Strategic Options for the Virginia Peanut Industry After the 2002 Farm Bill: a Linear Programming Model

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Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Master of Science
In
Agricultural and Applied Economics

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October 7, 2005

Blacksburg, Virginia

Keywords:

Peanut production, Virginia-type peanuts, Vertical Coordination, Linear Programming

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ABSTRACT

The passage of the 2002 Farm Bill and the removal of the peanut quota system revealed underlying fundamental problems in the Virginia peanut industry. Lower yields and high costs plague producers at the farm level, acreage levels continue to decline and it is doubtful that peanut production in Virginia will continue at levels seen in the past. The structured market due to the quota system has provided little incentive in the past for technological investment. Investment in technology such as high oleic peanuts and capturing value at the consumer level are seen as ways to improve the situation in Virginia. In particular increased coordination at all levels of the supply chain would be needed to ensure that the consumer is brought a product with characteristics they desire.

The literature provides ample information regarding the formation of alliances and coordination in general. According to Cozzarin and Barry (1998), vertical integration, similar to vertical alliances are set up for the following reasons: mitigating transactions costs, taking advantage of output or input price differentials of a competitor, and reducing uncertainties in costs and/or prices. Cozzarin and Barry (1998) also note that there is an increasing move toward vertical coordination in many agriculture sectors, the reasons cited for the current trend include: a) the growing influence of consumers in controlling the agri-food agenda; b) the increasing marketing power of large food companies; and (c) technological changes that necessitate coordination. Of these three reasons, the peanut industry falls under the first two.

Vertical coordination is seen to be a solution when two or more entities are able to accomplish more efficiently their objectives than they are able to on their own. For the peanut industry, the agency theory and in particular principal-agent theory is the most applicable to the peanut industry. A linear model is used to examine the effects of increased coordination along the supply chain. The linear model also provides a snapshot of how decisions made at the farm level reverberate through the entire supply chain. The linear model includes the comparison of increased profits due to premiums at the consumer level.

Results of the linear model indicate that the Virginia peanut industry will have difficulty maintaining current production levels without investment in the sector, without changing the way the supply chain operates. Principal-agent theory and specifically the work done on contracts in the pork and poultry industries provide a framework within which the peanut industry could avoid asymmetric information and moral hazard. This study attempts to identify underlying problems along with possible solutions or the Virginia peanut industry.

DEDICATION

I dedicate this work to Regina Kroll.

ACKNOWLEDGEMENTS

I would like to thank first and foremost Dr. James Pease and Dr. Wayne Purcell for their help throughout the research and writing of this project. I have learned a tremendous amount from each about life and peanuts. I would also like to thank Dr. Daniel Taylor for his comments on this study and in particular for his support and willingness to help in any way throughout my studies here at Virginia Tech. I would also like to thank Mike Roberts and Pat Phipps for their advice and expert opinion throughout this process.

I would like to thank my fellow classmates Steve Buck, Ewa Kleczyk, Jason Maupin, and Jacob Ricker-Gilbert for their support and their friendship. I would also like to thank my roommate Jilian Fath, without whom Blacksburg would not have become a welcoming place near as fast.

Last, but certainly not least I want to thank my family, my parents and four sisters. To my parents James and Patricia for their unwavering faith in me and the values they instilled in me. To my sisters Amy, Laura, Susan and Maria for being one of the greatest gifts in my life, for their support and their love.

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CHAPTER 1: INTRODUCTION and BACKGROUND

1.1 PEANUT INDUSTRY OVERVIEW

U.S. peanut farmers produced an estimated 5.142 billion pounds of peanuts in 2005 (NASS, 2005). Peanut production in the U.S. is concentrated in three different regions: the Southeast: Georgia, Alabama, Florida and South Carolina; the Mid-Atlantic: Virginia and North Carolina; and the Southwest: Texas, Oklahoma, and New Mexico. U.S. producers' account for around 10% of total peanut production in the world, with export competition coming primarily from China and Argentina. For U.S. peanut producers, policy has always played an important role in marketing and growing decisions. Policy implications are felt up and down the supply chain, with changes affecting more than just producers. The removal of the quota program from U.S. farm program benefits has left U.S. and in particular Virginia peanut farmers adjusting to a new market environment.

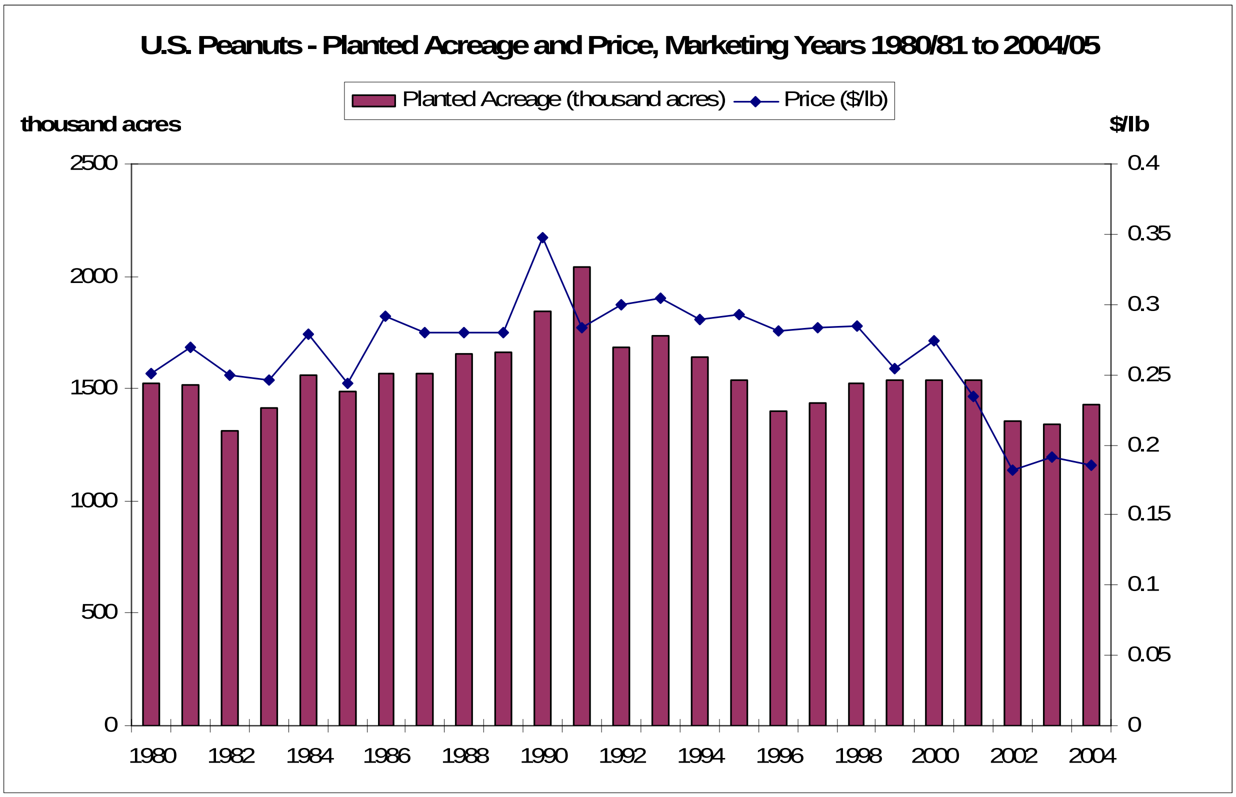
1.1.1 U.S and VIRGINIA MARKET OVERVIEW

There are four market-type peanuts grown in the U.S.: runners, Valencia, Spanish, and Virginia type peanuts. Runner peanuts, grown primarily in Georgia, Alabama, Florida, Texas, and Oklahoma, have become a popular variety due to their uniform kernel size and good yields. Runner peanuts are high in oil and over half are used in peanut butter. Valencia peanuts are grown primarily in New Mexico. Valencia's are typically roasted and sold in-shell. Spanish peanuts are grown in the Southwest region of the United States particularly Texas and Oklahoma. The high oil content makes this variety ideal for crushing to be used as peanut oil. The majority of Spanish peanuts are used in candies with some used for the snack peanut market and in peanut butter (Virginia-Carolina Peanuts, 2004).

The Virginia-type peanut is noted for its large kernel size and dominates the roasted peanut and processed in-shell markets. Virginia and North Carolina previously produce about 80% of all Virginia type peanuts, however the Mid-Atlantic region accounts for only around 10-15% of total U.S. production (NASS, 2005). Recently the Southwest region has taken some of the market share from the Virginia/North Carolina region.

With the passage of the 2002 Farm Bill market supply and demand fundamentals have changed dramatically. A decline in both production and price has occurred at the national level for American farmers (Figure 1.1).

Figure 1.1: U.S. Peanuts, Planted Acreage and Price



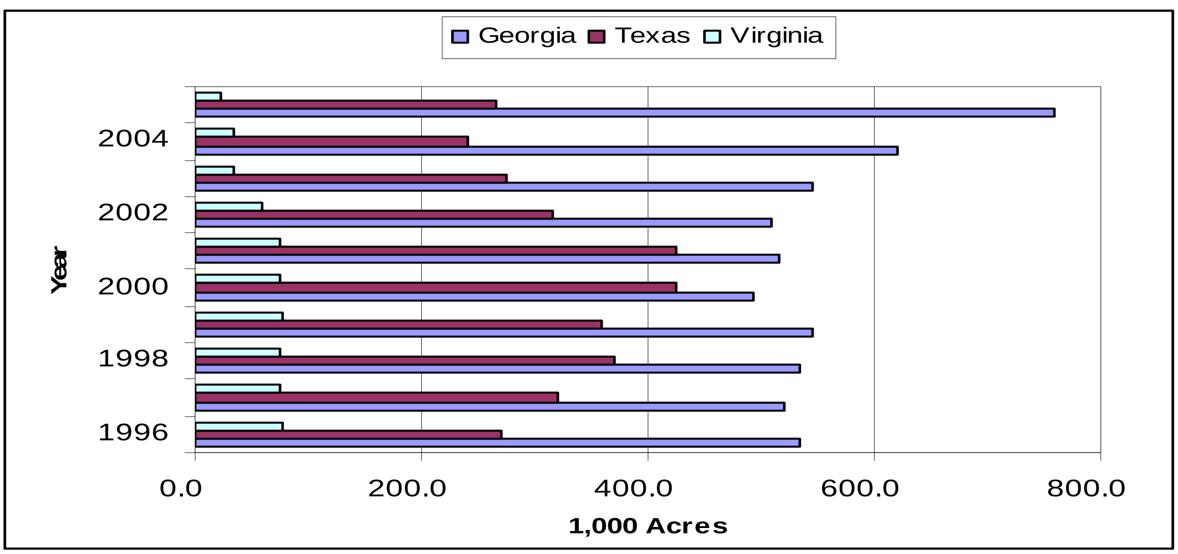
Source: NASS, USDA. Crop Production, various years. NASS, USDA, Ag Prices, various years.

Production in Virginia is concentrated in the Southeast corner of the state, primarily in the jurisdictions of Dinwiddie, Greensville, Isle of Wight, Prince George, Southampton, City of Suffolk, Surry and Sussex. The state of Virginia produced an estimated 104,000,000 pounds of peanuts in 2004, up slightly from the drastic decline to 95,700 pounds in 2003. Recent production peaked in 1990 at 309,915,000 pounds (NASS). From 1990, 2003 production declined 69 percent. Forecasts for 2005 are even lower at 67,200 pounds (NASS).

The decline in acreage and production is due to changes in farm policy by the U.S. government. The 2002 Farm Bill sanctioned the removal of the quota system and reduced marketing loan rates from $610 to $355 per ton. Specific details regarding past and present policy is discussed later in this chapter.

Planted acreage in 2001, was 75,000 acres. In 2002 planted acreage declined 23% to 58,000 acres and then even further to 34,000 acres in 2003. In 2004, planted acreage was estimated at 35,000 in Virginia and 2005 acreage is even lower, estimated to be only 24,000 planted acres. In just four years, acreage has dropped 51,000 acres. Some of the decline in the past four years may have been drought induced, but even with some decline attributed to drought, there has been a significant move away from peanut production in Virginia. Texas and North Carolina are seeing declines in acreage, but Virginia has seen the largest percentage decline. Some states are increasing peanut acreage (Figure 1.2).

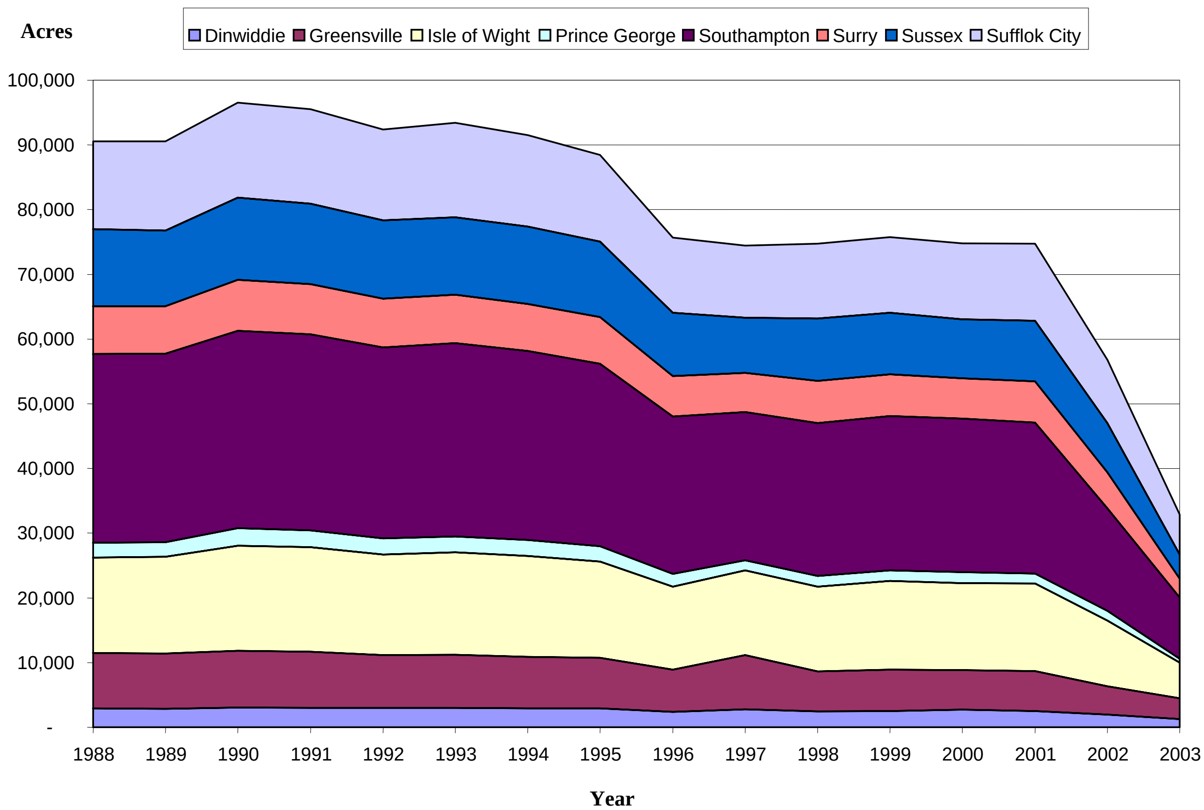
Figure 1.2: Georgia, Texas and Virginia Planted Acreage, 1996 -2005



Source: National Agricultural Statistics Service, USDA. Crop Production 1996-2005

Unlike North Carolina, the land taken out of production in Virginia has not been replaced by production in other Virginia jurisdictions as there is not other land suitable for growing peanuts (Figure 1.3).

Figure 1.3: Virginia Peanut Acreage by County, 1990-2003



Source: Virginia Agricultural Statistics Service Bulletin, 1988-2003.

Acreage losses in the top three producing areas have been replaced in part by increased acreage in corn, soybeans, wheat and cotton. However, looking back over the past census data it is clear that for the most part acreage has been lost entirely to enterprises outside of agriculture. Table 1.1 looks back at the last four agriculture census and compares the changes in number of farms and acreage in farms for the top three producing jurisdictions in Virginia. With the exception of Isle of Wight, there has been a reduction in planted acreage for these jurisdictions.

Table 1.1: Select Virginia Jurisdiction Census Data

County	2002		1997		1992		1987	
	# of Farms	Acreage	# of Farms	Acreage	# of Farms	Acreage	# of Farms	Acreage
Southampton	275	168,709	277	185, 496	329	178, 469	407	188,832
Suffolk City	247	70,592	218	76,222	268	83,047	314	87,761
Isle of Wight	204	86,521	190	88,030	212	86,247	245	83,901

Source: NASS, 1987, 1992, 1997, 2002 Census Data

Analysis of model farms in the six major peanut producing states by Pease et al. (2003) indicated that the financial health of Virginia farmers was undesirable both before and after the quota program was removed. With the exception of Alabama, Virginia peanut producers were in the poorest financial position. Virginia producers' situation was due to higher debt and higher depreciation expenses than farms in the other six states studied (Pease et al., 2003).

According to the USDA's cost-of-production budgets for 2004, Texas, Oklahoma, and New Mexico (Southwest region) have a significant advantage over the Virginia/North Carolina (VC or Mid-Atlantic) region. Operating costs which include seed, fertilizer, chemicals, custom operations, operating and repair costs for machinery, irrigation costs, and interest on operating inputs, for the Southwest are estimated at $253.15 per acre while the VC areas operating costs are $345.66 (ERS). The Virginia/North Carolina operating costs are $38.59 per acre higher than the U.S. average of $307.07. The largest discrepancy between this area and the rest of the U.S. are the costs associated with chemicals. The Virginia/North Carolina region spends 207% more on chemicals than the Texas, Oklahoma, and New Mexico region (ERS). Total costs per acre are 12.8% higher than the Southwest and the Virginia/North Carolina region does not make up this difference in yield. Reports from processors in Southeast Virginia indicated that Texas is the primary source of supply for production losses seen in Virginia and North Carolina (Garner, 2004). Table 1.2 details the USDA's estimated peanut production costs for the different regions in the United States.

