ECONOMIC FEASIBILITY OF GROWING SORGHUM AS A BIOENERGY CROP

by

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Abstract

The purpose of this research is to evaluate and gain a better understanding of the economic feasibility of Kansas farmers growing energy sorghum for biofuel production. The net returns for 11 crop systems that included a no-till or reduced-till option and the rotations involved wheat, grain sorghum, dual-purpose sorghum, and photoperiod sensitive sorghum were simulated in SIMETAR© developed by Richardson, Shumann, and Feldman (2004) using historical data on yields and prices. The price and yield data originates from an agronomic study conducted in Hesston, KS. The biomass yields for the 3 varieties of sorghum are based on experimental work performed in Manhattan, KS. The sorghum biomass prices were obtained from the United States Department of Agriculture Agricultural Marketing Service. Costs for the crop systems are based on the 2014 Kansas State University Herbicide handbook (Thompson et al. 2014), Dhuyvetter, O'Brien, and Tonsor (2014), and Dhuyvetter (2014).

The net returns were simulated under five contract scenarios including: a Spot Market contract, a Minimum Price contract, a BCAP Price contract, and 2 levels of the Gross Revenue Guarantee contracts – 60% and 100%. Risk analysis was performed on the simulated net returns through use of the Excel add-in SIMETAR©. Stochastic efficiency analysis was used to evaluate the systems based on the distribution of net returns and risk preferences.

The findings are summarized around three important factors influencing farmers' economic feasibility of growing sorghum for biofuel use: crop systems, risk preferences, and contract specification. Results indicate that the no-till wheat and dual-purpose sorghum crop system without biomass production has the lowest costs and the no-till

wheat and photoperiod sensitive sorghum system has the highest production cost. The crop systems that have a no-till option allow for the highest grain and biomass yields. Also, crop systems rotated with wheat are more preferred among producers due to higher net returns. The NTWDPS With system under the BCAP Price contract has the highest net returns and is highest in preference. The findings indicate that the risk aversion does affect the decision to produce sorghum for biofuel, but the effect is not very significant. In terms of contract specification, the results indicate that for Kansas producers, the BCAP Price contract will offer the highest net returns.

These findings contribute additional insight on factors affecting Kansas farmers' economic feasibility of producing sorghum for biofuel and can have important implications for biofuel industry actors and policy makers.

Table of Contents

List of Figures

List of Tables

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Chapter 1 - Introduction

1.1. Problem Statement and Research Motivation

Government policies may require increased biofuel production. The Renewable Fuel Standard 2 (RFS2) under The Energy Independence and Security Act of 2007 requires that by 2022, 36 billion gallons of biofuel be produced in the United States with 16 billion of those gallons are expected to come from cellulosic sources. The Biomass Research and Development Act of 2000 calls for 30% of petroleum use to be replaced by biomass products by the year 2030 (U.S. Department of Energy 2003).

There is also an advocacy campaign created called 25 by ’25. The 25 by ’25 vision is for the U.S. to have 25% of our energy to come from renewable resources by 2025, which includes biofuels (“About 25x’25” 2014). These policies and initiatives drive the need for increased biomass harvest and dedicated feedstock production. The growing need for biomass feedstocks, in turn, will potentially open physically and economically sizable new markets for agricultural producers and processors. While the policy goals for biofuel production have been increasing over time, efforts for securing an adequate supply of bioenergy crops is still a work in progress. Continued research is necessary for informing policy and industry efforts focused on assessing and enhancing the supply potential of bioenergy crops.

Although the research on energy crop supply for biofuel production continues to grow, most studies tend to focus at regional, state, or county level analysis of feasibility and the potential of biofuel feedstock supply (Epplin et al. 2007)(Graham 1994; Heid Jr. 1984; Kim and Dale 2004; McLaughlin et al. 2002; Perlack et al. 2005; Walsh et al. 2003). Farm-level analysis is relatively less extensive compared to the more aggregate-level analysis of biofuel supply in the literature (Bergtold, Fewell, and Williams 2011; English et al. 1992; Jensen et al. 2007; Larson, English, and Lambert 2007; Lynes et al. 2012). Many questions related to factors affecting producers' willingness to grow energy crops remain unanswered. Among such factors are input and output prices, contractual arrangements and financial incentives, as well as farmers' existing production characteristics and risk preferences.

1.2. Purpose and Objective

The purpose of this research is to evaluate and gain a better understanding of the potential economic feasibility of Kansas farmers growing energy sorghum for biofuel production given their production characteristics, personal risk preferences, price risk, and yield variability. The specific objectives are to understand under which levels of net return and risk preferences Kansas farmers are willing to produce sorghum for biomass use. The findings will contribute additional insight to inform policy decisions focused on enhancing biofuel supply and facilitating development of the biofuel industry to help meet the goals set by the government. The results will also inform industry decisions and will be particularly useful for biofuel processors who plan to develop or expand their procurement base to Kansas and the region.

1.3. Methods

This study utilizes simulation of yields and prices to calculate net returns and assess farmers' willingness to produce sorghum for biomass. The simulated net returns are for 11 crop systems and 5 contract scenarios. The 11 cropping systems include grain sorghum

(GS) [Sorghum bicolor (L.) Moench], dual-purpose sorghum (DPS), photoperiod sensitive sorghum (PPS), and wheat (W). The rotations are between wheat and grain sorghum, and continuous grain sorghum. Yields and net returns are analyzed in both no-till and reduced-till rotations as well as with and without biomass harvesting. Five contract scenarios include a Spot Market contract, Minimum Price contract, 2 levels of the Gross Revenue Guarantee contract, and a Biomass Crop Assistance Program (BCAP) Price contract.

Factors and production characteristics used for the study are typical to central Kansas and include biomass and grain prices, biomass and grain yields from sorghum and wheat, fertilizer and chemical prices, tillage practices, and crop rotations. The data on grain and biomass yields and prices are based on agronomic studies performed in Hesston, KS and Manhattan, KS, and have been obtained from Pachta (2010), Brammer (2014), and "USDA Agricultural Marketing Service" (2014). Input costs for chemicals, fertilizer, seed prices, and field operations are obtained from the databases of K-State Research and Extension and the Kansas State University (KSU) Department of Agricultural Economics. Analysis is conducted using SIMETAR©, a risk analysis software developed by Richardson, Schumann, and Feldman (2004) as an Excel add-in. SIMETAR© uses simulated yields and prices to calculate and compare the gross net returns for each cropping system under different contract scenarios.

The following is a list of steps used for achieving research objectives.

1. Collect the crop rotations and tillage system yields typical for the south central area of Kansas, collect biomass data from Manhattan, KS, and identify five alternative contract scenarios to secure a biofuel supply

2. Develop and update the enterprise budgets that include input costs such as fertilizer, herbicide, and field operations costs, as well as grain prices and yields, and biomass prices and yields.
3. Simulate distributions of net returns using SIMETAR© in Excel to identify the systems preferred over a range of risk preferences.
4. Compile and analyze the results of the stochastic efficiency procedures and summarize the findings.

1.4. Overview of Key Findings

The key findings of this research can be summarized around three important factors influencing farmers' economic feasibility of growing sorghum for biofuel use: crop system, risk preferences, and contract specification. With regards to crop systems, when the analysis includes all 11 crop systems, the No-till Wheat and Dual-Purpose Sorghum Rotation with biomass production (NTWDPS With) is the system ensuring the highest net returns under the stochastic efficiency tests. In the analysis of 8 systems involving wheat and grain sorghum rotations, the Reduced-till Wheat and Grain Sorghum Rotation with biomass production (RTWG With) ensures the highest average net returns. It was determined that crop systems rotated with wheat are preferred most by producers. The costs of systems that produce biomass are higher than their non-biomass producing rotations. The No-till Wheat and Dual-purpose Sorghum Rotation without biomass (NTWDPS W/O) system are shown to have the lowest costs while the No-Till Wheat and Photoperiod Sensitive Sorghum rotation (NTWPPS) is the most expensive. The results indicate that for Kansas producers, the BCAP Price contract will offer the highest average net returns. Even when the matching payment is reduced by 50%, the BCAP Price contract is still most preferred majority of the observations under the SERF results.

The findings indicate that the risk preferences do affect the decision to produce sorghum for biofuel, but the affect is not very significant. It was expected that the risk preferences would create noteworthy differences between crop systems with the highest utility of net returns under the different contract scenarios. Based on the results, the producers' risk aversion has no influence over which crop system is most preferred under SERF analysis.

The findings of this research provide insights on factors affecting Kansas farmers' economic feasibility of producing sorghum for biofuel and can have important implications for biofuel industry actors and policy makers. Results concerning net returns and contract preferences will benefit biorefineries that plan to expand their input supply procurement base to Kansas. Due to high transportation costs, because dedicated energy crops are usually bulky in nature, learning information about the local supply is important, as a biorefinery will most likely get its supply within a small radius of its location. (Larson, English, and Lambert 2007; Qualls et al. 2012; Lynes et al. 2012).

The findings will also be useful for farmers growing crops interested in diversifying their production and enhancing revenue per acre. The results from the comparison of net returns accounting for input costs such as harvesting, chemicals, and tillage practices for the 11 crop systems will provide useful information for producers' decisions regarding which crops to grow and what tillage option to apply when considering growing for biomass supply.

Local and regional policymakers who are involved in biofuel production policies will also find the results of his research useful, such as contract preference and net returns required to cover the higher costs associate with biomass. It will assist in designing incentive mechanisms, government assistance programs to stimulate the biofuel supply chain, and how progress might be affected in biofuel production goals.

Chapter 2 - Literature Review

2.1. Increasing Need for Biofuel Production

2.1.1. United States Policy

Government policies are a defining determinant in requiring increased biofuel production. The Renewable Fuel Standard 2 (RFS2) under The Energy Independence and Security Act of 2007 requires that by 2022, 36 billion gallons of biofuel be produced in the United States. Sixteen billions of those gallons are expected to come from cellulosic products. The Biomass Research and Development Act of 2000 calls for 30% of petroleum use to be replaced by biomass products by the year 2030 (U.S. Department of Energy 2003).

Biomass accounts for 4.5% of energy consumption in the United States and makes up almost half of total renewable energy consumed (U.S. Energy Information Administration 2014). Current reports state that a total of 1.07 billions gallons of biodiesel were produced in 2013 (U.S. Energy Information Administration 2013), not quite meeting the projected volume production of 1.28 billion gallons for that year (U.S. Environmental Protection Agency, Office of Transportation and Air Quality 2013a). The U.S. Environmental Protection Agency (EPA), under The Energy Independence and Security Act of 2007, has set the annual projected volume of total renewable fuel at 15.21 billion gallons in 2014 (U.S. Environmental Protection Agency, Office of Transportation and Air Quality 2013b). This is much lower than the original expected volume of renewable energy, set at 18.15 billion gallons when RFS2 was instated (*H.R. 6 (110th): Energy Independence and Security Act of 2007* 2007).

2.1.2. Global Drivers

A feasible, long-term energy replacement for fossil fuels is paramount and biofuels are at the top of the list. According to Goldemberg and Johansson (2004) and Goldemberg (2007), our reserves of fossil fuel are predicted to last between 41 to 700 years. 2010 may have been the start of "Peak-Oil", which will see oil production decreasing until fossil fuels are depleted (Escobar et al. 2009). Growth of feedstocks for biofuels to replace dwindling sources like natural gas and coal gives the advantage of decreasing dependency on major oil exporters. This will provide energy security and independence (Scarlat and Dallemand 2011; Koh and Ghazoul 2008; Demirbas 2009a; Kocar and Civas 2013). The resulting diversification will contribute to an increase in jobs and an economic rise in the agricultural sector (Scarlat and Dallemand 2011; Demirbas 2009a; Kocar and Civas 2013; Demirbas 2009b; Sheehan and Himmel 1999).

Another driver of an increase in biofuel development is the potential for positive environmental effects and impacts. Reduction in greenhouse gas emissions such as carbon dioxide, and its renewability and sustainability are cited as some of the major benefits to the environment (Demirbas 2009b; Scarlat and Dallemand 2011; Demirbas 2007). Charles et al. (2007) agrees with its environmental benefits due to its nature of being water-soluble, biodegradable, and non-toxic.

With these local and global reasons and number projections in mind, the need for increased biofuel production is evident. Next, we look at the current literature on feasibility of growing energy crops and the factors that affect a farmers' willingness to grow.

2.2. Sorghum as an Energy Crop

Corn is the leading crop for ethanol production in the United States (Kim and Dale 2004; Rajagopal et al. 2007). While corn has been established as an energy crop for a long time, research contributes to the opinion that sorghum, especially newer varieties, would be a better alternative for biofuel production. Pfeiffer, Montross, and Barrett (2013) suggest that sweet sorghum can produce more gallons of ethanol per acre than corn, with maximum potential ranging from 530 to 700 gallons and 420 gallons, respectively. Sweet sorghum is also more input-efficient and cost-efficient compared to corn because it requires less water, fertilizer, and nitrogen inputs (Pfeiffer, Montross, and Barrett 2013; Taylor et al. 2010; Lipinsky and Kresovich 1980).

Sorghum can be grown in a multitude of climates from sub-tropical to semi-arid (Shoemaker and Bransby 2010). Its adaptability to varying soil qualities and uncertain water availability are a couple of reasons that make it a suitable crop to include in existing crop rotations or as a secondary crop, especially on marginal lands. When drought occurs, sorghum is capable of becoming dormant instead of dying, which makes it an efficient crop in arid environments (Shoemaker and Bransby 2010; Balat, Balat, and Oz 2008). Byrt, Grof, and Furbank (2011) support the idea of sweet sorghum being suitable to grow on marginal lands while still yielding sufficient amounts of sugar to be used in ethanol production. Sorghum is increasingly noticed as a promising biofuel feedstock due to its potential high biomass yield. Byrt, Grof, and Furbank (2001) also discuss how climate models predict the increase in average temperatures and less predictable rainfall amounts, which incidentally

Prasad et al. (2009) states that higher temperature and more amounts of CO2 improve sorghum's ability to yield biomass and sugar.

2.3. Willingness to Grow

In this section, relevant literature is summarized concerning a farmer's willingness to grow. It is separated into two categories: the first includes research done at the state, region, and county level and the second focuses at farm-level. Subcategories are conditions under which farmers will grow and benefits to those who produce energy crops. In the articles reviewed, two of the key findings for conditions that producers will grow biofuel feedstocks are use of contracts and financial assistance.

2.3.1. State, region, and county level analysis

2.3.1.1. Benefits to Farmers for Growing Bio-crops

Larson et al. (2005). defines the benefits a farmer would receive from growing energy crops given their farm characteristics. They conclude that by growing bio-crops along with traditional crops, a farmer can increase overall profits, receive consistency in revenues and gain positive risk management benefits through diversification. Epplin et al. (2007) supports the idea of diversification of crops with the inclusion of switchgrass, and suggesting that its benefits are due to a wider window of harvesting and providing use of marginal land and poor soil. This results in higher economic value as well. In Heller et al. (2004), the production of willow biomass would benefit farmers environmentally with its potential to increase habitation for wildlife, create geographical diversity, and reduce soil erosion. Results showed that by using feedstocks such as switchgrass, the market would lean toward vertical integration, which was deemed preferable by biomass processors (Epplin et al. 2007).

2.3.1.2. Factors Affecting Farmers' Willingness to Grow Bioenergy Crops

Larson et al. (2008) suggests the need for financial assistance, but in the form of planting incentives to persuade farmers to cultivate switchgrass. Chamberlain and Miller (2012) look to determine how to minimize environmental impact while persuading farmers to grow switchgrass. The best recommendation is to give nitrate-reduction incentives.

Concerning marginal land, Okwo and Thomas (2014) reveals that a contract that guarantees a price per acre is more desirable. On the opposite side, a contract that assures a price per unit biomass is preferred when a farmer owns high-quality land.

2.3.2. Farm-level analysis

2.3.2.1. Factors Affecting Kansas Farmers' Willingness to Grow Bioenergy Crops

In Kansas, shorter contract time was desirable in growing sorghum for energy purposes because of farmers' uncertainty (Bergtold et al. 2011). Monetary incentives and insurance availability included in contracts had a positive effect with farmers in growing bioenergy plants according to Bergtold et al. (2012). Bergtold et al. (2011) says use of contracts was favorable when net returns were higher, and availability of insurance, government incentive and options for biomass harvest were provided. Also for biomass harvest, Lynes et al. (2012) and Bergtold et al. (2012) indicate that if a harvester was available to harvest the crops for the farmer, the farmer would be much more likely to let them harvest crop residue or grow a biomass crop.

Lynes et al. (2012) concludes that the larger the farm, the more likely a farmer would be to grow bioenergy crops. Yang et al. (2012) showed that when land quality was lower, a farmer would opt to grow energy crops, such as switchgrass, in lieu of traditional crops. Other characteristics that have an impact on willingness to grow include, age of the farmer and the geographic location (Paulrud and Laitila 2010).

2.4. Contracting for Bioenergy Crops

2.4.1. Contracts in Agriculture

MacDonald and Korb (2011) state that there are two main types of contracts in agriculture: marketing contracts and production contracts. A marketing contract lays out the terms of agreement for the sale of products from producers while a production contract contains the terms for the entire production process. They also state that in 2008, 39% of the U.S. agricultural production value is covered under contracts.

One of the advantages of using contracts is the reduction of price and production risk (MacDonald and Korb 2011). Markets for biofuels are relatively underdeveloped (Epplin et al. 2007). Contracting can act as a substitute to spot markets because contracts can offer more guarantees for crop prices than a spot market, which fluctuates a great deal more (MacDonald and Korb 2011). Contracts can provide a standardized means for producers to grow and supply a steady flow of product with guaranteed prices to biorefineries who need a consistent flow of the biofuel feedstocks.

Financial assistance was noted as important to include in the contract provisions in Lajili et al. (1997) and Bijman et al. (2009). Pricing options were regarded as influential to farmers' preferences of contract by Altman et al. (2008) and by Yang et al. (2012). Altman et al. (2008) and Kudadjie-Freeman et al. (2008) discussed specificity in contract provisions and how it helps to decrease miscommunication and misunderstanding. This helps the producer and processor understand what is needed from both sides. It can offer incentives and create commitment to align the goals of both parties (Alexander et al. 2012).

2.4.2. Influence of Risk in Contracts

When deciding to contract, the effects of risk are noted in Katchova and Miranda (2004), Altman et al. (2008), Kudadjie-Freeman et al. (2008), Elepu and Nalukenge (2009), Bijman et al. (2009), and Yang et al. (2012). Risk affected a farmers' preference for the coordination mechanism of the transaction. Risk adverse farmers were more likely to lease land to processors rather than growing bioenergy crops themselves (Yang et al. 2012). On the opposite side, if they were open to risk, producers would opt for a profit sharing contract. Both Katchova and Miranda (2004) and Kudadjie-Freeman et al. (2008) indicated that to offset risk, specialized farmers contracted more often. Bijman et al. (2009) went a step further and suggested the nucleus estate model and the multipartite model were the best at reducing risk when deciding on a contract structure. The nucleus estate model is when a processor contracts with a large number of small farms and also has its own production facilities. The multi-partite model is a partnership of the state, a private firm, and the producers. Since risk aversion and risk preference affected the farmers' choice of contract and whether or not they would contract at all, reducing is important, especially in an undeveloped market for biomass feedstocks.

Chapter 3 – Methods and Data

3.1 Introduction and Overview

This study utilizes simulation of yields and prices to calculate net returns and assess farmers' preference under risk to produce sorghum for biomass. The simulations are based on 11 crop systems and 5 contract scenarios. Enterprise budgets are created for the 5 contract scenarios and the 11 different cropping systems, which include grain sorghum (GS) [Sorghum bicolor (L.) Moench], dual-purpose sorghum (DPS), photoperiod sensitive sorghum (PPS), and wheat (W). The rotations are between wheat and grain sorghum, and continuous grain sorghum. Yield and net returns are analyzed in both no-till and reduced-till rotations as well as harvesting with and without biomass.

The data on grain and biomass yields and prices are obtained from Pachta (2010), Brammer (2014), and “USDA Agricultural Marketing Service” (2014). The data used in Pachta (2010) and Brammer (2014) came from agronomic studies performed in Hesston, KS and Manhattan, KS, respectively. Input costs for chemicals, fertilizer, seed prices, and field operations are supplied by K-State Research and Extension and from the Kansas State University (KSU) Department of Agricultural Economics.

Five contract scenarios are applied to understand at what different net returns and risk preferences farmers are willing to produce the sorghum for biomass use. They are a Spot Market contract, Minimum Price contract, 2 levels of the Gross Revenue Guarantee contract, and a Biomass Crop Assistance Program (BCAP) Price contract.

The Excel add-in SIMETAR©, created by Richardson, Schumann, and Feldman (2004), is used to analyze and interpret the data of the 11 crop systems. The systems are compared in yields, costs, and net returns across tillage systems, rotations, net returns, and risk preferences. SIMETAR© uses simulated yields and prices to calculate the gross net returns.

3.2 Budget Simulations

The budgets are modeled after the enterprise budgets from Pachta (2010). For the research done in Pachta (2010), there were 13 crop systems. The crops soybean and corn were also included in rotation with wheat and there was a continuous wheat rotation as well. Biomass was not a part of Pachta's research.

