SELECTED TOPICS IN PEANUT PRODUCTION: ECONOMIC FEASIBILITY OF AN ENERGY CROP ON A SOUTH ALABAMA COTTON-PEANUT FARM AND DO ECONOMIES OF SIZE EXIST ON PEANUT FARMS IN THE SOUTHEAST?

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IN THE SOUTHEAST?

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Edward Todd Frank, son of Edward and Patsy Frank, was born on December 6, 1979 in Elberta, Alabama. He graduated from Foley High School in 1998 and entered Auburn University in September 1998. He graduated with a Bachelor of Science in Agricultural Economics with a minor in Agronomy and Soils in May 2002. He entered Graduate School in August of 2002 and was employed as a Graduate Research Assistant in the Department of Agricultural Economics and Rural Sociology.

THESIS ABSTRACT

SELECTED TOPICS IN PEANUT PRODUCTION: ECONOMIC FEASIBILITY OF AN ENERGY CROP ON A SOUTH ALABAMA COTTON-PEANUT FARM AND DO ECONOMIES OF SIZE EXIST ON PEANUT FARMS IN THE SOUTHEAST?

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The possibility of low prices farmers receive for peanuts at the farm gate may cause them to implement alternative production practices. This thesis is comprised of two separate papers, formatted for publication with the help of Patricia Duffy, Robert Taylor, and David Bransby, for the purpose of analyzing two possible alternatives. In the first paper, linear programming and enterprise budgeting are used to analyze possible crop rotations that include a bioenergy crop (velvet bean) on a cotton-peanut farm in southeast Alabama. The price for velvet bean is parameterized from a point where a velvet bean-peanut rotation is optimal and then increased to a point where continuous velvet bean

production is optimal. The second paper uses a regression model to estimate the influence of peanut acres, education, age, and primary occupation on average cost per unit of output and to determine whether economies of size exist on peanut farms located in the Southeast.

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INTRODUCTION

Peanut farms in southeast Alabama (the Wiregrass) have had to face low peanut prices since The Farm Security and Rural Investment Act of 2002 which eliminated the production quota system for peanuts. Without the quota system, peanuts are sold on the open market, which can be very volatile. Also lowering the price of peanuts is the expansion of peanut production in areas where peanuts were not grown. Producers in these new areas of production began growing peanuts as a result of lower cotton and grain prices, land that was free of peanut pests, and the elimination of the quota system. With little disease pressure, producers in these areas had, on average, higher yields compared to traditional peanut producing counties in southeast Alabama.

The increase in peanut acres and the elimination of the quota system has decreased the average price of peanuts from $532 per ton in the 2000 marketing year to $328 per ton in 2002, according to the Alabama Agricultural Statistic 2004 Bulletin. With lower prices, peanut producers in southeast Alabama may need to look at alternative production practices. Producers may look into crop rotations with non-traditional crops that may be more profitable and may increase peanut yields. One crop that could benefit producers is velvet beans.

In the section “Economic Feasibility of an Energy Crop on a South Alabama Cotton-Peanut Farm,” the economic feasibility of velvet bean, peanut, and cotton rotation is analyzed. A rotation with velvet bean could be profitable for producers if there is an increase in demand for its biomass. If new markets open, such as feedstock for energy production, producers could switch production from continuous peanuts or cotton to velvet bean rotations. Also, research has shown that velvet bean can improve soil productivity and negatively affect soil pests. Velvet beans suppress or control organisms such as root-knot nematode, Reniform nematode, and white mold. By decreasing the incidence of soil pests, producers could possibly lower production costs by applying fewer insecticides and fungicides to peanuts or cotton. Also producers could realize an increase in peanut or cotton yields with this rotation. In the chapter, a level of prices received for velvet bean biomass is parameterized to maximize velvet bean-peanut, velvet bean-velvet bean-peanut and continuous velvet bean rotations.

Peanut producers in southeast Alabama could also decide whether or not an increase in peanut acres would help increase net farm income. In the section “Do Economies of Size Exist on Peanut Farms in the Southeast?,” an average cost per unit of output (pounds of peanuts) model is used to decide whether economies of size exist on peanut farms in the Southeast region of the United States. Variables that may also influence average cost per unit of output include total peanut acres, education, age of the producer, and the primary occupation of the producer.

ECONOMIC FEASIBILTY OF AN ENERGY CROP ON A SOUTH ALABAMA COTTON-PEANUT FARM

Introduction

The U.S. Department of Energy (DOE) is seeking alternative fuel sources, such as energy crops, so that the United States can become less reliant on foreign fuel and also to reduce pollution associated with fossil fuels. The biomass from velvet bean production can be used as an alternative source of fuel. Also, because of velvet beans' effects on soil pests and its soil building properties, a rotation with velvet beans can increase the yields of peanuts and cotton. Unfortunately, there is not currently enough information about the net returns of velvet bean biomass to allow producers to make educated decisions about including this crop in a rotation. The objectives of this paper are to analyze the economic attractiveness of producing velvet beans in south Alabama and to find the prices at which velvet beans would be a competitive source of income for producers in this area.