Table 1.2: Peanut production costs per planted acre, USDA estimates

	United States 2002	Southwest 2002	AL, GA 2002	VA,NC 2002
	dollars per planted acre			
Operating costs:				
Seed	73.57	60.66	75.38	93.24
Fertilizer	39.09	21.68	47.42	43.96
Chemicals	92.18	38.52	115.14	143.60
Custom operations	9.92	12.63	9.55	4.25
Fuel, lube, and electricity	41.62	61.50	31.44	26.57
Repairs	30.93	34.24	30.10	27.43
Interest on operating inputs	2.60	2.11	2.75	2.88
Commercial drying	17.16	21.81	17.57	3.73
Total, operating costs	307.07	253.15	329.35	345.66
Allocated overhead:				
Total, allocated overhead	346.72	401.63	315.86	350.12
Total costs listed	653.79	654.78	645.21	695.78

1/ Developed from survey base year, 1995.

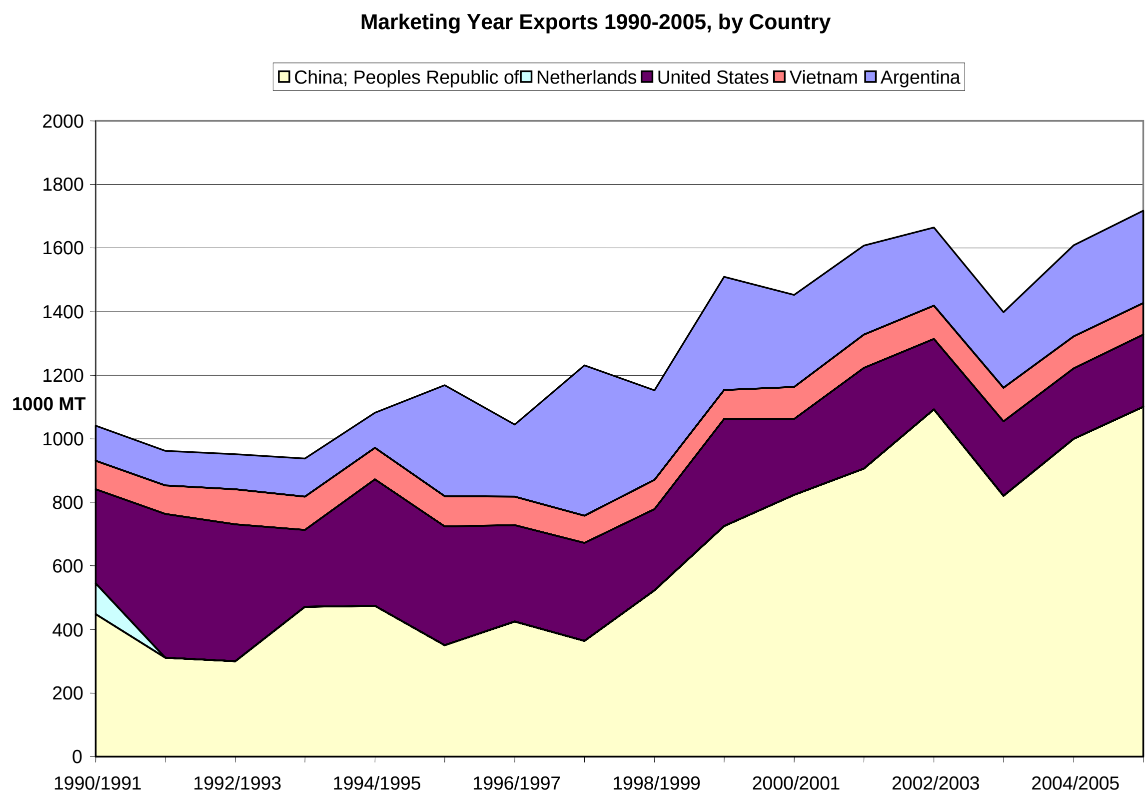
Source: USDA, ERS, commodity costs and return budgets, 2005

As is evident, the ability of Virginia peanut producers to compete in the U.S. market, much less the world market, on a cost basis only is sub par at best. This indicates that perhaps peanut production in Virginia should be discontinued if producers cannot compete with other producers in the United States and foreign countries. However, peanut production in these jurisdictions in Virginia provides income to producers and to others in related economies. Alternatives in 2005 for the land in peanut production, such as cotton or other commodities, are only temporary solutions as these commodities will eventually come under pressure from world trade and producers will find themselves in a similar situation.

1.1.2 WORLD SITUATION

Besides the changes in the farm bill making domestic competition more prevalent, peanut producers now face stiffer competition from imports as well, although the world market does continue to be somewhat of a residual market for most countries (Revoredo and Fletcher, 2002). In the past, imports have played a negligible role in the U.S. domestic peanut market and have accounted for around only 1% of total consumption. Previous farm policy dictated that import restrictions exist in order to keep oversupply from occurring as foreign production could have undercut the domestic price. However, various trade agreements are nearing their final days and access to the U.S. market for foreign competitors will increase. Several agreements involving tariff rate quotas (TRQs) have eliminated much of the restriction to U.S. markets both for peanuts and peanut products. Import quota changes are the result of negotiations from the Uruguay Round Agreement on Agriculture (URAA) and the North American Free Trade Agreement (NAFTA). TRQ's allow for a certain amount of product to enter the market at a lower tariff rate and imports above that level are subject to a much higher tariff. The U.S. agreed to a more open market and the percentage allowed at the lower TRQ level increased in both of these meetings. With the higher levels, current imports are about 6% of domestic use and will continue to climb (Dohlman, 2003). Under NAFTA, all imports from Mexico will be tariff-free by 2008 (Dohlman, 2004). Overall world trade and the world market is becoming more and more important as each year trade barriers decrease. Figure 1.4 shows the increase in world trade through exports by country.

Figure 1.4: Marketing Year Peanut Exports, 1990 – 2005, by country

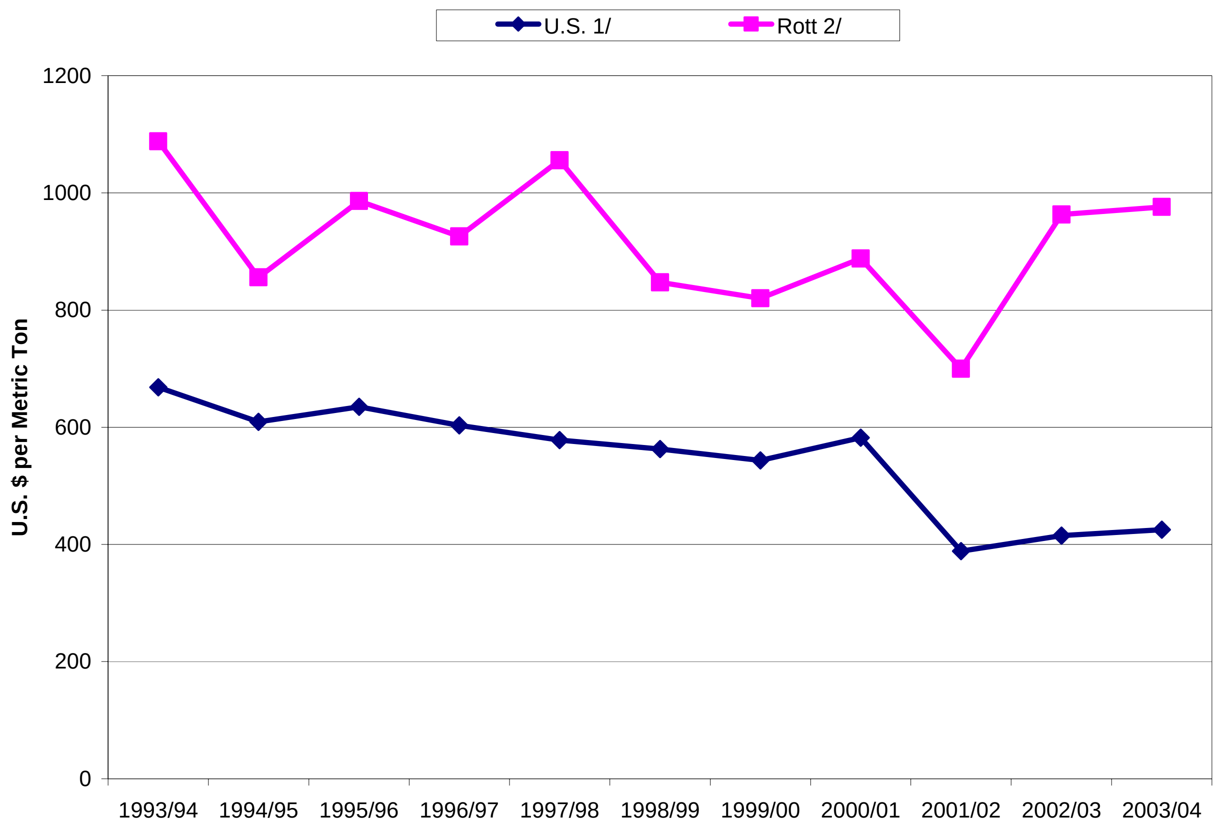


Source: USDA, Production Supply & Disappearance database. 2005

Virginia producers and U.S. producers in general will be forced to compete with the lowest cost producer in the world. Thus adapting to the new market dynamics and moving away from a commodity based market will become essential. As seen with other commodities, it may become increasingly difficult to compete with foreign countries strictly on a cost basis as foreign countries typically achieve lower cost of production due to cheaper inputs especially when examining labor costs.

However, the U.S has become more competitive in the last two years as the U.S. and world prices are converging. Figure 1.5 shows U.S. domestic prices compared with world prices. World production continues to increase, but there are also indications that demand for peanuts may be on the rise as well. Peanuts are one of the few foods that are beneficial both to consumers that are overweight and those underweight. Peanuts have high energy density as well as being filling (Kirkmeyer and Mattes, 2000). Exploiting this trait could increase world demand for peanuts.

Figure 1.5: U.S. and World Peanut Prices, Oct-Sept Average



1/ U.S. farm price in-shell USDA. 2/ Rott CIF; US Runners 40/50%, Shelled Basis, Oil World.

Source: Foreign Agricultural Services, Cotton , Oilseeds, Tobacco and Seeds Division, 2005

1.2 POLICY ENVIRONMENT

1.2.1 FARM PROGRAM HISTORY AND CURRENT BENEFITS

Modern farm policy dates back to 1933. After World War I, prices fell as Europe started to recover from the war and demand for U.S. goods waned (Becker, 1999). With the Great Depression, farmers saw further decline in prices, so the Agriculture Adjustment Act of 1933 was passed as part of the New Deal legislation. The new farm policy included mandatory price supports, direct subsidy payments, and supply controls (Becker, 1999). During the 1960's as farm programs for other major commodities moved away from supply control, peanut policy continued to utilize quotas to support farmers. Production continued to be restricted and prices were higher for peanuts grown for the domestic edible market versus those grown beyond the quota. In 1981, Congress changed the acreage allotments to poundage quotas (Becker, 1999). At that time, quotas could not be sold across county or state lines. In 1990 the peanut program changed to support increases in production costs and the peanut loan rate was raised to $678/ton. Unfortunately, the poundage quota set by the government was greater than actual demand and the government began to build stocks of peanuts. With the buildup of stocks, political pressures began to grow to reduce the cost of the program and movement toward abolition of the quota system began (Becker, 1999).

The 1996 farm bill, the Federal Agriculture Improvement and Reform Act (FAIR), moved to further limit the role of the U.S. government in agricultural markets (Becker, 1999). Planting flexibility for U.S. farmers was introduced and Agriculture Market Transition Act (AMTA) payments had no connection to actual plantings in the current year. For peanut producers the loan rate for peanuts grown under quota was reduced to $610/ton, down from the $678/ton under the 1990 program. The 1996 policy also eliminated the minimum poundage quota and allowed the USDA to set an annual poundage quota based on expected demand for the coming year. Peanuts marketed without quota protection were called "additionals" and could be exported or marketed in the U.S. for nonedible uses, but the loan rate for these peanuts was set at $132/ton, well below production costs (Becker, 1999). Quota rights could be sold across county lines, allowing for acreage to move to the low-cost regions within states. Texas saw acreage shift from Central Texas to West Texas. Other states saw fewer transfers of quota rights. (Pease et al., 2003) However, quota rights were still kept within state boundaries, allowing states to maintain acreage at historical levels, despite lower production costs in other areas of the United States. The farm program supports under the 1996 bill were still at a level that did not precipitate a drastic shift in the market dynamics. However, increasing concern over farm subsidies in Washington as the United States struggled to comply with World Trade Organization (WTO) agreements resulted in significant changes when the 2002 Farm Bill was passed (Dohlman, 2003).

In 2002, Congress passed the Farm Security and Rural Investment Act of 2002 (FSRI), which eliminated the peanut quota system and the guaranteed price for domestic edible production. Instead peanut producers now face a farm program similar to grains and cotton. The 2002 Farm Bill included a loan rate of $355/ton, direct payment of $36/ton, and a target price of $495/ton (Dohlman, 2003). The 2002 Farm Bill also provided a buyout program for those holding quota rights. Direct payments and target price payments are not tied to production, but are instead determined based on historical production. Peanut producers now have the same planting flexibility as the other major commodities with all producers having access to all facets of the program. Producers in Virginia now face direct competition from all other areas of the United States. Table 1.3 from the USDA provides a comparison of the 1996 farm bill and the new farm program, detailing the changes now in effect for all peanut producers in the United States.

Table 1.3: 1996 FAIR Act and 2002 FSRI Act

Provisions	**1996-2001 farm legislation**	**2002 Farm Bill**
Peanuts		
Price support	Quota peanuts (those for domestic edible consumption) and "additional" peanuts are two different classifications.	Direct and counter-cyclical payments, and nonrecourse loans with marketing loan provisions. Quota is eliminated. Quota buyout is provided for previous owners.
	The support rate for quota peanuts is $610 per short ton, reduced from $678 in 1995. Loans for "additional" peanuts is set at $132/ton. The marketing assessment, shared by growers and purchasers, was 1.15% of the loan rate for the 1996 crop and 1.2% for 1997-2002 crops.	Producers with or without a history of peanut production are eligible. The peanut loan rate is fixed at $355 per ton. Producers can pledge their stored peanuts for up to 9 months and then repay the loan at a rate that is the lesser of 1) $355 per ton plus interest or 2) a lower, USDA-determined repayment rate designed to minimize commodity forfeiture, government-owned stocks, and storage costs and to allow peanuts to be marketed freely and competitively, both domestically and internationally.
Direct payments	No similar provisions.	A new direct payment of $36 per ton is available to peanut producers. These payments are fixed and are made regardless of current prices. Payments are made on eligible base period (1998-2001) peanut production.

Table 1.3 Cont.: 1996 FAIR Act and 2002 FSRI Act

Provisions	1996-2001 farm legislation	2002 Farm Bill
Peanuts		
Counter-cyclical payments	Supplemental legislation provided payments to peanut producers in CY 2000 and 2001.	Peanut producers are eligible for new counter-cyclical payments when market prices are below an established target price of $495 per ton. The payment is based on the difference between the target price and the higher of: • the 12-month national average market price for the marketing year for peanuts plus the $36-per-ton fixed direct payment, and • the marketing assistance loan rate of $355 per ton plus the $36-per-ton fixed direct payment. Payments are made on eligible base-period (1998-2001) peanut production.
Payment yields and base acres for peanuts	No similar provisions.	Payment quantity for direct payments and counter-cyclical payments is the product of payment yields and payment acres. Payment yields are determined as the average yield on the farm for CY 1998-2001. Historic peanut producers may elect to assign county average yields for 1990-97 for not more than 3 of the 4 years. Payment acres are determined as 85% of average area planted for CY 1998-2001. Adjustments are provided for prevented plantings.
Quota buy-out (compensation for loss of quota asset value)	The minimum national quota and provisions for carryover of under-marketings were eliminated. Quota was redefined to exclude seed use but temporary seed quotas were granted. Government entities and out-of-State nonfarmers could not hold quotas. Sale, lease, and transfer of quota were permitted across county lines within a State up to specified amounts of quota annually.	Marketing quota for peanuts is repealed. Quota owners receive compensation for the lost asset value of their quota in 5 annual installments during FY 2002-06. An annual payment of $0.11 per pound of quota is made to eligible quota holders based on 2001 quota levels. Quota owners may opt to take the outstanding payment due to them in a lump sum.

Source: Economic Research Service, USDA. Farm Bill, Title I- Commodity Programs.

http://www.ers.usda.gov/Features/farmbill/titles/titleIcommodities.htm#e

1.2.2 MARKET RISK TOOLS AVAILABLE

For peanut producers in the United States, much of the price risks that other commodity producers faced were mitigated by the quota program. Market risks are greater now that the quota price support system has been eliminated. According to Blank et al. producer risk is best determined by examining the variability of annual income levels which are the product of variability in output price, input prices, input quantities and yield. Thus many markets have price risk tools as well as yield risk tools. Price risk tools include forward cash contracts and/or hedging through a futures market. The yield risk tool used in the United States is primarily crop insurance. There is only one insurance program available to peanut producers, the Multiple Peril Crop Insurance (MPCI) program. According to information from the USDA, the MPCI program is designed to protect farmers from yield losses occurring from natural causes. In 1994, low-cost catastrophic coverage was introduced along with an increase in premium subsidies (ERS). Peanut producers do not have access to the other major insurance program offer by the USDA, Revenue Insurance. Revenue Insurance is designed to cover revenue losses below a certain level whereas MPCI's focus is on yield levels only.

