TWO ESSAYS ON THE EFFECTS OF POLICIES AND PERSPECTIVES OF THE U.S. TOBACCO INDUSTRY

by

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(Under the Direction of Genti Kostandini)

ABSTRACT

The United States tobacco industry is rich in history. It was one of the first government subsidized crops, experienced rapid growth in the late 1800s and early 1900s, experienced declining domestic demand for the last 50 years, and most recently adjusted after the deregulation of the federal tobacco program. We examine some of these events in two essays: the first is an analysis of tobacco productivity before and after the tobacco buyout of 2004 and the second is an evaluation of the perceptions of tobacco producers' knowledge, concern, and willingness to adopt biopharming.

INDEX WORDS: Tobacco, Productivity, Buyout, Tobacco Program, Quota, County Level, Exit, Stay, Enter, Yield, Biopharming, Producer, Perception, Concern, Knowledge, Adopt

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CHAPTER 1

TWO ESSAYS ON THE EFFECTS OF POLICIES AND PERSPECTIVES OF THE U.S. TOBACCO INDUSTRY

1.1 Introduction

The tobacco plant has richly contributed to America's economic establishment. It provided the original Virginia settlement with a valuable crop to export back to Great Britain and is recognized as an early catalyst for economic growth, throughout the remaining colonies. Tobacco plantations in the Chesapeake colonies rose from a few hundred in 1617 to over half a million by 1776. Tobacco exports, during that same time period, rose from 20,000 to 100 million pounds, which contributed significantly to economic growth (Robert, 1967).

Until the 1960's, the U. S. was the number one tobacco producer and manufacturer in the world. However, starting in the 1930's, researchers were beginning to document the negative correlation between tobacco consumption and life expectancy. In 1964, Surgeon General, Luther L. Terry, formally condemned tobacco consumption because of the negative impacts cigarette smoking has on overall health (Gale et al., 2000). Consequently, the government took a formal stance on cigarette smoking, and aggregate tobacco consumption in the U.S. began and continues to decline today.

The U.S. tobacco industry has undergone dramatic economic changes, including becoming one of the first government subsidized crops in the 1930's, experiencing rapid growth in the late 1800's and early 1900's, domestic declining demand for the last 50 years, and most recently adjusting to a free market after government support for tobacco was eliminated in 2004.

Prior to 2004, the government supported the tobacco market by restricting supply through quotas, which increased the price farmers received.

1.2 Problem Statement

The tobacco industry has been ever changing since the colonists first began growing the tobacco plant in the Virginia settlement. There is an abundance of tobacco issues that can be addressed through economic research. For example, there are many economic theories that could be tested from a government controlled market that is forced to transition into a free market. The lessons can be applied to other agricultural markets that use quotas or other support mechanisms, such as the U.S. sugar market. For example, studying the tobacco buyout can reveal how a market adjusts itself to equilibrium after government intervention is removed. We can also see how resources are reallocated to achieve production efficiency by studying changes in productivity. Additionally, we can identify which resources stay in production and which ones switch to some other production activity.

Although U.S. tobacco production has declined, mainly due to less demand for tobacco, as well as more competition from producers outside the U.S., scientists have found other uses of tobacco, which are quite different from smoking. Biopharming, which refers to the production of pharmaceuticals in genetically modified plants, is a new promising field with opportunities for tobacco production. Thus, producers may have the opportunity to produce and sell tobacco intended for biopharmaceutical companies. However, little is known on how tobacco farmers perceive biopharming and the conditions under which they may be willing to grow tobacco for pharmaceutical use.

1.3 Research Objectives

There are three main objectives we aim to achieve from studying the changes of the tobacco market structure. First, we would like to analyze the productivity changes in the tobacco industry, after the tobacco quota was removed in 2004. It is important to study the changes in productivity in order to identify the market forces responsible for shifts in production. The results provide information to tobacco farmers to make better decisions about future production. It can also give information for businesses that are affected by tobacco production or regional policy makers concerned about local economies. The findings can also be used to analyze future deregulations in other markets that are government supported.

Second, we would like to analyze the characteristics of those that exited, stayed, or entered the tobacco industry post buyout. The producer characteristics are important to study because it helps identify some of the changes in the industry including: farm size, farm numbers, and crop regions. Again, this information is valuable for farmers, businesses, and regional policy makers because with more information they can make better decisions, which can lead to a better allocation of resources and improve social welfare.

Finally, we would like to quantify tobacco producers' knowledge of biopharming, as well, as their willingness to grow tobacco for biopharming under different production scenarios. This information is important for decision and policy making for biotechnology firms and future participants in the tobacco biopharming market

1.4 Hypotheses

According to microeconomic theory, a competitive market will yield efficient prices and quantities. Economists agree that if the price signals are right, then a well-behaving competitive market will be efficient. Given the restrictions of the tobacco quotas, we hypothesize that tobacco productivity was stifled by governmental market intervention and when the quota was removed, resources were allocated more efficiently, prices adjusted and overall tobacco productivity increased. Therefore, we expect the yields after the buyout to increase because the most efficient farmers will stay in the industry and the others will exit. The quotas that tobacco producers were renting in order to grow more tobacco, were tied to the land. However, it could be the case that the land may have been more suitable for other agricultural activity, but it was confined to tobacco production. Once quotas were eliminated, in 2004, we expect those that wanted to produce more tobacco but could not because of the quota rental rates and those that did not want to produce tobacco but could not transition to another crop would adjust accordingly. Tobacco farms would then consolidate because of increasing returns to scale, and tobacco production would be allocated to the most productive land. However, this hypothesis is tested at the county level as farm level tobacco production data was not available.

We also examine what type of characteristics counties that exit, stay, and enter in the tobacco industry possess. We hypothesize that counties with a relatively higher number of larger farms, areas where tobacco production is not predominant, relatively higher number of older farmers, and areas with a broad array of economic activity would be more likely to exit. Larger farms are more likely to have a diversified crop portfolio, so it is expected that if they were producing tobacco on land more suitable for other production they would have greater ease transitioning out of the tobacco industry by switching to some other crop already in production. Counties with less agricultural acres relative to other land uses would be more apt to exit the industry because there is likely some other dominant industry that could offer a more productive use for the land. Older farmers would be more likely to exit because they are generally more risk averse when considering potential losses (Albert and Duffy, 2012).[1] Finally, counties with a higher employment rate would be more likely to exit because this would be an indicator there are other opportunities to pursue. Conversely, we hypothesize counties with a relatively larger number of medium farms, areas where tobacco production has historically been more predominant, younger farmers, and areas with less economic alternatives would be more likely to stay in the tobacco industry.

When analyzing tobacco producers' willingness to adopt the new technology of biopharming, we hypothesize that younger producers with more acres, higher incomes, higher education, and little concern over the new technology's potential drawbacks would be more likely to adopt biopharming. Younger producers have a longer time horizon and therefore, have more time to recover sunk costs from transitioning into a new industry. Also, those with higher income and education would be willing to take on more risks because people typically display decreasing absolute risk aversion as wealth increases (Greer Jr., 1974). Finally, we expect that farmers that are less concerned about biopharming would be more likely to grow pharmaceutical crops because they do not perceive it as risky as those that reported concern.

1.5 Method and Data

There are two types of econometric models used in this study. We use a linear log model that is estimated using ordinary least squares to measure the changes in the productivity of tobacco production before and after the buyout. We also use probit models to determine the characteristics of those who stay, enter, and exit the tobacco industry. Data from the 2002 and 2007 wave of the United States Census of Agriculture are used for the county-level analysis. This data allows us to measure productivity before and after the elimination of the quota, which

[1] The literature proves there is a divide on whether risk aversion increases with age. Once deregulation occurred, farmers would no longer be protected by government price supports from market volatility. Therefore, older farmers would exit the industry to protect themselves from potential losses.

occurred in 2004. It also allows us to observe the counties that exited the industry, new entrants as well as those that remained. Additional variables are collected from the United States Census of 2007.

When analyzing tobacco producers' perceptions of biopharming, we use probit models to determine the characteristics that affect producers' willingness to adopt biopharming technologies. We conducted a survey among tobacco producers in July 2012 to elicit this information.

1.6 Organization of Thesis

The thesis is comprised of two separate papers. The first paper is an analysis of the productivity and participation in the tobacco industry after the Tobacco Transition Payment Program of 2004 and is presented in Chapter 2. The second paper is an analysis of tobacco producers' perception of biopharming and is presented in Chapter 3. Both papers include background information, literature reviews, data overviews, methodologies, results, and conclusions. A comprehensive discussion of implications, results, and conclusions is provided in Chapter 4.

