	0.02	0.00	0.02	0.12	0.01	0.13

TS	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
TO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TU	-0.01	0.00	-0.02	0.00	0.00	0.00	0.02	0.00	0.02
TR	-0.02	0.00	-0.02	0.00	0.00	0.00	0.02	0.01	0.03
TN	-0.09	-0.01	-0.09	0.02	0.00	0.02	0.13	0.01	0.13
TW	-0.02	0.00	-0.03	0.00	0.00	0.01	0.03	0.01	0.04
UN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UP	-0.03	0.00	-0.03	0.01	0.00	0.01	0.04	0.01	0.04
WA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
WE	-0.03	0.00	-0.03	0.01	0.00	0.01	0.04	0.01	0.04
WR	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.01
WG	0.00	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.01
WY	-0.01	0.00	-0.01	0.00	0.00	0.00	0.02	0.00	0.02
WB	-0.08	-0.01	-0.08	0.02	0.00	0.02	0.11	0.01	0.12
WL	-0.02	0.00	-0.02	0.00	0.00	0.00	0.02	0.01	0.03
WH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WI	-0.04	-0.01	-0.05	0.01	0.00	0.01	0.06	0.01	0.07
WS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WK	-0.01	0.00	-0.01	0.00	0.00	0.00	0.01	0.00	0.02
WO	-0.12	-0.01	-0.13	0.02	0.00	0.03	0.17	0.01	0.18
Total	-5.32	-0.68	-6.00	1.09	0.14	1.23	7.50	0.96	8.46

Unit: million dollars

APPENDIX 6 Full economic impact of corn production for industry sectors

Sector	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
1	-5.32	-0.33	-5.65	1.09	0.07	1.16	7.50	0.47	7.97
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	-0.34	-0.34	0.00	0.07	0.07	0.00	0.47	0.47
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	-5.32	-0.68	-6.00	1.09	0.14	1.23	7.50	0.96	8.46

Unit: million dollars

APPENDIX 7 Full economic impact of soybeans production for counties

Counties	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
AP	0.01	0.00	0.01	0.01	0.00	0.02	0.02	0.01	0.03
AT	0.02	0.00	0.02	0.03	0.00	0.04	0.05	0.01	0.06
BC	0.01	0.00	0.01	0.02	0.00	0.03	0.03	0.01	0.04
BX	0.05	0.00	0.06	0.12	0.01	0.13	0.18	0.01	0.19
BL	0.01	0.00	0.01	0.02	0.00	0.03	0.03	0.01	0.04
BA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BW	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
BR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
BH	0.02	0.00	0.02	0.03	0.01	0.04	0.05	0.01	0.06
BE	0.03	0.00	0.04	0.07	0.01	0.08	0.11	0.01	0.12
BI	0.02	0.00	0.03	0.05	0.01	0.06	0.08	0.01	0.09
BY	0.08	0.01	0.09	0.18	0.01	0.19	0.28	0.02	0.30
BT	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.02
BO	0.08	0.00	0.08	0.16	0.01	0.17	0.25	0.01	0.26
BN	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
BU	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01
BK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
BS	0.01	0.00	0.01	0.02	0.00	0.02	0.03	0.01	0.03
CU	0.05	0.00	0.05	0.11	0.01	0.12	0.17	0.01	0.18
CM	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02
CZ	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02
CL	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01
CT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CR	0.00	0.00	0.01	0.01	0.00	0.01	0.02	0.01	0.02
CH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
CE	0.03	0.00	0.04	0.07	0.01	0.08	0.11	0.01	0.12
CG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
CA	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
CY	0.03	0.00	0.04	0.07	0.01	0.08	0.11	0.02	0.12
CN	0.01	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.02
CI	0.01	0.00	0.01	0.02	0.00	0.03	0.03	0.01	0.04

