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Links among Farm Productivity, Off-Farm Work, and Farm Size in the Southeast

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This paper examines the linkages among agricultural total factor productivity, farm size, and farm household participation in the off-farm labor market for the Southeastern states for the period 1960–1996. We find evidence of a simultaneous relationship between productivity and measures of farm structure. The results support the expected relationships between the endogenous variables, namely that productivity and farm size are positively related, farm size and off-farm work participation are negatively related, and off-farm work and productivity are negatively related. We find positive and significant impacts of government policies (investments in public research, extension, and highways) on productivity growth.

Key Words: farm size, off-farm work, productivity, Southeast, structural change

JEL Classifications: J22, O47, Q15, Q16, Q18

The industrialization and consolidation of the food system is proceeding at a rapid rate. This is especially evident, and of considerable social interest, in the agricultural production component of the food system. For example, agricultural production has become concentrated on a smaller share of farms. At the same time, society benefits greatly from having a highly productive farm system because of the resulting low food prices. Another important policy question has to do with the well-being of the family farm. Off-farm income has been the major source of income for farm households for decades.

The Southeast region (Alabama, Florida, Georgia, Kentucky, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia) has experienced a higher productivity growth rate than aggregate U.S. agriculture. The significant body of literature on the sources of growth in productivity at the U.S. level has found investments in research and development (R&D) to be a major factor. However, in examining regional sources of growth in productivity, Yee et al. found the rate of return to public R&D in the Southeast to be lower than in most other regions of the United States. Thus, one may ask what other factors, such as structural change, may have been involved in promoting this higher than average productivity growth in the Southeast. The purpose of this paper is to investigate this paradox by more closely examining (1) the relationship between farm sector productivity and farm structural change, and (2) the role of public policies in affecting productivity and structure. This objective is carried out for the Southeast by estimating a three-equation simultaneous model for 1960–1996.

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Comparison of the U.S. and Southeastern Farm Sector

The total farmland in the Southeast is about 80 million acres, and just over half of that is in cropland. Except for Florida and Georgia, only a small percentage of the land is irrigated (<3%). The major commodities of the Southeast are broilers, cattle, and greenhouse and nursery products. Several of the states have other leading commodities specific to their state, such as oranges, sugar cane, and tomatoes in Florida; horses in Kentucky; peanuts in Georgia; hogs in North Carolina; and tobacco in the Carolinas and Kentucky. To emphasize the uniqueness of the agricultural productivity and structure of the Southeast, we offer a very brief comparison of the Southeast to the trends for the whole United States.

Productivity

Over the past century, productivity has been the major force behind the changes in U.S. agricultural output. Aggregate U.S. agriculture has experienced relatively high total factor productivity (TFP) growth compared with other sectors of the economy (Ahearn et al.). For the period 1960–1996, the average annual rate of productivity growth for the U.S. agricultural sector was 1.95%, with input use actually declining slightly during the period. Aggregate U.S. and regional agricultural productivity growth rates, however, mask variations across states (http://www.ers.usda.gov/data/stateproductivity/rank.xls).

Productivity growth rates in the Southeastern states ranged from 1.86% for both Alabama and West Virginia to 2.71% for North Carolina for the period. Six of the nine Southeastern states grew more rapidly than the U.S. average.[1] All of the states of the Southeast experienced increases in output, and all but Alabama, Florida, and Georgia experienced a decline in inputs. There is no simple explanation for the differences in the TFP growth rates being above or below the U.S. level in terms of aggregate outputs or inputs. For example, the states with the highest TFP rates did not clearly have the greatest output growth rates or the lowest input growth rates during the period. In the case of the state with the highest TFP rate in the Southeast, North Carolina, there was a decline in the input index and an increase in outputs. However, Florida experienced a greater increase in output than did North Carolina, but its input index grew at a positive rate during the period.