There currently is no futures market for peanuts and thus hedging is not an option for producers in Virginia. The peanut industry in the United States is too small to allow for the volatility that would be needed to ensure a futures market that was able to manage risk. Processors also face the task of securing inputs that are perishable, seasonable and volatile while having to maintain a relatively stable end-product price (Leiffer, 1990). Producers, shellers, and processors are thus without a price risk tool unless forward contracting is used. Even with the forward contracting, there are price discovery issues and risks that are difficult to manage without a futures market. The futures market in other commodities allows for all participants to take information and adjust expectations of supply and demand on a second by second basis and adjust prices and other factors accordingly.

1.2.3 GRADING STANDARDS

With increased competition from both U.S. producers and foreign producers, the producers and shellers and manufacturers involved in the Virginia peanut market need to adapt and change. The current grading and quality standards are inadequate. U.S. peanut standards focus primarily on size and visible characteristics of the peanuts. However, surveys indicate that taste and health attributes are important when making purchasing decisions about in-shell and shelled peanuts (Rimal et al., 2000). While it may be impractical to update the current standards due to the requirements set out by the USDA for a change in grading standards, increased coordination and technological investments could be an adequate substitution. This would allow for identification of health and taste preferences that the consumer desires. Currently high oleic variety peanuts are being developed and grown in some areas of the United States. This variety of peanut and studies conducted on the traits of these varieties indicate health benefits which are not valued by the current grading standards.

Grading standards as defined by the USDA are detailed and specific but focus primarily on the size of the peanut and whether or not the peanut is left in the shell. Table 1.4 and 1.5 detail the current specifics for all Virginia-type peanuts.

Table 1.4: U.S. Peanut Grading Standards, Grades and Definition of Cleaned Virginia-type in the Shell Peanuts

Type	Specifications
U.S. Jumbo Hand Picked	i. Consists of cleaned VA type peanuts in the shell which are mature, dry and free from loose peanut kernels, dirt or other foreign material, pops, paper ends and from damage caused by cracked or broken shells, discoloration or other means.
	ii. Peanuts shall not pass through a screen having 37/64 x 3 inch perforations.
	iii. Unless otherwise specified, shall not average more than 176 count per pound

Table 1.4 Cont.: U.S. Peanut Grading Standards, Grades and Definition of Cleaned Virginia-type in the Shell Peanuts

Type	Specifications
U.S. Fancy Hand Picked	i. Consists of cleaned VA type peanuts in the shell which are mature, dry and free from loose peanut kernels, dirt or other foreign material, pops, paper ends and from damage caused by cracked or broken shells, discoloration or other means.
	ii. Peanuts shall not pass through a screen having 32/64 x 3 inch perforations.
	iii. Shall not average more than 225 count per pound
Unclassified	i. Consists of cleaned VA type peanuts in the shell, which fails to meet the requirements of either of the foregoing grades.
	ii. This is not a grade, simply shows that no definite grade has been applied to the lot.
Definitions	i. Mature – means that the shells are firm and well developed
	ii. Pops – Means fully developed shells, which contain practically no kernels.
	iii. Paper Ends – means peanuts which have very soft and/or this ends
	iv. Damage – means any injury or defect, which materially affects the appearance, edible or shipping quality.
	1. Cracked or broken shells – shells which have been broken to the extent that the kernel within is plainly visible w/o minute examination and with no application of pressure, or appearance is materially affected.
	2. Discolored shells – dark discoloration caused by mildew, staining or other means affecting ½ or more of the shell surface. Peanut shall be judged as it appears with the talc.
	3. Rancid or decayed kernels
	4. Moldy kernels

Table 1.4 Cont.: U.S. Peanut Grading Standards, Grades and Definition of Cleaned Virginia-type in the Shell Peanuts

Type	Specifications
	5. Sprouts extending more than 1/8 inch from the end of the kernel
	6. Dirty kernels
Definitions	7. Wormy kernels
	8. Kernels, which have dark yellow color penetrating the flesh.
	v. Count per pound – means the number of peanuts in a pound, one single kernel peanut shall be counted as ½ peanut.

Source: AMS, USDA, United States Standards for Grades of Cleaned Virginia Type in the Shell Peanuts, 1997

Table 1.5: U.S. Peanut Grading Standards, Grades and Definition of Shelled Virginia-type Peanuts

Type	Specification
U.S. Extra Large VA	i. Consists of shelled VA type of similar varietal characteristics which are whole and free from foreign material, damage and minor defects
	ii. Not pass through a screen having 20/64 x 1 inch openings
	iii. Not average more than 512 per pound
U.S. Medium VA	i. Consists of shelled VA type of similar varietal characteristics which are whole and free from foreign material, damage and minor defects
	ii. Not pass through a screen having 18/64 x 1 inch openings
	iii. Not average more than 640 per pound
U.S. No. 1 VA	i. Consists of shelled VA type of similar varietal characteristics which are whole and free from foreign material, damage and minor defects
	ii. Not pass through a screen having 15/64 x 1 inch openings
	iii. Not average more than 864 per pound

Table 1.5 Cont.: U.S. Peanut Grading Standards, Grades and Definition of Shelled Virginia-type Peanuts

Type	Specification
U.S. Virginia Splits	i. Consists of shelled VA type of similar varietal characteristics which are free from foreign material, damage and minor defects
	ii. Not pass through a screen having 20/64 inch round openings
	iii. Not less than 90%, by weight, shall be splits
U.S. No. 2 VA	i. Consists of shelled VA type of similar varietal characteristics which may be split or broken, but are free from foreign material, damage and minor defects
	ii. Not pass through a screen having 17/64 inch round openings

Source: AMS, USDA, United States Standards for Grades of Shelled Virginia Type Peanuts, 1997

1.3 HIGH OLEIC ACID PEANUTS

Recent advancement in breeding and identification of peanut traits has lead to the development of high oleic acid peanuts. High oleic acid peanuts have higher levels of oleic acid which increases the shelf life of the peanut as well as providing health benefits to the consumer. Oleic acid has been proven to have health benefits such as lowering blood cholesterol (Kris-Etherton et al, 1999) and lowering risk of developing type II diabetes (Hu, 1998). Widespread use of high oleic acid peanuts as a variety has not been seen in the United States, but other countries such as Australia have seen greater adoption. Interest in high oleic varieties is high among researchers, but cooperation and adoption by producers and manufacturers has been lagging.

1.4 PROBLEM STATEMENT

Virginia peanut producers are some of the highest cost producers in the United States and the world. The nature of the peanut industry is such that producers are operating in a nearly purely competitive environment and Virginia peanut producers are not able to compete in this lowest-cost based market. The change in farm policy has brought to the forefront some of the issues facing the peanut industry and in particular has exposed underlying economic problems and opportunities for the Virginia peanut industry.

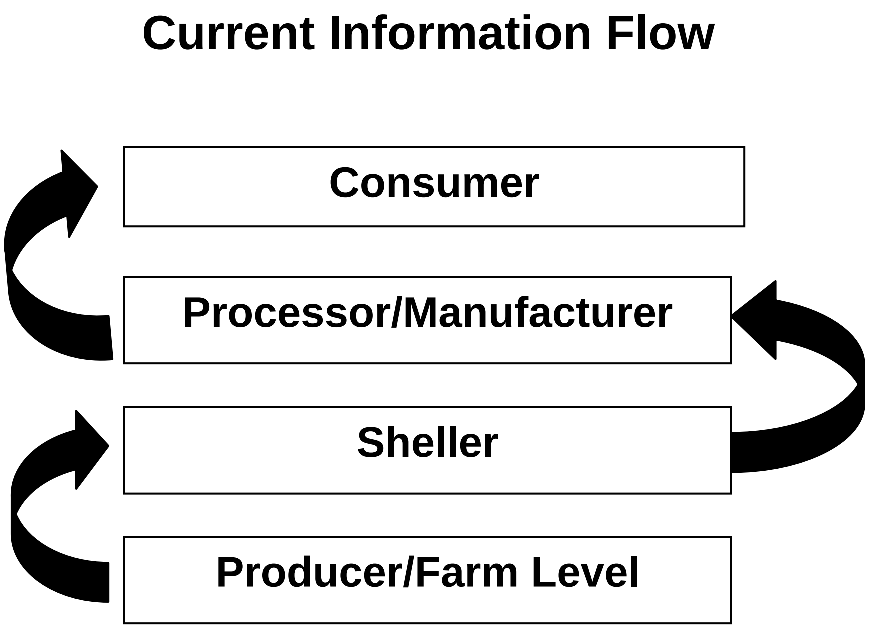
There are several factors putting pressure on the Virginia peanut market. Two of these mentioned previously are the relative high cost of production in Virginia and the lack of market tools to manage this risk. The second is that products in a competitive market are homogeneous goods and current grading standards in the peanut industry are not adequate to set apart Virginia or U.S. peanuts from other varieties and/or from other countries. Additionally, current grading standards do not convey back to the producer those traits important to the consumer.

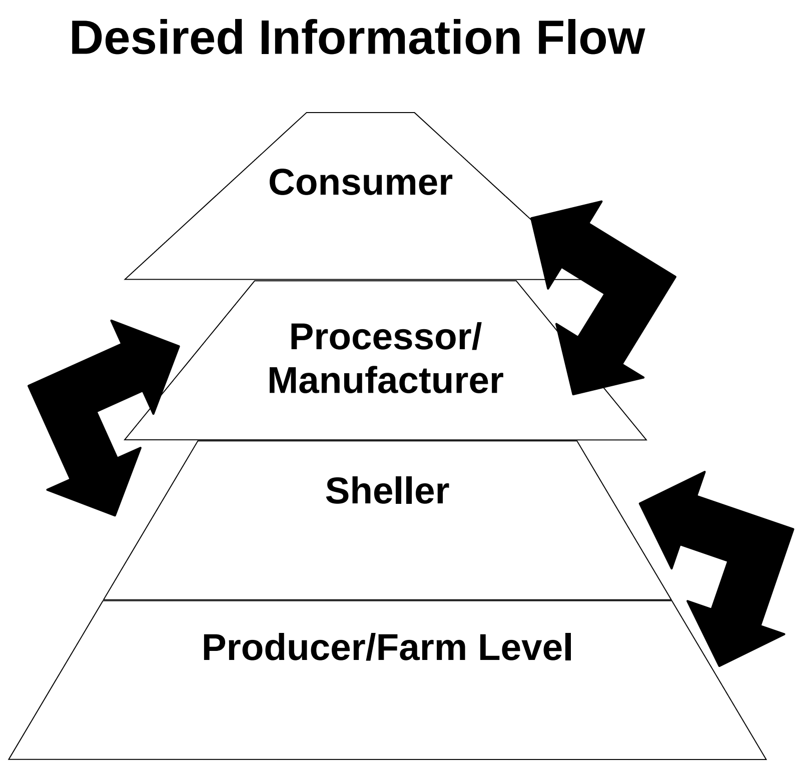
Within the Virginia peanut sector there has not been an aggressive push to move the industry forward nor has there been a significant amount of investment in technology in the peanut sector. A market that was artificially supported by government programs did not provide incentive among participants to focus on investment. Instead we are currently hearing about disinvestment by producers and shellers in the Virginia region. Producers and supporting industries report equipment sales and the closing of shelling facilities in recent years. Processors need assurance that an investment in technology will pay off. Producers need assurance that a market will be available after they make an investment. All sectors need assurance that their investments, which are specific to peanuts, will be able to generate and protect profits. The untapped potential in the market provides an opportunity to explore possible alternatives for the Virginia peanut sector and to keep peanut producers in Virginia from losing profits due to the change in farm policy.

The trend currently seen occurring for Virginia-type peanuts and the peanut industry in Virginia is one that could eventually affect the entire peanut sector. A similar situation developed in the U.S. beef industry and poultry industry. Focusing on characteristics the consumer desires has brought added value to their respective sectors. If peanut production in Virginia is to continue, Virginia peanuts must add value along the entire supply chain and generate methods of vertical coordination that ensure progressive producers and processors have a chance to benefit. One option is to explore the benefits of high oleic acid peanuts in the supply chain and their potential impact for the industry.

Market imperfections such as a lack of price discovery, inadequate risk management strategies, asymmetric and restricted information flow (Figure 1.6), and adjusting to the change from a controlled environment to an open or free market lead to the need for the examination of possible alternatives for entities involved in the Virginia peanut industry. Determining the impact of different managerial decisions and the impact of cooperation among sector participants will allow for the addressing of this problem. Impact in this study is defined as increasing or decreasing profits to the entire sector. Cooperation is defined as advantages from different vertical organizational solutions. Participants in this study include the producer, sheller, processor and consumer of Virginia peanuts.

Figure 1.6: Current and Desired Information Flows





1.5 OBJECTIVES

The main objective of this study is to develop long term strategic planning and management options for the entire Virginia peanut sector in order to move this industry away from a commodity-based market. The following are specific objectives:

- From a baseline model, determine impacts to the supply chain by growing high oleic variety peanuts which have superior health improving qualities, growing runner-type peanuts which have lower production costs, or growing varieties with larger percentages of Jumbo size peanuts which garner a premium.

- From a baseline model, determine impacts to supply chain with changes in grading and or contracting specifications to include premiums from high oleic acid peanuts and the health claims associated with these peanuts.

- To model the benefits/costs of the above strategies to the entire Virginia peanut sector and determine the viability or need to invest in technology by those involved in the Virginia peanut industry.

- To examine steps needed to further coordinate the peanut supply chain in Virginia.

1.6 METHODS

Modeling the Virginia peanut industry and determining the need for further investment in technology by the industry as well as defining possible steps to achieve product differentiation will be based upon development of a baseline model of the current situation, modeling alternatives to the baseline model and examining the steps needed for coordination. A linear programming model of the sector will be used to evaluate different strategies.

- Development of baseline model: Using previous studies as well as expert opinion, estimates for cost and premiums will be estimated for use at the three levels of industry being examined. The first level is the farm level followed by the sheller level and lastly by the processor level and/or consumer level.

- Each alternative will be modeled against the current situation or baseline using expert opinion and similar industries where premiums and studies exist.

- Examination of steps for coordination will be based upon other agricultural industry coordination and the theories surrounding the formation of these organizations.

1.7 THESIS ORGANIZATION

This thesis attempts to address the above questions within the following chapters.

- Chapter 2 provides background information regarding consumer preferences, high oleic acid peanuts and the relevant theory to address the need for organizational changes in the Virginia peanut industry.

- Chapter 3 provides an explanation of the linear model used to evaluate current peanut industry and proposed changes along with explanations of data used for estimation in the model.

- Chapter 4 contains the results of the model.

- Chapter five includes a summary along with limitations and recommendations for the industry.

CHAPTER 2: CONCEPTUAL FRAMEWORK

2.0 INTRODUCTION

The lack of coordination along the supply chain and the asymmetric information between producers and consumers suggests an examination of potential benefits from greater coordination in the Virginia peanut industry is needed. Neoclassical economic theory states that individuals or firms acting rationally will maximize their utility or profit based on the information available to them. Improving the information available to participants should then increase profits. One area where better or more relevant information does not flow easily is between the producers at the very bottom and consumers at the very top of the supply chain. There is considerable literature devoted to vertical coordination along the supply chain. In particular there exists theory surrounding the formation of agricultural alliances all the way up to vertical integration.

This chapter contains conceptual framework concerning:

- Consumer preferences and how such preferences are not served by the current peanut grading standards.
- Properties associated with high oleic acid varieties of peanuts which contain elements that are potential characteristics important to the consumers.
- Theory behind vertical coordination in agricultural industries.

2.1 CONSUMER PREFERENCES

The grading standards discussed in Chapter 1 do not allow for changes in consumer preferences through time. The current grading standards seem to lend themselves primarily to the production and processing of peanut butter. Consumer preferences have changed over time and yet the grading standards are not adequately capturing this change or indicating back to the producer those attributes that the consumer desires and is willing to pay for.

Moon et al. (1999) studied consumer preferences for peanuts in Bulgaria during a transition economy. They specifically examined the effects of product attributes and consumer characteristics on attitude and behavior, and hypothesized that the perceived product attributes and certain household characteristics such as income and location would influence both consumer attitude about peanuts as well as the actual consumption of peanuts. Using Fishbein's multiattribute model, which links the overall attitude of consumers with the perceived attributes, Moon et al. (1999) found that the perceived attributes with respect to taste and price did influence both overall attitude and consumption. Perceived health attributes, while influencing attitude about peanuts, did not directly affect consumption, instead taste and price were the primary determining factors for peanut consumption.

Young et al. (2005) attempted to evaluate U.S. consumer acceptance of peanuts intended for export from the United States, China and Argentina and examine the descriptors associated with peanuts from each country. In the study Young et al. found price and taste to be the most important characteristics among panelists they surveyed. Their study found that peanuts from the United States were described as sweet, aromatic, roasted peanut and dark roast. In contrast, the peanuts from China were characterized by woody/hulls/skins, bitter and sour and the Argentine peanuts were mostly characterized as musty and sweet. The off-flavor of "musty" more often characterized the Argentine peanut when compared with the U.S. peanuts and bitter taste more often characterized the Chinese peanut over the U.S. peanuts. Overall the study determined that U.S. consumers preferred the U.S. peanuts over those from China and Argentina. Their findings suggest that further concentration on the aspects of the U.S. peanuts found desirable by consumers such as the sweet, aromatic and roasted peanut flavors combined with the health benefits from peanuts may be a way to continue to capture at least a portion of the market in the United States. Building on the positive attributes already associated with U.S. peanuts could be the next step in increasing demand for U.S. peanuts.