CHAPTER 2

ANALYZING PRODUCTIVITY AND PARTICIPATION IN THE U.S. TOBACCO INDUSTRY AFTER THE 2004 BUYOUT: COUNTY-LEVEL EVIDENCE

2.1 Introduction

The Tobacco Transition Payment Program of 2004, better known as the “tobacco buyout”, was a significant piece of legislation for U.S. agriculture (Federal Register, 2005). Historically, tobacco production in the U.S. has been supported through a system of minimum price levels and quotas. The industry’s 66 year support was taken away and the tobacco industry was left with Adam Smith’s invisible hand to guide the market, thereafter.

The federal tobacco support program was a part of the Agricultural Adjustment Act of 1933 and 1938, which was originally a stimulus response to the economic conditions caused by the Great Depression (Womach, 2005). The government offered farmers payments in return for leaving some land fallow. The intent was to decrease supply, via quota, and increase prices to restore profitability in farming. The tobacco support program was amended several times since its creation but largely remained the same up until it was eliminated in 2004.[2] During its existence, tobacco producers were required to agree through a referendum every three years on whether a price support would continue. Once the price support was approved, the producers

[2] Flue-cured and burley tobacco were governed by similar but distinct support programs. Specific program policies also differed between states.

were subjected to a marketing quota.[3] Subsequently, this federal government program increased the price of tobacco in two ways: restricting the supply via quota and ensuring a minimum price level (Womach, 2005).

A number of studies have examined the potential and actual effects of the tobacco buyout program in the U.S. at the farm level (e.g. Beach et al., 2006; Brown et al., 2007; Foreman and McBride, 2011; Hart, 2011; Kirwan et al., 2012; Rucker et al., 1996; Serletis and Fetzer, 2008; Tiller et al., 2010). However, little is known on the effects of the tobacco buyout program at the county level. We do this by examining the major determinants of tobacco productivity before and after the buyout program as well as the characteristics of those counties that exited, stayed and entered the tobacco industry.

2.2 History of the Tobacco Support Program

2.2.1 Marketing Quota

The yearly, aggregate quotas were determined by the announced sum of purchase intentions by U.S. cigarette manufacturers, a three year average of exports, and adjustments for inventories from tobacco cooperatives (Brown and Martin, 1996). A farmer's individual quota was based on production from a historical base year (Foreman and McBride, 2006). The quotas were earmarked to the land.[4] New tobacco farmers or existing farmers that wanted to increase acreage could only do so by purchasing or renting quota land from other farmers. Not only could farmers not grow tobacco without a quota, but tobacco production was restricted to being grown to the land that the quota was originally allocated to. Over time quotas were distributed among

[3] The original policy used acreage allotments to restrict production until 1965, and then quotas that were based on poundage were used instead (Brown et al., 2007).

[4] Before 1962, flue cured tobacco allotments were tied to the land the allotment was originally assigned to. After 1962, the allotments (and then quotas in 1965) were permitted to be leased and transferred and not tied to the land. In 1987, the rules reverted and flue cured tobacco quotas were tied to the land (Rucker et al., 1995).

heirs of tobacco quota owners, quota land owners that did not produce, and active farmers who inherited or purchased quotas (Brown and Martin, 1996)

As the demand for tobacco began to decline in the 1960's (Gale et al., 2000), the government strengthened the tobacco restrictions by reducing the quota so they could maintain the support prices (Tiller et al., 2004). This resulted in quotas becoming valuable assets for owners and costly expenses for farmers that wanted to grow tobacco and did not have access to a quota.

2.2.2 Commodity Credit Corporation Loans

In addition to the quota, the federal tobacco program also supported tobacco farmers by ensuring a minimum price level received at auction.[5] Tobacco that was not sold at auction above the support price would be sold to a cooperative that funded its purchases with loans from the Commodity Credit Corporation (CCC). The cooperative would store and sell the tobacco at a later date, using the tobacco as collateral for the government insured loan. The earnings from the later sell date would repay the CCC's principal loan and interest (Womach, 2005).

2.2.3 No-Net Cost Program Act of 1982

Over the course of the tobacco program's existence, the CCC loaned the tobacco cooperatives $10 billion to support tobacco prices. Due to market volatility and agricultural uncertainties, the tobacco cooperatives paid back all but $700 million (Snell, 2007). In 1982, Congress passed the No-Net Cost Tobacco Program Act as a way to shield taxpayers' dollars from supporting defaulted cooperative loans when the tobacco could not be sold (Womach, 2005). Thereafter, tobacco farmers and buyers were required to split fees that were designated to

[5] The price levels were determined by a weighted average of changes in productions costs and lagged market prices (Brown and Martin, 1996).

an escrow account and would be used to cover any losses the government incurred from unpaid loans (Womach, 2005).

Although it was established 22 years prior to the buyout, the No-Net Cost Program can be seen as a significant impetus leading up to the tobacco quota elimination in 2004. The program shifted the cost of supporting tobacco prices from the government to tobacco farmers and buyers (Womach, 2005). Tobacco farmers began to experience diminishing benefits from the program after the No-Net Cost legislation. Since they were partially responsible to pay for the support price, which was accomplished through legislation in 1985, it was no longer in their interest to have the price significantly propped up (Womach, 2005).

2.2.4 Reasons for the Buyout

Congressional efforts to eliminate the federal tobacco program began in 1997. At the time, the larger issue at hand was a public debate of cigarette manufacturers' liability for increased health care costs. However, between 1997 and 2004, twelve bills were introduced in Congress that would eliminate the tobacco program. Tobacco farmers, cigarette manufacturers, and health advocates largely supported a buyout of tobacco quotas (Brown et al., 2007).

Tobacco farmers supported a buyout due to the increase in quota rental rates (Snell et al., 2003). In the 2000's, quota rental rates had soared to a quarter of the total cost of producing tobacco (Hart, 2011). This increase in quota rental rates was due to decreased U.S. and foreign demand in tobacco. As mentioned, the demand for tobacco was declining significantly in the 1990's and 2000's (Gale et al., 2000) due to health concerns, increased excise taxes, and smoking restrictions. Additionally, U.S. tobacco exports were vulnerable to the increase in high quality tobacco from foreign competition, which further decreased demand (Brown, et al., 2007) and led the government to reduce the quota's poundage in order to support the minimum price levels (Brown and Snell, 2003). With fewer quotas available, the tobacco producers were worse off as the benefits of the tobacco program continued to diminish with decreasing demand.[6] Therefore, tobacco farmers supported the elimination of the government made assets in order to lower cost and become more competitive in the international market (Brown et al., 2007). Cigarette manufacturers had similar incentives to support the quota buyout (Brown, et al., 2007).

2.2.5 Tobacco Transition Payment Program of 2004

After several years of failed legislative bills, the Tobacco Transition Payment Program of 2004, known as the tobacco buyout, was signed into law. In short, the tobacco buyout was tax legislation on cigarette manufacturers used to compensate quota owners for the value of the quota and for assistance to adjust to a free market. The program cost of $10.14 billion, all of which will be financed by U.S. cigarette manufacturers. The payments total to $9.6 billion and are to be dispersed to tobacco quota owners. The remaining $540 million is used to transfer government loan stocks from CCC back to tobacco cooperatives. Quota owners received $7 for each pound based on the 2002 quota level. The payments are dispersed over ten years, from 2005 to 2014, in equal payments of $0.70 per pound. Growers could receive an additional $3 per pound, called the “grower incentive”, if they actively grew tobacco in 2002, 2003, and 2004. Likewise, the payments would be dispersed in equal payments of $0.30 per pound over ten years (Federal Register, 2005). A grower could also receive partial payments of one third or two thirds of $3 per pound, if they grew tobacco one or two of the years between 2002 and 2004 (Brown, 2005).

[6] The price supports were not very responsive to declining demand for tobacco. Production cost is one half of the calculation for a given year’s minimum price level. Therefore, since production costs are inversely related to declining demand, due to quota rates, the price support will not respond the same as free market prices with declining demand (Brown and Martin, 1996).

2.3 Literature Review

Several studies have examined the effect of the quotas, price support system, and other restrictions on tobacco farming. Nine years before the program was eliminated, Rucker, Thurman and Sumner (1995) analyzed the deadweight loss created from the restrictions on the inter-county transfer of quotas. They estimated demand functions for quotas in North Carolina counties. They found that quota income and producer surplus at the state level would be relativity the same if the restriction to the transfer rights across county lines were removed. However, they found that at the county level, rates and income received from quotas would change considerably.

After the buyout legislation was passed, more research on the impacts that the buyout would have on tobacco production were forecasted. Brown et al. (2007) presented welfare impacts and production estimates from eliminating the flue-cured tobacco program using regional and state level supply and demand functions. Their simulations suggested that tobacco production in the U.S. would increase from 470.9 million in 2003 to 782.8 million pounds in 2007. They also reported that North Carolina would benefit the most from the production gains in flue cured production, and all other states would experience some increases in production.