The DOE has been searching for alternative energy sources since the energy crisis of the 1970's. Recently, the department has been looking at ways to meet the demands of electrical generation facilities. In early tests, waste biomass feedstocks -- such as logging residues, wood processing mill residue, urban wood wastes, and selected agricultural residues -- were used to meet some of the demand. Currently, certain locations have limited quantities of these biomass feedstocks available. To meet the demand of these electrical generation facilities and to expand the biomass industry, other sources of biomass must be considered. Biomass supply from crop residue could be used to meet these needs. Crop residue could potentially displace about 12.5 percent of petroleum imports or 5 percent of electricity consumption (Gallagher et al., 2003). One crop that could be used for its biomass qualities is velvet beans.

The velvet bean was first produced in the southern portion of the United States in the late 1800's. Its uses have included livestock feeding and grazing, and it has been recognized as having the potential to improve soil productivity and to have a depressive effect on soil pests. Velvet beans suppress root-knot nematode (*Meloidogyne arenaria*) in cotton, peanut, soybeans, and other crops. The crop also provides some suppression of Southern blight, (*Sclerotium rolfsii,* also known as White mold), and it is the only known means of control of Reniform nematode (*Rotylenchulus reniformis*). Articles in old literature suggest that velvet beans can be used to control weeds such as bermudagrass and Johnson grass, but there are no current experiments in Alabama that back these claims (Taylor and Rodriguez-Kabana, 1998).

On average, velvet beans produce about 15,692 kilograms of biomass per hectare (7 ton/ac). Recently southeastern producers have turned away from growing velvet beans since there is a limited market for the crop, strictly involving livestock feeding. Instead, producers exclusively grow conventional crops, such as peanuts and cotton, which have higher net returns at current prices. A peanut-cotton rotation is a fairly common practice in southeastern Alabama.

The benefits of crop rotation have been well documented in professional journals. Taylor and Rodriguez-Kabana (1999a) noted the suppression of root-knot nematode and Southern blight fungus in cotton-peanut and velvet bean-peanut rotations. Both organisms can be suppressed with pesticides, but control with this method is becoming less efficacious and more expensive. According to their findings, the limited effect of peanuts following one year of cotton increased the peanut yield by 691.9 kg/ha and two years of cotton followed by peanuts increased peanut yields by 1227 kg/ha. One year of velvet beans preceding peanuts increases peanut yields by 654.5 kg/ha, while two years of the crop prior to peanuts increases the peanut yield by 1096 kg/ha (Taylor and Rodriguez-Kabana, 1999a).

Conway (1996) states that "one of the major objectives of sustainable agricultural systems is to reduce inputs into crop production." One way to lower inputs is to include crop rotations in monoculture agricultural systems. He states that crop rotation is a natural type of soil sanitation. Conway referenced Sumner, Doupnik, and Boosalis (1981) when showing the benefits of 2-4 year rotations of non-host crops (such as corn or sorghum) with peanuts, which can significantly decrease inoculum of Southern blight fungus following a severe outbreak and reduce the occurrence of root-knot nematodes (Conway, 1996).

Under the Farm Security and Rural Investment Act of 2002, producers enjoy greater flexibility with respect to their planting decisions. Under the 1996 FAIR Act, cotton program payments were decoupled from planting decisions, but peanuts remained under a marketing quota system. The Farm Security and Rural Investment Act of 2002 substantially changed the farm policy for peanuts. Peanut quotas were eliminated, and the current program provides for payments to producers based on past production. Producers may now plant alternative crops on their historical peanut acreage without loss of farm program payments. Also, there are sections in the current farm bill that may benefit producers such as subsidies that promote soil conservation and environmental awareness. An alternative use for velvet bean, such as for a biomass feedstock, improved soil quality, and higher subsequent cotton and peanut yields, may help persuade producers to include this low-input crop in their current crop rotations. In addition, the 2002 Farm Bill contains a section that allocates funds for biomass research and development. Nineteen projects received $23 million in fiscal year 2003. A total of $22 million is offered for 2004 (Duffield and Shapouri, 2003).

Other legislation also affects the economic feasibility of energy crops. The Energy Policy Act of 1992 established a 10-year 1.5 cents per kilowatt-hour production tax credit (PTC) for privately owned as well as investor-owned wind projects and biomass plants using dedicated crops (closed-loop) brought on-line between 1993 and 1994, respectively, and June 30, 1999. In addition, the Act instituted the Renewable Energy Production Incentive (REPI), which provides a 1.5 cents per kilowatt-hour incentive, for generation from biomass and other forms of renewable energy, to tax-exempt publicly owned utilities and rural cooperatives (Moore, 1996). The credit has been adjusted upward for inflation, to reach 1.8 cents per kilowatt-hour. The Economic Security and Recovery Act of 2001 included a two-year extension of the credits, which are now due to expire in December 2003. The Energy Policy Act of 2003, which contains provisions affecting biomass sources for energy, is currently stalled in the Senate.

Energy subsidies, provided to plants for use of co-fired biomass, could raise demand for biomass to the point where velvet beans become economically attractive. An issue that has been studied on only a limited basis is how much electric plants would have to pay agricultural producers to ensure an adequate supply of this crop.

Data and Methods

Enterprise budgeting and linear programming were used to find the prices at which velvet beans become profitable crop alternatives on south Alabama cotton and peanut farms. Yield data for the enterprise budgets came from field tests performed from 1993 to 1998 at the Wiregrass Substation in Headland, Alabama. Rotations considered were: continuous peanut, velvet bean-peanut, cotton-peanut, velvet bean-velvet bean-peanut, and cotton-cotton-peanut. The experimental yields are reported in Table 1.1. Energy crop yield data were not collected for many of the trials, as indicated.

