EVALUATING A PROPOSED MODIFICATION TO

FEDERAL CROP INSURANCE

By

SHUQIONG LING

(Under the Direction of Barry J. Barnett)

ABSTRACT

A proposed modification to the Federal Crop Insurance Program would allow crop producers to simultaneously purchase both farm-level crop insurance policy and a supplemental county-level crop insurance policy. This study evaluates this proposal for representative cotton farms in Georgia. The goal is to test whether the additional risk protection provided by the supplemental policy is considered to be worth the additional cost.

Key words: certainty equivalent, combined insurance product, group risk plan, multiple peril crop insurance

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SHUQIONG LING

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SHUQIONG LING

Major Professor: Barry J. Barnett

Committee: Dmitry V. Vedenov
Xiaohui Deng

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
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CHAPTER 1

INTRODUCTION

1.1 Background of Federal Insurance Program

Agriculture is a risky trade all over the world not only because it is faced with unfavorable weather conditions but also because it will be influenced by price fluctuation. In order to manage various kinds of risks and deal with unfavorable conditions, the U.S. government has helped crop producers manage yield and price risks through various income support programs, disaster assistance, and crop insurance.

A standing disaster payment program was an important component of U.S. agricultural policies during the 1970s, 1980s and early 1990s. However, there is currently no standing U.S. disaster program though policy-makers occasionally provide ad hoc disaster assistance.

Purchasing crop insurance is another risk management option for crop producers. Crop insurance is a collective system for reducing uncertainties to crop failures. To help farmers efficiently manage price and yield risks, the U.S. Federal Crop Insurance Program (FCIP) offers federally subsidized and reinsured yield and revenue insurance policies to crop producers.

The FCIP was created in 1938 as an experimental program. Crop insurance worked as an experiment until the introduction of the Federal Crop Insurance Act in 1980. The 1980 Act provided significant premium subsidies to purchasers and expanded the crop insurance program to more crops and regions. The 1980 Act also began a public-private partnership whereby private insurance companies sell and service insurance policies according to federal crop insurance policies and procedures. The FCIP is administered by the Risk Management Agency (RMA) of the U.S. Department of Agriculture. The federal government establishes premium rates, reimburses administrative and operating costs, and provides reinsurance for the private insurers who sell and service FCIP policies. In addition, the RMA provides premium subsidies to farmers who purchase crop insurance policies.

The Federal Crop Insurance Program (FCIP) is a portfolio of crop insurance products. FCIP yields insurance policies protect crop producers against yield losses caused by natural perils such as drought, excess moisture, wind damage, disease, and insect infestation. FCIP revenue insurance policies protect crop producers against revenue shortfalls caused by low yields and/or low prices.

The traditional federal crop insurance product is Multiple Peril Crop Insurance (MPCI) that is also known as Actual Production History (APH) insurance. MPCI provides comprehensive protection against both whole farm-level[1] and sub-farm level yield losses due to unfavorable weather causes and natural perils. Historically, MPCI has suffered from low participation and high losses. Due to its heavy losses in the early 1940's, MPCI was discontinued but restored in 1945. Since 1980, MPCI has taken possession of a prominent role in farm policies. Currently, MPCI is available for most insured crops and regions.

While the farm-level insurance products protect against farm-level yield losses, they are subject to problems such as adverse selection and moral hazard (Knight and Coble, 1997). Several studies have argued that these problems affect farm-level insurance products (Quiggin, Karagiannis, and Stanton, 1993; Smith and Goodwin, 1996; Coble et al., 1997; Just, Calvin, and Quiggin, 1999). Adverse selection is a primary cause of poor actuarial performance of MPCI. In some cases, policyholders will be misclassified to their benefit, which means that they have a

[1] The terms "farm-level" and "county-level" are used here to distinguish these two classes of insurance products. However, under certain conditions, farmers can purchase MPCI and some of the farm-level revenue insurance products at a sub-farm level. That is, different parts of the farm can be insured as separate insurance units.

premium cost less than the expected indemnity. In other cases, policyholders will be misclassified to their detriment when their premium cost is higher than the expected indemnity. Moral hazard occurs with farm-level yield or revenue insurance when policyholders can alter their behavior in order to increase the potential likelihood of and/or magnitude of an indemnity. Moral hazard always creates a premium cost that exceeds the expected indemnity. These problems may result in low participation in crop insurance. To increase participation, the U.S. government provides federal premium subsidies.

Yield Insurance Policies

For farm-level yield insurance policies, the premium rate depends on the crop, the county where the crop is produced, production practices (e.g., irrigated versus non-irrigated), the level of insurance coverage (where coverage is 100 percent minus the deductible percentage selected by the policyholder), and the APH yield. The insurance purchaser pays only part of the total premium cost, and government pays the rest. The government has attempted to boost participation in crop insurance by increasing premium subsidy levels since 1980. The Crop Insurance Reform Act of 1994 expanded premium subsidies through various coverage levels. The 2000 Act increased subsidy levels for higher coverage levels. By 2004, the premium subsidy totaled nearly $2.5 billion and accounted for almost 60% of total premium cost. Table 1.1 shows how the premium subsidy rates have changed for farm level insurance products under the three crop insurance reform acts.

While subsidized premiums reduce crop producer's costs and increase participation, the premium subsidy increases the government expenditure. Based on 17,557 Iowa corn farms, Skees examined the relationship between premiums and benefits from crop insurance. His results indicated that "increasing the premium subsidy worsened the actuarial soundness" (Skees, 2001, Page 19). In addition, many low-risk farmers who purchase crop insurance were paying more in premiums than they were receiving in benefits. Skees said "What was once a good idea - using crop insurance to share risk in agriculture – has become bad public policy in America. What was touted as a 'market-based-solution' is now very costly, inefficient, and inequitable because of the subsidy design." (Skees, 2001, Page 21).

The 1990 farm bill allowed the Federal Crop Insurance Program (FCIP) to test new insurance policies. As a result, index insurance began to be one part of FCIP insurance products in 1993. In that year, FCIP started offering a county-level yield insurance product known as the Group Risk Plan (GRP) for selected commodities and regions. GRP protects producers against a widespread crop failure. This product pays indemnities based on county-level yield losses rather than farm-level yield shortfalls. County-level yields are estimated by the National Agricultural Statistical Service (NASS).

Since indemnities depend on county-level yield rather than the individual producer's realized yield, insured parties can not alter their behavior so as to increase the potential likelihood or magnitude of a loss. Therefore, county-level crop insurance is less subject to moral hazard problems. In addition, since county-level insurance is based on widely available information, there is less potential for adverse selection.

County-level insurance products are most attractive to farmers whose production is closely correlated with county performance. Unlike traditional farm-level crop insurance policies, county-level insurance products do not require underwriting and inspections of individual farms. County-level insurance policies can be sold as simple certificates with a structure that is uniform across the underlying index, therefore the terms of contracts are relatively easy to understand.

Moreover, crop producers do not have to provide production history or evidence of loss because payments are based on losses suffered from the county expected yield.

Because farm-level yields are not perfectly correlated with the county-level yield, basis risk is an inherent challenge for county-level insurance products. It is possible for the insurance purchaser to receive an indemnity when no farm-level losses occurred. Conversely, it is also possible for a policyholder to experience production losses on his/her farm but not receive an indemnity because there was no county-level yield loss. Without sufficient correlation, county-level insurance is not an effective risk management tool (Skees, Barnett, and Hartell, 2005).

Revenue Insurance Policies

One of the FCIP objectives is to reduce disaster assistance by increasing crop insurance participation and introducing new insurance products to new crops and regions. New farm-level revenue insurance products (e.g., Crop Revenue Coverage (CRC) and Revenue Assurance (RA)) became available in the mid-1990s. The CRC insurance protection is based on APH yield and the higher of the base market price or the harvest price. RA provides dollar-denominated coverage by the producer selecting a dollar amount of target revenue from a range of 65%-75% of expected revenue. RA has two variations: RA with base price (BP) option and RA with the harvest price (HP) option. The standard RA policy contains the base price (BP) option, which determines the level of the revenue guarantee using futures prices. The revenue guarantee will not increase even if the futures price rises by harvest. The second variation of RA policy allows producers to purchase RA insurance with the harvest price (HP) option, under which the revenue guarantee will increase if the harvest price is higher than the futures prices, just as it does under CRC. The HP option carries a higher premium than the BP option does (RMA online; Edward and Hofstrand, 2007).

Another revenue insurance product is Income Protection (IP). IP protects producers against reductions in gross revenue. IP uses futures prices to set the level of gross income protection, but protection levels will not increase if the harvest price rises. The only difference in coverage is that IP is available only for whole-farm enterprise units whereas CRC and RA are available for sub-farm level optional units (ISU extension; Edward and Hofstrand, 2007).

In the late 1990s, a county-level revenue insurance product known as Group Risk Income Protection (GRIP) was offered for selected crops and regions. GRIP makes indemnity payments only when the average county revenue for the insured crop falls below the gross revenue chosen by the farmer. The average county revenue is based on futures contract prices at harvest. Trigger levels and indemnity payments for GRIP are calculated in a manner similar to that used for GRP (ISU extension; RMA online, 2007).

The 1994 Act created catastrophic (CAT) coverage. CAT coverage pays 55 percent of the established price of the commodity on crop losses in excess of 50 percent. The premium on CAT coverage is paid by the Federal Government; however, producers must pay a $100 administrative fee for each crop insured in each county. Limited-resource farmers may have this fee waived. CAT coverage is not available on all types of policies (RMA online, 2007).

Table 1.3 lists insurance products which are available in U.S.. Currently, More than 100 commodities are covered by available insurance policies. In 2006, approximately 75% of program liability was for farm-level yield and revenue insurance policies. Approximately 14% of program liability was for county-level yield and revenue insurance policies. The remaining 11% of liability was for a variety of insurance products targeted primarily to producers of specialty crops.

Hybrid of Farm-level and County-level Insurance

Currently, crop insurance policies are mutually exclusive. This means that crop insurance purchasers can not choose more than one federal crop insurance policy for a given crop in a given county. The policyholder must choose either a yield or a revenue insurance product and must choose either a farm-level or an area insurance policy. In addition, since full coverage (100% coverage) is not available for any FCIP policy, purchasers must cover the deductible by themselves.

In the 109th Congress, Representative Randy Neugebauer (TX) introduced legislation H.R.721 that authorized the RMA to offer GRP coverage as a supplement to an underlying farm-level insurance policy (MPCI or one of the farm-level revenue insurance products). Farmers can choose to purchase GRP coverage up to the deductible portion of the farm-level policy. The purpose of H.R.721 is to enhance the set of available risk management tools by allowing producers to buy a combination of farm-level insurance and county-level insurance. In introducing the legislation, Representative Neugebauer argued that the combined insurance is a good option for farmers who want to insure against a farm-level loss and have extra coverage against a county-wide or disaster loss.

This idea was also included in the Administration's 2007 farm bill proposal. The Administration proposes to amend the Federal Crop Insurance Act to allow the USDA crop insurance program to offer the new insurance option. The supplemental deductible coverage would strengthen the safety net provided by crop insurance by providing full coverage in the event of county-level disasters. The maximum amount of GRP coverage is equal to the deductible on the farm-level insurance policy times the GRP maximum protection. For instance, producers who chose 55% coverage on the farm-level policy would be able to purchase GRP up to 45% of the GRP maximum protection. Producers can choose any share less than or equal to the maximum protection determined by the deductible on the farm-level insurance policy.

1.2 Indemnity Structures of Three Crop Insurance Products of Interest

The farm-level yield and revenue insurance products are based on the farm's actual production history (APH) yield. The APH yield is a long-run yield average for the insured unit. In its most basic form, the APH yield is a 10-year moving average of the crop producer's yield history. APH yields can also be initiated with as few as four years of yield records and then built to ten years. Producers whose production records are less than four years are required to use a percentage of the county T-Yield[2] for those years without production records.

MPCI pays indemnities when the farmer's production is lower than the trigger yield which is determined by the APH yield and selected coverage. MPCI indemnities per acre are calculated as

(1.1) $$\tilde{n}_{MPCI} = \max(0, \bar{y}_i - \tilde{y}_i) \times price\ election$$

(1.2) $$\bar{y}_i = APH\ \ yield \times Coverage$$

where $\tilde{n}_{MPCI}$ is the indemnity per acre, $\bar{y}_i$ is a trigger yield, and $\tilde{y}_i$ is the stochastic realized farm-level yield. For MPCI, the available coverage levels range from 50% to 85% in 5% increments. The price election converts the yield shortfall into a dollar-denominated indemnity. The maximum price election is established by the Risk Management Agency (RMA) every year. Policyholders can choose a price election anywhere between 60% and 100% of the maximum.

[2] The county T-Yield is an estimate of the expected county yield.

GRP indemnities are paid when the realized county yield falls below a trigger yield which is determined by expected county yield and the selected coverage. Expected county yield is based on the county's yield history.

For GRP, the indemnity per acre is calculated as

(1.3) $$\tilde{n}_{GRP} = max\left(0, \frac{\bar{y}_c - \tilde{y}_c}{\bar{y}_c}\right) \times dollar\ amount\ of\ \ protection$$

(1.4) $$\bar{y}_c = expected\ county\ yield \times Coverage$$

where $\tilde{n}_{GRP}$ is the GRP indemnity, $\bar{y}_c$ is a trigger yield, and $\tilde{y}_c$ is the stochastic realized county yield. For GRP, the available coverage levels range from 70% to 90% in 5 percent increments. The dollar amount of protection per acre is calculated as

(1.5) $$dollar\ amount\ of\ \ protection = expected\ county\ yield \times price\ election \times scale$$

where *scale* is selected by insurance purchaser, and $90\% \leq scale \leq 150\%$.

The indemnity per acre for the combined insurance product is calculated as

(1.6) $$\tilde{n}_{combined} = \tilde{n}_{MPCI} + \left((1 - coverage_{MPCI}) \times \tilde{n}_{GRP(\max)}\right)$$

where $\tilde{n}_{combined}$ is the indemnity per acre on the combined product, $\tilde{n}_{MPCI}$ is as defined in equation (1.1), coverage_{MPCI} is the coverage level selected for the MPCI portion of the policy, and $\tilde{n}_{GRP(\max)}$ is defined as

(1.7) $$\tilde{n}_{GRP(max)} = max\left(0, \frac{\bar{y}'_c - \tilde{y}_c}{\bar{y}'_c}\right) \times maximum\ amount\ of\ \ protection$$

where $\bar{y}'_c$ is a trigger yield with coverage set at 90%, and *maximum amount of protection* is set 150% scale.

The supplemental policy would be offered at several coverage levels so that all or only a portion of the deductible would be covered. Purchasers can choose the supplemental GRP policy with a coverage level anywhere from 70% to 90% and a scale level anywhere from 90% to 150%.

1.3 Objectives

The objective of this study is to evaluate the implications of H.R.721 for representative cotton farms in Georgia. This study will test whether the proposed combined insurance is a good alternative for Georgia cotton farmers and whether the additional risk protection provided by the supplemental GRP policy is worth the additional cost. Specifically, comparisons will be made between MPCI (at various coverage levels), GRP, the proposed combined insurance product, and MPCI with the additional subsidy offered by the GRP portion of the combined insurance policy for representative farms in ten Georgia Counties. This study is also based on the assumption that there is no other additional cost for the combined policy (i.e. additional administrative costs).

Cotton is the top ranked crop in Georgia. Cotton production has increased a lot recently and yield almost doubles. Table 1.2 shows the cotton production for the period of 1975-2005 in Georgia. This study compares various insurance products based on representative cotton farms.

Ten counties, Early, Mitchell, Dooly, Colquitt, Worth, Brooks, Wilcox, Crisp, Irwin and Turner were chosen from the 159 counties in Georgia. The first two counties are located in crop reporting district (CRD) 70 and the other eight counties are located in CRD 80. CRD 70 and 80 were selected since approximately 75% of cotton production in Georgia is from these two districts. In addition, counties with the most available farms in our dataset were used in order to have enough original farm yield data to simulate pseudo farm-level yield. Therefore, 2 counties were selected from CRD70 and 8 counties were selected from CRD80. For each county, there are more than 40 farms available in the dataset. Table 1.4 presents cotton farms and production from these counties in years 2002 and 1997. The percentage of total production for these 10 counties is 35.25% of the state production in 2002 and 30.34% in 1997. These data are collected from National Agricultural Statistics Service (NASS).

This thesis was broken down in to 5 steps to achieve the overall objective mentioned above:

1. Obtain farm and county yield data.
2. Use available data to generate pseudo farm-level yields for the representative farms.
3. Simulate joint kernel density functions for the representative farm-level yield and the county-level yield;
4. Calculate revenue net of insurance purchasing for different insurance products using actual premium rates;
5. Compare certainty equivalent revenues across different scenarios for an assumed utility function.

1.4 Organization

There are four chapters in the thesis. The history of the Federal Crop Insurance Program, the indemnity structure of selected insurance products, and the objectives for the research are introduced in Chapter 1. Chapter 2 reviews relevant literature. The methodology and decision making criteria are described in Chapter 3. The results, conclusions and implications for the combined crop insurance, and suggestions for further research are presented in Chapter 4.

Table 1.1 Premium Subsidy Percentages for MPCI

Coverage level	1980 Act	1994 Act	2000 Act
50	30	55	67
55	N/A	46.1	64
60	N/A	37.8	64
65	30	41.7	59
70	N/A	31.9	59
75	17	23.5	55
80	N/A	17.3	48
85	N/A	13	38

Table 1.2 Cotton Production in Georgia

Year	Planted (1000 acres)	Harvested (1000 acres)	Yield/acre (pounds)	Production (1000 bales)
1975	165	160	443	148
1980	170	160	258	86
1985	255	245	725	370
1990	355	350	555	405
1995	1,500	1,490	625	1,941
2000	1,500	1,350	591	1,663
2005	1,220	1,210	849	2,140

Source: National Agricultural Statistical Service

http://www.nass.usda.gov/QuickStats/Create_Federal_All.jsp

Table 1.3 Current Major Crop Insurance Products in U.S.

	Farm-Level Insurance	County-Level Insurance
Yield Insurance	MPCI	GRP
Revenue Insurance	IP, CRC, RA	GRIP

Table 1.4 Cotton production: 2002 and 1997

County	2002 # of Farms	2002 Harvested Acres	2002 Production (Bales)	1997 # of Farms	1997 Harvested Acres	1997 Production (Bales)
Early	88	33,598	43,219	103	33,922	45,166
Mitchell	89	40,422	55,930	71	25,839	32,610
Dooly	127	75,684	95,555	155	75,783	84,785
Colquitt	148	76,530	103,148	239	77,302	119,044
Worth	107	48,641	57,633	185	59,985	72,522
Brooks	104	45,996	59,004	138	46,766	72,220
Wilcox	76	24,582	28,195	135	33,158	37,461
Crisp	65	37,203	40,963	87	39,125	43,859
Irwin	92	32,979	39,996	120	34,659	46,026
Turner	88	26,079	28,090	113	26,466	28,393
State Total	3,216	1,267,150	1,564,995	4,410	1,464,105	1,918,779

Source: “2002 Census of Agricultural”

http://www.nass.usda.gov/census/census02/volume1/ga/st13_2_025_025.pdf

CHAPTER 2

LITERATURE REVIEW

2.1 Review of Current Insurance Products

The Federal Crop Insurance Program was initiated in 1938. Since then, it has developed into a public-private partnership including various insurance products. In 1979, only one federal crop insurance product was available for only 29 crops. In 2000, several insurance products were offered for over 100 commodities (crops and livestock).

