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Black-White Human Capital Differences: Impact on Agricultural Productivity in the U.S. South

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In a dynamic environment, schooling of farmers and agricultural extension have the potential for enhancing the efficiency of agricultural production. In the U.S. South, a relatively large number of blacks have operated farms since emancipation. In the segregated school systems, these black farmers obtained lower quality and fewer years of schooling than white farmers. The public sector extension service had the potential for mitigating the effects of lower quality black education on farm production efficiency. In eleven of the sixteen southern states, however, the Extension Service was completely segregated, and the services provided to black farmers were fewer and seem to have been of lower quality than those provided white farmers.

The objective of this study is to present econometric estimates of productivity differences on black and white operator farms in the U.S. South. The results from fitting a production function to county data for 1964 show that the quantity and quality of farmers' education and of extension are the primary sources of differential productivity on black and white farms. The lower productivity of black farms is undoubtedly one of the factors contributing to the exodus of black farmers from southern agriculture at double the rate of white farmers during the 1950's and 1960's when agricultural technology was changing rapidly.

The paper is organized as follows. Section I discusses sources of managerial skill differences. A model for investigating productivity differences on black and white operator farms is presented in Section II. In Section III, the empirical measures of the variables and the estimate of the production function are presented and discussed. The last section contains the implications and conclusions.

I. The Sources of Managerial Skill Differences of Black and White Farmers in the U.S. South

In a technically and economically dynamic environment, schooling of farmers and agricultural information have the potential for enhancing the efficiency of agricultural production (see Finis Welch, 1970, and my 1977 paper). Many adjustments in farming are required when new and potentially better opportunities become available. These opportunities may arise because of changes in market conditions caused by shifts in demand for farm output, by unexpected changes in environmental variables affecting production, and by the development of new technology that changes the potential nature of supply. Farmers differ in their ability to respond to these changes, and if managerial skill differs by race of farmer, it may be an important source of comparative advantage of one group over another.

A. *Training*

In this study, training that may enhance the managerial ability of farmers, and hence be a source of differential ability between races, is the quantity and quality of schooling and past farming experience. In 1964, the only year that data are available, the *Census of Agriculture, 1964* shows large differences in the years of schooling completed by black and white farm operators in the U.S. South. Nonwhite farm operators had completed only 5 years of schooling, but

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white operators had completed 9.5 years. The farmers of 1964 were born largely between 1900 and 1944, and attended formal schooling between 1906 and 1958.

Although the exact role of schooling quality in later managerial performance is unknown, the quality of schooling of black farmers seems to have been inferior to the schooling quality of southern white farmers. Differences exist at both the preschool and formal schooling level. Black children of this era were generally handicapped relative to white children in the U.S. South before entering school because of the generally low levels of completed schooling and of literacy of their parents. Because of slavery (before 1865) and the legislated discrimination against the schooling of blacks in the South, they got started slowly relative to whites in obtaining schooling.[1] Blacks born in the early 1900's were only one or two generations away from slavery, and only modest progress had been made in financing schooling for blacks in the South between 1865 and 1900 (see Welch, 1973b). The lower schooling levels of black parents reduced the potential for teaching their children basic skills and discipline before entering school, and also for assisting their children with homework after entering school. One effect of this differing family background is that black children were less well prepared for formal schooling than were white children. One piece of evidence is the relatively high retention rates in first grade of students in black schools. Between 1910 and 1940, the ratio of enrollment in first to enrollment in second grade was about 2, suggesting that each child spent twice as long in first grade as in second grade. For all *U.S.* schools, it was about 1.5 (Welch 1973a,b).

Between 1900 and 1940, the differences in characteristics of black and white schools were such that they suggest large quality differences in the South. In 1896, the U.S. Supreme Court sanctioned the "separate-but-equal" schools for whites and for blacks. This removed the legal and social pressure that previously existed for equality. Although there was a persistent upward trend in average days of school attended by students in black schools after 1900, relative differences in daily attendance between black schools and southern white schools widened and then moved toward equality. Between 1900 and 1940, teachers' salaries in black schools were approximately one-half as large, and annual per pupil expenditures were approximately one-third as large for black schools as for southern white schools (see Welch, 1973b). Number of pupils enrolled per classroom teacher was about 1.5 times larger in black schools than in all *U.S.* schools. After about 1940, but before the 1954 Supreme Court decision against separate-but-equal schools, Welch (1973a) concludes that relative differences between black and white schools were steadily decreasing.

In farming, intergeneration transfer of information may be important, especially during periods when the environment is technically static and "rule of thumb" decision making performs well. Fathers may pass on useful information about planning, managing, and financing a farm business to their sons (and daughters) as they work and learn on their father's farm. Even for this training, black farmers were disadvantaged relative to most white farmers. The reason is that only a few generations of black farmers had the opportunity of independent farming experience where they made and bore the financial consequences of farm management and marketing decisions, and of credit and long-term debt decisions.[2] Thus, the lower quality training of black farmers could be expected to affect their ability to compete with white farmers in producing agricultural output. Their disadvantage might be mitigated, however, if they had access to superior information and agricultural technology specifically designed for their type and size of farms and their decision-making skill level.

