DIVISION OF AGRICULTURE

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University of Arkansas System

Productivity Analysis of Arkansas Agriculture

AG -1288

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May 2013

AG-1288

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Table of Contents

Productivity Analysis of Arkansas Agriculture

Arkansas agriculture consists of diverse production of crops and livestock. Livestock production is concentrated in the western portion of the state, and crop production is concentrated in eastern Arkansas. Livestock production includes poultry and eggs, cattle and calves, hogs, and milk. Crop production is led by field crops consisting of soybeans, corn, grain sorghum, rice, cotton and wheat. Hay is produced in areas with cattle production. Agriculture in Arkansas is a significant contributor to the U.S. food and fiber supply, as well as an important component of the state economy (Dunn and Flanders 2013; McGraw, Popp, and Miller 2012).

In 2011, 52% of total Arkansas agricultural production revenue was from livestock products and 48% was from crops (USDA, ERS 2013). Figure 1 shows the percentages of total revenue for each major commodity group. Food grains include rice and wheat, and feed crops include corn, grain sorghum, oats, and hay. Oil crops include soybeans and peanuts. Meat animals consist of cattle, calves, and hogs. Poultry and eggs are the largest commodity category with 43% of total crop and livestock revenue. Oil crops are the largest crop category with 17% of revenue, and food grains are a close second with 16% of total crop and livestock revenue.

Figure 2 shows increasing production during 1960-2012 for total quantities of poultry and eggs, soybeans, food grains, cotton, feed crops, meat animals, and milk (USDA, NASS 2013). In 1960, total production was 5.4 million tons, and production reached a maximum of 20.4 million tons in 2007. Production in 2012 of 19.7 million tons reversed a declining trend for the previous four years. Appendix 1 shows production quantities for poultry and eggs, major field crops, and hay for 1960-2012. Arkansas produced more field crops with 14.2 million tons in 2012 than at any time in the state's history. Poultry and eggs reached a maximum in 2008 with 3.8 million tons, and are following a decreasing trend in subsequent years. Decline in Arkansas broiler production coincides with U.S. trends. Total U.S. egg production is increasing while egg production in Arkansas is decreasing. Hay production has a decreasing trend for the most recent three years. Appendix 2 presents production quantities for cattle and calves, milk, and hogs. Cattle and calves have a decreasing trend since the 1970's that has moderated in recent years. Decreasing production follows decreasing U.S. cattle production since 2000. The decrease in hogs has stabilized since 2010. Milk production continues a rapid decrease that began in 1990. Nationally, production of pork and milk is increasing, and decreases in Arkansas represent geographical redistribution out of the state.