The farm-level insurance products MPCI, CRC, RA, and IP protect against actual losses incurred by the policyholder. GRP and GRIP policies use a county index as a proxy for the loss incurred. Various studies have examined the current insurance products using many different conceptual frameworks.

Farm-level Insurance Products

A number of studies have investigated what factors influence participation in farm-level insurance (Goodwin, 1993; Kramer, 1983). Since there is asymmetric information about risk exposure between policyholders and insurers, farm-level insurance products are susceptible to inherent insurance problems such as adverse selection and moral hazard. Many documents have identified and analyzed adverse selection and moral hazard problems (Skees and Reed, 1986; Quiggin, Karagiannis, and Stanton, 1993; Smith and Goodwin, 1996; Coble et al., 1997; Just, Calvin, and Quiggin, 1999). These problems have led to higher premium rates and inequities in program benefits, though often masked by federal premium subsidies (Skees, 2001). Barnett

(2004) said that “In the long run, both of these problems can cause insurers to increase premium rates, driving lower-risk insurance purchasers out of the market”.

Coble et al. (1997) empirically analyzed moral hazard on MPCI indemnity using five years production and insurance data from Kansas wheat farms. Tobit models were used to estimate the indemnities for farms in three regions. Their results suggested that moral hazard had a significant effect on expected MPCI indemnities in most poor production years but not in favorable production years.

Since moral hazard increases the potential likelihood of and/or magnitude of an indemnity, the insurer’s exposure to risk is increased. In the short run, insurers will pay indemnities which are higher than anticipated because they are not aware of the changes in policyholders’ behavior. Over time, insurers will respond by increasing premium rates for all policyholders. However, this does not correct the underlying moral hazard but makes this problem worse. Those who are not engaged in moral hazard may quit the insurance program rather than pay the higher premium rate. As premiums are ratcheted up over time, policyholders who are engaged in moral hazard behaviors are more and more disproportionately represented in the pool of insurance purchasers. “In extreme cases, the only ones purchasing insurance at the very high premium cost are those who intend to engage in moral hazard behaviors.” (Barnett 2004, Page 7)

Adverse selection occurs when the insurer can not accurately classify potential policyholders according to their risk exposure. This means that the insurer likely has less information than potential policyholders who know their true level of risk exposure. Goodwin presented an empirical analysis of the demand for MPCI by Iowa corn producers for the period of 1985 to 1990. Based on his findings, he stated that “refinements in premium rate setting techniques should be considered in order to address the problems associated with an adversely-selected pool of participants" (Goodwin, 1993, Page 432).

Barnett (2004) denotes as "misclassified to their benefit" potential policyholders who have been charged a premium rate that underestimates their true level of risk exposure. These policyholders are more inclined to purchase insurance since the actual cost is lower than the expected indemnity. Barnett (2004) also denotes as "misclassified to their detriment" potential policyholders who have been charged a premium rate that overestimates their true level of risk exposure. These policyholders are less likely to purchase insurance. Since an adversely selected pool of insurance purchasers is disproportionately composed of those who have been misclassified to their benefit, indemnities will be higher than anticipated. As a result, the insurer will likely increase premium rates for all policyholders. This does not address the underlying misclassification problem but deteriorates it further. Since premium rates increase over time, those policyholders who have been misclassified to their benefit become more and more disproportionately represented in the insurance pool. In the extreme case, the only ones purchasing insurance at the very high premium rate are those who are misclassified to their benefit (Barnett, 2004).

County-level Insurance Products

The county-level insurance products offer many potential advantages over the farm-level crop insurance. County-level insurance involves less paperwork and lower administrative costs. This is obviously beneficial to some growers who have no historic yield data required to establish an APH yield. It is also unnecessary for insurers to collect and record farmers yield reports.

Compared with the inherent problems of traditional insurance, county-level insurance is less subject to these problems. Moral hazard is essentially eliminated since the indemnities depend on the county-level yield realization rather than the individual producer's actual realized yield. Adverse selection is significantly reduced because potential policyholders have no better information than the insurer about the distribution of county-level yields (Skees, Barnett and Hartell, 2005).

While county-level insurance products have several benefits, they simultaneously have one limitation, basis risk. The existence of basis risk is inherent for county-level insurance since these policies protect farmers only when the average county yield is low, not when more isolated problems hit their own farms. Basis varies from year to year in the difference between county-level and farm-level yield in each specific year. Unless the farm-level yield is perfectly correlated with the county-level yield, the basis will be different from year to year. This implies that it is possible for insurance purchaser to receive an indemnity but not suffer a yield loss. Conversely, it is also possible that a policyholder may experience a yield shortfall on his/her farm but not receive an indemnity from a GRP policy because there was no county-level yield loss. The magnitude of the basis risk is affected mainly by two factors: the area used for establishing the yield index and the procedure for forecasting the central tendency in yields for the area (Skees, Black, and Barnett, 1997). Skees, Barnett, and Hartell (2005) stated that careful design of index insurance policy parameters (coverage period, trigger, measurement site, etc.) can help reduce basis risk.

Barnaby and Skees presented arguments for county-level insurance and explained how such a program might operate in 1990. Miranda (1991) applied a sample of 102 soybean farms from 22 counties in western Kentucky in an empirical framework to evaluate the effectiveness and equity of county-level yield crop insurance. For a farmer in a given county, the farmer's stochastic yield $\tilde{y}_i$ can be decomposed into one systematic component which is correlated to the county yield and another unsystematic component $\tilde{\varepsilon}_i$ which is uncorrelated with county yield. Miranda measured the sensitivity of the farm yield to county yield by using the individual beta (β) coefficient. The β is defined as

(2.1) $\tilde{y}_i - \mu_i = \beta_i(\tilde{y}_c - \mu_c) + \tilde{\varepsilon}_i$

(2.2) $\beta_i = cov(\tilde{y}_i, \tilde{y}_c) / \sigma_{\tilde{y}}^2$

where $E(\tilde{\varepsilon}_i) = 0$ and $E(\tilde{y}_i) = \mu_i, E(\tilde{y}_c) = \mu_c$. The county-level insurance is risk reducing if and only if $\beta_i > \beta_c$. β_c, critical beta, is defined as

(2.3) $$\beta_c = -\frac{\sigma_{\tilde{n}}^2}{2\,cov(\tilde{y}_c, \tilde{n})}$$

where $\tilde{n}$ is the indemnity of county-level insurance, and $\sigma_{\tilde{n}}^2$ is the variance of indemnity. Since county yield $\tilde{y}_c$ and indemnity $\tilde{n}$ are negatively correlated, $\beta_c > 0$.

Miranda assumed actuarially fair premiums in his empirical analysis. He compared farm-level yield insurance with "full coverage" and "optimal coverage" county-level insurance. "Full coverage" was defined as having coverage set at 88.5% and *scale* set at 100%. For the "optimal coverage", coverage was set at 95% and *scale* was set to minimize the variance of net yield. On average, "optimal coverage" county-level insurance provided greater risk protection than farm-level insurance but "full coverage" county-level insurance was not as effective as farm-level insurance.

Mahul further examined the optimal design of a county-level insurance contract in the expected utility model when the indemnity was based on the aggregate yield of a surrounding area. The result showed that the optimal scale level was equal to the individual positive beta (β_i), and it did not depend on the producer's degree of risk aversion or the insurance premium.

Barnett et al. (2005), in their empirical analysis, compared MPCI and GRP crop insurance contracts for 66,686 corn farms in 10 Corn Belt States (Indiana, Illinois, Kansas, Kentucky, Michigan, Minnesota, Nebraska, Ohio, and Texas) and 3,152 sugar beet farms from two States (North Dakota and Minnesota). They modeled MPCI at 65%, 75% and 85% coverage levels and three different GRP scenarios. The first had coverage set at 90% and scale at 100%. The second had coverage set between 70% and 90% and scale set subject to the constraints imposed by the actual GRP contract. Specifically, the scale was solved for β_l as in equation (2.4). For the third GRP scenario, coverage was set between 70% and 130% and scale was unconstrained. For the second and third scenarios, optimal GRP coverage and scale would vary across states, but the same coverage and scale were applied for each farm within a given state.

Barnett et al. estimated optimal scale for GRP as

$$(2.4) \quad \tilde{y}_{il} = \alpha_l + \beta_l \tilde{n}_{cl} + \tilde{\varepsilon}_{il} \qquad \forall i \in c = county \in l = state, cooperative$$

where $\tilde{n}_{cl}$ is the GRP indemnity for county *c* in multi-county region *l*, and β_l is the optimal scale level.

For corn, the most constrained GRP contract (coverage was at 90% and scale at 100%) generated more risk protection than MPCI with 65% coverage in every state except for Nebraska, Texas, and Michigan. The second GRP scenario provided more risk reduction than MPCI with 65% coverage for every state except for Nebraska and Michigan,4e and more risk reduction than MPCI with 75% coverage in Illinois, Minnesota, Kentucky, Iowa, Ohio, and Indiana. However, MPCI with 85% coverage generated more risk reduction than the first two GRP contracts. For the third contract (coverage was up to 130% and scale was unconstrained), more risk protection was generated by GRP than that of MPCI with 65% coverage for every state except for Michigan, MPCI with 75% coverage for all states except for Texas and Michigan, and MPCI with 85% coverage in Illinois, Kentucky, Iowa, and Ohio. These results are consistent with the notion that county-level yield insurance works best in relatively homogeneous production regions (Skees, Black, and Barnett, 1997).

For sugar beets, the region (*l*) was defined as the processing cooperative. For farms associated with the Southern Minn cooperative, all three GRP contracts provided more risk reduction than MPCI with 65% and 75% coverage. GRP with unconstrained scale generated more risk reduction than MPCI with 85% coverage. For farms associated with American Crystal, three GRP scenarios performed better than MPCI with 65% coverage. Only GRP with unconstrained scale generated more risk reduction than 75%. For farms associated with the Min-Dak cooperative, no GRP contracts provided as much risk reduction as MPCI with 65% coverage. Barnett et al. concluded that for corn and sugar beets produced in some regions, GRP had opportunities for reductions in net yield variance compared with MPCI.

2.2 Review on Proposed Combined Insurance

For many crop producers, purchasing farm-level crop insurance at high coverage levels is extremely expensive. With the proposed combined insurance product, producers could purchase lower levels of farm-level crop insurance combined with some level of county yield insurance. This creates an opportunity for crop producers to combine these products to best suit their needs.

There is only one other study that has examined the impacts of the combined insurance product proposed in H.R. 721. Knight (2006) evaluated the proposed combined insurance product for six representative farms: one cotton farm in Texas, one cotton farm in Mississippi, one corn farm in Ohio, one corn farm in Kansas, and two wheat farms in Kansas. For each farm, three levels of MPCI yield protection were considered (50%, 65%, and 75%) in combination with 90% GRP coverage. Actuarially fair premium rates were used for both MPCI and GRP. APH premiums and indemnities were based on the 100% of the maximum price election in 2006.

In his study, Knight compared three scenarios: no insurance purchasing, MPCI, and the combined insurance. He developed distributions for county-level yield (used for GRP) and farm-level yield (used for APH). Combining with a price distribution, he used 100,000 Monte Carlo simulations of county-level yield, farm-level yield and prices to generate the revenue distribution under different scenarios. Percentiles of the simulated revenue distributions illustrated how the insurance coverage reduced the likelihood of bad revenue outcomes. For the cotton farm in Texas, for example, the 10th percentile of the revenue distribution for APH with 50% coverage was \$57.43 and the 10th percentile for the combined insurance (APH with 50% coverage and GRP with coverage at 90% and scale at 150%) was \$70.20.

Knight's findings indicated that the combined insurance product offered under H.R. 721 would provide additional revenue risk protection for all of the representative farms compared to simply purchasing an MPCI policy. The combined insurance product provided the greatest benefit (relative to an MPCI policy alone) in counties where yield risk for the insured crop was relatively high. In counties with relatively low yield risk, the combined insurance product generated only modest additional benefits relative to an MPCI policy alone. The added benefits of the combined insurance product declined for higher MPCI coverage levels.

This study extends Knight's analysis to consider the feasibility and the implications of the proposed combined insurance product for representative cotton farms in 10 Georgia counties.

CHAPTER 3

METHODOLOGY

3.1 Expected Utility

The neoclassical theory of perfect competition assumes that firms have perfect information. This means that firms know exactly how much they will produce, the exact price they will receive for their output, and the exact prices that they will pay for resources. In reality, firms always face a variety of risks and uncertainties. For example, farmers face with yield risk due to unfavorable weather and price risk due to changes in both supply and demand.

Expected utility theory is widely used to model decision-making under risk and uncertainty. The first formalized explanation of expected utility was introduced by Daniel Bernoulli. In the 1940s, Neumann and Morgenstern established an axiomatic treatment which formed the basis of modern expected utility theory. A brief review of this theory is summarized in this section.

The method of expected utility theory is to construct a weighted average of utility based on the utility in each possible state of nature and the probability of occurrence. The decision-maker replaces the monetary wealth (w) with the utility of wealth ($U(w)$). The weight is the estimate of the probability of each state. The expected utility is thus an expectation in terms of probability theory. The decision-maker selects his/her choice under risk and uncertainty by maximizing the expected utility. The expected utility is defined as:

(3.1) $$EU(w) = \sum_{i=1}^{n} p(w_i)U(w_i)$$ for the discrete case

(3.2) $$EU(w) = \int U(w)f(w)dw$$ for the continuous case

where $U(w)$ is a utility function of wealth w, $p(w_i)$ is the probability corresponding to wealth w_i, and $f(w)$ is the probability density function of w.

For every decision-maker who is facing risk and uncertainty, there is a sum of money that would make him/her indifferent between facing the risk and accepting the sum of money. This sum is the lowest value he/she is willing to pay in order to get rid of the risk. This certain sum of money is called the "certainty equivalent" (CE) of the risk. The mathematical definition of the certainty equivalent is denoted as:

(3.3) $$U(CE) = EU(w)$$

Particularly, for the continuous case, equation (3.3) can be represented by the following equation:

(3.4) $$U(CE) = \int U(w)f(w)dw$$

Since the expected utility is an increasing monotonic transformation function of wealth, CE, denoted by w^*, can be solved by its inverse function shown as

(3.5) $$CE = w^* = U^{-1}(EU(w)) = U^{-1}(\int U(w)f(w)dw)$$

Investors can be characterized into three groups: risk averse, risk neutral and risk seeking. Risk aversion is characterized by a utility function that is concave over the domain of wealth as shown in Figure 3.1.[3] The difference between the expected wealth $E(w)$ and the certainty equivalent w^* is referred to as risk premium, π. This means that a risk averse individual is willing to give up some of his/her expected wealth π so that the risk can be shifted to someone else. In other words, a risk averse individual is willing to pay an insurance premium.

[3] A utility function convex to the origin would represent risk seeking while a straight line would represent risk neutral behavior. Risk neutral is equivalent to an investor having perfect knowledge of outcomes.

The more concave the utility function, the greater the degree of risk aversion. Arrow and Pratt showed that the risk premium can be interpreted by absolute risk aversion (A_a) and relative risk aversion (A_r). These two terms are defined in the following equations:

(3.7) $$A_a = -\frac{U''(w)}{U'(w)} \quad \text{and} \quad A_r = -\frac{U''(w) \cdot w}{U'(w)} = A_a \cdot w$$

Depending on the curvature of the utility function, risk aversion can be classified as decreasing absolute risk aversion (DARA, when $\frac{\partial A_a}{\partial w} < 0$), constant absolute risk aversion (CARA, when $\frac{\partial A_a}{\partial w} = 0$) and increasing absolute risk aversion (IARA, when $\frac{\partial A_a}{\partial w} > 0$). The exponential utility, described as $U(w) = -\exp(-\lambda w)$, is a commonly used CARA utility function ($A_a = \lambda$)[4].

There are also three different measures of relative risk aversion including decreasing relative risk aversion (DRRA, when $\frac{\partial A_r}{\partial w} < 0$), constant relative risk aversion (CRRA, when $\frac{\partial A_r}{\partial w} = 0$) and increasing relative risk aversion (IRRA, when $\frac{\partial A_r}{\partial w} > 0$).

[4] $U'(w) = \lambda \exp(-\lambda w)$ and $U''(w) = -\lambda^2 \exp(-\lambda w)$, so $A_a = -\frac{U''(w)}{U(w)} = \lambda$

The constant relative risk aversion function is defined as $\frac{w^{1-r}}{1-r}$, when $A_r = r > 1$; or $\ln(w)$, when $A_r = 1$ ($A_r = r$)[5].

3.2 Data

There are two kinds of data used in this study. The first is farm-level yield data collected from the USDA's Risk Management Agency (RMA). These data are APH yield histories from Georgia cotton farmers who purchased farm-level insurance product in 2001. Thus, the data is collected from 1991 to 2000. Farms which had actual yield data for at least the last 6 consecutive years are included in this study[6].

The second is historical county yield data obtained from USDA's National Agricultural Statistics Service (NASS). These data are available for cotton production in Georgia from 1971 to 2005. Since county level yield data reveal an upward trend over time, the county yields were detrended. County-level yields can be described by the following simple linear regression:

(3.8) $$CY_t = \beta_0 + \beta_1 t + \varepsilon_i$$

where CY is the same as the notation $\tilde{y}_c$ in equation (1.3), and CY_t is the county yield in year *t*. For each county, a vector of predicted county yields CY^{pred} with 35 elements is captured by the regression.

---

[5] $U'(w) = w^{-r}$ and $U''(w) = -rw^{-r-1}$, so $A_r = -\frac{U''(w)}{U(w)} \cdot w = r$ for $r \neq 1$

$U'(w) = \frac{1}{w}$ and $U''(w) = -\frac{1}{w^2}$, so $A_r = -\frac{U''(w)}{U(w)} \cdot w = 1$ for $r = 1$

[6] Only actual verified yield data are included in the analysis (e.g., T-yields, etc. have been excluded). The actual yield data have been aggregated to the whole-farm or "enterprise unit" level.

Detrended county yields can be described as:

(3.9) $$CY_t^{\det} = \frac{CY_t}{CY_t^{pred}} CY_{2005}^{pred}$$

where $CY_t^{\det}$ is the detrended county yield, CY_t^{pred} is the predicted county yield in year *t*, and CY_{2005}^{pred} is the predicted county yield for year 2005. Figure 3.1 to Figure 3.10 show the original and detrended yield for each county.