Consolidation

Because the aggregate amount of agricultural land has been relatively fixed during the 20th century, the change in the number of farms is closely correlated with the change in the size of farms, which has generally been increasing until recent years. The rising average acres operated per farm over time masks the growth in the share due to small farms. Most of today's farms are small farms by some definition, and many are classified as retirement and lifestyle farms (Hoppe). After 1978, the total number of farms has remained about 2 million, declining only slightly in the four agricultural censuses since 1978. The number of large farms (>1,000 acres) and smallest farms (<50 acres) has increased, but the number of midsized farms has declined (USDA 1999). Although the Southeast accounts for only 9% of the farmland in the United States, it accounts for nearly one quarter of the farms. This is because of the smaller average size for farms in this region. Tennessee and Kentucky, in particular, have a small farm structure. The average acres per farm is <165 acres in these two states (compared with the 487-acre average for the United States), and a small share of their farms (about 1%) are in the largest gross sales class of $500,000 or more. In spite of the small farm size, however, the share of national net farm income earned in this region is comparable with the share of the U.S. farms in this region.

Farm Household Labor Allocations

The majority of workers on U.S. farms are the operators and their families, contributing at

[1] Acquaye and Jefferson also found that agricultural productivity growth rates were much higher in the Southeast (2.87%) than the U.S. average (1.90%) from 1949 to 1991.

least two thirds of the labor hours worked. By definition, all operators work on the farm, but also 40% of spouses, primarily women, work on the farm. In addition, most farm families (70% in 1999) have at least one family member working in a nonfarm occupation, and in about half of those families both the operator and spouse work off the farm (USDA 2001). Operators are more likely than spouses to work off the farm—56% compared with 46% (USDA 2001). Overall only 10% or less of total farm household income is from farm sources (Hoppe; Mishra et al.). Also, as has been the case for some time, off-farm income has played a major role in closing the income gap between farm and nonfarm households and in reducing income inequality among farm operator households. The most recent Census of Agriculture reports that off-farm income of farm households increased 300% between 1988 and 1998 (USDA 2001). The states of the Southeast are even more dependent on off-farm income sources than the average U.S. farm operator household. About half of the operators in the United States have a major occupation other than farming, and in the nine Southeastern states that proportion varies from 50% to 64%. The relative shares of off-farm income from various sources is the same in the Southeast as it is throughout the United States, with the majority of off-farm income coming from wage and salary income. There is more variation within the Southeastern region, however, in off-farm sources of income. For example, although half of off-farm income is from cash wages and salary in the United States and region-wide, in Florida cash wages account for <40% of off-farm income, and nonfarm business and retirement income are relatively more important. In neighboring Georgia, the opposite is true. Although their off-farm wage and salary earnings account for the same share of their total off-farm income as for the average U.S. farmer, farm operators in the Southeast are more likely to work 200 days or more per year off their farm than the average U.S. farmer. Alabama's 50% was the highest share of farmers working 200 or more days off the farm (of farms in the Southeast in 1997) compared with 39% for the United States as a whole.

Conceptual Issues: Review of the Literature

A single integrative economic framework for linking productivity and structure does not exist. However, an assortment of piecemeal theories exists and makes useful contributions. We briefly review strands of the literature below including the following: productivity measurement (rooted in production economics), sources of productivity growth, structural change, and the economics of farm household labor allocations.

Productivity

A large literature exists on measurement of productivity, both in general economics and agricultural economics. A recent volume discussing measurement issues is Ball and Norton. A smaller but significant literature explains the trends in farm TFP. Most of the literature focuses on the importance of investments in public and private research and development and public extension (e.g., Huffman and Evenson 1993; Yee et al.). More recently and directly relevant to our work, the research by Huffman and Evenson (2001) and Ahearn, Yee, and Huffman expanded the traditional model to address questions about the relationship between farm productivity and farm structure. Huffman and Evenson (2001) include structural change variables in their TFP equations, but they do not include TFP in their structural change equations. The model of Ahearn, Yee, and Huffman allows for TFP and two key measures of structural change, farm size and off-farm work, to be simultaneously determined. Both works estimated national models with regional fixed effects. This paper will apply a model similar to Ahearn, Yee, and Huffman to the Southeast region. In addition, our work considers the impact of state fixed effects (Baltagi; Hsiao).

Farm Structural Change

In contrast to the productivity measurement literature, which is solidly rooted in production theory, the literature on the changing farm structure, although very large, lacks a consensus and clear direction. The large literature on structural change in agriculture results from a continual interest to policy makers, producers, and society in general. The motivation for this enduring interest includes issues associated with social sentiments regarding family farms and more recently recognition of the multifunctionality of agriculture, usually associated with family farms (OECD). Because it is such a large literature, and mostly because it lacks a consensus, we will not attempt to summarize it here. However, many useful volumes exist (e.g., Hallam).