CO	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01
CF	0.01	0.00	0.02	0.03	0.01	0.04	0.05	0.01	0.06
CQ	0.05	0.00	0.05	0.10	0.01	0.11	0.15	0.01	0.16
CB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
CX	0.03	0.00	0.04	0.07	0.01	0.08	0.11	0.01	0.12
CW	0.01	0.00	0.01	0.02	0.00	0.02	0.02	0.01	0.03
CD	0.03	0.00	0.03	0.06	0.01	0.06	0.09	0.01	0.10
CP	0.05	0.00	0.05	0.11	0.01	0.12	0.17	0.01	0.18
DD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DR	0.11	0.01	0.11	0.23	0.01	0.24	0.35	0.02	0.37
DA	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01
DG	0.05	0.01	0.05	0.10	0.01	0.11	0.16	0.02	0.18
DY	0.05	0.00	0.05	0.10	0.01	0.11	0.16	0.01	0.17
DU	0.05	0.00	0.05	0.10	0.01	0.11	0.16	0.01	0.17
DO	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01
ER	0.07	0.01	0.08	0.15	0.02	0.16	0.22	0.03	0.25
EC	0.02	0.00	0.02	0.04	0.00	0.04	0.06	0.01	0.07
EF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
EB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EM	0.01	0.00	0.01	0.01	0.00	0.01	0.02	0.01	0.02
EV	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02
FN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FY	0.01	0.00	0.01	0.02	0.00	0.02	0.02	0.01	0.03
FL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
FK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FU	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
GI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GL	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01
GN	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
GO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GR	0.06	0.00	0.07	0.14	0.01	0.15	0.21	0.01	0.23
GE	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01
GW	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01

HM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HK	0.01	0.00	0.01	0.01	0.00	0.01	0.02	0.01	0.02
HR	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
HS	0.01	0.00	0.01	0.03	0.01	0.03	0.04	0.01	0.05
HA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HE	0.01	0.00	0.01	0.01	0.00	0.01	0.02	0.01	0.02
HY	0.01	0.00	0.01	0.02	0.00	0.02	0.02	0.01	0.03
HT	0.04	0.00	0.04	0.08	0.01	0.09	0.13	0.01	0.14
IR	0.04	0.00	0.04	0.09	0.01	0.09	0.13	0.01	0.14
JK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
JA	0.01	0.00	0.01	0.02	0.00	0.02	0.03	0.01	0.03
JD	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.02
JF	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01
JS	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01
JH	0.01	0.00	0.01	0.01	0.00	0.02	0.02	0.01	0.03
JO	0.01	0.00	0.02	0.03	0.00	0.03	0.04	0.01	0.05
LR	0.02	0.00	0.02	0.04	0.00	0.04	0.05	0.01	0.06
LN	0.02	0.00	0.02	0.05	0.01	0.05	0.07	0.01	0.08
LS	0.02	0.00	0.02	0.04	0.01	0.04	0.05	0.01	0.06
LE	0.06	0.00	0.06	0.13	0.01	0.14	0.20	0.01	0.22
LI	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01
LC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
LG	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
LW	0.03	0.00	0.04	0.07	0.01	0.08	0.11	0.01	0.12
LU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MF	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
MC	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01
MA	0.08	0.00	0.08	0.16	0.01	0.17	0.25	0.01	0.26
MD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
MR	0.04	0.00	0.04	0.09	0.01	0.10	0.14	0.01	0.15
MW	0.01	0.00	0.01	0.02	0.00	0.02	0.03	0.01	0.04
MI	0.06	0.00	0.07	0.13	0.01	0.14	0.20	0.01	0.22
ML	0.05	0.00	0.06	0.12	0.01	0.13	0.18	0.01	0.19
MO	0.02	0.00	0.02	0.03	0.00	0.04	0.05	0.01	0.06

