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## **Patterns of Post-War Agricultural Productivity in the Southeast and Delta Regions**

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## **Patterns of Post-War Agricultural Productivity in the Southeast and Delta Regions**

Much has been written about US agricultural productivity using less land and labor and more capital and purchased inputs, and steadily increasing compared to the immediate postwar period. However, much less is known about the changing composition of these input categories at the national level, and even much less for individual states. This concentration of interest at the national-level compared to the state-level may be due to unavailability of relevant data. Until recently, the United States Department of Agriculture (USDA), the principal source of data for agricultural input and output prices and quantities, did not report state specific productivity indexes, but since Ball and Nehring the USDA has reported state-specific input, output, and productivity growth rates. This is in response to the need for more disaggregated price and quantity data to improve the measurement of aggregate price and quantity, and serves the additional purpose of providing state-specific input, output, and productivity measures for comparison among states and with the U.S. aggregate.

The most common method of measuring agricultural productivity using growth accounting methods with index numbers. Three problems that need to be solved in order to correctly use index numbers are the choice of an indexing procedure, aggregation, and the level of disaggregation. A number of studies (e.g., Diewert 1976) have shown that a chain-linked index — specifically an approximation of a *Divisia* index — is to be preferred in the choice of indexing procedure. For state-specific price, quantity and productivity indices, the aggregation problem can be avoided by using the most appropriate (state-specific and not national average) prices and quantity data in forming the indices.<sup>1</sup> As much as possible, the data used to form the

price, quantity, and productivity indexes must be as finely disaggregated as possible. As shown formally by Star, one is safe in using preaggregated data only if all inputs (outputs) in the class are growing at the same rate or are perfect substitutes for one other.<sup>2</sup>

Using state specific data that have been further disaggregated to show the various composition of the labor, land, capital and purchased inputs, we intend to show how agriculture in the southeast and delta regions have changed over time. These patterns will be compared with the average trend for continental US to highlight any differences in the way agriculture has developed in the south.<sup>3</sup>

The second section presents a brief background that places the patterns of growth in productivity, output, and input in the southeast and delta states in context with the general U.S. pattern. Section three discusses the data and methods used in this paper. Section four presents the results and the discussions. Finally, the conclusions of the paper are presented in section five.

## **Background**

**[Figure 1: Spatial pattern of state output growth rates, 1949 - 1991]**

Output growth in the southeast and delta regions was quite impressive in relation to U.S. average annual growth from 1949 to 1991. Outside of the pacific region, output grew fastest in the southeast and delta regions at rates that were substantially higher (2.55 and 2.42 percent per year respectively) than the U.S. average of 1.72 percent per year. At the state level, four of the ten states with the fastest growing agricultural outputs were in the southeast and delta states.

**[Figure 2: Spatial pattern of state productivity growth rates, 1949 - 1991]**

On average, U.S. agricultural productivity grew at a rate of 1.90 percent per year which accounted for an output growth rate of 1.72 percent per year — agricultural inputs contracted at a rate of 0.19 percent per year — from 1949 to 1991. During this period, agricultural productivity growth rates were highest in the southeast and delta regions<sup>4</sup> and noticeably higher than the U.S. average (2.87 percent and 2.97 percent per year respectively). Productivity growth rates for the individual states in the southeast and delta regions were thus among the highest among all 48 contiguous states — six of the top ten state average annual productivity growth rates were for southeast and delta states, with Florida being the only exception.

**[Figure 3: Spatial pattern of state input growth rates, 1949 - 1991]**

The share of US agricultural labor (in hours worked on-farm) accounted for by the south decreased from 20 percent to 13 percent and the share of agricultural land (in acres) fell from 10 percent to 7 percent from 1949 to 1991. However, on average, agricultural productivity in the southeast and delta grew by 2.87 and 2.97 per year respectively — reflecting increased production — during this period. This study presents evidence of how inputs were reorganized in the south to increase productivity in the region.