For the *s* years when both farm-level and county-level yield data are available ($6 \le s \le 10$), the ratio of the farm yield to the county yield is calculated as:

(3.10) $$\varepsilon_{is} = \frac{\tilde{y}_{is}}{CY_s}$$

where $\tilde{y}_{is}$ is yield for farm *i* in year *s* and ε_{is} is the ratio of the yield on farm *i* to the county yield in year *s*.

It is assumed that farm-level yield variability is determined by two location-specific random components: county yield and farm deviations from the county yield. Following Miller, Barnett, and Coble (2003), pseudo farm yields are calculated by combining the detrended county yield data with the estimates of ε_{is} for the farms in the county. Assuming all the values of ε_{is} are equally likely to happen in any given year, a vector of pseudo farm yields for each county is calculated as the direct product of each ε_{is} and each value of $CY_t^{\det}$

(3.11) $$y_m^{pseudo} = \varepsilon_{is} \times CY_t^{\det}$$

where $m = 1, ..., M$. Since farms with at least the last 6 consecutive years of yield data are used in this study and there are 35 years of county yield data, the minimum number of pseudo farm yield observations for each representative farm is $M = 35 \times 6 \times N$ and the maximum is $M = 35 \times 10 \times N$, where *N* is the number of farms in the county for which farm-level data are available. This procedure can generate a small number of unreasonably high pseudo farm yields, so pseudo farm yields were censored at 2,000 pounds per acre. Table 3.1 presents the number of farms and number of pseudo farm yield observations for each representative farm.

3.3 Yield distribution

There are various methods to represent crop yield distributions. Among these available methods, two primary groups are established. The first one is tied to a known parametric distribution such as a gamma distribution or beta distribution. Gallagher (1987) noted that a normal distribution is inappropriate because crop production is nonsymmetric and negatively skewed. For example, Babcock and Hennessy (1996) postulated a beta yield distribution to study the effects of insurance on fertilizer application rates. There are two steps in this method. At first, a specific parametric distribution is selected. Then parameters of the distribution are estimated on the observed data set. However, these distributional choices may be incorrect. Therefore, inaccurate predictions and misleading inferences may occur (Goodwin and Ker, 1998).

The second method is a nonparametric distribution. A variety of nonparametric methods have been developed to estimate yield distributions. Nonparametric density estimation does not assume a particular functional form for the yield distributions. It uses the observed data to represent the most appropriate crop yield distribution. Nonparametric methods have been widely used in recent years. Goodwin and Ker (1998) used nonparametric density estimation procedures to evaluate county-level yield distributions. Deng et al. (2006) applied a joint kernel density function to evaluate the efficiency of index crop insurance products on representative corn farms in four counties in South Georgia.

Nonparametric density estimation, also known as a distribution-free method, offers a consistent approach to smoothing observations to obtain a continuous density estimation. This method can be used on all types of data including nominal, ordinal, interval and ratio scaled. Generally, nonparametric methods are more powerful than parametric estimation not only because they are based on the original observed data but also because they require fewer constraining assumptions.

In this study, the county and representative farm yield distributions were estimated using a nonparametric distribution. Because of the inherent correlations between farm yields and county yields, a joint kernel density function is used to estimate the county and representative farm yield distributions. Formally, if y_m^{pseudo} with *m=1,…,M*, is designated each element of the vector y^{pseudo} and each county yield $CY^{\det}$ is repeated for the corresponding element of y^{pseudo} , a matrix with *M* rows and 2 columns is obtained. Recall that *M* is equal to the number of pseudo farm yields in a given county.

The joint kernel density estimate of farm-level and county-level yield, $f(y^{pseudo}, CY^{\det})$, based on a given county is described as:

$$
\begin{aligned}
f(y^{pseudo}, CY^{\det}) &= \frac{1}{n}\sum_{i=1}^{n} \varphi_H (y^{pseudo} - y_i^{pseudo}, CY^{\det} - CY_i^{\det}) \\
&= \frac{1}{nH_{y^{pseudo}} H_{CY^{\det}}} \sum_{i=1}^{n} \varphi\left(\frac{y^{pseudo} - y_i^{pseudo}}{H_{y^{pseudo}}}, \frac{CY^{\det} - CY_i^{\det}}{H_{CY^{\det}}} \right)
\end{aligned} \tag{3.12}
$$

where $H_{y^{psrudo}}$ and $H_{CY^{\det}}$ are bandwidths, and $H_{y^{pseudo}} > 0$, $H_{CY^{\det}} > 0$. Bandwidth is important to determine the final shape of the estimated distribution. The larger the bandwidth, the smoother the surface. $\varphi_H \left(y^{pseudo}, CY^{\det}\right)$ is the rescaled normal density, which is described as following:

(3.13) $$\varphi_H\left(y^{pseudo},CY^{\det}\right)=\frac{1}{H_{y^{pseudo}}H_{CY^{\det}}}\varphi\left(\frac{y^{pseudo}}{H_{y^{pseudo}}},\frac{CY^{\det}}{H_{CY^{\det}}}\right)$$

where $\varphi\left(y^{pseudo},CY^{\det}\right)$ is the standard normal density.

(3.14) $$\varphi\left(y^{pseudo},CY^{\det}\right)=\frac{1}{2\pi}\exp\left(-\frac{y^{pseudo^2}+CY^{\det^2}}{2}\right)$$

The marginal density function of the representative farm yield is calculated as:

(3.15) $$f(y^{pseudo})=\int\frac{1}{nH_{y^{pseudo}}H_{CY^{\det}}}\sum_{i=1}^{n}\varphi\left(\frac{y^{pseudo}-y_i^{pseudo}}{H_{y^{pseudo}}},\frac{CY^{\det}-CY_i^{\det}}{H_{CY^{\det}}}\right)dCY^{\det}$$

and the marginal density function of the county level yield is calculated as:

(3.16) $$f(CY^{\det})=\int\frac{1}{nH_{y^{pseudo}}H_{CY^{\det}}}\sum_{i=1}^{n}\varphi\left(\frac{y^{pseudo}-y_i^{pseudo}}{H_{y^{pseudo}}},\frac{CY^{\det}-CY_i^{\det}}{H_{CY^{\det}}}\right)dy^{pseudo}$$

(SAS online study menu).

The estimated joint kernel density functions for representative farm yield and county yield were used to evaluate the performance of each insurance product.

3.4 Revenue calculation

Per acre market revenue is calculated as the product of the realized farm-level yield and the loan rate of $0.53 per pound for cotton. Since the insurance products being analyzed protect only against yield shortfalls rather than revenue shortfalls, price is treated as a constant rather than as a stochastic variable.

In this study, for MPCI, GRP, and the proposed combined insurance product, the per acre premium cost was calculated using RMA FCI-35 premium rate tables available on the RMA website. MPCI premium rates are conditioned on the APH yield which was set equal to the mean of the yield distribution for each representative farm.

The corresponding premium subsidies were applied to each product to generate subsidized premium costs. The subsidized premium for MPCI is calculated as:

(3.17) $$\pi_{MPCI} = \bar{y}_i \times premium\ rate \times price\ election \times subsidy\ \ factor$$

where $\bar{y}_i$ is a trigger yield as in equation (1.1). And the subsidized premium for GRP is calculated as:

(3.18) $$\pi_{GRP} = protection\ \ election \times premium\ rate \times subsidy\ \ factor$$

For each of the insurance products, per acre revenue net of insurance purchasing is calculated as

(3.19) $$R_k^{net} = R^{market} + \tilde{n}_k - \pi_k$$

where k is an insurance purchasing choice equal to either no insurance, MPCI, GRP, or the proposed combined insurance product, R^{market} is market revenue without an insurance contract, $\tilde{n}_k$ is the insurance indemnity as calculated in equations (1.1), (1.3), or (1.6), and π_k is the premium. Note that if k is no insurance, $R_k^{net} = R^{market}$. To further analyze whether the additional risk protection from the combined product is worth the additional cost, we investigate a scenario in which the additional premium subsidy inherent in the supplemental GRP policy is simply added to an MPCI policy with 85% coverage. In this case,

(3.20) $$R^{net} = R^{market} + \tilde{n}_{MPCI} - \pi_{MPCI} + Supplemental\ GRP\ \ premium\ subsidy\ \ .$$

Thus, thirteen scenarios were compared in this analysis for each of the representative farms.

1. No insurance protection

2. MPCI with 55% coverage of APH yield and 100% price election
3. MPCI with 75% coverage of APH yield and 100% price election.
4. MPCI with 85% coverage of APH yield and 100% price election
5. Combined insurance with 55% coverage of MPCI in combination with 45% of the 2006 GRP maximum protection.
6. Combined insurance with 75% coverage of MPCI in combination with 25% of the 2006 GRP maximum protection.
7. Combined insurance with 75% coverage of MPCI in combination with 25% of the 2006 GRP setting at 90% coverage and 125% scale
8. Combined insurance with 75% coverage of MPCI in combination with 25% of the 2006 GRP setting at 80% coverage and 150% scale
9. Combined insurance with 75% coverage of MPCI in combination with 25% of the 2006 GRP setting at 70% coverage and 150% scale
10. Combined insurance with 85% coverage of MPCI in combination with 15% of the 2006 GRP maximum protection.
11. GRP with 90% coverage of county yield and 150% scale.
12. GRP with 90% coverage of county yield and 100% scale.
13. MPCI with 85% coverage of APH yield supplemented with the premium subsidy inherent in a GRP policy with 15% of the 2006 GRP maximum protection.

3.5 Decision Criterion

The representative farmer's expected utility over net revenue is assumed to be characterized by a utility function with constant relative risk aversion:

(3.21)
$$U_k = \frac{R_k^{net\,1-\gamma}}{1-\gamma} \quad when\ \gamma \neq 1,\ and$$
$$U_k = \log\left(R_k^{net}\right) \quad when\ \gamma = 1$$

where R_k^{net} is from (3.20), and γ is the measure of relative risk aversion. The coefficient of relative risk aversion is set at 1, 2 and 4 in this study to test the impact of risk aversion on preference of farmers. The certainly equivalent of (3.21) is

(3.22a)
$$CE_k = U^{-1}\left(EU_k\left(R_k^{net}\right)\right)$$

or for each of the insurance choices

(3.22b)
$$CE_{No\ Insurance} = U^{-1}(\iint U(R^{market})f(y^{pseudo}, CY^{\det})dCY^{\det}dy^{pseudo})$$

(3.22c)
$$CE_{MPCI} = U^{-1}(\iint U(R^{market} + \tilde{n}_{MPCI} - \pi_{MPCI})f(y^{pseudo}, CY^{det})dCY^{det}dy^{pseudo})$$

(3.22d)
$$CE_{GRP} = U^{-1}\left(\iint U(R^{market} + \tilde{n}_{GRP} - \pi_{GRP})f(y^{pseudo}, CY^{det})dy^{pseudo}dCY^{det}\right)$$

(3.22e)
$$CE_{Combined} = U^{-1}\begin{pmatrix} \iint U(R^{market} + \tilde{n}_{MPCI} - \pi_{MPCI} \\ +(1-coverage_{MPCI})\times(\tilde{n}_{GRP(max)} - \pi_{GRP(max)}))f(y^{pseudo}, CY^{det})dCY^{det}dy^{pseudo} \end{pmatrix}$$
.

where $f(y^{pseudo}, CY^{\det})$ is the joint kernel density as equation (3.12). Numerical methods were used to integrate under the joint kernel density functions.

The results of the study are based on the comparison of certainty equivalent revenues of the ten different scenarios.

Table 3.1 Farm-level Yield Data Summary

County	# of farmers used in this study	# of pseudo farm yield observations
Brooks	73	18,513
Colquitt	92	25,706
Crisp	58	16,655
Early	43	12,355
Mitchell	57	14,709
Dooly	105	33,550
Worth	75	20,597
Wilcox	57	16,621
Irwin	62	15,991
Turner	51	14,708

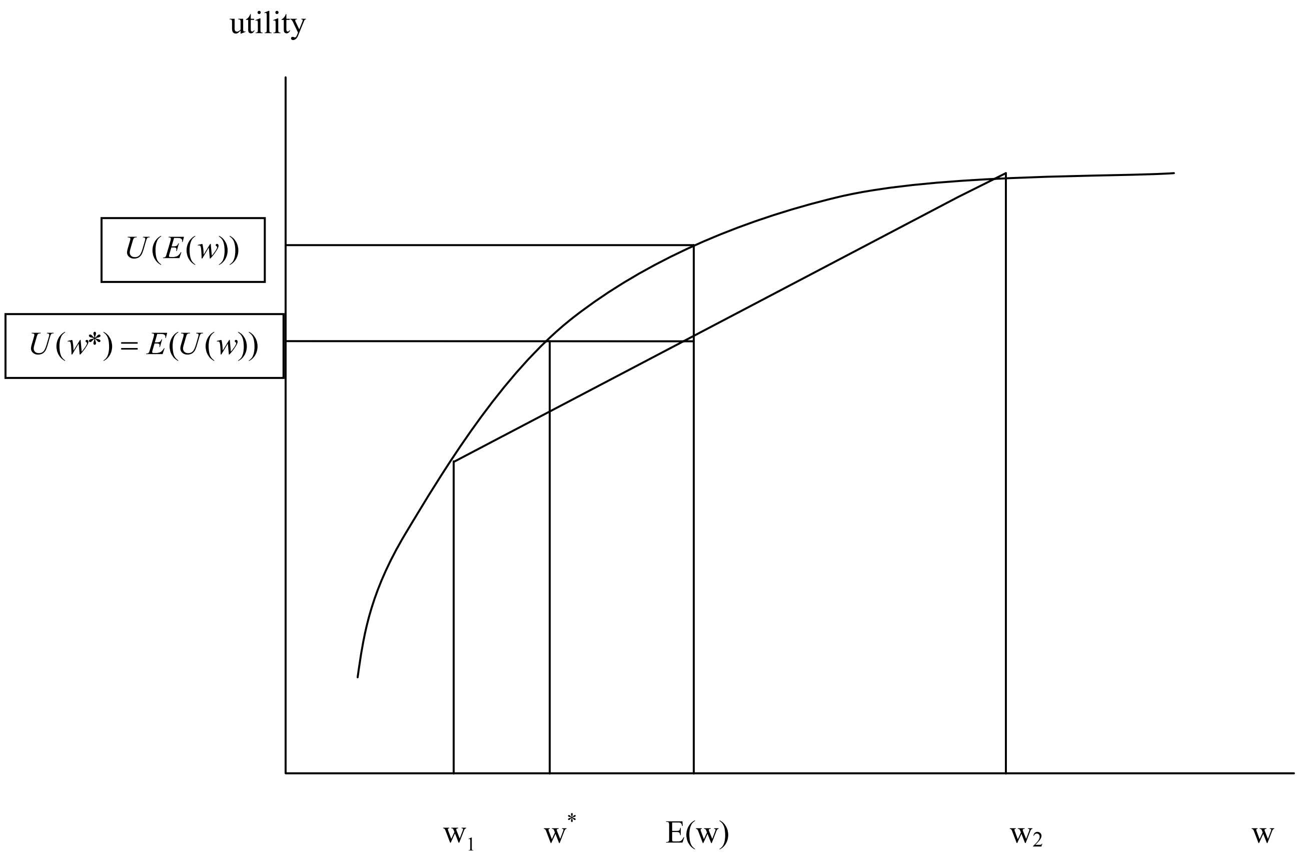
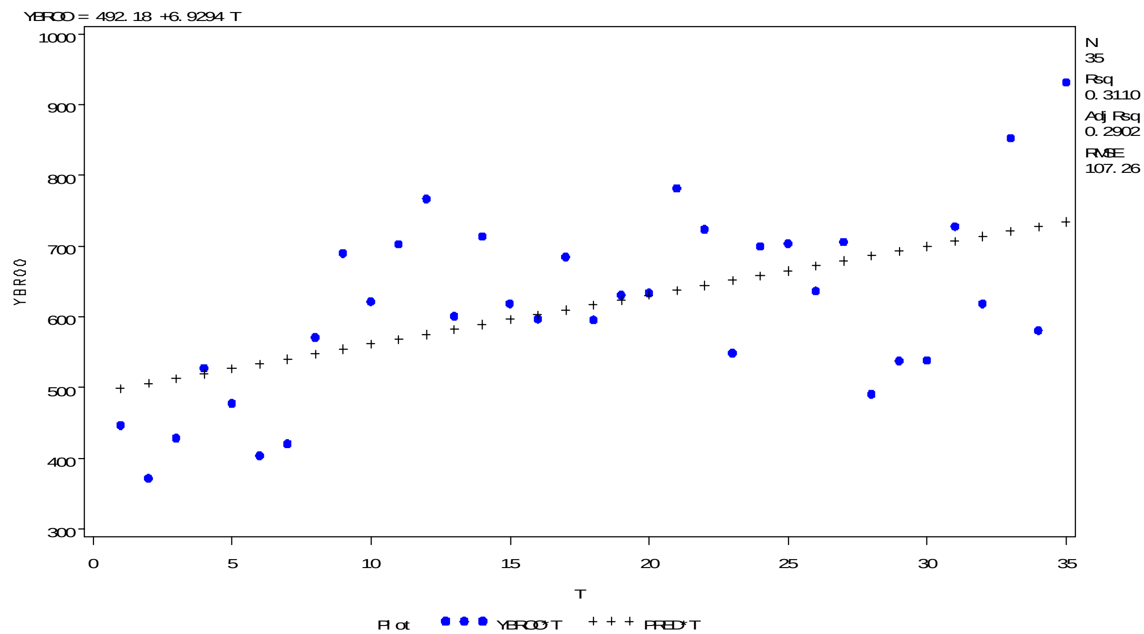