Household Production and Labor Allocations

Because farm households provide most of the labor on the farm and have a tripartite choice of time allocation (farm, off-farm, and leisure hours), the household production literature is a relevant link to our work. The household production model is an extension of the basic labor-leisure model (e.g., Becker) and agricultural household models (e.g., Strauss). The conceptual model combines the decisions of agricultural households relating to production, consumption, and labor supply into a theoretically consistent model. The individual is assumed to allocate time to farm work, off-farm work, and leisure in such a fashion that the optimal allocation is achieved when the marginal values of time devoted to the activities are equal. Because of the dependence of farm households on off-farm income sources and the fixed supply of household labor, an important component of this literature is the empirical literature on estimating off-farm labor participation and supply (e.g., El-Osta and Ahearn; Hallberg, Findeis, and Lass; Mishra and Goodwin).

Estimating the Model and the Results

We employ a three-equation model with feedback across the equations:

$$(1) \quad TFP = \alpha_1 Size + \alpha_2 Off + \alpha_3 X_1 + \varepsilon_1$$

$$(2) \quad Size = \beta_1 TFP + \beta_2 Off + \beta_3 X_2 + \varepsilon_2$$

$$(3) \quad Off = \gamma_1 TFP + \gamma_2 Size + \gamma_3 X_3 + \varepsilon_3.$$

Endogenous Variables

The three equations are for TFP (*TFP*), farm size measured as a constructed land rent per farm (*Size*), and because of the extensive supply of hours to off-farm work by farm households, the odds that farm operators work off-farm at least 200 days per year (*Off*). We estimate the model by three-stage least squares incorporating cross-equation correlation of disturbances. The observations are the panel of nine Southeastern states over the period 1960–1996.

Total factor productivity is the ratio of total outputs to total inputs. The TFP numbers for each state are spatially adjusted so that they are comparable across states. It should be noted that the labor input used to construct productivity is quality adjusted to take into account age and education effects. This is why age and education can appear as variables in the farm size and off-farm work equations, but not in the productivity equation.[2]

There are a variety of ways to measure farm size. The most useful farm size concept is one that yields a measure of the productive capacity of a farm firm. The most traditional way to measure farm size, for example in censuses of agriculture, is in acres. Another common way to measure farm size is by the gross value of sales or product. Although the number of acres in a farm, an input-based measure, is easy to quantify and usually does not change often, it has the distinct disadvantage of not accounting for the productive capacity of land. For example, an acre of irrigated

[2] To get an idea of the effect of education, gains in education accounted for 8.6% of the increase in output at the U.S. level from 1948 to 1994 (Ahearn et al.).

farmland has a much different productive capacity in a dry-land farming area than would an acre that is not irrigated. Gross sales, an output-based measure, is an improvement over acres in that it provides some indication of the productive capacity of the land. Gross sales are relatively easy to measure, although they change for reasons unrelated to farm size over time, such as from the impacts of weather on yields or annual fluctuations in commodity prices.

Land market data provide us with a preferred alternative for capturing a farm size concept based on the productive capacity of land. Land market data (land values and cash rent) both capture information about the expectations for future agricultural returns of land and are not affected by short-term fluctuations in yields and prices. Unfortunately, land value data also capture the value of land for other than agricultural uses. In particular, market values for farmland near cities includes the value associated with expected future development options.[3] In contrast, agricultural rents do not generally capture this premium from expectations for future development. This is because the land is not owned by the renter; the renter is only purchasing the temporary services of the land for agricultural purposes. The example of farm land values and farm land rents is the example used by Ricardo in describing his classic economic concept of rent. Hence, we draw on the richness of the rental market data to capture the agricultural services, or productive capacity, of farmland in each state, assuming that the land and farm structures rented are representative of all land and structures in the state. Our empirical measure of farm size is calculated as the product of the rental rate per acre and the average acres per farm (both owned and rented) by state for each year.