[1]Robert Fogel and Stanley Engerman (pp. 39–40) indicated that in 1850, 73 percent of male slaves were unskilled farm fieldhands, and education for them was considered unnecessary. Only 7 percent of slaves held managerial positions.

[2]Black sharecroppers did have the opportunity to learn from white landowners (see Joseph Reid, 1977).

B. *The Organization of Public Agricultural Research and Extension*

Land grant colleges and the Extension Service are the major public sector sources of agricultural research, and of practical and timely information for farmers. Most of the research is conducted by the agricultural experiment stations. Although a few states established stations on their own during the 1870's and 1880's, the Hatch Act (1887) authorized federal support to each state that would establish an agricultural experiment station in connection with its land-grant college. This Act established agricultural experiment stations in each of the states. In the early years, all of the funding for the stations was federal, but over time state matching of funds was required, and now federal support of agricultural experiment station research is only 30 percent of the total budget.

Although much of the work in the agricultural experiment stations in early years served to facilitate the transfer and adoption of techniques developed by farmers and farm machinery manufacturers, agricultural research in later years has produced increments to basic knowledge and applied research. Some of the applied research attempts to increase agricultural output (for example, new or improved crop varieties, decision-making aids and schemes, and final agricultural products) while others attempt to maintain previous technological gains. The performance of much of agricultural technology is sensitive to local environmental factors and resource endowments, including size of farm and managerial skill of farmers. Thus, widespread direct interstate borrowing of applied research products is generally limited, and intrastate research must be targeted to the needs of different locations and types of farms.

Studies by Zvi Griliches (1964) and Robert Evenson (1971, 1980) have shown that public sector investments in agricultural research (and extension) have increased the productivity of *U.S.* agriculture. All farmers, however, inherently do not have equal access to new technology. Operators of large farms have a greater incentive to search and experiment than do operators of small farms (see my 1977 paper). Farmers in different geoclimatic regions may have differential access because of technological-environmental interactions (see Griliches, 1957; Evenson, 1980). Some technology may be profitable only when applied on a large scale. Finally, some operators may have more skill for acquiring and interpreting information, and are thereby better able to experiment, sort out relevant facts, and make modifications for their farming situation.

The Extension Service has the potential to be a substitute for high managerial skill of farmers. The Extension Service, established with federal-state coordination in 1914, is the most important public sector source of information to farmers, but it is only one of many private and public institutions providing information to them. Agricultural extension personnel assemble, organize, and interpret market information, simplify technical information, and develop resource management schemes for disseminating to farmers. They also demonstrate new farming techniques and consult directly with farmers on specific production and management problems. Tough problems are to be referred to state extension specialists or to experiment station researchers. Thus, the Extension Service has attempted to develop an information system that enhances information transfer and adoption of new technology by linking farmers to the expertise of state extension specialists and to researchers at experiment stations.

In the U.S. South, the organization of agricultural research and extension seems to have contributed to unequal access to new technology by black and white farmers. The original land-grant colleges, established by the Morrill Act of 1862, developed as segregated institutions for whites, and the Land-Grant Act of 1890 authorized the establishment of separate-but-equal land-grant colleges for blacks. All sixteen southern states and Missouri established "Colleges of 1890" under this Act.[3] State and federal financial support, especially for

[3]Edward Eddy (p. 291) presents a list of the seventeen land-grant colleges of 1890. During the early years of these colleges, most of their students were enrolled in courses at the elementary and high school level because few blacks had completed high school.

TABLE 1—EXPENDITURES AND STATE AND FEDERAL APPROPRIATIONS FOR THE SEVENTEEN WHITE (1862) AND BLACK (1890) LAND-GRANT COLLEGES IN THE U.S. SOUTH, 1945–60 (Thousands of Current Dollars)

	1945		1950		1955		1960[a]	
Item	White	Black	White	Black	White	Black	White	Black
Total Expenses for Educational and General Purposes	55,942	4,302	128,858	13,072	188,828	20,191	306,664	27,102
a) State Government Appropriations	24,920	3,088	67,614	9,994	107,108	15,852	169,137	22,144
b) Funds of Federal Origin	24,287	519	43,220	2,344	36,477	627	67,895	854
Total Expenditures on Organized Research	9,872	1	19,367	16	37,259	31	70,460	115
a) Regular Federal Land-Grant Appropriations for Research (Experiment Station)	1,571	0	4,398	0	7,604	0	11,920	0
Total Expenditures on Extension and Public Information	20,107	88	31,473	282	44,447	214	66,443	488
a) Regular Federal Land Grant Appropriations for Cooperative Extension	10,473	0	15,741	0	19,861	0	26,026	47

Sources: U.S. Office of Education, 1947, 1951, 1956, 1961.
[a]For sixteen states—West Virginia did not have a black land-grant college in 1960.