The prices for grain and the input costs are updated for each budget scenario. Field operation costs in Pachta (2010) were based on 2008 costs and input costs are from 2009 from the Hesston, KS study performed at the Harvey County Experiment Station. To update the budgets, 2014 costs for field operations and inputs are applied (Thompson et al. 2014; Dhuyvetter, O'Brien, and Tonsor 2014; Dhuyvetter 2014). Grain prices were also updated from 1997-2009 to prices based on 2007 to 2013 data (USDA NASS). In addition, biomass prices, yields, and input costs for biomass are added in specifically for this research. The same agronomic study was used for grain yields as they were in Pachta (2010).

To calculate net returns in the budgets, costs for the different inputs, field operations, harvesting, and interest are added together then subtracted from the gross returns received. Gross returns depend on the crop grown and whether or not biomass production is produced and harvested. The sections in the budgets (Table A.1, Table A.9, Table A.17, Table A.25, table A.33, Table A.41) highlighted in blue are the costs associated with biomass production.

There are a total of 11 different crop systems analyzed for each scenario:

1. Reduced-Till Continuous Grain Sorghum without biomass production (RTGG W/O)
2. Reduced-Till Continuous Grain Sorghum with biomass production (RTGG With)
3. No-Till Continuous Grain Sorghum without biomass production (NTGG W/O)
4. No-Till Continuous Grain Sorghum with biomass production (NTGG With)
5. Reduced-Till Wheat-Grain Sorghum without biomass production (RTWG W/O)
6. Reduced-Till Wheat-Grain Sorghum with biomass production (RTWG With)
7. No-Till Wheat-Grain Sorghum without biomass production (NTWG W/O)
8. No-Till Wheat-Grain Sorghum with biomass production (NTWG With)
9. No-Till Wheat-Dual Purpose Sorghum without biomass production (NTWDPS W/O)
10. No-Till Wheat-Dual Purpose Sorghum with biomass production (NTWDPS With)
11. No-Till Wheat-Photoperiod Sensitive Sorghum (NTWPPS)

Table 3.4 provides a summary of the crop systems. Biomass is only harvested from the sorghum crops, not wheat. Photoperiod sensitive sorghum only produces biomass so the NTWPPS rotation only includes a biomass option.

The wheat and sorghum annual average grain prices are from years 2007 to 2013 (USDA NASS), while the sorghum stover prices are collected from 2010 to 2013 ("USDA

Agricultural Marketing Service" 2014). Historical yields for wheat and grain sorghum under different tillage options are based on the data in the period from 1997 to 2006 (Pachta 2010). Yields for photoperiod sensitive sorghum and dual-purpose sorghum are based on the data in the period from 2007 to 2011 (Brammer 2014). Input costs were updated to include the projected 2014 annual costs.

Prices and yield distributions were specified as triangular distributions using historical data. The distribution statistics were simulated through SIMETAR©. The price distribution statistics are presented in Table 3.5 and the yield distribution statistics are presented in Table 3.6.

Fertilizer replacement for sorghum biomass is estimated as a function of the amount of biomass harvested. The biomass harvested is calculated using the procedure from Shearer (2014). Wortmann et al. (2008) found that the conversion rate of sorghum residue is one ton for every 40 bushels of sorghum yield. The equation for maximum residue removed for GS in tons/acre is:

$$\frac{tons\ residue}{ac} - \frac{(.715\ tons - \frac{tons\ residue}{ac} \times 0.1)}{0.88}$$

The biomass harvested for DPS and PPS used a slightly modified equation for maximum residue removed:

$$\frac{tons\ residue}{ac} - \frac{\left(.715\ tons - \frac{tons\ residue}{ac} \times 0.05\right)}{0.88}$$

The 0.1 and 0.05 in the above equation accounts for the harvesting efficiency loss, as it is not possible to harvest 100% of the residue. The .715 tons is what is left per acre for conservation purposes. The second half of the equations is divided by 0.88 to account for winter decay (Anand et al. 2011). The original amount of residue available in the field is subtracted from the residue amount necessary for conservation to equate the maximum amount of residue that can be removed and harvested.

The amount of nitrogen (N), phosphorous (P), and potassium (K) needed in lbs./tons of biomass is presented in Table 3.4 and was obtained from Propheter (2009). For application in the research, the amounts were then converted into lbs. /bu. to be multiplied by the amounts of grain sorghum biomass harvested in the RTGG, NTGG, RTWG, and NTWG scenarios. In the table, the 3rd, 4th, and 5th columns are rates to be multiplied by the bushel amounts to determine pounds of fertilizer needed.

Table 3.1 Fertilizer Application Amounts[1]

		Conversion Rate: lbs./bu. of Grain			Lbs. of Fertilizer		
Grain Sorghum from[2]:	**Bushels**	**N**	**P-2O5**	**K-2O**	**N**	**P-2O5**	**K-2O**
RTGG	73.08	0.948	0.140	2.996	69.27	10.23	218.92
NTGG	73.11				69.30	10.23	219.01
RTWG	88.41				83.80	12.37	264.84
NTWG	90.52				85.80	12.67	271.17

Fertilizer data from Propheter (2009)

[1] Nitrogen (N), Phosphorous (P-205), Potassium (K-20)

[2] Reduced-till Continuous Grain Sorghum (RTGG), No-till Continuous Grain Sorghum, Reduced-till Wheat-Grain Sorghum (RTWG), No-till Wheat-Grain Sorghum (NTWG)

3.3 Data

The budgets for the research are modeled after the budget scenarios from Pachta (2010). Each budget system includes values for grain prices and yields, biomass prices and yields where applicable, fertilizer, herbicides, seed prices, and field operation costs. The budgets differ based on rotation, tillage option, and production of biomass.

Grain prices and grain yields, which originated from experimental work done in Hesston, KS, (Table 3.2 and Table 3.7) are obtained from Pachta (2010). Table 3.2 presents the simulated prices for wheat and sorghum grain, and the simulated biomass prices for the spot market price, minimum price, BCAP price, and revenue guarantee price.

Table 3.2 Mean Values of Simulated Grain and Biomass Prices

Prices		
Simulated Wheat Price	$7.06	$/bushel
Simulated Sorghum Price	$4.90	$/bushel
Simulated Biomass Market Price	$69.58	$/ton
Simulated Biomass Price with Minimum Price	$70.00	$/ton
Simulated Biomass Price with BCAP	$89.58	$/ton
Simulated Biomass Price with Gross Revenue Guarantee	$69.24	$/ton

Table 3.7 shows the grain yields for wheat and grain under the different rotations and tillage options for years 1997 to 2006, plus the statistics of those yields. The grain sorghum biomass yields are functions of the grain sorghum grain yields. The data on biomass yields for photoperiod sensitive sorghum and dual-purpose sorghum is from Brammer (2014), which originated from experimental work in Manhattan, KS (Table 3.8).

The wheat and sorghum annual average grain prices for years 2007 to 2013 are from USDA National Agricultural Statistics Service (NASS) (Table 3.9). The United States Department of Agriculture Agricultural Marketing Service (USDA AMS) provided the sorghum stover prices from 2010 to 2013 (Table 3.3). In the tables, the statistics of mean, standard deviation, minimum, and maximum are calculated from all the data points. The correlation matrices and the p-value statistics of the grain yields, PPS and DPS yields, and the grain prices are summarized in Appendix B (Tables B.1 – B.6). The biomass yields obtained from the work in Manhattan, KS are not correlated with the data taken from the Hesston, KS agronomic study.

Table 3.3 Historical Sorghum Stover Prices ($/ton)

	Sorghum Stover ($/ton)
2010	$61.16
2011	$66.82
2012	$70.66
2013	$78.33
Mean	$69.24
Std. Dev.	$7.21
Min	$61.16
Max	$78.33

Input costs of various herbicides were obtained from the 2014 Kansas State University Herbicide handbook presented in Table 3.10 (Thompson et al. 2014). The fertilizer and seed costs were found in Dhuyvetter, O'Brien, and Tonsor (2014). In Table 3.10 under the subheading of Chemicals, the first two columns represent if the chemical is applied to grain sorghum (G), and/or wheat (W).

Kansas Farm Management Association (KFMA) provided farm characteristics and crop rotation data available on their website (http://www.agmanager.info/kfma/). Field operation costs, divided into categories of planting, chemical and fertilizer application, tilling, and harvesting, are the projected 2014 costs from Dhuyvetter (2014) from the KSU Department of Agricultural Economics (Table 3.11)

3.4 Contract Scenarios

There are five contract scenarios that are applied in the research. The first is a Spot Market contract and the producer assumes all revenue risk. The spot market price for biomass was simulated with a triangular distribution of the mean, minimum, and maximum prices of the sorghum stover prices from 2010 to 2013.

The second contract scenario is a Minimum Price contract where an established minimum price is paid to the producer per ton of biomass. In this research the minimum price is set at $70 per ton of biomass.

The third and fourth is a Gross Revenue Guarantee contract where annual gross revenue is based on contract prices multiplied by mean yield per acre of biomass product. The revenue amount is set at 2 levels: 60% and 100% of the targeted revenue based on the predicted biomass market price (Tables 3.12 and 3.13). The revenue guarantee amount was determined by finding the mean of the sorghum stover prices from 2010 to 2013. The Gross Revenue Guarantee contract significantly reduces price or yield risk taken on by the producer for biomass.

The fifth contract scenario is based on the BCAP Price contract (CRS, USDA, and Commodity Credit Corporation 2010). It allows a matching payment up to $20 per ton of biomass material in its collection, harvest, storage, and transportation fees. The BCAP contract with matching payments is usually a two-year contract in the agriculture industry.

3.5 Analysis

The data and results are interpreted using Stochastic Efficiency with Respect to a Function (SERF). Hardaker et al. (2004) states that SERF orders alternatives in terms of certainty equivalents (CEs) across a range of risk attitudes. CEs represent the dollar amount at which the decision maker chooses to take rather than selecting a higher return with more uncertainty attached. Utility weighted risk premiums (RPs) are also determined. A RP is calculated by subtracting the certainty equivalent (CE) of a less-preferred strategy (L) from the CE of one that is more preferred (P):

$$RP_{L,P,RA} = CE_{P,RA}(w) - CE_{L,RA}(w).$$

It represents the minimum amount of money that a decision maker would accept in order to justify their switch from the strategy preferred to the alternative less preferred. Risk premiums are calculated across the risk aversion coefficients in order to clarify the amounts producers would need to be paid considering their risk preferences.

Within the SERF analysis, negative exponential utility functions are used, which allows the researcher to state the recognized assumption that decision makers would prefer less risk to more under the same expected returns.

A lower bound and upper bound for risk aversion are applied in SIMETAR©, known as absolute risk aversion coefficients (ARACs) and is calculated in the equation defined by Pratt (1964), where the u(w) represents the decisions maker's utility function:

$$RA(w) = -u''(w)/u'(w).$$

For this research, the range of coefficients is assumed to be 0 to 0.0053. An ARAC at zero indicates that the producer is risk neutral. As the coefficient goes up toward the upper coefficient, it signifies that the producer is more risk averse. The upper bound was calculated using the method found in Hardaker et al. (2004), dividing 4.0 by a relevant level of wealth per acre. For this research, the level of wealth is the average net worth per acre of farms in the south-central Kansas Farm Management Association in 2013, which is found to be .0053 [= 4.0/($1,401,613/1849 acres)] ("KFMA" 2013).

Chapter 3 Tables

Table 3.4 Crop Systems Summary

		Sorghum Type[1]			Rotation[2]		Tilling Option[3]		Biomass Production	
System	**Description**	**GS**	**DP**	**PPS**	**C**	**WW**	**RT**	**NT**	**With**	**Without**
RTGG W/O	Reduced-Till Continuous Grain Sorghum without Biomass	X			X		X			X
RTGG With	Reduced-Till Continuous Grain Sorghum with Biomass	X			X		X		X	
NTGG W/O	No-Till Continuous Grain Sorghum without Biomass	X			X			X		X
NTGG With	No-Till Continuous Grain Sorghum with Biomass	X			X			X	X	
RTWG W/O	Reduced-Till Wheat-Grain Sorghum without Biomass	X				X	X			X
RTWG With	Reduced-Till Wheat-Grain Sorghum with Biomass	X				X	X		X	
NTWG W/O	No-Till Wheat-Grain Sorghum without Biomass	X				X		X		X
NTWG With	No-Till Wheat-Grain Sorghum with Biomass	X				X		X	X	
NTWDPS W/O	No-Till Wheat-Dual-Purpose Grain Sorghum without Biomass		X			X		X		X
NTWDPS With	No-Till Wheat-Dual-Purpose Grain Sorghum with Biomass		X			X		X	X	
NTWPPS	No-Till Wheat-Photoperiod Sensitive Grain Sorghum with Biomass			X		X		X	X	

[1] GS (Grain), DP (Dual-purpose), PPS (Photoperiod sensitive)
[2] C (Continuous), WW (With Wheat)
[3] RT (Reduced-till), NT (No-till),

Table 3.5 Triangular Distribution Statistics for Prices

Prices	Mean	St. Dev.	CV	Min.	Max.	
Simulated Wheat Price	$7.05	$1.51	$21.46	$3.66	$11.00	$/bushel
Simulated Sorghum Price	$4.90	$1.04	$21.23	$2.63	$7.48	$/bushel
Simulated Biomass Price	$69.58	$3.51	$5.04	$61.68	$77.89	$/ton
Simulated Biomass Price with Minimum Price	$69.71	$3.28	$4.71	$65.00	$77.89	$/ton
Simulated Biomass Price with BCAP[1]	$89.58	$3.51	$3.92	$81.68	$97.89	$/ton

[1] Biomass Crop Assistance Program

Table 3.6 Triangular Distribution Statistics for Yields

Yields	Mean	St. Dev.	CV	Min.	Max.	
Simulated RTGG Sorghum Grain	77.01	15.05	19.55	44.21	114.36	Bu./acre
Simulated RTGG Sorghum Biomass	1.43	0.42	29.33	0.52	2.47	Tons/acre
Simulated NTGG Sorghum Grain	81.14	16.75	20.64	46.57	123.31	Bu./acre
Simulated NTGG Sorghum Biomass	1.54	0.47	30.20	0.58	2.72	Tons/acre
Simulated RTWG Wheat Grain	48.28	6.98	14.47	31.49	63.53	Bu./acre
Simulated RTWG Sorghum Grain	96.21	23.38	24.30	45.45	153.70	Bu./acre
Simulated RTWG Sorghum Biomass	1.96	0.65	33.15	0.55	3.56	Tons/acre
Simulated NTWG Wheat Grain	51.11	6.60	12.92	37.24	66.75	Bu./acre
Simulated NTWG Sorghum Grain	95.89	19.41	20.24	53.39	143.70	Bu./acre
Simulated NTWG Sorghum Biomass	1.95	0.54	27.65	0.77	3.29	Tons/acre
Simulated Photoperiod Sensitive Sorghum Biomass	9.85	1.72	17.48	5.90	13.60	Tons/acre
Simulated Dual Purpose Sorghum Grain	73.21	20.73	28.32	24.26	123.04	Bu./acre
Simulated Dual Purpose Sorghum Biomass	8.44	0.97	11.47	6.20	10.75	Tons/acre

Table 3.7 Grain Yield Statistics (bu./acre)[1]

	Wheat		Grain Sorghum		Grain Sorghum Continuous	
Rotation	W/GS	W/GS	W/GS	W/GS	GS/GS	GS/GS
Tillage	RT	NT	RT	NT	RT	NT
1997	52.79	36.43	115.98	121.08	90.33	85.55
1998	42.53	41.63	105.47	108.02	97.50	94.48
1999	30.63	42.08	85.87	97.50	72.01	70.58
2000	33.31	37.03	115.19	109.13	83.80	86.67
2001	40.89	37.03	55.12	60.38	47.00	47.16
2002	55.61	48.03	58.15	56.56	50.50	50.98
2003	58.88	68.70	43.33	51.46	42.38	44.77
2004	64.83	65.72	156.93	145.78	115.66	125.54
2005	51.15	51.30	81.25	81.41	66.91	65.96
2006	62.90	53.68	66.75	73.92	64.68	59.43
Mean	49.35	48.16	88.41	90.52	73.08	73.11
St. Dev.	11.99	11.72	35.03	30.97	23.72	25.29
Min	30.63	36.43	43.33	51.46	42.38	44.77
Max	64.83	68.70	156.93	145.78	115.66	125.54

Grain yield data from Pachta (2010)

[1] Wheat (W), Grain Sorghum (GS), No-Till (NT), Reduced-Till (RT)

Table 3.8 Photoperiod Sensitive Sorghum and Dual-Purpose Sorghum Yield Statistics[1]

	PPS	DPS	DPS
	Biomass (Tons/acre)	Grain (Bu./acre)	Biomass (Tons/acre)
2007	13.74	124.87	7.21
2008	11.37	93.98	8.40
2009	5.82	43.04	6.42
2010	10.65	83.18	10.36
2011	10.81	21.21	10.91
Mean	10.48	73.25	8.66
St. Dev.	2.88	41.27	1.94
Min	5.82	21.21	6.42
Max	13.74	124.87	10.91

Biomass yields for DPS and PPS from Brammer (2014)

[1] Photoperiod Sensitive Sorghum (PPS), Dual-Purpose Sorghum (DPS)

Table 3.9 Wheat and Grain Sorghum Historical Grain Prices ($/bushel)

	2007	2008	2009	2010	2011	2012	2013
Wheat							
January	$4.47	$8.76	$5.46	$4.25	$7.79	$6.61	$7.78
February	$4.60	$10.67	$5.02	$4.06	$8.33	$6.73	$7.42
March	$4.61	$11.09	$5.08	$4.01	$7.40	$6.51	$7.18
April	$4.62	$8.89	$5.17	$4.04	$8.06	$6.17	$7.06
May	$4.64	$7.67	$5.90	$3.97	$8.23	$6.02	$7.37
June	$5.36	$8.32	$5.83	$3.58	$7.78	$6.43	$7.08
July	$5.59	$7.78	$4.92	$4.59	$7.16	$8.13	$6.77
August	$6.09	$7.82	$4.46	$5.61	$7.70	$8.38	$6.81
September	$7.74	$6.87	$3.90	$6.12	$7.31	$8.40	$6.77
October	$7.96	$5.44	$4.24	$6.09	$6.67	$8.47	$7.27
November	$7.64	$4.99	$4.55	$6.18	$6.63	$8.62	$6.81
December	$9.03	$4.93	$4.36	$7.07	$6.38	$8.16	$6.49
Mean	$6.51						
Std. Dev.	$1.61						
Min	$3.58						
Max	$11.09						
Grain Sorghum							
January	$3.56	$4.38	$2.88	$2.97	$5.60	$5.99	$6.74
February	$3.82	$4.64	$2.67	$2.83	$6.05	$6.06	$6.71
March	$3.64	$4.89	$2.88	$2.93	$5.89	$5.95	$6.89
April	$3.21	$5.32	$3.05	$2.88	$6.53	$5.79	$6.17
May	$3.28	$5.22	$3.37	$2.96	$6.31	$5.57	$6.32
June	$3.41	$6.15	$3.34	$2.77	$6.50	$5.65	$6.54
July	$2.87	$5.76	$2.48	$3.08	$6.20	$7.02	$6.07
August	$3.02	$4.54	$2.58	$3.35	$6.72	$7.55	$5.46
September	$3.29	$4.47	$2.51	$4.00	$6.43	$7.01	$4.57
October	$3.25	$3.23	$3.02	$4.73	$5.96	$7.00	$4.06
November	$3.52	$2.77	$3.16	$4.77	$6.12	$7.06	$3.97
December	$3.88	$2.65	$3.12	$5.04	$5.83	$6.78	$4.03
Mean	$4.66						
Std. Dev.	$1.53						
Min	$2.48						
Max	$7.55						

Historical grain prices from USDA National Agriculture Statistics Service

Table 3.10 Input Costs (2014)

Seed Prices

	Seeds/lb.	Lb./bag	Seeds/bag	$/bag		
Certified Wheat		90		$15.30	**$0.17**	$/lb.
G.S. (Gaucho treated)	13000	50	650000	$162.50	**$0.25**	$/1000 seeds
Dual Purpose Sorghum	13000	50	650000	$180.00	**$3.60**	$/lbs.
Photosensitive Sorghum	13000	50	650000	$180.00	**$3.60**	$/lbs.

Fertilizers

Item Name	Price			
46-0-0 Urea	$555	$/ton	$0.603	$/lb. of actual N
18-46-0 DAP	$605	$/ton	$0.303	$/lb.
0-46-0 TSP	$615	$/ton	$0.668	$/lb. of actual P
0-0-60 potash	$604	$/ton	$0.503	$/lb. of actual K
Lime (with application)	$96	$/ton	$0.048	$/lb.

Chemicals

Crops[1]		Item Name	% A.I	Price	Unit	Price	Units used
G	W	2,4-D Amine 4 L		$18.65	gallon	$0.15	fl .oz.
G	W	2,4-D LVE 4 EC		$24.50	gallon	$0.19	fl .oz.
G	W	AMSU Adjuvant		$0.34	lbs.	$0.34	lb.
G		Atrazine 4 L		$15.85	gallon	$1.98	pint
G		Atrazine 90 DF		$3.50	lbs.	$3.50	lb.
G	W	Banvel or Clarity		$82.00	gallon	$0.64	fl .oz.
G		Bicep II Magnum		$42.32	gallon	$10.58	qt.
G		Buctril + Atrazine		$50.72	gallon	$6.34	pint
G		COC		$14.26	gallon	$0.11	fl .oz.
G		Dual II Mag		$125.00	gallon	$15.63	pint
	W	Non-ionic Surfactant		$32.26	gallon	$0.25	fl .oz.
G	W	Placement ProPak Adjuvant		$44.37	gallon	$0.35	fl .oz.
G	W	Roundup Original Max	4.5	$29.30	gallon	$0.23	fl .oz.
G	W	Select		$105.00	gallon	$0.82	fl .oz.
	W	Superb HC COC		$26.40	gallon	$0.21	fl .oz.