Exogenous Variables

The set of exogenous variables (X_1) included in the *TFP* equation are public agricultural research stocks (from originating state and spill-ins), public extension, infrastructure in highways, government programs (payments and set asides), ratio of capital rental-to-hired farm wage, dairy production, tenure, weather, and geographic region. The set of exogenous variables (X_2) included in the *Size* equation are public agricultural research stocks (from originating state and spill-ins), public extension, government programs payments, ratio of capital rental-to-hired farm wage, tenure, college education, share of aged operators, and geographic region. The set of exogenous variables (X_3) included in the *Off* equation include infrastructure in highways, government payments (from both commodity and conservation programs), manufacturing wage rate, dairy production, tenure, college education, share of young operators, and geographic region. See Table 1 for a list of the variables and Appendix A for more details about their measurement.

The existing agricultural economics literature is the source of our direction on the specification of the three equations of our simultaneous equations system. Our general strategy in specifying all three equations was to be as inclusive as possible. Hence, we invested heavily in developing state-level databases for our study time period from the Census of Agriculture and other primary sources of data. Theory and previous empirical studies suggest some factors we consider important in our model of productivity and farm structure (e.g., R&D and weather in the *TFP* equation, the manufacturing wage in the *Off* equation, as well as the right-hand-side endogenous variables in each equation. See the references cited earlier in our discussion of the literature). Factors we consider to be of lesser importance were included in an equation generally based on significance and expected sign. As a check, we estimated many specifications (including models for other regions and time periods) and feel confident that our qualitative results about the major factors influencing productivity and farm structure are robust to the inclusion or exclusion of one or more variables, especially in the *TFP* and *Off* equations.

The expected relationships between the en-

[3] Approximately one third of farms are located in areas designated as metropolitan, and another one third are in areas adjacent to metropolitan areas.

Table 1. Variable Definitions

Variable	Definition
tfp	Level of total factor productivity (relative to Alabama in 1987)
size	Real productive capacity per farm
off	Proportion of farm operators who worked 200 or more days off farm
ownrd	Own research stock
spillin	Spillin research stock
ext	Extension stock per farm
hiway	Highway stock
compay	Real commodity payments per farm
conpay	Real conservation payments per farm
setaside	Diverted acres per farm
college	Proportion of farm operators with a 4-year college education or more
young	Proportion of farm operators under 35 years old
old	Proportion of farm operators 65 years old and over
tenant	Proportion of farm operators who are full tenants
kw	Farm machinery price—hired farm labor wage ratio (lagged 1 year)
mfg	Real manufacturing wage (lagged 1 year)
drought	Drought dummy
flood	Flood dummy
dairy	Dairy share of total cash receipts

Notes: "ℓ" in front of a variable denotes taking the log (e.g. ℓtfp); State dummy variables are included in each equation. The states considered in this paper are: AL, FL, GA, KY, NC, SC, TN, VA, and WV.

dogenous variables and the exogenous variables are fairly obvious, and hence we will not elaborate in detail about each expected sign. However, we will make a few comments about less obvious relationships. First of all, public investment in improved transportation infrastructure (e.g., highway improvements) reduces production costs for farmers and manufacturing firms alike. The empirical evidence supports the expectation that highways have a positive impact on productivity in both the agricultural and nonagricultural sectors (Antle; Morrison and Schwartz; Yee et al.). Hence we include it in the *TFP* equation. Transportation infrastructure, as a provider of access to the local labor market, is also important in explaining off-farm labor supply of farm households. Hence we include it in the *Off* equation. The highways variable we use is a stock measure constructed using expenditures and the perpetual inventory method.

The role of government in the agricultural sector is pervasive. Government programs affect productivity through the allocation of resources and outputs. The government commodity programs are the most common example of government involvement in agriculture. There has been relatively little research that investigates the impact of government programs on agricultural productivity, but what does exist finds a significant positive relationship between government programs and productivity in agriculture (Huffman and Evenson 1993; Makki and Tweeten). For example, high effective farm prices may encourage substitution of improved capital inputs for labor and increase the rate of new technology adoption. We include commodity program payments in all three equations. In addition, we include conservation payments, largely Conservation Reserve Program (CRP) payments, in our *Off* equation. The justification for this is because participation in the CRP program, like off-farm work participation, is a substitute for generating income through farm commodity production. We did not include conservation payments in our *TFP* equation because the "output" associated with conservation programs is expected to be outside the market (i.e., lessening of environmental degradation) and is not accounted for in the measure of TFP.