Beach et al. (2006) used a unique data set, ranging between 1997 and 2004, that surveyed tobacco producers about their preferences, resource endowments, market incentives, risks, factors on considering exiting the industry, changing tobacco acreage, and diversifying their crop portfolio. The researchers found that if a buyout occurred 35% of respondents indicated they would exit the industry, 39% would stay and increase tobacco acreage, 21% would keep tobacco acreage the same, and 4% would decrease their acreage. The study also found that producers with more acres were more likely to indicate that they would increase their acreages if a buyout occurred compared to those with fewer acres. The findings of Beach et al. (2006) are similar to other research (Snell, 2005; Tiller and Brown, 2003) right after the buyout. It was widely agreed that the tobacco industry would experience rapid consolidation.

A more recent study conducted by Tiller et al. (2010) surveyed burley tobacco growers to find a relationship between both personal and farm characteristics that affected the probability of exiting the tobacco industry after the buyout. Their survey reported that 54% of the sample exited the tobacco industry by 2006. They found tobacco yield, tobacco farm cash receipts, tobacco price, off farm employment, and farm size to be the main determinants that influenced producers to exit the industry.

Even more recent, Kirwan et al.(2012) estimated farm productivity levels before and after the buyout for burley tobacco growers in Kentucky. They decomposed aggregate productivity into farm level productivity and resource reallocation productivity and found that Kentucky tobacco productivity increased by 44%, of which, 22% was contributed to resource reallocation. They also report the number of farms that exited, stayed, or entered the tobacco industry and the corresponding tobacco acres harvested in Kentucky. They found that farms that stayed in production increased their acres harvested by an average of 3.5 acres. The farms that entered the industry had comparable average acres harvested to those of stayers (around 11 acres).

Our study extends this literature by focusing on all U.S. counties using data from the Census of Agriculture waves of 2002 and 2007. This study examines productivity before and after the buyout and uses several explanatory variables (e.g. machinery, seeds and plants, fertilizers, chemicals, land and building, and labor) to examine any changes in productivity, as well as the main drivers behind those that exited, stayed, or entered in the industry after the tobacco buyout in 2004. Thus, we do broaden the geographic base by using all tobacco producing counties in the U.S. rather than one state and offer further quantitative analysis on the determinants of exiters, stayers, and entrants in the tobacco industry.

2.4 Data and Methods

2.4.1 Summary Data

As mentioned, data used for the analysis of productivity changes after the tobacco buyout of 2004 and probability estimates for counties exiting, entering, and staying in the tobacco industry were collected from the Census of Agriculture waves of 2002 and 2007. A summary of the variables used for modeling productivity are presented in Table 2.1. The variables for machinery value, seeds and plants, fertilizers, land and building, chemicals, and labor were reported by the Census of Agriculture in absolute dollars. Since the dependent variable, yield, is a per acre value, the regressors are divided by the total number of agricultural acres in the counties so they are also a per acre value. The natural log is used because it expected that yield will increase at a decreasing rate as an input increases.

Table 2.1 Summary Statistics for the Tobacco Productivity Model.

Variable	Obs. 2002	Mean 2002	Std. Dev. 2002	Obs. 2007	Mean 2007	Std. Dev. 2007
Tobacco Production:						
Yield	447	1891.636	395.701	341	2044.99	378.883
Acres Harvested	447	949.277	1413.601	341	1029.71	1700.113
Pounds	450	1927744	2996022	341	2231617	3794802
Regional Dummies:						
Southeast	450	0.131	0.338	341	0.100	0.300
Mid-Atlantic	450	0.680	0.467	341	0.748	0.435
Northeast	450	0.082	0.275	341	0.076	0.266
Mid-West	450	0.107	0.309	341	0.076	0.266
Per Acre Values (in dollars):						
Machinery	423	10016.46	17149.13	326	14242.97	20974
Seeds and plants	417	289.962	875.63	324	390.177	913.291
Fertilizers	423	453.196	1000.81	326	803.92	1714.86
Land and building	423	80225.64	141683	326	109553.8	152984.20
Chemicals	420	211.995	596.02	324	271.738	689.801
Labor (hired and contracted)	406	650.574	1015.70	308	804.87	1538.799
Logarithm of Per Acre Values:						
Machinery	423	8.391	1.299	326	8.802	1.282
Seeds and plants	417	4.653	1.300	324	5.070	1.195
Fertilizers	423	5.364	1.128	326	5.924	1.115
Land and building	423	10.483	1.292	326	10.882	1.267
Chemicals	420	4.534	1.165	324	4.798	1.095
Labor (hired and contracted)	406	5.854	1.081	308	6.026	1.087

Table 2.2 shows the four dummy variables used to identify regional differences in tobacco production. Mid-Atlantic is used as the baseline and includes the largest tobacco producing counties in the states of Kentucky, North Carolina, Tennessee, Virginia, and West Virginia. Mid-West includes counties in Illinois, Indiana, Iowa, Kansas, and Missouri. Northeast includes counties in Connecticut, Maryland, Massachusetts, Ohio, and Pennsylvania. Southeast includes counties in Alabama, Florida, Georgia, Louisiana, and South Carolina. The Mid-

Atlantic region is the only one that increased its percentage after the buyout relative to all U.S. tobacco producing counties.

Table 2.2 Region Frequencies and Percentages.

	2002		2007	
Region	**Frequency**	**Percent**	**Frequency**	**Percent**
Mid-Atlantic	306	68	255	74.78
Mid-West	48	10.67	26	7.62
Northeast	37	8.22	26	7.62
Southeast	59	13.11	34	9.97
Total	450	100	341	100

Next, Table 2.3 presents a summary of the variables used for the probit models. The data are collected from the United States Census in year 2007. Agricultural acres are used as a regressor because it is expected counties with more agricultural production would be less likely to exit. The percentage of those that are farmers by principal occupation is used as a regressor because it is expected that counties with more full-time farmers would be less likely to exit. The percentage of those that are employed is used as a regressor because it is expected that counties with lower employment rates have less job opportunities outside of farming and would be less likely to exit. The percentage of those ages 55 to 59 is used as a regressor because it is the average of age tobacco farmers and one would expect they would be more likely to exit costs because the industry will be exposed to more volatility once it is deregulated. The percentage of farms with 10 to 49 farming acres is considered as a medium farm because the average size of a tobacco farm in 2007 was approximately 10 acres (Snell, 2009). The percentage of farms with 50 acres or more are considered large farms. Both farm percentages are expected to be significant in affecting the probability of exiting, staying, and entering.[7]

Table 2.3 Summary Statistics for the Probit Models.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Yield (2002)	434	1890.218	392.2282	399	3067.28
Yield (2007)	334	2040.895	379.0517	790	3697.619
Exits	446	0.251121	0.434145	0	1
Entrants	446	0.020179	0.140771	0	1
Stayers	446	0.7287	0.44513	0	1
Agricultural Acres	578	122899.8	82433.99	2299	535756
Percent of principal farmers	578	0.010601	0.009647	5.23E-05	0.063056
Percent employed	578	0.490422	0.129807	0.158658	0.901895
Percent age 55 to 59	578	0.065835	0.007325	0.036173	0.091688
Percent of medium farms	578	0.351465	0.092964	0.047059	0.605263
Percent of large farms	578	0.243756	0.133238	0.018692	0.755877
Population	578	78301.24	149484.2	2205	1219922

* All variables are from 2007, unless otherwise noted.

2.4.2 Methodology

In order to measure productivity in tobacco production, we use the per acre yield as a proxy variable. As shown in Table 2.1 average yields for U.S. tobacco producing counties in 2007 is higher than in 2002. We use a t-test to determine whether the yields in each year are significantly different and results (presented below) confirm our hypothesis.

To further analyze the productivity changes between 2002 and 2007, we use the log of capital, labor, and intermediates to explain yields.

A linear log model is used for each year of data, 2002 and 2007. The model is as followed:

[7] The size of the farm has already been proven to be significant in affecting the probability of exiting, staying, and entering the industry from Beach et al. (2006); Kirwan et al. (2012); and Tiller et al. (2010).

$$(2.1)\ Y_{ij} = (\beta_0 + \sum \beta(\ln X_{ij}) + \sum \alpha D_{ij} + \varepsilon_{ij})$$

where Y_{ij} is the average tobacco yield in the *ith* county in the *jth* year, calculated as the total of average production in pounds divided by the total tobacco acres harvested. The right side of the equation includes β_0, which is the y-intercept, X_{ij} is a vector of continuous explanatory variables, D_{ij} is a vector of geographic dummy variables and ε_{ij} is assumed to have a normal distribution. More specifically, X_{ij} represents the logarithm of input variables for production of tobacco in terms of per acre values in dollar amounts (machinery value per acre, seeds and plants value per acre , fertilizers value per acre, land and building value per acre, chemical value per acre, labor value per acre). Additionally, counties' average tobacco acres are used as weights to delineate the importance of tobacco production for counties with significant acres relative to counties with fewer acres.