Seed prices and ferlizer costs from Dhuyvetter, O'Brien, and Tonsor (2014)
Chemical cost from Thompson et al. (2014)

[1] Grain (G), Wheat (W)

Table 3.11 Field Operation Costs (Projected 2014 Costs)

Field Operation	Costs	
Planting		
No-till drill and/or air-seed with fertilizer	$17.40	$/acre
No-till plant with fertilizer	$18.05	$/acre
Regular-till plant with fertilizer	$16.59	$/acre
Chemical		
Field cultivation without fertilizer	$9.68	$/acre
Spray chemical (ground rig)	$6.01	$/acre
Broadcast dry fertilizer		
Tillage		
Sweep/undercut without fertilizer	$9.09	$/acre
Chisel, less than 12 inches deep	$12.99	$/acre
Grain Harvesting	$5.95	$/acre
Harvest wheat	$23.38	$/acre
Wheat yield above base rate (22 bu./ac)	$0.23	$/bushel
Harvest grain sorghum	$24.00	$/acre
Grain sorghum yield above base rate (36 bu./ac)	$0.23	$/bushel
Biomass Harvesting [1]		
Swath	$18.00	$/acre
Raking	$7.00	$/bale
Baling (alfalfa, straw, CRP)	$14.00	$/bale
Stacking	$4.00	$/bale

Field operation costs are from Dhuyvetter (2014)

[1] 2013 costs

Table 3.12 Gross Revenue Guarantee – 60%[1]

Revenue Guarantee - 60%	Yield (tons/acre)	Revenue ($/acre)
RTGG Sorghum Biomass	1.4296	$59.39
NTGG Sorghum Biomass	1.544	$64.14
RTWG Sorghum Biomass	1.9642	$81.60
NTWG Sorghum Biomass	1.9554	$81.24
Photoperiod Sensitive Sorghum Biomass	9.8624	$409.72
Dual Purpose Sorghum Biomass	8.4397	$350.62
Price	**$69.24 ($/ton)**	

[1] Reduced-till Continuous Grain Sorghum (RTGG), No-till Continuous Grain Sorghum (NTGG), Reduced-till Wheat-Grain Sorghum (RTWG), No-till Wheat-Grain Sorghum (NTWG)

Table 3.13 Gross Revenue Guarantee – 100%[1]

Revenue Guarantee - 100%	Yield (tons/acre)	Revenue ($/acre)
RTGG Sorghum Biomass	1.4296	$98.99
NTGG Sorghum Biomass	1.544	$106.91
RTWG Sorghum Biomass	1.9642	$136.00
NTWG Sorghum Biomass	1.9554	$135.39
Photoperiod Sensitive Sorghum Biomass	9.8624	$682.87
Dual Purpose Sorghum Biomass	8.4397	$584.36
Price	**$69.24 ($/ton)**	

[1] Reduced-till Continuous Grain Sorghum (RTGG), No-till Continuous Grain Sorghum (NTGG), Reduced-till Wheat-Grain Sorghum (RTWG), No-till Wheat-Grain Sorghum (NTWG)

Chapter 4 - Results

4.1 Overview

The net returns from the crop system budgets and the results from the Excel add-in SIMETAR© are described in detail in this section. Chapter 4 is organized in 3 large parts. Part 1 includes the comparisons of yields, costs, and net returns for all 11-crop systems under the 5 contract scenarios. Part 2 contains results from the analysis between all 11 crop systems and the 5 contracts scenarios. Part 3 looks only at the results for the 8 crop systems performed in the agronomic study performed in Hesston, KS.

First, the grain and biomass yield comparisons between the crop rotations are discussed in section 4.2 under Part 1. The yield outcomes are affected by the rotation, tillage option, and production of biomass. Second, the differences in costs across the 11 crop systems are discussed in section 4.3 of Part 1. The costs associated with each cropping system include costs of inputs such as fertilizer and herbicides, field operations, and harvesting. The costs of the crop systems in each budget are totaled into two categories: with and without production of biomass. And third, the net returns for each 11 crop systems are calculated and compared using four different contract scenarios (section 4.4).

The net returns are calculated using two different approaches. The first approach used Excel budgets and calculated net returns based on the average prices and yields. The second approach used SIMETAR© and calculated the net returns based on simulated means from 2,000 iterations. It uses other statistical measure besides the averages to calculate the net returns, including the standard deviation and the minimum and maximum values.

Part 2 includes sections that discuss the Stochastic Efficiency with Respect to a Function (SERF) results for all 11 cropping systems under each contract scenario and then compares the contract scenarios against each other (sections 4.5, 4.6, 4.7, and 4.8). Part 3 (sections 4.9-4.11) includes sections that discuss results of the analysis, which included only the crop rotations that were in the original experimental work performed in Hesston, KS (RTGG, NTGG, RTWG, NTWG). These crop systems are specific to south central Kansas and are already grown in that area.

The next comparison is through Stochastic Efficiency with Respect to a Function (SERF) within the 5 contract scenarios. The system with the most utility of net returns is used to calculate the risk premiums in relation to it. The risk premiums translate to the minimum prices ($/acre in net returns) at which a system with lower utility will be equally preferred to the one with higher utility. The risk premiums are negative, but are interpreted as an absolute value. It is examined in fuller detail in Part 2, section 4.6 and Part 3, section 4.10.

StopLight analysis is the next analysis used, found in section 4.7. It is a tool in SIMETAR© that provides a table and graphical representation of color-coded percentages within a system. There is a calculated lower cut-off value and upper cut-off value within a StopLight graph. The percentages represent the chance a system will have net returns lower than the lower cut-off value (red), the net returns will be between the lower and upper values (yellow), and the chance the net returns will be above the upper cut-off value (green). StopLight analysis is only discussed in Part 2 because the percentages are the same whether comparing all 11 systems or only the 8 systems from the Hesston, KS study (Pachta 2010).

To complete the analysis, the contracts are compared against one another using SERF. The most preferred/highest-ranking crop system under each contract scenario is compared to their respective counterparts. The mean net returns for the crop systems are taken from the simulations ran in SIMETAR©. The results of the comparison are discussed in length in section 4.8 under Part 2 and in section 4.12 under Part 3.

Part 1 – Comparison of Yields, Costs, Net Returns of 11 Crop Systems Under Different Contract Scenarios

4.2 Yields Comparison

A triangular distribution was implemented to simulate the grain yields for wheat, grain sorghum, and dual-purpose sorghum. The maximum residue removed equation from Shearer (2014) was used to calculate estimates for the biomass yields for grain sorghum, dual-purpose sorghum, and photoperiod sensitive sorghum. The results are summarized in Table 4.1. The yields for sorghum and wheat are presented in their respective crop systems. The grain yield values are in bushels/acre while the biomass yields are in tons/acre.

Grain sorghum grain yields are an average 17 bushels/acre higher when rotated with wheat compared to a continuous grain sorghum planting. There are higher grain yields when the system is no-till for the continuous grain sorghum rotation. The no-till option also shows higher wheat grain yields, around 3 bushels more per acre than the reduced-till system when rotated with grain sorghum. The grain sorghum grain yields are lower under the no-till option when sorghum is rotated with wheat. For example, there are 96.22 bu./acre versus 95.92 bu./acre for RTWG and NTWG for grain sorghum grain respectively.

The differences in grain sorghum biomass yields are very minimal, especially when compared to the differences in its grain yields. There is a slightly higher increase in the biomass yields for the wheat and grain sorghum rotation versus the continuous grain sorghum rotation. There is also a smaller difference between tillage systems than rotation systems. It is slightly higher in a no-till system than reduced-till. Table 4.1 shows that RTGG sorghum biomass is 1.43 tons/acre compared to 1.54 in the NTGG rotation and 1.96 biomass tons/acre for the RTWG system.

The grain sorghum grain yields produced an average of 96.22 bushels per acre, more than any other grain yield from the other sorghum varieties or wheat regardless of the rotation or tillage system. PPS demonstrated an estimated significantly higher biomass yield than grain sorghum. Table 4.1 reveals 9.86 tons/acre for PPS biomass compared to grain sorghum biomass yields of 1.43, 1.54, 1.96, and 1.96 tons/acre for RTGG, NTGG, RTWG, and NTWG respectively. Photoperiod sensitive sorghum (PPS), which is only grown for biomass, is estimated to yield 9.86 tons per acre. This is almost 1.5 tons more per acre in biomass than DPS, its closest competitor for biomass output.

Overall, the no-till systems allowed for the most grain and biomass yields compared to the reduced-till options. Comparing the rotation systems, grain sorghum (GS) produced more grain and biomass bushels when rotated with wheat versus continuous GS planting. Grain sorghum had the highest amount of grain yields under the RTWG system. PPS produced the most biomass tons per acre than the dual-purpose sorghum or grain sorghum varieties.

Table 4.1 Average Grain Yields and Estimated Biomass Yields from the Triangular Distribution

System	Yields		
Simulated RTGG Sorghum Grain	77.04	Bu./acre	
Simulated RTGG Sorghum Biomass	1.43	Tons/acre	Estimate
Simulated NTGG Sorghum Grain	81.14	Bu./acre	
Simulated NTGG Sorghum Biomass	1.54	Tons/acre	Estimate
Simulated RTWG Wheat Grain	48.27	Bu./acre	
Simulated RTWG Sorghum Grain	96.22	Bu./acre	
Simulated RTWG Sorghum Biomass	1.96	Tons/acre	Estimate
Simulated NTWG Wheat Grain	51.10	Bu./acre	
Simulated NTWG Sorghum Grain	95.92	Bu./acre	
Simulated NTWG Sorghum Biomass	1.96	Tons/acre	Estimate
Simulated PPS Biomass	9.86	Tons/acre	Estimate
Simulated DPS Grain	73.11	Bu./acre	
Simulated DPS Biomass	8.44	Tons/acre	Estimate

4.3 Costs Comparison

Table 4.2 shows the categorization of the costs for each of the 11 systems. They are categorized into grain costs and biomass costs. More fertilizer and harvesting are required when there is biomass involved which increases the cost of the associated system. Overall, the lowest cost system is the No-till Wheat and Dual-Purpose Sorghum without biomass (NTWDPS W/O) at $173.84 per acre. On the other end of the spectrum, the system with the highest cost out of the 11 available is the No-Till Wheat and Photoperiod Sensitive Sorghum with biomass (NTWPPS With) at $442.06/acre. It has significantly higher fertilizer and harvesting costs due to the biomass from the photoperiod sensitive sorghum (PPS).

Comparing the systems that do not produce biomass, the costs are fairly similar. The greatest difference is between the NTWDPS W/O and RTWG W/O, which is just shy of $30 per acre. The other systems range from $215.60 to $223.13 per acre (Table 4.2). Interestingly, between the RTGG W/O and the NTGG W/O the reduced-till option costs more, but between RTWG W/O and NTWG W/O the no-till costs more. Usually when a system is no-till, there is an increased cost for herbicides and chemicals. The reduced-till for the W/G rotation requires field operations for tilling, but the difference in chemical costs outweighs the difference made by not tilling.

There are 6 systems that involve biomass production. At $442.06/acre, the NTWPPS With is the most expensive and at $269.89 per acre the RTWG With is the least expensive (Table 4.2). NTWPPS With has the highest cost, because the fertilizer and harvesting costs are much more than the other systems, $101.51/acre and $175.81/acre respectively. This is due to much higher biomass yields from photoperiod sensitive sorghum than the other two sorghum varieties. The two costliest systems in terms of fertilizer application and harvesting biomass are the NTWPPS With and the NTWDPS With.

The reduced-till systems include RTGG W/O, RTGG With, RTWG W/O and RTWG With. The reduced-till continuous grain sorghum rotation is more expensive per acre to produce than the wheat and grain sorghum rotation. They both follow the trend that when biomass is produced the costs increase and are higher than their no-biomass counterparts. The field operation costs are higher for RTWG than RTGG.

The continuous grain sorghum rotation, wheat and grain sorghum rotation, wheat and photoperiod sensitive sorghum rotation, and the wheat and dual-purpose sorghum rotations all have no-till option systems. With the reduced-till, the systems with biomass production are more costly than the ones without. The NTWDPS W/O is the cheapest no-till, no biomass option at $173.84/acre compared to $215.60 and $217.29 per acre for

NTGG W/O and NTWG W/O, respectively. The lowest cost of the no-till, biomass options is the NTWG With at the cost of $283.12 per acre (Table 4.2). Sitting at $442.06/acre, the highest is the NTWPPS With and it is the costliest of all the 11 systems. The two no-till systems with both a biomass and non-biomass component that have the biggest difference between them are the NTWDPS systems. To produce the rotation with biomass would cost more than twice the amount it would take to produce only grain from the system.

To summarize, the systems with biomass production cost more than their non-biomass production counterparts due to more harvesting costs and applications of fertilizer to replace nutrients. Biomass production systems that include DPS and PPS have higher biomass costs because of the higher biomass yields. It is the cheapest to go with the NTWDPS W/O system, and the NTWPPS With is the most expensive out of all the 11 different systems. The rest of the systems range from $203.82/acre to $393.51/acre.

4.4 Net Returns Comparison

There are two approaches to calculating the net returns. In the first approach, the net returns are calculated in the Excel budgets by taking into account only the averages of the prices and yields with no other statistical measure or distribution. It also shows the breakdown of costs, gross returns, and net returns. The results of the first approach are presented in Table 4.3. The second approach uses the net returns calculated through 2,000 iterations simulating prices and yield figures in SIMETAR©. It factors in the mean of the simulation runs, which include the averages of the prices and yields, as well as their correlations, standard deviations, and the minimum and maximum numbers. The results under the second approach are presented in Table 4.4.

Visually, the net returns in the two approaches are very similar, but the net returns presented in Table 4.4 are a slightly more precise measure of the expected net returns. Consequently, in the discussion of the outcomes and interpretations, more attention is given to the net returns from the simulation. Table 4.5 represents the net return statistics once the 2,000 iterations are processed in SIMETAR© for the different contract scenarios. The mean net returns in Table 4.5 are inserted in Table 4.4.

Both Table 4.3 and Table 4.4 report the net returns found in each of the contract scenarios: Spot Market Contract, Minimum Price Contract, BCAP Contract, and the Gross Revenue Guarantee Contract at 60% and 100% of the target revenue based on estimated market price. To note, the crop systems that do not produce biomass don't change in net returns per acre. The contracts scenarios only change the net revenues of the systems that have biomass production.

4.4.1 Net Returns Under Spot Market Contract

Under Table 4.4, the highest net returns received will be through the NTWDPS With system at $259.40 per acre. The NTWPPS system has the lowest net returns. It sits at $81.65/acre, less than one-third of the highest returns amount. Recall that NTWPPS also had the highest costs out of the different systems due to producing the highest amounts of sorghum biomass. The rest of the systems range from $152.33 to $204.52 per acre. If the system has both a biomass and non-biomass option, it varies which option has higher net returns than its counterpart. The RTGG and NTGG systems with biomass production have net returns that are smaller than the non-biomass ones. On the other hand, the RTWG, NTWG, and NTWDPS biomass production systems have higher returns than their non-biomass producing counterparts.

4.4.2 Net Returns under Minimum Price Contract

The $70 minimum price is slightly higher than the market price in this research. Therefore, the net revenues will be slightly higher. The highest amount is $266.41/acre for the NTWDPS With (Table 4.4). The smallest amount is found to be $89.79/acre under the NTWPPS system. The other 9 systems range in price per acre from $154.04 to $206.11. Under this contract scenario, all the biomass production systems have higher net returns than their non-biomass producing equivalents.

4.4.3 Net Returns under BCAP Price Contract

The trends under the BCAP Price Contract are the same as the ones in the minimum price scenario. The highest net returns earning is still seen in the NTWDPS With system at $343.80/acre. The lowest is no longer the NTWPPS system, but the RTGG W/O system at $154.04 per acre. This can be accounted by the fact that the $20/ton is for biomass production and makes NTWPPS more profitable than RTGG W/O. The range for the other systems goes from $180.29 to $224.18 per acre (Table 4.4).

4.4.4 Net Returns under Gross Revenue Guarantee Contract

There are 2 gross revenue guarantee percentages: 60% (Table 3.12) and 100% (Table 3.13) of the target revenue based on the estimated biomass price of $69.24/ton.

Under the 60% Gross Revenue Guarantee contract, NTWPPS has the lowest net returns of the systems (Table 4.4). NTWDPS With has the highest net returns at $259.40/acre. The other 9 systems' net returns fall between $153.13/acre and $205.55/acre. All but the RTGG With system has smaller net returns than their non-biomass system complements. NTWDPS With is almost $74/acre more than NTWDPS W/O.

The highest net return under the 100% Gross Revenue Guarantee contract belongs to NTWDPS With at $273.54/acre and the lowest coming in at $106.47/acre from NTWPPS. All of the systems with biomass production have higher net returns per acre than their non-biomass producing counterparts.

4.4.5 Net Returns Comparison Overview

Figure 4.1 presents a vertical bar chart to visually display the net returns comparison results. The BCAP Price Contract holds the highest net returns out of all the contract scenarios at $343.80/acre under the NTWDPS With system. NTWDPS With under the 100% Gross Revenue Guarantee contract has the second highest net returns at $273.54/acre. The lowest net return found is in the NTWPPS system under the Spot Market contract calculated at $81.65/acre. The spot market scenario has the trend of lower net returns in RTGG With and NTGG With than RTGG W/O and NTGG W/O, but RTWG With, NTWG With, and NTWDPS With have higher returns than their non-biomass producing counterparts. The 100% Revenue Guarantee contract, Minimum Price contract, and the BCAP contract have the same net return trend in that all of the biomass producing systems makes more than the non-biomass producing systems under the same crop rotations. In the 60% Gross Revenue Guarantee contract, the only biomass producing system that has lower net returns than the non-producing system is RTGG With.

Chapter 4-Results, Part 1 Tables and Figures

Figure 4.1 Net Returns Comparison Across Systems and Contracts ($/acre)

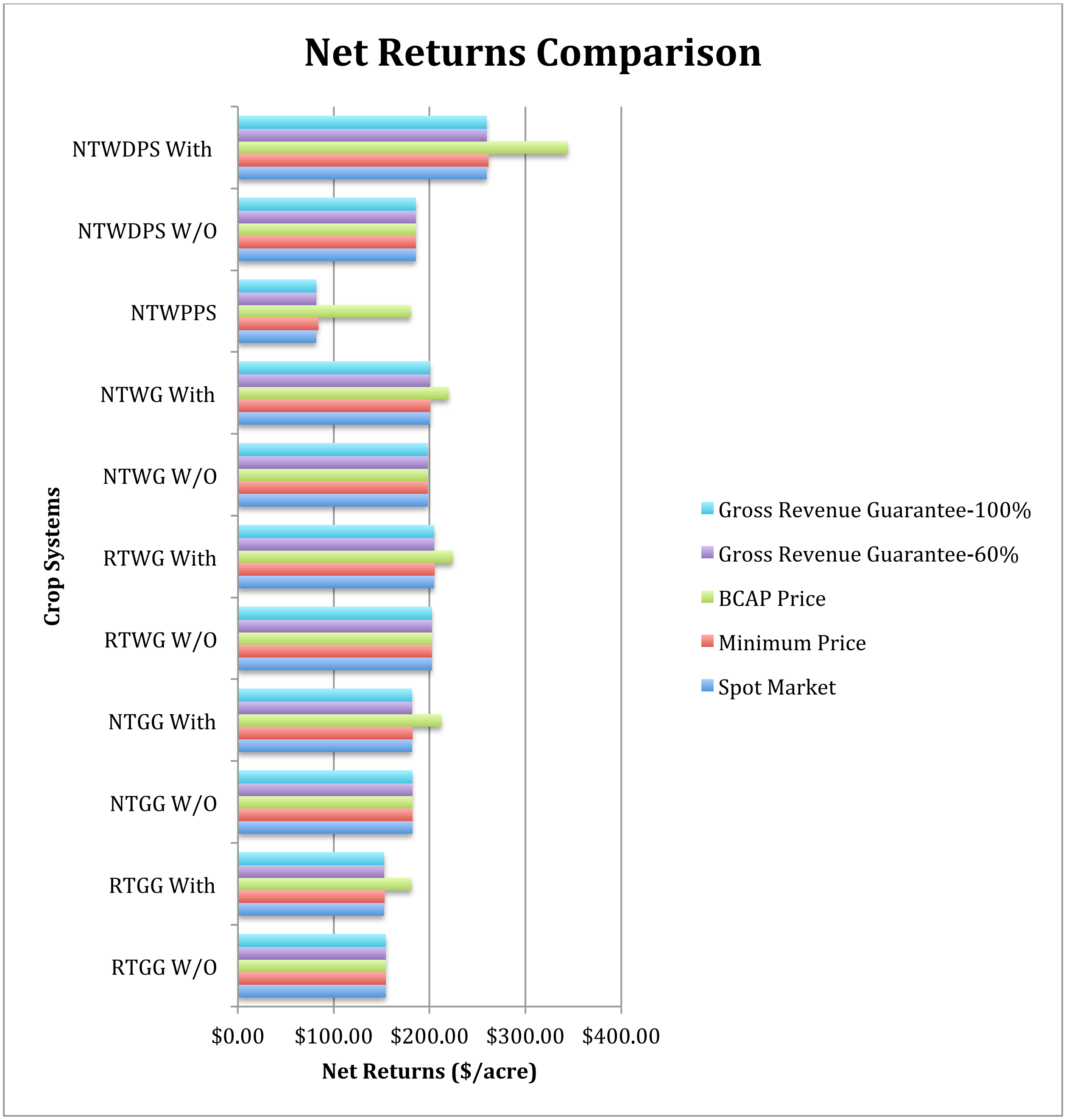


Table 4.2 Costs of the Crops and Tillage Systems ($/acre)