MY	0.01	0.00	0.01	0.01	0.00	0.02	0.02	0.01	0.03
MG	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.02
MU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ME	0.03	0.00	0.03	0.07	0.01	0.07	0.10	0.01	0.11
NE	0.01	0.00	0.01	0.01	0.00	0.02	0.02	0.00	0.02
OC	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01
OG	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
PA	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
PE	0.09	0.00	0.10	0.20	0.01	0.21	0.30	0.02	0.32
PI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PR	0.01	0.00	0.01	0.01	0.00	0.02	0.02	0.01	0.03
PK	0.01	0.00	0.01	0.03	0.00	0.03	0.04	0.01	0.05
PO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
PU	0.05	0.00	0.05	0.10	0.01	0.11	0.16	0.01	0.17
PM	0.01	0.00	0.01	0.01	0.00	0.02	0.02	0.01	0.03
QU	0.02	0.00	0.03	0.05	0.01	0.06	0.08	0.02	0.09
RA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RH	0.08	0.01	0.08	0.17	0.01	0.18	0.26	0.02	0.28
RI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
RO	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.02
SH	0.04	0.00	0.05	0.10	0.01	0.10	0.15	0.01	0.16
SN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
SE	0.04	0.01	0.05	0.09	0.02	0.11	0.14	0.03	0.17
SP	0.01	0.00	0.01	0.02	0.00	0.03	0.03	0.01	0.04
ST	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SW	0.03	0.00	0.04	0.07	0.01	0.08	0.11	0.02	0.13
SU	0.08	0.00	0.08	0.17	0.01	0.18	0.26	0.01	0.28
TA	0.02	0.00	0.02	0.04	0.01	0.05	0.07	0.01	0.07
TL	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01
TT	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01
TR	0.05	0.00	0.06	0.12	0.01	0.12	0.18	0.01	0.19
TF	0.02	0.00	0.02	0.03	0.01	0.04	0.05	0.01	0.06
TE	0.06	0.00	0.06	0.12	0.01	0.13	0.19	0.01	0.20
TH	0.06	0.00	0.07	0.14	0.01	0.14	0.21	0.01	0.22
TI	0.03	0.00	0.04	0.07	0.01	0.08	0.11	0.01	0.12

TS	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.02
TO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TU	0.01	0.00	0.01	0.02	0.00	0.02	0.03	0.01	0.03
TR	0.01	0.00	0.01	0.02	0.00	0.03	0.03	0.01	0.04
TN	0.04	0.00	0.05	0.10	0.01	0.10	0.15	0.01	0.16
TW	0.02	0.00	0.02	0.04	0.01	0.05	0.06	0.01	0.07
UN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UP	0.02	0.00	0.02	0.05	0.00	0.05	0.07	0.01	0.08
WA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WN	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01
WE	0.01	0.00	0.01	0.02	0.00	0.03	0.03	0.01	0.04
WR	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01
WG	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.02
WY	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.02
WB	0.04	0.00	0.05	0.09	0.01	0.10	0.15	0.01	0.16
WL	0.01	0.00	0.01	0.02	0.00	0.02	0.03	0.01	0.04
WH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WI	0.04	0.00	0.05	0.09	0.01	0.10	0.14	0.01	0.15
WS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
WK	0.01	0.00	0.01	0.02	0.00	0.03	0.03	0.01	0.04
WO	0.04	0.00	0.05	0.10	0.01	0.10	0.15	0.01	0.16
Total	2.74	0.34	3.08	5.90	0.74	6.64	9.07	1.14	10.21

Unit: million dollars

APPENDIX 8 Full economic impact of soybeans production for industry sectors

Sector	Low			Mean			Upper		
	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact	Direct Impact	Indirect Impact	Total Impact
1	2.74	0.16	2.90	5.90	0.35	6.26	9.07	0.55	9.61
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.17	0.17	0.00	0.37	0.37	0.00	0.57	0.57
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	2.74	0.34	3.08	5.90	0.74	6.64	9.07	1.14	10.21

Unit: million dollars

APPENDIX 9 Full employment impact of cotton and peanuts production for counties

Counties	Cotton			Peanuts		
	Lower	Mean	Upper	Lower	Mean	Upper
AP	1	2	2	0	0	1
AT	2	3	4	0	0	1
BC	2	3	5	0	1	1
BX	4	7	10	0	1	3
BL	1	1	2	0	0	0
BA	0	0	0	0	0	0
BW	0	0	0	0	0	0
BR	0	0	0	0	0	0
BH	4	7	10	1	2	5
BE	7	13	18	1	2	5
BI	1	2	3	0	0	1
BY	2	4	5	0	1	2
BT	1	2	2	0	0	1
BO	8	13	19	1	2	4
BN	0	1	1	0	0	0
BU	1	1	1	0	0	0
BK	0	1	1	0	0	0
BS	1	2	2	0	0	1
CU	6	10	14	1	2	5
CM	1	2	2	0	0	1
CZ	1	2	2	0	0	1
CL	0	0	1	0	0	0
CT	0	0	0	0	0	0
CR	1	2	3	0	0	1
CH	0	0	1	0	0	0
CE	4	6	9	0	1	3
CG	0	0	0	0	0	0
CK	0	0	0	0	0	0
CA	0	0	0	0	0	0
CY	3	5	7	0	1	3
CN	0	1	1	0	0	0
CI	2	3	4	0	0	1