In general, the impressive growth rates of outputs in the southeast and delta regions were achieved while inputs were contracting, and we can get a better understanding of how this was achieved by taking a closer look at the patterns of growth of the input subaggregates. In order to achieve this, one has to quantify inputs (and outputs) over time, which involves aggregating over

heterogeneous goods and services, using prices that are not always observed on the appropriate units, and this gives rise to index number and aggregation problems. To limit the index number and aggregation problems, we make choices about the indexing and aggregation procedures, taking into account the composition of input and output aggregates, with particular reference to quality issues and the spatial dimension.

## **Data and Methods**

The data to be used for this study are from Craig and Pardey (1996) who have state specific data for 1949 to 1991. These data have state specific input and output price and quantity data for the seven states used for this study. Table 1 gives a summary description of the input and output data coverage in the Craig and Pardey data set. The data distinguish among 58 types of inputs and 55 output categories to capture changes in the composition and quality of inputs and outputs. In most cases, prices used are the relevant state-specific prices (for further discussion and explanation on how these data were put together, see Craig and Pardey 1996; Craig, Pardey, and Acquaye 2002; and Acquaye 2000).

### **[Table 1: Input, Output, and Spatial Details]**

The index used to aggregate goods and services each state is the Fisher index. This is a chain-linked *Divisia* procedure that uses current and past prices as weights for the individual state-specific quantities.<sup>5</sup> The annual growth rate is calculated by taking the natural logarithm of the ratio of the index for the current and past year, and the simple average of the annual growth rates is reported as the average annual growth rate.

## Results and Discussion

In 1949, the agricultural sector accounted for 7.6 percent of national gross domestic product (GDP), but since then has shrunk in many relative senses (to 1.4 percent of GDP in 1990), while continuing to grow in absolute terms. Not all states have shared in that growth or developed in the same way. In 1949, the share of value of U.S. agricultural output produced in the southeast and delta regions was 10.5 percent. Since then this share has steadily increased and was 13.9 percent in 1991. On the other hand, with regards to input use, the U.S. value of inputs accounted for by the southeast and delta regions in 1949 and 1991 was almost the same (12.7 in 1949 and 12.4 in 1991).<sup>6</sup>

### *Inputs*

The area of land used in southeast agriculture decreased from 144 million acres in 1949 to 78 million acres in 1991. In general, the number of acres of land used in agriculture contracted from 1949 to 1991 in the U.S. as a whole. The composition of the land input in agriculture also underwent some drastic changes from 1949 to 1991. The area of grassland and cropland decreased both in total and for all states from 1949 to 1991. The area of irrigated cropland grew by almost 400 percent from 1949 to 1991; in Alabama and Georgia the increase in irrigated cropland acreage was by about 22.2 thousand percent each (table 3).

[**Table 3:** Change in Number of Acres of Irrigated Cropland in the Southern States, 1949 and 1991]

Just as with the U.S. as whole, use of agricultural labor in the southeast and delta changed substantially. In 1949, 4.1 billion hours of labor were employed in the southeast and delta states

compared with 861 million hours in 1991. The composition of the labor input also changed dramatically, with an increase in the proportions of hired labor and better-educated and older operators. Whereas the total hours of hired, family, and operator labor decreased, the share of hired labor in total labor hours increased markedly from 19 percent to 37 percent between 1949 and 1991. In 1949, the largest proportion of hours by farm operators (67 percent) were by operators with less than eight years of education; in 1991, the largest proportion had four years of high school education. The effects of adjusting for changes in the composition of the farm labor force reveal a striking contrast in certain states (e.g., in Florida, the average quality of labor increased dramatically during 1949-91).