Panel A

System	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With
Grain costs						
Field Operations	$32.35	$32.35	$0.00	$0.00	$43.12	$43.12
Planting	16.59	16.59	18.05	18.05	33.99	33.99
Seeds	10.50	10.50	10.50	10.50	25.80	25.80
Chemicals (application+ inputs)	31.22	31.22	53.90	53.90	39.13	39.13
Fertilizer (application + inputs)	91.48	91.48	91.48	91.48	184.55	184.55
Harvest	33.44	33.44	34.38	34.38	67.27	67.27
Interest (7%)	7.55	7.55	7.29	7.29	13.78	13.78
Biomass Costs						
Fertilizer (application +inputs)		33.06		35.71		45.40
Harvest		64.80		68.53		82.27
Interest		3.43		3.65		4.47
Total Cost W/O Biomass	**$223.13**		**$215.60**		$407.64/2= **$203.82**	
Total Cost With Biomass		**$324.42**		**$323.49**		$539.78/2= **$269.89**

Panel B

System	NTWG W/O	NTWG With	NTWPPS With	NTWDPS W/O	NTWDPS With
Grain costs					
Field Operations	$0.00	$0.00	$0.00	$0.00	$0.00
Planting	35.45	35.45	35.45	35.45	35.45
Seeds	25.80	25.80	32.11	32.11	32.11
Chemicals (application+ inputs)	106.22	106.22	53.39	53.39	53.39
Fertilizer (application + inputs)	184.55	184.55	152.35	152.35	152.35
Harvest	67.85	67.85	30.07	62.61	62.61
Interest (7%)	14.70	14.70		11.76	11.76
Biomass Costs					
Fertilizer (application +inputs)		45.22	203.02		130.27
Harvest		82.00	347.83		294.21
Interest		4.45	29.90		14.86
Total Cost W/O Biomass	$434.57/2= **$217.29**			$347.67/2= **$ 173.84**	
Total Cost With Biomass		$566.24/2= **$283.12**	$884.12/2= **$442.06**		$787.01/2= **$393.51**

Table 4.3 Average Net Returns Calculated with Average Yields and Average Prices ($/acre)

	Spot Market	Minimum Price	BCAP Price	Gross Revenue Guarantee-60%	Gross Revenue Guarantee -100%
RTGG W/O	$154.19	$154.19	$154.19	$154.19	$154.19
RTGG With	$152.39	$153.00	$180.99	$152.39	$152.39
NTGG W/O	$181.80	$181.80	$181.80	$181.80	$181.80
NTGG With	$181.35	$182.00	$212.23	$181.35	$181.35
RTWG W/O	$202.20	$202.20	$202.20	$202.20	$202.20
RTWG With	$204.44	$204.86	$224.08	$204.44	$204.44
NTWG W/O	$197.97	$197.97	$197.97	$197.97	$197.97
NTWG With	$200.16	$200.57	$219.72	$200.16	$200.16
NTWPPS	$81.47	$83.55	$180.11	$81.47	$81.47
NTWDPS W/O	$185.57	$185.57	$185.57	$185.57	$185.57
NTWDPS With	$259.50	$261.29	$343.90	$259.50	$259.50

Table 4.4 Average Net Returns Calculated with Simulated Yields and Prices ($/acre)

	Spot Market	Minimum Price	BCAP Price	Gross Revenue Guarantee-80%	Gross Revenue Guarantee-100%
RTGG W/O	$154.04	$154.04	$154.04	$154.04	$154.04
RTGG With	$152.33	$154.64	$180.92	$153.13	$164.34
NTGG W/O	$181.72	$181.72	$181.72	$181.72	$181.72
NTGG With	$181.37	$183.85	$212.25	$182.19	$194.76
RTWG W/O	$202.20	$202.20	$202.20	$202.20	$202.20
RTWG With	$204.52	$206.11	$224.18	$205.55	$213.82
NTWG W/O	$198.06	$198.06	$198.06	$198.06	$198.06
NTWG With	$200.31	$201.90	$219.87	$200.72	$208.08
NTWPPS	$81.65	$89.79	$180.29	$81.71	$106.47
NTWDPS W/O	$185.48	$185.48	$185.48	$185.48	$185.48
NTWDPS With	$259.40	$266.41	$343.80	$259.40	$273.54

Table 4.5 Simulated Net Return Distribution Characteristics by Contract Scenario

Panel A

SIMETAR$^{\copyright}$ Simulation Results for 500 Iterations © 2011.

Variable	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With	NTWPPS	NTWDPS W/O	NTWDPS With
Spot Market Contract											
Mean	$154.04	$152.33	$181.72	$181.37	$202.20	$204.52	$198.06	$200.31	$81.65	$185.48	$259.40
St. Dev.	$107.58	$111.21	$116.11	$120.25	$100.40	$102.68	$96.29	$97.91	$51.68	$90.62	$91.03
CV	69.84%	73.00%	63.90%	66.30%	49.65%	50.21%	48.62%	48.88%	63.30%	48.86%	35.09%
Min	-$90.73	-$104.07	-$79.67	-$92.75	-$38.68	-$43.71	-$34.76	-$38.39	-$51.23	-$9.33	$45.18
Max	$557.85	$572.28	$619.20	$636.64	$538.31	$539.13	$525.04	$524.75	$274.59	$491.67	$575.13
Minimum Price Contract											
Mean	$154.04	$154.64	$181.72	$183.85	$202.20	$206.11	$198.06	$201.90	$89.79	$185.48	$266.41
St. Dev.	$107.58	$111.46	$116.11	$120.53	$100.40	$102.85	$96.29	$97.99	$49.72	$90.62	$89.91
CV	69.84%	72.08%	63.90%	65.56%	49.65%	49.90%	48.62%	48.53%	55.37%	48.86%	33.75%
Min	-$90.73	-$102.03	-$79.67	-$90.61	-$38.68	-$43.71	-$34.76	-$38.39	-$33.13	-$9.33	$62.42
Max	$557.85	$572.28	$619.20	$636.64	$538.31	$543.65	$525.04	$528.78	$274.59	$491.67	$575.13
BCAP Contract											
Mean	$154.04	$180.92	$181.72	$212.25	$202.20	$224.18	$198.06	$219.87	$180.29	$185.48	$343.80
St. Dev.	$107.58	$117.06	$116.11	$126.91	$100.40	$106.44	$96.29	$100.52	$58.55	$90.62	$90.94
CV	69.84%	73.00%	63.90%	66.30%	49.65%	50.21%	48.62%	48.88%	63.30%	48.86%	35.09%
Min	-$90.73	-$92.05	-$79.67	-$80.15	-$38.68	-$36.84	-$34.76	-$29.24	$22.81	-$9.33	$120.19
Max	$557.85	$618.31	$619.20	$686.85	$538.31	$572.41	$525.04	$546.15	$393.79	$491.67	$657.51

Table 4.5 Simulated Net Return Distribution Characteristics by Contract Scenario - Continued

Panel B

SIMETAR© Simulation Results for 500 Iterations © 2011.

Variable	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With	NTWPPS	NTWDPS W/O	NTWDPS With
Gross Revenue Guarantee - 60%											
Mean	$154.04	$153.13	$181.72	$182.19	$202.20	$205.55	$198.06	$200.72	$81.71	$185.48	$259.40
St. Dev.	$107.58	$120.26	$116.11	$130.67	$100.40	$101.74	$96.29	$97.58	$65.45	$90.62	$91.49
CV	69.84%	78.54%	63.90%	71.72%	49.65%	49.50%	48.62%	48.61%	80.11%	48.86%	35.27%
Min	-$90.73	-$112.78	-$79.67	-$101.54	-$38.68	-$27.06	-$34.76	-$29.88	-$92.90	-$9.33	$29.27
Max	$557.85	$601.80	$619.20	$669.37	$538.31	$539.13	$525.04	$524.75	$312.21	$491.67	$586.74
Gross Revenue Guarantee - 100%											
Mean	$154.04	$164.34	$181.72	$194.76	$202.20	$213.82	$198.06	$208.08	$106.47	$185.48	$273.54
St. Dev.	$107.58	$111.95	$116.11	$121.54	$100.40	$97.47	$96.29	$94.31	$52.72	$90.62	$90.63
CV	69.84%	68.12%	63.90%	62.41%	49.65%	45.58%	48.62%	45.32%	49.52%	48.86%	33.13%
Min	-$90.73	-$73.19	-$79.67	-$58.78	-$38.68	-$1.95	-$34.76	-$2.81	-$18.48	-$9.33	$66.37
Max	$557.85	$601.80	$619.20	$669.37	$538.31	$539.13	$525.04	$524.75	$312.21	$491.67	$586.74

Part 2 –Stochastic Efficiency, StopLight

4.5 Stochastic Efficiency with Respect to a Function (SERF) Analysis

The results of SERF are presented in both tables and graphs generated by SIMETAR©. The table lists the risks premiums in relation to the preferred cropping system. It tells us the minimum amount of net returns it will take to have the decision maker change from the most preferred system to a less preferred system (be equally preferred) depending on their risk aversion level. The graph is a line graph representation of the risk premiums across the risk levels from 0 (risk neutral) to .0053 (risk adverse). The values along the vertical axis are negative because you would need to pay a producer more in net returns ($/acre) for the system to be equally preferred to the most preferred system.

When a system has a negative correlation between the absolute risk premiums and the ARAC, it means that it will take less money for a system to be preferred as the risk aversion preference increases. For example, under the Spot Market Contract in Part 2, NTWPPS relative to NTWDPS With has a negative correlation (Table 4.11 and Figure 4.14). At the ARAC of 0, the additional amount to make it equally preferred is $177.75. But when the ARAC increases to .0053, the amount decreases to $164.13/acre. When a system has a positive correlation, it will take more in net returns per acre as the risk coefficient increases for a decision maker to equally prefer it to the superior system. The RTGG W/O system under the Spot Market contract in Part 2 represents a positive correlation. At 0, the net return value is $105.36/acre but increases to $112.42/acre when the ARAC increases to .0053. Because the correlations are based on the absolute risk aversion coefficients and the graphs presents the RACs as negative numbers, when there is a positive correlation, it is presented as a downward sloping line on the SERF graphs. A negative correlation appears as an upward sloping line. The negative and positive correlations are due to the shapes of the net return distributions.

The risk premiums change across the 5 different contract scenarios. The crop system that is selected to compare the other systems to changes as well, depending on the one that gives the most utility under SERF. In all cases, the range of absolute risk aversion coefficients (ARACs) will remain the same.

4.5.1 SERF Results Under Spot Market Contract

The cropping systems are in relation to NTWDPS With under the Spot Market contract. Table 4.8 lists the risk premiums for this scenario. At an ARAC of 0, it would take an additional $54.87 per acre more for a risk neutral producer to switch from growing the NTWDPS With rotation to the RTWG With rotation, the closest in utility to NTWDPS With. At an ARAC of .0027, it would take $57.65/acre more to switch and an additional $2.41 more at the highest risk aversion level.

The system that is least superior to NTWDPS With is NTWPPS. A producer would need to be provided with $177.75, $170.62, and $164.13 more per acre at the 0, .0027, and .0053 coefficients respectively to be preferred (Table 4.8). It takes more money as the risk aversion level increases to persuade the decision maker to switch from NTWDPS With to RTWG With. In contrast, it takes less money when trying to negotiate a switch from NTWDPS With to NTWPPS. The trend of increasing monetary values when risk aversion increases appear in RTGG W/O, RTGG With, NTGG W/O, NTGG With, RTWG W/O, NTWG W/O, and NTWG With. Like the trend seen in NTWPPS, the amount needed to switch decreases in NTWDPS W/O as risk aversions increase. Figure 4.9 presents a line graph representation of the risk premiums for the Spot Market contract.

4.5.2 SERF Results Under Minimum Price Contract

The risk premiums are relative to NTWDPS With under the Minimum Price Contract. The closest in utility is RTWG With and the farthest is NTWPPS, same as in the Spot Market contract scenario. At the ARAC values of 0, .0027, and .0053, it would take $60.30, $63.39, and $66.11 more per acre in net returns for RTWG With to be preferred (Table 4.9). This shows a positive correlation between risk premiums and the value of risk aversion. All but the cropping system NTWPPS have this positive correlation.

NTWPPS would take the most in additional net returns for it to be equally preferred to NTWDPS With. When risk neutral, it would take $176.62 more per acre. At a higher risk adverse level (.0027), an additional $169.50/acre would be required. At the highest risk aversion preference, $163.02/acre more would be necessary for equal preference. Figure 4.10 is the graphical representation of the risk premiums along the horizontal axis values for the risk aversion bounds.

4.5.3 SERF Results Under BCAP Price Contract

Like the Spot Market contract and Minimum Price contract scenarios, the risk premiums under the BCAP Price contract are relative to NTWDPS With. RTWG With is again closest in utility, but the farthest is now RTGG W/O. At the 3 risk aversion values of 0, .0027, and .0053, it would take $119.62/acre, $123.39/acre, and $126.66/acre more in net returns for RTWG With to be just as preferred as NTWDPS With under the BCAP contract

(Table 4.10). For RTGG W/O to be in equal preference, it would require $189.75, $193.67, and $196.81 more per acre.

There are two systems that do not show the positive correlation between the ARAC value and the risk premiums amount: NTWPPS and NTWDPS W/O. They both demonstrate an inverted correlation (Figure 4.11)

4.5.4 SERF Results Under Gross Revenue Guarantee Contract

Gross Revenue Guarantee – 60%

The NTWDPS With system is again the highest in utility of net returns under the 60% Gross Revenue Guarantee contract. RTWG With is the second most preferred and will need an additional $53.85, $56.23, and $58.17 per acre to be equally preferred to NTWDPS With at the ARAC of 0, .0027, and .0053, respectively (Table 4.11).

NTWPPS has the highest risk premiums in this contract scenario and to be equally preferred will require $168.02 to $177.69 more in net returns along the risk spectrum. NTWPPS and NTWDPS W/O both show a negative correlation between the ARACs and the absolute risk premiums (Figure 4.12).

Gross Revenue Guarantee – 100%

For the 100% guarantee contract scenario, the NTWDPS With is the system with the highest utility and the risk premiums are relative to it (Table 4.12). RTWG With has the second highest utility. When the decision maker is risk neutral, an extra $59.72/acre in net returns will make RTWG With equally preferred to NTWDPS With. When the decision maker is slightly more risk adverse, $61.24 per acre more in net returns will make RTWG With equally preferred. At the highest risk aversion level of .0053, it will take more to make it equally preferred at a value of $62.48 more per acre. NTWPPS is still the system with the lowest utility of net returns. At an ARAC of 0, .0027, and .0053, the risk premiums are $167.07/acre, $160.16/acre, and $153.85/acre, respectively.

There are 2 systems with a negative correlation: NTWPPS, and NTWDPS W/O. The other 8 have a positive correlation, which means it will take more in additional net returns the higher the risk aversion preference becomes. Figure 4.13 presents the line graph representation of the risk premiums as they change with the risk aversion level.

4.5.5 SERF Results Overview

The Stochastic Efficiency with Respect to a Function (SERF) results provide an analysis of the risk premium values as risk aversion changes. Under all the contract scenarios, NTWDPS With has the highest utility and the risk premiums are calculated in relation to it. NTWPPS is the lowest in utility in all contract scenarios except the BCAP scenario, where RTGG W/O is the lowest.

4.6 StopLight Analysis

StopLight is a graphical tool within SIMETAR©. Using the net return distributions, it displays the probabilities of net returns being above an upper cut-off value or below a lower cut-off value, or in-between the upper and lower cut-off values. The upper and lower cut-off values are one standard deviation above and below the mean (net return), respectively (Ascough II et al. 2009). It uses color code to illustrate unfavorable (red), cautionary, (yellow), or favorable (green) probability levels. Red represents the probability that the systems' net returns will be less than the lower cut-off value. The yellow is the probability that the net returns for that system will be between the lower and upper cut-off values. The probabilities in green (favorable) represent the percentage that the net returns will be greater than the upper cut-off value.

Table 4.13 presents the summary of StopLight analysis of crop systems under the Spot Market contract scenario. The upper cut-off value is $152.33 and the lower cut-off value is $0.00. All the StopLight tables are structured the same. The first row lists the probabilities that a system is unfavorable, or described as the probability that a system will have net returns below the lower cut-off value. For example, for RTGG W/O there's a 5% chance that its net returns will be lower than $0.00 (Table 4.13). The second row lists the probabilities of a system having net returns between $47.41 and $259.41. NTWDPS With has a 39% chance of its net returns lying between the two cut-off values (Table 4.13). The third row lists the favorable probabilities, or the chance a crop system will have net returns above the upper cut-off value. Figure 4.14 puts the percentages in bar chart form. The percentages for the systems that do not produce biomass will not change across the contract scenarios.

NTWPPS has a 9% chance of its net returns being above $152.33 seen as 9% within the green portion, while NTWDPS With has a 0% chance of its net returns being lower than $0.00, seen as 0% in the red area (Table 4.13). For further comparisons, Table C.1 – C.4 and Figure C.1 – C.4 in Appendix C are the other StopLight Analysis results from the other 4 contract scenarios.

4.7 Stochastic Efficiency Analysis Across Contract Scenarios

Analysis has been done for the cropping systems within each of the 5 contract scenarios. This section will focus on the comparison of the most preferred systems within each contract scenario. The NTWDPS With is the most preferred system in all 5 contract scenarios presented.

Table 4.6 displays the net return statistics based on 2,000 iterations performed in SIMETAR© under the contracts comparison. The contract that is most preferred is the BCAP Price contract when producing NTWDPS With (Table 4.14). The 100% Gross Revenue Guarantee contract producing NTWDPS With is the second most preferred. The least preferred is the 60% Gross Revenue Guarantee.

The risk premiums are displayed in Table 4.6 and are relative to the BCAP Price contract producing NTWDPS With. The Minimum Price contract with NTWDPS With and the 100% Gross Revenue Guarantee with NTWDPS With has a negative correlation between the risk premium amount and the ARACs. For Minimum NTWDPS With to be equally preferred to BCAP NTWDPS With, it would take an extra $77.39/acre, $77.13/acre, and $76.84/acre more in net returns at the absolute risk aversion coefficient (ARAC) of 0, .0027, and .0053, respectively. The 60% Gross Revenue Guarantee contract has a positive correlation relative to the BCAP contract. Interestingly, the Spot Market contract has a positive correlation between the ARACs of 0 to .0031, and then a negative correlation from there till .0053. The graphical representation of the risk premiums for the contract comparison can be found in Figure 4.15.

The results from StopLight are displayed in Table 4.15 and Figure 4.16. The lower cut-off value is $0.00 and the upper cut-off is $164.34. The BCAP contract producing

NTWDPS With has the highest percentage of green at 99%, which translates to net returns being higher than $164.34 99% of the time.

Table 4.6 Simulated Net Returns Characteristics for each Preferred Crop System for Contract Scenarios

	Mean	St. Dev.	CV	Min	Max
SPOT-NTWDPS With	$259.40	$91.03	$35.09	$45.18	$575.13
Min-NTWDPS With	$266.41	$89.91	$33.75	$62.42	$575.13
BCAP-NTWDPS With	$343.80	$90.94	$26.45	$120.19	$657.51
60%-NTWDPS With	$259.40	$91.49	$35.27	$29.27	$586.74
100%-NTWDPS With	$273.54	$90.63	$33.13	$66.37	$586.74

4.7.1 Stochastic Efficiency Analysis Across Contract Scenarios When BCAP Price is $10/ton

To continue comparing the contract scenarios, the BCAP Price contract was changed to a lower matching payment. It now has a $10/ton matching payment for biomass material versus the original amount of $20/ton. The BCAP Price contract containing the $20/ton matching payment is kept in the data for comparison. Table 4.7 contains the net return statistics from the 2,000 iterations when run with the inclusion of the BCAP Price contract set at a matching payment of $10/ton of biomass.

The risk premiums relative to the BCAP contract do not change (Table 4.16). The only differences are now the risk premiums associated with the BCAP Price contract with the $10/ton matching payment. It demonstrates a negative correlation. At the ARAC of 0, $42.20/acre more is required for equal preference. To get the producer to switch at the ARACs of .0027 and .0053, it would take an additional $42.17 and $42.13 more per acre in net returns. The risk premiums are graphically displayed in Figure 4.17.

According to the StopLight analysis, the $10/ton BCAP contract will have higher returns of $164.34 95% of the time, be between the values of $0 and $164.34 5% of the time, and be below the lower cut-off value 0% of the time (Table 4.17 and Figure 4.18).