Farm acreage and farm employment have been decreasing during the period that production has been increasing. There were 103,000 farms in 1960 with 17.9 million acres. There was a decrease to 48,300 farms with 13.5 million acres in 2011. There has been a corresponding decrease in farm employment as acreage has decreased. In 1960, total employment of proprietors and hired labor consisted of 158,000 jobs. Total employment was 55,000 jobs in 2011. Employment included 43,000 proprietors and 12,000 jobs for hired labor (USDA, NASS 2013; USDC, BEA 2013). Increased production with a decrease of acreage and labor indicates production efficiencies in Arkansas agriculture.
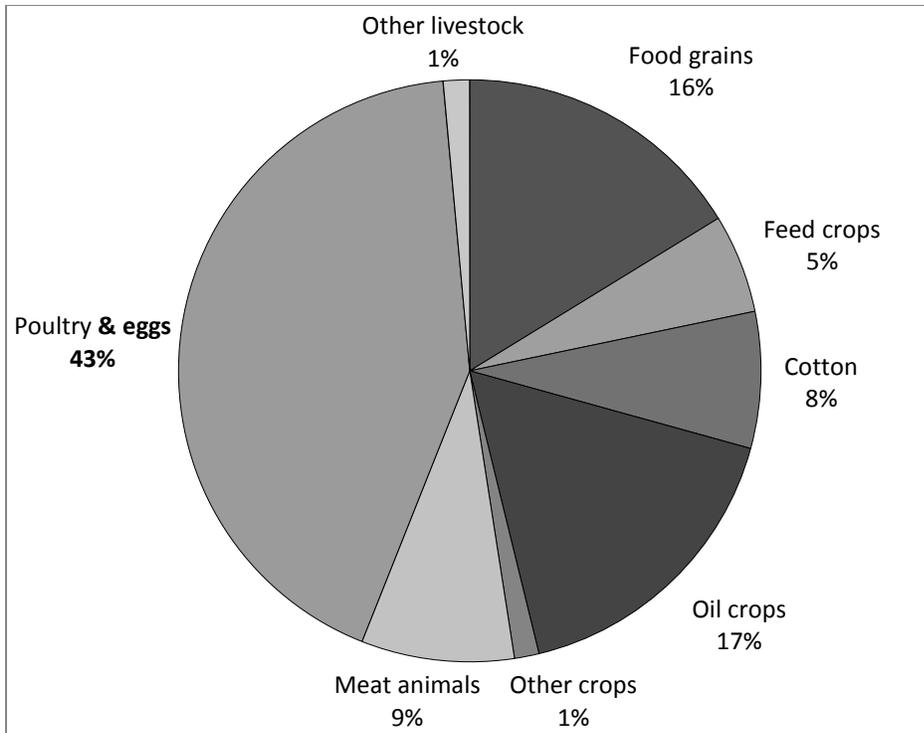
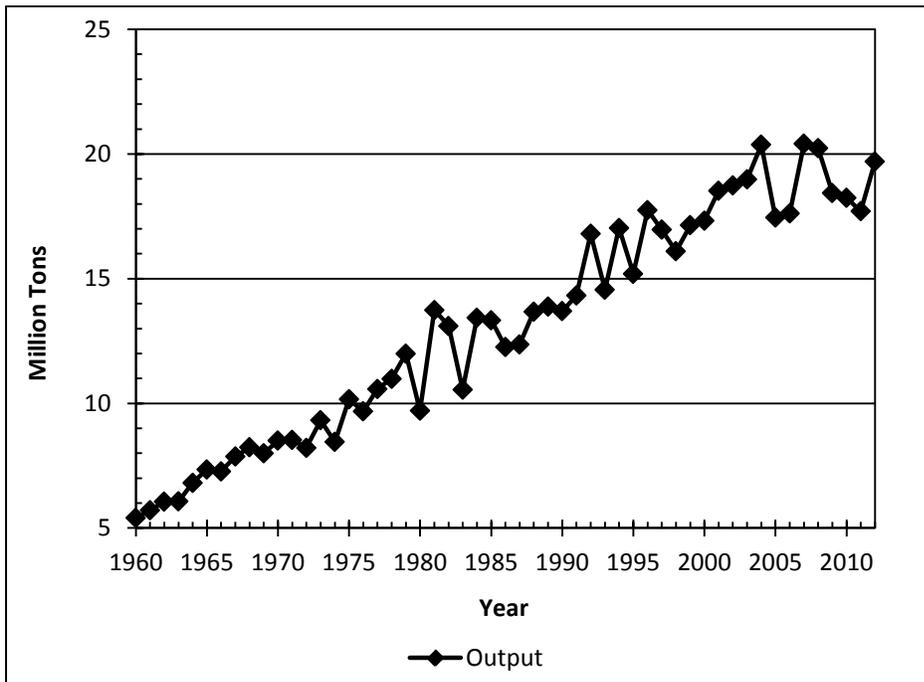Figure 1. Percent of Total Production Revenue, by Commodity Category, Arkansas, 2011

Figure 2. Production, Arkansas Major Crops and Livestock Products, 1960-2012

Productivity

A basic determination of productivity is comparing a single output to a single input. Single-factor productivity measures one output (y) and one input (x). If the single input is labor, its productivity is expressed as productivity = y/x. Labor productivity increases as the ratio increases either by increasing y, decreasing x, or a combination. Total factor productivity (TFP) includes all products and services of the Arkansas agricultural economy and accounts for all inputs applied to produce output. Calculating TFP requires a method of aggregating outputs and inputs for comparing relative trends. Tornqvist indexes are a measure to aggregate diverse agricultural commodities into an output index and to aggregate numerous inputs into a composite input index. The objective of this research is to develop a method for evaluating productivity of Arkansas agriculture.