**[Figure 4: Use of tractors and combines in southeast and delta states, 1949-1991]**

Quantities of combines and tractors increased steadily between 1949 and the late 1970s, but after that the numbers gradually fell (figure 4). To illustrate the similarity among states in the southeast and delta, and the difference to some other states, Florida had the equivalent of about 186 medium-capacity combines (the least in the two regions), compared with over two thousand medium-capacity combines in Arkansas, and one-medium capacity combine in Rhode Island in 1991. South Carolina had the equivalent of about ten-thousand numeraire (two-wheel drive, 55 horsepower) tractors compared with about 28 thousand numeraire tractors in Arkansas, and 263 numeraire tractors in Rhode Island in 1991.

In contrast, the use of agricultural chemicals increased steadily until 1958 (two years earlier than the rest of the U.S.), and then rose more rapidly to a peak in the early 1980s. In 1949,



purchased inputs accounted for 21 percent the cost of agricultural inputs, but by 1991 they accounted for the 43 percent of the cost of inputs. With the changing costs, quality, and efficiency of inputs, and the changing concentration of outputs, agriculture in the southern states was reorganized so that capital and purchased inputs — making up about 33 percent of the cost of inputs in 1949 — accounted for 59 percent of input costs in 1991.

### *Output Growth Patterns*

Figure 1 shows all southeast and delta states increased their total output. The patterns of output growth differed among output categories. National agricultural output grew by 1.72 percent per year between 1949 and 1991, which was considerably slower than the output growth rates of southeast and delta regions. Output in Florida grew the fastest (3.27 percent per year). The aggregate output index also masks important variation within categories, among states.

[**Table 2:** Annual Average Growth Rates of Output Categories for the Southeast, Delta, and 48-state Aggregate]

Greenhouse and nursery products and livestock are the only categories with a positive growth rate for every state in the two regions. In addition, the livestock regional average growth rates of 3.47 percent and 3.00 percent per year were higher than all other regions, and the regional average growth rate of greenhouse and nursery products for the southeast was the highest among all regions. In the southeast, output production contracted in the production of field crops in Alabama and South Carolina only. Production of fruits and nuts and vegetables contracted in all delta states.

[**Figure 5:** Share of national output produced in southeast and delta states, by category, 1949 - 1991]

Production has tended to become more spatially concentrated, with a greater specialization of states in particular outputs, and a greater concentration of output among states. Figure 5 shows a comparison of the share of national output categories produced in southeast and delta states in 1949 and 1991. The share of the national value of production of field crops and fruits and nuts produced in southeast and delta states declined only slightly, and the value of vegetables, livestock, and greenhouse and nursery products increase substantially from 1949 to 1991. In general, within the southeast and delta regions, production of field crops became less important where as production of livestock, and greenhouse and nursery products became more important.<sup>7</sup>

With regards to the importance of individual outputs to the southeast and delta states, in 1949, cotton, milk, corn, hogs, and cattle accounted for about 70 percent of the value of output, but in 1991, these five outputs accounted for 32 percent of the output of the two regions. In 1991, the five most important outputs were broilers, cattle, cotton, greenhouse and nursery products, and soybeans. These five outputs accounted for 58 percent and 41 percent of the value of production in the two regions in 1991 and 1949 respectively.

## **Conclusion**

This study provides a good picture of the changes in the composition of inputs that have been used for agriculture in the seven southern states from 1949 to 1991. It also presents a picture of the various outputs that have been produced and the relative importance in the region over this

period. Also, we have compared how the southern states have fared in comparison to the US aggregate. These results give us a good idea of how agriculture in the south has developed and how issues of resource use have been addressed.

The structure of agricultural labor in the U.S. has changed dramatically since 1949. This changed includes a reduction of the number of hours employed in agriculture, and the characteristics of farm operators, and this pattern of change is no different in southeast and delta states. The share of US agricultural labor (in hours worked on farm) accounted for by the south decreased from 20 percent to 13 percent. In addition, agriculture employed more experienced and educated farm operators in 1991 than it did in 1949.

Some significant changes have also taken place with the use of agricultural land. The share of agricultural land use (in acres) in the south fell from 10 percent to 7 percent from 1949 to 1991, and the number of acres cultivated for agricultural purposes in the south 1991 was about only half of the acreage in 1949. Less of the lower-quality land (in the form of non-irrigated cropland and pasture and rangeland) was cultivated for agricultural purposes, and more irrigated cropland was used.