Table 4.7 SIMETAR© Net Returns Simulation Results under Contracts Comparison with $10/ton BCAP Payment - Part 2

	Mean	St. Dev.	CV	Min	Max
SPOT-NTWDPS With	$259.40	$91.03	$35.09	$45.18	$575.13
Min-NTWDPS With	$266.41	$89.91	$33.75	$62.42	$575.13
BCAP-NTWDPS With	$343.80	$90.94	$26.45	$120.19	$657.51
60%-NTWDPS With	$259.40	$91.49	$35.27	$29.27	$586.74
100%-NTWDPS With	$273.54	$90.63	$33.13	$66.37	$586.74
BCAP 10-NTWDPS With	$301.60	$90.86	$30.12	$82.68	$612.90

Chapter 4-Results, Part 2 Tables and Figures

Table 4.8 Risk Premiums Relative to NTWDPS With under the Spot Market Contract - Part 2

ARAC	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With	NTWPPS	NTWDPS W/O	NTWDPS With
0	(105.36)	(107.07)	(77.68)	(78.03)	(57.19)	(54.87)	(61.34)	(59.08)	(177.75)	(73.92)	-
0.0002	(105.72)	(107.52)	(78.25)	(78.71)	(57.39)	(55.12)	(61.45)	(59.23)	(177.13)	(73.91)	-
0.0004	(106.07)	(107.96)	(78.81)	(79.37)	(57.58)	(55.37)	(61.55)	(59.37)	(176.51)	(73.90)	-
0.0007	(106.42)	(108.39)	(79.35)	(80.02)	(57.78)	(55.61)	(61.66)	(59.51)	(175.91)	(73.90)	-
0.0009	(106.76)	(108.81)	(79.89)	(80.66)	(57.97)	(55.85)	(61.77)	(59.65)	(175.30)	(73.89)	-
0.0011	(107.09)	(109.23)	(80.42)	(81.29)	(58.15)	(56.08)	(61.87)	(59.79)	(174.70)	(73.88)	-
0.0013	(107.42)	(109.64)	(80.93)	(81.90)	(58.34)	(56.31)	(61.97)	(59.92)	(174.11)	(73.87)	-
0.0015	(107.74)	(110.04)	(81.44)	(82.51)	(58.52)	(56.54)	(62.08)	(60.06)	(173.51)	(73.86)	-
0.0018	(108.06)	(110.44)	(81.93)	(83.10)	(58.70)	(56.77)	(62.18)	(60.19)	(172.93)	(73.85)	-
0.0020	(108.37)	(110.83)	(82.42)	(83.68)	(58.87)	(56.99)	(62.28)	(60.33)	(172.34)	(73.84)	-
0.0022	(108.67)	(111.21)	(82.90)	(84.25)	(59.05)	(57.21)	(62.38)	(60.46)	(171.77)	(73.83)	-
0.0024	(108.97)	(111.59)	(83.36)	(84.81)	(59.22)	(57.43)	(62.48)	(60.59)	(171.19)	(73.82)	-
0.0027	(109.27)	(111.96)	(83.82)	(85.36)	(59.39)	(57.65)	(62.58)	(60.72)	(170.62)	(73.81)	-
0.0029	(109.56)	(112.33)	(84.27)	(85.90)	(59.56)	(57.86)	(62.68)	(60.85)	(170.06)	(73.80)	-
0.0031	(109.84)	(112.69)	(84.71)	(86.43)	(59.73)	(58.07)	(62.78)	(60.98)	(169.50)	(73.79)	-
0.0033	(110.12)	(113.04)	(85.15)	(86.95)	(59.89)	(58.28)	(62.88)	(61.11)	(168.94)	(73.78)	-
0.0035	(110.39)	(113.39)	(85.57)	(87.46)	(60.05)	(58.49)	(62.97)	(61.23)	(168.39)	(73.77)	-
0.0038	(110.66)	(113.73)	(85.99)	(87.96)	(60.21)	(58.69)	(63.07)	(61.36)	(167.84)	(73.76)	-
0.0040	(110.93)	(114.07)	(86.40)	(88.45)	(60.37)	(58.89)	(63.16)	(61.48)	(167.30)	(73.75)	-
0.0042	(111.19)	(114.40)	(86.80)	(88.94)	(60.53)	(59.09)	(63.26)	(61.61)	(166.76)	(73.74)	-
0.0044	(111.44)	(114.72)	(87.19)	(89.41)	(60.69)	(59.29)	(63.35)	(61.73)	(166.23)	(73.72)	-
0.0046	(111.70)	(115.04)	(87.58)	(89.88)	(60.84)	(59.49)	(63.45)	(61.85)	(165.70)	(73.71)	-
0.0049	(111.94)	(115.36)	(87.96)	(90.34)	(60.99)	(59.68)	(63.54)	(61.97)	(165.17)	(73.70)	-
0.0051	(112.18)	(115.67)	(88.33)	(90.79)	(61.14)	(59.87)	(63.63)	(62.09)	(164.65)	(73.69)	-
0.0053	(112.42)	(115.97)	(88.70)	(91.23)	(61.29)	(60.06)	(63.72)	(62.21)	(164.13)	(73.67)	-

Figure 4.9 Risk Premiums Relative to NTWDPS With under the Spot Market Contract Graph - Part 2

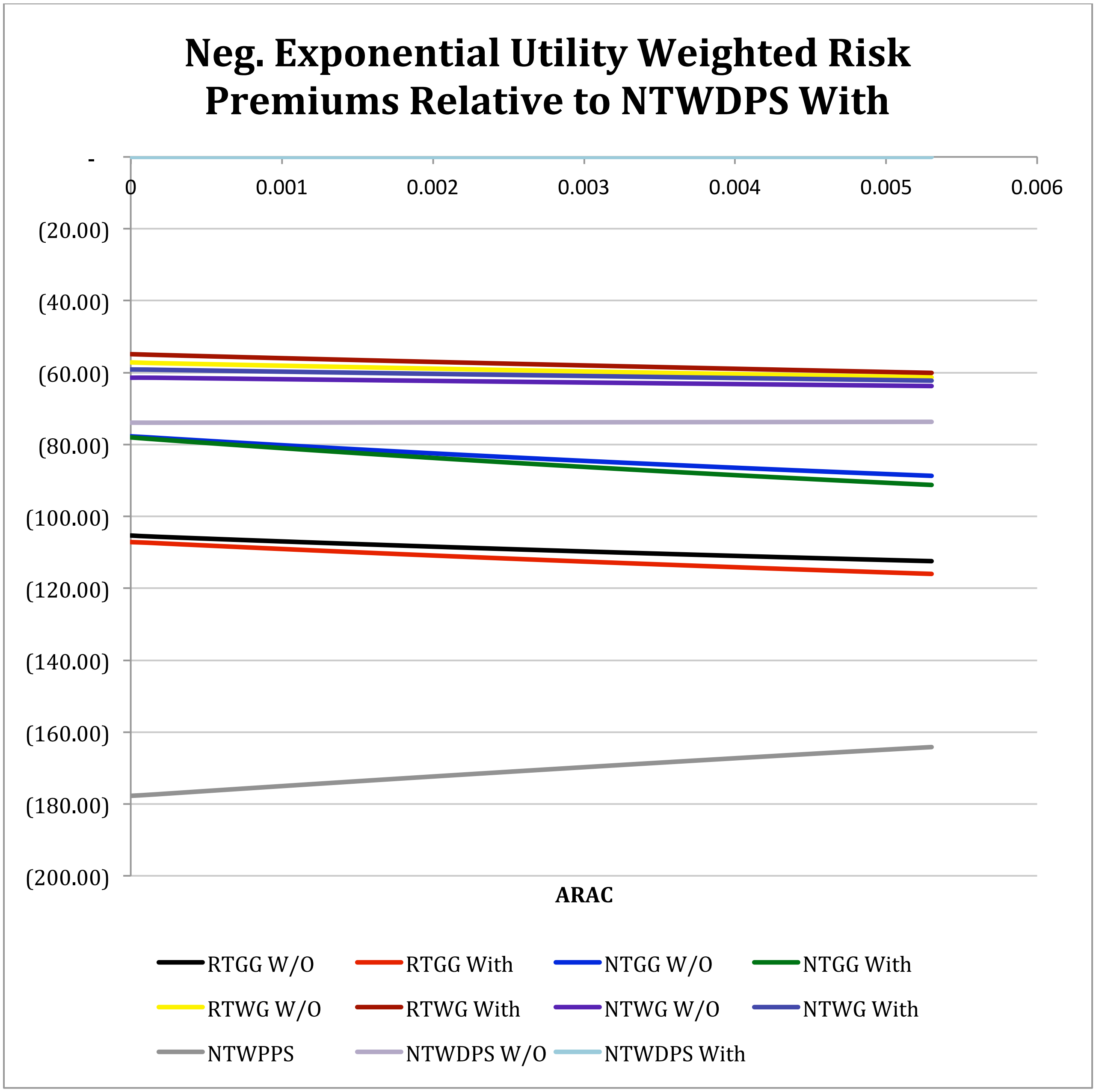


Table 4.9 Risk Premiums Relative to NTWDPS With under the Minimum Price Contract - Part 2

ARAC	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With	NTWPPS	NTWDPS W/O	NTWDPS With
0	(112.37)	(111.77)	(84.69)	(82.56)	(64.21)	(60.30)	(68.35)	(64.51)	(176.62)	(80.93)	-
0.0002	(112.75)	(112.25)	(85.28)	(83.26)	(64.42)	(60.58)	(68.48)	(64.68)	(176.00)	(80.95)	-
0.0004	(113.12)	(112.71)	(85.86)	(83.96)	(64.64)	(60.85)	(68.61)	(64.84)	(175.39)	(80.96)	-
0.0007	(113.49)	(113.17)	(86.43)	(84.64)	(64.85)	(61.11)	(68.74)	(65.01)	(174.78)	(80.97)	-
0.0009	(113.86)	(113.63)	(86.99)	(85.30)	(65.07)	(61.38)	(68.87)	(65.17)	(174.17)	(80.99)	-
0.0011	(114.21)	(114.07)	(87.54)	(85.96)	(65.27)	(61.64)	(68.99)	(65.33)	(173.58)	(81.00)	-
0.0013	(114.56)	(114.51)	(88.08)	(86.61)	(65.48)	(61.90)	(69.12)	(65.49)	(172.98)	(81.02)	-
0.0015	(114.91)	(114.94)	(88.60)	(87.24)	(65.68)	(62.15)	(69.25)	(65.65)	(172.39)	(81.03)	-
0.0018	(115.25)	(115.37)	(89.12)	(87.86)	(65.89)	(62.41)	(69.37)	(65.81)	(171.80)	(81.04)	-
0.0020	(115.58)	(115.79)	(89.63)	(88.47)	(66.09)	(62.65)	(69.49)	(65.97)	(171.22)	(81.05)	-
0.0022	(115.91)	(116.20)	(90.13)	(89.07)	(66.28)	(62.90)	(69.62)	(66.13)	(170.64)	(81.07)	-
0.0024	(116.23)	(116.61)	(90.62)	(89.66)	(66.48)	(63.15)	(69.74)	(66.28)	(170.07)	(81.08)	-
0.0027	(116.55)	(117.00)	(91.10)	(90.24)	(66.67)	(63.39)	(69.86)	(66.43)	(169.50)	(81.09)	-
0.0029	(116.86)	(117.40)	(91.57)	(90.81)	(66.86)	(63.63)	(69.98)	(66.59)	(168.94)	(81.10)	-
0.0031	(117.16)	(117.78)	(92.04)	(91.36)	(67.05)	(63.86)	(70.10)	(66.74)	(168.38)	(81.12)	-
0.0033	(117.47)	(118.17)	(92.49)	(91.91)	(67.24)	(64.10)	(70.22)	(66.89)	(167.82)	(81.13)	-
0.0035	(117.76)	(118.54)	(92.94)	(92.45)	(67.42)	(64.33)	(70.34)	(67.04)	(167.27)	(81.14)	-
0.0038	(118.05)	(118.91)	(93.38)	(92.98)	(67.60)	(64.56)	(70.46)	(67.19)	(166.72)	(81.15)	-
0.0040	(118.34)	(119.27)	(93.81)	(93.50)	(67.78)	(64.79)	(70.58)	(67.34)	(166.18)	(81.16)	-
0.0042	(118.62)	(119.63)	(94.23)	(94.02)	(67.96)	(65.01)	(70.69)	(67.49)	(165.64)	(81.17)	-
0.0044	(118.90)	(119.99)	(94.65)	(94.52)	(68.14)	(65.23)	(70.81)	(67.63)	(165.11)	(81.18)	-
0.0046	(119.17)	(120.33)	(95.06)	(95.01)	(68.32)	(65.46)	(70.92)	(67.78)	(164.58)	(81.19)	-
0.0049	(119.44)	(120.68)	(95.46)	(95.50)	(68.49)	(65.67)	(71.04)	(67.92)	(164.06)	(81.20)	-
0.0051	(119.71)	(121.01)	(95.85)	(95.98)	(68.67)	(65.89)	(71.15)	(68.07)	(163.54)	(81.21)	-
0.0053	(119.97)	(121.35)	(96.24)	(96.45)	(68.84)	(66.11)	(71.27)	(68.21)	(163.02)	(81.22)	-

Figure 4.10 Risk Premiums Relative to NTWDPS With under the Minimum Price Contract Graph - Part 2

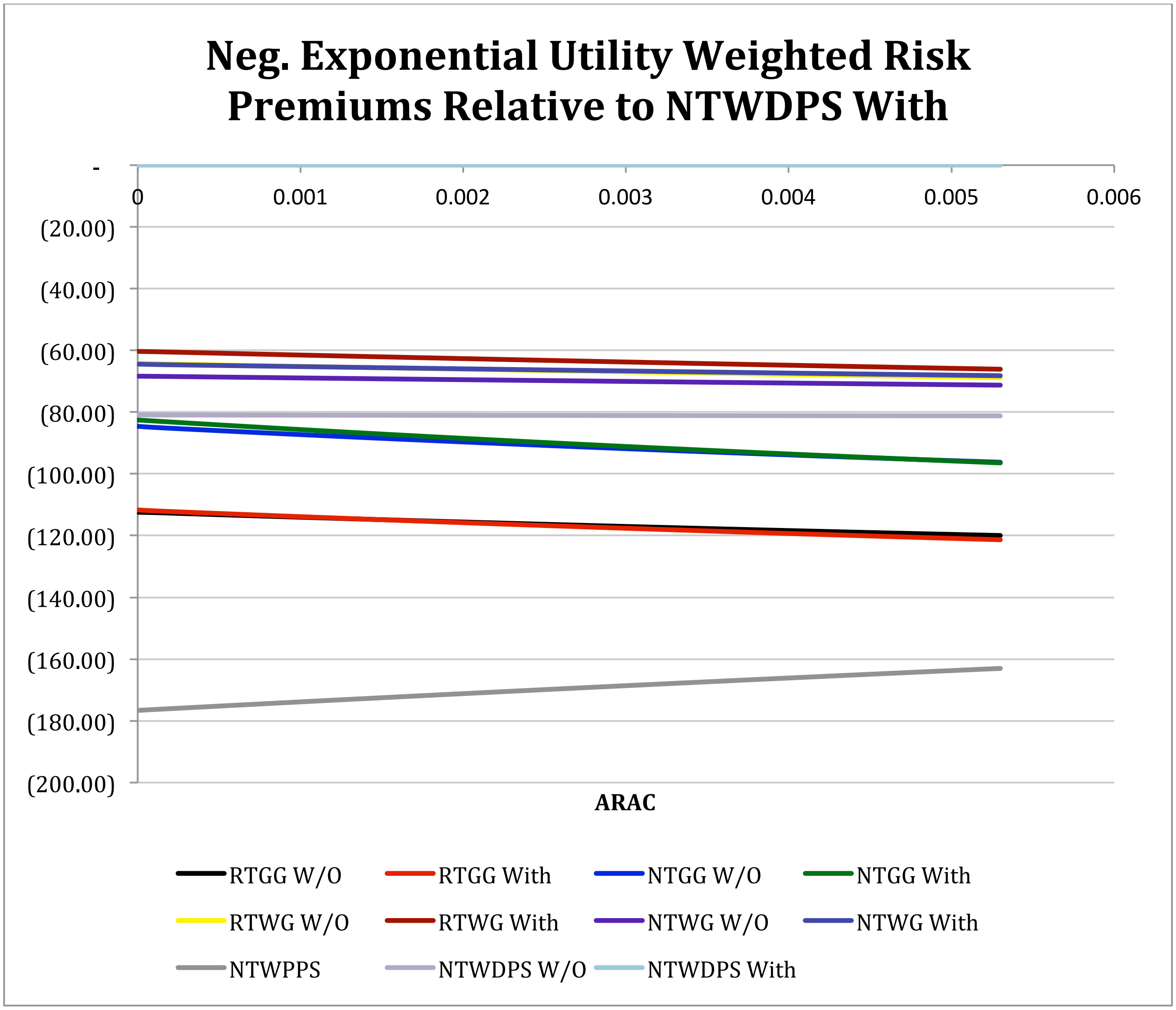


Table 4.10 Risk Premiums Relative to NTWDPS With under the BCAP Contract - Part 2

ARAC	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With	NTWPPS	NTWDPS W/O	NTWDPS With
0	(189.75)	(162.88)	(162.08)	(131.55)	(141.59)	(119.62)	(145.73)	(123.92)	(163.51)	(158.32)	-
0.0002	(190.11)	(163.47)	(162.65)	(132.41)	(141.79)	(119.96)	(145.84)	(124.12)	(162.98)	(158.31)	-
0.0004	(190.47)	(164.06)	(163.21)	(133.25)	(141.99)	(120.29)	(145.95)	(124.32)	(162.45)	(158.31)	-
0.0007	(190.82)	(164.63)	(163.76)	(134.08)	(142.18)	(120.61)	(146.06)	(124.52)	(161.93)	(158.30)	-
0.0009	(191.16)	(165.20)	(164.29)	(134.89)	(142.37)	(120.94)	(146.17)	(124.72)	(161.41)	(158.29)	-
0.0011	(191.49)	(165.76)	(164.82)	(135.69)	(142.56)	(121.26)	(146.27)	(124.91)	(160.89)	(158.28)	-
0.0013	(191.82)	(166.31)	(165.34)	(136.47)	(142.74)	(121.57)	(146.38)	(125.10)	(160.38)	(158.27)	-
0.0015	(192.15)	(166.85)	(165.84)	(137.24)	(142.92)	(121.88)	(146.48)	(125.29)	(159.87)	(158.27)	-
0.0018	(192.46)	(167.39)	(166.34)	(138.00)	(143.10)	(122.19)	(146.59)	(125.48)	(159.37)	(158.26)	-
0.0020	(192.77)	(167.91)	(166.83)	(138.74)	(143.28)	(122.50)	(146.69)	(125.67)	(158.87)	(158.25)	-
0.0022	(193.08)	(168.43)	(167.30)	(139.47)	(143.45)	(122.80)	(146.79)	(125.85)	(158.37)	(158.24)	-
0.0024	(193.38)	(168.94)	(167.77)	(140.19)	(143.63)	(123.09)	(146.89)	(126.04)	(157.88)	(158.23)	-
0.0027	(193.67)	(169.44)	(168.23)	(140.89)	(143.80)	(123.39)	(146.99)	(126.22)	(157.40)	(158.22)	-
0.0029	(193.96)	(169.93)	(168.68)	(141.58)	(143.97)	(123.68)	(147.09)	(126.40)	(156.91)	(158.21)	-
0.0031	(194.25)	(170.42)	(169.12)	(142.26)	(144.13)	(123.96)	(147.18)	(126.58)	(156.43)	(158.20)	-
0.0033	(194.52)	(170.89)	(169.55)	(142.93)	(144.29)	(124.25)	(147.28)	(126.75)	(155.96)	(158.19)	-
0.0035	(194.80)	(171.37)	(169.97)	(143.58)	(144.46)	(124.53)	(147.38)	(126.93)	(155.49)	(158.17)	-
0.0038	(195.07)	(171.83)	(170.39)	(144.23)	(144.62)	(124.80)	(147.47)	(127.10)	(155.02)	(158.16)	-
0.0040	(195.33)	(172.28)	(170.80)	(144.86)	(144.77)	(125.08)	(147.56)	(127.27)	(154.56)	(158.15)	-
0.0042	(195.59)	(172.73)	(171.20)	(145.48)	(144.93)	(125.35)	(147.66)	(127.44)	(154.11)	(158.14)	-
0.0044	(195.84)	(173.18)	(171.59)	(146.09)	(145.08)	(125.61)	(147.75)	(127.61)	(153.65)	(158.12)	-
0.0046	(196.09)	(173.61)	(171.97)	(146.69)	(145.23)	(125.88)	(147.84)	(127.78)	(153.20)	(158.11)	-
0.0049	(196.33)	(174.04)	(172.35)	(147.28)	(145.38)	(126.14)	(147.93)	(127.95)	(152.76)	(158.09)	-
0.0051	(196.57)	(174.46)	(172.72)	(147.86)	(145.53)	(126.40)	(148.02)	(128.11)	(152.31)	(158.08)	-
0.0053	(196.81)	(174.88)	(173.08)	(148.43)	(145.68)	(126.66)	(148.11)	(128.27)	(151.88)	(158.06)	-

Figure 4.11 Risk Premiums Relative to NTWDPS With under the BCAP Contract Graph - Part 2