Data and Empirical Analysis

Production

Data for productivity analysis is from farm income data that includes revenue and expenses for Arkansas during 1960-2011 (USDA, ERS 2013). Commodity prices and input prices (USDA, NASS 2013) are applied to determine output and input quantities by an indirect approach in which Quantity = Value/Price for outputs and Quantity = Expense/Price for inputs. The Tornqvist quantity index is a weighted average of quantity expressed as:

(1) $$Q_{01} = \prod_{i=1}^{N} \left[\frac{q_{i1}}{q_{i0}} \right]^{\frac{w_{i0} + w_{i1}}{2}}$$

where *1* is the current year, *0* represents the base year, *i* represents each commodity or input in the index, and *w* is a weight determined by the percentage of total revenue or expense derived for commodity or input *i* in each time period (Coelli et al 2005). Tornqvist measures are chained indexes that are calculated for each pair of years between 1960 and 2011. Quantities are normalized to a value of 1960 = 1.0 so that annual indexes represent change from the base year.

Tornqvist output quantities are determined for aggregated crops, livestock and products, and other output sold by farms. Crop production categories are food grains, feed crops, cotton, oil crops, fruit and tree nuts, vegetables, and all other crops. Livestock production categories are meat animals, dairy products, poultry and eggs, and miscellaneous livestock. Another revenue category includes other farm income, machine hire, and custom work.

Input categories are purchased inputs, capital consumption, labor, and land. Purchased inputs include farm origin inputs (feed, livestock and poultry, and seed) and manufactured inputs (fertilizers and lime, pesticides, and energy). Another category of purchased inputs consists of repairs and maintenance, machine hire and custom work, and services.

Tornqvist TFP is calculated as the ratio of Tornqvist output to Tornqvist input. Tornqvist total output and input indexes, as well as TFP are presented in Figure 3. Output for Arkansas agriculture in Figure 3 indicates that production follows a steady upward trend over the previous 51 years. Output increases average 2.8% per year. Inputs increased during 1960-2011 at an average rate of 0.7% per year. Comparing annual output indexes to input indexes with a ratio formulation leads to a Tornqvist TFP that increases by an average of 2.2% per year.

Figure 4 is a detailed presentation of agricultural inputs. Output increases during 1960-2011 were accompanied by input increasing at a lower rate than output. Since 1994, continued output increases are sustained with decreasing rates of inputs. During the previous decade of 2002-2011, Arkansas agricultural output averages 370% greater than in 1960, while input averages only 40% more than in 1960. Efficiencies leading to productivity increases explain how Arkansas agricultural production is expanding during a period when farm acreage and the number of farms are declining.

Prices

The Tornqvist price index for all output and input categories is a weighted average of prices expressed by Coelli et al (2005) as:

$$(2) \qquad P_{0t} = \prod_{i=1}^{N} \left[\frac{p_{i1}}{p_{i0}} \right]^{\frac{w_{i0} + w_{i1}}{2}} ,$$

where *1* is the current year, *0* represents the base year, *i* represents each value category, and *w* is a weight determined by the percentage of total revenue or expenses derived from category *i* in each time period. Aggregated real price indexes are calculated for each pair of years between 1960 and 2011. Figure 5 presents price indexes for output, input, and a ratio of output prices to input prices. Output prices in Figure 5 indicate that commodity prices follow a steady downward trend over the previous 51 years. Output price decreases average 0.5% per year. Input prices increased during 1960-2011 at an average rate of 1.4% per year. A ratio of output prices to input prices results in an average annual decrease of 1.7% in output prices relative to input prices during 1960-2011.

A declining price ratio is an indicator of production efficiencies that coincide with increased agricultural productivity. Increased input prices create producer incentives to decrease inputs in order to maintain profitability. Declining output prices allow increased revenue only with increased production. Producer response to increased input prices with decreased output prices has been to increase production while reducing inputs.