Figure3.1 Impact of Risk on Utility



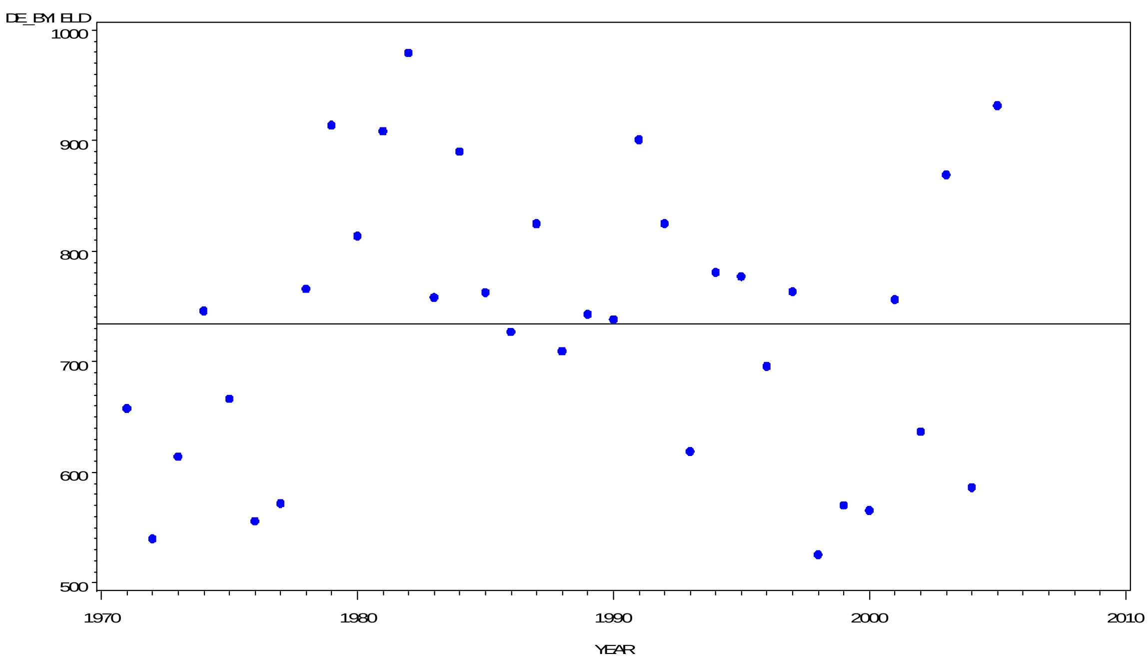
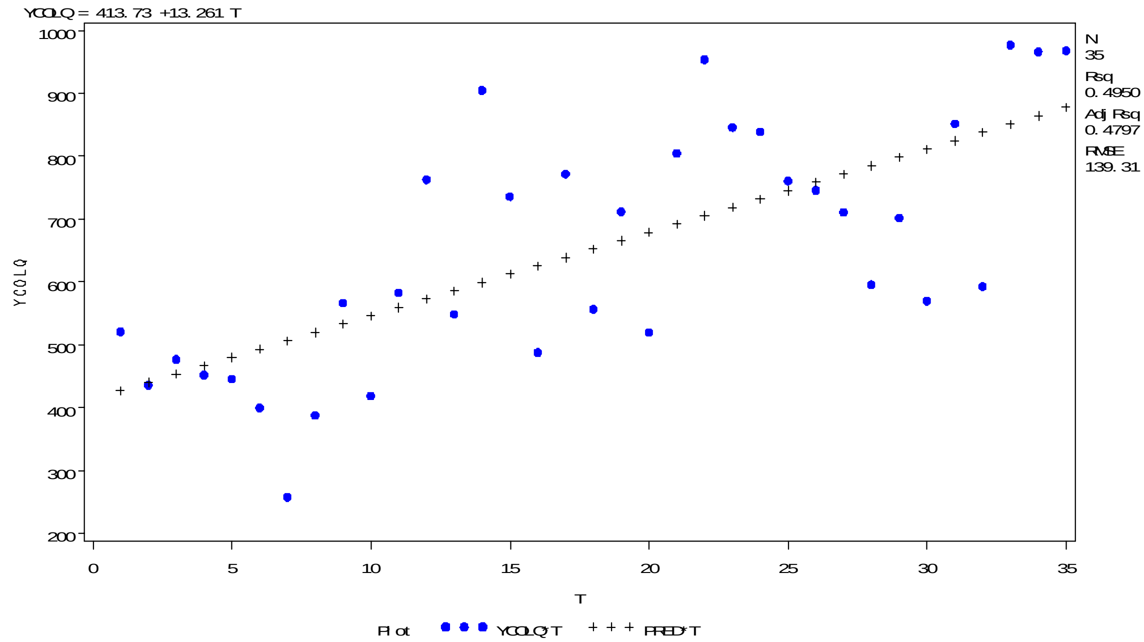


Figure 3.2 Brook County yields before and after detrended



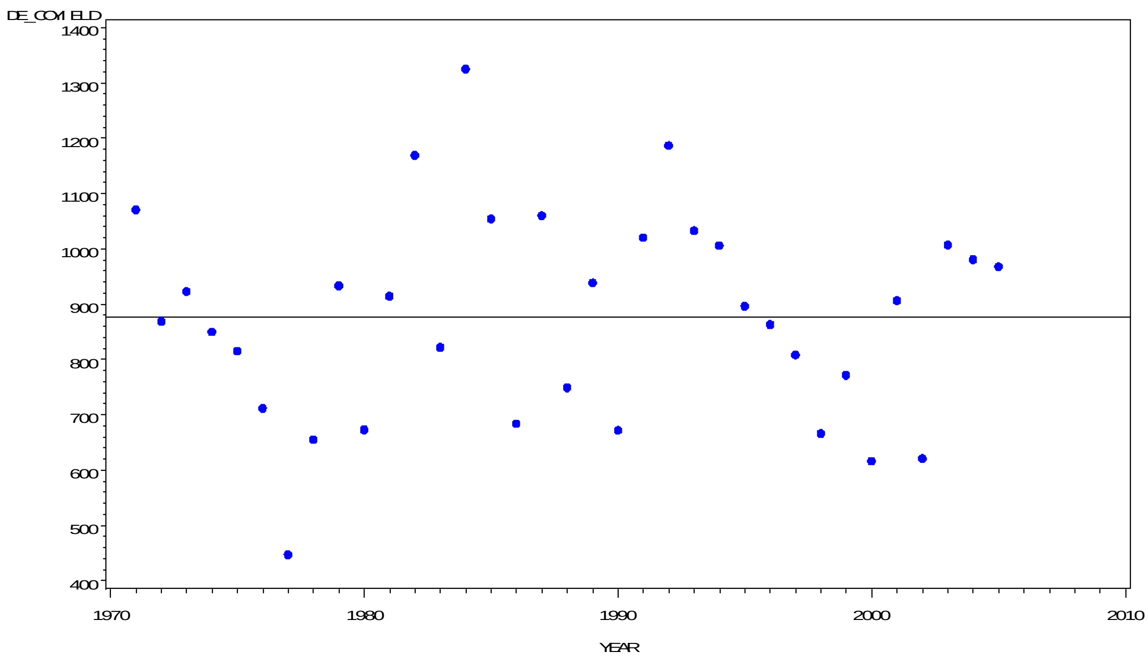


Figure 3.3 Colquitt County yields before and after detrended

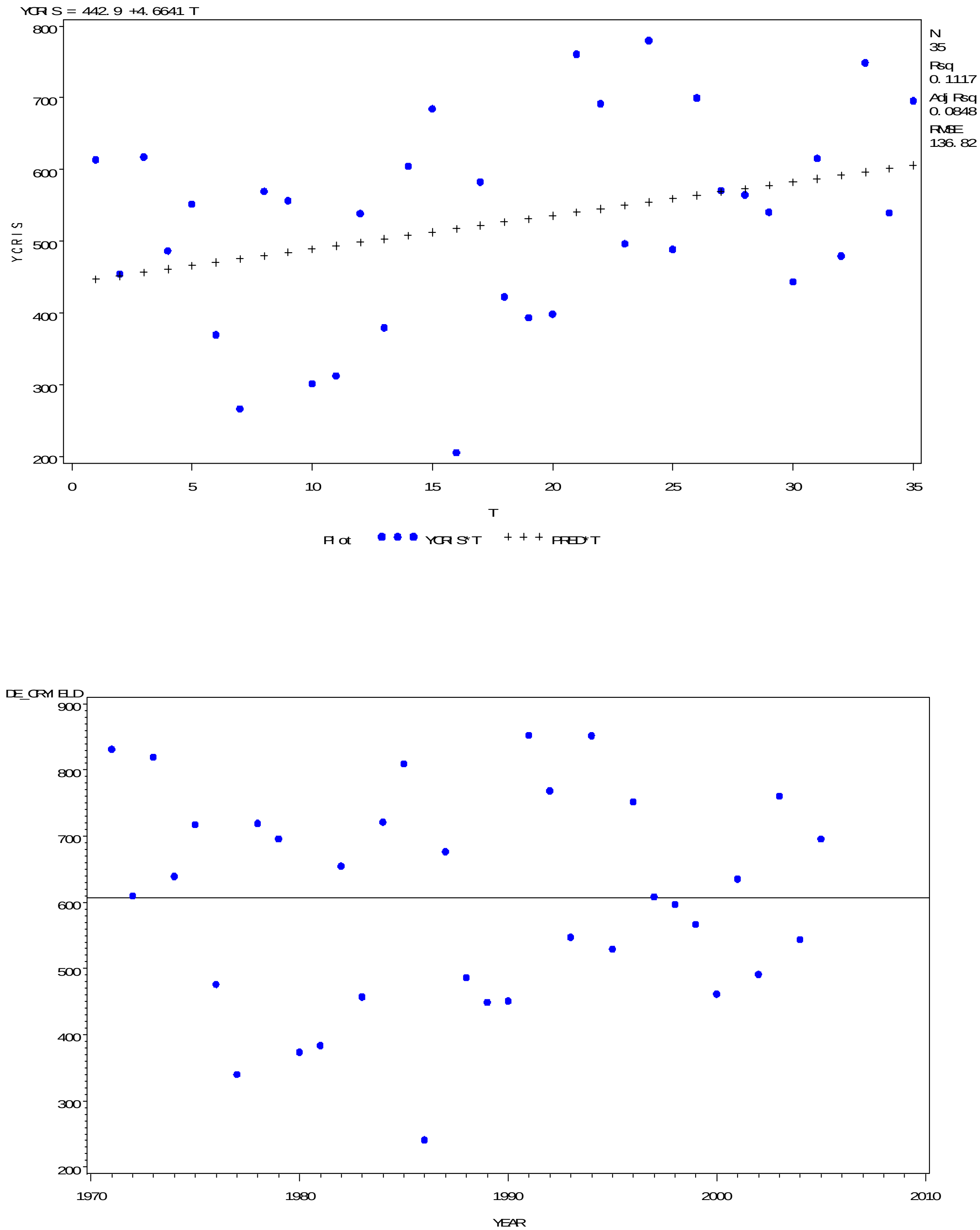


Figure 3.4 Crisp County yields before and after detrended

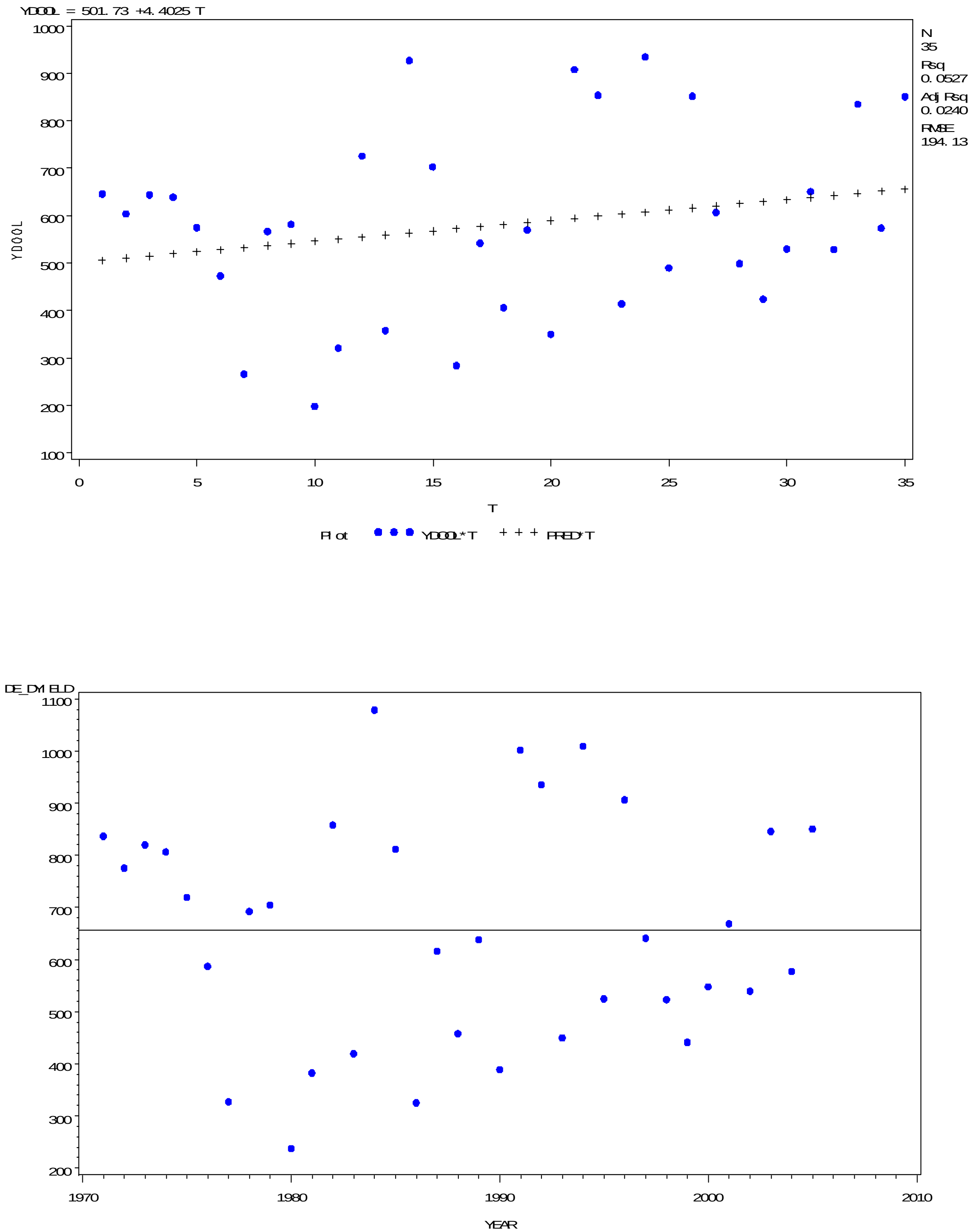
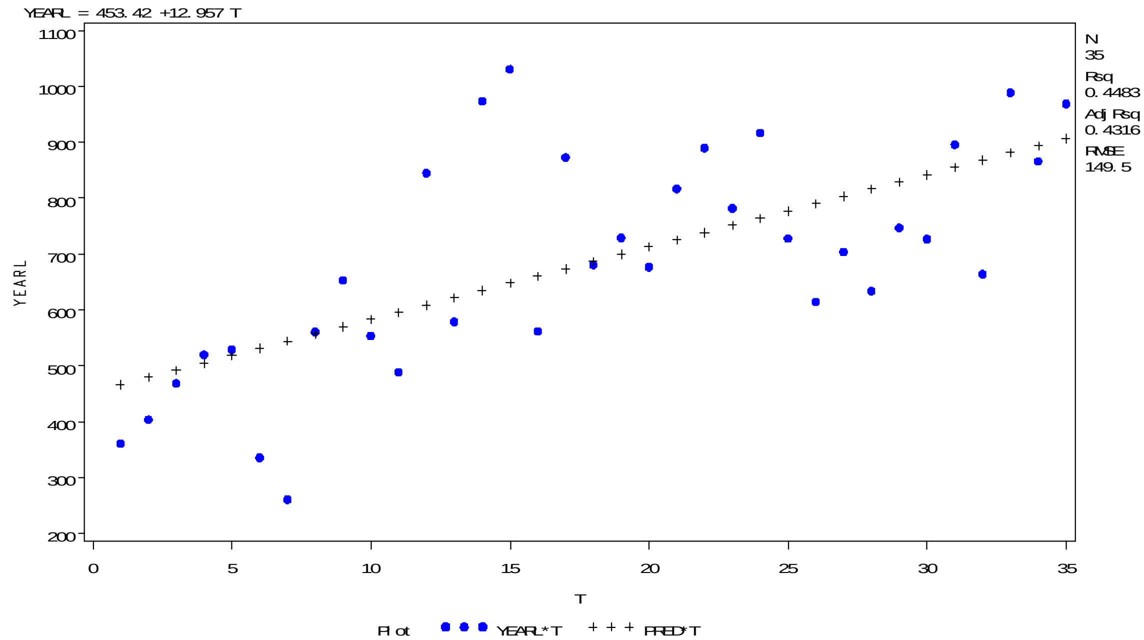


Figure 3.5 Dooly County yields before and after detrended



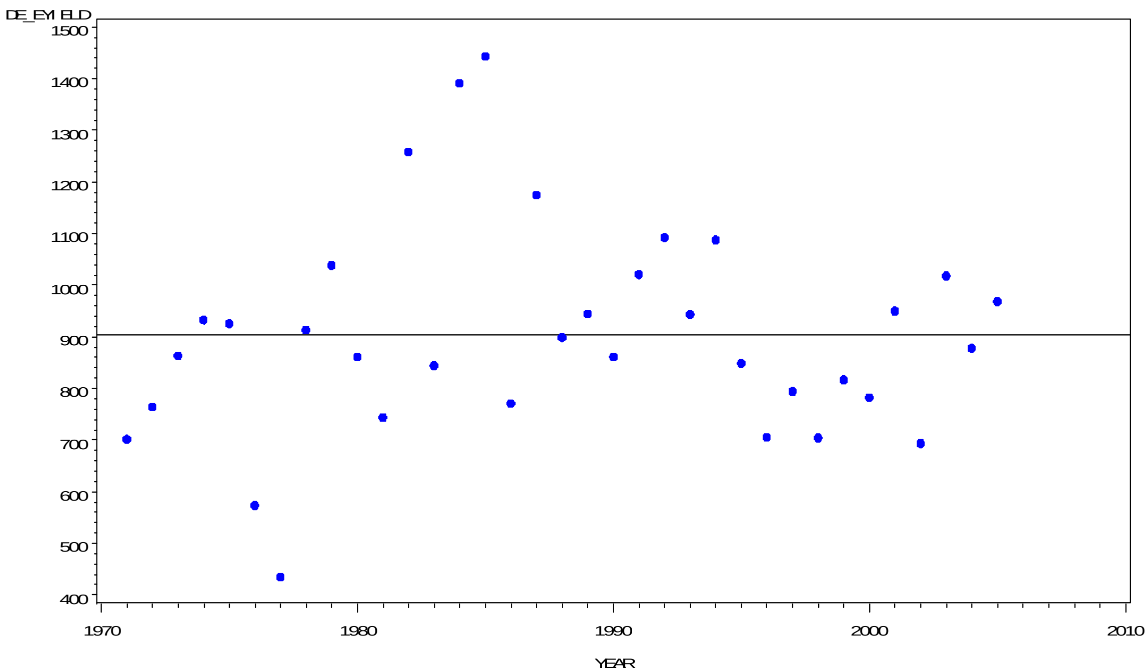
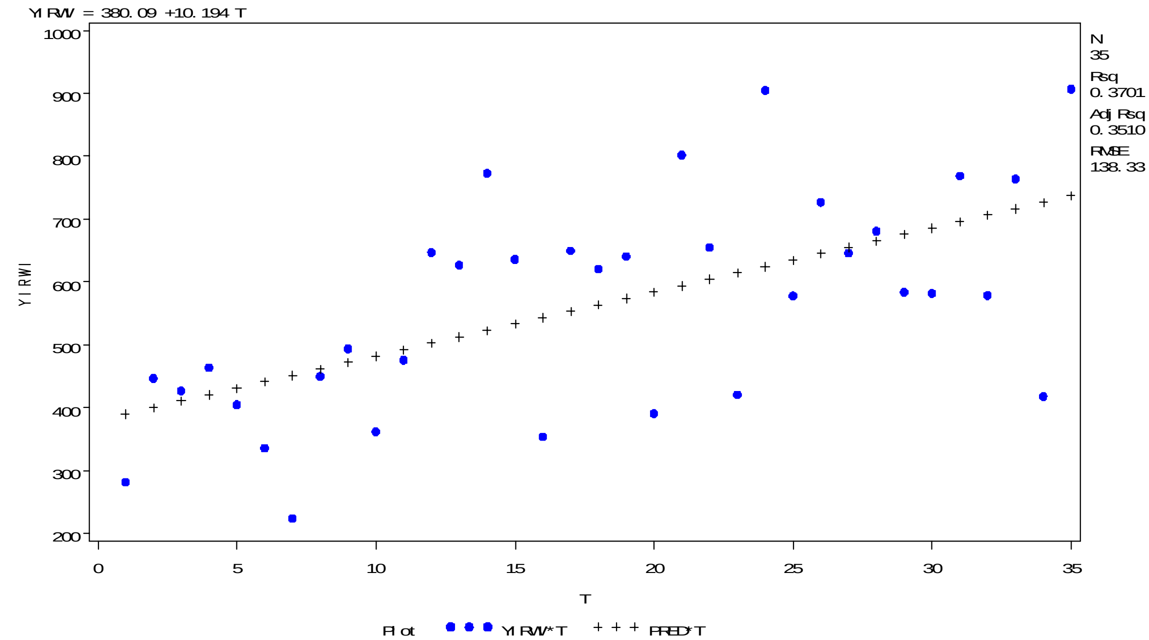