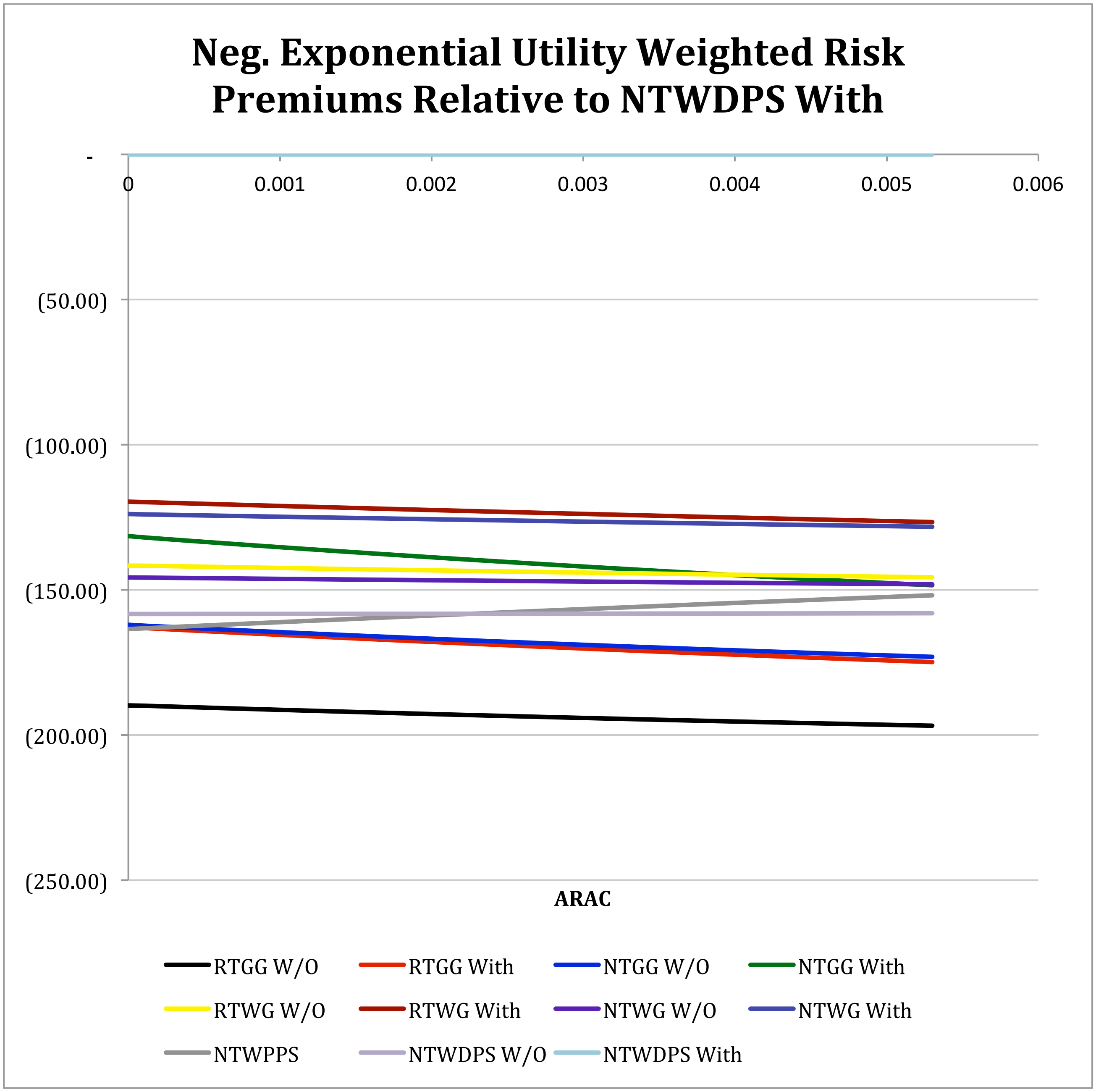


Table 4.11 Risk Premiums Relative to NTWDPS With under the 60% Gross Revenue Guarantee Contract - Part 2

ARAC	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With	NTWPPS	NTWDPS W/O	NTWDPS With
0	(105.36)	(106.27)	(77.68)	(77.21)	(57.19)	(53.85)	(61.34)	(58.68)	(177.69)	(73.92)	-
0.0002	(105.71)	(106.94)	(78.24)	(78.16)	(57.38)	(54.07)	(61.44)	(58.81)	(177.24)	(73.90)	-
0.0004	(106.05)	(107.59)	(78.79)	(79.09)	(57.57)	(54.28)	(61.53)	(58.93)	(176.80)	(73.88)	-
0.0007	(106.39)	(108.24)	(79.32)	(80.01)	(57.75)	(54.49)	(61.63)	(59.05)	(176.36)	(73.87)	-
0.0009	(106.72)	(108.87)	(79.85)	(80.91)	(57.93)	(54.70)	(61.73)	(59.17)	(175.92)	(73.85)	-
0.0011	(107.04)	(109.50)	(80.37)	(81.79)	(58.10)	(54.90)	(61.82)	(59.29)	(175.49)	(73.83)	-
0.0013	(107.36)	(110.11)	(80.87)	(82.66)	(58.27)	(55.10)	(61.91)	(59.41)	(175.06)	(73.81)	-
0.0015	(107.67)	(110.71)	(81.36)	(83.51)	(58.45)	(55.30)	(62.01)	(59.53)	(174.63)	(73.79)	-
0.0018	(107.97)	(111.31)	(81.85)	(84.34)	(58.61)	(55.49)	(62.10)	(59.65)	(174.21)	(73.77)	-
0.0020	(108.27)	(111.89)	(82.32)	(85.16)	(58.78)	(55.68)	(62.19)	(59.76)	(173.80)	(73.75)	-
0.0022	(108.57)	(112.46)	(82.79)	(85.96)	(58.94)	(55.86)	(62.28)	(59.87)	(173.38)	(73.73)	-
0.0024	(108.85)	(113.03)	(83.24)	(86.75)	(59.10)	(56.05)	(62.36)	(59.98)	(172.98)	(73.70)	-
0.0027	(109.14)	(113.58)	(83.69)	(87.52)	(59.26)	(56.23)	(62.45)	(60.09)	(172.57)	(73.68)	-
0.0029	(109.41)	(114.12)	(84.13)	(88.27)	(59.41)	(56.41)	(62.54)	(60.20)	(172.17)	(73.66)	-
0.0031	(109.68)	(114.66)	(84.56)	(89.02)	(59.57)	(56.58)	(62.62)	(60.31)	(171.77)	(73.63)	-
0.0033	(109.95)	(115.19)	(84.97)	(89.74)	(59.72)	(56.75)	(62.70)	(60.41)	(171.38)	(73.61)	-
0.0035	(110.21)	(115.70)	(85.39)	(90.46)	(59.87)	(56.92)	(62.79)	(60.52)	(170.99)	(73.58)	-
0.0038	(110.46)	(116.21)	(85.79)	(91.16)	(60.01)	(57.08)	(62.87)	(60.62)	(170.61)	(73.56)	-
0.0040	(110.71)	(116.71)	(86.18)	(91.84)	(60.16)	(57.25)	(62.95)	(60.72)	(170.23)	(73.53)	-
0.0042	(110.96)	(117.20)	(86.57)	(92.51)	(60.30)	(57.41)	(63.03)	(60.82)	(169.85)	(73.51)	-
0.0044	(111.20)	(117.68)	(86.95)	(93.17)	(60.44)	(57.57)	(63.11)	(60.92)	(169.48)	(73.48)	-
0.0046	(111.43)	(118.15)	(87.32)	(93.82)	(60.58)	(57.72)	(63.18)	(61.01)	(169.11)	(73.45)	-
0.0049	(111.66)	(118.62)	(87.68)	(94.46)	(60.71)	(57.87)	(63.26)	(61.11)	(168.74)	(73.42)	-
0.0051	(111.89)	(119.08)	(88.03)	(95.08)	(60.85)	(58.02)	(63.33)	(61.20)	(168.38)	(73.39)	-
0.0053	(112.11)	(119.52)	(88.38)	(95.69)	(60.98)	(58.17)	(63.41)	(61.30)	(168.02)	(73.36)	-

Figure 4.12 Risk Premiums Relative to NTWDPS With under the 60% Gross Revenue Guarantee Contract - Part 2

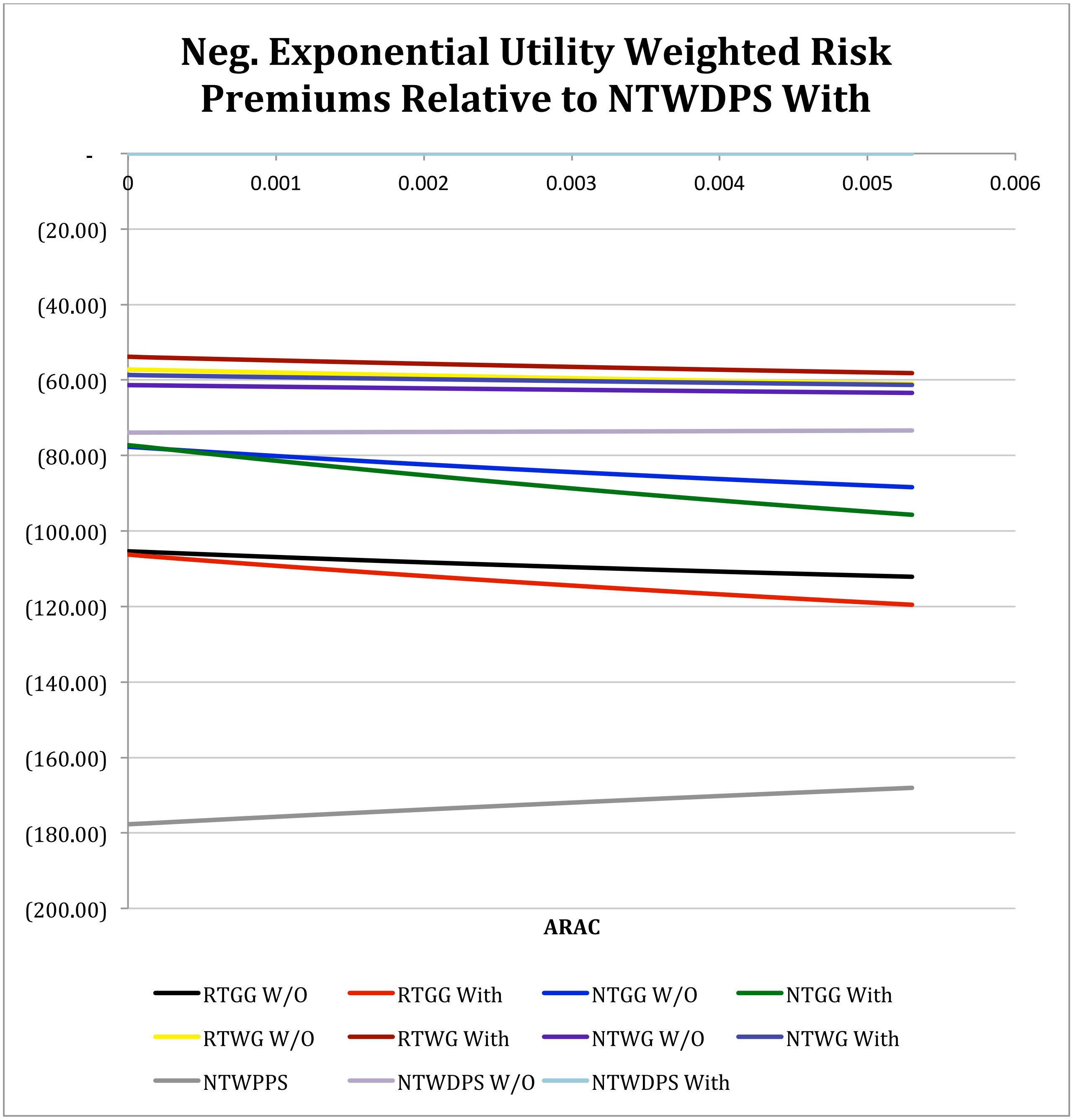


Table 4.12 Risk Premiums Relative to NTWDPS With under the 100% Gross Revenue Guarantee Contract - Part 2

ARAC	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With	NTWPPS	NTWDPS W/O	NTWDPS With
0	(119.50)	(109.20)	(91.82)	(78.78)	(71.34)	(59.72)	(75.48)	(65.46)	(167.07)	(88.06)	-
0.0002	(119.87)	(109.67)	(92.40)	(79.50)	(71.54)	(59.86)	(75.60)	(65.53)	(166.47)	(88.06)	-
0.0004	(120.23)	(110.13)	(92.97)	(80.19)	(71.74)	(60.00)	(75.71)	(65.61)	(165.88)	(88.06)	-
0.0007	(120.58)	(110.59)	(93.52)	(80.88)	(71.94)	(60.14)	(75.83)	(65.68)	(165.29)	(88.06)	-
0.0009	(120.93)	(111.03)	(94.06)	(81.55)	(72.14)	(60.27)	(75.94)	(65.75)	(164.70)	(88.06)	-
0.0011	(121.27)	(111.46)	(94.60)	(82.20)	(72.33)	(60.40)	(76.05)	(65.82)	(164.12)	(88.06)	-
0.0013	(121.61)	(111.88)	(95.12)	(82.84)	(72.53)	(60.53)	(76.16)	(65.90)	(163.54)	(88.06)	-
0.0015	(121.94)	(112.29)	(95.63)	(83.46)	(72.71)	(60.65)	(76.28)	(65.97)	(162.97)	(88.06)	-
0.0018	(122.26)	(112.70)	(96.14)	(84.07)	(72.90)	(60.77)	(76.39)	(66.03)	(162.40)	(88.06)	-
0.0020	(122.58)	(113.09)	(96.63)	(84.66)	(73.09)	(60.89)	(76.50)	(66.10)	(161.83)	(88.06)	-
0.0022	(122.90)	(113.48)	(97.12)	(85.24)	(73.27)	(61.01)	(76.60)	(66.17)	(161.27)	(88.05)	-
0.0024	(123.20)	(113.86)	(97.59)	(85.81)	(73.45)	(61.13)	(76.71)	(66.24)	(160.72)	(88.05)	-
0.0027	(123.51)	(114.23)	(98.06)	(86.36)	(73.63)	(61.24)	(76.82)	(66.30)	(160.16)	(88.05)	-
0.0029	(123.80)	(114.59)	(98.52)	(86.90)	(73.81)	(61.36)	(76.93)	(66.37)	(159.61)	(88.05)	-
0.0031	(124.10)	(114.94)	(98.97)	(87.43)	(73.98)	(61.47)	(77.03)	(66.44)	(159.07)	(88.05)	-
0.0033	(124.38)	(115.29)	(99.41)	(87.95)	(74.15)	(61.57)	(77.14)	(66.50)	(158.53)	(88.04)	-
0.0035	(124.67)	(115.63)	(99.84)	(88.46)	(74.32)	(61.68)	(77.24)	(66.56)	(157.99)	(88.04)	-
0.0038	(124.94)	(115.96)	(100.27)	(88.95)	(74.49)	(61.79)	(77.35)	(66.63)	(157.46)	(88.04)	-
0.0040	(125.22)	(116.28)	(100.68)	(89.43)	(74.66)	(61.89)	(77.45)	(66.69)	(156.93)	(88.03)	-
0.0042	(125.48)	(116.60)	(101.09)	(89.90)	(74.82)	(61.99)	(77.55)	(66.75)	(156.41)	(88.03)	-
0.0044	(125.75)	(116.91)	(101.50)	(90.37)	(74.99)	(62.09)	(77.66)	(66.82)	(155.89)	(88.03)	-
0.0046	(126.01)	(117.21)	(101.89)	(90.82)	(75.15)	(62.19)	(77.76)	(66.88)	(155.37)	(88.02)	-
0.0049	(126.26)	(117.51)	(102.28)	(91.26)	(75.31)	(62.29)	(77.86)	(66.94)	(154.86)	(88.02)	-
0.0051	(126.51)	(117.80)	(102.66)	(91.69)	(75.47)	(62.38)	(77.96)	(67.00)	(154.35)	(88.02)	-
0.0053	(126.76)	(118.08)	(103.03)	(92.11)	(75.63)	(62.48)	(78.06)	(67.06)	(153.85)	(88.01)	-

Figure 4.13 Risk Premiums Relative to NTWDPS With under the 100% Gross Revenue Guarantee Contract - Part 2

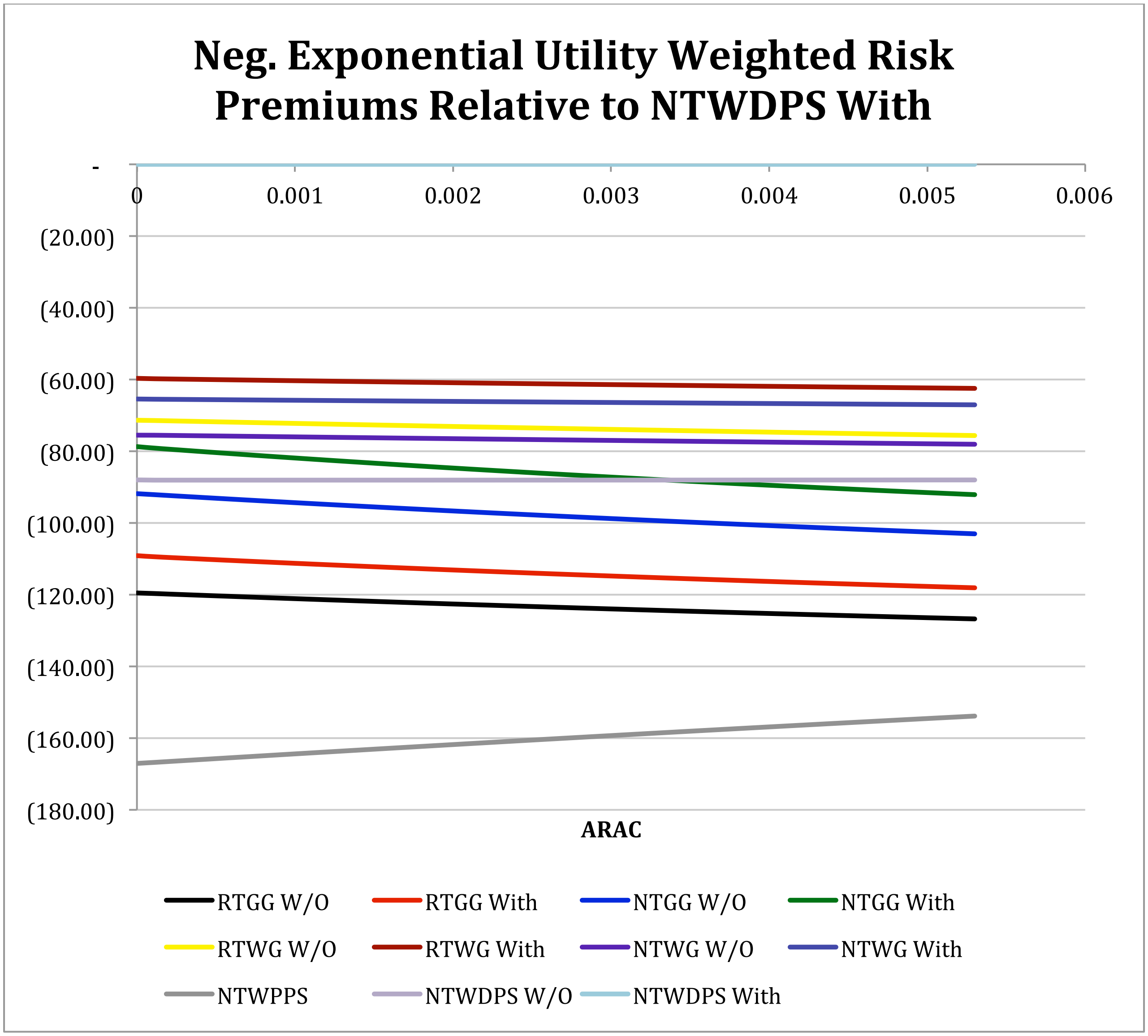


Table 4.13 StopLight Analysis Results Example – Spot Market Contract

StopLight Analysis Results © 2011

Lower Cut-Off Value	**$0.00**		Upper Cut-Off Value		**$152.33**						
System	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With	NTWPPS	NTWDPS W/O	NTWDPS With
Prob. (Unfavorable)	**0.05**	**0.06**	**0.03**	**0.04**	**0.01**	**0.01**	**0.01**	**0.01**	**0.04**	**0.00**	**0.00**
Prob. (Cautionary)	**0.49**	**0.49**	**0.42**	**0.42**	**0.33**	**0.32**	**0.34**	**0.33**	**0.87**	**0.39**	**0.12**
Prob(Favorable)	**0.46**	**0.45**	**0.55**	**0.55**	**0.66**	**0.67**	**0.65**	**0.67**	**0.09**	**0.61**	**0.88**