agricultural research and extension, has been extremely unequal for the 1862 and 1890 colleges (see Table 1). For the period 1945–60, the 1862 land-grant colleges made more than 99 percent of the total expenditures on organized research by southern white and black land-grant colleges, and they received all the regular federal appropriations for agricultural experiment station research. The decision on allocating federal experiment station funds between land-grant colleges was made by each state's legislature or by its governor, but in every southern state, all of the federal funds for agricultural experiment stations were allocated to the 1862 (white) land-grant institutions. Furthermore, none of the black land-grant college researchers had direct access to an on-campus experiment station, except in Texas where a branch station was located at Prairie View A and M. Although black farmers have had about 5 percent (1945–60) of agricultural sales in the South, the black land-grant colleges have had few research resources for developing new agricultural technology specifically designed for small, low-skill, limited-resource black farmers. Given the political reality of obtaining state support for experiment station research in the South, the agricultural experiment stations of the 1862 colleges undoubtedly targeted applied research to the needs of white rather than to the needs of black farmers.[4]

The Extension Service had the potential to mitigate the effects of low skill levels of black farmers on differential access to new technology and on farm management, but this potential was not realized. The Morrill Act of 1890 required that state legislatures designate either an 1862 or an 1890 land-grant college to administer the extension of information to rural people. In the seventeen states with segregated land-grant col-

[4]A sizeable percentage of black farmers have been crop-share tenants (57 percent in 1940 and 40 percent in 1960). Thus, some of them may have benefited from applied research targeted to their white landlords. Others were undoubtedly made worse off by new technology that reduced the demand for farm labor and crop-share tenants (see Richard Day).

leges, the white land-grant college was chosen to administer the total extension program, but over time, a segregated structure developed. In eleven of the southern states where most of the rural blacks lived, the Extension Service was segregated from the state offices down to the local level and, the services provided to black farmers seem to have been inferior to those provided to white farmers.[5]

The offices of the state staff for the white Extension Service, located at the white land-grant colleges, were well staffed with generally well-trained specialists in a large number of subject areas (see U.S. Commission on Civil Rights (USCCR), 1965, p. 26). In 1960, the number of agricultural and home economics extension staff members operating at or from white land-grant colleges in the eleven southern states with completely segregated systems was 896 or 1 for each 1,186 white farmers (see Office of Education (USOE), 1961). These extension personnel also had direct access to the researchers of the state experiment stations.

In contrast, the offices of the state staff of the black Extension Service were located at the black state land-grant colleges, except in Mississippi where they were located in Jackson and not associated with a college, in Alabama where they were located at the private black Tuskegee Institute, and in Arkansas where they were located at the white land-grant college in Fayetteville. The black land-grant colleges had a small budget for extension and public information (see Table 1), few well-trained specialists, and a small extension staff (see USCCR, 1965, pp. 25–26). In 1960, eight states had offices of the state staff located at black land-grant colleges. For these eight states, the number of agricultural and home economics extension staff members operating at or from black land-grant colleges and universities was 74 or 1 for each 2,156 black farms, compared with one white state staff member for each 1,123 white farms in these states (see USOE, 1961). These black state extension staffs had little direct research support. Furthermore, as late as the early 1960's, regular contact between the state black and white extension personnel in the eleven southern states with segregated Extension Services did not exist, except in North Carolina, Mississippi and Texas (see USCCR, 1965).

In counties where both the black and white extension services had personnel, they had separate offices, supporting staffs, and equipment, and their personnel had different training. Agents were segregated for extension training, except in North Carolina, and the training of white agents was longer, more comprehensive, and more detailed than for black agents (see USCCR, 1965, pp. 30–36). In some counties that had a large number of black farm families, there was no black extension personnel. They were not assigned to counties where strong sentiment against such action existed.[6] Furthermore, the white county extension personnel seem to have provided only minimal assistance to black farmers (see USCCR, 1965, p. 40) in these counties.[7] Although good data do not exist, the size of black county extension staff was small relative to the size of its potential audience and compared to the potential audience of the white Extension Service.[8] Thus, it is clear that extension and schooling have been of lower quality and less available to black than to white farmers.[9] But we

[5]These states were Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, Virginia, and Arkansas. In 1960, these eleven states had 97 percent of the black farm operators in the sixteen southern states.

[6]The placement of black extension personnel in a county was determined by availability of federal, state, and county funds, the size of the black rural population, and the willingness of a county to have black extension workers.

[7]For meeting local needs, federal extension officials believe that local people must help prepare annual county extension plans. Blacks were involved in making plans only in counties where black extension personnel were present. No attempt was made in other counties to include blacks locally (see USCCR, 1965).

[8]One piece of evidence shows the order of magnitude of the inequality of black-white extension funding. For 1925-37, black farmers operated about 27 percent of all farms in the U.S. South, but expenditures for extension for blacks was roughly 6 percent of total (federal, state, and county) funds allocated for agricultural extension work (see Office of Education, 1949, p. 28).

[9]Civil Rights audits in 1969 of state Extension Services in the U.S. South show that pervasive discrimination in distribution of services to black and

would like to know how these differences translate into effects on agricultural productivity in the U.S. South.