A study by Rimal and Fletcher (2001) took data from a Gallup poll for the National Peanut Council administered in 1997 and studied the influence of product attributes and household characteristics on consumers' attitude and purchase patterns of in-shell peanuts. Rimal and Fletcher also used Fishbein's multiattribute model to determine the impact of perceived attributes on purchasing behavior. While peanuts are perceived as being high in vitamins and nutrients, they are also believed to be high in fat and high in cholesterol (2001). However, Rimal and Fletcher found that taste was the only attribute that influenced consumers' purchase decision. Consumers' attitudes or beliefs about peanuts did not impact their purchasing decision. Exercise habits did contribute to consumers' attitude regarding in-shell peanuts, but not necessarily their purchase of in-shell peanuts.

While Rimal and Fletcher (2001) as well as Moon et al. (1999) did not find that health attributes impacted buying decisions, emphasizing the health benefits and changing consumers' perception of the positive impact peanuts can have on a diet may become more important in the future. Currently the impact of the low-carbohydrate diets throughout the food industry is being seen. A simple survey of grocery store offerings as well as advertisements on T.V. and in print media indicates a focus on low carbohydrate diets. Thus grading standards, contracts and a production focus on taste and the health benefits from peanuts has the potential to increase the demand for peanuts.

As evident from the tables presented in Chapter 1, the current grading standards evaluate peanuts primarily on a size and color scale. As the above research indicates, these are not the traits that consumers find important and thus there is a breakdown between the consumer level and the producer level. Conveying the message of consumers back to the producer is more readily accomplished with a vertical alliance or coordination at some level. According to Cozzarin and Barry (1998), one of the advantages of vertical alliances is the sharing of information as all sectors work together. Additionally, this should reduce the transaction cost associated with passing information down the supply chain to the producer, with whom the biggest impact on the final product rests. As mentioned previously, recent studies show peanuts as having health benefits such as reducing the risk of heart disease and type II diabetes (Hu, 1998). Peanuts are also high in fiber and contain what many refer to as the “good fat”. None of these attributes are currently being captured by the grading system in place at this time.

Determining the characteristics important to the consumer and the consumer’s willingness to pay for those characteristics is vitally important in determining the future of the Virginia peanut industry. As seen in the literature from above, it is not always true that attitudes about characteristics will translate into buying tendencies. However, taste as a component of buying influences seems undisputed and there is potential in this aspect as Virginia peanuts are noted for their taste and increased shelf life from high oleic acid peanuts would increase customer satisfaction.

2.2 HIGH OLEIC ACID PEANUTS

High oleic acid peanuts refer to those peanuts with a higher level of oleic to lanoleic acid ratio. This trait was found to occur naturally and since that time varieties have been bred to include this trait. High oleic acid peanuts were first bred at the University of Florida in the 1990’s, however the variety was susceptible to tomato spotted wilt virus, and thus widespread adoption has been curtailed as producers’ first experience with these varieties was negative. Since that time other scientists around the United States and Australia have developed varieties that perform better and are on a competitive level with other varieties of runner peanuts (Gorbet, 2004). High oleic acid peanuts are currently being adopted in Australia and there a number of studies detailing the health and shelf life advantages from varieties that possess the high oleic trait. Currently much of the work has been on runner variety peanuts, but Virginia-type peanuts are making gains as well (Gorbet, 2004).

The characteristics of the high oleic acid peanut make it an attractive alternative as the health and shelf-life benefits are traits or characteristics desired by the end consumer as well as the processors further up the supply chain. Australia has already begun to grow and develop a high oleic acid peanut market in their country (Gorbet, 2004). However, there is little awareness at the consumer level regarding the benefits of high oleic acid peanuts in the United States.

Andersen et al. (1998) compared the fatty acid and amino acid profiles of six high oleic varieties of peanuts with ten normal oleic varieties. Their findings indicated that the six high oleic varieties showed improved oil chemistry in regard to the ratio of oleic acid to linoleic acid. Previous studies cited in Anderson et al. contribute the ratio between oleic and linoleic acid to be an indicator of oil stability. Braddock et al. (1995) found that the oleic to linoleic acid ratio is linked to greater shelf life and decreased the rancidity of peanuts. The Braddock et al. study found that the increased shelf life ranged from 5 to 15 times longer than normal peanut varieties. Braddock et al. also found that the high oleic acid peanuts performed better in sensory characteristics such as roasted peanutty, raw beany, cardboardy, painty, sweet, dark roasted/toasted and crunchiness than seen in the normal peanut varieties. Increased shelf life allows for decreased costs to the processor as well as increasing the satisfaction of the consumer.

Health benefits from peanuts and specifically high oleic acid peanuts are beginning to become recognized by the health industry. The Harvard School of Public Health released a study showing that a half serving of peanut butter or an ounce of peanuts eaten five or more times a week is correlated with a lower risk of developing type II diabetes (Hu, 1998). A study from the University of Florida indicated that high oleic acid peanuts combined with a low fat diet have the potential to help lower blood cholesterol (Kris-Etherton et al., 1999). The same study indicated that diets high in “good” fats when compared with a low-fat diet and an average diet indicated that the diet high in “good” fat reduced some of the risk factors for heart disease. The low-fat diet reduced the risk of heart disease by 12% whereas the diet with peanuts and peanut butter (the “good” fats) was found to reduce total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides by 21%. The advantage of peanuts in a diet is that peanuts also lower triglycerides which are a concern for some low-fat diets.

A problem with the current peanut grading system is that increased shelf life, health benefits from a higher proportion of oleic acid, and other traits such as decreased rancidity are not measured. There are also exists the issue of educating the consumer regarding the health benefits of peanuts. The issue regarding the grading system can be addressed through vertical coordination.

2.3 TRANSACTION COST AND VERTICAL COORDINATION THEORY

Even if consumers were willing to pay a premium for high oleic acid peanuts or processors were interested in the benefits from longer shelf life, it is not evident that such information would reach the producers. The producers' decisions have impacts that reach all the way to the consumer and without adequate flow between the two groups, even if consumers are willing to pay, there is no guarantee they will have the opportunity to choose high oleic acid peanuts. Vertical coordination can provide such an avenue for information flow.

2.3.1 OVERVIEW

There has been considerable attention paid to the coordination that occurs vertically within the agriculture market. Literature relating specifically to the peanut industry is harder to find. However, the existing literature referring to vertical coordination provides insight as to some of the logistics behind these markets and the incentive or reasoning behind the coordination. Vertical coordination refers to various levels of coordination along the supply chain. This coordination can be as simple as loose contracts and associations or can be as strict as complete vertical integration between entities. Addressing the needs of the peanut sector and the asymmetric information that exists between consumers and the rest of the supply chain will allow for more efficient and relevant production.

Barry et al. (1992) provides insight into one of the reasons that Virginia peanut industry might benefit from increased cooperation along the supply. Barry et al. (1992) state that the need to differentiate products (i.e. moving away from a commodity based and open market system) at the farm level has put considerable pressure on the market and the relationships of the open market. This pressure may lead to vertical integration and/or contracting. The inability of Virginia peanut producers to differentiate their product from peanuts grown in Texas and other areas will eventually lead to the erosion of their percentage of the in-shell and Fancy markets. Finding a way to differentiate their product through high oleic benefits and taste preferences might allow for a niche to be formed that Virginia growers are able to fill. However, the economic theory dictates that the economic rents Virginia growers would be able to capture would have a limited lifetime if continued investment did not occur.

Cozzarin and Barry (1998) provide a review of the literature on organizational structure in agricultural production alliances. Cozzarin and Barry (1998) identify three driving forces behind the increase in production alliances. The first of these is the increasing power of consumers. As consumers demand healthier and more convenient food options, the agriculture sector has been prompted to meet these new demands. The marketing power of large food companies is also growing, again forcing all entities along the supply chain to coordinate their efforts. Technological advances that allow for greater information about the consumer have also increased the need for coordination. There are three theories surrounding vertical alliances that are examined briefly here: transaction cost theory, agency theories, and resource-based theory. These theories attempt to explain the organization of entities by determining: how risk is managed and shared, incentives for all involved, management responsibilities, and asset ownership (Cozzarin and Barry, 1998).

2.3.2 TRANSACTION COST THEORY

Transaction cost theory was first introduced by Coase in his 1937 article "The Nature of the Firm". Transaction costs are those activities not directly related to production that are required to carry out the functions of the firm. Coase (1937) maintained that the primary objective of firms was to minimize these costs. Williamson's (1997) work took Coase's theory further and he defined transaction costs as the "economic equivalent of friction in physical systems". Transaction cost theory states that if two firms can internalize these transaction costs, then a vertical alliance or vertical coordination will ensue. Williamson (1997) describes transaction cost economics as the study of economic organization of all kinds. Transaction cost theory as a reason for organization has application for the peanut sector especially when considering 'idiosyncratic' transactions or 'hostage resources'. Idiosyncratic transactions are those transactions that require significant investment in highly specific technology. The more specific the asset or technology then the greater the transaction cost and the more likely long-term and complicated contracting or vertical integration will be used (Barry et al., 1992). For the peanut industry, determining what the consumer is willing to pay for and investing in the technology to assure quality and consistency for the consumer in these areas poses a cost that will require some sort of assurance or insurance through long term contracting or even stricter coordination as suggested above.

Transaction cost theory then is the idea that firms would engage in coordination in an effort to reduce their transaction costs. Barry et al. (1992) caution that the more specific the asset or technology that is already available or has to be invested in, the greater the transaction costs for redirecting this asset, and thus the contracts involved will be more complex and possibly longer term due to this risk. Complexity and length of contract are two areas of difficulty that can arise when vertical coordination occurs. Transaction cost theory provides a base reason for the benefits associated with vertical coordination. The following three theories look more closely at the relationships between the entities involved with specific attention paid to the principal-agent theory.

2.3.3 AGENCY THEORY

The Agency Approach includes both principal-agent theory and positive agency theory. Positive agent theory views the firm as a group of contracts and entities, instead of a principal-agent relationship. The contracts must provide efficient monitoring and bonding devices in order to minimize costs and negate moral hazard. The positive agency theory also states that integration or coordination should allow for valuable private information to move freely between parties. In smaller alliances it is easier to reduce the moral hazard that can be associated with this approach. This theory is more team oriented than principal-agent theory. (Cozzarin and Barry, 1998)

Principal-agent theory consist of two players: the principal and the agent. Typically the principal offers a contract to the agent. However, moral hazard and adverse selection are two aspects that decrease the efficiency and ease with which vertical coordination in a principal-agent relationship occurs. Moral hazard occurs when the agent acts in their own best interest which may be in conflict with the best interests of the principal. Thus the focus is on designing contracts to mitigate this problem, by lining up incentives between the agent and principal such that the agent acts as the principal would (Cozzarin and Barry, 1998). For the peanut industry, moral hazard could exist between processor and sheller and/or between sheller and farmer.

Adverse selection occurs when either side has more information than the other. Contracts are thus needed to address this problem. After a contract is made to ensure the agent acts in the best interest of the principal, there is the issue of monitoring to ensure that the agent or principal upholds their side of the contract. For example, in the peanut industry shellers and/or processors would have to sample at least a portion of the product to ensure that variety and other specifics detailed in the contracts were delivered. This adds further costs to the transaction.

With both agency theories, there is considerable attention in the literature regarding the problems associated with the underlying structure of vertical coordination. Barry et al. (1992) explains that the principal desires the agent to act in conjunction with the objectives desired by the principal. However, often such conjecture does not occur. Instead self-interest, limited cognitive power, information asymmetries and uncertainty that the agent faces leads to adverse actions by the agent. These factors can become costs to the principal and agent if not accounted for through contracting. Even with intense and specific contracting there are often costs to the principal that are incurred. Barry et al. (1992) lists such costs as monitoring, expenditures to insure against adverse actions, residual loss from incomplete contracts and misaligned incentives.

There exists considerable literature that is devoted to examining the ideal or most efficient contracts for principal agent relationships. Presented below are several methods and observations of contracts in agriculture industries.

Ligon (2004) points out that previous farm models were based upon the farmer buying and selling in spot markets. However, changes in dynamics for the agriculture sector would suggest such a model does not take into account the increased use of contracts for buying and selling. Ligon discusses how incentives in contracting can result in certain decisions by the farmer and that farmers have the ability to influence output by their decisions. Ligon suggests a simple model where a risk-neutral firm contracts to a risk-averse farmer. The farmer produces a commodity q that may vary in both quantity and quality. The farmer can thus control both the quantity and quality of his output based upon decisions he makes and can influence the quantity and quality of product available for use by the firm or principal. In turn, the principal can influence the outcome of commodity q by influencing some of the inputs used by the agent. The result is that commodity q is a function of decisions made by both the principal and the agent. Thus a contract should be designed so that the output of commodity q results in a specific quantity and quality while taking into account uncertainties faced by the principal and agent and yet induces the producer to sign the contract. Ligon incorporates these two aspects by requiring that the principal assume at least a portion of the production risk prior to planting and by assuming that the producer has a reservation utility. The expected utility then from the contract must be greater than the reservation utility. Ligon purports that most contracts do not transfer all of the risk from the producer to the firm or principal. There exists asymmetric information between the two parties as it is difficult for the principal to know all actions taken by the producer. This asymmetric information must be taken into account when designing a contract. Ligon lists 2 primary steps to designing an efficient contract. The first is to collect and understand the agronomic data for the commodity being produced. The second is to understand and/or guess the producers preferences (Ligon, 2004).

Eisenhardt's (1985) discussion of complete information and incomplete information expands on the idea presented above regarding asymmetric information. With complete information a behavior-based contract is optimal. If asymmetric information exists then investments in monitoring must occur or else the incentives be based on profitability instead of behavior.

Dubois and Vukina (2004) closely examined the risk aversion of growers and the cost of moral hazard that is seen in livestock production contracts. Their work focused on determining the risk aversion of growers in the livestock industry and the subsequent cost of moral hazard to both the processor and the producer resulting from the producer's aversion to risk. Currently the contracts in the livestock sector use specific and complicated incentives which are written into contracts in an effort to align incentives between the principal and the agent. Dubois and Vukina

(2004) also mention that the literature indicates that linking pay to performance increases output. When writing contracts, such linkage may be important in order to align incentives between producers and processors.

The broiler industry and pork industry provide the vast majority of research regarding principal agent theory and the contracts used in these types of relationships. Key and McBride (2003) examined contracts and productivity in the U.S. pork industry. They compared the productivity from contracting versus the productivity from independence. Key and McBride (2003) in a study of the hog industry state that contracts offer advantages such as lower transaction costs prevalent in an open market environment. The cost of finding and negotiating and then transferring products is lessened through contracts. Asymmetric information with respect to product quality between the buyer and seller is also reduced. Often improved coordination of product delivery is a benefit of contracts. For pork producers the majority of inputs are supplied by the contractors. This allows for the contractors to control inputs and thus have greater control over the product they receive from the producer. The provision of inputs by the contractors can also allow for the producers to free up production credit than can be used to invest or apply inputs to increase efficiency. Key and McBride note however, that the investment by producers in idiosyncratic technology reduces their bargaining power. This can result in the producer choosing not to invest in the most efficient technology, thus reducing overall optimality. Key and McBride did find that contract operations were more productive than independent operations. They found that contract operations had around 20% more production than independent operations. They site the transfer of knowledge as well as the possibility that the inputs provided by the contractors may be superior to the independent operations. These two advantages line up with Ligon’s (2004) first step that emphasis an understanding of the agronomic factors of production for a particular commodity.

Goodhue (2000) made similar observations when examining the broiler industry. She found that most broiler contracts included two key elements: relative compensation measures and processor control of inputs. Goodhue found that producers had to relinquish control over marketing and management in order to benefit from a reduction in risk tied to price. The contracts provided incentive for the producer to use the supplied inputs in the most efficient manner. Sheldon

(1996) points out that while contracts can reduce risk and uncertainty to all parties' involved, complete reduction of risk is not possible because of the imperfect information that exists between the entities involved. While contracting can mitigate the issues of moral hazard and adverse selection, it cannot perfectly model situations.

2.3.4 RESOURCE BASED THEORY

Resource-based theory focuses on the advantage from resources owned by each separate entity, which provide a competitive advantage. These resources can be in the form of physical capital, human capital or organizational capital (Westgren, 2000). There may also be intellectual property and intangible assets such as brand names that are included in the resource portfolio of the company. However, all entities involved must see increased advantage within the alliance over their individual endeavor (Cozzarin and Barry, 1998). The problem arises of assigning the rents to the appropriate party, the problem of dividing up the gains between the entities involved. Contracts are thus set up reflecting the ownership of property rights and the entities are viewed as a bundle of rights. In the property rights approach the goal is to have the most efficient asset use based on the entities involved (Cozzarin and Barry, 1998).

2.3.5 OVERALL CONSIDERATIONS

In order for the strategies discussed in Chapter 1 and evaluated in Chapter 3 and 4 to really make an impact and to work effectively in the Virginia peanut industry, we examined the Virginia industry as though increased coordination does occur. Laid out below are the disadvantages/problems of vertical coordination as seen in the theory surrounding the formation of these types of organizations and following that are requirements or concerns that will need to be addressed through contracts or alliances.

Factors found to be important by Cozzarin and Barry (1998) when examining the pork industry are applicable in the Virginia peanut industry and include portions of all three major theories. These factors identified include: identification of the involved sectors or entities, the degree of power and influence held by each entity, the incentives motivating each entity and the determination of aligning incentives, understanding information asymmetries that exist, risk sharing, monitoring and bonding agreements, the resource portfolio of each entity and the resulting effect on rent seeking. Addressing these issues will be important for any coordination along the peanut supply chain.