Next, a probit model is used to estimate the main determinants of exiting, staying, or entering the tobacco industry. The model is as followed:

$$(2.2)\ \Pr(Y_i = 1 | X_i) = \Phi(X_i{}'\beta)$$

where Pr denotes probability and Φ represents the Cumulative Distribution Function (CDF) of the standard normal distribution. The β parameters are estimated using Maximum Likelihood and X_i is a vector of explanatory variables namely; agricultural acres, percentage of those that are farmers by principal occupation, percentage of those that are employed, percentage of those age 55 to 59, percentage of farms of medium farms (10 to 49 acres) and percentage of large farms (50 acres or more) for the *ith* county. The probit model is used to examine three different outcomes: county exits, stays, or enters. The dependent variable for the first model (exiters) is $Y = 1$, if the county had production in 2002 and then exited the tobacco industry in 2007 and no tobacco production was reported, otherwise $Y = 0$. The dependent variable for the second model (stayers) is $Y = 1$, if the county had tobacco production in 2002 and stayed in the industry and had production in 2007, otherwise $Y = 0$. The dependent variable for the third model (entrants) is $Y = 1$, if the county had no production in 2002 and entered the industry and reported production in 2007, otherwise $Y = 0$. Table 2.4 indicates the frequencies and percentages for the three production scenarios: exit, stay, enter.[8]

Table 2.4 Frequencies and Shares of Exits, Stayers, and Entrants.

Production Dummy	Frequency	Percent
Exited	118	25.71
Did not exit	341	74.29
Total	459	100.00
Stayed	332	72.33
Did not stay	127	27.67
Total	459	100.00
Entered	9	1.96
Did not enter	450	98.04
Total	459	100.00

*Of the nine entrants, only four had tobacco production data. The others reported "(D)" for production.

2.5 Results

This section presents the results from analyzing pre and post data from the Tobacco Transition Payment Program of 2004. First, we use two sample t-tests to determine whether the average yields increased or decreased as would be expected from economic theory. After the market adjusted, the most efficient farmers would be those that stayed or entered and those less

[8] Some values for tobacco production collected from Census of Agriculture are reported as "(D)". This abbreviation is used in order to avoid disclosing data for individual operations. Therefore, if a county has a "(D)" for tobacco production in either 2002 or 2007 we count this as production occurring when creating the dummy variables for exit, stay, or enter. However, when calculating the productivity model, if a county for a given year has "(D)" for production it is not used in the model because we cannot calculate the average yield.

efficient would exit. Hence, overall tobacco yield should increase, given the increase in productivity. Table 2.5 presents the results from these t-tests. Group 1 is a t-test between the average yields in 2002 for those counties that exited the tobacco industry and those that stayed in the industry. If a county exited the industry, then there would only be tobacco production reported in year 2002. Therefore, the data used for this test is strictly from 2002. We find that the average yield for an exiter in 2002 is 195.795 pounds less than for a stayer and this difference is significant. Group 2 is a t-test between the average yields in 2007 for those counties that entered the tobacco industry and those that stayed in the industry. If a county entered the industry, then there would only be tobacco production reported in year 2002. Therefore, the data used for this test is strictly from 2007. We find that average yield for an entrant in 2007 is 188.034 pounds more than for a stayer. However, the difference is not significant. Group 3 is a t-test between the average yields in 2002 and 2007, regardless of whether they were an exiter, stayer, or entrant. Though by design, the average yield in 2002 is comprised strictly of exiters and stayers, and the average yield in 2007 is comprised strictly of entrants and stayers. We find that the average yield in 2002 is 153.361 pounds less than 2007 average yield, and the difference is significant.

Table 2.5 Two Sample T-tests for Average Yields.

	Group 1 (2002)		**Group 2 (2007)**		**Group 3**	
	Exiter	**Stayer**	**Entrant**	**Stayer**	**2002**	**2007**
Average yields	1746.213	1942.008	2159.916	2041.882	1891.636	2044.997
Difference	-195.795		118.034		-153.361	
t-stat (p-value)	3.9577 (0.0001)		-0.922 (0.3572)		-5.49 (0.0000)	
Ho: Diff. in means=0 Ha: Diff. in means≠0	Reject the null		Fail to reject the null		Reject the null	

2.5.1 Results from Tobacco Productivity Model

Table 2.6 presents the results from the linear log models that are used to see how productivity changes before and after the tobacco buyout. The dependent variable in all both models is yield, with model 1 (first column) including production in year 2002 and model 2 (second column) includes production in year 2007. Results from model 1 suggest that the logarithm of machinery, fertilizers, and seeds and plant are positively associated with increased productivity. More specifically, a one percent increase in machinery value per acre would increase yield by an average of 2.12 pounds per acre. The reason for these results may be that production efficiency in year 2002 came mainly from the inputs included in this model. However, after the tobacco buyout, quotas were eliminated and tobacco could be grown anywhere, which caused resources to reallocate. Production efficiency in 2007 may have been less impacted by specific inputs and more impacted by which farms were growing tobacco and in which locations, as location, prior to 2004, was tied to specific farms. Larger farms could take better advantage of increasing returns to scale from mechanized harvesting, specifically for flue-cured tobacco. Most mechanization for tobacco harvesting occurred in the 1960's but, perhaps, it was more difficult for farms to be more productive, prior to the tobacco buyout given the quota restrictions (Hart and Chestang, 1996).

Turning to other explanatory variables, in 2002, results indicate that a one percent increase in seeds and plants value per acre would increase yield by 0.7973 pounds per acre, while a one percent increase in 2007 increases yield by 1.078 pounds per acre. A t-test shows that the coefficients for seeds and plants are not significantly different from each other. Results on fertilizer levels show that a one percent increase in fertilizer value per acre generated an average yield increase of 1.917 pounds per acre in 2002 and an average of 0.05671 pounds per acre decrease in 2007 (the result in 2007 is not significantly different from zero). Again, we suggest input variables affected yield more significantly prior to the tobacco buyout than afterwards. The 2002 value of land and building per acre was not significant, but in 2007 a one percent increase would result in a 1.852 increase in pounds per acre. Our results suggest that land, in particular, became more productive as a result of tobacco production being allocated to more productive land. With respect to chemicals (such as insecticides, herbicides, fungicides), a one percent increase, in year 2002, resulted in a decrease of 0.7080 pounds per acre and in 2007 were no longer significantly different from zero. Labor value per acre was not found to be significant in either year.

Next, we discuss the regional dummy variable coefficients. The Mid-Atlantic is used as the base region, thus the coefficients on the other regions should be interpreted relative to the Mid-Atlantic. The Southeast region's average yield was 159.2 pounds greater than the Mid-Atlantic in 2002, holding all else constant. The Northeast region's average yield was also greater than the Mid-Atlantic in 2002 by 309.3 pounds. In 2007, there are no significant differences between the Mid-Atlantic and the other regions' average yields. The Mid-Atlantic region grows the most tobacco in the country, and therefore the quota restrictions may have been felt the most by this region. Therefore, it is expected that average yield was higher in other regions of the country in 2002 because there was less competition for quotas, mainly due to crop diversification in other regions.[9] Therefore, in 2007 we expect that there are generally no differences in average yield across regions because production has been shifted to the most efficient land.

[9] Weather was not controlled for in this model, and would be expected to have impacts on regional yields.

Table 2.6 OLS Linear Log Tobacco Productivity Models.

Variables	Yield 2002	Yield 2007
Logarithm of per acre dollar values:		
Machinery	212.2***	90.92
	(56.66)	(91.11)
Seeds and Plants	79.73***	107.8**
	(30.55)	(45.92)
Fertilizers	191.7***	-56.71
	(55.6)	(72.94)
Land and Building	-28.5	185.2**
	(55.23)	(81.15)
Chemicals	-70.80**	38.9
	(35.81)	(57.71)
Labor (hired and contracted)	-18.69	19.5
	(25.65)	(29.95)
Southeast	159.2***	2.842
	(40.99)	(54.66)
Mid-West	51.54	-33.47
	(107.5)	(142.9)
Northeast	309.3***	-2.422
	(72.52)	(88.47)
Observations	399	306
R-squared	0.24	0.16
F-Stat	6.26	13.66
Prob>F	0.0000	0.000

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

2.5.2 Determinants of Exiters, Stayers and Entrants in the Tobacco Industry

Table 2.7 presents the results for the three probit models. The first column reports the estimated impacts on the probability of a county exiting the industry. The results show that counties with a higher percentage of medium farms and more agricultural acres are less likely to exit the industry. Counties with a higher percentage of large farms and more people age 55 to 59 were more likely to exit. This result confirms our hypothesis. Larger farms, 50 acres or greater, would not be strictly producing tobacco. Therefore, large farms would already have crop diversification and infrastructure, and could more easily exit the industry than medium farms that may not be growing a significant amount of other crops.