Table 2. Three-stage Least Squares Estimates of Productivity and Structure Model, 1960–96 (n = 333)

	ℓtfp		ℓsize		ℓ[off/(1 − off)]	
Variables	Coefficient	*t*-Statistic	Coefficient	*t*-Statistic	Coefficient	*t*-Statistic
Endogenous variables						
ℓtfp			2.113	4.321	−0.939	−5.213
ℓsize	0.061	2.242			−0.381	−6.569
ℓ[off/(1 − off)]	−0.386	−7.833	−0.929	−1.975		
Exogenous variables						
ℓownrd	0.048	2.553	−0.147	−1.181		
ℓspillin	0.367	11.957	−1.214	−5.334		
ℓext	0.121	5.227	0.079	0.700		
ℓhiway	0.091	2.570			0.369	5.652
ℓcompay	0.002	0.607	−0.022	−1.549	−0.004	−0.836
ℓconpay					−0.033	−3.901
setaside	−0.297	−1.801				
ℓkw	0.042	1.881	0.035	0.239		
ℓmfg					0.416	2.147
ℓcollege			0.870	4.519	0.356	8.216
ℓyoung					0.333	6.311
ℓold			−2.204	−5.238		
ℓtenant	−0.149	−4.590	−0.852	−3.821	−0.520	−10.915
drought	−0.012	−2.324				
flood	−0.000	−0.023				
dairy	−0.011	−4.752			−0.022	−4.555
States						
FL	0.234	8.489	−0.862	−3.525	0.165	2.163
GA	0.072	2.895	−0.145	−0.845	0.199	2.796
KY	0.106	3.231	0.613	6.101	0.135	2.184
NC	−0.011	−0.330	0.557	4.218	0.284	3.045
SC	−0.013	−0.321	0.470	4.486	0.451	5.647
TN	−0.099	−3.198	0.750	5.422	−0.137	−3.123
VA	−0.153	−4.547	0.852	7.490	−0.073	−1.402
WV	−0.528	−11.065	0.770	2.292	−0.883	−5.225
Intercept	−9.610	−20.143	39.406	6.978	−2.401	−2.754
R^2	0.967		0.855		0.838	

We include dairy production as a government policy variable in the *TFP* equation. No direct payments were made under the dairy program during the study period, but the price of milk was maintained artificially high by the government price support program through purchased manufactured dairy products. This government intervention in the dairy market is expected to affect TFP. In addition, dairy production stands out among farm specialties as requiring a high intensity of labor, hence we include this variable in our *Off* equation. We specify dairy production as exogenous in our model because of the specialized investment in structures and equipment that is very difficult, once in place, to shift to alternative uses.

Results

The regression results for our productivity-structure model are presented in Table 2. A large share of the estimated coefficients are significantly different from zero, and the share of the variation explained is good: 97% for the *TFP* equation, 86% for the *Size* equation, and 84% for the *Off* equation.

Public investments in R&D, extension, and highways all have positive and significant impacts on total factor productivity.[4] These results imply that these investments have yielded benefits to society. Surprisingly, spill-in R&D has a bigger impact than a state's own R&D. Findings of high geographical spillovers may imply a greater role for the federal government and/or regional collaboration in public agricultural research management. Past studies have found mixed results about the role of extension in explaining productivity growth (Huffman and Evenson 1993). In contrast, we find very strong and positive results for the role of extension in explaining productivity in the Southeast. In contrast to public investments in R&D, extension, and highways, commodity payments did not have a significant effect on productivity. Also, the set-aside acres of land that were diverted from production as a requirement of commodity program participation in some years did not have a significant impact on productivity. Having significant dairy production in a state is shown to reduce agricultural productivity.

Having a higher share of full-tenants, rather than full or part ownership, tends to lower productivity. Drought has an expected negative effect on productivity. Flood has an insignificant effect on productivity.

The two structural endogenous variables, farm size and off-farm work, are both significant in explaining productivity. An increase in off-farm work of farmers reduces productivity. With off-farm work, a farmer's time and effort are diverted to nonfarm activities, and this can change the timeliness of farming activities in ways that reduce agricultural productivity (see Wozniak). We find a positive effect of farm size on productivity, suggesting that a type of economies of size is operating.