II. A Model for Investigating Productivity Differences on Black and White Operator Farms

An aggregate production function provides the framework for quantifying the economic significance of differences in quantity and quality of black and white operator schooling and extension on agricultural productivity. The specification of the production function explicitly parameterizes potential productivity differences between races, and input quantities and estimates of the parameters are used to quantify these productivity differences.

The production function is

$$(1)\quad ln\,Y=\alpha_0+(\alpha_1+\beta_1\rho)ln\,MACH + (\alpha_2+\beta_2\rho)ln\,LIVST + (\alpha_3+\beta_3\rho)ln\,FS+(\alpha_4+\beta_4\rho)ln\,A + (\alpha_5+\beta_5\rho)ln\,L + \alpha_6\,ln\,E+\alpha_7 ln\,X+\sum_k d_k R_k$$

where

ρ = share of livestock products in total farm output
$MACH$ = aggregate machinery input
$LIVST$ = aggregate livestock input
FS = aggregate fertilizer and seed input
A = aggregate composite farmland input:
$A=\Sigma_i\Sigma_j a_{ij}A_{ij}$, A_{ij} = aggregate acres, $i=1$ for white operators, 2 for black operators, $j=1$ for cropland, 2 for noncropland
$FA=\Sigma_i\Sigma_j A_{ij}$ = aggregate acres of farmland
L = aggregate composite operator and hired farm labor input:
$L=\Sigma_i l_i L_i+hH$, L = aggregate composite farm labor input
L_i = aggregate days operator labor; H = aggregate days of hired farm labor
$LAB=\Sigma_i L_i+H$ = aggregate days of operator and hired labor
E = aggregate composite education index of farm operators:
$E=\Sigma_i e_i E_i$, E_i = years of school completed
$ED=\Sigma_i E_i$ = aggregate years of schooling completed, all farm operators
X = aggregate composite agricultural extension index:
$X=\Sigma_i f_i X_i$, X_i = days of extension input, $i=1$ for white extension, 2 for black extension
$EXT=\Sigma_i X_i$ = aggregate days of agricultural extension input
R_k = regional dummy variables

The function is an extension of the Cobb-Douglas where input coefficients are a linear function of the mix of output ρ, measured as the livestock output share of total farm output. This functional specification permits the input-output relationship to vary by farm product mix and thereby to better fit observations differing widely in crop-livestock mix of output (see Griliches, 1963; my 1976 paper).[10]

Composite inputs, consisting of a component for white operator and for black operator farms, are hypothesized where productivity of inputs might be expected to differ by race, and where data are available on input usage by race of farm operator. The coefficients of the components of the composite inputs permit differential weighting due to productivity differences. The production function is, however, a non-linear function in the unknown parameters of the composite land, labor, education, and extension inputs. The method applied here to linearize these indexes is an approximation by

white farmers continues to be a problem (see USCCR, 1973).

[10]Discussions can be found elsewhere on potential problems with existence of aggregate production functions (Franklin Fisher; Robert Hall; John H. A. Green), on statistical identification of the production function (Griliches and Vidar Ringstad), on simultaneous equation bias (Irving Hoch; Arnold Zellner), and on the importance of land tenure arrangements (Stephen DeCanio; Reid, 1976, 1977).

Taylor-series expansion, ignoring second- and higher-order terms, about the equal productivity loci.[11]

Linearization of farmland, labor, education, and extension inputs creates a set of inputs that can be easily constructed from available data. Each of the linearized functions enters equation (1) as a function of a simple summation of the unadjusted components of the composite input (for example, for land, it is $ln\,(FA)$) and a ratio formed by dividing individual components by the simple aggregate input (for example, for land, the ratios are $(A_{11}+A_{21})/FA$, A_{21}/FA, and A_{22}/FA).[12] For education and extension the parameterization is $ln\,ED+[(e_2-e_1)/e_1^0]E_2/ED$ and $ln\,EXT+[(f_2-f_1)/f_1^0]X_2/EXT$, respectively, where the coefficient of E_2/ED is the relative difference in the productivity of a year of black operator schooling compared with a year of white operator schooling and the coefficient of X_2/EXT is the relative difference in the productivity of a unit of black extension compared with a unit of white extension. Thus, we expect the estimated coefficients of E_2/ED and X_2/EXT to be negative and significantly different from zero, if a unit of black operators' schooling (black extension) is less productive than a unit of white operators' schooling (white extension).

[11]DeCanio has used a similar model for investigating productivity differences of black and white operator farms in the postbellum South.

[12]For land, the approximation is $ln\,A \sim c_0+ln\,FA+c_1(A_{11}+A_{21})/FA+c_2(A_{21}/FA)+c_3(A_{22}/FA)$, where the unknown parameters $c_1=(a_{11}-a_{12})/a_{11}^0$, $c_2=(a_{21}-a_{11})/a_{11}^0$, and $c_3=(a_{22}-a_{12})/a_{11}^0$ show the relative difference in productivity of an acre of (a) cropland compared with an acre of other farmland, (b) cropland on black operator farms compared with cropland on white operator farms, and (c) other farmland on black operator farms compared with other farmland on white operator farms, respectively. For labor, the approximation is

$$ln\,L \sim \gamma_0+ln\,LAB+\frac{(l_1-h)}{l_1^0}\frac{L_1+L_2}{LAB}+\frac{(l_2-l_1)}{l_1^0}\frac{L_2}{LAB}$$

where the estimate of $(l_2-l_1)/l_1^0$ shows the relative difference in productivity between black and white operator labor.