The second column presents results for the estimated impacts on the probability of a county staying in the industry. Counties with a higher percentage of medium farms were more likely to stay in the industry while counties with a higher percentage of large farms were less likely to stay in the industry. The results for counties that stayed were the opposite of counties that exited.

Finally, the third column indicates results for the estimated impacts on the probability of a county entering the industry. Counties with a high percentage of medium sized farms and people age 55 to 59 were less likely to enter the industry the tobacco industry in 2007. However, we need to state that we cannot draw any conclusions from these results because there were only nine counties that entered.

Table 2.7 Probit Models for Exiters, Stayers, and Entrants.

Variable	Exits	Stayers	Entrants
Percent of medium farms	-2.1334***	2.4839***	-3.0412*
	(0.7765)	(0.7645)	(1.7170)
Percent of large farms	2.4182***	-2.2822***	-0.3906
	(0.6451)	(0.6336)	(1.4277)
Agricultural acres	-0.0000**	0.0000*	0.0000
	(0.0000)	(0.0000)	(0.0000)
Percent employed	0.5534	-0.3168	-2.3616
	(0.5467)	(0.5401)	(1.5649)
Percent of principal farmers	-14.9316	13.2400	6.3208
	(9.4830)	(9.1359)	(19.5147)
Percent age 55 to 59	15.9247*	-8.5417	-53.5934**
	(9.3632)	(9.1879)	(22.7599)
Correctly Classified	73.77%	71.30%	97.98%
Observations	446	446	446

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2.8 reports the marginal effects from the probit models detailed above. Results in the first column suggest that a one percent increase in the percent of medium farms in a county would decrease the probability of the county exiting the industry by 0.8306. Conversely, one percent increase in the percent of medium farms in a county would increase the probability of the county staying in production by 0.9696. The results move inversely for large farms relative to medium farms. A one percent increase in the share of large farms increases the probability of the county exiting by 0.6091 but decrease the probability of the county staying by 0.5665. Also, a counties probability of exiting decreases by a marginal increase in the percent of farmers as their principal occupation by 5.3362, and a counties probability of staying in the industry increase by a marginal increase in farmers by 4.9515. More agricultural acres in the county decrease the probability of the county exiting, but the marginal effect is minute.

Table 2.8 Marginal Effects for Exiters, Stayers, and Entrants.

Variables	Exits	Stayers	Entrants
Percent of medium farms	-0.8306***	0.9696***	-0.0729
	(0.2284)	(0.2362)	(0.0466)
Percent of large farms	0.6091***	-0.5665***	-0.0386
	(0.2114)	(0.2186)	(0.0427)
Agricultural Acres	-0.0000*	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
Percent employed	-0.1200	0.2010	-0.0543*
	(0.1348)	(0.1414)	(0.0321)
Percent of farmers principally occupied	-5.3362*	4.9515*	0.2855
	(2.8824)	(2.9059)	(0.4786)
Percent age 55 to 59	4.5835	-2.4766	-1.3462**
	(2.8294)	(2.9169)	(0.6173)
Observations	459	459	459

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

2.6 Conclusions

In 2004, the tobacco industry experienced a dramatic transformation when the federal tobacco program was eliminated after 66 years of support. This study quantifies the economic changes the market experienced transitioning into a free market. According to the U.S. Census of Agriculture, production has decreased by 95,048,587 pounds from 2002 to 2007. We confirm that the productivity is significantly higher in 2007 than 2002 by 153.361 pounds per acre. Next, our study attempts to further understand why the yield is significantly higher in 2007. We hypothesize that the reallocation of inputs and producers after the government support was eliminated increase yield. We test the significance of inputs: machinery, seeds and plants, fertilizers, land and building, other inputs, and labor on county level yield in 2002 and 2007, using U.S. Census of Agriculture data. Our results suggest that machinery, seeds and plants, fertilizers, and chemicals are significant in determining 2002 yield. Also, the Southeast and Northeast have significantly higher yields than the tobacco abundant region of the Mid-Atlantic in 2002. Our hypothesis for the 2007 yield was confirmed that input variables had less significance on determining yield and there was no difference in regional yields. Input variables should have less effect on determining yield because the most efficient farmers should be producing in 2007. The producers' farm management is perhaps the main determinant of yield after the market has adjusted to equilibrium. Therefore, inputs are less determinant factors than the efficiency in management of the best tobacco producers. However, we cannot measure the management efficiency in this study.

This study also analyzed the characteristics of counties that exited, stayed and entered the industry after the tobacco buyout. Counties with more medium sized farms (10 to 49 acres) and farmers by principal occupation were more likely to stay in the industry while counties with more large sized farms (50 acres or more), fewer farmers by principal occupation, and fewer agricultural acres were more likely to exit the industry. We suggest that large farms tend to have more crop diversification and therefore, it was easier to exit the industry.

The elimination of federal crop programs is rare and tobacco industry is a unique one to be studied.

CHAPTER 3

FARMERS' PERCEPTIONS OF BIOPHARMING: INSIGHTS FROM A TOBACCO BIOPHARMING SURVEY

3.1 Introduction

Genetically engineered crops have been a success for almost two decades, greatly improving productivity, enhancing nutritional value in crops and increasing welfare (Khush, 2012). A recently developed new generation of genetically engineered crops has the prospect of becoming a cheaper and efficient alternative to producing pharmaceutical products for human use (Ahmad et al., 2011). This technology has been termed "biopharming."

Biopharming is the cultivation of crops for a pharmaceutical purpose, giving them the ability to produce desired therapeutic proteins, which are then extracted, purified and used by the pharmaceutical industry to produce large-molecule protein-based drugs. Corn, rice, tobacco, and alfalfa are among the top candidates for being widely used in biopharming (USDA, 2012).

Among others, biopharming is important for four primary reasons. First, studies show that biopharming can be significantly cheaper than the most common method of therapeutic protein production[10] (e.g. Hood et al. 2002; Mison and Curling, 2000; Morrow, 2002). Second, biopharming may be able to provide a more stable supply and increase consumers' access to much needed medicines (Ahmad et al., 2012). Third, therapeutic proteins from biopharming are

[10] The current most common method of therapeutic protein production is using bioreactors (big steel containers with controlled temperature, humidity, etc.) where suspension cells with the desired proteins are grown. This is called the upstream process. After the cells are fully grown, they are harvested and go through several steps in order to extract and purify the desire protein. This is called the downstream process (Hood and Howard, 2007).

believed to be purer than the ones produced by mammalian cell cultures because generally plants do not carry potentially harmful human or animal viruses (Elbehri, 2005). Finally, biopharming offers possibilities to develop new treatments that have thus far been too complex to reproduce by current production methods (Rehbinder et al., 2009).

Private firms have invested hundreds of millions of dollars in research and development for plant-made pharmaceuticals. Some of the therapeutic proteins that have already been successfully produced in plants can be used in the treatment of different types of cancer, HIV, diabetes, cholera, Alzheimer's disease, cystic fibrosis, hepatitis B, and malaria (Ahmad et al, 2012) and they are going through the necessary approval process to reach market approval.

Although not many plant-made pharmaceuticals have made their way to the market, this is not because biotechnology firms are not attracted to the technology, but because biopharming is a relatively new field and it usually takes about 12 years to get a product from the lab stages to the pharmaceutical market. Before this technology can be commercialized, it must overcome many regulatory challenges from the Federal Drug Administration (FDA) (same approval process that all other non plant-made pharmaceutical go through) and from the United States Department of Agriculture (USDA), if grown in the field.

Among these challenges, an important one is to eliminate the risk of biopharming crops contaminating the food supply. This is the main reason why tobacco is one of the most commonly researched crops (USDA, 2012). Tobacco also has other unique advantages that address some of the other concerns regarding biopharming. First, the plant is harvested before it reaches maturity or the tops are cut, so the tobacco plant does not flower, reducing the risk of contamination through pollen drift (Nevitt et al., 2003). Second, there is also a novel gene that delays the expression of the foreign protein in the field. The new protein would not be expressed until after the tobacco is harvested (Nevitt et al., 2003). Additionally, the nicotine found in tobacco makes the plant less desirable for animal species to feed on, which reduces the risks of contaminating the food supply and endangering local animals (Nevitt et al., 2003).

As biopharming progresses, regulatory agencies are challenged to address public and environmental concerns, while allowing biotech firms and farmers to make further advancements in the industry. There have been several studies that evaluate public opinions toward biopharming (e.g. Nevitt et al., 2006; Einsiedel and Medlock, 2005; Cook and Fairweather, 2007). However, thus far, there have been no quantitative studies that evaluate farmers' perceptions of biopharming. Most public opinion research was conducted in the mid 2000s, and with the exception of 17 tobacco producers interviewed in a qualitative study conducted by Nevitt et al. (2003), to our knowledge, there has been no research on U.S. farmers' opinions on biopharming.