Figure 3.6 Early County yields before and after detrended



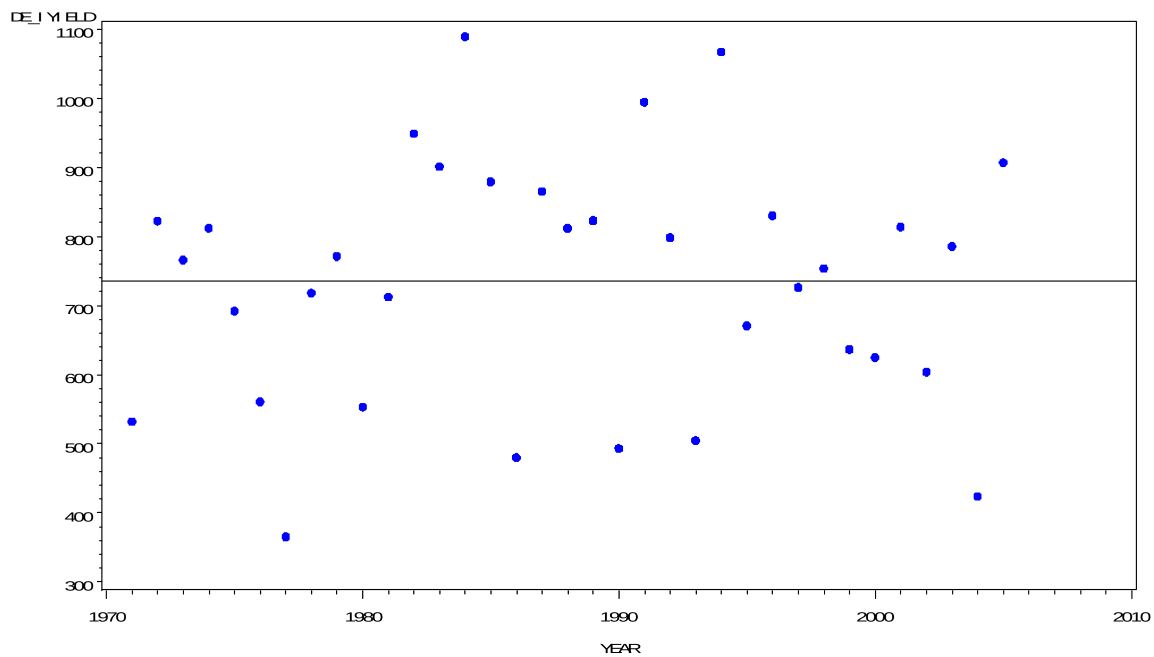
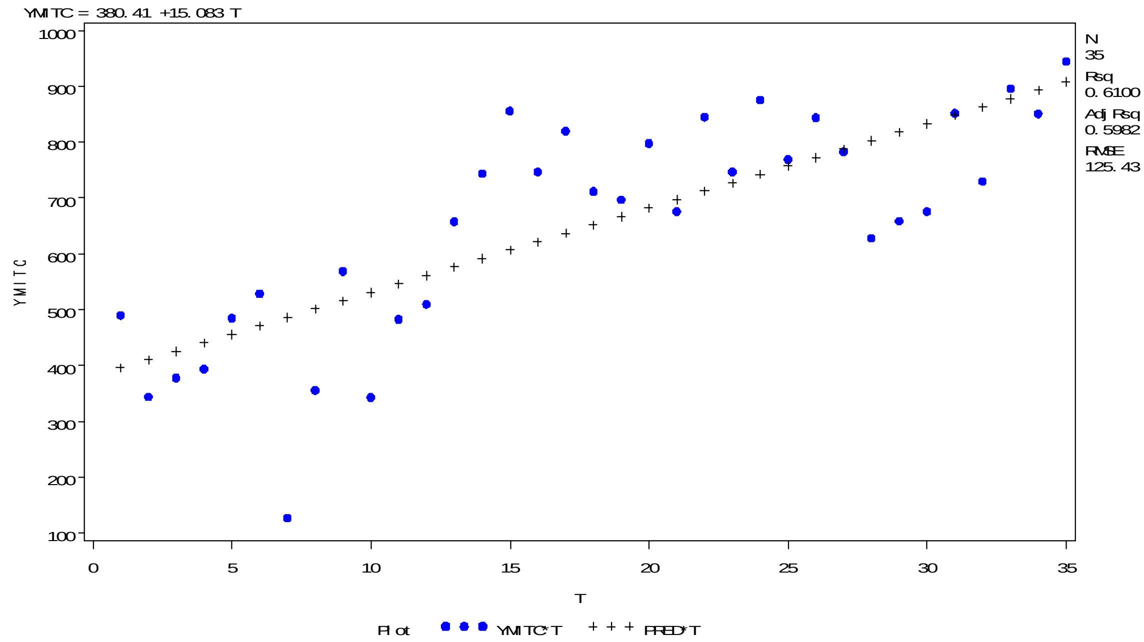


Figure 3.7 Irwin County yields before and after detrended



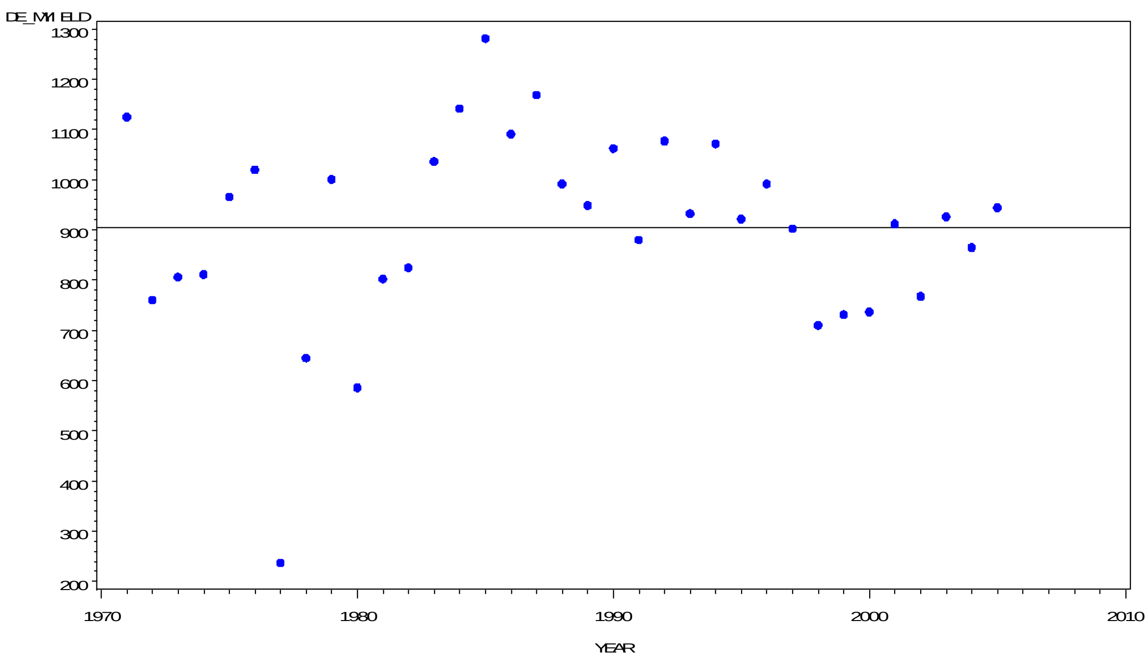
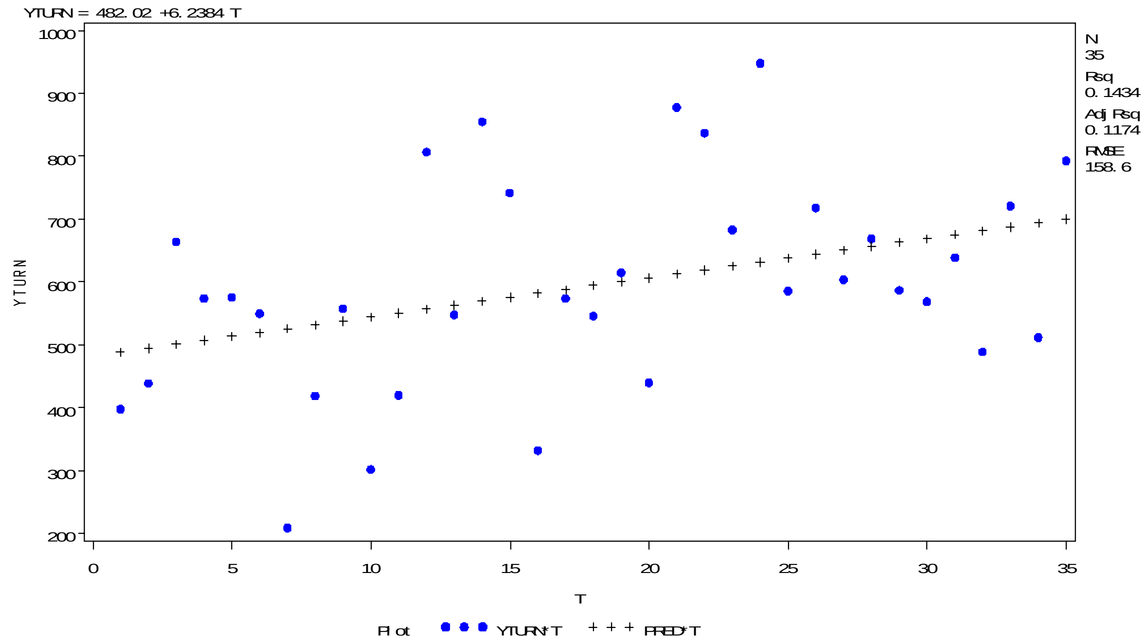


Figure 3.8 Mitchell County yields before and after detrended



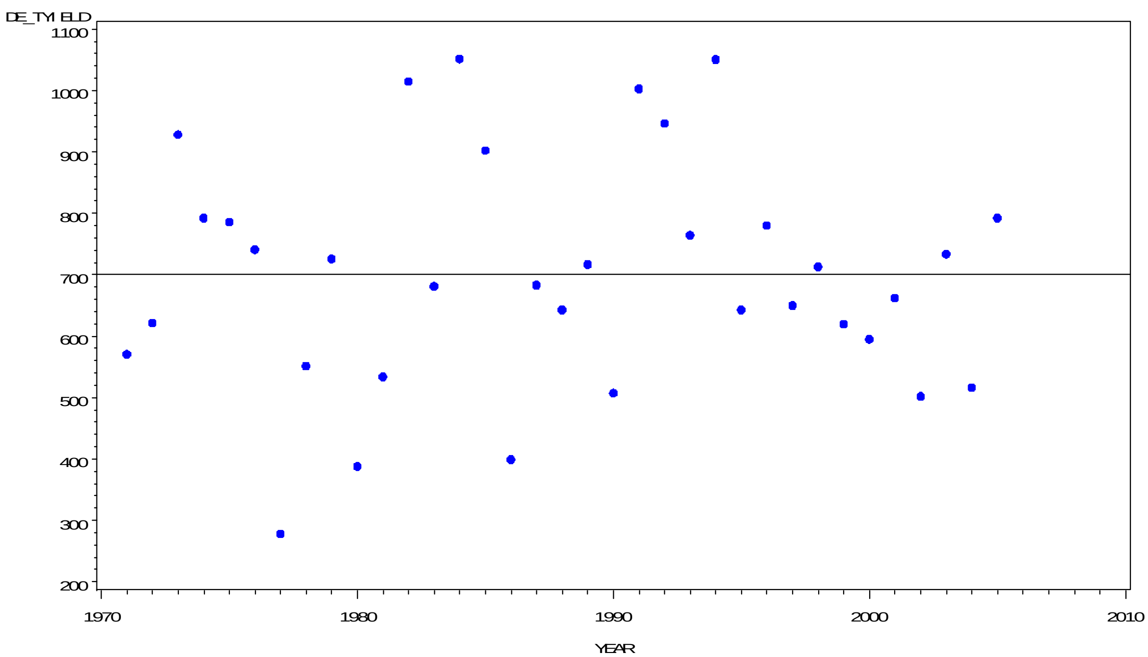
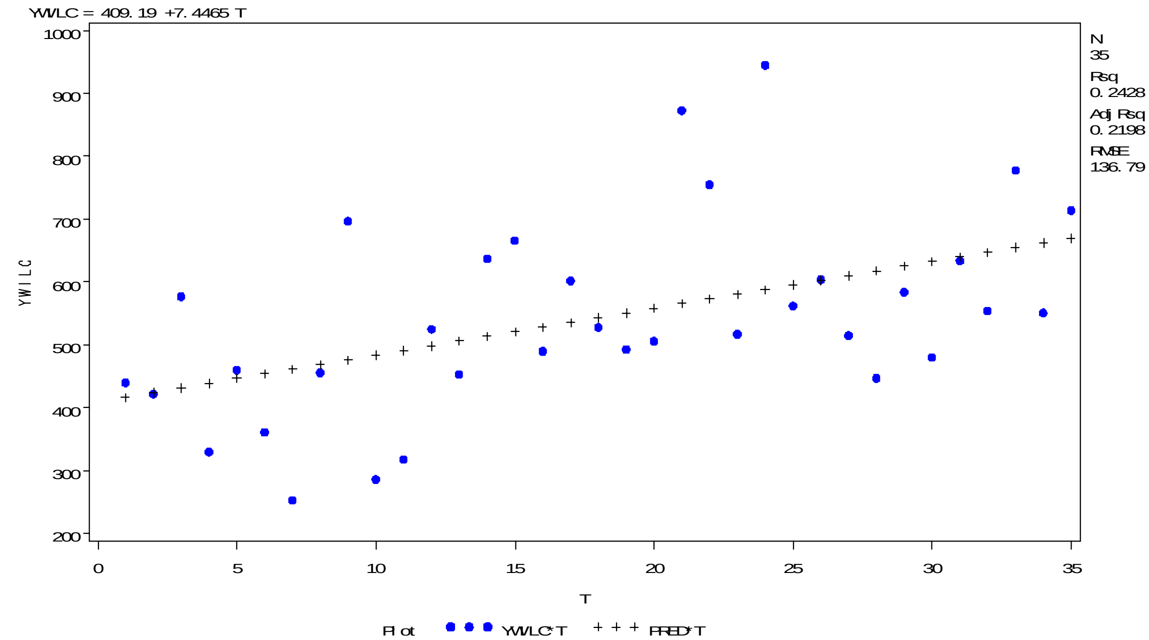


Figure 3.9 Turner County yields before and after detrended



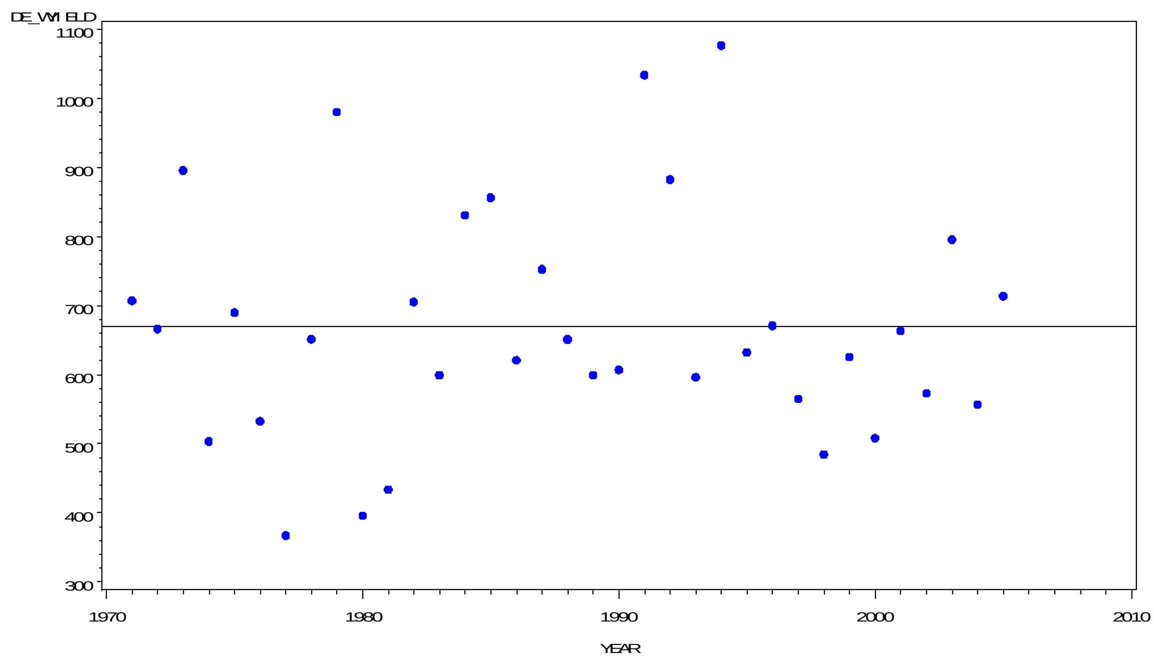
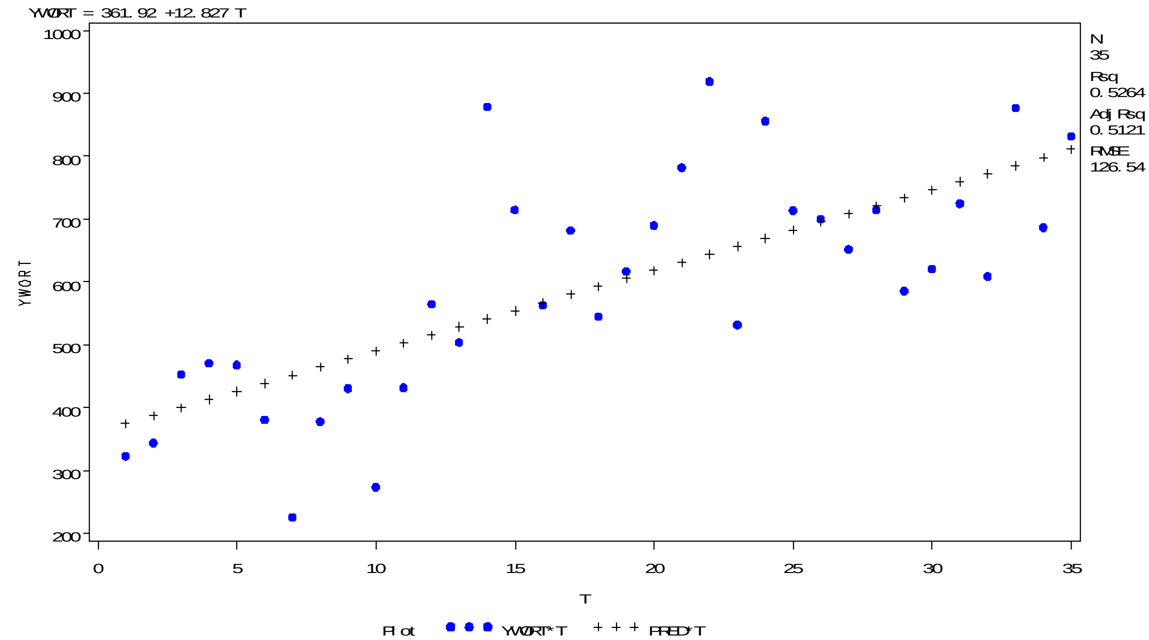