For the purpose of the model, the experimental yields were adjusted downward to reflect farm condition yields. Peanut yields were deflated by 22 percent to represent an expected yield under producer's field conditions (Taylor and Rodriguez-Kabana, 1999a). Machine-picked lint cotton yield was only 20 percent of the hand picked seed cotton yield. The yield from machine-picked cotton is only 50 percent of hand-picked seed cotton and lint cotton is only about 39 percent of seed cotton yield (Taylor and Rodriguez-Kabana, 1999b). The adjusted yields are reported in Table 1.2. The adjusted yields were used to compute the percentage increase in yields resulting from crop rotation effects.

Alabama Cooperative Extension System enterprise budgets for south Alabama were used for the variable and fixed costs of producing cotton and peanuts, as well as for the base yields (without rotation) of these crops. Since there is no recent enterprise budget for velvet beans, one was developed using information provided by the Alabama Cooperative Extension System and from the Alabama Agricultural Experiment Station. A yield of 15692 kilograms (about 7 ton/ac) per hectare was used in the budget, the approximate yield achieved in the experimental plots. Because velvet beans need some type of structural support to grow upright, they are intercropped with sorghum and the cost of sorghum seed is included in the budget. The velvet bean budget is reported in Table 1.3.

In the budgets, the expected price for peanuts was set at \$0.44 (\$400/ton) per kilogram and price for lint cotton was \$1.28 (\$0.58/lb) per kilogram. The price received for dry velvet bean biomass was parameterized, over the range \$0.033 (\$30/ton) per kilogram to \$0.05 (\$45/ton). The returns above variable costs from the enterprise budgets were imported into a linear programming model, which included the rotation restrictions under the assumption of equilibrium cropping patterns, and a land restriction. The land available for production was limited to 404.7 hectares (about 1000 acres), which is a representative, average-size, commercial cotton-peanut farm in the southeast region of Alabama. The linear programming model, for the "base" situation of \$0.033 per kilogram biomass, is reported in Table 1.4.

In the model, with the yield of biomass held constant at 15692 kg/ha, the price for a kilogram of biomass began at the base level of \$0.033 and increased parametrically until velvet beans entered the solution as part of a rotation, and then again until continuous velvet bean was found to be optimal.

To find price sensitivity, the price received for lint cotton was then varied over the range of \$0.99/kg (\$0.45/lb) to \$1.54/kg (\$0.70/lb) and the biomass yield was varied from 8,967 kg/ha (4 ton/ac) to 20,175 kg/ha (9 ton/ac).

Results

Model results are reported in Table 1.5. When the energy crop is priced below \$0.0396 per kilogram of biomass, the farm would select a cotton-cotton-peanut rotation. When the energy crop is priced between \$0.0396 and \$0.0397 per kilogram of biomass, a velvet bean-velvet bean-peanut rotation is selected. At or above \$0.0398 per kilogram, it would be optimal to plant velvet beans only. The increased energy crop prices were associated with increased returns above variable cost for the farm.

Table 1.6 and 1.7 show the price sensitivity analysis of the velvet bean-velvet bean-peanut and continuous velvet bean rotations. When cotton prices reach \$1.32 per kg., continuous cotton and continuous velvet bean rotations compete for resources. As cotton prices decrease below \$1.32 per kg., the velvet bean- velvet bean-peanut and cotton-cotton-peanut rotations are competing for the limited resource (land). The decision between the rotations will depend on the price received for the velvet bean biomass and the potential biomass yield per hectare.

Results of this analysis support those found by De La Torre Ugarte et al. (2003). Using a market-level simulation tool (POLYSYS), they found that at a price of \$0.044 per dry ton for switchgrass, 17 million hectares of cropped, idled, pasture or CRP acres would be converted to biomass production.   Our farm-level analysis discovered a similar energy price would be necessary to convert traditional cropland to biomass production.

Discussion

Velvet beans are not economically attractive in a rotation on a representative south Alabama cotton and peanut farm until the price reaches $0.0396 per kilogram of biomass. Producers will have to be offered at least this price at the farm gate before they can consider the rotation above a cotton-cotton-peanut rotation. For producers to grow only velvet beans, the price must increase to $0.0398 per kilogram of biomass.

As velvet bean yields vary and the price of cotton changes, price received for velvet bean will be the determining factor when producers have to make planting decision. At a lint cotton price of $1.32/kg, the prices at which velvet bean biomass must reach is between $0.032 and $0.73 per kilogram, depending on the biomass yield (between 8,967 and 20,175 kg/ha). As cotton prices increase, the price for the biomass must also increase so that the velvet bean rotation can remain competitive for limited resources.

Depending on the distance of a farm from a power plant and the outcome of the pending federal legislation, which includes incentives for co-firing biomass, prices in this range of those found in this study to induce velvet bean production could be realized in the near future.

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Table 1.1. Actual Yields of Cotton, Peanut, and Velvet Beans Grown on Wiregrass Experiment Farm Located in Headland, Alabama

	Year:	1993		1994		1995		1996		1997		1998	
		Yield	**Crop**	**Yield**	**Crop**	**Yield**	**Crop**	**Yield**	**Crop**	**Yield**	**Crop**	**Yield**	**Crop**
Plot Number	**2**	2875.2	P	4665.4	P	4041.5	P	4231.4	P	2468.3	P	2983.7	P
	4	-	VB	5424.9	P	-	VB	4801	P	-	VB	3526.2	P
	6	2550.1	CT	5207.9	P	3987.3	CT	4855.3	P	2902.3	CT	3634.7	P
	8	-	VB	-	VB	5560.5	P	15340.3	VB	-	VB	3987.3	P
	9	2658.6	CT	2142.8	CT	5587.6	P	2983.7	CT	2631.1	CT	4068.7	P

Yield in kilogram per hectare. P = peanuts. VB = velvet beans. CT = cotton.