III. The Empirical Analysis

This section discusses the data set, the measurement of the variables, and the estimated aggregate production function. Investigating productivity differences of black and white operator farms would be facilitated if separate data on inputs and outputs by race of operator were available. Although the *Census of Agriculture, 1964* provides state level data that can be used to derive separate inputs and outputs for white and for nonwhite operator farms in fifteen southern states, these data do not provide enough observations for fitting production functions. Thus, these state level data are useful primarily as descriptive information. At the county level, the *Census of Agriculture, 1964* provides only partial information on the separate characteristics of white and nonwhite operator farms in the U.S. South. The data base is obtained by combining these county data with unpublished U.S. Department of Agriculture (USDA) data on the white and black Extension Services and information from USDA publications of the same period.[13]

The observations are county aggregates for the 295 counties of North Carolina, South Carolina, Mississippi, and Alabama. These four states in the U.S. South were chosen because they had the largest number of black farm operators in 1964; they had 58 percent of all black farm operators in the sixteen southern states (and 97.5 percent of the nonwhite farmers were black). These states also represent different parts of the South, the Mid South, and the Deep South.

A. *Empirical Measures of the Variables*

The derivation of key variables is presented to aid in assessing the empirical results. Farm output is measured as the value of all farm products sold, crops plus live-

[13]One might ask what is unique about 1964? It is the year in which the Civil Rights Act was passed. One effect of this Act was to make illegal a separate black and white Extension Service. Also, the *Census of Agriculture, 1964* is the only one to present data on years of schooling completed by farm operators.

stock, and livestock products.[14] The share of livestock products in total farm output is measured as the sales of livestock and livestock products divided by total farm output. Farmland is defined in this study as cropland harvested and nonwoodland pasture land. This definition excludes land in farms that are relatively unproductive, for example, idle cropland, woodland, and wasteland.[15] Total acres of farmland and acres of cropland (harvested) on white and black operator farms are reported in U.S. Bureau of the Census (1967).

The input of farmlabor services is derived from data on hours worked and expenditure data, and it is measured as annual man-days of farm work. Average annual days of farm work per farm operator in a county are estimated as the state average days of farm work by all farmers (see U.S. Bureau of the Census, 1968), less the net difference between the state and the county average days of off-farm work per farm operator (see U.S. Bureau of the Census, 1967). Separate county data on days of farm work by race of operator are not available in the *Census*. A measure of total days of farm work by black operators in a county was obtained by multiplying the above average days of farm work by all operators by the number of black operators.[16] Days of hired labor are derived as annual expenditure on hired labor divided by the state average daily wage rate in 1964 for hired farmlabor (see USDA, 1965). To obtain the total days of operator and hired farmlabor, the days of hired farmlabor were multiplied by 0.872 in Alabama, North Carolina, and South Carolina, and by 0.923 in Mississippi to adjust for differences in average length of work day (see Walter Sellers) and added to days of operator labor.

The aggregate education level of all farm operators is constructed by weighting the number of farm operators in each of seven schooling completion classes: 0–4, 5–7, 8, 9–11, 12, 13–15, ≥ 16 (see U.S. Bureau of the Census, 1967) by years of schooling completed. For a given county, the average education level of black farm operators was assumed to be proportional to the average number of years of schooling completed by all black males 25 years of age and older in 1970 in the county (see U.S. Bureau of the Census, 1972, Table 125).[17] This average schooling level was rescaled so that for each state the derived average education level of black farmers is equal to the state average education level of nonwhite farm operators in the *Census of Agriculture, 1964*.

Extension variables are derived from unpublished federal Extension Service data (see USDA, 1961) on annual time allocations of black and white extension personnel.[18] The simple aggregate extension variable was derived as the annual days devoted to crops, livestock, and planning and management of farm businesses by white and black agents doing primarily agricultural work.

[14]Using sales as the measure of output might reduce the size of blacks' farm output relative to whites' farm output. The average number of persons per household is larger for black operators (4.7) than for white operators (3.4). Thus, black families might be expected to consume a larger share of their farm output. Experiments with output measured as sales and as sales plus home consumption, obtained by distributing the USDA's state level estimates of home consumption among counties on the basis of the number of persons in farm households, showed very similar production function estimates.

[15]With this measure of farmland it was impossible to obtain separate measures of other farmland by race of operator. Land defined to include all land in farms always performed poorly as an input. Its estimated coefficient was unstable in sign and not significantly different from zero.

[16]Although in general black operators have smaller farms than white operators, they also work fewer days per year at nonfarm jobs than white operators (an average of 49.1 for blacks compared with 80.2 for whites). The assumption is that these two differences have approximately offsetting effects on days of farm work.

[17]The share of black rural farm males in all black males is not constant across counties, and education levels differ between farm and nonfarm resident blacks. However, the derived variable seems likely to meet the requirement for an instrumental variable.