Farmers are an important link in the prospect of commercialized biopharming, and a better understanding of farmers' knowledge and attitudes on biopharming is crucial for setting up the appropriate regulatory framework for the technology. In addition to general knowledge on farmers' perception of biopharming, it is also particularly important to understand whether they would be willing to grow biopharming crops and under what conditions.

To begin answering some of these questions, we conducted a survey with U.S. tobacco farmers. Our analysis of this data aims to augment the biopharming literature by shedding some light on farmers' knowledge of biopharming, attitudes, and conditions under which they would be involved in biopharming. The findings of this study will benefit not only tobacco farmers, but also biopharming companies, as well as consumers and policy makers to better understand producer knowledge of biopharming, their attitudes and further improve the regulatory process

3.2 Biopharming Progress and Market Approvals

Research on biopharming started more than two decades ago. However, the first commercial approval did not come until 2006 when, Dow AgroSciences received the first approval of a plant- made pharmaceutical for a poultry vaccine created from tobacco cells (Katsnelson et al., 2006). Since then, many biotechnology firms have attempted to receive approval from the FDA and other countries' regulatory agencies (Obembe et al., 2011).

In 2006, Planet Biotechnology received approval in Europe for CaroRX™, which is a topical treatment for the prevention of dental caries (Planet Biotechnology, 2012). However, CaroRX™ was registered as a medical device, so the product avoided the approval process as a plant-made pharmaceutical (Twyman et al., 2012). The company is currently in Phase II of the clinicial trials in the FDA approval process in the U.S. (Planet Biotechnology, 2012). [11]

A Hepatitis B antibody made from tobacco plants was approved in Cuba, in 2006 (Twyman et al., 2012). The antibody is not the active ingredient in the vaccine but it is used in the purification of the vaccine during the traditional production method. However, this product was subject to the same approval process as plant-made pharmaceuticals that are used as active ingredients (Twyman, 2012). Additionally, as a result of more lenient regulatory policies, there have been several other approvals for plant-made products used for non- pharmaceutical purposes (Spok and Karner, 2008).

In May 2012, Protalix Biotherapeutics, an Israeli company received the FDA's first approval for a plant-made pharmaceutical product intended for humans. The protein is used for the treatment of Type I Gaucher's disease and is cultured in genetically engineered carrot cells (Maxmen, 2012; Opar, 2011; Protalix.com, 2013). It is currently being marketed by Pfizer, in the U.S. and Israel, under the product name Elelyso (Maxmen, 2012; Opar, 2011; Protalix.com,

[11] The FDA approval process is comprised of three phase clinical trials.

2012). However, this protein is currently produced in carrot cells under laboratory conditions, and there are no farm-based whole plants used in the production method (Morrow, 2012). Nevertheless, many stakeholders in biopharming working with whole plants believe the approval of Elelyso sets a precedent for future approvals (Maxmen, 2012).

Studies (e.g. Rehbinder, 2004; Twyman 2012) indicate that the global value of the biopharmaceutical market will continue to grow from the current value of $106 billion to a forecasted $177 billion in 2017 (IMARC, 2012). Therefore, biotechnology firms have substantial incentives to invest in research. However, as one biotechnology executive stated "pharmaceutical companies don't grow tobacco; only farmers do" (Nevitt, et al., 2003). Thus, to further understand the prospects of this emerging technology, it is important to examine plant producers' attraction to it as well as adoption barriers.

3.3 Prior Research on Producers' and Consumers' Attitudes on Biopharming

Nevitt et al. (2003) conducted a broad study on the opinions of different stakeholders in tobacco biopharming including the agricultural sector, private industry, academia, activist groups, and government officials. Among others, 17 tobacco producers from Tennessee, Virginia, and North Carolina were interviewed. Most of those interviewed had some knowledge of biopharming technology, but none reported a great deal of knowledge. All tobacco producers expressed an interest in growing pharmaceutical tobacco, and had little concern about production as long as it was profitable. The concerns were focused on purchasing new equipment and changing current production practices. A few reported concern with maintaining a relationship with their contracted tobacco companies.

Nevitt et al. (2006) also administered a telephone survey of U.S. consumers' on their opinions on tobacco biopharming. First, respondents were asked if they held concern in the following categories; (a) companies owning the rights to genetically engineered tobacco; (b) negative effects on human health; (c) negative effects on the environment; and (d) moral/ethical considerations. Health and environmental concerns were the most frequent responses. Health and environmental concerns were the most frequent responses. They found that socioeconomic characteristics and prior knowledge did not have significant correlation with concerns about biopharming. They also found that acceptance of the technology depended on the intended pharmaceutical purpose, as well as societal benefits (Nevitt et al., 2006). Overall, this study concluded that most consumers accept biopharming technology, but there is also a considerable share of the public that is strictly opposed to it. The next step to help advance this technology, in terms of public acceptance, is to educate people about the associated benefits and risk. People's unwillingness to support the technology would be anticipated to change thereafter.

Researchers at the University of Calgary also conducted a biopharming perception study in 2005, with focus groups in four regions of Canada (Einsiedel and Medlock, 2005). The study aimed to report public awareness, reactions to specific biopharming uses, and opinions on different containment strategies. Since most of the public is unaware of biopharming, the researchers provided background information and gave participants more time to reflect on the issues. The study reported that only two of the 48 participants had heard of biopharming prior to the study. The initial reactions were mixed, but the number of positive reactions was slightly higher. The most common areas of concern were contamination with food crops, regulations, long term health effects, and commercial interests overriding public safety. In terms of acceptability, when considering the end product from biopharming crops, participants had mixed views but tended slightly more toward acceptability. Also, results indicated that participants tended to be more acceptable or less acceptable, as opposed to the extremes of fully acceptable and unacceptable found by Nevitt et al. (2006).

In New Zealand, Cook and Fairweather (2007) also studied public attitudes toward biopharming. They found that only 26% would support biopharming in New Zealand. However, this is high compared to consumers' willingness to purchase GM food, which is only 10%. They also reported that a high percentage of support is correlated with a higher medical benefit. This study concluded that public support would likely change when apprehension about the technology was lessened. The apprehension is largely based on the same concerns from other studies (Nevitt et al., 2006; Einsiedel and Medlock, 2005) and if addressed would be expected to change the public's overall opinion of biopharming.

3.4 Data and Methods

In July 2012, we conducted a telephone survey with 1,129 tobacco producer contacts and collected data on 145 tobacco farmers in Georgia, Kentucky, North Carolina, Tennessee and Virginia with a response rate of 13%. First, the respondents were presented with the following statement: "Currently scientists are using genetic engineering to develop tobacco that can be used to create pharmaceutical medicines. Some believe this technology can be used as a cost efficient alternative to meet the demand for medicines. Others believe it might lead to unexpected effects on humans or the environment. Tobacco plants used to create medicines are regulated by the United States Department of Agriculture's Animal Plant and Health Inspection Service. They require that plots of transgenic tobacco be a minimum of 1320 ft. from any other tobacco in the field. Non-transgenic tobacco cannot be grown in the same plot for 1 year following transgenic tobacco. Regulators will visit the site several times a year."

Then we asked a series of questions to tobacco producers' that consisted of: (a) concerns about unexpected effects from biopharming, (b) willingness to grow tobacco for pharmaceutical uses under different conditions regarding production methods and net return per acre, (c) knowledge of biopharming prior to the survey and (d) characteristics such as gender, age, income, and education.

Table 3.1 summarizes respondents' personal characteristics and prior knowledge about biopharming. The sample of 145 was composed of 95% men and the average age was 57. Among respondents who reported their household income, 63.4% earned between $100,000 and $120,000 in 2011, 36% hold a four year degree or higher and 73.6% has been growing tobacco for 31 or more years. Questions targeted at eliciting the respondents' level of knowledge on the subject prior to the survey show that 68.4% of those interviewed knew "not much" or "nothing at all" prior to the survey.[12]

Table 3.1 Personal Characteristics of Respondents.

Attribute	% of responders
Male	95.0%
Age >55 years	67.7%
Income $100k -$120k	63.4%
Four year degree or higher	36.0%
Growing tobacco 31+ years	73.6%
Prior knowledge	
A lot	5.1%
Some	26.5%
Not much	41.9%
Nothing at all	26.5%

[12] The question on how much they knew prior to the survey was asked towards the end of the survey.