However, on average, agricultural productivity in the southeast and delta grew by 2.87 and 2.97 per year respectively – reflecting increased production – during this period. This study presents evidence of how inputs were reorganized in the south to come by this growth in productivity in the region.

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## Notes

1. For example, in forming a state-specific land quantity index, one needs to use state-specific prices for the different components of land (i.e., non-irrigated crop land, irrigated crop land, pastures and range lands) as weights for the respective quantities in forming the aggregate land index.
2. If, for example, the rate of growth of the higher-priced inputs (outputs) exceeds the rate of growth of the lower-priced inputs (outputs), the estimated rate of growth of the group will be biased downwards when preaggregated data are used. Hence, growth rates of agricultural productivity will tend to be overstated if the quantities of higher-priced (higher-quality) inputs are growing relatively quickly.
3. For a more complete coverage for all 48 contiguous states see Acquaye et al. (2003).
4. The southeast region consists of Alabama (AL), Florida (FL), Georgia (GA), and South Carolina (SC), and the delta region consists of Arkansas (AR), Louisiana (LA), and Mississippi (MS).
5. Following Alston, Norton and Pardey (1996), the fisher index was computed as

$$QI_t = \left( \left( \frac{\sum_i^N P'_{it-1} Q_{it}}{\sum_i^N P'_{it-1} Q_{it-1}} \right) \times \left( \frac{\sum_i^N P'_{it} Q_{it}}{\sum_i^N P'_{it} Q_{it-1}} \right) \right)^{\frac{1}{2}} QI_{t-1}$$

where  $QI_t$  is the quantity for period  $t$ ,  $P_{it}$  is the price of commodity  $i$  in period  $t$ , and  $Q_{it}$  is the quantity of commodity  $i$  in period  $t$ .

6. Between 1973 and 1982 the share of the value of inputs in the southeast and delta states shrunk from 13.1 percent to 11.4 percent though the share of output value did not shrink during

this period.

7. Here, the total value of the output category determines the importance of the category.

**Table 1: Input, Output, and Spatial Details**

Inputs/Outputs	Subcategory	Examples (where applicable)
<b>Inputs</b>		
Land	Cropland	
	Irrigated cropland	
	Pasture and grassland	
Labor	Family labor	
	Hired labor	
	Operator labor	Thirty classes characterized by: Education--0-7years; 8 years; 1-3 years of high school, 4 years of high school, 1-3 years of college, 4 years or more of college. Age--25-34, 35-44, 45-54, 55-64, or 65 or more years of age.
Capital	Physical capital	Automobiles, combines, mowers and conditioners, pickers and balers, tractors, and trucks.
	Biological capital	Breeding cows, chickens, ewes, milking cows, and sows.
Purchased		Electricity, purchased feed, fuel, hired machines, pesticides, nitrogen, phosphorous, potash, repairs, seeds, and miscellaneous purchases.
<b>Outputs</b>		
Crops	Field crops	Barley, corn, cotton, flax, oats, peanuts, rice, rye, sugar beets, sugarcane, sorghum, soybeans, tobacco, tomatoes for processing, wheat.
	Fruits and Nuts	Almonds, apples, apricots, avocados, cherries, cranberries, grapefruit, grapes, lemon, oranges, pears, peaches, pecans, strawberries, walnuts.
	Vegetables	Beans, broccoli, carrots, cauliflower, celery, cucumber, fresh tomatoes, lettuce, onions, peas, potatoes, sweet corn (fresh, and for processing).
	Greenhouse and Nursery Products	
Livestock		Broilers, cattle, eggs, hogs, honey, milk, sheep, turkeys, wool.
Machines rented out		
Returns from CRP		