[18]Extension data for 1960 (rather than 1963 or 1964) were used because of data availability considerations. One can expect a lag between expenditure of agents' time and the observed effect on agricultural production. Alternatively, one can view the 1960 extension variable as an instrumental variable for extension in a later year, and lagged extension reduces the potential for simultaneous equation bias.

TABLE 2—MEAN VALUE OF INPUTS AND OUTPUT PER FARM: WHITE AND BLACK OPERATOR FARMS IN NORTH CAROLINA, SOUTH CAROLINA, MISSISSIPPI, AND ALABAMA, 1964

Variables	Unit	White Operator Farms	Black Operator Farms
Output (Y)	\$/yr	8,621.3	2,897.4
Machinery ($MACH$)	\$/yr	1,402.8	479.7
Livestock and Feed ($LIVST$)	\$/yr	2,102.9	117.6
Fertilizer and Seed (FS)	\$/yr	622.5	257.6
Farmland[a] (FA)	Acres/yr	75.9	25.3
Operator and Hired Labor (LAB)	Days/yr	314.7	250.2
Schooling (ED)	Yrs.	8.70	5.56
Extension (EXT)	0.1 Days/yr	0.105	0.064
Share Livestock Products in Output (ρ)		0.358	0.058
Share Cropland in Farmland ($A_{.1}/FA$)		0.592	0.740
Share Operator Labor in Operator and Hired Labor (L/LAB)		0.616	0.909

[a]The average number of acres of all land in farms is 168.1 acres for white operators and 49.6 acres for black operators.

Machinery services are measured as the rental on an inventory of a selected group of machines on farms in 1964, plus expenditures on petroleum products and on machinery hire.[19] The livestock and feed input is measured as the rental on the inventory of breeding stock, plus expenditures on purchased livestock and feed. Fertilizer and seed are lumped together and measured as the price-weighted primary plant nutrients, plus the expenditure on seeds. The geographical dummy variables, representing groups of counties with similar soil types, weather in 1964, and general climatic conditions, are state parts of agricultural subregions (see Donald Ibach and James Adams).

Table 2 presents average values for farm output and inputs for white and for black operator farms in North Carolina, South Carolina, Mississippi, and Alabama. These averages by race are obtained by applying the preceding definitions of inputs and output to the state level tables that summarize the characteristics of white and nonwhite operator farms for these states (see U.S. Bureau of the Census, 1967, Tables 18 and 18a). The sample mean values show that black operator farms are on average about one-third as large as white operator farms. Black operator farms produce almost exclusively crops, but livestock products are 36 percent of the farm output of white operator farms. Although black operators have one-third as much farmland per farm as white operators, black operators have a larger (fifteen percentage points) share of their land in cropland. The average schooling level of black operators is 3.14 years lower than for white operators, and the black extension variable is 64 percent as large as the white extension variable. Thus, the average values of inputs and output of black and white operator farms show large differences.

B. *The Estimated Production Function*

The results from fitting the aggregate production function by the method of least squares to the 295 observations are reported in Table 3. The production function was fitted to average per farm values of the levels of the inputs, except for extension which is the county total.[20] The total, rather than average per farm, is relevant if there are large economics of numbers in extending extension information to farmers, for example, by using meetings, demonstra-

[19]Separate machinery data for black and white operator farms do not exist at the county level.

[20]For aggregate data, averages per farm reduce the problem of heteroscedasticity of the random disturbance term in the production function.

TABLE 3—ESTIMATED PRODUCTION FUNCTION FOR SOUTHERN AGRICULTURE: INPUT PRODUCTIVITY DIFFERENCES ON BLACK AND WHITE OPERATOR FARMS, 1964 (295 OBSERVATIONS)

Variables[a]	Coefficients[b] Being Estimated	Estimate	*t*-ratio
Machinery (*ln MACH*)	α_1	0.313	5.42
Livestock and Feed (*ln LIVST*)	α_2	–	–
Fertilizer and Seed (*ln FS*)	α_3	0.207	4.45
Farmland (*ln FA*)	α_4	0.090	2.49
Share of Cropland in all Farmland $((A_{11}+A_{21})/FA)$	$\alpha_4\left[\frac{a_{11}-a_{12}}{a_{11}^0}\right]$	0.331	3.09
Operator and Hired Labor (*ln LAB*)	α_5	0.614	11.63
Education (*ln ED*)	α_6	2.039	3.11
Share of Black Operators' Schooling in Total Operator Schooling (E_2/ED)	$\alpha_6\left[\frac{e_2-e_1}{e_1^0}\right]$	−0.011	−0.05
Extension (*ln EXT*)	α_7	0.751	3.07
Share of Black Extension in Total Extension (X_2/EXT)	$\alpha_7\left[\frac{f_2-f_1}{f_1^0}\right]$	−0.126	−2.91
(Education)×(Extension) ((*ln ED*)×(*ln EXT*))	γ_1	−0.338	−2.89
$\rho \times ln\ LIVST$	β_2	0.620	20.70
$\rho \times ln\ FS$	β_3	−0.253	−3.87
Share of Livestock Products in Farm Output (ρ)	γ_2	−2.890	−5.79
Share of Blacks' Farms in All Farms	γ_3	0.235	1.24
R^2		0.978	
s^2		0.0098	

[a]Output and inputs are county averages per farm, except for *EXT* which is a county total.
[b]Coefficients were estimated for twenty-seven geographical dummy variables. Estimates of these coefficients are reported in Table 4.

tions, and media sources to reach many farmers simultaneously, as opposed to one-to-one consulting. The production function was fitted with an interaction term between education and extension and with two variables that are to capture residual effects of product mix (ρ) and racial mix of farm operators on farm output.