Van Duren et al. (1994) examined the creation of vertical alliances and the theory surrounding their creation in the Canadian food sector. Van Duren points out the importance of a shared understanding of what the participants in a vertical strategic alliance want from the relationship. The process for creating a vertical strategic alliance is intertwined with the goals and the motivation for creating such a relationship and is akin to building trust.

While vertical alliances offer organizational advantages that we believe allow for increased profit to the entire sector, as seen above, there are still obstacles that have to be overcome and/or worked out. Primarily an aligning of objectives and incentives between the principal and the agent will be the two areas that will need to be discussed and determined. Contracts will likely be the primary vehicle to attempt to align the separate entities.

The theory discussed above provides basis and guidance for the examination of the Virginia peanut industry if coordination was increased and transaction costs were minimized. A linear mathematical model will provide a basis for modeling the industry and the impact of coordination.

CHAPTER 3 : METHODS

3.0 INTRODUCTION

This chapter will:

- Examine data and information needed to model the entire Virginia peanut sector.
- Discuss linear programming and sector modeling as a method for identifying an optimal solution for the peanut industry based on given data and assumptions.
- Describe the data and tools available to develop the sector model.
- Define notation, equations and assumptions of model.
- Discuss limitations of model.

The Virginia peanut industry is a complex system focused primarily on three very different players. The first of these is the peanut producer whom makes decisions at the farm level. Even within the farm sector there are multiple facets that determine and impact the decision making of the producer. There are soil limitations, rotation limitations, farm program benefits for all crops grown on the farm, livestock grown on the farm, weather limitations, financing limitations, equipment and capital limitations. All of these factors come into play when making decisions at the farm level. For the most part, producers are trying to maximize their profit based upon the farm as a whole. The shelling and processor/manufacturing entities are equally separate decision makers. Their primary focus is to minimize costs in an effort to make the most profit. Part of minimizing costs is to obtain inputs as cheaply as possible. Without coordination and communication, each sector is working from different goals and incentives than those above and below on the supply chain. Understanding those goals and incentives as well as all costs and profits for each player in the industry would allow for the most accurate picture of the industry and allow for evaluating the impact of decisions made at each level. However, attempting to model an entire industry is extremely difficult as most of the information needed is confidential. With each player making decisions independent of the others, the model becomes very complicated. Therefore examining the industry as though one owned the entire supply chain is one way to reduce the transaction costs between each entity and allow for a common goal of profit maximization for the industry as a whole, instead of at each segment. The linear model provides a framework within which to evaluate the proposed solutions for the Virginia peanut industry.

3.1 LINEAR PROGRAMMING and SECTOR MODELING

Linear programming became popular during World War II. During this time there was considerable incentive to ensure the most efficient use of the resources available (Hiller and Lieberman, 1995). Since that time, research on methods and the use of computers has greatly enhanced our ability to model and find solutions to problems.

Linear programming models use algorithms to solve and find the optimal solution. These iterative processes are typically solved by computer programs. This study used the modeling software General Algebraic Modeling System (GAMS) to estimate the optimal number of acreage and the varieties and rotations with the best economic return. GAMS is a modeling program that allows for linear, nonlinear, and mixed integer optimization problems. GAMS also permits sensitivity analysis, increasing the versatility and application of the problem. The sensitivity analysis allows one to examine the impact of one more unit of resources and constraints would have on the objective function holding other variables and constraints constant. As defined on the GAMS (2005) website,

> "Using GAMS, data are entered only once in familiar list and table form. Models are described in concise algebraic statements which are easy for both humans and machines to read. Whole sets of closely related constraints are entered in one statement. GAMS automatically generates each constraint equation, and lets the user make exceptions in cases where generality is not desired. Statements in models can be reused without having

to change the algebra when other instances of the same or related problems arise. The location and type of errors are pinpointed before a solution is attempted. GAMS handles dynamic models involving time sequences, lags and leads and treatment of temporal endpoints."

The above statement along with the ease with which programming is accomplished made GAMS the most attractive computer program to use for this study. For this particular study the MINOS solver was used.

There are four primary assumptions of linear programming: proportionality, additivity, divisibility, and certainty. The assumptions as stated in Hiller and Lieberman (1995) are: proportionality, additivity, divisibility, and certainty. Given the generic objective function below the assumptions according to Hiller and Lieberman are:

"$Z = c_j\, x_j$ subject to $b_j\, a_{ij}$ where
$Z =$ value of overall measure of performance
x_j = level of activity j
c_j = increase in Z that would result from each unit increase in level of activity *j*
b_j = amount of resource *i* that is available for allocation
a_{ij} = amount of resource *i* consumed by each unit of activity *j*"
(Hiller and Lieberman, 1995. p 32)

Proportionality: "The contribution of each activity to the value of the objective function Z is proportional to the level of the activity x_j, as represented by the c_jx_j term in the objective function. Similarly, the contribution of each activity to the left-hand side of each functional constraint is proportional to the level of the activity x_j, as represented by the $a_{ij}x_i$ term in the constraint. Consequently, this assumption rules out any exponent other than 1 for any variable in any term of any function (whether the objective function or the function on the left-hand side of a functional constraint) in a linear programming model." (Hiller and Lieberman, 1995. p 38)

Additivity: **"**Every function in a linear programming model is the sum of the individual contributions of the respective activities." (Hiller and Lieberman, 1995. p 41)

Divisibility: **"**Decision variables in a linear programming model are allowed to have any values, including noninteger values, that satisfy the functional and nonnegativity constraints. Thus, these variables are not restricted to just integer values. Since each decision variable represents the level of some activity, it is being assumed that the activities can be run at fractional levels." (Hiller and Lieberman, 1995. p 43)

Certainty: **"**The value assigned to each parameter of a linear programming model is assumed to be a known constant." (Hiller and Lieberman, 1995. p 44)

Sector modeling in linear programming allows for the examination of an entire industry instead of looking at only one portion of that industry. As explained by Hazell and Norton (1986) the sector model takes into account all sources of supply and demand for the product in question. The interest in returns to the entire Virginia peanut supply sector, make this type of modeling the most applicable in order to achieve the stated objectives. In particular determining the overall impact from decisions made at different points within the supply chain will be seen easiest with sector modeling.

A study by Omeregie and Thomson (2001) measured regional competitiveness in oilseed production and processing in Nigeria. Omeregie and Thomson (2001) used a spatial equilibrium linear model which examined the competitiveness of different regions in Nigeria and determined the optimal location and number of firms for Nigeria. Their study provides a framework within which to examine the peanut industry in Virginia. Omeregie and Thomson's goal was to determine the competitiveness of each region relative to each other. This was then used to direct policy and funding that allowed for the most efficient use of resources within the oil sector of Nigeria. The objectives of this study are to determine the most efficient organization and varieties for the Virginia peanut sector, which is similar to Omeregie and Thomson (2001).

Omeregie and Thomson (2001) define competitiveness as the "effectiveness and efficiency in the use of limited resources either within the economy or between different economies". Omeregie and Thomson (2001) define two approaches to determining competitiveness. The first of these is the cost approach which focuses on cost minimization. The second approach focuses on the highest economic returns to the region or state as having the competitive advantage. The cost minimization framework was used by Omeregie and Thomson, but not appropriate for the objectives of this study. Our primary object in this study is to increase or determine the profitability of the entire sector based on a reduction in transaction costs through vertical coordination and through the growing of high oleic acid peanuts. Thus, using a net returns approach will provide a more accurate measure for this study. We are not interested in reducing the costs as an objective. It is already evident that on a cost basis alone, the Virginia peanut sector has difficulty competing. Therefore a net returns approach will allow us to choose the strategy that provides the highest economic returns. This in turn will also help to determine if there is incentive for investment in the peanut supply sector.

Identification of the entities involved in the Virginia peanut industry was the first step in developing a sector model. Along with the different enterprises involved, identifying the products or in this case the different strategies considered were important for building the base of the model. This study focused on three different enterprises within the Virginia peanut sector: the farm, the sheller, and the processor. The next focus was on growing different varieties at the farm level and evaluating the impact of these varieties on each sector in the model. Using sector modeling and the returns approach as defined by Omeregie and Thomson (2001) the model was built using available data and expert opinion.

3.2 MODEL ASSUMPTIONS, NOTATION AND EQUATIONS

3.2.1 MODEL ASSUMPTIONS

Hazell and Norton (1986) lay out five primary components of a sector model that are determined either implicitly in the model or explicitly as assumptions. These five aspects are the following: a description of producers' economic behavior; a description of the production functions available to producers; resource endowments held by each group in the model; specification of the market environment; and policy environment. Attempts to address these five components of the model are discussed below.

Producers at the farm level in this model are assumed to act rationally to maximize profit. Their concern is first and foremost covering their variable costs and then in the long run to cover fixed costs as well. Producers have different varieties to choose between and each farm has specific characteristics associated with it. In the case of varieties, we assume the same resource endowment for each variety, the equipment and soil types available are the same across all varieties and across all producers. The resource endowment of the sheller and processors are assumed sufficient to not impact the overall model. Due to the decline in peanut acreage in Virginia and shellers leaving the area, it was assumed that both storage capacity and shelling capacity are at levels that will not constrain the model. Previous production levels in Virginia suggests that capacity to handle production levels indicated by the model are adequate. However, it is likely that updates to these facilities would be needed, this cost was not figured into the model. It was also assumed that at the processor level, the amount of peanuts produced by the Virginia sector is not enough to have constraints placed on this sector. Additionally, resources available at the processor level were adequate to handle the amount of peanuts produced in Virginia. The market environment surrounding the peanut industry varies for each segment. For producers, they face considerable risk and uncertainty in the form of price and weather. Shellers have the task of managing margins and contracting with processors and producers is the primary vehicle for buying and selling. Product that is not covered by contracts to processors is managed through gourmet and specialty processors who need peanuts to fill their orders. Processors face a market that is controlled by demand at the consumer level. Processors respond to signals sent by consumers through price. Policy for the three segments really only has an impact at the farm level. Producers fall under the 2002 farm bill and are guaranteed a loan rate for their peanuts, which helps to reduce uncertainty to a degree, but for most producers the loan rate is set at or below their breakeven costs.

This model assumes that the peanuts produced at the farm level were then shipped to the shelling facility. After going through the shelling facility the product was then sent to the processor. After the processor or manufacturer, the product was passed on to the consumer. The consumer level was where the values added from the changes at each level are realized and where the premiums for the different strategies are realized. Due to data limitations the purpose of this model was to show costs associated with production along the supply chain in Virginia and to show the differences in costs and output based on varieties and soil quality levels. This model was not a comprehensive study of the Virginia peanut supply sector.

3.2.2 MODEL NOTATION AND EQUATIONS

The proposed model includes three different levels of the supply chain: farm level, sheller level, and consumer level. The model includes five different peanut varieties. Four of the varieties are Virginia-type varieties with one of the Virginia-type varieties is a high oleic acid variety. The final variety is a runner type variety. The model includes a choice between a three- and four-year rotation that is made up of one year of peanuts and two or three years of cotton. At the farm level there are two levels of soil quality, high and low soil quality. Soil quality has an impact on how each variety grades and yields of the varieties. Acreage is limited at the farm level to 75,000 acres of high quality soil and 100,000 acres of good soil quality. Costs associated with a buying point and shelling along with costs from the farm level are subtracted from the price received at the consumer level.

Table 3.1 :Input Variables

Notation	Description	Units
VCF (j,l)	Variable Cost of peanuts at the farm level for variety j on soil quality l	$/acre
VCFct (l)	Variable Cost of cotton at the farm level on soil quality l	$/acre
Y (j,l)	Yield for peanut variety j on soil quality l	lbs per acre
Yct (l)	Yield for cotton on soil quality l	lbs per acre
Grade (l,j, i)	Percentage for peanut variety j at grade i on soil quality l	%
P(j,l)	Price at the farm level of peanuts for variety j on soil quality l	$ per lbs
Pct	Price at the farm level for cotton	$ per lbs
DCB (j,l)	Direct Cost at the buying point for peanut variety j on soil quality l based on Georgia buying point	$ per lbs
RCull	Culling rate of peanuts, used in conversion of peanuts from Farmer Stock yield to manufactured yield	Lbs
PCONin	Price per pound at the consumer level for in-shell peanuts	$ per lbs based on culled yield
PCONsh	Price per pound at the consumer level for shelled peanuts	$ per lbs based on culled and shelling rates
PPB	Price per pound at the consumer level for Peanut Butter	$ per lbs based on culled and shelling rates
PShell	Cost of shelling based on estimates for a shelling facility in Georgia	$ per lbs

Table 3.2 Decision Variables

Notation	Description
AC (j,l)	Acreage of peanuts for variety j, soil quality l, in a 3-year rotation
ACct (l)	Acreage of cotton, soil quality l, in a 3-year rotation
ACR4 (j,l)	Acreage of peanuts for variety j, soil quality l, in a 4-year rotation
ACR4ct(l)	Acreage of cotton, soil quality l, in a 4-year rotation

The following assumptions are critical to the model:

1. Demand is horizontal or perfectly elastic when focusing on the amount of production possible by the Virginia sector.

2. Shelling and processing capacity will not be changed during this time. Both are capital intensive and thus current availability will not change.

3. Premium is available at the retail level for high oleic acid peanuts.

Objective Function

The objective function of the model is

$$\text{Max(Tprofit)} = \Sigma_j \Sigma_l \ \text{ELKYield}_{j,l} \ AC_{j,l} \times \text{PCONin} + \Sigma_j \Sigma_l \ \text{ShellYield}_{j,l} \ AC_{j,l} \times (\text{PCONsh} - \text{PShell}) + \Sigma_j \Sigma_l \ \text{PBYield}_{j,l} \ AC_{j,l} \times (\text{PPB-PShell}) - \Sigma_j \Sigma_l \ Y_{jl} \ AC_{jl} \ P_{jl} - \Sigma_j \Sigma_l \ Y_{jl} \ AC_{jl} \ DCB_{jl} + \Sigma_l \ Yct_l \ ACct_l \ Pct_l - \Sigma_l \ VCct_l \ ACct_l + \Sigma_j \Sigma_l \ \text{ELKYieldR4}_{j,l} \ AC\,R4_{j,l} \times \text{PCONin} + \Sigma_j \Sigma_l \ \text{ShellYield}\,R4_{j,l} \ AC\,R4_{j,l} \times (\text{PCONsh} - \text{PShell}) + \Sigma_j \Sigma_l \ \text{PBYield}\,R4_{j,l} \ AC\,R4_{j,l} \times (\text{PPB-PShell}) - \Sigma_j \Sigma_l \ Y\,R4_{jl} \ AC\,R4_{jl} \ P_{jl} - \Sigma_j \Sigma_l \ Y\,R4_{jl} \ AC\,R4_{jl} \ DCB_{jl} + \Sigma_l \ Y\,R4ct_l \ AC\,R4ct_l \ P\,R4ct_l - \Sigma_l \ VC\,R4ct_l \ AC\,R4ct_l$$

ELKYield refers to Farmer Stock yield multiplied by the percentage going into the in-shell market.

ShellYield refers to Farm Stock yield multiplied by the percentage going into the shelled market.

PBYield refers to the farm yield multiplied by the percentage going into the peanut butter market.

Input and decision variables for the four year rotation are designated with a *R4, 3-year rotations are without additional notation.

Constraints

SH "High Soil Quality Land Available"

$$\Sigma_j \Sigma_l Ac_{jl} + \Sigma_j \Sigma_l AcR4_{jl} + ACct_{high} < 75{,}000 \text{ acres}$$

SG "Good Soil Quality Land Available"

$$\Sigma_j \Sigma_l Ac_{jl} + \Sigma_j \Sigma_l AcR4_{jl} \ Acct_{good} < 110{,}000 \text{ acres}$$

R3 "3-year Rotation"

$$2/3 \ \Sigma_j \Sigma_l Ac_{jl} - 1/3 \ \Sigma_l Act = 0$$

R4 "4-year Rotation"

$$3/4 \ \Sigma_j \Sigma_l AcR4_{jl} - 1/4 \ \Sigma_l ACR4ct = 0$$

The objective function is a maximization of the total profit to the entire sector based upon:

1. The gross margin from peanuts entering the in-shell market. In-shell market gross margins are the result of ELKYield multiplied by the acreage multiplied by the price at the consumer level for in-shell peanuts for all varieties j and for both soil levels.

2. Adding gross margin from peanuts entering the shelled market. Shelled market gross margins are the result of: ShellYield multiplied by the acreage multiplied by the price at the consumer level for shelled peanuts for all varieties j and for both soil levels.

3. Adding gross margin from peanuts entering the peanut butter market. Peanut butter market gross margins are the result of: PBYield multiplied by the acreage multiplied by the price at the consumer level for peanut butter for all varieties j and for both soil levels.

4. Subtracting the costs associated with the farm level. Determined by the price at the farm level multiplied by acreage multiplied by yield for all varieties j and for both soil levels.

5. Subtracting the costs associated at the buying point. Determined by the direct costs at the buying point multiplied by acreage multiplied by yield for all varieties j and for both soil levels.

6. Plus the price of cotton at the farm level times cotton acreage times cotton yield

7. Minus the variable cost at the farm level times the cotton acreage.

8. The model then chooses between a 3-year and a 4-year rotation.

Subject to the following constraints:

1. Total land available of high quality soil, capped at 75,000 acres, based on recommendations from experts at the Tidewater Research Center.

2. Total land available of good quality soil, capped at 110,000 acres, based on recommendations from experts at the Tidewater Research Center.

3. Three year rotation constraint.

4. Four year rotation constraint.

For this particular model we are assuming that the demand side of the market is a horizontal line. We are assuming that demand is beyond the range of what the Virginia market can alone produce. This assumption would not hold up with application to the entire U.S. or world peanut industry.