CO	0	0	0	0	0	0
CF	2	3	4	0	0	1
CQ	9	16	22	1	2	5
CB	0	1	1	0	0	0
CX	16	27	38	1	4	9
CW	1	1	2	0	0	1
CD	2	3	4	0	0	1
CP	10	17	24	1	2	5
DD	0	0	0	0	0	0
DW	0	0	0	0	0	0
DR	4	7	10	1	2	4
DA	0	0	0	0	0	0
DG	5	9	12	0	1	2
DY	3	6	8	0	1	2
DU	6	10	14	1	2	4
DO	0	0	1	0	0	0
ER	9	15	21	1	3	8
EC	5	8	12	0	1	3
EF	0	1	1	0	0	0
EB	0	0	0	0	0	0
EM	1	2	3	0	0	1
EV	1	1	1	0	0	0
FN	0	0	0	0	0	0
FY	1	1	1	0	0	0
FL	0	0	0	0	0	0
FO	0	0	0	0	0	0
FK	0	0	0	0	0	0
FU	0	0	1	0	0	0
GI	0	0	0	0	0	0
GL	1	1	2	0	0	0
GN	1	1	2	0	0	0
GO	0	0	0	0	0	0
GR	11	19	27	1	3	7
GE	0	0	1	0	0	0
GW	0	0	0	0	0	0

HM	0	0	0	0	0	0
HL	0	0	0	0	0	0
HK	2	3	4	0	0	1
HR	0	0	0	0	0	0
HS	2	3	4	0	1	1
HA	0	0	0	0	0	0
HE	0	1	1	0	0	0
HY	1	1	1	0	0	0
HT	2	4	5	0	1	1
IR	7	12	16	1	2	6
JK	0	0	0	0	0	0
JA	1	1	2	0	0	0
JD	1	1	2	0	0	1
JF	0	1	1	0	0	0
JS	0	1	1	0	0	0
JH	2	3	4	0	0	1
JO	1	2	3	0	0	1
LR	1	2	3	0	0	1
LN	8	14	19	1	2	4
LS	3	6	8	0	1	2
LE	7	12	18	1	2	5
LI	0	1	1	0	0	0
LC	0	0	0	0	0	0
LG	0	1	1	0	0	0
LW	9	15	21	1	2	5
LU	0	0	0	0	0	0
MF	0	1	1	0	0	0
MC	0	1	1	0	0	0
MA	2	4	5	0	1	1
MD	0	0	0	0	0	0
MR	3	5	7	0	1	2
MW	1	2	2	0	0	1
MI	5	8	12	0	2	4
ML	8	14	19	1	2	5
MO	1	1	2	0	0	0

MY	2	3	4	0	0	1
MG	0	1	1	0	0	0
MU	0	0	0	0	0	0
ME	1	3	4	0	0	1
NE	0	1	1	0	0	0
OC	0	0	0	0	0	0
OG	0	0	0	0	0	0
PA	0	0	0	0	0	0
PE	5	9	13	0	1	3
PI	0	0	0	0	0	0
PR	1	2	3	0	0	1
PK	1	2	3	0	0	1
PO	0	0	0	0	0	0
PU	4	7	10	0	1	2
PM	1	1	2	0	0	0
QU	2	3	4	0	1	1
RA	0	0	0	0	0	0
RH	5	8	11	1	2	5
RI	0	0	1	0	0	0
RO	0	1	1	0	0	0
SH	3	6	8	0	1	2
SN	0	0	1	0	0	0
SE	5	8	12	1	2	4
SP	2	3	4	0	0	1
ST	0	0	0	0	0	0
SW	3	5	7	0	1	3
SU	6	11	15	1	2	4
TA	2	3	5	0	1	1
TL	0	1	1	0	0	0
TT	1	1	1	0	0	0
TR	2	4	6	0	1	2
TF	4	8	11	0	1	3
TE	6	11	15	1	2	4
TH	10	18	25	1	2	5
TI	11	19	27	1	3	7