Several specifications of the basic equation were fitted to check on consistency of estimated coefficients across variables. In the final regression, consistency across estimated coefficients is imposed in the sense that, if the direct estimate of β_i (or of a relative productivity coefficient) was not significantly different from zero, then coefficients to be estimated that contained β_i as one part of a product were set equal to zero.

The results show that parameters of the production function differ by product mix of output. As the share of livestock output in total farm output increases, the coefficient of the livestock (fertilizer and seed) input increases (decreases). When the livestock output is zero and crop output is positive, the coefficient of the livestock input is zero; clearly a plausible finding. The coefficient of the fertilizer and seed input is largest when only crop output is produced, and it declines as the share of livestock output increases. The decline is plausible because livestock manures can substitute for commercial fertilizer in crop production. The negative and significant coefficient of ρ implies that the (constant of the) production function shifts down as the share of livestock products in total output increases. This effect seems to reflect the greater use of inputs for maintenance in livestock than in crop production.[21]

The estimated coefficients of the education and extension variables are all significantly different from zero, except for the extension ratio term. The estimated coefficient of the education-extension interaction effect is negative, suggesting that farmers' education and agricultural extension are substitutes in southern agricultural production in the sense that higher education (extension) levels reduce the coefficient of extension (education). At sample mean values, the estimated coefficient of education is 0.058 $[=2.038-0.338(5.861)]$ and of extension is 0.051 $[=0.751-0.338(2.071)]$.

The coefficients of black operators' schooling share and of black extensions' share of total extension are estimates of the average relative quality differences of a unit of black compared with a unit of white schooling and extension, respectively. Given an estimated education coefficient of 0.058 at the sample mean, the estimated coefficient of black operators' schooling share of -0.011 implies that the average quality of a year of black operators' schooling as it affects agricultural production is 19 percent lower than white operators' schooling. The estimated coefficient is, however, not significantly different from zero. Thus, for effects on agricultural productivity, the primary black-white schooling difference is from years of schooling completed and not from schooling quality.

The coefficient of black extensions' share of total extension days is negative and significantly different from zero at the 5 percent level. Given the estimated extension coefficient of 0.051 at the sample mean, the estimated coefficient of the black extension share of -0.126 implies that the average quality of a day of black extension as it affects agricultural production is 247 percent lower than a day of white extension. Thus for effects on agricultural productivity, both low quality and quantity of black extension input are sources of black-white differences.[22]

Other results are that cropland is significantly more productive than other (nonwoodland pasture) land. Given the estimated coefficient for land of 0.090, the estimated coefficient of the share of cropland in all farmland of 0.331 implies that an acre of cropland is 3.68 times more productive than an acre of nonwoodland pasture. Also, there is no significant difference in the productivity of a day of operator labor compared with hired labor, of a day of black operator labor compared with white operator labor, or of an acre of black operator cropland compared with white operator cropland. The positive but not significantly different from zero coefficient of the variable "share of farm operators that are black" suggests that major black-white productivity differences have been accounted for by other included variables.[23]

IV. Implications and Conclusions

It is well known that blacks have been discriminated against historically in quantity and quality of educational opportunities. This study has illuminated the dis-

[21] The economic significance of the nonzero βs is that they imply optimal relative input combinations change when the output mix changes, holding relative input prices constant.

[22] In 47 percent of the sample counties, black farmers were present, but black extension personnel were not. A dummy variable was used to test for an effect on farm output of absence of black extension to assist black farmers. The coefficient of this dummy variable was generally negative but not significantly different from zero. Thus, the effects of black extension on farm output seem to be adequately represented by the ratio of black to total extension input.

[23] When the full model was estimated, the coefficients containing β_4 and β_5 (for example, $\beta_4 c_1, \beta_4 c_2, \beta_4 c_3$, etc.) were not significantly different from zero. When the variables associated with these coefficients were excluded from the full model, the estimated coefficients of A_{21}/FA and L_2/LAB were not significantly different from zero. Furthermore, the null hypothesis that the coefficients of the eleven variables excluded from the full model to obtain the reported production function are simultaneously equal to zero cannot be rejected at the 5 percent significance level. The calculated F-value is 0.89, and under standard least squares assumptions, the tabled F-value for 11 and 243 degrees of freedom at the 5 percent level is 1.82.