3.3 MODEL DATA

Data for this study were difficult to obtain. Because the peanut industry has been so regulated for such a long period of time, price and acreage, were influenced by the policy. This occurred both through production quotas which caused contrived prices and price quotas which also skewed the historical price data. In many cases both poundage and price were essentially controlled by the government. Thus historical data is not necessarily an accurate depicter of the underlying economic factors at work in the U.S. peanut industry. With the removal of the quota system, the problem of price discovery continues as weekly reporting is often unavailable due to a lack of sales. Contracts have eliminated much of the open market and so determining price at the farm level is still difficult.

Data at the sheller and processor levels were also difficult to obtain as many of the companies are privately held and the government does not require price reporting at this level of the market. Again, contracts are used primarily in these instances as well. The exception would be small gourmet processors purchasing leftovers from the shellers in the area. Currently there is only one major sheller and processor in Virginia. Birdsong is a family-owned company that has had a presence in the peanut industry since 1911. Thus historical sheller and processor data was unavailable for this study.

3.3.1 FARM LEVEL DATA

Data representing the farm level came primarily from variety tests performed at the Tidewater Research Station in Suffolk, VA and/or from farm management and peanut scientist in the Southeast portion of Virginia. Yield and price at the farm level were from the variety tests performed in 2004 at the research center (Phipps, Coker, & Faircloth, 2004). Data came primarily from tests done to compare the yield, maturity, value and susceptibility to tomato spotted wilt virus between Virginia- and Runner-type peanuts. These variety tests were conducted on land that was planted to peanuts in 2001, corn in 2002 and wheat in 2003. The plots consisted of two, 35-ft rows spaced 3-ft apart. The varieties were planted in four randomized blocks. The plots were planted on May 7, 2004 with Temik 15G and Orthene 97 at 10 oz per acre applied on June 4 for thrips control. Varieties were also treated June 9, 2004 with granular 420 landplaster. The rows were then inverted on October 18, 2004. The Virginia-type peanuts were harvested with a two-row combine on October 22, 2004. The runner-type peanuts were harvested on October 29, 2004. Rainfall from May to September was 14.3 in above normal. Temperature maximums and minimums were within two degrees Fahrenheit of normal. Variable costs are based upon budgets estimated by the farm management specialist in the area. Variable costs were for a strip-till peanut acreage and conventional tillage for the cotton acreage. See appendix for detailed budgets on variable costs. Table 3.3 details the data used at the farm level for each of the five varieties included in the study.

Table 3.3: Farm level data for all five varieties

	Variable Cost		**Yield**	
Variety	High Soil	Good Soil	High Soil	Good Soil
Base	566.88	559.00	2715	2172
1	578.39	568.21	3509	2807
2	563.38	556.21	2474	1979
High Oleic	570.11	561.59	2938	2350
Runner	535.06	524.57	4936	3949

3.3.2 SHELLER LEVEL DATA

Because margins and costs are proprietary, estimates from a study (Smith et al., 2002) at the University of Georgia were used to determine costs at the sheller level. After interviews with experts in the Suffolk area, it was determined that costs at the sheller level would remain unchanged regardless of variety and whether or not there is more or less coordination along the supply chain. Segregation of peanuts already occurs through the separation of peanuts for seed stock, so further separation for the high oleic acid and non-high oleic peanuts should not cause an increase in costs (Phipps, 2005). Budgets and information from the University of Georgia were also available for the buying point (Webb, 2000).

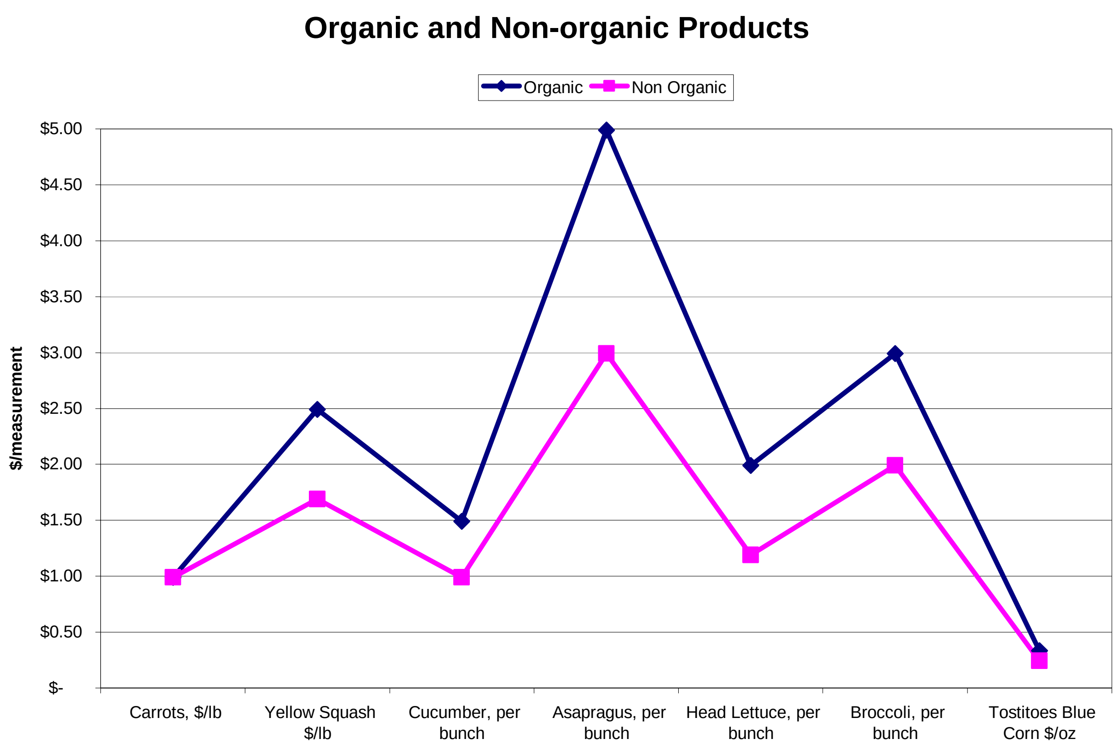
3.3.3 PROCESSOR/CONSUMER LEVEL DATA

The same problems exist for obtaining processor data that exists at the sheller level. Costs and gross margins are primarily proprietary and historical data of consumer prices is not readily accessible. Also, in this instance, interest was primarily in current consumer price levels and examining the difference between products with health claims. Data from local grocery stores indicate that there are premiums available at the retail level for traits that the consumer considers desirable. Retail prices at the local grocery store were used to estimate prices for peanut butter, shelled peanuts and in-shell peanuts.

3.3.4 PREMIUM DATA

In order to determine premiums at the consumer level, a survey of prices currently being paid by the consumer was used. When examining current premiums demanded by other products at the consumer level, it is evident that consumer willingness to pay is very high for some products and traits. Various levels of price differences were used as there currently is no premium at the consumer level for high oleic acid products. There are considerable premiums available at the consumer level for organic foods and for other foods that are considered "healthy". Currently the foods that are low in carbohydrates demand a premium at the consumer level. For example, organic foods over non-organic foods tend to command a premium of at least 130%. Figure 3.1 provides examples of a few organic versus non-organic foods available in a local large scale grocery store.

Figure 3.1 Organic and Non-organic Food Products.



Source: Kroger Grocery Store, Blacksburg, VA July 2005

3.4 LIMTATIONS OF MODEL

The purpose of this limited model is to provide a starting point for evaluating the peanut industry and in particular the Virginia peanut industry in an effort to understand current market fundamentals and to begin the process of improving the financial situation if possible. The following are limitations that if addressed, the author believes could lead to different conclusions.

- Differentiating costs for the different rotations presented. Differentiating yields for the different rotations presented using actual data or expert opinion.

- Research data for soil quality difference instead of expert opinion

- Further/more detailed breakdown of percentages of peanuts being sent to each of the consumer levels.

- More detailed costs at the processor level.

- Better understanding of the motivations and/or incentives for each entity in the sector to provide easier drafting of contracts.

CHAPTER 4: RESULTS OF LINEAR PROGRAMMING MODEL

Chapter 4 discusses the results of the linear model that was detailed in the previous chapter. Specifically this chapter includes

- Results of the baseline model
- Results regarding growing Runner-type peanuts
- Results with all varieties included
- The impact of rotation choice on the models
- The impact from increased percentages of peanuts that grade Fancy
- Increased premiums at the consumer level for the health benefits associated with high oleic acid peanuts.

4.1 RESULTS BASELINE MODEL

The baseline model used the variety designated “b” in the model. This is variety NC-V11. During variety trials the variety graded 74% Fancy, 49% ELK (Extra Large Kernel), and was 76% kernels. This particular variety was chosen based upon the recommendation from peanut scientists and farm management experts in the Southeast area of Virginia. The baseline model found that the optimal solution consisted of 25,000 acres of peanuts in high quality soil and 33,333 acres in good quality soil. The remainder of the land was planted in cotton to satisfy the 3-year rotation chosen by the model. This resulted in gross margin to the sector of $145,569,122. This figure includes farm costs, buying point costs, and shelling cost, but does not include manufacturing costs.

While the baseline peanut variety was grown, it is important to note that the baseline model is not profitable at each individual point in the model. A constraint that required profitability at the farm level results in all acreage shifting to cotton acreage. While the costs and revenue from this variety are only estimates, the results do coincide with opinion from the field and seems to be in agreement with the continued decline of peanut acreage in Virginia. This highlights the necessity of coordination along the supply chain. One of the primary disadvantages of this variety is the low yield. It is doubtful that Virginia peanut producers and processors will continue to operate if the baseline model continues to be the manner in which the supply chain in Virginia operates.

The marginal values listed in Table 4.1 indicate the impact on the objective function. Throughout the model, it appears that the higher return from a four year rotation exactly offsets the lower more frequent return from a three-year rotation. Thus the marginals for the peanut acreage in the four year rotations for varieties chosen in the solution are listed as zero. However, the model chooses the three-year rotation because of the rotation constraint that is in place. In other words, adding one acreage of the peanut in a four-year rotation also includes taking acreage from the cotton. This is where the objective function would be reduced and the reason that the model chooses the three-year over the four-year when at first glance it appears that the model is indifferent between the different rotations. In short one must take the cotton marginals and multiply by three in order to get the full effect of adding one unit of peanut acreage not chosen by the model.

Table 4.1: Results and Sensitivity Analysis, Baseline Variety

		Level	Marginal
Objective Function		$ 145,569,122	
3-Year Rotation		(acres)	($ impact on obj fnct)
Peanut Acreage			
b.high		25000	-
b.good		33333	-
Cotton Acreage			
high		50000	-
good		66667	-
4-Year Rotation			
Peanut Acreage			
b.high		-	-
b.good		-	-
Cotton Acreage			
high		-	$ -181
good		-	$ -146

4.2 RESULTS: BASELINE WITH RUNNER VARIETY

Variety runner was designated “r” in the model, and is variety DP-1. This runner variety performed the best out of those studied during field trials when looking strictly at the farm level. During variety trials this variety had yields that were far superior to the Virginia-type varieties. This particular variety was chosen based upon the recommendation from peanut scientists and farm management experts in the Southeast area of Virginia. The model chose to put 25,000 acres in the runner variety high quality soil and 33,333 acres of runner peanuts in good quality soil. Acreage of 50,000 and 66,667 in high and good quality respectively were designated cotton acreage. This leads to an objective function of $178,489,257 for the entire sector.

Runner variety peanuts are increasingly being substituted for Virginia-type peanuts in the shelled market where the large runner peanuts can be substituted (Roberts, 2005). The higher yields and lower cost make runner type peanuts an attractive alternative especially when they can be substituted for some of the more premium products that Virginia-type peanuts typically are grown. In this run of the model the marginal values indicate that by growing just one acre of Virginia peanuts in the high quality soil instead of an acre of runner peanuts, the objective function decreases by $607. Similarly putting the land into a four year rotation instead of the three-year rotation picked and growing the baseline variety would decrease the objective function by $693 and there would be further reduction due to the cotton acreage of $220 times 3 acres. Thus for each additional unit of land planted to a four-year baseline variety the loss is actually $1353 to the objective function (Table 4.2).

Compared with the baseline model, the objective function is 22.6% higher than for the previous baseline model. The increase reconfirms the reasoning behind the push to use the large runner peanuts as substitutes for the Virginia-type peanut. If Virginia-type peanut producers are going to continue to maintain and/or increase their market-share, it is important that they find a way to compete on a level other than cost and yield.

Table 4.2: Results and Sensitivity Analysis, Baseline Variety and Runner Variety

		Level	Marginal
Objective Function		$ 178,489,257	
3-Year Rotation		(acres)	($ impact on obj fnct)
Peanut Acreage			
b.high		-	$ -607
b.good		-	$ -532
r.high		25000	-
r.good		33333	-
Cotton Acreage			
high		50000	-
good		66667	-
4-Year Rotation			
Peanut Acreage			
b.high		-	$ -693
b.good		-	$ -606
r.high		-	-
r.good		-	-
Cotton Acreage			
high		-	$ -220
good		-	$ -180

4.3 RESULTS: ALL VARIETIES

The third model examined the optimal solution using all the varieties chosen. The baseline variety along with two other Virginia-type varieties, a Virginia-type high oleic variety and a runner variety were all included in this trial. The baseline variety is designated “b” in the model and is officially known as variety NC-V11.

Variety one was designated “1” in the model, is variety Perry. During variety trials this variety had the highest yield of all the Virginia-type peanuts considered in this model. However, the percentage that graded Fancy was only 65%, nearly 10% below that of the baseline variety. The percentage grading ELK was the second highest of the Virginia-type peanuts at 55% and total kernel percentage was at 78%.

Variety two was designated “2” in the model and is variety VA 98R. During variety trials variety two had the lowest yield of all the varieties considered. This variety graded out at only 66% Fancy and 45% graded as ELK.

The high oleic variety was designated “ho” in the model. This is variety N00098ol. This variety is not available at this time for commercial use and has been studied only in variety trials. However, the variety shows promise as yields are higher, compared with the other Virginia-type varieties studied here and it contains the high oleic trait. The benefits from high oleic as discussed in Chapter 2 include increased shelf life and a higher ratio of oleic to lanoleic acid. During variety trials N00098ol graded the highest of those listed in this model for Fancy and ELK at 82% and 57% respectively. Those peanuts grading Fancy and ELK go toward the higher end products that the consumer buys.

The Runner-type variety was designated “r” in the model, and is variety DP-1. It is characterized by high yields. All of the runner peanuts were pushed toward the peanut butter sector for this model.

The model found the optimal solution to include 25,000 acres of variety 1 in high quality soil with the remaining high quality soil going into cotton to satisfy the three-year rotation constraint. The good quality soil was also planted to a three year rotation of variety one and cotton. This combination produces an objective function value of $185,801,757. Based on the acreage and yield for this variety, the results would indicate 181 million pounds of peanut produced by VA peanut producers. This is much higher than current acreage and production.

The marginal values in this model represent the decline in the objective function if one unit of acreage was shifted away from variety one towards a different variety. It allows for us to examine the next best alternative. In this case, the next best alternative is to grow runner variety peanuts and after that to grow the high oleic variety. As mentioned previously, the marginal values in the four-year rotations do not take into account the full impact of growing each variety in a four-year rotation. The full impact includes the marginal from each respective variety as well as the four-year cotton marginal times three units (Table 4.3).

Table 4.3: Results and Sensitivity Analysis, All Varieties

		Level	Marginal
Objective Function		$ 185,801,757	
3-Year Rotation		(acres)	($ impact on obj fnct)
Peanut Acreage			
b.high		-	$ -782
b.good		-	$ -621
1.high		25000	-
1.good		33333	-
2.high		-	$ -1,114
2.good		-	$ -880
ho.high		-	$ -373
ho.good		-	$ -290
r.high		-	$ -174
r.good		-	$ -89
Cotton Acreage			
high		50000	-
good		66667	-
4-Year Rotation			
Peanut Acreage			
b.high		-	$ -891
b.good		-	$ -708
1.high		-	-
1.good		-	-
2.high		-	$ -1,270
2.good		-	$ -1,003
ho.high		-	$ -425
ho.good		-	$ -331
r.high		-	$ -199
r.good		-	$ -102
Cotton Acreage			
high		-	$ -231
good		-	$ -186

4.4 RESULTS: INCREASE IN FANCY PERCENTAGE

Virginia-type peanuts are typically used in the in-shell and snack peanut market due to the large size of the kernel and taste. These markets typically demand a premium over other markets such as oil and peanut butter. Thus increasing the percentage of peanuts available to be used in these higher priced end-products would increase overall gross margin to the sector. In this run of the model Fancy percentages were increased by 2.5% and 5% from the original variety trials. The increase in Fancy pushes more peanuts toward both the in-shell and shelled market. As expected, increasing the percentage of peanuts that grade Fancy resulted in an increase in the objective function. The objective function increased to $187,240,431 for a 2.5% increase in Fancy percentages. For a 5% increase in Fancy percentages, the objective function rose to $189,240,431. All peanut acreage stayed in variety one as expected due to the high yields of this variety.

If gains in technology would allow for significant increases in the percentage of peanuts that grade at the higher priced levels, then this might be an area that Virginia-type peanuts could begin to carve out their own market.

4.5 RESULTS: HIGH OLEIC PREMIUMS

In order to examine the impact that premiums for high oleic acid peanuts would have on the market, we evaluated at what level the model began to shift the acreage from the aforementioned optimal solution consisting of variety 1 to the high oleic variety. With a premium of 20%, the model found the optimal solution to include the high oleic variety of the peanut. The model continued to choose the 3-year rotation. This acreage resulted in an objective function value of $212,637,341. Table 4.4 details the results of the model. Premiums of 40% and 60% kept the same acreage but increased the objective function to $258,477,722 and $304,318,102 respectively. The increases in the objective function are 14.4% for a premium of 20%, 39.1% for a premium of 40% and 64% for a premium of 60%.