Figure 3.10 Wilcox County yields before and after detrended



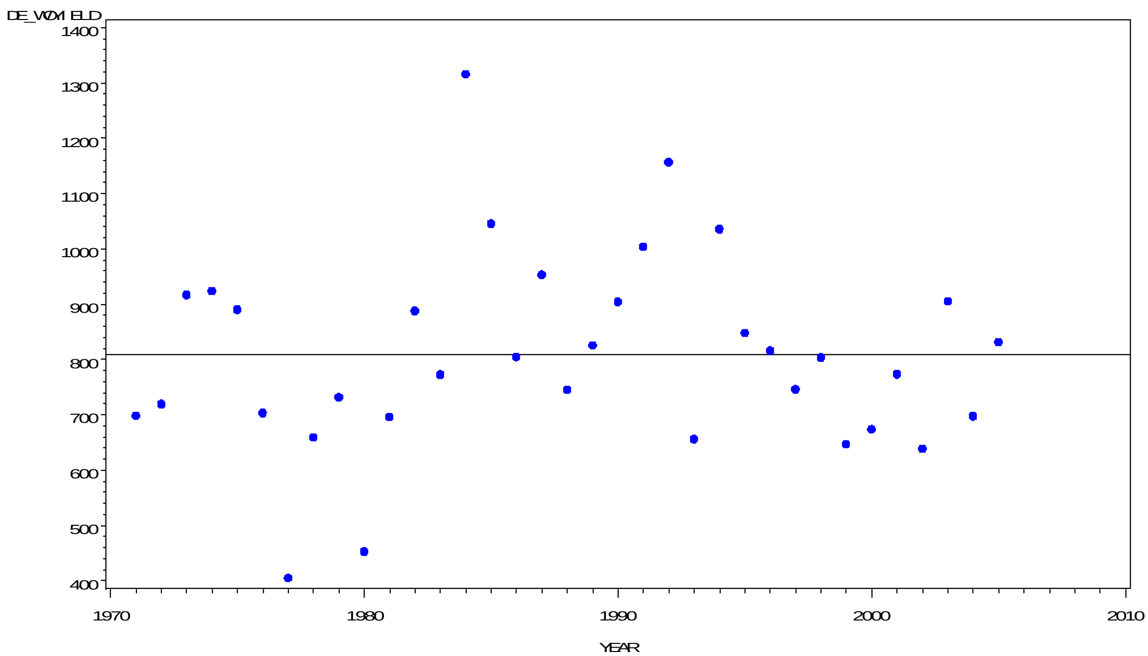


Figure 3.11 Worth County yields before and after detrended

CHAPTER 4

RESULTS AND CONCLUSIONS

The background of various current insurance products was introduced in Chapter 1. Then related literatures on farm-level and county-level insurance and the proposed combined insurance were reviewed in Chapter 2. The research methodology was presented in Chapter 3. Now in this chapter, the certainty equivalent revenues (CERs) for the thirteen scenarios introduced in Chapter 3 and the comparison of CERs are presented. These results will help to answer the questions proposed by this research and lead to the conclusions.

4.1 Results

Representative farm pseudo yields are generated from county yield and farm deviations that are derived from county yield (see equations 3.10 and 3.11). Table 4.1 presents Pearson's correlation coefficients between the simulated representative farm-level yield and county-level yield. In every county, the correlation is always small (between 0.3 and 0.6). The Dooly County has the lowest correlation coefficient (0.32986) among ten counties. This likely implies that GRP provides limited risk protection in this county.

The estimated joint kernel densities for pseudo farm yields and county-level yields are plotted in Figure 4.1-4.10. Since actual yields are not distributed only in the range which is simulated by the observed data, zero is set as the minimum yield for farm-level yield and 2100 (maximum pseudo farm yield is 2000) as the maximum farm-level yield for the joint kernel distribution. In addition, a number 5% lower than the observed minimum county-level yield is set as the minimum yield and a number 5% higher than the observed maximum county-level yield is set as the maximum for the joint kernel density function. After the kernel smoothing process, the joint kernel density becomes smooth and undulate.

The APH yield for each representative farm is set equal to the mean of the farm yield marginal density of the joint kernel density function. These numbers are used to determine the premium rates and the trigger yield for MPCI policy. Table 4.2 presents the APH yield which is integrated under the joint kernel density function by numerical methods.

Table 4.3 - table 4.5 show certainty equivalent revenues (CERs) for the expected utility of net revenues among different insurance products. The insurance choices are the MPCI alone (*coverage* level at 55%, 75% and 85%), the proposed combined insurance policy (*coverage* level for MPCI portion at 55%, 75% and 85%, and *coverage* level for GRP portion at 90%), GRP (*coverage* level at 90% with *scale* at 150% or 100%), and the MPCI (*coverage* level at 85%) with the additional inherent premium subsidy inherent in the GRP portion of the combined insurance policy.

At the levels of risk aversion considered, *no insurance* generates the lowest CERs in each representative farm. The CERs for any of the insurance choices are higher than the CER without insurance. This is not surprising since the premiums on the insurance products are subsidized. As would be expected, the difference between certainty equivalents with insurance and those without insurance increases as risk aversion increases. MPCI with higher coverage level has greater CERs than MPCI with lower coverage level. For the 90% coverage GRP policy, a scale of 150% is always preferred to a scale of 100% with the exception of Irwin County representative farm.

For the scenarios that the combined insurance is preferred to MPCI alone, the additional utility provided by the combined policy relative to the MPCI policy alone decreases as the MPCI coverage level increases. This result is consistent with Knight's (2006) findings that the lower the MPCI coverage, the larger the difference between the CERs for the combined insurance policy and those for the MPCI policy alone. When the underlying MPCI policy is at 85% coverage, the supplemental GRP policy generates only small increases in CERs. When the underlying MPCI policy is at 55% coverage, the supplemental GRP policy generates larger increases in CERs. The intuition behind this finding is that, the lower the MPCI coverage (higher the MPCI deductible), the greater the benefit of having a supplemental GRP policy that provides additional protection against yield losses.

When the coefficient of γ equal to 1 or 2 is considered, GRP with 90% coverage and 150% scale is preferred to either MPCI alone or the combined policy in Wilcox and Brooks Counties. Among the ten county representative farms, the combined policy is preferred to MPCI alone in 7 of the ten counties at any MPCI coverage level. The exceptions are Early, Crisp, and Dooly County representative farms. The 85% MPCI policy supplemented with the additional premium subsidy inherent in the GRP portion of the combined insurance policy is preferred to the 85% MPCI combined policy with the exception of Turner County. At this low level of risk aversion, the additional risk protection provided by the supplemental GRP policy does not generate much additional utility. This suggests that the combined insurance policy is generally preferred to an MPCI policy alone not because the GRP policy provides significant additional risk protection but rather because of the additional premium subsidy inherent in the supplemental GRP.

Table 4.5 presents the certainty equivalent revenues when γ is 4 among different insurance products. At any MPCI coverage level, the combined policy is preferred to MPCI alone in 8 of the ten representative farms. The exceptions are Early and Dooly Counties. The Crisp County representative farm is essentially indifferent between the combined policy and the MPCI policy alone. At the higher level of risk aversion, the 85% MPCI combined policy is now preferred to the 85% MPCI coverage supplemented with the additional premium subsidy inherent in the GRP policy in 7 of the ten counties. The exceptions are again Early, Crisp, and Dooly Counties. This indicates that highly risk-averse producers will value more highly the additional risk protection provided by the combined policy. The exceptions (Early, Crisp, and Dooly Counties) are cases where MPCI policy is preferred to the combined insurance. GRP with 90% coverage and 150% scale is preferred to either MPCI alone or the combination policy in Wilcox and Brooks counties even at the higher level of risk aversion. However, the difference in certainty equivalents between the GRP policy and the MPCI alone is smaller at the higher level of risk aversion.

Table 4.6 presents a comparison among 4 different combinations for the combined insurance with 75% MPCI coverage (GRP portion is set 90% *coverage* and 150% *scale*, 90% *coverage* and 125% *scale*, 80% *coverage* and 150% *scale*, and 70% *coverage* and 150% *scale*). For the combined policy with 75% MPCI coverage and 90% GRP coverage, 150% GRP scale is always preferred to 125% scale in each representative farm. For the 75% MPCI combined insurance, some of the representative farms always prefer GRP with 90% coverage (Early, Turner, and Crisp Counties) and some always prefer GRP with 80% coverage (Colquitt, Irwin, Mitchell, Worth, and Brooks Counties). Wilcox and Dooly Counties prefer 80% GRP coverage when γ equals to 1 or 2 and 90% GRP coverage when γ equals to 4. For the combined policy with 75% MPCI coverage and GRP with 70% coverage has lowest CERs in most representative farms at the levels of risk aversion used. The exceptions are Colquitt and Worth Counties when γ is 1, and Mitchell, Worth and Early Counties when γ is 4.

4.2 Conclusions

To help crop producers manage yield and price risk, the U.S. Federal Crop Insurance Program has offered various insurance products including farm-level and county-level yield and revenue insurance. The proposed combined insurance offers GRP coverage as a supplement to an underlying farm-level yield or revenue insurance. The maximum amount of GRP coverage equals to the deductible on the farm-level insurance multiplied by the GRP maximum protection. The combined insurance product is good for crop producers who want to protect against farm-level risk and insure extra coverage against county-level losses. The purpose of this proposed insurance is to enhance the set of available risk management tools.

This study compared MPCI, GRP, and the proposed insurance product. The comparison was conducted on representative cotton farms in 10 Georgia counties. The purpose of the analysis was to test whether the proposed insurance is a good alternative for Georgia cotton farmers and whether the supplemental GRP policy contained in the combined insurance product is worth the additional cost compared with a stand alone MPCI policy.

The results show that, given the assumed risk preference, any insurance purchasing choice is better than *no insurance*. MPCI with higher coverage level is always preferred to MPCI with lower coverage level. For the GRP policy with 90% coverage, a scale of 150% provides more risk protection than a scale of 100% for nine of the 10 representative farms.

For a given MPCI coverage level, the combined insurance product generates higher certainty equivalent revenues than the MPCI policy for seven of the 10 representative farms at lower level of risk aversion and for eight representative farms at higher level of risk aversion. For this reason, the proposed combined insurance product would likely have a promising market if it offered to Georgia cotton producers. In addition, the difference between the combined product certainty equivalent revenues and the MPCI certainty equivalent revenues is larger for lower levels of MPCI coverage. Thus, those who purchase lower levels of MPCI coverage would likely be most interested in the combined policy.

The results also show that MPCI with 85% coverage level supplemented with portion of GRP premium subsidy provides the greatest certainty equivalent revenue for 7 of the 10 representative farms at lower level of risk aversion. This suggests that while farmers with lower risk aversion would prefer the combined insurance policy to an MPCI policy alone, this preference is based more on being able to capture more premium subsidy from the supplemental GRP policy than any additional risk protection. However, at higher level of risk aversion, the 85% MPCI combined policy is preferred to the 85% MPCI coverage supplemented with the additional premium subsidy inherent in the GRP policy in 7 of the ten county representative farms. This suggests that farmers with higher risk aversion can obtain additional risk protection from the combined insurance rather than seeking more premium subsidy.

The comparison of different combined coverage and scale shows that for the combined insurance with the same MPCI coverage and the same GRP coverage, the higher scale level is preferred to the lower scale level. For the combined policy with 75% MPCI coverage, GRP with 70% coverage provides relatively lower risk protection compared with higher GRP coverage level. For a fixed MPCI coverage level, some county representative farms prefer a fixed GRP coverage for the combined insurance even though the measure of risk aversion varies. However, this preference in some counties would be different while the level of risk aversion changes.

4.3 Limitation and Further Research

One limitation is that this study uses a representative farm approach rather than a long-time series of data for actual farms. Pseudo farm yields are generated based on actual short-term (6 to 10 years) of the farm-level yield data and county yield. Yield distributions are simulated by using these pseudo farm-level yield and county-level yield. It is unclear how consistent and robust the findings would be across the simulated data sources and alternative simulating procedures.

Basis risk is an inherent problem for GRP and it can not be eliminated. The basis will be different from year to year even in a same county. Any study on GRP needs to be done on a specific commodity and a specific region. This study only investigated the proposed insurance for 10 Georgia cotton representative farms. Further research on this subject should investigate the feasibility of the proposed combined insurance for other crops and regions.

The results show that the combined insurance offering GRP coverage as a supplement to an underlying MPCI policy is preferred to the MPCI policy only. Further research is needed to study whether a combination of MPCI coverage as a supplement to an underlying county-level insurance is preferable. Revenue insurance combinations could be considered to provide more choices for insurance purchasers. Revenue insurance combination may offer county-level revenue coverage (GRIP) as a supplement to an underlying farm-level revenue insurance policy (IP or RA).

Table 4.1 Pearson Correlation Coefficients between Farm-level and County-Level Yield

County	Pearson Correlation
Brooks	0.42306
Colquitt	0.58376
Crisp	0.46650
Dooly	0.32986
Early	0.48839
Irwin	0.57759
Mitchell	0.50280
Turner	0.56568
Wilcox	0.49886
Worth	0.51658

Table 4.2 APH Yield for the Representative Farm in a Given County

County	APH yield for representative farm
Brooks	709.7838287
Colquitt	874.9383507
Crisp	606.9616855
Dooly	616.7188410
Early	925.0540160
Irwin	789.4077643
Mitchell	931.1074373
Turner	667.1724511
Wilcox	730.1433136
Worth	871.1568805

Table 4.3 Representative Farm Certainty Equivalent Revenues (r =1)

County where Representative Farm in Located	No Insurance	MPCI 55% Coverage	MPCI 75% Coverage	MPCI 85% Coverage	Combined Policy with 55% MPCI Coverage and GRP with 90% Coverage and 150% Scale	Combined Policy with 75% MPCI Coverage and GRP with 90% Coverage and 150% Scale	Combined Policy with 85% MPCI Coverage and GRP with 90% Coverage and 150% Scale	GRP with 90% Coverage and 150% Scale	GRP with 90% Coverage and 100% Scale	85% MPCI Coverage and part of GRP Premium Subsidy
Colquitt	422.743	447.258	461.364	475.363	460.904	468.552	477.08	473.236	449.653	485.638
Irwin	501.22	526.983	550.278	571.37	546.342	566.603	580.006	519.688	523.404	587.15
Mitchell	419.847	468.997	489.97	505.233	486.509	501.882	507.469	491.327	438.583	517.084
Wilcox	323.489	350.374	368.346	380.467	378.872	384.822	388.118	410.739	399.005	397.863
Worth	412.428	430.002	445.78	465.388	450.036	453.074	470.336	427.362	412.772	477.351
Early	339.473	464.628	489.602	508.742	457.938	474.69	478.906	384.753	369.653	511.026
Turner	295.491	324.29	341.007	349.947	353.409	359.528	365.563	354.773	321.607	360.637
Crisp	227.647	311.832	328.537	345.095	298.394	312.007	322.77	273.48	243.448	347.673
Dooly	252.66	289.633	312.275	331.215	269.733	289.75	301.254	263.764	259.735	333.089
Brooks	342.445	378.304	383.755	400.003	396.608	399.536	407.845	439.78	422.676	417.796

Table 4.4 Representative Farm Certainty Equivalent Revenues (*r* =2)

County where Representative Farm in Located	No Insurance	MPCI 55% Coverage	MPCI 75% Coverage	MPCI 85% Coverage	Combined Policy with 55% MPCI Coverage and GRP with 90% Coverage and 150% Scale	Combined Policy with 75% MPCI Coverage and GRP with 90% Coverage and 150% Scale	Combined Policy with 85% MPCI Coverage and GRP with 90% Coverage and 150% Scale	GRP with 90% Coverage and 150% Scale	GRP with 90% Coverage and 100% Scale	85% MPCI Coverage and part of GRP Premium Subsidy
Colquitt	384.512	425.459	446.468	465.398	443.148	456.789	470.588	455.653	439.429	475.672
Irwin	464.706	503.778	536.653	563.73	531.143	546.022	575.108	511.454	517.776	579.51
Mitchell	376.605	444.662	473.373	496.796	471.548	490.774	503.443	473.214	438.442	508.647
Wilcox	286.041	328.591	351.791	370.804	362.738	372.324	383.879	403.739	389.895	388.225
Worth	370.989	407.232	430.126	454.773	433.276	442.682	463.388	411.342	402.675	466.736
Early	281.175	447.788	472.836	496.352	441.429	460.879	470.477	319.675	302.767	498.635
Turner	269.716	299.985	321.275	340.067	338.207	348.938	360.012	337.766	312.006	350.757
Crisp	159.992	293.772	316.166	334.247	278.879	299.098	316.003	256.387	192.266	336.824
Dooly	203.666	274.085	301.159	319.183	251.776	277.005	294.898	236.758	213.453	321.057
Brooks	290.808	355.025	368.854	388.108	379.776	387.247	401.24	421.378	408.988	405.901

Table 4.5 Representative Farm Certainty Equivalent Revenues (r =4)