Agricultural production is sustainable only if producer profitability is maintained. Net farm income has a long-term average centered on approximately $2.0 billion in Figure 6. Net farm income for the agricultural sector in Arkansas was increasing until 2004 and follows a declining trend in recent years.
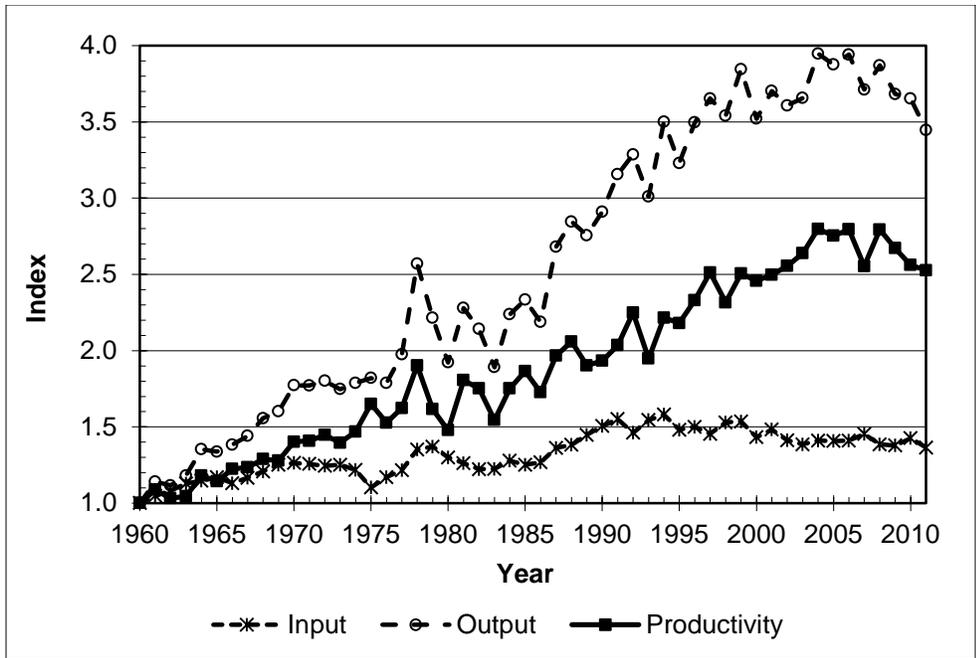
Figure 3. Tornqvist Input, Output, and Productivity, Arkansas Agriculture, 1960-2011, 1960=1.0
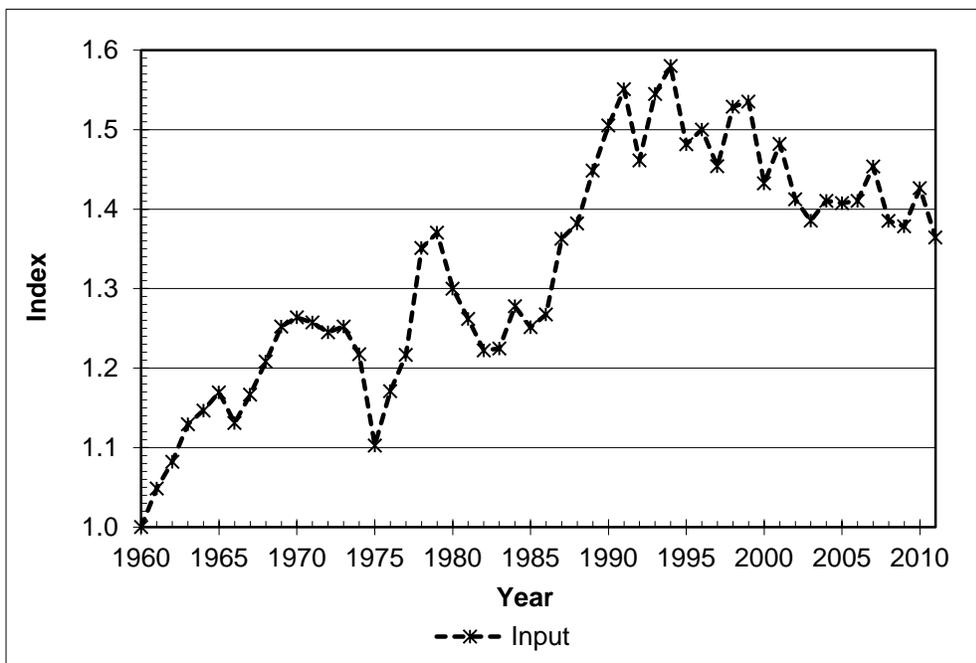