Table 4.4: Results and Sensitivity Analysis, High Oleic Premium of 20%

		Level	Marginal
Objective Function		$ 212,637,341	
3-Year Rotation		(acres)	($ impact on obj fnct)
Peanut Acreage			
ho.high		25000	-
ho.good		33333	-
Cotton Acreage			
high		50000	-
good		66667	-
4-Year Rotation			
Peanut Acreage			
ho.high		-	-
ho.good		-	-
Cotton Acreage			
high		-	$ -380
good		-	$ -307

The same problem that existed for the baseline model exists in this model as well. We are assuming that even if profits are not seen at the farm level, the producer still chooses to plant peanuts. This lack of profitability at the farm level for high oleic acid peanuts means that some of the gross margins to the entire sector would need to be shared all the way back to the producers or this objective would never be realized as the producer would not choose to plant high oleic acid peanuts because variable costs are higher than the price received for the product. This highlights the reasoning behind needing coordination up and down the entire supply chain in order for changes to be seen.

4.6 CONCLUSION

The results of the linear model indicate that based on cost and return estimates available, the Virginia peanut sector will have difficulty being profitable without high yielding varieties that will offset the costs up and down the supply chain. There is also indication that premiums at the consumer level for traits that the high oleic variety poses would be adequate at fairly low levels. Based on data collected from foods that are either low-carb or organic, such premiums are not unrealistic, but studies to indicate consumers willingness-to-pay would be needed before investment in this segment of the market would be needed. The results of this model are only significant to the degree that our underlying assumptions are feasible and are limited by the fact that costs and returns are merely estimates.

CHAPTER 5: CONCLUSIONS AND IMPLICATIONS

5.1 CONCLUSIONS

The peanut industry in Virginia has seen changes to its market environment with the discontinuation of the peanut quota program. However, underlying fundamental problems exist for the sector. High production costs, encouraged by falsely elevated support prices for over 70 years, inadequate grading standards, and inadequate risk management and price discovery tools now plague the market environment. Adapting to the new market environment will likely only be brought about by investment in technology and coordination by those entities directly involved in the supply side of the market. The issues facing the Virginia peanut industry could be seen at a larger scale in the future for the entire U.S. peanut industry. Therefore the issues discussed here are relevant for the entire peanut industry.

The strategy recommended then for the Virginia peanut industry is to consider cooperation and coordination up and down the supply chain combined with investment in the sector. Without investment, the land currently dedicated to growing peanuts should be put into production in a different and more efficient system.

As the results from the linear programming model indicated, investment in the sector is profitable only when yields are at a more competitive level than the Virginia region currently is averaging or when there is a premium at the consumer level for health benefits associated with high oleic acid peanuts. The level of coordination to ensure adequate returns on investment for all entities involved would need to be explored further. Without an advantage provided by increased coordination and investment in technology such as the high oleic acid (an advantage that will be copied in other regions and thus returns eventually lost) it is neither economically feasible nor beneficial for Virginia peanut producers to produce at levels seen in the past.

5.2 CONCEPTUAL AND PRACTICAL IMPLICATIONS

Vertical coordination should be able to address some of the issues faced by the industry. Detailed and long-term contracts would allow for some insurance for investment in technology. Asymmetric information would still exist but could be diminished by contracts and clear communication between entities. Transaction cost theory, agency theory and resource-based theory provide the theoretical background behind vertical coordination.

With each of these theories there are downsides that occur or wrinkles that would need to be ironed out. For principal-agent theory in particular the aligning of goals and incentives between the principal and agent is important. If we assume that coordination did occur up and down the supply chain and consumers were willing to pay for increased health benefits from high oleic acid peanuts, several aspects of the Virginia peanut industry would have to change.

1. It is likely that there would be an increase in the price of contracts. The farmer would need adequate compensation in order to choose to grow high oleic acid peanuts. This same philosophy applies to the sheller as well. Producers and shellers would need to share in some of the gains from the consumers' willingness to pay. In other words, the agent in the relationships will need incentive to align their goals with those of the principal in the relationship.

2. Monitoring to ensure that the farmer and the sheller are providing what the contract specifies is needed. For high oleic, this would mean testing and adequate documentation of procedures at each level that the peanut passes through.

3. Guarantee of adequate infrastructure before investments in technology would occur. The easiest vehicle to ensure this aspect of coordination involves long-term contracting. For the producer to invest in equipment he/she needs a guarantee that the shelling facilities and buying points would be available is important. The sheller in turn needs assurance of adequate supply to run the plant before making necessary investments.

In general, the profit potential of the supply chain will be a function of additional costs, added value and a discounting of the opportunities and the potential added revenue stream. Each participants profit is based upon these same factors. A very simple model details what will impact the decision each entity will make. Where:

q is the profit from coordination and new investment
c is the added cost from new investment and coordination
m is the added value from new investment and coordination
d is the discounting due to uncertainty

$$q = m - c - d$$

Thus in order for coordination and new investment to occur, minimization of the cost of investment and coordination, maximization of value added to the product, maximization of benefits from coordination and minimization of discounting should be the goal of participants. Coordination allows for the reduction of uncertainty and costs by coordinating product flow. The coordination of product flow which includes a consistent and quality product allows for each entity to take advantage of economies of scale, to operate at the minimum of their cost curve and it ensures that product inputs and outputs are in the correct place at the right time. Insuring that each participant acts as needed for the goals of the entire supply chain is the role of contracts. Making these contracts realistic is the role of the participants. Ligon (2004), Key and McBride (2003) and Goodhue (2000) indicate that designing efficient contracts is difficult, but is possible. The contracts can provide some assurance which in turn reduces the uncertainty. The biggest obstacle to coordination is the discounting by participants. As is evident from the simple model above, discounting has a direct impact on the profit of the sector. It is important that each participant in the model understand that discounting all risk to the participants would not allow for any investment to occur and will simply perpetuate the current situation.

5.3 RECOMMENDATIONS

There are several recommendations that resulted from this study. These recommendations listed below are for policy makers, for interested parties in the Virginia peanut sector, and for further research.

1. Research to better understand the costs and returns to the sector for modeling and to determine profitability.

2. Education of the customer regarding the health attributes of peanuts and in particular the additional benefit from high oleic acid peanuts. The customer in this case would refer to both consumers where health benefits might demand a premium and to manufactures where the increased shelf-life from high oleic acid peanuts would increase customer satisfaction and could allow for a decrease in storage costs.

3. Further research to determine consumer willingness-to-pay for health benefits and manufacturer's willingness-to-pay for increased shelf life.

4. Determine components needed to foster cooperation amongst players in the peanut industry. Cooperation and possibly compromise by each separate entity would be necessary in order for cooperation to be successful. Hammering out these details will take considerable effort and drive by everyone involved.

5. Policy makers and government should provide assistance in the coordination and general cooperation among the different peanut sectors. The abrupt change in farm policy has not allowed for this industry to adapt and change at a slower pace. Instead change has been forced and rapid.

6. Research by peanut breeding scientist to continue to develop and flush out the health benefits available from peanuts.

APPENDIX A: GAMS MODELS

A.1 GAMS MODEL: ALL VARIETIES

```
sets  j     variety of commodity / b, 1, 2, ho, r/
      l     Quality of soil/ high, good/
      i     Grade percentages / LSK, SMK, FM, Fancy, ELK, SS, OKD, Hulls, TK/
;

Table VCF (j,l) Variable Cost for variety j soil quality l in $ per acre
        high       good
b       566.88     559.00
1       578.39     568.21
2       563.38     556.21
ho      570.11     561.59
r       535.06     524.57;

Parameter VCFct (l) Variable Cost for cotton j soil quality l in $ per acre
      /high  364.74,
      good  356.52/;

Table Y (j,l) Yield for variety j soil quality l in lbs per acre in 3-year rotation
        high     good
b       2715     2172
1       3509     2807
2       2474     1979
ho      2938     2350
r       4936     3949;

Scalar RCull Culling Rate /.88/;

Y(j,l) = Y(j,l)*RCull;

*Need the original yield for buying point and farm cost

Table YFS (j,l) Yield for variety j soil quality l in lbs per acre in 3-year rotation Farmer Stock
        high     good
b       2715     2172
1       3509     2807
2       2474     1979
ho      2938     2350
r       4936     3949;
```

A.1 GAMS MODEL: ALL VARIETIES Cont.

```
Table YR4 (j,l) Yield for variety j soil quality l in lbs per acre for 4-year rotation
          high       good
b       3095.1       2476.08
1       4000.26       3200.208
2       2820.36       2256.288
ho      3349.32       2679.456
r       5627.04       4501.632;

YR4(j,l) = YR4(j,l)*RCull;

*Need the original yield for buying point and farm cost

Table YFSR4 (j,l) Yield for variety j soil quality l in lbs per acre for 4-year rotation
          high       good
b       3095.1       2476.08
1       4000.26       3200.208
2       2820.36       2256.288
ho       3349.32       2679.456
r       5627.04       4501.632;


Parameter Yct (l) Yield for cotton soil quality l in lbs per acre
        /high  750,
        good  650/;

Table Grade (l,j,i) Percentage for variety j at grade i for high soil quality
            LSK    SMK    FM     Fancy   ELK    SS     OKD    Hulls   TK
high.b      0.05   0.7    0.01   0.74    0.49   0.04   0.02   0.24    0.76
high.1      0.05   0.7    0.01   0.65    0.55   0.07   0.01   0.22    0.78
high.2      0.05   0.73   0.01   0.66    0.45   0.02   0.02   0.22    0.77
high.ho     0.08   0.7    0.01   0.82    0.57   0.05   0.03   0.23    0.78
high.r      0.00   0.71   0.00   0.00    0.00   0.04   0.04   0.21    0.79
good.b      0.05   0.7    0.01   0.74    0.39   0.04   0.02   0.24    0.76
good.1      0.05   0.7    0.01   0.65    0.45   0.07   0.01   0.22    0.78
good.2      0.05   0.73   0.01   0.66    0.35   0.02   0.02   0.22    0.77
good.ho     0.08   0.7    0.01   0.82    0.47   0.05   0.03   0.23    0.78
good.r      0.00   0.71   0.00   0.00    0.00   0.04   0.04   0.21    0.79
;

Parameter FYield (l,j) Fancy Yield for variety j at soil quality l
Loop (l,
Loop (j,
FYield (l,j) = (Grade(l,j,"Fancy")*Y(j,l))));
```

A.1 GAMS MODEL: ALL VARIETIES Cont.

```
display 'Fancy Yield', FYield;

Parameter ELKYield (l,j) ELK Yield for variety j at soil quality l
Loop (l,
Loop (j,
ELKYield (l,j) = (Grade(l,j,"ELK")*Y(j,l))));
display 'ELK Yield',  ELKYield;

Parameter TKYield (l,j) Total Kernal Yield for variety j at soil quality l
Loop (l,
Loop (j,
TKYield (l,j) = (Grade(l,j,"TK")*Y(j,l))));
display 'TK Yield',  TKYield;

Parameter ShellYield (l,j) (Fancy - ELK) * TK * Yield for variety j at soil quality l
Loop (l,
Loop (j,
ShellYield (l,j) = ((Grade(l,j,"Fancy")-Grade(l,j,"ELK"))* Grade(l,j,"TK")*Y(j,l))));
display 'Shelled Yield',  ShellYield;

Parameter LessF(l,j) One minus Fancy Percentage
Loop (l,
Loop (j,
LessF(l,j) = 1 - (Grade(l,j,"Fancy"))));
display '1-Fancy Percentage', LessF;

Parameter PBYield (l,j) (1 - Fancy) * TK * Yield for variety j at soil quality l
Loop (l,
Loop (j,
PBYield (l,j) = LessF(l,j)*TKYield(l,j)));
display 'Peanut Butter Yield',  PBYield;

*Starts Yield determination for 4-year Rotation*
Parameter FYieldR4 (l,j) Fancy Yield for variety j at soil quality l in 4 year rotation
Loop (l,
Loop (j,
FYieldR4 (l,j) = (Grade(l,j,"Fancy")*YR4(j,l))));
display 'Fancy Yield, 4-YR', FYieldR4;

Parameter ELKYieldR4 (l,j) ELK Yield for variety j at soil quality l in 4 year rotation
Loop (l,
Loop (j,
ELKYieldR4 (l,j) = (Grade(l,j,"ELK")*YR4(j,l))));
display 'ELK Yield, 4-YR',  ELKYieldR4;
```

A.1 GAMS MODEL: ALL VARIETIES Cont.

```
Parameter TKYieldR4 (l,j) Total Kernal Yield for variety j at soil quality l in 4 year rotation
Loop (l,
Loop (j,
TKYieldR4 (l,j) = (Grade(l,j,"TK")*YR4(j,l))));
display 'TK Yield, 4-YR',  TKYieldR4;

Parameter ShellYieldR4 (l,j) (Fancy - ELK) * TK * Yield for variety j at soil quality l in 4 year
rotation
Loop (l,
Loop (j,
ShellYieldR4 (l,j) = ((Grade(l,j,"Fancy")-Grade(l,j,"ELK"))* Grade(l,j,"TK")*YR4(j,l))));
display 'Shelled Yield, 4-YR',  ShellYieldR4;

Parameter LessFR4(l,j) One minus Fancy Percentage in 4 year rotation
Loop (l,
Loop (j,
LessFR4(l,j) = 1 - (Grade(l,j,"Fancy"))));
display '1-Fancy Percentage, 4-YR', LessFR4;

Parameter PBYieldR4 (l,j) (1 - Fancy) * TK * Yield for variety j at soil quality l in 4 year
rotation
Loop (l,
Loop (j,
PBYieldR4 (l,j) = LessFR4(l,j)*TKYieldR4(l,j)));
display 'Peanut Butter Yield, 4-YR',  PBYieldR4;


Table P (j,l) Price at the farm level for variety j soil quality l all rotations $ per pound
      high        good
b   0.18686     0.18520
1   0.19308     0.19142
2   0.18790     0.18624
ho   0.18635     0.18474
r   0.18470     0.18470;

Scalar Pct Price at the farm level for cotton per pound /0.52/;
```

A.1 GAMS MODEL: ALL VARIETIES Cont.

```
Table DCB (j,l) Direct Cost at the buying point for variety j soil quality l per lb based on Georgia
buying point $ per pound
       high        good
b      0.02187     0.02187
1      0.02187     0.02187
2      0.02187     0.02187
ho     0.02296     0.02296
r      0.02187     0.02187
;

Scalar PShell Price per pound for shelling costs /0.61364/;
Scalar PCONin Price per pound at the consumer level for in-shell peanuts /1.67/;
Scalar PCONsh Price per pound at the consumer level for shelled peanuts /2.47/;
Scalar PPB Price per pound at the consumer level for Peanut Butter /1.91733/;
variables
       z
       AC (j,l)
       ACct (l)
       ACR4 (j,l)
       ACR4ct(l);

Positive variables
       AC (j,l)
       ACct (l)
       ACR4 (j,l)
       ACR4ct(l);

Equations
      TProfit       "Objective Function, Maximize Profit"
      HighLimit      "High Soil Quality Constraint"
      GoodLimit      "Good Soil Quality Constraint"
      RSH3          "3-year Rotation, High Soil"
      RSH4          "4-year Rotation, High Soil"
      RSG3          "3-year Rotation, Good Soil"
      RSG4          "4-year Rotation, Good Soil"
      ;


Tprofit.. z =e= ((sum((j,l), (ELKYield(l,j)* AC(j,l)))* PCONin))
+ ((sum((l,j), (ShellYield(l,j)*AC(j,l)))*(PCONsh-PShell)))
+ ((sum((l,j),(PBYield(l,j)*AC(j,l)))*(PPB-PShell)))
-((sum((j,l), P(j,l)*AC(j,l)*YFS(j,l))))
-((sum((j,l), DCB(j,l)*AC(j,l)*YFS(j,l))))
+(sum((l), ACct(l)*Yct(l)*Pct))
```

```
-(sum((l), VCFct(l)*ACct(l)))
+
((sum((j,l), (ELKYieldR4(l,j)* ACR4(j,l)))* PCONin))
+ ((sum((l,j), (ShellYieldR4(l,j)*ACR4(j,l)))*(PCONsh-PShell)))
+ ((sum((l,j),(PBYieldR4(l,j)*ACR4(j,l)))*(PPB-PShell)))
-((sum((j,l), P(j,l)*ACR4(j,l)*YFSR4(j,l))))
-((sum((j,l), DCB(j,l)*ACR4(j,l)*YFSR4(j,l))))
+(sum((l), ACR4ct(l)*Yct(l)*Pct))
-(sum((l), VCFct(l)*ACR4ct(l)))
;


HighLimit.. AC('b','high') + ACct('high') + ACR4('b',"high") + ACR4ct("high")+
AC('1','high') + ACR4('1',"high")
+ AC('2','high') + ACR4('2',"high")
+ AC('ho','high') + ACR4('ho',"high")
+ AC('r','high') + ACR4('r',"high")
=l= 75000 ;

GoodLimit.. AC('b',"good")+  ACct("good") + ACR4('b',"good")+ ACR4ct("good")
+ AC('1',"good") + ACR4('1',"good")
+ AC('2',"good") + ACR4('2',"good")
+ AC('ho',"good") + ACR4('ho',"good")
+ AC('r',"good") + ACR4('r',"good")
=l= 100000;

RSG3.. (2/3)*(sum((j,l), AC(j,"good"))) - (1/3)* (sum ((l), ACct("good"))) =l= 0;
RSG4.. (3/4)*(sum((j,l), ACR4(j,"good"))) - (1/4)*(sum((l), ACR4ct("good"))) =l= 0;
RSH3.. (2/3)*(sum((j,l), AC(j,"high"))) - (1/3)* (sum ((l), ACct("high"))) =l= 0;
RSH4.. (3/4)*(sum((j,l), ACR4(j,"high"))) - (1/4)*(sum((l), ACR4ct("high"))) =l= 0;


model peanuts /all/;
option limcol=0;
option limrow=6;
solve peanuts using lp maximizing z;
```

APPENDIX B: CROP BUDEGETS AT THE FARM LEVEL

Table B.1 Baseline Variety, High Quality Soil, Variable Cost at the Farm Level

Baseline Variety, High Quality Soil CROP BUDGET GUIDE **Peanut STRIP TILL**			
		TOTAL $ / Acre	
OPERATING COSTS (VARIABLE)			
Seed, (lbs / ac.)	110		64.90
Nitrogen			
P2O5, Pro-rated (lbs.)	50		10.00
K2O, Pro-rated (lbs.)	100		18.00
Spreading/Ac, Pro-rated			$5.00
Plaster		$ 27.82	
Lime, ton	0.33		9.90
Chem.-Nemat. (80% Metam)		$ 34.85	
Herb.		$ 47.33	
Insecticides (Thrips, Rootworm, Sp.Mtes, Leafhpr)		$ 26.86	
Fungicides (scler 40%, leafspot, stem rot)		$ 80.16	
Other(adjuv. & foliar nutrients)		$ 4.14	
Production Machinery:			
Repairs			$9.83
Fuel,oil			$6.66
Harvest Machinery:			
Repairs			$56.38
Fuel,oil			$17.81
Gas,elec			$39.37
Marketing		.....	
Crop Insurance			$17.00
Miscellaneous			$20.00
6 Mos. Production Interest / ac	$365.45		$12.79
Labor			$58.08
Variable Cost at the Farm Level			$566.88

Source: Mike Roberts, Master Budget Calculator 2005.