TS	1	1	2	0	0	0
TO	0	0	0	0	0	0
TU	2	3	4	0	0	1
TR	1	1	2	0	0	1
TN	4	8	11	0	1	3
TW	3	5	6	0	0	1
UN	0	0	0	0	0	0
UP	1	2	2	0	0	1
WA	0	0	0	0	0	0
WN	0	0	1	0	0	0
WE	2	3	5	0	1	1
WR	1	1	1	0	0	0
WG	1	1	2	0	0	0
WY	1	1	2	0	0	1
WB	6	10	15	1	2	4
WL	2	3	4	0	0	1
WH	0	0	0	0	0	0
WD	0	0	0	0	0	0
WI	7	13	18	1	2	4
WS	0	0	0	0	0	0
WK	1	2	3	0	0	1
WO	8	14	19	1	2	5
Total	332	572	812	30	95	220

Unit: number of jobs

APPENDIX 10 Full employment impact of corn and soybeans production for counties

Counties	Corn			Soybeans		
	Lower	Mean	Upper	Lower	Mean	Upper
AP	0	0	0	0	0	0
AT	0	0	0	0	0	0
BC	0	0	0	0	0	0
BX	-1	0	1	0	1	1
BL	0	0	0	0	0	0
BA	0	0	0	0	0	0
BW	0	0	0	0	0	0
BR	0	0	0	0	0	0
BH	-1	0	1	0	0	1
BE	-1	0	2	0	1	1
BI	0	0	0	0	0	1
BY	0	0	1	1	2	3
BT	0	0	0	0	0	0
BO	-1	0	1	1	1	2
BN	0	0	0	0	0	0
BU	0	0	0	0	0	0
BK	0	0	0	0	0	0
BS	0	0	0	0	0	1
CU	-1	0	2	0	1	2
CM	0	0	0	0	0	0
CZ	0	0	0	0	0	0
CL	0	0	0	0	0	0
CT	0	0	0	0	0	0
CR	0	0	0	0	0	0
CH	0	0	0	0	0	0
CE	-1	0	1	0	1	2
CG	0	0	0	0	0	0
CK	0	0	0	0	0	0
CA	0	0	0	0	0	0
CY	-1	0	1	0	1	1
CN	0	0	0	0	0	0
CI	0	0	0	0	0	0

CO	0	0	0	0	0	0
CF	0	0	0	0	0	0
CQ	-1	0	2	0	1	2
CB	0	0	0	0	0	0
CX	-2	0	3	1	2	2
CW	0	0	0	0	0	0
CD	0	0	0	0	1	1
CP	-1	0	1	1	1	2
DD	0	0	0	0	0	0
DW	0	0	0	0	0	0
DR	-2	0	2	1	1	2
DA	0	0	0	0	0	0
DG	0	0	1	1	1	2
DY	-1	0	1	0	1	1
DU	-1	0	1	0	1	2
DO	0	0	0	0	0	0
ER	-2	0	3	1	1	2
EC	-1	0	1	0	1	1
EF	0	0	0	0	0	0
EB	0	0	0	0	0	0
EM	0	0	0	0	0	0
EV	0	0	0	0	0	0
FN	0	0	0	0	0	0
FY	0	0	0	0	0	0
FL	0	0	0	0	0	0
FO	0	0	0	0	0	0
FK	0	0	0	0	0	0
FU	0	0	0	0	0	0
GI	0	0	0	0	0	0
GL	0	0	0	0	0	0
GN	0	0	0	0	0	0
GO	0	0	0	0	0	0
GR	-3	1	4	1	2	3
GE	0	0	0	0	0	0
GW	0	0	0	0	0	0