The estimates for the farm size model are the least satisfactory of the three equations because of the small number of significant variables. We do not find much evidence for the concern that government policies (investments in public research, extension, and commodity payments) encourage the growth in farm size. A college education is positively associated with farm size. Increased off-farm work is associated with a smaller farm size, as more time spent working off-farm means less time available for working on the farm. Again, we find a positive relationship between productivity and farm size.

The estimate of the off-farm equation shows that the real manufacturing wage, our indicator of the off-farm opportunity cost, has a positive and significant effect on the odds of farmers working off-farm more than 200 days per year. Schooling of farm operators has a positive and significant effect. A higher level of education expands the opportunities for off-farm work. The highway stock has a positive effect on off-farm work by making it easier for farmers to get to their off-farm jobs. Commodity and conservation payments both have negative effects on off-farm work. Government payments increase the value of the farmer's time working on the farm, relative to the off-farm wage rate. An increase in the share of dairy in total cash receipts is associated with a lower level of off-farm work. This is the usual finding in studies of off-farm labor supply because of the high labor requirements of a dairy farm.

The two endogenous variables are both significant in explaining off-farm work. We find a negative relationship between productivity and off-farm work. It is possible that low productivity operators may be more likely to work off-farm out of necessity. An increase in farm size is associated with lower off-farm work as the farmer has more work to do on the farm as the size of the operation increases.

Implications and Concluding Remarks

The Southeast has experienced a high rate of agricultural productivity growth compared with the U.S. average. Yee et al. found the rate of return to public R&D in the Southeast to

[4] These results are consistent with Yee, Huffman, and Ahearn, who estimated a single total factor productivity equation for the Southeast without any farm structure measures included as explanatory variables.

be lower than in most other regions of the United States. One of the primary purposes of this paper was to examine possible factors, including other government policies and structural change, that may have contributed to this high productivity growth in the Southeast.

We found positive and significant impacts of government policies (investments in public research, extension, and highways) on productivity growth. These results imply that these investments have yielded benefits to society. We also found that farm structure variables, in particular farm size, have significant positive impacts on productivity in the Southeast.

Comparing our results with Yee et al., it is interesting to note that the inclusion of farm structural variables in the TFP equation reduces the impact of R&D. Yee et al. estimate a rate of return to R&D for the Southeast of about 45%. We used the rate of return formulas given in Yee et al. and computed a rate of return to R&D for the Southeast of 27%. This implies that some of the positive impacts of farm structure on productivity are attributed to R&D when farm structure is omitted from the TFP equation. The impact of R&D on productivity is also diminished because of the negative impact of R&D on farm size and farm size has a positive impact on productivity.

Findings regarding these public investments in R&D, extension, and highways are in sharp contrast to the lack of any significant impacts on productivity from government outlays on farm programs. Taken together, these results imply that if the primary objective of government outlays directed at agriculture is to increase agricultural productivity, then investments in R&D, extension, and highways are preferred to outlays in commodity programs.

Of course, government commodity programs have multiple objectives. One of the stated objectives is often to preserve the "family farm," generally implying that the march to consolidation be slowed. In fact, our results indicate that commodity programs had no impact on farm size, but that investments in public R&D (spillin) had a significant negative impact on farm size. Knowledge of the significance and direction of the relationships between R&D and farm structure is timely, as there are recent indications that agricultural research institutions are concerning themselves with these types of outcomes (NRC).

The majority of farm operator households receive most of their income from nonfarm sources. Our analysis supports the findings of previous studies that found that government payments tend to reduce the reliance of farm households on off-farm sources of income. Although recent agricultural budget outlays would not indicate that the government is reducing its transfer of income to the sector, there have been clear policy design attempts to transfer income in ways that lessen the impacts on production decisions. To the extent that these efforts are successful, we may find that government commodity program payments will no longer tend to reduce the off-farm work participation of farm operators depending on how transfer payments impact household labor-leisure trade-off decisions. Of course, the extent to which farm households are able to work off their farms depends on nearby off-farm job opportunities.