Table B.2 Baseline Variety, Good Quality Soil, Variable Cost at the Farm Level

Baseline Variety, Good Quality Soil		
CROP BUDGET GUIDE		
Peanut STRIP TILL		
		TOTAL $ / Acre
OPERATING COSTS (VARIABLE)		
Seed, (lbs / ac.)	110	64.90
Nitrogen		
P2O5, Pro-rated (lbs.)	50	10.00
K2O, Pro-rated (lbs.)	100	18.00
Spreading/Ac, Pro-rated		$5.00
Plaster		$ 27.82
Lime, ton	0.33	9.90
Chem.-Nemat. (80% Metam)		$ 34.85
Herb.		$ 47.33
Insecticides (Thrips, Rootworm, Sp.Mtes, Leafhpr)		$ 26.86
Fungicides (scler 40%, leafspot, stem rot)		$ 80.16
Other(adjuv. & foliar nutrients)		$ 4.14
Production Machinery:		
Repairs		$9.83
Fuel,oil		$6.66
Harvest Machinery:		
Repairs		$56.38
Fuel,oil		$17.81
Gas,elec		$31.49
Marketing		.....
Crop Insurance		$17.00
Miscellaneous		$20.00
6 Mos. Production Interest / ac	$365.45	$12.79
Labor		$58.08
Variable Cost at the Farm Level		$559.00

Source: Mike Roberts, Master Budget Calculator 2005.

Table B.3 Variety One, High Quality Soil, Variable Cost at the Farm Level

Variety One, High Quality Soil — CROP BUDGET GUIDE — Peanut STRIP TILL		TOTAL $ / Acre
OPERATING COSTS (VARIABLE)		
Seed, (lbs / ac.)	110	64.90
Nitrogen		
P2O5, Pro-rated (lbs.)	50	10.00
K2O, Pro-rated (lbs.)	100	18.00
Spreading/Ac, Pro-rated		$5.00
Plaster		$ 27.82
Lime, ton	0.33	9.90
Chem.-Nemat. (80% Metam)		$ 34.85
Herb.		$ 47.33
Insecticides (Thrips, Rootworm, Sp.Mtes, Leafhpr)		$ 26.86
Fungicides (scler 40%, leafspot, stem rot)		$ 80.16
Other(adjuv. & foliar nutrients)		$ 4.14
Production Machinery:		
Repairs		$9.83
Fuel,oil		$6.66
Harvest Machinery:		
Repairs		$56.38
Fuel,oil		$17.81
Gas,elec		$50.88
Marketing		.....
Crop Insurance		$17.00
Miscellaneous		$20.00
6 Mos. Production Interest / ac	$365.45	$12.79
Labor		$58.08
Variable Cost at the Farm Level		$578.39

Source: Mike Roberts, Master Budget Calculator 2005.

Table B.4 Variety One, Good Quality Soil, Variable Cost at the Farm Level

Variety One, Good Quality Soil		
CROP BUDGET GUIDE		
Peanut STRIP TILL		
		TOTAL $ / Acre
OPERATING COSTS (VARIABLE)		
Seed, (lbs / ac.)	110	64.90
Nitrogen		
P2O5, Pro-rated (lbs.)	50	10.00
K2O, Pro-rated (lbs.)	100	18.00
Spreading/Ac, Pro-rated		$5.00
Plaster		$ 27.82
Lime, ton	0.33	9.90
Chem.-Nemat. (80% Metam)		$ 34.85
Herb.		$ 47.33
Insecticides (Thrips, Rootworm, Sp.Mtes, Leafhpr)		$ 26.86
Fungicides (scler 40%, leafspot, stem rot)		$ 80.16
Other(adjuv. & foliar nutrients)		$ 4.14
Production Machinery:		
Repairs		$9.83
Fuel,oil		$6.66
Harvest Machinery:		
Repairs		$56.38
Fuel,oil		$17.81
Gas,elec		$40.70
Marketing		.....
Crop Insurance		$17.00
Miscellaneous		$20.00
6 Mos. Production Interest / ac	$365.45	$12.79
Labor		$58.08
Variable Cost at the Farm Level		$568.21

Source: Mike Roberts, Master Budget Calculator 2005.

Table B.5 Variety Two, High Quality Soil, Variable Cost at the Farm Level

Variety Two, High Quality Soil		
CROP BUDGET GUIDE		
Peanut STRIP TILL		TOTAL $ / Acre
OPERATING COSTS (VARIABLE)		
Seed, (lbs / ac.)	110	64.90
Nitrogen		
P2O5, Pro-rated (lbs.)	50	10.00
K2O, Pro-rated (lbs.)	100	18.00
Spreading/Ac, Pro-rated		$5.00
Plaster		$ 27.82
Lime, ton	0.33	9.90
Chem.-Nemat. (80% Metam)		$ 34.85
Herb.		$ 47.33
Insecticides (Thrips, Rootworm, Sp.Mtes, Leafhpr)		$ 26.86
Fungicides (scler 40%, leafspot, stem rot)		$ 80.16
Other(adjuv. & foliar nutrients)		$ 4.14
Production Machinery:		
Repairs		$9.83
Fuel,oil		$6.66
Harvest Machinery:		
Repairs		$56.38
Fuel,oil		$17.81
Gas,elec		$35.87
Marketing		.....
Crop Insurance		$17.00
Miscellaneous		$20.00
6 Mos. Production Interest / ac	$365.45	$12.79
Labor		$58.08
Variable Cost at the Farm Level		$563.38

Source: Mike Roberts, Master Budget Calculator 2005.

Table B.6 Variety Two, Good Quality Soil, Variable Cost at the Farm Level

Variety Two, Good Quality Soil		
CROP BUDGET GUIDE		
Peanut STRIP TILL		
		TOTAL $ / Acre
OPERATING COSTS (VARIABLE)		
Seed, (lbs / ac.)	110	64.90
Nitrogen		
P2O5, Pro-rated (lbs.)	50	10.00
K2O, Pro-rated (lbs.)	100	18.00
Spreading/Ac, Pro-rated		$5.00
Plaster		$ 27.82
Lime, ton	0.33	9.90
Chem.-Nemat. (80% Metam)		$ 34.85
Herb.		$ 47.33
Insecticides (Thrips, Rootworm, Sp.Mtes, Leafhpr)		$ 26.86
Fungicides (scler 40%, leafspot, stem rot)		$ 80.16
Other(adjuv. & foliar nutrients)		$ 4.14
Production Machinery:		
Repairs		$9.83
Fuel,oil		$6.66
Harvest Machinery:		
Repairs		$56.38
Fuel,oil		$17.81
Gas,elec		$28.70
Marketing		.....
Crop Insurance		$17.00
Miscellaneous		$20.00
6 Mos. Production Interest / ac	$365.45	$12.79
Labor		$58.08
Variable Cost at the Farm Level		$556.21

Source: Mike Roberts, Master Budget Calculator 2005.

Table B.7 Variety High Oleic, High Quality Soil, Variable Cost at the Farm Level

Variety High Oleic, High Quality Soil		
CROP BUDGET GUIDE		
Peanut STRIP TILL		
		TOTAL $ / Acre
OPERATING COSTS (VARIABLE)		
Seed, (lbs / ac.)	110	64.90
Nitrogen		
P2O5, Pro-rated (lbs.)	50	10.00
K2O, Pro-rated (lbs.)	100	18.00
Spreading/Ac, Pro-rated		$5.00
Plaster		$ 27.82
Lime, ton	0.33	9.90
Chem.-Nemat. (80% Metam)		$ 34.85
Herb.		$ 47.33
Insecticides (Thrips, Rootworm, Sp.Mtes, Leafhpr)		$ 26.86
Fungicides (scler 40%, leafspot, stem rot)		$ 80.16
Other(adjuv. & foliar nutrients)		$ 4.14
Production Machinery:		
Repairs		$9.83
Fuel,oil		$6.66
Harvest Machinery:		
Repairs		$56.38
Fuel,oil		$17.81
Gas,elec		$42.60
Marketing		.....
Crop Insurance		$17.00
Premium on Seed		$25.00
Miscellaneous		$20.00
6 Mos. Production Interest / ac	$365.45	$12.79
Labor		$58.08
Variable Cost at the Farm Level		$595.11

Source: Mike Roberts, Master Budget Calculator 2005.

Table B.8 Variety High Oleic, Good Quality Soil, Variable Cost at the Farm Level

Variety High Oleic, Good Quality Soil CROP BUDGET GUIDE **Peanut STRIP TILL**		TOTAL $ / Acre
OPERATING COSTS (VARIABLE)		
Seed, (lbs / ac.)	110	64.90
Nitrogen		
P2O5, Pro-rated (lbs.)	50	10.00
K2O, Pro-rated (lbs.)	100	18.00
Spreading/Ac, Pro-rated		$5.00
Plaster		$ 27.82
Lime, ton	0.33	9.90
Chem.-Nemat. (80% Metam)		$ 34.85
Herb.		$ 47.33
Insecticides (Thrips, Rootworm, Sp.Mtes, Leafhpr)		$ 26.86
Fungicides (scler 40%, leafspot, stem rot)		$ 80.16
Other(adjuv. & foliar nutrients)		$ 4.14
Production Machinery:		
Repairs		$9.83
Fuel,oil		$6.66
Harvest Machinery:		
Repairs		$56.38
Fuel,oil		$17.81
Gas,elec		$34.08
Marketing		.....
Crop Insurance		$17.00
Premium on Seed		$25.00
Miscellaneous		$20.00
6 Mos. Production Interest / ac	$365.45	$12.79
Labor		$58.08
Variable Cost at the Farm Level		$586.59

Source: Mike Roberts, Master Budget Calculator 2005.

Table B.9 Runner Variety, High Quality Soil, Variable Cost at the Farm Level

Runner Variety , High Quality Soil		
CROP BUDGET GUIDE		
Peanut STRIP TILL		
		TOTAL $ / Acre
OPERATING COSTS (VARIABLE)		
Seed, (lbs / ac.)	140	98
Inoculant		5
Nitrogen		4.35
Phosphate	30	3.9
Potash	90	18.9
Boron	2.5	$1.73
Plaster	12	$22.80
Lime, ton	0.5	15
Herbicides		$62.10
Insecticides		$44.08
Fungicides		$70.64
Scouting		$7.00
Hauling		$19.76
Drying and Cleaning		32.93
Crop Insurance		$22.00
Tractor/Machinery		$48.08
Labor		21.18
Interest on Capital		$17.76
Misc		$19.85
Variable Cost at the Farm Level		$535.06

Source: Gary Bullen, David Jordan, and Sam Walton. NC State, Dept. Agricultural and Resource Economics. 2003 Budgets

Table B.10 Runner Variety, Good Quality Soil, Variable Cost at the Farm Level

Runner Variety , Good Quality Soil		
CROP BUDGET GUIDE		
Peanut STRIP TILL		
		TOTAL $ / Acre
OPERATING COSTS (VARIABLE)		
Seed, (lbs / ac.)	140	98
Inoculant		5
Nitrogen		4.35
Phosphate	30	3.9
Potash	90	18.9
Boron	2.5	$1.73
Plaster	12	$22.80
Lime, ton	0.5	15
Herbicides		$62.10
Insecticides		$44.08
Fungicides		$70.64
Scouting		$7.00
Hauling		$19.76
Drying and Cleaning		32.93
Crop Insurance		$22.00
Tractor/Machinery		$48.08
Labor		21.18
Interest on Capital		$17.76
Misc		$9.36
Variable Cost at the Farm Level		$524.57

Source: Gary Bullen, David Jordan, and Sam Walton. NC State, Dept. Agricultural and Resource Economics. 2003 Budgets

Table B.11 Cotton, High Quality Soil, Variable Cost at the Farm Level

Cotton , High Quality Soil		
CROP BUDGET GUIDE		
Conventional Tillage, Conventional Seed Variety		TOTAL $ / Acre
OPERATING COSTS (VARIABLE)		
Seed (lbs / Ac)		20.00
Nitrogen (15lb starter & 60 lb sidedress)	10	22.88
P2O5	75	8.00
K2O	40	21.60
Spreading	120	5.00
Lime,ton,Pro-rated	1	12.00
Chemicals:	0	
Herb.		28.99
Insecticides		26.26
Growth Reg., Boron		10.79
Defoliants,		7.50
Scouting, IPM, Soil Sampling		8.50
Production Machinery:		
Repairs		16.70
Fuel,oil		11.27
Harvest Machinery:		
Repairs		29.35
Fuel,oil		16.51
Ginning costs (incl. Module credit)		
- Minus Seed Credit	90.00	
	-48.94	41.06
Crop Insurance		9.00
BWEP		4.35
Miscellaneous:		5.00
7.2 Mos. Production interest:		8.38
Labor	199.48	51.60
Variable Cost at the Farm Level		364.74

Source: Mike Roberts, Master Budget Calculator 2005.

Table B.12 Cotton, High Quality Soil, Variable Cost at the Farm Level

Cotton , Good Quality Soil		
Conventional Tillage, Conventional Seed Variety		TOTAL $ / Acre
OPERATING COSTS (VARIABLE)		
Seed (lbs / Ac)	10	20.00
Nitrogen (15lb starter & 60 lb sidedress)	75	22.88
P2O5	40	8.00
K2O	120	21.60
Spreading	1	5.00
Lime,ton,Pro-rated	0	12.00
Chemicals:		
Herb.		$ 28.99
Insecticides		$ 26.26
Growth Reg., Boron		$ 10.79
Defoliants,		$ 7.50
Scouting, IPM, Soil Sampling		$ 8.50
Production Machinery:		
Repairs		$16.70
Fuel,oil		$11.27
Harvest Machinery:		
Repairs		29.35
Fuel,oil		16.51
Ginning costs (incl. Module credit)	90.00	
- Minus Seed Credit	-42.4125	
		$35.59
Crop Insurance		$ 9.00
BWEP		$ 4.35
Miscellaneous:		$ 5.00
7.2 Mos. Production interest:	199.48	$8.38
Labor		51.60
Variable Cost at the Farm Level		359.26

Source: Mike Roberts, Master Budget Calculator 2005.

Table B.13 Peanut Price at the Farm Level based on grading percentages

High Quality Soil	Baseline	Var 1	Var 2	Var ho	Var r
Yield	2715	3509	2474	2938	4936
FM	27	35	25	29	0
Net Weight	2688	3474	2449	2909	4936
LSK (% x Yield)	136	175	124	235	0
Net Weight less LSK	2552	3298	2326	2674	4936
Kernel Value less LSK	18.45	19.12	18.63	18.70	18.47
ELK Prem	0.86	0.96	0.79	1.00	0.00
Value/lbs exclude LSK	19.31	20.08	19.42	19.70	18.47
Excess: Damage, FM, Spilts		0.12	0.00	0.04	0.00
LSK x 7 cents	9.50	12.28	8.66	16.45	0.00
Total	502.25	670.74	460.22	542.01	911.68
Total/yield	0.18	0.19	0.19	0.18	0.18
Total/yield-FM	0.1869	0.19308	0.18790	0.18635	0.18470

Good Quality Soil	Base	Var 1	Var 2	Var ho	Var r
Yield	2172	2807	1979	2350	3949
FM	22	28	20	24	0
Net Weight	2150	2779	1959	2327	3949
LSK (% x Yield)	109	140	99	188	0
Net Weight less LSK	2042	2639	1860	2139	3949
Kernel Value less LSK	18.45	19.12	18.63	18.70	18.47
ELK Prem	0.68	0.79	0.61	0.82	0.00
Value/lbs exclude LSK	19.13	19.91	19.24	19.52	18.47
Excess: Damage, FM, Spilts		0.12	0.00	0.04	0.00
LSK x 7 cents	7.60	9.83	6.93	13.16	0.00
Total	398.23	531.97	364.92	429.87	729.34
Total/yield	0.18	0.19	0.18	0.18	0.18
Total/yield-FM	0.18520	0.19142	0.18624	0.18474	0.18470

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