Figure 4. Tornqvist Input, Arkansas Agriculture, 1960-2011, 1960=1.0
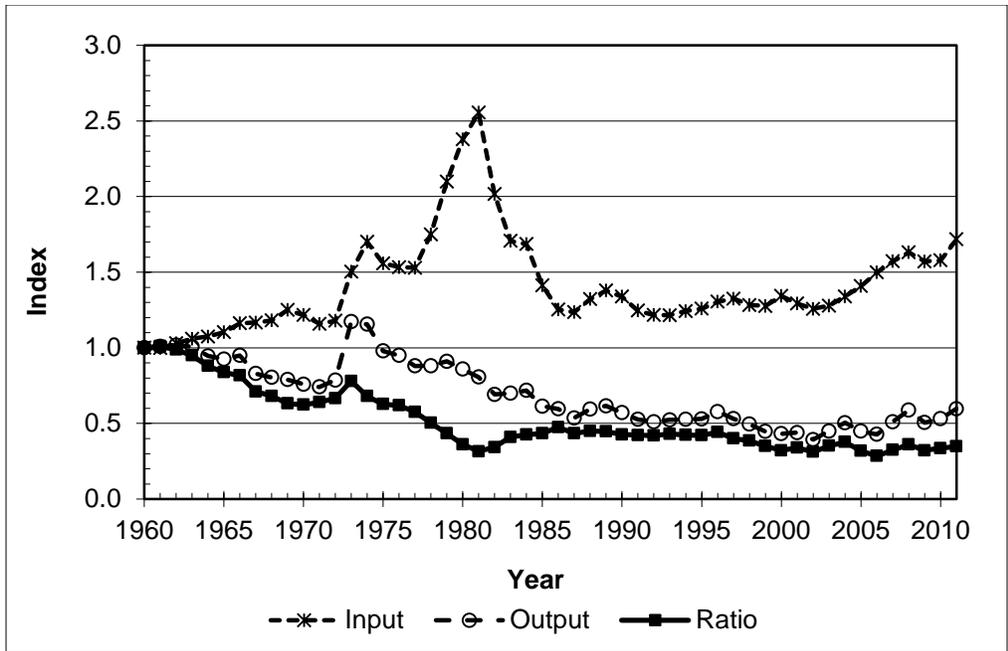
Figure 5. Tornqvist Input and Output Prices, Ratio, Arkansas Agriculture, 1960-2011, 1960=1.0
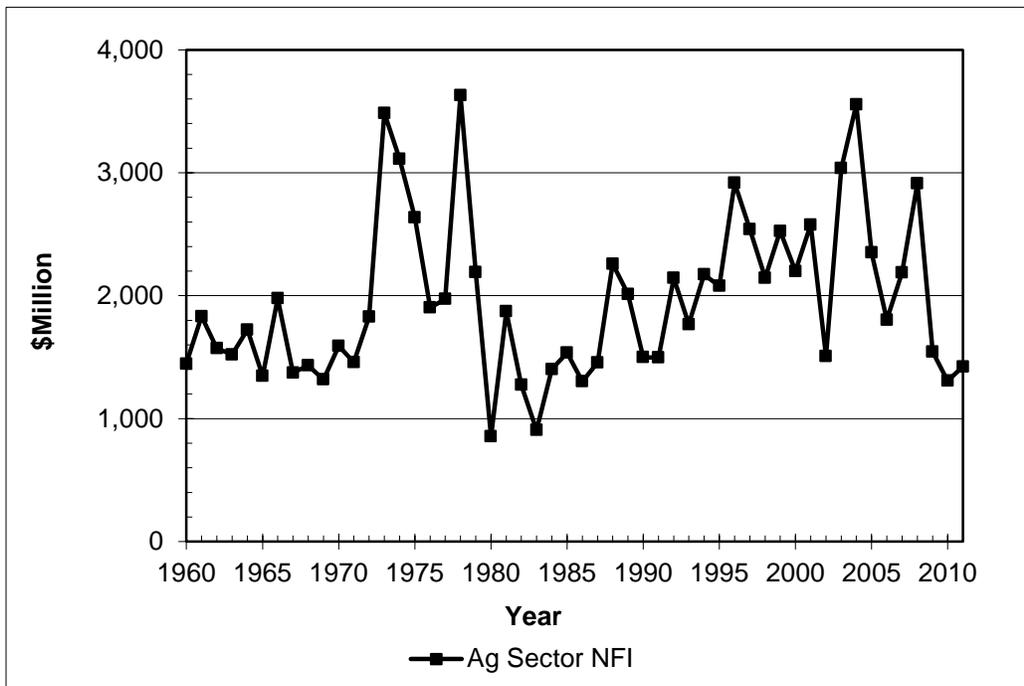

Figure 6. Net Farm Income for Agricultural Sector, Arkansas, 1960-2011, 2011 Dollars

Agriculture in the Economy

Crop and livestock production fulfills a basic nutritional need for a population, and per capita food quantities consumed are generally constant in a developed economy. In contrast, consumer demand for other products and services, including food services, increases with an expanding economy. Comparing trends for population increases and economic growth shows how an expanding agricultural production sector becomes a smaller portion of a national economy.