Table 3.2 summarizes the respondents' tobacco acreage, production and average prices earned in the previous year. In 2011, 50% of the respondents planted 100 acres of tobacco or less, 51% produced 100 tons or less, and the average price received was $1.82 per pound, with the commodity having a relatively uniform price (standard deviation was 0.19) considering that farmers grow different varieties of tobacco.[13]

Table 3.2 Production Summary Statistics.

Production Variable	Average	St. Dev.	Min.	Max.
Acres	143	145.45	1	750
Total Production (tons)	121	119.57	1	700
Price ($/lbs.)	1.82	0.19	1	2.6

In order to examine their willingness to grow tobacco for pharmaceutical use, tobacco growers were asked the following questions: If your net return per acre was more than the net return per acre when growing conventional tobacco, (a) would you be willing to grow tobacco using current equipment and production methods for a pharmaceutical company?, (b) would you be willing to grow transgenic tobacco for medicine if you were required to change production methods and work closely with a biopharmaceutical firm?, and (c) would you be willing to grow it if you have to purchase additional equipment and change production methods? For each scenario, each tobacco grower was given a randomized net return per acre above growing conventional tobacco. The assigned returns were randomized over farmers and scenarios, such that, even within respondents the percentage of net return per acre for a growing scenario was not dependent on the percentage given for the other two scenarios.

[13] Farmers were not asked on the tobacco variety they grow.

Next, we use probit models to highlight the main determinants of the decision to grow transgenic tobacco for each of the three growing scenario and their effect on the probability of growing transgenic tobacco. The model is as followed:

$$(3.1)\ \Pr(Y = 1 | X) = \Phi(X'\beta)$$

where Pr denotes the probability of growing transgenic tobacco for biopharming (Y=1 would be willing to grow, Y=0 would not be willing to grow) and Φ represents the Cumulative Distribution Function (CDF) of the standard normal distribution. The β parameters are estimated using Maximum Likelihood. We also estimate marginal effects, in order to interpret the magnitude the regressors have on the probability of *Y*=1. A probit model is necessary because each growing scenario is a binary choice. As mentioned, the probit model is used for three different scenarios: current production methods, change production methods, and additional equipment required. The dependent variable for the first model is *Y*=1, if the respondent would be willing to grow pharmaceutical tobacco under current production methods, otherwise *Y*=0. Similarly, the dependent variable for the second and the third model is *Y*=1, if the respondent would be willing to grow pharmaceutical tobacco under different production methods, and when additional equipment is required, respectively.

3.5 Results

Below we present our finding on concerns about biopharming and willingness to grow transgenic tobacco using summary statistics as well as probit models to examine factors that may affect farmers' decisions.

3.5.1 Concerns about Biopharming

As noted, survey participants were told that scientists can use tobacco to create pharmaceutical medicines and some believe it can be a cost efficient alternative to meet demand for medicines.

They were also told that others believe this technology could lead to unexpected effects. Then they were asked if they were concerned with (a) unexpected effects, (b) human health effects, and (c) environmental effects. These results of their responses are presented in Table 3.3. Despite reporting little familiarity with the technology, only 18.5% said they were concerned with the unexpected effects from biopharming, 4.8% were concerned with health effects, and 4.4% were concerned with the environmental effects.

Table 3.3 Concerns about Biopharming.

Types of Concern (respondents answered yes)	
Unexpected Effects	18.5%
Health	4.8%
Environment	4.4%

3.5.2 Willingness to Grow

Results on willingness to grow questions are reported in Table 3.4. Among those that answered[14], regardless of net return per acre: (a) 81% reported they would be willing to grow tobacco using current production methods, (b) 68% reported they would be willing to grow if required to change production methods and work closely with a biopharmaceutical firm, and (c) 60% reported they would be willing to grow if they had to change production methods and purchase additional equipment. Table 3.5 also reports the percentage of tobacco producers that answered yes for a given net return per acre and production scenario. Under current production methods, with a 5% increase in net return per acre, 58% would be willing to grow pharmaceutical tobacco. As expected, changing production and additional equipment scenarios

[14] Don't knows' were treated as refuse to answer for all summaries in this paper.

decreased the willingness to grow under all net return per acres. Changing production methods and the requirement of additional equipment dramatically affected whether a tobacco producer answered yes with only 17% and 7% willing to adopt, respectively, if they receive a 5% increase in returns. However, the gap reduces as the net return per acre increases indicating that profitability is a very important factor for farmers.

Table 3.4 Willingness to Adopt Biopharming Technology.

Willing to adopt technology			
Net Return Per Acre	(a) Current Production Methods	(b) Change Production Method	(c) Additional Equipment
5%	42.9%	7.4%	4.2%
10%	51.7%	23.5%	19.0%
25%	84.8%	71.9%	44.8%
40%	84.8%	78.8%	53.1%
More than 50%	80.0%	84.2%	69.2%

We also estimate a probit model on the willingness to grow for each of the three growing scenarios using the following explanatory variables: net return per acre, gender, age, education, income, concern about unexpected effects, level of knowledge about biopharming prior to the survey, and experience with growing tobacco (Table 3.5). Results suggest that the probability of a producer willing to grow pharmaceutical tobacco is largely influenced by economic incentives. Net return per acre is statistically significant and increases the probability that a farmer is willing to grow pharmaceutical tobacco under all three growing scenarios. Additionally, male farmers with an income of more than $50,000 are more likely to adopt the technology. Interestingly, those that have a four year degree or more are less likely to adopt if they have to purchase additional equipment. Table 3.6 shows the marginal effects for the growing scenarios.

Table 3.5 Probit Model for Biopharming Growing Scenarios.

Variables	(1) Current Production Probit	(2) Change Production Probit	(3) Additional Equipment Probit
Net return per acre	4.8535***	30.4315***	5.1832***
	(1.7820)	(7.1677)	(1.1645)
Male	0.1922	4.4860***	0.7135
	(0.6000)	(1.4721)	(0.8161)
Age	0.0073	-0.0181	0.0006
	(0.0155)	(0.0199)	(0.0164)
4 year degree or higher	-0.5808*	0.3405	-1.2153***
	(0.3378)	(0.4727)	(0.3934)
Income	0.0871**	0.0066	0.1001**
	(0.0355)	(0.0410)	(0.0390)
Concern	0.3717	0.7282	-0.4759
	(0.4398)	(0.6388)	(0.3983)
Prior level of knowledge	-0.4764	-0.2911	0.4698
	(0.3608)	(0.4373)	(0.3672)
Experience more than 20 years	0.3223	-0.3667	-0.2915
	(0.5322)	(0.7063)	(0.5395)
Correctly Classified	85.90%	90.00%	80.00%
Observations	111	98	95

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3.6 Marginal effects for biopharming growing scenarios.

Variables	(1) Current Production Marginal	(2) Change Production Marginal	(3) Additional Equipment Marginal
Net return per acre	1.0319***	0.7951***	1.9196***
	(0.3135)	(0.8821)	(0.4123)
Male	0.0448	0.9675***	0.2781
	(0.1521)	(0.0738)	(0.3115)
Age	0.0016	-0.0005	0.0002
	(0.0033)	(0.0008)	(0.0061)
4 year degree or higher	-0.1349*	0.0083	-0.4464***
	(0.0831)	(0.0124)	(0.1313)
Income	0.0185***	0.0002	0.0371***
	(0.0072)	(0.0011)	(0.0142)
Concern	0.0683	0.0113	-0.1829
	(0.0689)	(0.0141)	(0.1551)
Prior level of knowledge	-0.1114	-0.0088	0.1672
	(0.0883)	(0.0171)	(0.1239)
Experience more than 20 years	0.0783	-0.0070	-0.1025
	(0.1456)	(0.0117)	(0.1785)
Observations	111	98	95

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

To further investigate their willingness to grow pharmaceutical tobacco, as noted, producers were told about some of the current regulations with growing tobacco on the field, including a 1320 ft. fallow zone from other fields and a 1 year restriction to grow non-pharmaceutical crops after they have planted biopharming crops. These regulations do not seem to deter willingness to grow, as 86.5% reported it would not prevent them from growing pharmaceutical tobacco. However, when asked what percentage of their acres they would be willing to use for pharmaceutical tobacco, only 15.4% were willing to use 31% or more of their acres. Half of the respondents answered they would be willing to experiment with 6% to 20% of their acres.

A second probit model was used to analyze the probability that regulations would prevent them from growing pharmaceutical tobacco (Table 3.7). The predictors used were age, income greater than $50,000 a year, gender, experience with tobacco for more than 20 years, and tobacco acres. Results suggest that male producers earning more than $50,000 a year and farming a larger number of tobacco acres were more likely to report that regulations would not prevent them from growing pharmaceutical tobacco.

Table 3.7 Probit on Regulations Preventing Adoption.