Finally, there are a group of factors that have taken hold since the end of our study period. Before the recent slowdown, the U.S. economy had experienced a very large growth since the end of this study period, and there is still a divergence of views about the sources of that growth, but information technology is viewed as one of the keys. Information technology advancements have been adopted by some farm operators. The adoption of GM seeds has proceeded more rapidly than most agricultural technologies, although it has been slowed by consumer acceptance concerns. In addition, the post-1995 period has seen a major change in the mechanisms for transferring income to the farm sector. It will be interesting to extend this analysis to determine how these changes have affected Southeastern agricultural TFP and structure during this very recent period.

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Appendix A: Data and Variables

Our unit of analysis is the state, and all of our variables are constructed at the state level, designed to represent the whole of agriculture in a state.

Total Factor Productivity

Total factor productivity (TFP) is the ratio of total outputs to total inputs. Data on TFP by state are available from the ERS homepage at http://usda.mannlib.cornell.edu/data-sets/inputs/98003. The TFP numbers for each state are spatially adjusted so that they are comparable across states.

Farm output consists of all crop and livestock products. Farm inputs include capital (durable equipment and real estate), labor, and intermediate inputs. Intermediate inputs consist of fertilizer, pesticides, energy, feed, seed, and intermediate livestock inputs.

Some inputs, such as agricultural pesticides, have changed significantly over time. The current approach to dealing with variable input quality is to account for the quality changes in key inputs, where data availability permits, through a process of measuring the component characteristics of the input that are relevant to the observed quality changes. To properly account for changes in characteristics or quality of chemicals, price indexes of fertilizers and pesticides were constructed using the hedonic regression technique.

Although the number of workers employed in agriculture and total hours worked have declined, the quality per hour worked has increased. For example, in 1964 only about one third of all farmers had completed high school, compared with more than three quarters of farmers by 1990. The labor measure accounts for both change in hours worked and change in the quality of those labor hours.

Farm Size

The farm size concept in this paper is an agricultural productive capacity concept. We rely on the agricultural rental market to provide us with a measure of productivity capacity in a state. We assume that land and buildings rented, under both cash and share arrangements, is representative of all agricultural land and buildings in a state. We then calculate an annual rental rate for land and buildings per acre for each state from the various Censuses of Agriculture, interpolating between Census years. We then calculate the rental rate per farm as the product of the annual rental rate and the number of acres per farm for each year. We then deflate the series based on the GDP implicit price deflator. This farm size measure is a measure of the service flow from the land per farm.

R&D Stock

Data on public agricultural research expenditures to enhance and maintain agricultural productivity up to 1995 were compiled by Huffman, McCunn, and Xu (forthcoming) after making some improvements in the earlier Huffman and Evenson (1993) approach. The annual nominal agricultural research expenditures by state are converted to real (1,984 = 1.00) expenditures using Huffman and Evenson's agricultural research price index (Huffman and Evenson 1993).

Research expenditures in a given year are expected to have an impact on productivity for many years. However, including a large number of lagged research expenditures in the productivity equation uses up a large number of degrees of freedom. Also, the lagged values of the research expenditures tend to be highly correlated. Consequently, we constructed a research stock variable as a weighted sum of current and past research expenditures.

Most studies of the impact of research, especially private research in manufacturing, construct the stock of research capital from research expenditures using the perpetual inventory method and assuming geometric decay. Although geometric decay may be a reasonable assumption for physical capital, it is not plausible for research capital. We follow suggestions by Griliches (1979, 1998) to impose considerable structure on our timing weights. We constructed a research stock variable as a weighted sum of current and past research expenditures using the Huffman and Evenson (1993) trapezoidal timing weights over 33 years. The plot of the cumulative summation of these weights over time gives a sigmoid *S*-shaped pattern.

Two public research stock variables are used in this paper, an own-state and a spillin/spillover. For example, some of the public agricultural research discoveries in Iowa may spillover to one or more of the surrounding states or Iowa may benefit from public agricultural research conducted in surrounding states. We impose the simplifying assumption that benefits are regionally confined. For a given state in a region, the spillover (or spillin) stock is defined as the total public agricultural research stock of all states in the region less the state's own public agricultural research stock.