Table 1.2. Yields from Experiment Farm Adjusted to Simulate Real Farm Conditions

	Year:	1993		1994		1995		1996		1997		1998	
		Yield	**Crop**	**Yield**	**Crop**	**Yield**	**Crop**	**Yield**	**Crop**	**Yield**	**Crop**	**Yield**	**Crop**
Plot Number	**2**	2242.7	P	3639	P	3152.4	P	3300.5	P	1924.6	P	2327.3	P
	4	-	VB	4231.4	P	-	VB	3744.9	P	-	VB	2750.4	P
	6	510	CT	4062.7	P	797.5	CT	3787.1	P	580.5	CT	2835.1	P
	8	-	VB	-	VB	4337.2	P	15340.3	VB	-	VB	3110.1	P
	9	531.6	CT	428.6	CT	4358.4	P	596.7	CT	526.2	CT	3173.7	P

Yield in kilogram per hectare. P = peanuts. VB = velvet beans. CT = cotton.

Table 1.3. Enterprise Budget for Velvet Beans/Grain Sorghum Mix

Velvet bean for biomass
ESTIMATED ANNUAL COSTS PER ACRE
FOLLOWING RECOMMENDED MANAGEMENT PRACTICES 7 TON YIELD;

ENTERPRISE ACREAGE ======> 1 <=====

ITEM	UNIT	QUANTITY	PRICE OR COST/UNIT	TOTAL PER ACRE
Gross Receipts				
Velvetbean/grain sorghum	Ton	7	30	210
VARIABLE COSTS				
SEED (velvetbean)		1	30	30
Seed (sorghum)	LBS.	5	1.2	6
FERTILIZER				
NITROGEN	LBS.	0	0.28	0
PHOSPHATE	LBS.	0	0.2	0
POTASH	LBS.	0	0.15	0
LIME (PRORATED)	TONS	0.33	22.5	7.425
HERBICIDE	ACRE	0	6.75	0
INSECTICIDE	ACRE	1	0	0
TRACTORS & EQUIPMENT	ACRE	1	42.86	42.86
LABOR (WAGES & FRINGE)	HOUR	5.49	6.5	35.71
INTEREST ON OP. CAP.	DOL.	61.00	0.075	4.57
TOTAL VARIABLE COST				126.57
Income Above Variable Costs				83.43

Costs of production drawn from Alabama Cooperative Extension System budgets.

Table 1.4. Linear Programming Model for Velvet Bean, Cotton, and Peanut Crops in South Alabama

	year 1			year 2		year 3			
	vb	conpt	ct	pbrot	pcrot	p2brot	p3c2c1		RHS
Objective	83.43	34.82	152.51	103.25	103.64	187.40	194.69	MAX	
bprotc	-1			1				LE	0
cprotcon			-1		1			LE	0
bbprotc	-0.5					1		LE	0
ccprotc			-0.5				1	LE	0
Land	1	1	1	1	1	1	1	LE	1000

Table 1.5. Results of Linear Programming Model for Parameterized Velvet Bean Prices

Price Per kg. of Velvet bean Biomass	Optimal Rotation	Optimal Gross Net Return on 1000 Acres
Less than $0.0396	Cotton-Cotton-Peanut	$125,367.20
Between $0.0396 and $0.0397	Velvet bean-Velvet bean-Peanut	$125,413.90-$125,927.20
$0.0398 and above	Velvet bean-Velvet bean-Velvet bean	$125,985.80

Table 1.6. Results of Price Sensitivity Analysis for Velvet Bean-Velvet Bean-Peanut Rotation

	Lint Cotton Prices (Dollars/kg.)					
Biomass Yield (kg/ha)	$0.99	$1.10	$1.21	$1.32	$1.43	$1.54
8,967	0.043	0.053	0.063	0.073	0.083	0.094
11,208	0.034	0.042	0.051	0.058	0.066	0.075
13,450	0.029	0.035	0.042	0.049	0.055	0.062
15,692	0.024	0.030	0.036	0.042	0.047	0.053
17,934	0.021	0.026	0.032	0.036	0.042	0.046
20,175	0.019	0.023	0.028	0.032	0.036	0.042

Table 1.7. Results of Price Sensitivity Analysis for Continuous Velvet Bean Production

	Lint Cotton Prices (Dollars/kg.)					
Biomass Yield (kg/ha)	$0.99	$1.10	$1.21	$1.32	$1.43	$1.54
8,967	0.069	0.069	0.069	0.073	0.083	0.094
11,208	0.056	0.056	0.056	0.058	0.066	0.075
13,450	0.046	0.046	0.046	0.049	0.055	0.062
15,692	0.040	0.040	0.040	0.042	0.047	0.053
17,934	0.035	0.035	0.035	0.036	0.042	0.046
20,175	0.031	0.031	0.031	0.032	0.036	0.042

DO ECONOMIES OF SIZE EXIST ON PEANUT FARMS IN THE SOUTHEAST?