TABLE 4—ESTIMATES OF THE COEFFICIENTS OF THE GEOGRAPHICAL DUMMY VARIABLES IN THE PRODUCTION FUNCTION

Variables	Number of Counties in Subregion	Percent Nonwhite Farms in Subregion	Percent of Sample Nonwhite Farms in Subregion	Coefficients	
				Estimate	t-ratio
South Carolina					
SASR 15[a]	7	52.4	3.0	−3.605	−2.64
SASR 16	5	40.4	5.1	−3.452	−2.51
SASR 26	12	15.5	2.0	−3.565	−2.62
SASR 27	5	25.1	1.2	−3.550	−2.59
SASR 28	11	49.7	5.6	−3.544	−2.58
SASR 33	6	26.4	1.1	−3.582	−2.62
North Carolina					
SASR 14	9	46.4	4.3	−3.267	−2.38
SASR 15	18	25.3	4.5	−3.251	−2.37
SASR 16	6	42.9	3.6	−3.192	−2.33
SASR 17	14	27.7	8.9	−3.189	−2.33
SASR 18	3	19.8	4.6	−3.073	−2.25
SASR 25	22	0.8	0.2	−3.334	−2.46
SASR 26	18	6.8	1.5	−3.374	−2.47
Mississippi					
SASR 31	10	5.7	0.4	−3.580	−2.63
SASR 46	9	12.9	1.6	−3.303	−2.42
SASR 47	7	43.5	4.2	−3.449	−2.53
SASR 48	34	30.9	14.1	−3.461	−2.55
SASR 49	11	55.6	8.8	−3.351	−2.44
SASR 64	11	55.4	5.7	−3.347	−2.44
Alabama					
SASR 31	3	8.0	0.3	−3.443	−2.52
SASR 32	12	21.0	3.0	−3.521	−2.57
SASR 33	8	23.7	1.5	−3.431	−2.52
SASR 34	8	7.0	0.6	−3.440	−2.52
SASR 45	11	5.8	1.4	−3.335	−2.44
SASR 46	12	20.2	2.7	−3.436	−2.52
SASR 47	10	66.2	8.9	−3.567	−2.61
SASR 48	3	36.8	1.1	−3.567	−2.63
Total	295	26.6	100.0		

[a]*SASR* = State part of an agricultural subregion (see Ibach and Adams).

crimination against southern black farmers in quantity and quality of public agricultural extension assistance provided to them. The results from the estimated production function provide empirical support for the hypothesis of lower relative productivity or quality of black farmers' schooling and black extension compared with white farmers schooling and white extension.

The estimated production function (Table 3) and available state level data permit a comparison of productivity differences for black and white operator farms. Marginal products for black and for white operator farms are evaluated at their respective sample means for inputs (Table 2).[24] The implied marginal product of labor on black operator farms is only 42 percent as large as for white operator farms. The size of this black-white difference is consistent with urban black-white wage differences of this period (see Welch, 1973a). Although the estimated production function showed that quality per unit of black farmers' education and black extension is lower than for whites,

[24]The constant term from Table 4 is −3.390 for blacks and −3.370 for whites. These were obtained by weighting coefficients of *SASR*s by the actual distribution of farms by race.

the implied marginal products of black operators' schooling and of black extension are about three and ten times as large as the marginal product of white operators' schooling and extension, respectively.[25] The reasons for these large differences are the relatively small size of average black education and extension inputs, given diminishing marginal productivity, and the negative education-extension interaction effect in production. These positive effects more than offset the negative effects on output of lower quality of black schooling and extension. The positive difference in black-white marginal product of education is in direct contrast to educations' effect on rural income differences (see Welch, 1967). The implied marginal products for other inputs are essentially equal across the two races.

We can estimate the effect on total factor productivity if all farms were suddenly operated by blacks. In making this comparison, I attribute all productivity differences to effects of differences in quantity and quality of schooling and extension, and to racial mix of operators. Other changes in the switch are assumed to have neutral effects on the total productivity differential. The contribution of lower average schooling levels of black operators relative to white operators and of lower average black extension input relative to white is -26.7 percent [$= 2.039(-0.447) + 0.751(-1.342) - 0.338 \times (-4.883)$]. The contribution of lower average quality per year of black schooling and per day of black extension is -13.7 percent ($= -0.011 - 0.126$). Because all farms would now have black operators, the coefficient of the share of farmers that are black, γ_3, contributes 23.5 percent to the black-white farm productivity differential. Thus, the evidence is that if all white farms were suddenly operated by blacks, southern farm output would be about 17 percent lower than if all farms were operated by whites. The lower level of schooling and extension for black farmers than for white farmers would contribute twice as much to this productivity differential as lower quality of schooling and extension.

[25]These ratios were calculated as follows: for education as $[(2.039-0.338\times4.428)\hat{Y}_B/5.56]/[(2.039-0.338\times5.770)\hat{Y}_W/8.70]$ and for extension as $[(0.751-0.338\times1.716)\hat{Y}_B/83.76]/[(0.751-0.338\times2.163)\hat{Y}_W/320.67]$ where $\hat{Y}_W$ and $\hat{Y}_B$ are the imputed values of output for white and black operator farms, respectively.

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