The states are grouped together into regions using regional boundaries defined by Khanna, Huffman, and Sandler and McCunn and Huffman. The choice of regional boundaries is always somewhat subjective, but the McCunn and Huffman study found their seven regional boundaries to be adequate for a study of convergence in state agricultural TFP growth rates, and Khanna, Huffman, and Sandler found them adequate for a study of state government decisions on funding state agricultural experiment stations.

Extension Stock

Data on professional extension full-time equivalents (FTEs) by state and major program areas were compiled by Ahearn, Yee, and Bottum. Over most of the period, extension was organized into four program areas: agriculture and natural resources (ANR), community resource development (CRD), 4-H youth (4-H), and home economics (HE). This paper only considers the ANR program area, which includes crop production and management, livestock production and management, farm business management, agricultural marketing and supply, and natural resources. An extension capital stock for each state is obtained as a weighted sum of current and past FTEs with declining weights and dividing by the number of farms.

Highway Stock

Bell and McGuire have constructed the capital stock for federal highways. Data are available for 1931–1992 on capital stock from capital outlay and capital stock from maintenance (both in 1987 dollars) from the U.S. Department of Transportation, State Transportation Economic Division. In this data set, the standard perpetual inventory technique was used to generate the highway capital stock from expenditure data. We regressed highway stock on a constant, time, time squared, and time cubed and used the fitted equation to predict highway stock after 1992.

Weather

Extreme weather conditions (droughts and floods) affect agricultural productivity. We employed the USDA's precipitation data weighted by harvested crop acreage (available from the ERS homepage as an ERS data product) to create a variable (preplant) equal to cumulative February to July rainfall. We then created a drought dummy variable (drought) equal to 1 if preplant is <1 standard deviation below normal (and 0 otherwise) and a flood dummy variable (flood) equal to 1 if preplant is more than 1 standard deviation above normal (and 0 otherwise).

Dairy Share of Total Cash Receipts

Cash receipts are the value of agricultural production sold in a particular calendar year. As such, it would include the value of product produced in previous years that is stored and sold in the current year. It would exclude the value of product produced in the current year and stored for later sale. It would also exclude the value of product from the current year that is used on the farm from which it was produced (usually as livestock feed). Cash receipts are largely computed from annual USDA probability-based surveys of prices and quantities. In some cases, when a commodity is heavily concentrated in a few states or represents a small share of production, state-level agricultural statisticians provide the estimates of cash receipts of the commodity.

Commodity and Conservation Payments

Commodity payments are direct payments made to farm operators and others who own farmland and are eligible to receive subsidies under the continuing legislation of the so-called farm bill. The exact nature of the programs and eligibility of the programs has changed many times since the first Depression-era program. The payments are made largely by the federal government, although some state program subsidies are included. The data are annual administrative records information on payments made for the agricultural programs that are associated with agricultural production.

Diverted acres are those acres that were required to be set aside as part of voluntary federal farm programs in exchange for direct payments for the production of seven program crops. Acres that were diverted varied on an annual basis as announced by the Secretary of Agriculture. In some years, additional acreage could be diverted under the Paid Land Diversion program. The source of the data are administrative records.

A variety of conservation programs have been established during our study period. The largest program during the period is the Conservation Reserve Program, which was established in 1985. Conservation payments are for conservation programs, currently CRP, Wetlands Reserve Program, Wildlife Habitat Incentives Program, Environmental Quality Incentives Program, and different ones historically.

Input Prices

Where published government statistics existed we utilized those. However, for some years, state-level data were not available and so we estimated state-level data from regional data and/or interpolated between known benchmark data. Manufacturing wage rates came from the Current Population Survey, Bureau of Labor Statistics, Department of Labor, from various years. Farm wage rates came from the National Agriculture Statistics Service, USDA. Farm machinery price is a national price from the ERS homepage.

Educational Attainment

Operator educational attainment as a categorical variable is collected occasionally by the Census of Agriculture (e.g., 1964). For the most recent year of our data series, 1996, we used an average of 3 years (1995–1997) from the USDA's Agricultural Resource Management Survey. We interpolated between benchmarks.

Tenure

Tenure of farm operators is available from the Census of Agriculture. We interpolated between Census benchmarks.

Age of Operator

We construct two age variables, old and young. Young is the share of operators that are <35 years old. Another age variable, old, is the share of operators that are 65 years or older. Operator age is available from the Census of Agriculture. We interpolated between Census benchmarks.