Figure 7 shows that U.S. population increased from 1960 to 2011 at an average rate of 1.1% per year. Gross domestic product (GDP) in constant 2011 dollars increased at an average annual rate of 3.1%. The Tornqvist measure of agricultural output increasing at a rate of 1.8% per year represents a surplus in meeting the needs of an increasing population. One result of surplus production is downward pressure on commodity prices for the population consuming the products. Figure 7 shows that real output prices in the previous decade have trended almost 50% lower than the 1960 level. Relative to input prices, U.S. agricultural output prices in 2011 were 57% less than the 1960 level. Decreasing prices for basic nutritional needs leads to increased income available for other discretionary spending in the economy. Also, lower commodity prices allow increased profit margins for food processing and food service industries to expand output. In addition to benefits in the national economy, increased productivity for U.S. agriculture increases food availability with lower prices for exports to the global population.
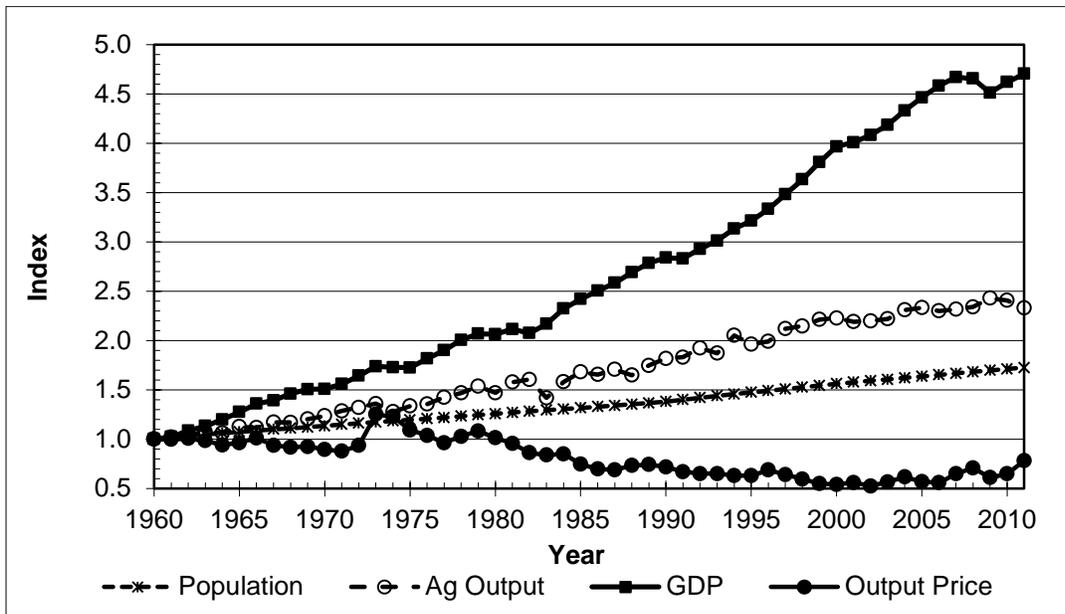

Figure 7. Population, Agricultural Output, Agricultural Output Prices, and Real GDP, US Indexes, 1960-2011, 1960=1.0

A generally constant per capita demand for agricultural commodities in a developed economy limits expectations for the portion of a national economy that consists of agricultural production. Consumers have increasing demand for most products and services in the economy, but the

demand for agricultural products increases at a rate corresponding to the rate of population increase. A common measure of an economy is GDP which is expressed in dollars. Total GDP of a national or state economy is the summation of sector value added components. Value added is the residual of sector revenue after production inputs are deducted. Because of the nature of basic agricultural commodities, a single metric of value added is not a representative indicator of agriculture in the economy. Figure 7 shows that agricultural output in the U.S. is increasing at a rate exceeding population increases, and decreasing output prices contribute to expansion of other industries in the national economy. Surplus production is exported and contributes to the global food supply.