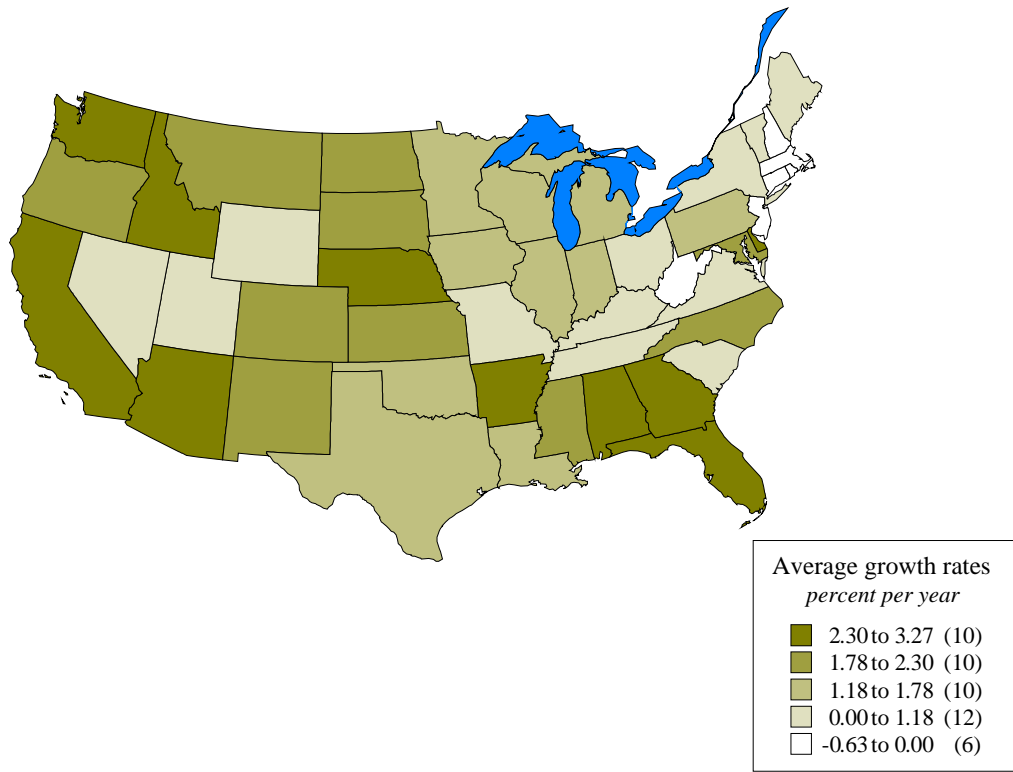
**Table 2:** Annual Average Growth Rates of Output Categories for the Southeast, Delta, and 48-state Aggregate

Region	State	Field Crops	Fruits & Nuts	Livestock	Vegetables	Greenhouse & Nursery	All Output
--- Annual average growth rate (%) ---							
Southeast:		<b>1.02</b>	<b>2.13</b>	<b>3.47</b>	<b>2.83</b>	<b>5.73</b>	<b>2.55</b>
	Alabama	-0.03	1.04	3.57	0.82	4.68	2.31
	Florida	3.54	1.96	3.32	3.03	6.26	3.27
	Georgia	1.58	4.91	3.83	3.42	4.35	2.92
	South Carolina	-0.21	3.17	2.07	2.32	5.81	0.92
Delta States:		<b>2.08</b>	<b>-1.46</b>	<b>3.00</b>	<b>-3.16</b>	<b>3.93</b>	<b>2.42</b>
	Arkansas	2.28	-3.18	4.47	-2.25	3.53	3.19
	Louisiana	2.32	-0.11	0.22	—	4.62	1.68
	Mississippi	1.56	-1.79	2.23	—	2.80	1.81
48-State Aggregate		<i>1.79</i>	<i>1.80</i>	<i>1.43</i>	<i>1.69</i>	<i>3.84</i>	<i>1.72</i>