Variables	**(1) Probit**	**(2) Marginal**
Age	0.0256	0.0038
	(0.0198)	(0.0029)
Male	-1.5022**	-0.4412**
	(0.7338)	(0.2748)
Income > $100K	-0.7793**	-0.1115**
	(0.3914)	(0.0548)
Experience more than 20 years	-0.4965	-0.0967
	(0.7376)	(0.1776)
Acres	-0.0037*	-0.0006*
	(0.0020)	(0.0003)
Correctly Classified	88.99%	-
Observations	109	109

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the participatory assessments that Nevitt et al. (2003) conducted, they reported that some tobacco producers expressed concern with maintaining relationships with the companies they currently contract with. Our study reveals a different outcome. We find that 95.4% of the tobacco farmers would be willing to grow tobacco for a company different than the one they usually contract with.

3.6 Conclusions

Previous research on perceptions of biopharming has focused on the consumers and the challenges policy makers face in addressing the diversity in public opinion. We explore producers' perceptions as they are also important stakeholders and will be subject to biopharming regulations if more commercialization takes place.

It appears that little is known by producers on biopharming and their responses are largely driven by the information presented to them, and most importantly, by economic profits. In addition, producers appear to have relatively less concerns about the technology compared to consumers.

As biopharming progresses and producers become more aware of the technology, more research will be needed to find how producers' willingness to grow changes and the characteristics of those that will participate. This survey did not address estimates of revenues and additional costs for producers or the specifics of contractual relationships between the biopharmaceutical firm and the producer. These could be important topics for future biopharming research.

Finally, given the low level of biopharming awareness, it is very important to provide producers with appropriate information on biopharming, its challenges and opportunities. This way they can better evaluate their costs, risks and benefits and provide important insights that will help shape current and future regulation.

CHAPTER 4

CONCLUSION

4.1 Conclusion

Tobacco was once revered as the economic juggernaut for the American colonies in the late 1600's. The crop continued to be a significant part of U.S. agricultural growth for the next two centuries. In the early 1900's, tobacco not only became one of the first government supported crops, but the U.S. began producing over 1 million pounds each year. It was only 37 years later and the U.S. was producing over 2 million pounds each year. Production peaked in 1963, one year before, the U.S. Surgeon General formally linked tobacco consumption with negative health effects. Since then, tobacco production has been on a steady decline and in present day most of the crop is exported because U.S. demand is dwindling.

This thesis draws upon the multifarious characteristics of the tobacco industry. We present two essays of policies and perspectives on the U.S. tobacco industry. We attempt to explain the market adjustments after the Tobacco Transition Payment Program of 2004, and we report findings from a survey conducted on tobacco farmers' willingness to grow pharmaceutical tobacco. Our findings suggest that, after the federal program was eliminated, the industry experienced rapid consolidation and only the most efficient farmers stayed in production. It is expected that more tobacco farmers will exit the industry in the future as demand continues to decrease. Areas with larger farms, more agricultural production, and higher employment rates will be more likely to exit the industry next.

Despite a declining tobacco production, some tobacco farmers may have opportunities to grow tobacco for pharmaceutical purposes. However, they are not very familiar with biopharming in general, and regulatory processes and contractual arrangements involved in biopharming. Farmers need to be provided with additional information on biopharming in order to gain more insights on the risks and benefits and be better able to make decision on their attitudes and willingness to grow transgenic crops for pharmaceutical use.

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APPENDIX

<u>Tobacco Producer's Perception on Genetically Altered Plants for Pharmaceutical Use</u>

A. Hello my name is [SURVEYOR NAME] and I am calling on behalf of the University of Georgia. We are conducting a study about making medicines from tobacco. May I speak with [GROWER NAME]?

[GO TO Q1] YES 1
NO 2

B. When may I call back to speak to him/her?

____

Q1. Currently scientists are using genetic engineering to develop tobacco that can be used to create pharmaceutical medicines. Some believe this technology can be used as a cost efficient alternative to meet the demand for medicines. Others believe it might lead to unexpected effects on humans or the environment. Are you personally concerned about the technology's unexpected effects?

YES 1
NO 2
DK 3
RF 4

Q2. Are you personally concerned that producing tobacco this way might negatively affect human health?

YES 1
NO 2
DK 3
RF 4

Q3. Are you personally concerned that producing tobacco this way might negatively affect the environment, including other plants and animals close to the fields?

YES 1
NO 2
DK 3
RF 4

Q4. How many acres of tobacco did you grow last year, how much did you produce and what average price did you sell it for?

Acres______ Total Production (tons)_____ Average Price ($/lb)_________

Q5. How long have you, yourself, been growing tobacco?

0-10 years 1
11 years to 20 years 2
21-30 years 3
31-40+ years 4

Q6. Which one of the following best describes your decision to grow tobacco and how much to grow every year?

YOU HAVE A CONTRACT WITH A TOBACCO COMPANY 1
YOU HAVE THE INFRASTRUCTURE 2
YOU LOOK AT WHAT OTHER TOBACCO FARMERS ARE DOING 3
THE OPPORTUNITY COST OF OTHER CROPS 4
FAMILY TRADITION 5
OTHER _ PLEASE SPECIFY________________________________
____

Q7. Would you be willing to grow tobacco under contract with a company different than the one you usually contract with?

YES 1
NO 2
DK 3
RF 4

Q8. Tobacco plants used to create medicines are regulated by the USDA-APHIS. They require that plots of transgenic tobacco be a minimum of 1320 ft. from any other tobacco in the field. Non-transgenic tobacco cannot be grown in the same plot for 1 year following transgenic tobacco. Regulators will visit the site several times a year. Will these regulations prevent you from further considering growing transgenic tobacco used for medicines?

YES 1
NO 2
DK 3
RF 4

Q9. Would you be willing to grow tobacco using current equipment and production methods for a pharmaceutical company if your net return per acre was [INSERT RANDOM NET RETURN PER ACRE] more than the net return per acre when growing conventional tobacco?

NET RETURN PER ACRE
A. 5%
B. 10%
C. 25%
D. 40%
E. More than 50%

YES 1
NO 2
DK 3
RF 4

Q10. Would you be willing to grow pharmaceutical tobacco, if you could no longer grow non transgenic tobacco because tobacco companies would no longer be willing to give you a contract?

YES 1
NO 2
DK 3
RF 4

Q11. If required to change current production methods and work more closely with biopharmaceutical companies, would you be willing to grow trangenic tobacco for medicine if your net return per acre was [INSERT RANDOM NET RETURN PER ACRE] more than the net return per acre when growing conventional tobacco?
NET RETURN PER ACRE
A. 5%
B. 10%
C. 25%
D. 40%
E. More than 50%

YES 1
NO 2
DK 3
RF 4

Q12. If required to purchase additional equipment and change production methods would you be willing to grow transgenic tobacco for medicine if your net return per acre was [INSERT RANDOM NET RETURN PER ACRE] more than the net return per acre when growing conventional tobacco?

NET RETURN PER ACRE
A. 5%
B. 10%
C. 25%
D. 40%
E. More than 50%

YES 1
NO 2

DK 3
RF 4

Q13. Of current farming acres how much would you be willing to experiment growing tobacco for pharmaceutical purposes? Stop me when you agree with the percentages read.

NONE 1
UP TO 5% 2
6% TO 20% 3
21% TO 30% 4
31% TO 40% 5
41% TO 50% 6
MORE THAN 50% 7

Q14. Prior to this survey, how much information did you know about genetically altered tobacco used to produce medicines?

A LOT 1
SOME 2
NOT MUCH 3
NOTHING AT ALL 4
DK 5
RF 6

Q15. What is your total farm acreage? _______

Q16. What is your age? ______________

Q17. What was the highest level of education you achieved?

DID NOT COMPLETE HIGH SCHOOL 1
HIGH SCHOOL DIPLOMA OR EQUILVALENCE 2
SOME COLLEGE 3
UNDERGRADUATE DEGREE 4
GRADUATE DEGREE 5

Q18. Please stop me when I get to the bracket that includes your best estimate of your total household income before taxes last year.

LESS THAN $20,000 1
BETWEEN $20,000 AND $30,000 2
BETWEEN $30,000 AND $40,000 3
BETWEEN $40,000 AND $50,000 4

BETWEEN $50,000 AND $60,000 5
BETWEEN $60,000 AND $70,000 6
BETWEEN $70,000 AND $80,000 7
BETWEEN $80,000 AND $90,000 8
BETWEEN $90,000 AND $100,000 9
BETWEEN $100,000 AND $120,000 10
OVER $120,000 11
RF 97
DON'T KNOW 98
NOT ASCERTAINED 99

Q19. GENDER * IF YOU CANNOT TELL THE GENDER OF THE RESPONDENT, ASK:
"Just one more question: our survey requires that I ask if you are a male or female?"

MALE 1
FEMALE 2

Those are all my questions. Thank you for your help with our study. Have a nice day/evening.