Introduction

The theory of economies of size has been discussed for many years in the agricultural industry. According to Arne Hallam (1991), an associate professor at Iowa State University, production agriculture in the U.S. has been characterized as an industry with many firms and few barriers to entry. However, since World War II, farm numbers have decreased while size has increased. This trend may indicate that larger farms are more economically efficient in that they may have decreasing average costs and increased overall output. Given the ongoing changes in agricultural structure, there should be greater interest in competitiveness and social issues.

Hallam (1991) included three areas of interest in economies of size and scale. The first issue deals with international competitiveness and changes in trade policies. In one country, economies of size may be exploited in order to maximize domestic welfare, while in another country, economies of size maybe subdued in order to protect an industry and accomplish other social goals (Hallam 1991, p. 155).

Another area of interest in economies of size concerns family farms. According to Hallam (1991), “if research shows that there are no economies of size for firms larger than ‘typical’ family farms, then policies that protect this entity are more palatable to those who argue for economic efficiency as a primary objective (Hallam 1991, p. 155).”

The third area of interest in economies of size is related to structural changes in the agricultural industry. Changes in technology, consumer preferences, and world conditions have forced industries to adapt. If these trends were capable of being predicted and understood, individual firms would be able to reduce uncertainty, consumers' stress about buying decisions would be eased, policy makers would be able to implement programs that are optimal for reaching desired goals, and investors would be able to make more educated decisions on the allocation of resources (Hallam 1991, p. 155-156).

Peterson (1997) looked at the efficiency of different size farms in the long run. In his paper "Are Large Farms More Efficient" he points out three measurement problems that can affect the estimates of return to scale in agriculture. The first problem deals with combining the farm dwellings with capital inputs. He states that the agricultural census asks respondent to report the value of land and all buildings, which includes the house. If the house is included in this category, the house is included as an input but its service flow does not show as farm output. Many small farms main output is from service flows, so there is an upward bias of inputs and a downward bias of output (Peterson, 1997).

The next problem with estimates of returns to scale is that yields are usually substantially higher on large farms compared to small farms. According to Peterson, this should be of concern since "a plant or an animal does not know if it is growing on a large or small farm (Peterson 1997, p.2)." If management and environmental conditions are held constant, the difference in yield can only be attributed to differences in the characteristics of the land. Large farms are usually situated on large, rectangular fields which require less travel time between fields and less turning times per acre. These factors lower the costs per unit output. Instead of being economies of scales, Peterson terms this situation "economies of fertile soil and large, level fields (Peterson 1997, p.6)."

The final problem is how to deal with off-farm employment. Producers on small farms are more likely to take off-farm work to help subsidize the farm income. With less time available, the level of management becomes less intensive. However, the opportunity cost is the risk of not planting and harvesting crops in a timely manner, which may lower the returns from the farm and lead to a reduction in the off-farm earnings. However, Peterson argues that these producers are not socially wasteful if their take-home pay from the farm and off-farm work is greater compared to what they would have earned from farming only. Peterson also points out that managerial ability is not the same between large and small farms. It is more difficult to manage a large farm than it is a small farm. It is assumed, therefore, that the long run average total curve begins to turn up at some level because of the limitation of managerial skill (Peterson, p.3-4).

Peterson used the 90 observations in ten Corn Belt states (IL, IN, IA, MI, MN, MO, NE, OH, SD, and WI) which came from the 1987 agricultural census. He categorized the farms into nine different classes based on total sales. By basic observation he noted the difference in yields between the smaller farms and the larger farms. As mentioned above, the differences may be attributed to land quality, off-farm employment, and/or managerial ability. He first ran a model using only variables for the different classes with the middle size as the reference dummy. In a second model, he included two additional variables**:** "corn yield" as a proxy for the differences in managerial skill and land quality (such as field size and topography), and "days of off-farm work," which would explain the differences in employment. Average total cost per dollar of output is the dependent variable in both models.

In the first model, farms with less than $10,000 of sales had a positive relationship to the long run average total cost per dollar of output, while larger farms had negative relationship. The second model, including the "corn yield" and "days of off-farm work" variables, resulted in a negative relationship to long run average total cost per unit of output for farms with less than $10,000 of sales. Larger farms had a positive relationship to the average total cost. Also, the "corn yield" variable had a negative relationship to the long run average total cost per dollar of output. This implies that land quality and managerial differences influence costs per dollar of output. Peterson notes that the "days of off-farm work" variable has a positive relationship to long run average total cost per unit of output and is highly significant, which means that part-time farmers may have higher costs due to more repairs and have the lack of timeliness associated to planting and harvesting. Peterson concluded that factors other than size can influence unit costs in agriculture. The factors include the quality of land and management and the impact of off-farm employment, which influence output and output costs. When considering these factors, Peterson found that small farms and part-time operators are at least as efficient as large farms, and that diseconomies of scale may exist as farm size increase (Peterson 1997, p. 12-13).

Tew et al. (1980) looked at the issue that lower prices are paid for variable inputs if purchased in large quantities. The theory that explains this phenomenon is called pecuniary internal economies of size. If this theory is true, large farms are not necessarily more physically efficient but they are more cost efficient because of these discounts. Tew et al., however, also note that there are other reasons why input prices may vary. He mentions that prices of firms at different locations vary due to interrelationship between volume of sales and technological economies of size, varying transportation costs between manufacturing and retail outlets and the seasonal nature of agricultural production. Also, prices may vary because of geographic differences and the specialization of farm firms. It may also be possible that large farms are able to purchase inputs during periods of seasonal low prices because of readily accessible financial capital and storage facilities (Tew et al. 1980, p. 151-152).