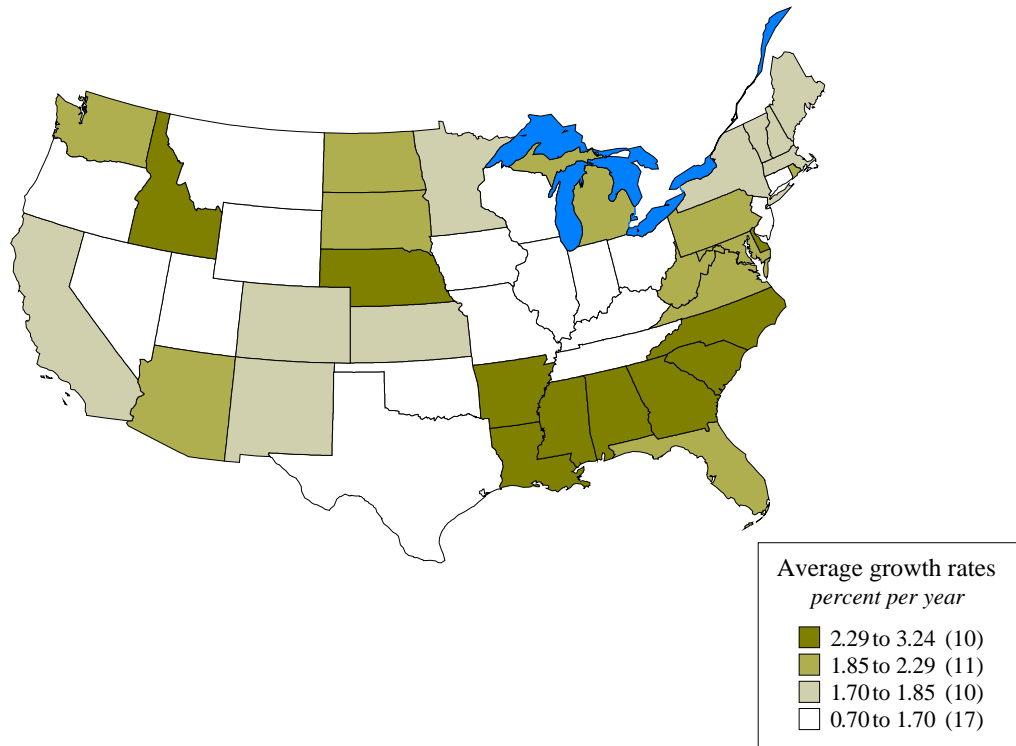


**Table 3:** Change in Number of Acres of Irrigated Cropland in the Southern States, 1949 and 1991

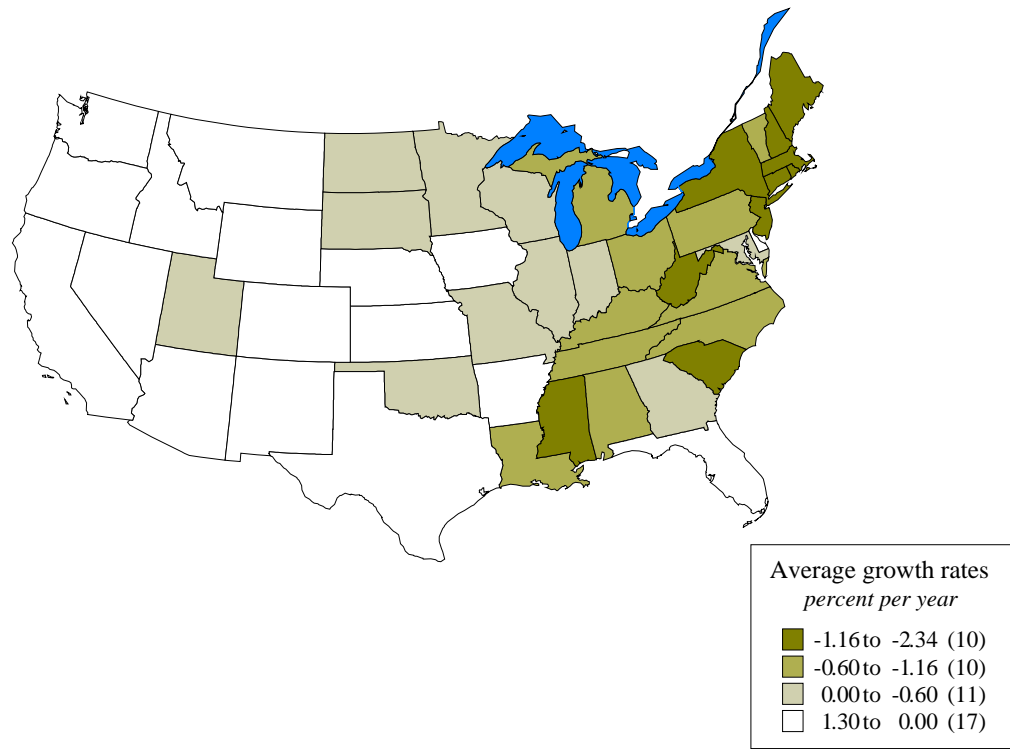
State	1949	1991	Change
	<i>(thousand acres)</i>		<i>(%)</i>
Alabama	0.37	82.42	22,176
Florida	365.42	1,616.17	342