Crop and livestock production in the U.S. economy is characterized by decreasing commodity prices which is a consequence of agricultural sector efficiency and productivity increases. Real price decreases for agricultural commodities leads to a lower value added component for the agricultural production sector of the economy as farm revenue declines with increased prices for production inputs. In 2011, after an extended period in which the rate of agricultural production increase was 64% greater than the population rate of increase, the agricultural production sector composed 1.1% of the national economy (USDC, BEA 2013; USDC, Census Bureau 2013).

A comparison of Arkansas population increase, GDP, and agricultural output is presented in Figure 8 for 1960-2011. Population increased at an average annual rate of 1.0%, and GDP increased at a rate of 3.5% per year. Agricultural output in Figure 8 increased at a rate of 2.8% per year. Although an increase in Arkansas agricultural production greatly exceeds the population rate of increase, the rate of increase is less than the expansion rate of the overall state economy. In 1963, crop and livestock production was 10.6% of the Arkansas economy, and in 2011, the measure for the sector decreased to 2.1% of state GDP (USDC, BEA 2013).
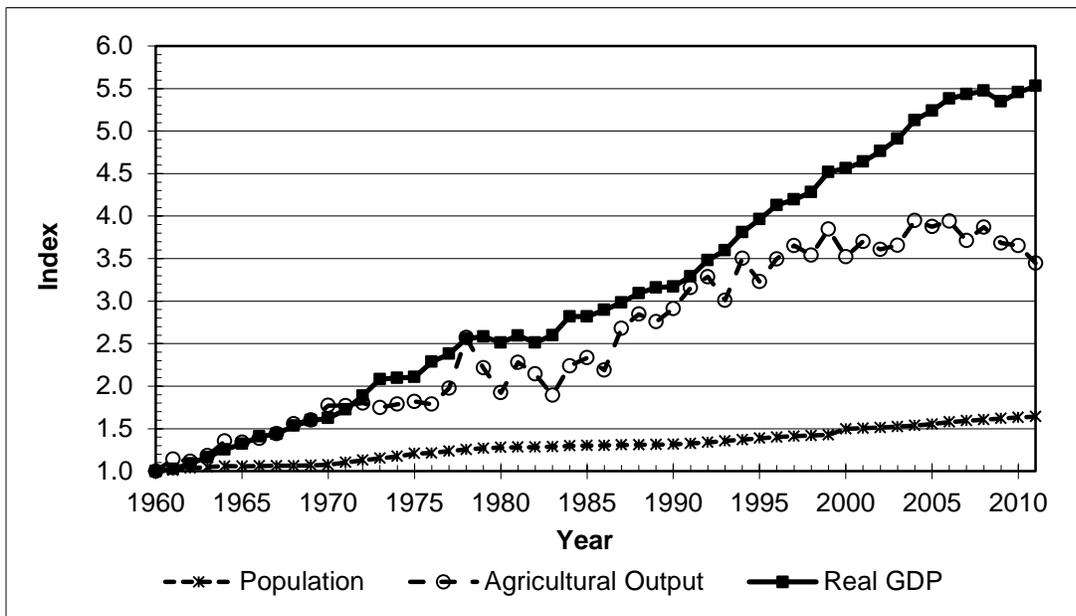

Figure 8. Population, Agricultural Output, and Real GDP, Arkansas Indexes, 1960-2011, 1960=1.0

Summary

Arkansas agricultural output has followed an increasing trend since 1960, and the 2011 quantity index of aggregate output is 345% of the 1960 level. Productivity analysis assesses the relationship between output and inputs utilized in the production process. Increases in output have been accompanied by relatively lower levels of input increases. The Tornqvist productivity index indicates an average annual productivity increase of 2.2% during 1960-2011. Productivity increases explain how Arkansas agricultural production is expanding during a period when farm acreage and the number of farms are declining. A declining price ratio of output prices to input prices is an indicator of production efficiencies that coincide with increased agricultural productivity. The ratio of Arkansas output prices to input prices indicates an average annual decrease of 1.7% in output prices relative to input prices during 1960-2011.

Per capita food quantities consumed are generally constant in a developed economy, while demand for other products and services increases with an expanding economy. Comparing trends for population increases and economic growth demonstrates that an expanding agricultural production sector becomes a smaller portion of an economy. Arkansas population increased at an average annual rate of 1.0%, and state GDP increased at a rate of 3.5% per year during 1960-2011. Agricultural output increased at a rate of 2.8% per year. Coupled with declining commodity prices, the agricultural production sector decreased as a percentage component of the state economy.