County where Representative Farm in Located	No Insurance	MPCI 55% Coverage	MPCI 75% Coverage	MPCI 85% Coverage	Combined Policy with 55% MPCI Coverage and GRP with 90% Coverage and 150% Scale	Combined Policy with 75% MPCI Coverage and GRP with 90% Coverage and 150% Scale	Combined Policy with 85% MPCI Coverage and GRP with 90% Coverage and 150% Scale	GRP with 90% Coverage and 150% Scale	GRP with 90% Coverage and 100% Scale	85% MPCI Coverage and part of GRP Premium Subsidy
Colquitt	310.465	393.902	424.893	449.021	419.985	439.841	461.782	427.374	418.48	459.294
Irwin	393.377	470.211	529.009	549.884	512.73	541.349	566.44	483.003	491.773	565.665
Mitchell	305.309	412.693	450.783	481.23	451.836	471.773	495.842	444.837	417.364	493.081
Wilcox	205.867	299.884	329.803	351.349	339.006	353.892	368.978	373.729	348.388	368.746
Worth	310.359	375.92	405.939	435.883	412.684	423.893	451.483	383.498	380.342	447.845
Early	211.885	421.734	451.005	479.405	417.093	441.281	456.981	289.372	282.455	481.689
Turner	197.542	267.899	299.482	322.402	316.976	329.227	345.729	310.387	291.834	333.093
Crisp	91.797	247.763	275.034	308.947	247.329	275.834	309.091	227.894	171.443	311.525
Dooly	138.65	246.708	279.376	303.729	232.755	259.492	281.003	209.753	201.436	305.602
Brooks	221.859	324.216	349.793	372.725	367.982	379.827	391.839	392.933	389.428	390.518

Table 4.4 Certainty Equivalent Revenues for different combinations

	r = 1				*r* = 2				*r* = 4			
County where Representative Farm in Located	Combined Policy with 75% MPCI Coverage and GRP with 90% Coverage and 150% Scale	Combined Policy with 75% MPCI Coverage and GRP 90% Coverage and 125% Scale	Combined Policy with 75% MPCI Coverage and GRP 80% Coverage and 150% Scale	Combined Policy with 75% MPCI Coverage and GRP 70% Coverage and 150% Scale	Combined Policy with 75% MPCI Coverage and GRP with 90% Coverage and 150% Scale	Combined Policy with 75% MPCI Coverage and GRP 90% Coverage and 125% Scale	Combined Policy with 75% MPCI Coverage and GRP 80% Coverage and 150% Scale	Combined Policy with 75% MPCI Coverage and GRP 70% Coverage and 150% Scale	Combined Policy with 75% MPCI Coverage and GRP with 90% Coverage and 150% Scale	Combined Policy with 75% MPCI Coverage and GRP 90% Coverage and 125% Scale	Combined Policy with 75% MPCI Coverage and GRP 80% Coverage and 150% Scale	Combined Policy with 75% MPCI Coverage and GRP 70% Coverage and 150% Scale
Colquitt	468.552	462.339	473.834	462.983	456.789	447.428	467.443	446.439	439.841	439.392	442.383	438.684
Irwin	566.603	567.493	569.332	557.78	546.022	547.983	547.78	536.849	541.349	542.789	552.02	530.342
Mitchell	501.882	490.486	504.345	486.979	490.774	481.738	496.037	479.384	471.773	462.33	482.394	467.329
Wilcox	384.822	383.004	388.031	379.943	372.324	368.985	372.484	361.77	353.892	350.029	352.992	348.342
Worth	453.074	451.081	456.584	451.382	442.682	440.53	451.893	432.983	423.893	420.328	437.359	421.377
Early	474.69	469.768	468.392	463.818	460.879	453.894	453.772	450.475	441.281	427.192	436.43	428.043
Turner	359.528	357.784	357.925	353.032	348.938	338.548	339.294	335.329	329.227	321.865	324.094	319.34
Crisp	312.007	309.472	307.024	303.98	299.098	294.471	295.006	292.322	275.834	267.801	266.717	265.318
Dooly	289.75	288.574	293.339	279.382	277.005	275.048	279.873	274.366	259.492	249.584	258.399	243.366
Brooks	399.536	396.361	401.056	392.591	387.247	381.439	386.832	376.003	379.827	371.287	379.982	363.498