In Tew et al. (1980), results show that there is evidence of pecuniary economies of size provided by some input prices, but there is little effect on total cost per acre. The differences in total costs per acre were negligible for those variable inputs, with a difference in per acre total selected variable input costs being $0.55 between 10 and 500 acres. This study supports the assumption of constant input costs (Tew et al. 1980, p. 153).

Technology and management skills have also been identified as variables that may affect average total costs. Larger farms may have more access to new technologies and better managers, which may allow these farms to allocate their resources more efficiently. However, it is difficult to quantify and collect data on these variables.

Problem Statement

The problem that will be looked at in this paper is if economies of size exist on peanut farms located in the southeastern region of the United States. There have been many journal papers written that support the contention that, as farm sizes increase, variable and fixed costs per unit of output decrease. This paper will look at average variable, fixed, and total costs per unit of output (pounds of peanuts), and determine if the costs per unit of output on a peanut farm decrease as farm size increases. The dependent variables studied are variable input costs such as fertilizer, seed, pesticide, and labor and fixed input costs such as depreciation, interest, taxes (property), and insurance. The primary occupation, age of producer, and level of education may affect the result so these variables should also be included in the analysis.

In the short run, the typical average total cost curve is often believed to be "U"-shaped with increasing return to size that leads to a minimum point where return to size is constant, and then a section of the curve where there is decreasing return to size. This decreasing returns to size section on average total cost curve is due to increasing demand for management and increasing average fixed costs.

If the theory of economies of size holds in peanut production, the average total cost curve would be much flatter. This would suggest increasing return to scale as output increases. The problem is that it is difficult to find the proper functional form to model this curve. Mafoua suggests using a flexible fixed cost quadratic model for multi-product firms. This framework allows producers to answer questions such as:

> "Are three-crop farms more cost efficient than two-crop or single-crop farms?"
>
> "How important are economies of scope (fixed-cost and variable-cost components) in two-crop and three-crop farms? (Mafoua 2002, p.1)"

Since this paper is only looking at one enterprise (peanuts), the flexible quadratic model may not be the proper form to model economies of size.

Other researchers have suggested using a log-linear or trans-log model to analyze a set of data accurately. In this paper, a quadratic model will be used to analyze average cost per unit of output.

Conceptual Model

Three conceptual models will be used to analyze economies of size. The dependent variables for the models will be average variable cost, average fixed cost, and average total cost, with respect to a unit of output. Since farms that use irrigation in peanut production have different costs (such as depreciation and interest) compared to dryland production, the data for the models were separated into dryland and irrigated.

The conceptual models will be in the following forms

1.) AVC=F(PA,EDU,PO, AGE)
2.) AFC= F(PA,EDU,PO, AGE)
3.) ATC= F(PA,EDU,PO, AGE)

Where,

AVC=average variable cost
AFC=average fixed cost
ATC=average total cost
PA=peanut acres
EDU=level of formal education
PO=primary occupation
AGE=age of producer on last birthday

Empirical Specification of the Model

The empirical specification of the quadratic model is:

$$AC=\beta_0+\beta_1 PA+\beta_2 PA^2+\beta_3 EDU+\beta_4 PO+\beta_5 AGE+\varepsilon$$

The independent variables may affect the average total cost per unit of output differently. If economies of size do exist, then as peanut acres increase, average total cost should decrease, which would demonstrate that producers of larger farms are able to produce the crop more cost efficiently.

The level of education is hypothesized to have a negative affect on average total cost. As the level of education increases, average total cost should decrease since it assumed that a knowledgeable producer is better able to reduce cost relative to output.

It is hypothesized that farms that are operated by full-time producers would have a lower average total cost per unit of production as compared to part-time and retired producers. The average fixed cost (depreciation and interest) for full-time farmers may be higher than part-time/retired farmers due to the expense of operating newer equipment. However, part-time/retired farers may have higher average variable costs because machinery on these farms may require more repairs.

The age of the producer may also affect the average total cost per unit of output. Younger producers may have higher fixed costs because of higher interest and depreciation costs compared to older producers. The higher interest costs may be due to the reliance on borrowed capital. These younger producers may also be classed as high risk and may have higher interest rates due to the lack of capital assets. Young farmers may also have more depreciation compared to older producers because they may buy newer equipment while older producers may choice not to invest in new equipment as they approach retirement.

Data

The data are from the “Peanut Farm Cost and Returns Survey 2001” which was administered through the National Center for Peanut Competitiveness, National Peanut

Board, Southern Peanut Farmers Federation, University of Georgia, Auburn University, and University of Florida. Producers from Alabama, Florida, and Georgia were surveyed about farm size, yields, costs (variable and fixed), varieties of peanuts, demographic characteristics of producer and the location of farms (region and state). The data are cross-sectional collected from different peanut producers over one time period (2001). Of the 750 producers surveyed, some respondents did not complete questions that were on the survey needed to run the model. The total number of usable respondents is 152. There are 107 dryland producers and 45 producers who used irrigation in peanut production.

The acres in peanut production on the farms surveyed ranged in size from 4 acres to 1300 acres. The average size in dryland peanut production is 111 acres and land in irrigated peanut production averages 230 acres. Most of the producers had at least completed high school, with some having some college education and others completing college. The average age of the producers was 52 and most worked full-time on the farm.