HM	0	0	0	0	0	0
HL	0	0	0	0	0	0
HK	0	0	0	0	0	1
HR	0	0	0	0	0	0
HS	0	0	1	0	1	1
HA	0	0	0	0	0	0
HE	0	0	0	0	0	0
HY	0	0	0	0	0	0
HT	0	0	0	0	1	1
IR	-1	0	2	0	1	1
JK	0	0	0	0	0	0
JA	0	0	0	0	0	0
JD	0	0	0	0	0	0
JF	0	0	0	0	0	0
JS	0	0	0	0	0	0
JH	0	0	0	0	0	0
JO	0	0	0	0	0	1
LR	0	0	0	0	0	1
LN	-1	0	1	0	1	1
LS	0	0	1	0	1	1
LE	-2	0	2	1	2	3
LI	0	0	0	0	0	0
LC	0	0	0	0	0	0
LG	0	0	0	0	0	0
LW	-1	0	2	0	1	2
LU	0	0	0	0	0	0
MF	0	0	0	0	0	0
MC	0	0	0	0	0	0
MA	0	0	1	0	1	1
MD	0	0	0	0	0	0
MR	-1	0	1	0	1	1
MW	0	0	0	0	0	1
MI	-1	0	1	0	1	1
ML	-2	0	2	1	1	2
MO	0	0	0	0	0	0

MY	0	0	0	0	0	0
MG	0	0	0	0	0	0
MU	0	0	0	0	0	0
ME	0	0	0	0	0	1
NE	0	0	0	0	0	0
OC	0	0	0	0	0	0
OG	0	0	0	0	0	0
PA	0	0	0	0	0	0
PE	-1	0	1	2	5	7
PI	0	0	0	0	0	0
PR	0	0	0	0	0	0
PK	0	0	0	0	0	1
PO	0	0	0	0	0	0
PU	0	0	1	0	1	1
PM	0	0	0	0	0	0
QU	0	0	1	0	0	1
RA	0	0	0	0	0	0
RH	-1	0	2	1	2	2
RI	0	0	0	0	0	0
RO	0	0	0	0	0	0
SH	-1	0	1	0	1	2
SN	0	0	0	0	0	0
SE	-1	0	2	0	1	1
SP	0	0	0	0	1	1
ST	0	0	0	0	0	0
SW	0	0	1	0	1	1
SU	-2	0	3	1	2	3
TA	0	0	1	0	1	1
TL	0	0	0	0	0	0
TT	0	0	0	0	0	0
TR	-1	0	1	1	1	2
TF	-1	0	1	0	1	1
TE	-1	0	2	1	1	2
TH	-2	0	2	1	1	2
TI	-1	0	2	1	1	2

TS	0	0	0	0	0	0
TO	0	0	0	0	0	0
TU	0	0	0	0	0	0
TR	0	0	0	0	0	0
TN	-1	0	1	0	1	1
TW	0	0	0	0	0	1
UN	0	0	0	0	0	0
UP	0	0	0	0	0	1
WA	0	0	0	0	0	0
WN	0	0	0	0	0	0
WE	0	0	0	0	0	0
WR	0	0	0	0	0	0
WG	0	0	0	0	0	0
WY	0	0	0	0	0	0
WB	-1	0	1	1	1	2
WL	0	0	0	0	0	0
WH	0	0	0	0	0	0
WD	0	0	0	0	0	0
WI	0	0	1	0	1	1
WS	0	0	0	0	0	0
WK	0	0	0	0	0	0
WO	-1	0	1	0	1	1
Total	-55	11	78	30	65	100

Unit: number of jobs

APPENDIX 11 Full employment impact of cotton and peanuts production for industry sectors

Sector	Cotton			Peanuts		
	Lower	Mean	Upper	Lower	Mean	Upper
1	311	536	761	29	89	206
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	20	35	49	2	6	14
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
Total	332	572	812	30	95	220

Unit: number of jobs

APPENDIX 12 Full employment impact of corn and soybeans production for industry sectors

Sector	Corn			Soybeans		
	Lower	Mean	Upper	Lower	Mean	Upper
1	-52	11	73	28	61	94
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	-3	1	5	2	4	6
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
Total	-55	11	78	30	65	100

Unit: number of jobs