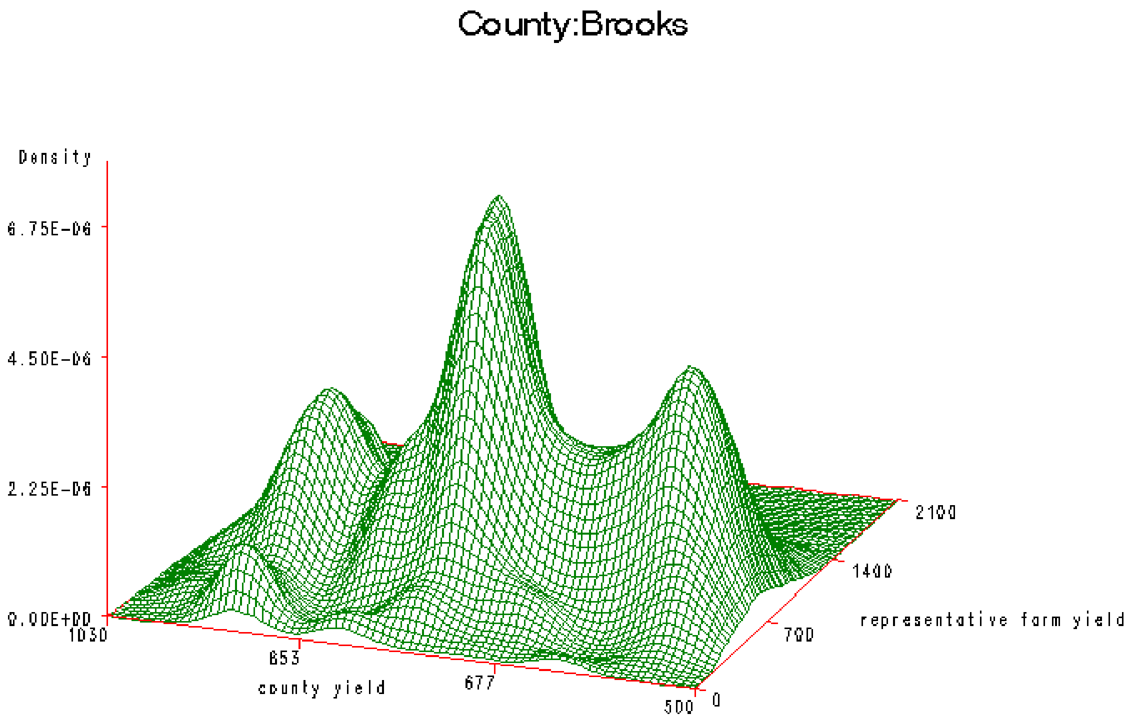


Figure 4.1 Estimated joint kernel distribution in Brooks

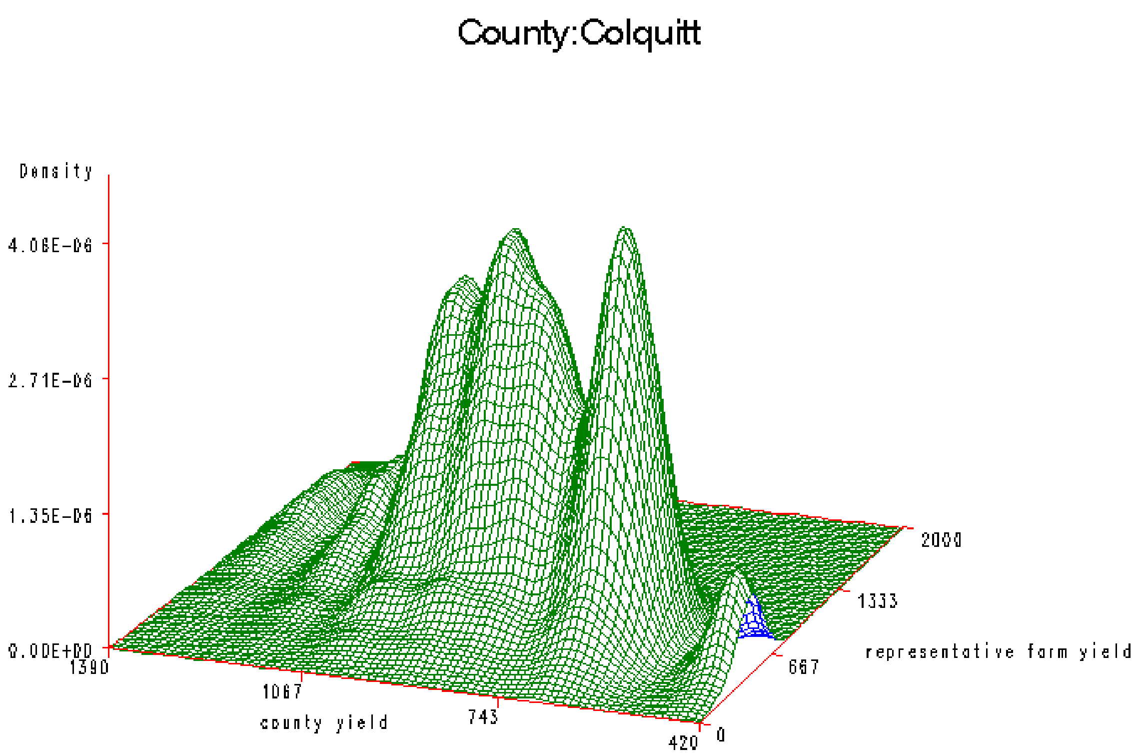


Figure 4.2 Estimated joint kernel distribution in Colquitt

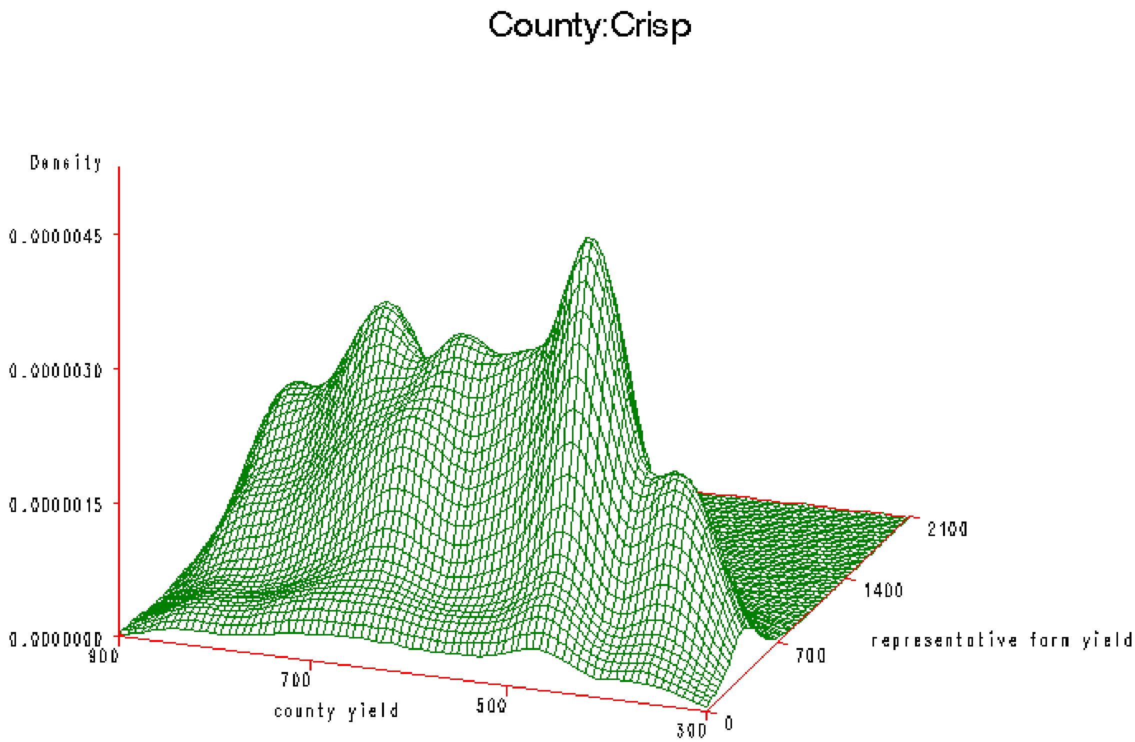


Figure 4.3 Estimated joint kernel distribution in Crisp

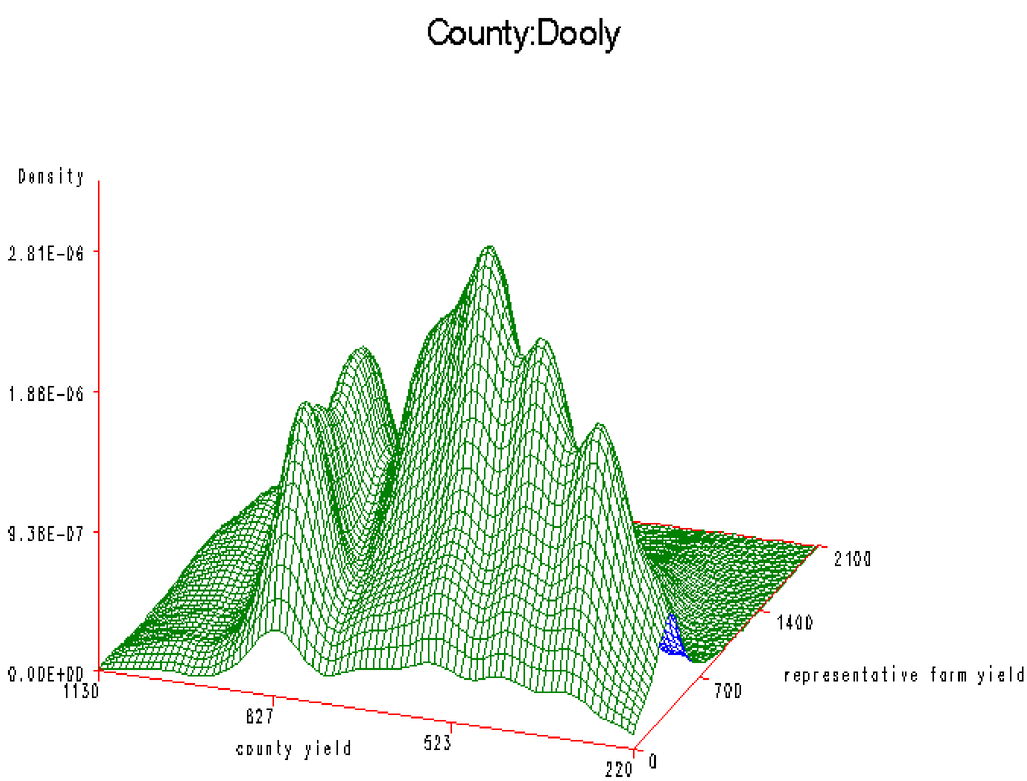


Figure 4.4 Estimated joint kernel distribution in Dooly

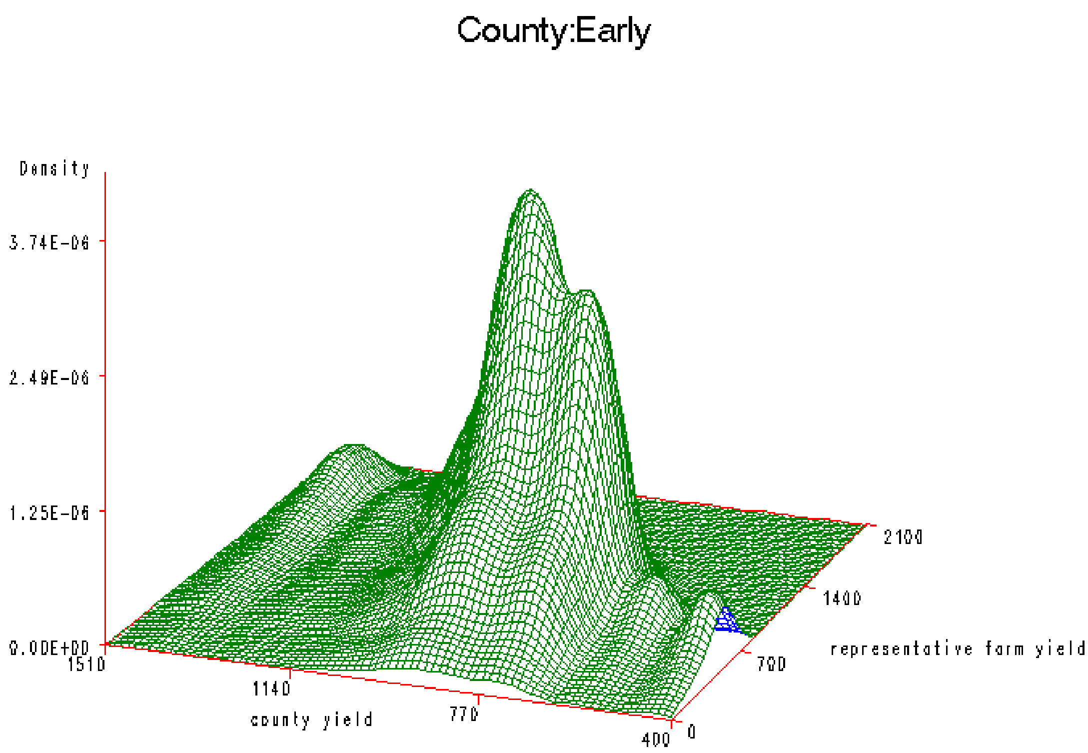


Figure 4.5 Estimated joint kernel distribution in Early

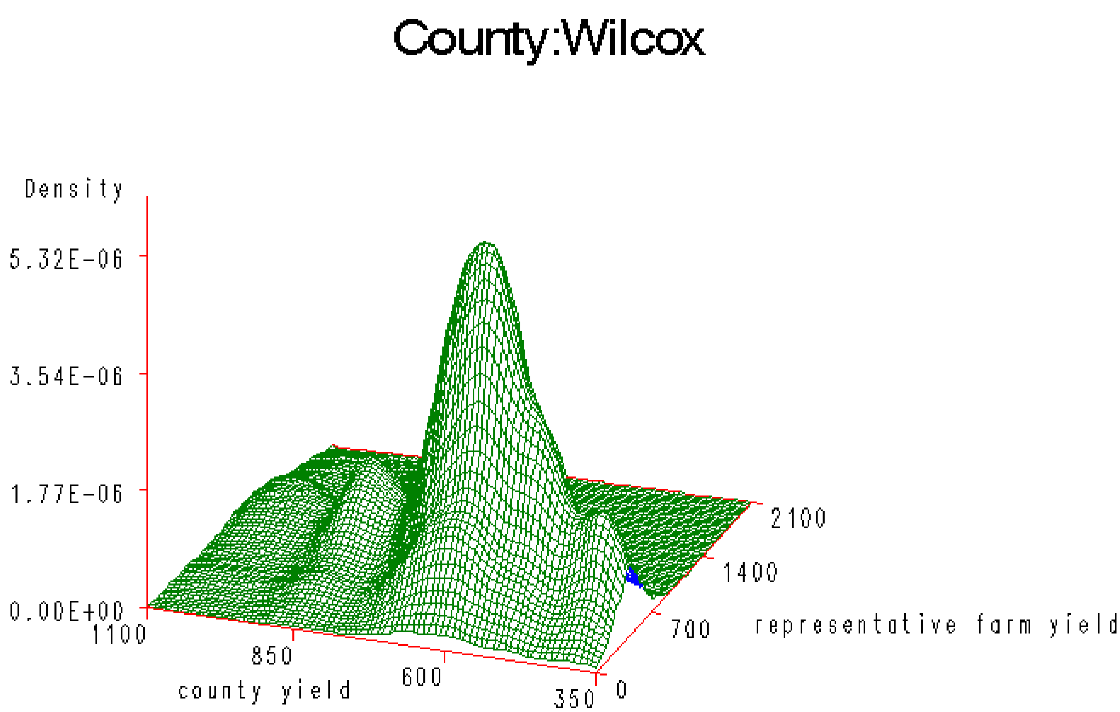


Figure 4.6 Estimated joint kernel distribution in Wilcox

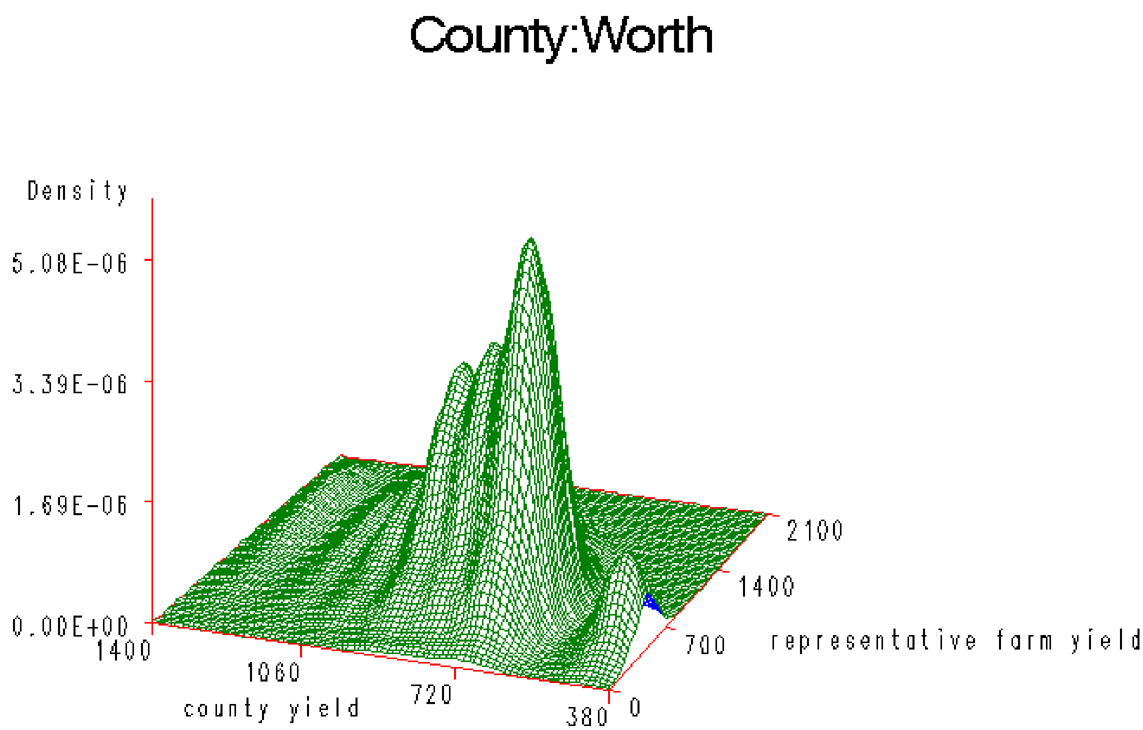


Figure 4.7 Estimated joint kernel distribution in Worth

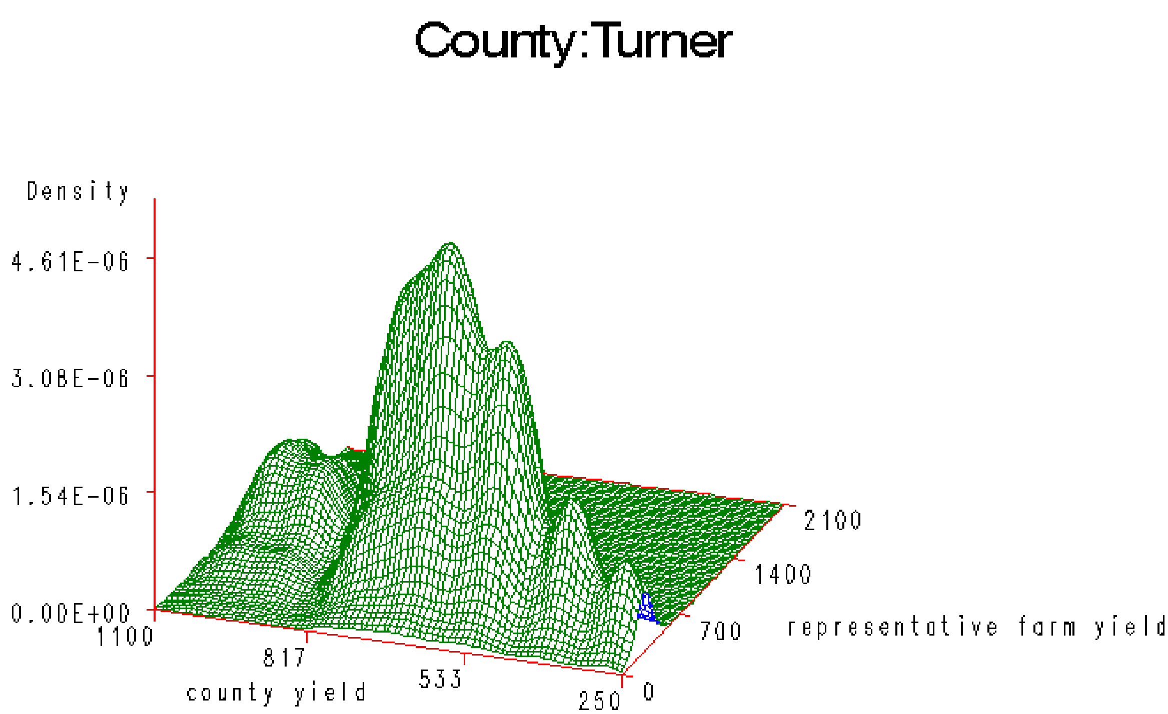


Figure 4.8 Estimated joint kernel distribution in Turner

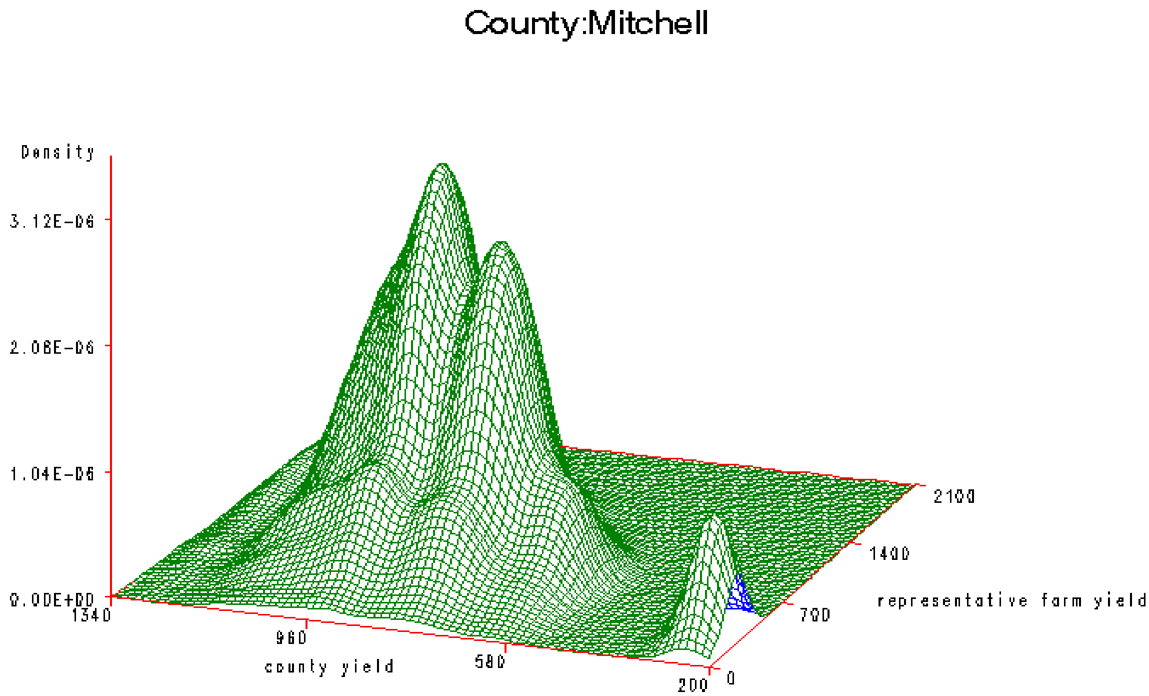


Figure 4.9 Estimated joint kernel distribution in Mitchell

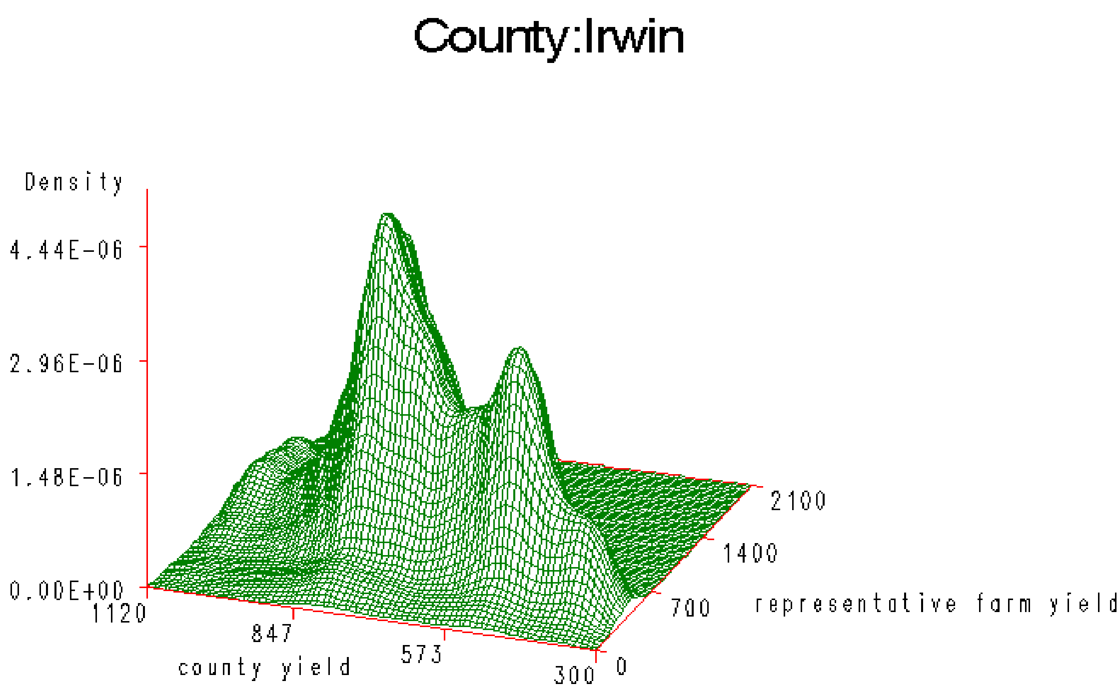


Figure 4.10 Estimated joint kernel distribution in Irwin

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APPENDICES

A. Georgia County Map

B. SAS Code (Simulating Pseudo Farm Yield)

```
proc iml;
use work.county2;
 read all var{year CoFips yield}  where(CoFips=27) into A;
 nm={year CoFips yearl} ;
 i=A[,1]-1970;
 B=A||i;
create one var{ year cofips ybroo t};
append from B;

data two;
 set one;
run;
Proc Reg ;
  model ybroo  = t;
  plot ybroo*t  p.   * t = '# '  / overlay;
  output out=final p=yhat r=resid;
run;
proc print data=final;
run;

proc iml;
use final;
read all into D;
E=D[,1]||D[,3]||D[,5];
print E;
X=E[,2]/E[,3];       /* annual yield devided by yield hat*/
PRINT X;
a=E[35,3];
print a;
Y=a*X;              /*combine annual yield and result of X*/
print Y;
Z=Y||E[,1:2];
print Z;
create out var{de_byield  year yield};;
append from Z;
run;

data detrend;
set work.out;
proc print;run;
proc means data=detrend;
var de_byield;
run;
proc gplot data=detrend;
      plot de_byield*year ;
run;
```

```
proc iml;
use work.out;
use work.clean80;
 read all var{Cnty any91 any92 any93 any94 any95 any96 any97 any98
any99 any00}  where(Cnty=27) into F;

 use work.county1;
 read all var{year CoFips yield}  where(CoFips=27) into G;
 nm={year CoFips yield};

N=nrow(F);print N;
ones = j(N,10,1);
AA=F||ones;
nm={Cnty any91 any92 any93 any94 any95 any96 any97 any98 any99 any00
cty91 cty92 cty93 cty94 cty95 cty96 cty97 cty98 cty99 cty00};
AA[,12]=G[1,3];
AA[,13]=G[2,3];
AA[,14]=G[3,3];
AA[,15]=G[4,3];
AA[,16]=G[5,3];
AA[,17]=G[6,3];
AA[,18]=G[7,3];
AA[,19]=G[8,3];
AA[,20]=G[9,3];
AA[,21]=G[10,3];

ones=j(N,10,1);
AAA=AA||ones;
AAA[,22]=AAA[,2]/AAA[,12];
AAA[,23]=AAA[,3]/AAA[,13];
AAA[,24]=AAA[,4]/AAA[,14];
AAA[,25]=AAA[,5]/AAA[,15];
AAA[,26]=AAA[,6]/AAA[,16];
AAA[,27]=AAA[,7]/AAA[,17];
AAA[,28]=AAA[,8]/AAA[,18];
AAA[,29]=AAA[,9]/AAA[,19];
AAA[,30]=AAA[,10]/AAA[,20];
AAA[,31]=AAA[,11]/AAA[,21];
a=AAA[,22];
b=AAA[,23];
c=AAA[,24];
d=AAA[,25];
e=AAA[,26];
f=AAA[,27];
g=AAA[,28];
h=AAA[,29];
i=AAA[,30];
j=AAA[,31];
W=a||b||c||d||e||f||g||h||i||j;

use work.out;
 read all var {de_dyield  year yield} into Z;
```

```
a1=W[1,]; bb=Z[,1];
aa1=a1@bb; a2=W[2,];
aa2=a2@bb; a3=W[3,];
aa3=a3@bb; a4=W[4,];
aa4=a4@bb; a5=W[5,];
aa5=a5@bb; a6=W[6,];
aa6=a6@bb; a7=W[7,];
aa7=a7@bb; a8=W[8,];
aa8=a8@bb; a9=W[9,];
aa9=a9@bb; a10=W[10,];
aa10=a10@bb; a11=W[11,];
aa11=a11@bb; a12=W[12,];
aa12=a12@bb; a13=W[13,];
aa13=a13@bb; a14=W[14,];
aa14=a14@bb; a15=W[15,];
aa15=a15@bb; a16=W[16,];
aa16=a16@bb; a17=W[17,];
aa17=a17@bb; a18=W[18,];
aa18=a18@bb; a19=W[19,];
aa19=a19@bb; a20=W[20,];
aa20=a20@bb; a21=W[21,];
aa21=a21@bb; a22=W[22,];
aa22=a22@bb; a23=W[23,];
aa23=a23@bb; a24=W[24,];
aa24=a24@bb; a25=W[25,];
aa25=a25@bb; a26=W[26,];
aa26=a26@bb; a27=W[27,];
aa27=a27@bb; a28=W[28,];
aa28=a28@bb; a29=W[29,];
aa29=a29@bb; a30=W[30,];
aa30=a30@bb; a31=W[31,];
aa31=a31@bb; a32=W[32,];
aa32=a32@bb; a33=W[33,];
aa33=a33@bb; a34=W[34,];
aa34=a34@bb; a35=W[35,];
aa35=a35@bb; a36=W[36,];
aa36=a36@bb; a37=W[37,];
aa37=a37@bb; a38=W[38,];
aa38=a38@bb; a39=W[39,];
aa39=a39@bb; a40=W[40,];
aa40=a40@bb; a41=W[41,];
aa41=a41@bb; a42=W[42,];
aa42=a42@bb; a43=W[43,];
aa43=a43@bb; a44=W[44,];
aa44=a44@bb; a45=W[45,];
aa45=a45@bb; a46=W[46,];
aa46=a46@bb; a47=W[47,];
aa47=a47@bb; a48=W[48,];
aa48=a48@bb; a49=W[49,];
aa49=a49@bb; a50=W[50,];
aa50=a50@bb; a51=W[51,];
aa51=a51@bb; a52=W[52,];
```

```
 aa52=a52@bb; a53=W[53,];
 aa53=a53@bb; a54=W[54,];
 aa54=a54@bb; a55=W[55,];
 aa55=a55@bb; a56=W[56,];
 aa56=a56@bb; a57=W[57,];
 aa57=a57@bb; a58=W[58,];
 aa58=a58@bb; a59=W[59,];
 aa59=a59@bb; a60=W[60,];
 aa60=a60@bb; a61=W[61,];
 aa61=a61@bb; a62=W[62,];
 aa62=a62@bb; a63=W[63,];
 aa63=a63@bb; a64=W[64,];
 aa64=a64@bb; a65=W[65,];
 aa65=a65@bb; a66=W[66,];
 aa66=a66@bb; a67=W[67,];
 aa67=a67@bb; a68=W[68,];
 aa68=a68@bb; a69=W[69,];
 aa69=a69@bb; a70=W[70,];
 aa70=a70@bb; a71=W[71,];
 aa71=a71@bb; a72=W[72,];
 aa72=a72@bb; a73=W[73,];
 aa73=a73@bb;

aaaa=aa1//aa2//aa3//aa4//aa5//aa6//aa7//aa8//aa9//aa10//aa11//aa12//aa
13//aa14//aa15//aa16//aa17//aa18//aa19//
aa20//aa21//aa22//aa23//aa24//aa25//aa26//aa27//aa28//aa29/
/aa30//aa31//aa32//aa33//aa34//aa35//aa36//
aa37//aa38//aa39//aa40//aa41//aa42//aa43//aa44//aa45//aa46//aa47//aa48
//aa49//aa50//aa51//aa52//aa53//
aa54//aa55//aa56//aa57//aa58//aa59//aa60//aa61//aa62//aa63//aa64//aa65
//aa66//aa67//aa68//aa69//aa70//aa71//aa72//aa73;

 create new from aaaa;
 append from aaaa;
```