Average total cost was found by summing total fixed costs and total variable costs. The total cost was then divided by total output (pounds of peanuts produced). The variable expenses were for fertilizer, lime, other nutrients, herbicides, insecticides, fungicides, seed, and any other inputs that were used to produce peanuts. The fixed cost was the amount of depreciation, insurance, property taxes, and interest used to produce peanuts. Producers indicated on the survey the percentage of the farm’s total fixed cost that was attributed to peanut production.

Respondents of the survey identified the total pounds of peanuts that were produced on their farm in 2001. This value is used to find the total pounds of peanuts produced by the individuals.

Producers indicated on the survey how many acres of peanuts they planted in 2001. The total acres include land rented for free, rented land, share-rent land, and land owned by the producer. Excluded from this value is land rented to other producers.

In the survey, producers were asked how much formal education they received. The producers were given 5 possible responses: 1) Did not complete high school, 2) Completed high school, 3) Some college, 4) Completed college, 5) Graduate school. For "education" variable**,** producers who had at least completed some college level courses, completed college, and/or pursued a graduate level degree received the value "1". Producers who did not go to college received the value "0".

Producers were asked on the survey about their primary occupation. This question was used to characterize producers for the "primary occupation" variable. If the producer indicated that he/she worked full-time on the farm, the value "1" was assess to that individual. For individuals who indicated that they were retired or had a primary occupation other than farming, they received the value "0".

In the survey, producers also indicated their age. This is used to determine if age will affect unit cost.

Regression Results

The data for the dependent and independent variables were imported into SAS and OLS estimators were calculated for each independent variable using a quadratic functional form. Tables 2.1 through table 2.3 are the results for the dryland peanut production and tables 2.4, 2.5, and 2.6 are the results for the irrigated peanuts.

As mentioned in the “Empirical Specification of the Model” section, it is hypothesized that peanut acres, education, primary occupation, and age will have negative affects on average cost per unit of output.

Table 2.1 shows the results for average variable cost per unit of output (pounds of peanuts produced) for dryland peanuts. None of the independent variables are significant at the 90% confidence level, but some may be economically important. The estimated peanut acre coefficient is negative which means it would decrease the average variable cost per pound of peanuts produced. The education and primary occupation variables are also negative. Age variable resulted in a positive coefficient. The R-squared is 0.035 which means the estimated model does not fit the data well.

In table 2.2, the results for dryland average fixed cost per unit of output show that peanut acres has a positive affect on the average fixed cost. However, the variable is not significant. The education, primary occupation, and age estimated coefficient are negative, which was hypothesized, but these are not significant either. The R-squared is 0.018.

Table 2.3 is the results for average total cost per unit of output in dryland production. The coefficients for this estimated model are not significant and the R-squared is 0.014. The peanut acre coefficient is positive, which will increase the average total cost per unit of output. Education and age coefficients are negative while primary occupation is positive.

Tables 2.4, 2.5, and 2.6 are the results for average variable cost, average fixed cost, and average total cost, respectively, per pound of peanuts produced on irrigated peanut farms. In table 2.4, the peanut acre and primary occupation coefficients are negative, while the education and age have positive coefficients. None of the coefficients are significant at the 90% confidence level and R-squared is 0.08.

Table 2.5 shows the results for average fixed cost per unit of output. The peanut acre coefficient is negative, but not significant. The estimated coefficients for education, primary occupation, and age are positive, which is the opposite of the affect on average fixed cost per unit of output that was hypothesized. These coefficients are not significant at the 90% confidence either. The R-squared for this estimated model is 0.11.

The results in table 2.6 for average total cost per unit of output are similar to the results in table 2.5. Education, primary occupation, and age coefficients have a positive affect on average total cost, and none of the coefficients are significant. The coefficient for peanut acres is positive but it is not significant. The R-squared for this model is 0.11.

All of the models were tested for heteroskedasticity using a test of first and second moment specification in the SAS program. None of the models tested positive for heteroskedasticity.

In addition to the regression analyses already reported, t-tests were also performed to test the hypothesis that large farms have lower unit costs. The hypothesis of identical per unit costs could not be rejected.

Discussion

The results of the estimated quadratic model did not indicate any return to scale for average variable cost, average fixed cost, or average total cost per pound of peanuts produced. None of the coefficients in the six models are significant at the 90% confidence level. However, some of the estimated coefficients may be economically important. The coefficients may have an affect on average cost per unit of output if some variables were included, for example technology. These specification issues may have over- or under-estimated the coefficients.

Data that could be included in the model to explain technology were not available in the response to the survey. Technology could affect the average cost per unit of output and fit the estimated model to the data. Larger farms may implement newer technology that might increase the farms initial expense. However, these farms may have a higher return on investment, which would lower average cost per unit of output.

It may be of interest that the education variable is estimated to have a negative affect on average variable cost, average fixed cost, and average total cost per unit of output for dryland production. However, the estimated coefficient for education for irrigated production is positive in the three cost models. The results of the education coefficient cannot be deciphered because none are significant at the 90% confidence level.

Overall, the results may be of economic importance. The affects of the coefficients may become significant if more data was available. A variable for technology may have helped estimate a better fit for the model. Also, if time-series data were included with the cross-sectional data, it may have helped explain changes in the cost structure across all farms.