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Appendices
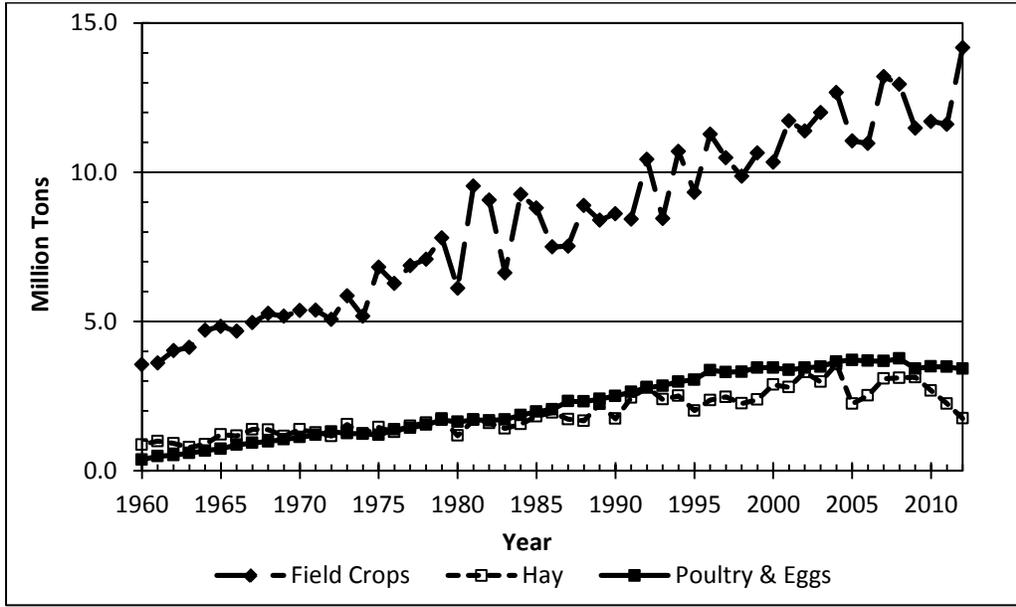
Appendix 1. Production of Field Crops, Hay, and Poultry & Eggs, Arkansas, Million Tons, 1960-2012
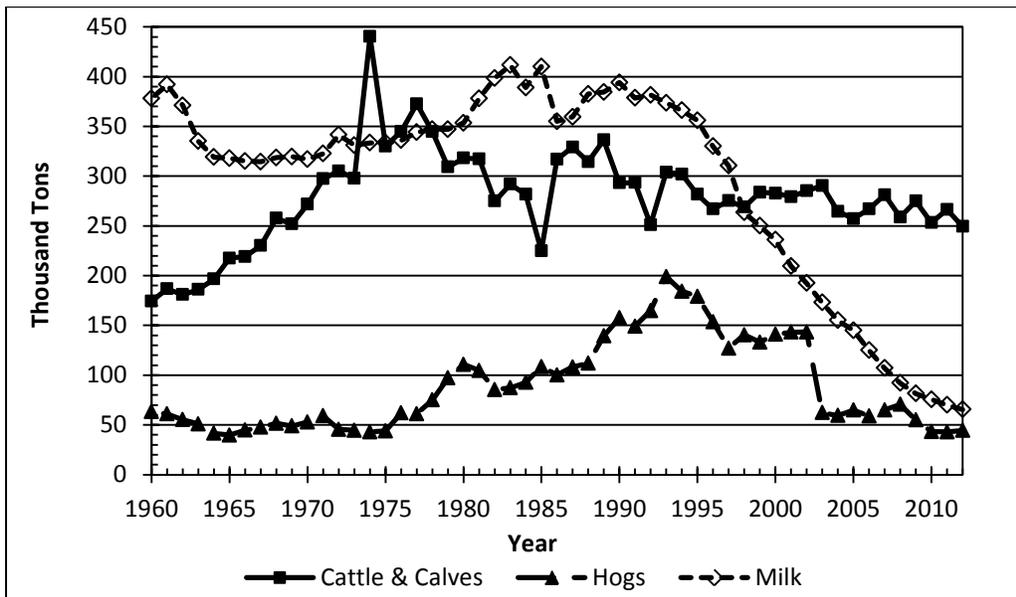
Appendix 2. Production of Cattle & Calves, Hogs, and Milk, Arkansas, Thousand Tons, 1960-2012