Georgia	3.16	703.54	22,164
South Carolina	6.41	76.66	1,096
Arkansas	422.11	2,712.79	543
Louisiana	576.17	835.82	45
Mississippi	5.09	848.97	16,579
48-state aggregate	24,207.15	46,931.95	94



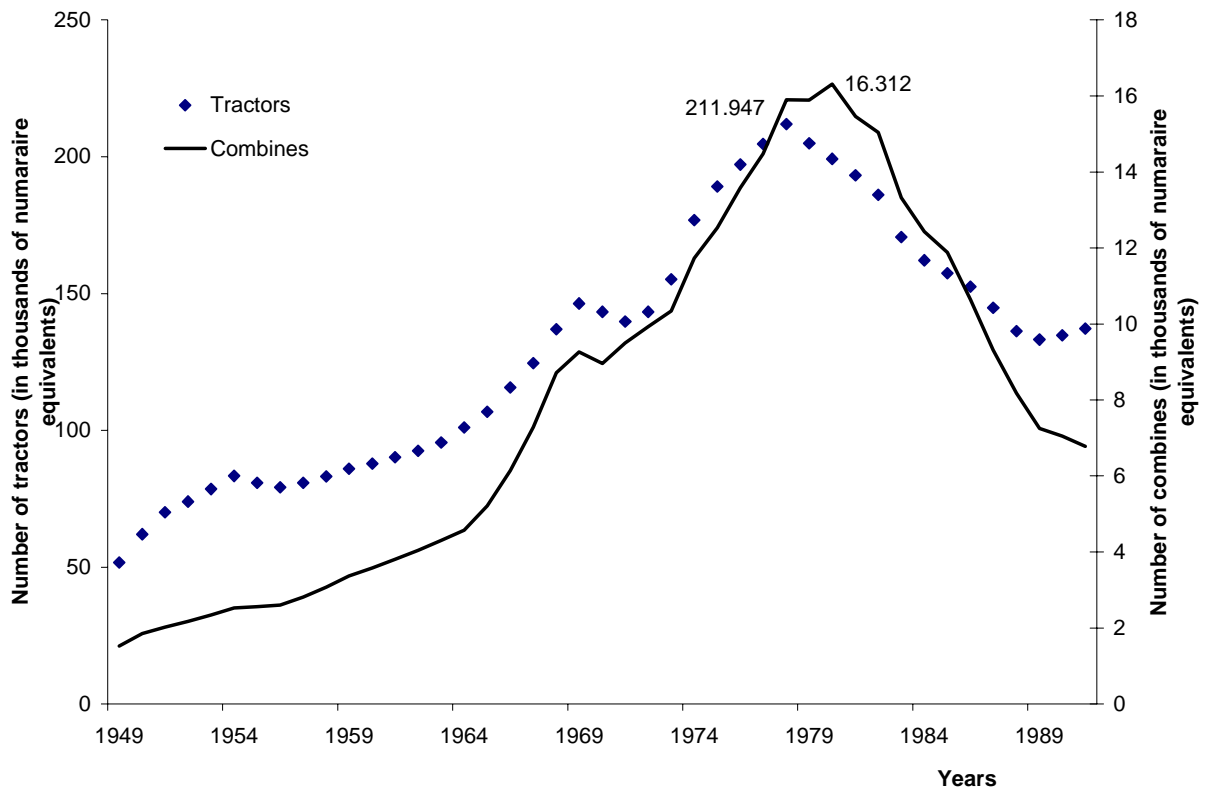
**Figure 1:** Spatial pattern of state output growth rates, 1949 - 1991