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Table 2.1. Estimated Average Variable Cost per Pound of Peanuts Produced on Dryland Farms

Variable	Coefficient	T-Value	R-squared = 0.0355
Constant	0.1759	2.32	
PA[1]	-1.7563 E-4	-0.58	
PA[2]	2.5911 E-7	0.45	
EDU[3]	-0.0319	-1.04	
PO[4]	-0.0139	-0.34	
AGE[5]	8.531 E-4	0.73	

Note: 1) Peanut acres; 2) Peanut acres squared; 3) Level of education (0=high school or less and 1=college or above); 4) Primary occupation (0=part-time/retired and 1=full-time); 5) age of the producer

Table 2.2. Estimated Average Fixed Cost per Pound of Peanuts Produced on Dryland Farms

Variable	Coefficient	T-Value	R-squared = 0.0176
Constant	0.0961	1.43	
PA[1]	1.9609	0.73	
PA2[2]	-2.7360 E-7	-0.54	
EDU[3]	-0.0136	-0.50	
PO[4]	-0.0076	-0.21	
AGE[5]	-9.0346 E-4	-0.87	

Note: 1) Peanut acres; 2) Peanut acres squared; 3) Level of education (0=high school or less and 1=college or above); 4) Primary occupation (0=part-time/retired and 1=full-time); 5) age of the producer

Table 2.3. Estimated Average Total Cost per Pound of Peanuts Produced on Dryland Farms

Variable	Coefficient	T-Value	R-squared = 0.0135
Constant	0.272	2.57	
PA[1]	2.046 E-5	0.05	
PA2[2]	-1.4492 E-8	-0.02	
EDU[3]	-0.0455	-1.06	
PO[4]	0.0215	-0.38	
AGE[5]	-5.028 E-5	-0.03	

Note: 1) Peanut acres; 2) Peanut acres squared; 3) Level of education (0=high school or less and 1=college or above); 4) Primary occupation (0=part-time/retired and 1=full-time); 5) age of the producer

Table 2.4. Estimated Average Variable Cost per Pound of Peanuts Produced on Irrigated Farms

Variable	Coefficient	T-Value	R-squared = 0.08
Constant	0.0630	0.76	
PA[1]	-9.89 E-6	-0.06	
PA2[2]	-2.5647 E-8	-0.18	
EDU[3]	0.0496	1.57	
PO[4]	-0.0013	-0.03	
AGE[5]	0.0011	0.91	

Note: 1) Peanut acres; 2) Peanut acres squared; 3) Level of education (0=high school or less and 1=college or above); 4) Primary occupation (0=part-time/retired and 1=full-time); 5) age of the producer

Table 2.5. Estimated Average Fixed Cost per Pound of Peanuts Produced on Irrigated Farms

Variable	Coefficient	T-Value	R-squared = 0.11
Constant	-0.0074	-0.32	
PA[1]	-4.766 E-5	-1.04	
PA2[2]	2.4960 E-8	0.65	
EDU[3]	0.0141	1.62	
PO[4]	0.0132	1.01	
AGE[5]	3.9560 E-4	1.15	

Note: 1) Peanut acres; 2) Peanut acres squared; 3) Level of education (0=high school or less and 1=college or above); 4) Primary occupation (0=part-time/retired and 1=full-time); 5) age of the producer

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Table 2.6. Estimated Average Total Cost per Pound of Peanuts Produced on Irrigated Farms

Variable	Coefficient	T-Value	R-squared = 0.11
Constant	0.0556	0.62	
PA[1]	-5.755 E-5	-0.32	
PA2[2]	-6.876 E-10	-0.00	
EDU[3]	0.0638	1.87	
PO[4]	0.0119	0.23	
AGE[5]	0.0015	1.14	

Note: 1) Peanut acres; 2) Peanut acres squared; 3) Level of education (0=high school or less and 1=college or above); 4) Primary occupation (0=part-time/retired and 1=full-time); 5) age of the producer

Overall Conclusion

Peanut producers in southeast may have to decide on innovative ideas in order to maximize profits and minimize costs when faced with lower farm gate prices. Two ways that producers can reach these goals are through crop rotation and expansion of peanut acres. With crop rotations, producers may be able to increase peanut yields, have higher returns when producing nontraditional crops, and lower input costs because of the benefits of the rotation (for example lower the incidence of soil parasites). If economies of size exist on peanut farms, producers can also increase peanut acres in order to lower average cost per unit of output.

In “Economic Feasibility of an Energy Crop on a South Alabama Cotton-Peanut” section, velvet beans are analyzed as possible rotation crop with peanuts and cotton in southeast Alabama. Velvet beans could be profitable for producers if the energy industry realize its economic benefits when used in the co-firing process of electrical generation. Producers would not shift from a cotton-cotton-peanut rotation to a velvet bean-velvet bean-peanut until a price of $41.00 per ton of dry velvet bean biomass. At a price of $45.00 per ton of dry biomass, continuous velvet bean production would be optimal for producers.

The regression results in the section “Do Economies of Size Exist on Peanut Farms in the Southeast?” are not significant as to whether economies of size exist at the average variable, average fixed, or average total cost level. The outcome does not imply that economies of scales do not exist on peanut farms because either some critical data or variables were possibly excluded from the model. One possible variable that is not included in the model is technology since the data is not available from the survey used in the analysis.

In conclusion, southeast Alabama peanut producers will have to look at alternative production practices in order to remain in business. As stated prior, these producers could implement a rotation that included a bioenergy crop, or, if further research implies that economies of size exist, they could possible increase peanut acres.