Figure 4.14 StopLight Results Graph Example – Spot Market Contract

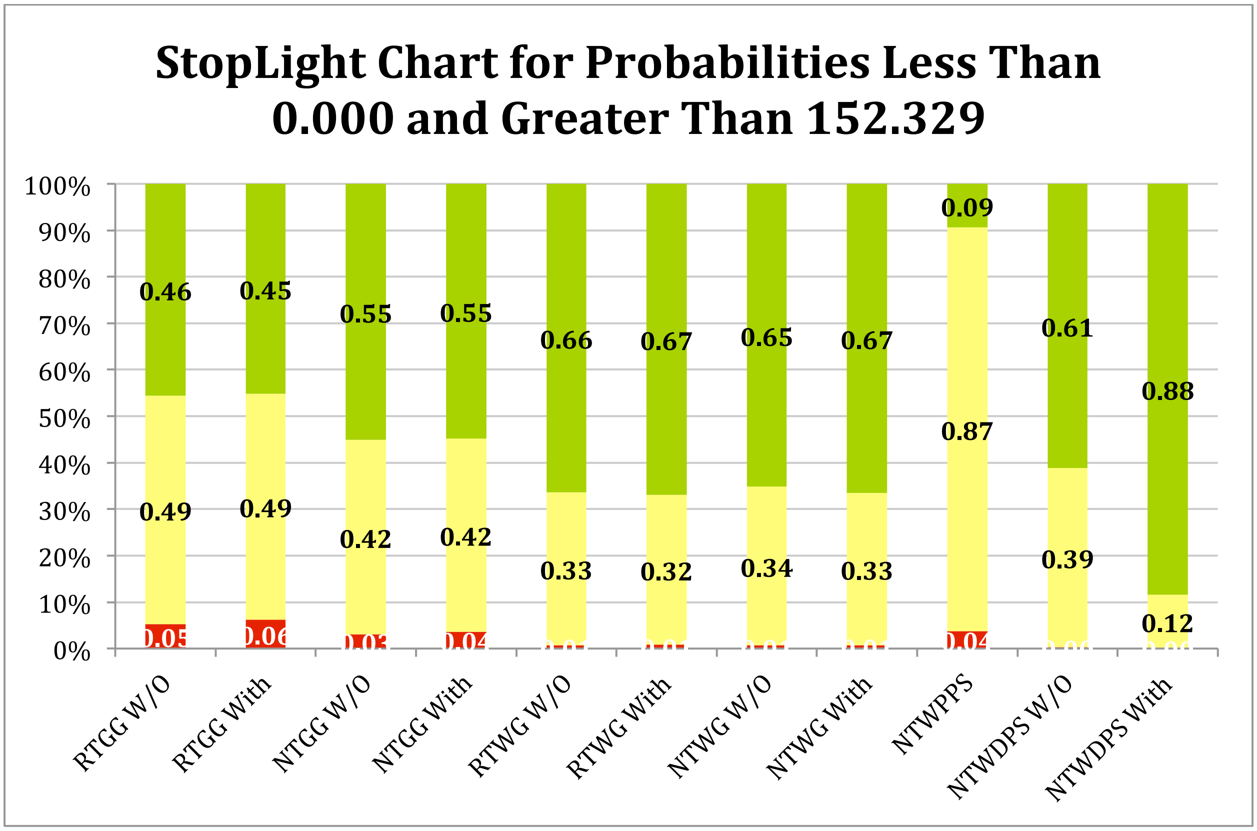


Table 4.14 Risk Premiums Relative to BCAP NTWDPS With under Contracts Comparison - Part 2

ARAC	SPOT-NTWDPS With	Min-NTWDPS With	BCAP-NTWDPS With	60%-NTWDPS With	100%-NTWDPS With
0	(84.40)	(77.39)	-	(84.40)	(70.26)
0.0002	(84.40)	(77.37)	-	(84.41)	(70.25)
0.0004	(84.40)	(77.34)	-	(84.42)	(70.24)
0.0007	(84.40)	(77.32)	-	(84.43)	(70.24)
0.0009	(84.40)	(77.30)	-	(84.44)	(70.23)
0.0011	(84.40)	(77.28)	-	(84.45)	(70.22)
0.0013	(84.40)	(77.26)	-	(84.47)	(70.21)
0.0015	(84.41)	(77.24)	-	(84.48)	(70.21)
0.0018	(84.41)	(77.22)	-	(84.49)	(70.20)
0.0020	(84.41)	(77.19)	-	(84.50)	(70.19)
0.0022	(84.41)	(77.17)	-	(84.51)	(70.18)
0.0024	(84.41)	(77.15)	-	(84.53)	(70.18)
0.0027	(84.41)	(77.13)	-	(84.54)	(70.17)
0.0029	(84.41)	(77.10)	-	(84.55)	(70.16)
0.0031	(84.41)	(77.08)	-	(84.56)	(70.15)
0.0033	(84.40)	(77.06)	-	(84.58)	(70.14)
0.0035	(84.40)	(77.04)	-	(84.59)	(70.13)
0.0038	(84.40)	(77.01)	-	(84.60)	(70.12)
0.0040	(84.40)	(76.99)	-	(84.62)	(70.11)
0.0042	(84.40)	(76.96)	-	(84.63)	(70.10)
0.0044	(84.40)	(76.94)	-	(84.64)	(70.09)
0.0046	(84.39)	(76.92)	-	(84.66)	(70.08)
0.0049	(84.39)	(76.89)	-	(84.67)	(70.07)
0.0051	(84.39)	(76.87)	-	(84.69)	(70.06)
0.0053	(84.39)	(76.84)	-	(84.70)	(70.05)

Figure 4.15 Risk Premiums Relative to BCAP NTWDPS With under Contracts Comparison Graph- Part 2

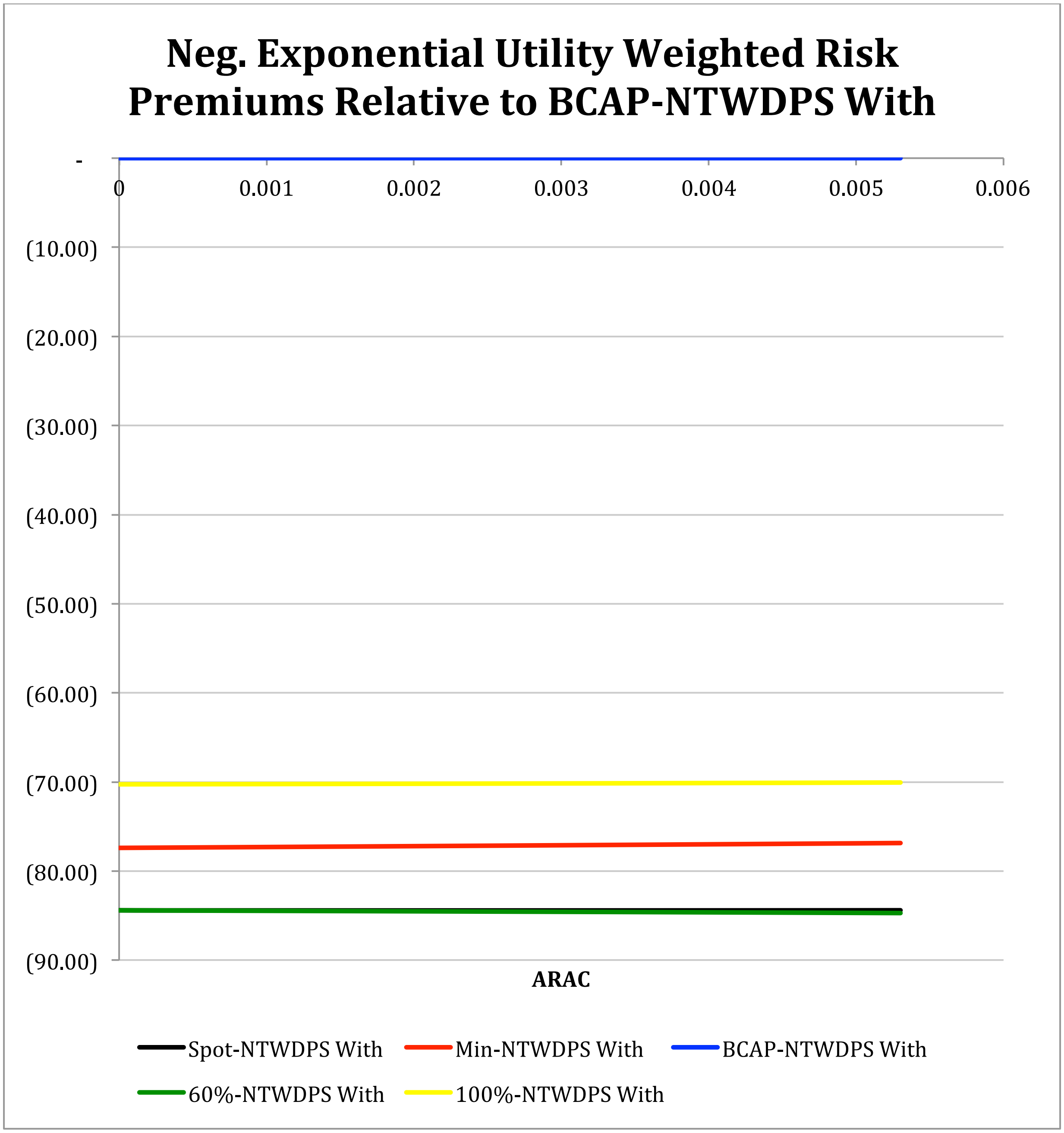


Table 4.15 StopLight Analysis Results– Contracts Comparison - Part 2

StopLight Analysis Results © 2011

Lower Cut-Off Value	**$0.00**		Upper Cut-Off Value	**$164.34**	
System	**SPOT-NTWDPS With**	**Min-NTWDPS With**	**BCAP-NTWDPS With**	**60%-NTWDPS With**	**100%-NTWDPS With**
Prob. (Unfavorable)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Prob. (Cautionary)	**0.15**	**0.12**	**0.01**	**0.14**	**0.11**
Prob. (Favorable)	**0.85**	**0.88**	**0.99**	**0.86**	**0.89**

Figure 4.16 StopLight Results Graph– Contracts Comparison - Part 2

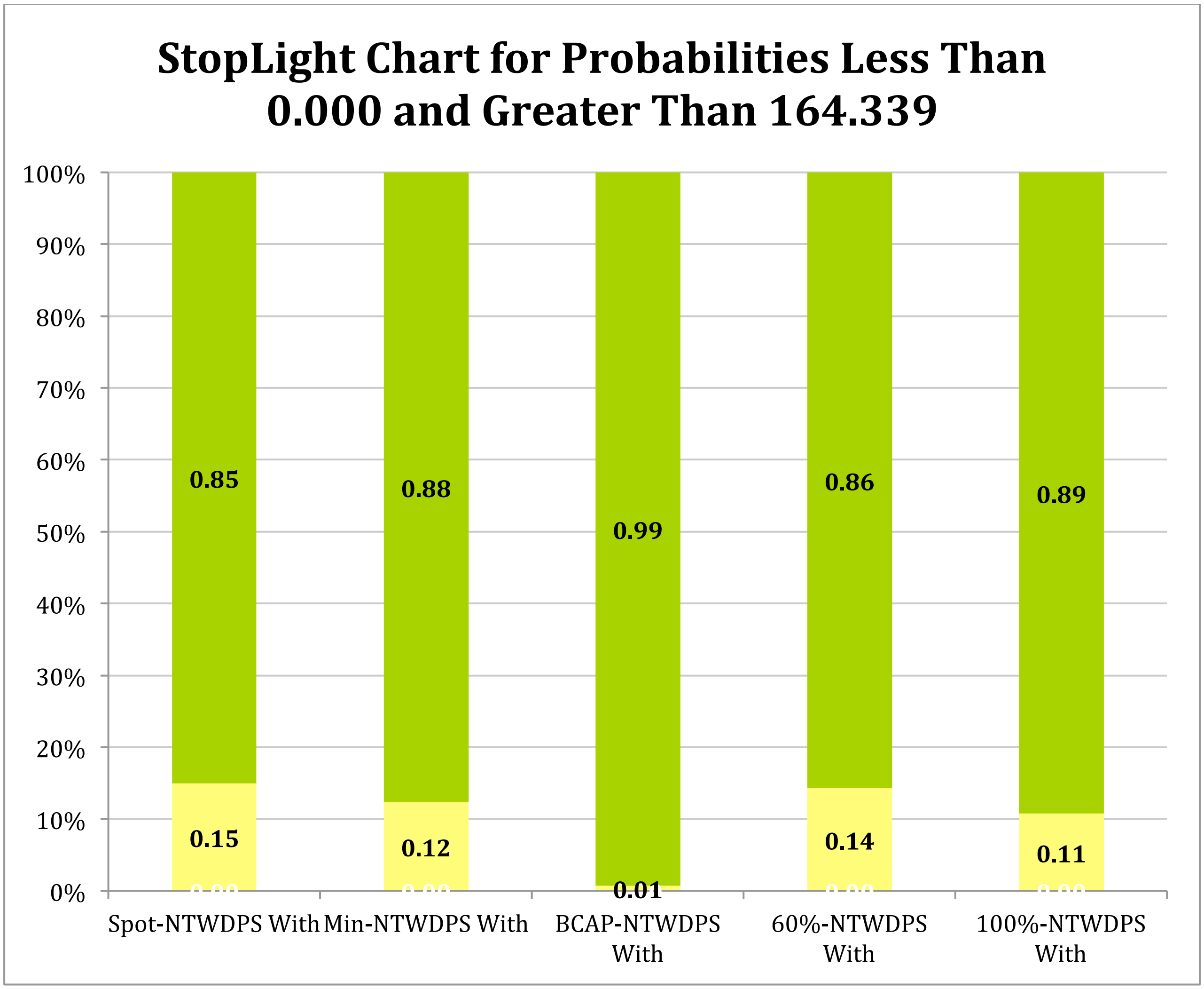


Table 4.16 Risk Premiums Relative to BCAP-NTWDPS With under Contracts Comparison with $10/ton BCAP Payment - Part 2

ARAC	SPOT-NTWDPS With	Min-NTWDPS With	BCAP-NTWDPS With	60%-NTWDPS With	100%-NTWDPS With	BCAP 10-NTWDPS With
0	(84.40)	(77.39)	-	(84.40)	(70.26)	(42.20)
0.0002	(84.40)	(77.37)	-	(84.41)	(70.25)	(42.20)
0.0004	(84.40)	(77.34)	-	(84.42)	(70.24)	(42.20)
0.0007	(84.40)	(77.32)	-	(84.43)	(70.24)	(42.19)
0.0009	(84.40)	(77.30)	-	(84.44)	(70.23)	(42.19)
0.0011	(84.40)	(77.28)	-	(84.45)	(70.22)	(42.19)
0.0013	(84.40)	(77.26)	-	(84.47)	(70.21)	(42.19)
0.0015	(84.41)	(77.24)	-	(84.48)	(70.21)	(42.18)
0.0018	(84.41)	(77.22)	-	(84.49)	(70.20)	(42.18)
0.0020	(84.41)	(77.19)	-	(84.50)	(70.19)	(42.18)
0.0022	(84.41)	(77.17)	-	(84.51)	(70.18)	(42.18)
0.0024	(84.41)	(77.15)	-	(84.53)	(70.18)	(42.17)
0.0027	(84.41)	(77.13)	-	(84.54)	(70.17)	(42.17)
0.0029	(84.41)	(77.10)	-	(84.55)	(70.16)	(42.17)
0.0031	(84.41)	(77.08)	-	(84.56)	(70.15)	(42.17)
0.0033	(84.40)	(77.06)	-	(84.58)	(70.14)	(42.16)
0.0035	(84.40)	(77.04)	-	(84.59)	(70.13)	(42.16)
0.0038	(84.40)	(77.01)	-	(84.60)	(70.12)	(42.16)
0.0040	(84.40)	(76.99)	-	(84.62)	(70.11)	(42.15)
0.0042	(84.40)	(76.96)	-	(84.63)	(70.10)	(42.15)
0.0044	(84.40)	(76.94)	-	(84.64)	(70.09)	(42.15)
0.0046	(84.39)	(76.92)	-	(84.66)	(70.08)	(42.14)
0.0049	(84.39)	(76.89)	-	(84.67)	(70.07)	(42.14)
0.0051	(84.39)	(76.87)	-	(84.69)	(70.06)	(42.13)
0.0053	(84.39)	(76.84)	-	(84.70)	(70.05)	(42.13)

Figure 4.17 Risk Premiums Relative to BCAP NTWDPS With under Contracts Comparison Graph with $10/ton BCAP Payment - Part 2

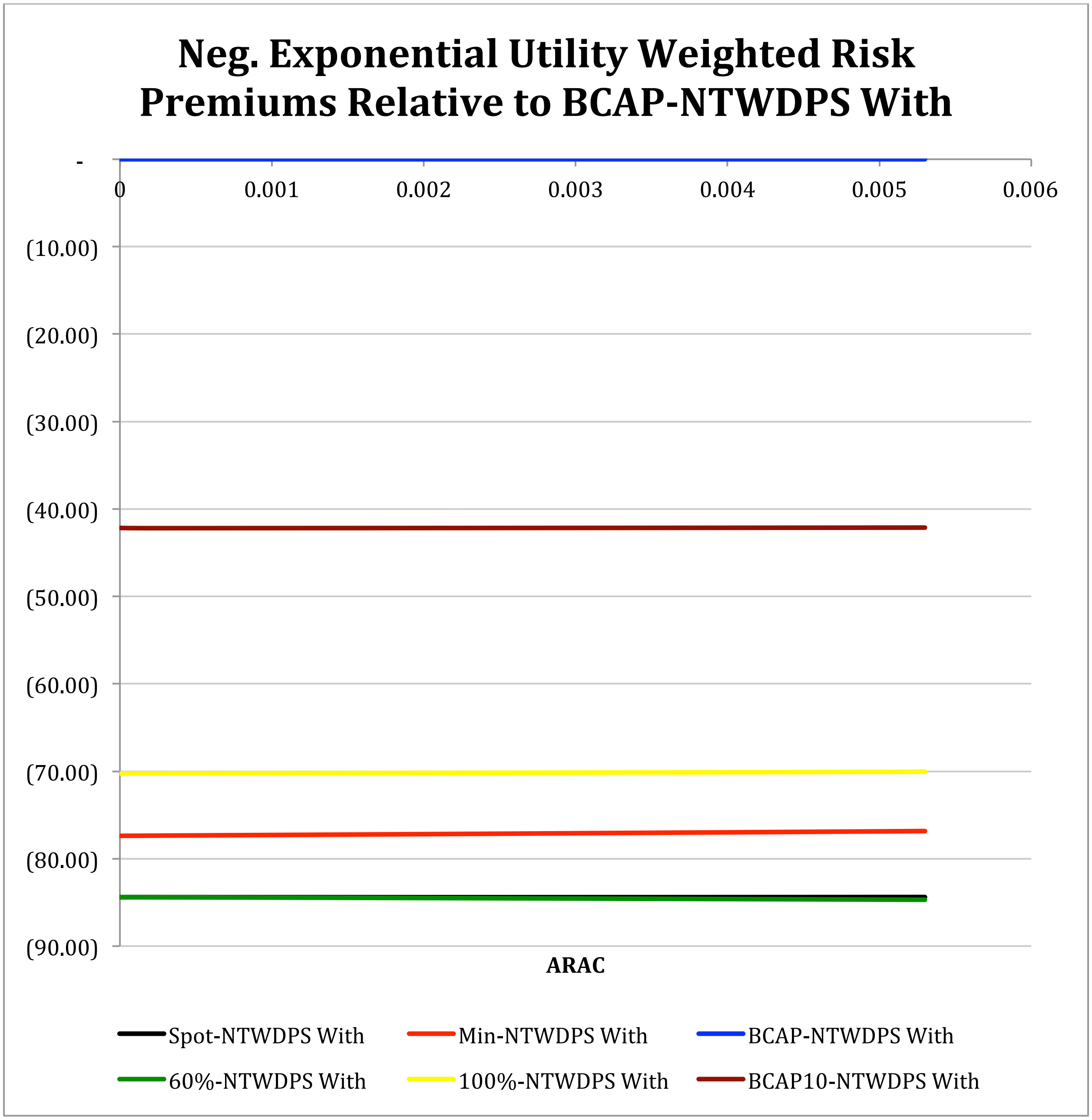
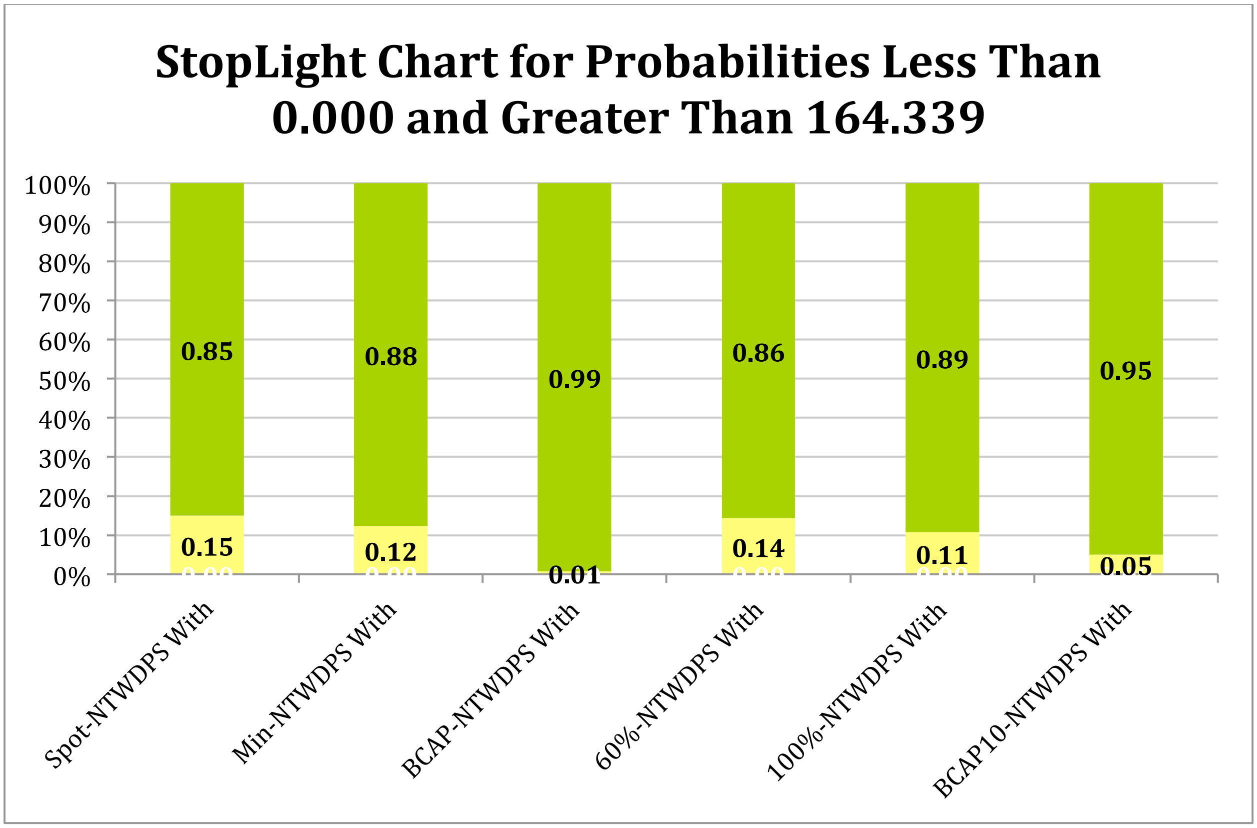


Table 4.17 StopLight Analysis Results– Contracts Comparison with $10/ton BCAP Payment - Part 2

StopLight Analysis Results © 2011

Lower Cut-Off Value	$0.00		Upper Cut-Off Value	$164.34		
System	SPOT-NTWDPS With	Min-NTWDPS With	BCAP-NTWDPS With	60%-NTWDPS With	100%-NTWDPS With	BCAP 10-NTWDPS With
Prob. (Unfavorable)	0.00	0.00	0.00	0.00	0.00	0.00
Prob. (Cautionary)	0.15	0.12	0.01	0.14	0.11	0.05
Prob. (Favorable)	0.85	0.88	0.99	0.86	0.89	0.95

Figure 4.18 StopLight Results Graph– Contracts Comparison with $10/ton BCAP Payment - Part 2



Part 3 –Stochastic Efficiency Analysis for Eight Crop Systems Practiced in South Central Kansas

Out of the 11 cropping systems analyzed in Part 2, only 8 are already practiced in the field in South Central Kansas. They represent the original set of cropping systems included in the experimental work done in Hesston, KS and studied by Pachta (2010) and Brammer (2014). The rotations not practiced are NTWPPS, NTWDPS With and W/O. Part 3 of the Results section presents the outcomes of the analysis using only these 8 cropping systems to focus on crop rotations that are already being practiced in the field.