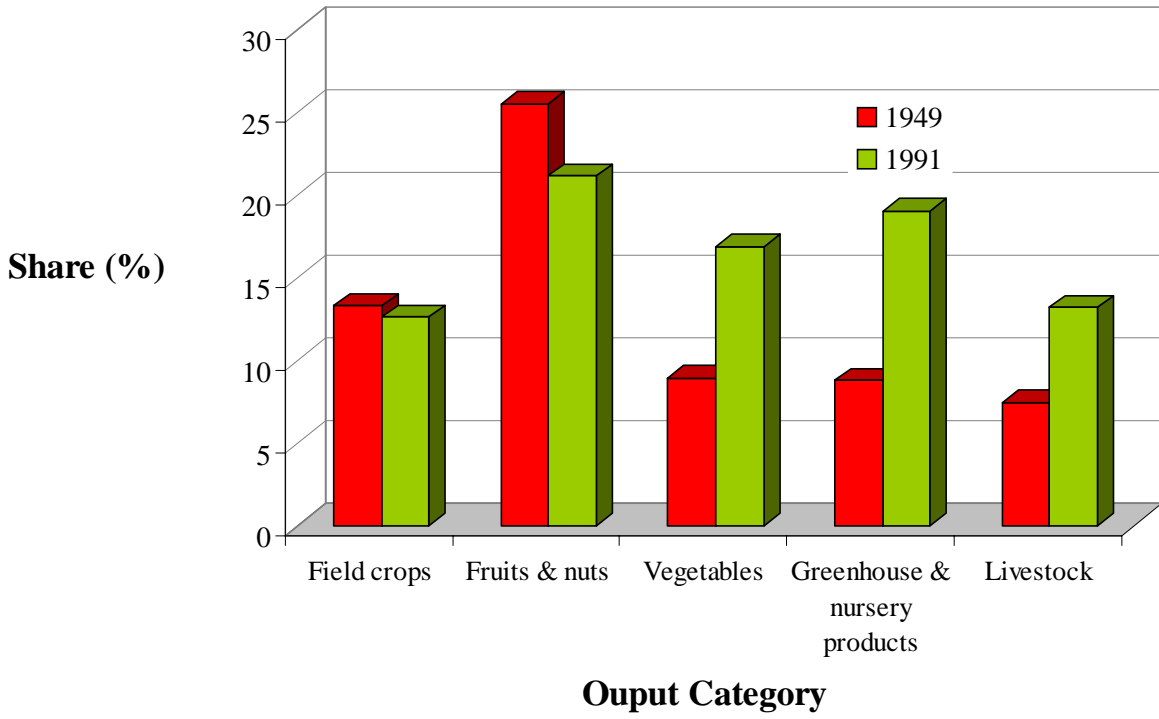
**Figure 2:** Spatial pattern of state productivity growth rates, 1949 - 1991



**Figure 3:** Spatial pattern of state input growth rates, 1949 - 1991



**Figure 4:** Use of tractors and combines in southeast and delta states, 1949-1991



**Figure 5:** Share of national output produced in southeast and delta states, by category, 1949 - 1991