The SERF results will be recreated using only the cropping systems that contain wheat and/or grain sorghum. StopLight analysis does not need to be done for Part 3 because the favorable, unfavorable, and cautionary percentages do not change for those 8 systems.

4.8 Stochastic Efficiency with Respect to a Function (SERF) Analysis

4.8.1 SERF Results under Spot Market Contract

Risk premiums are relative to RTWG With because it is the highest in utility of net returns under the SERF results. RTWG W/O is the second highest in utility. To be equally preferred, it would take \$2.32/acre, \$1.74/acre, and \$1.23/acre more in net returns at the ARAC of 0, .0027, and .0053, respectively (Table 4.20). The RTGG With is the lowest in utility and would take \$52.20, \$54.31, and \$55.91 per acre more to be equally preferred at the ARACs of 0, .0027, and .0053, respectively. Like RTWG W/O, NTWG W/O and NTWG With have a negative correlation between the risk premiums and the ARACs. Figure 4.19 presents the risk premium graph for the Spot Market contract scenario.

4.8.2 SERF Results under Minimum Price Contract

Again the risk premiums are relative to the crop system RTWG With. Moving from the lower bound to the upper bound, it would take \$3.90/acre to \$2.73/acre more to have a producer switch to RTWG W/O (Table 4.21). RTGG W/O has a higher risk premium than RTGG With at the ARAC of 0, but at the upper bound RTGG With has higher risk premiums. The risk premium graph for this contract scenario is presented in Figure 4.20.

4.8.3 SERF Results under BCAP Price Contract

With a \$20/ton matching payment under the BCAP Price contract, the system with the highest utility is RTWG With. Relative to it, RTGG With, NTGG With and W/O have a positive correlation between the risk premiums and the ARACs. RTWG W/O, NTWG W/O, and NTWG With have a negative correlation. RTGG W/O has a positive correlation until .0029, and then becomes a negative correlation. NTWG With is the second highest in utility and it would take \$4.30/acre, \$2.83/acre, and \$1.62/acre more for it to be equally preferred at the 0, .0027, and .0053 ARACs, respectively (Table 4.22). RTGG W/O is lowest in utility of net returns and would require \$70.13/acre, \$70.29, and \$70.15/acre more in net returns for equal preference. The risk premiums are also presented in Figure 4.21.

4.8.4 SERF Results under Gross Revenue Guarantee Contract

The crop system with the highest utility under the 60% and 100% Gross Revenue Guarantee contracts is the same: RTWG With. The lowest in utility is RTGG With. It takes

$52.42/acre more at the ARAC of 0, $57.35/acre more at .0027, and $61.35/acre more in net returns at .0053 to be equally preferred at the 60% level (Table 4.23)

When Stochastic Efficiency with Respect to a Function (SERF) results are determined under the 100% Gross Revenue Guarantee contract, the second highest is NTWG With. For NTWG to be equally preferred, it takes $5.74/acre, $5.06/acre, and $4.58/acre more in net returns at the 3 absolute risk aversion coefficients (ARACs) mentioned previously (Table 4.24). The lowest in utility is RTGG W/O. At the lower bound of 0, where a decision maker is risk neutral, the risk premium is $59.78/acre. At the upper bound of .0053, where a decision maker is risk adverse, the risk premium is $64.28 per acre. Figure 4.22 and 4.23 present the risk premiums in graphical form for the 60% and 100% guarantee contracts, respectively.

4.8.5 SERF Results Overview

RTWG With is the highest in utility under all 5 contract scenarios. RTGG With is lowest in utility of net returns under the Spot Market, Minimum Price, and 60% Gross Revenue Guarantee contract. For the BCAP Price contract and the 100% Gross Revenue Guarantee contract, RTGG W/O is the least preferred.

4.9 Stochastic Efficiency Analysis Across Contract Scenarios

The crop systems that only include grain sorghum and/or wheat have been analyzed across the 5 different contract scenarios to determine how they compare to each other. The crop system that performed best within each contract is compared to one another in this section. This will allow us to determine which contract scenario is most preferred. RTWG With is the most preferred under the Spot Market contract, the Minimum Price contract, the BCAP Price contract, and the 60% and 100% Gross Revenue Guarantee contract. Table 4.20 presents the net return statistics from SIMETAR© of the contract comparison.

The BCAP Price contract is the highest in utility and the risk premiums are calculated in respect to it (Table 4.25). All the contracts have a negative correlation between the ARACs and the risk premium absolute values. The risk premiums for the Spot Market contract producing RTWG With are \$19.65/acre, \$18.67/acre, and \$17.79/acre in net returns at the ARAC of 0, .0027, and .0053, respectively. At the same ARAC levels, the risk premiums for the Minimum Price contract are \$18.07/acre, \$17.13/acre, and \$16.29/acre. The Gross Revenue Guarantee – 100% contract has a steeper negative correlation than the other contracts. For it to be equally preferred, it would take \$10.36/acre, \$8.03/acre, and \$5.87/acre in net returns at the 0, .0027, and .0053 ARACs. Under the 60% Gross Revenue Guarantee contract, the risk premiums range from \$18.63 to \$16.21 per acre in net returns as you move from the lower ARAC bound to the upper bound. Figure 4.24 presents the risk premiums in graphical form when comparing the contract scenarios.

In StopLight, the lower cut-off value is again \$0.00 and the upper cut-off value is \$153.13. The BCAP contract will have net returns higher than the upper cut-off value 73% of the time. 26% of the time will it have net returns between \$0.00/acre and \$153.13/acre and 1% of the time the BCAP contract will have net returns lower than \$0.00 per acre. The rest of the probabilities can be seen in Table 4.26 and Figure 4.25.

Table 4.18 SIMETAR© Net Returns Simulation Results under Contracts Comparison - Part 3

	Mean	St. Dev.	CV	Min	Max
SPOT-RTWG With	$204.52	$102.68	$50.21	-$43.71	$539.13
Min-RTWG With	$206.11	$102.85	$49.90	-$43.71	$543.65
BCAP- RTWG With	$224.18	$106.44	$47.48	-$36.84	$572.41
60%-RTWG With	$205.55	$101.74	$49.50	-$27.06	$539.13
100%-RTWG With	$213.82	$97.47	$45.58	-$1.95	$539.13

4.9.1 *Stochastic Efficiency Analysis Across Contract Scenarios When BCAP Price is $10/ton*

The BCAP Price contract has a matching payment of $20/ton in net returns for biomass product. To see how the contracts would change in preference, the matching payment is lowered to $10 per ton of biomass. Table 4.19 presents the net return statistics for the 6 contract scenarios.

Table 4.19 SIMETAR© Net Returns Simulation Results under Contracts Comparison with $10/ton BCAP Payment - Part 3

	Mean	St. Dev.	CV	Min	Max
SPOT-RTWG With	$204.52	$102.68	$50.21	-$43.71	$539.13
Min-RTWG With	$206.11	$102.85	$49.90	-$43.71	$543.65
BCAP- RTWG With	$224.18	$106.44	$47.48	-$36.84	$572.41
60%-RTWG With	$205.55	$101.74	$49.50	-$27.06	$539.13
100%-RTWG With	$213.82	$97.47	$45.58	-$1.95	$539.13
BCAP 10-RTWG With	$214.35	$104.53	$48.76	-$40.27	$555.35

The risk premiums for the Spot Market contract, Minimum Price contract, and the Gross Revenue Guarantee contracts are the same because the original BCAP Price contract is still highest in utility according to the SERF results. The risk premiums for the $10/ton matching payment are $9.83/acre, $9.32/acre, and $8.87/acre in net returns for the ARACs of zero, .0027, and .0053 (Table 4.27). This means there is a negative correlation between the risk premiums and the absolute risk aversion coefficients (ARACs). From the ARAC values of 0 to 0.0009, the second most preferred system is the 100% Gross Revenue Guarantee contract. From .0011 to .0053, as the decision maker becomes more risk adverse, the second highest in preference becomes the BCAP Price contract with the $10/ton matching payment. Figure 4.26 presents the SERF results for the contracts comparison that includes the $10/ton matching payment BCAP Price contract.

The StopLight results are displayed in Table 4.28 and Figure 4.27. The lower cut off-value is $0.00 and the upper cut-off is $153.13 again. The probability that the $10/ton BCAP contract will be favorable (higher than the upper cut-off value) is 70%. The probabilities that it will be cautionary and unfavorable (between the two values and less than the lower cut-off value) are 29% and 1%, respectively.

Chapter 4-Results, Part 3 Tables and Figures

Table 4.20 Risk Premiums Relative to RTWG With under the Spot Market Contract - Part 3

ARAC	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With
0.00000	(50.48)	(52.20)	(22.81)	(23.16)	(2.32)	-	(6.46)	(4.21)
0.00022	(50.59)	(52.39)	(23.13)	(23.59)	(2.27)	-	(6.32)	(4.11)
0.00044	(50.70)	(52.59)	(23.44)	(24.01)	(2.22)	-	(6.19)	(4.00)
0.00066	(50.81)	(52.78)	(23.75)	(24.41)	(2.17)	-	(6.05)	(3.90)
0.00088	(50.91)	(52.97)	(24.04)	(24.81)	(2.12)	-	(5.92)	(3.80)
0.00110	(51.01)	(53.15)	(24.33)	(25.21)	(2.07)	-	(5.79)	(3.71)
0.00133	(51.10)	(53.33)	(24.62)	(25.59)	(2.02)	-	(5.66)	(3.61)
0.00155	(51.20)	(53.50)	(24.89)	(25.96)	(1.97)	-	(5.54)	(3.52)
0.00177	(51.29)	(53.67)	(25.16)	(26.33)	(1.93)	-	(5.41)	(3.43)
0.00199	(51.38)	(53.84)	(25.43)	(26.69)	(1.88)	-	(5.29)	(3.33)
0.00221	(51.46)	(54.00)	(25.68)	(27.04)	(1.83)	-	(5.17)	(3.25)
0.00243	(51.54)	(54.16)	(25.93)	(27.38)	(1.79)	-	(5.05)	(3.16)
0.00265	(51.62)	(54.31)	(26.17)	(27.71)	(1.74)	-	(4.93)	(3.07)
0.00287	(51.70)	(54.47)	(26.41)	(28.04)	(1.70)	-	(4.82)	(2.99)
0.00309	(51.77)	(54.61)	(26.64)	(28.36)	(1.65)	-	(4.71)	(2.91)
0.00331	(51.84)	(54.76)	(26.86)	(28.67)	(1.61)	-	(4.59)	(2.82)
0.00353	(51.91)	(54.90)	(27.08)	(28.97)	(1.56)	-	(4.48)	(2.74)
0.00375	(51.97)	(55.04)	(27.30)	(29.27)	(1.52)	-	(4.38)	(2.67)
0.00398	(52.03)	(55.17)	(27.50)	(29.56)	(1.48)	-	(4.27)	(2.59)
0.00420	(52.09)	(55.30)	(27.70)	(29.84)	(1.44)	-	(4.16)	(2.51)
0.00442	(52.15)	(55.43)	(27.90)	(30.12)	(1.39)	-	(4.06)	(2.44)
0.00464	(52.21)	(55.55)	(28.09)	(30.39)	(1.35)	-	(3.96)	(2.36)
0.00486	(52.26)	(55.68)	(28.28)	(30.66)	(1.31)	-	(3.86)	(2.29)
0.00508	(52.31)	(55.79)	(28.46)	(30.92)	(1.27)	-	(3.76)	(2.22)
0.00530	(52.36)	(55.91)	(28.63)	(31.17)	(1.23)	-	(3.66)	(2.15)

Figure 4.19 Risk Premiums Relative to RTWG With under the Spot Market Contract Graph- Part 3

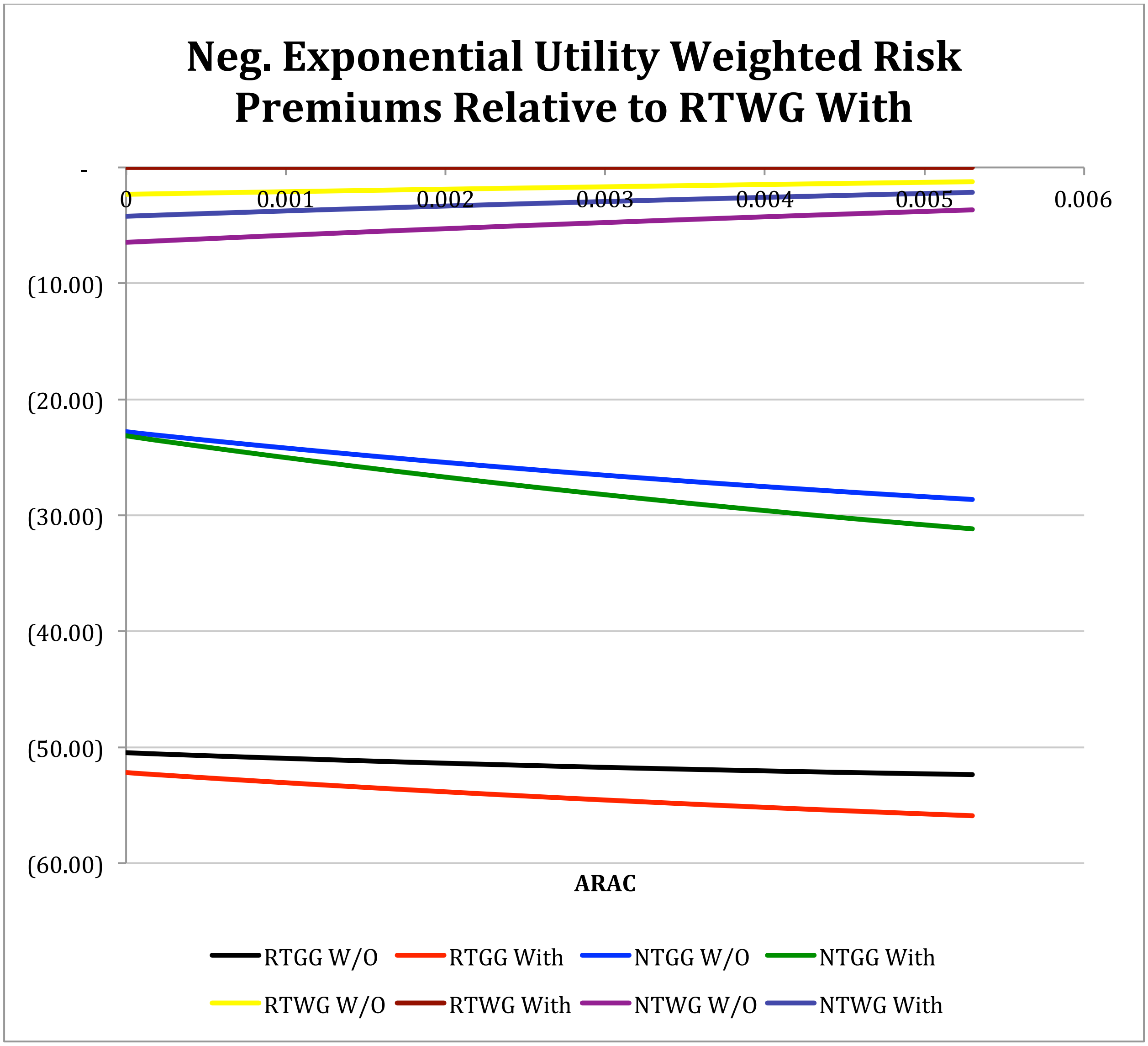


Table 4.21 Risk Premiums Relative to RTWG With under the Minimum Price Contract - Part 3

ARAC	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With
0.00000	(52.06)	(51.47)	(24.39)	(22.26)	(3.90)	-	(8.05)	(4.21)
0.00022	(52.17)	(51.67)	(24.71)	(22.69)	(3.85)	-	(7.90)	(4.10)
0.00044	(52.28)	(51.87)	(25.02)	(23.11)	(3.79)	-	(7.76)	(4.00)
0.00066	(52.38)	(52.06)	(25.32)	(23.52)	(3.74)	-	(7.62)	(3.89)
0.00088	(52.48)	(52.25)	(25.61)	(23.93)	(3.69)	-	(7.49)	(3.79)
0.00110	(52.57)	(52.43)	(25.90)	(24.32)	(3.64)	-	(7.35)	(3.69)
0.00133	(52.67)	(52.62)	(26.18)	(24.71)	(3.58)	-	(7.22)	(3.60)
0.00155	(52.76)	(52.79)	(26.45)	(25.09)	(3.53)	-	(7.09)	(3.50)
0.00177	(52.84)	(52.96)	(26.72)	(25.45)	(3.48)	-	(6.97)	(3.41)
0.00199	(52.93)	(53.13)	(26.98)	(25.82)	(3.43)	-	(6.84)	(3.31)
0.00221	(53.01)	(53.30)	(27.23)	(26.17)	(3.38)	-	(6.72)	(3.22)
0.00243	(53.08)	(53.46)	(27.47)	(26.51)	(3.33)	-	(6.59)	(3.13)
0.00265	(53.16)	(53.62)	(27.71)	(26.85)	(3.28)	-	(6.47)	(3.05)
0.00287	(53.23)	(53.77)	(27.95)	(27.18)	(3.23)	-	(6.36)	(2.96)
0.00309	(53.30)	(53.92)	(28.17)	(27.50)	(3.19)	-	(6.24)	(2.88)
0.00331	(53.37)	(54.07)	(28.39)	(27.82)	(3.14)	-	(6.12)	(2.79)
0.00353	(53.43)	(54.21)	(28.61)	(28.12)	(3.09)	-	(6.01)	(2.71)
0.00375	(53.49)	(54.35)	(28.82)	(28.42)	(3.04)	-	(5.90)	(2.63)
0.00398	(53.55)	(54.49)	(29.02)	(28.72)	(3.00)	-	(5.79)	(2.55)
0.00420	(53.61)	(54.62)	(29.22)	(29.00)	(2.95)	-	(5.68)	(2.47)
0.00442	(53.67)	(54.75)	(29.41)	(29.28)	(2.91)	-	(5.57)	(2.40)
0.00464	(53.72)	(54.88)	(29.60)	(29.56)	(2.86)	-	(5.47)	(2.32)
0.00486	(53.77)	(55.00)	(29.78)	(29.82)	(2.82)	-	(5.36)	(2.25)
0.00508	(53.81)	(55.12)	(29.96)	(30.09)	(2.77)	-	(5.26)	(2.17)
0.00530	(53.86)	(55.24)	(30.13)	(30.34)	(2.73)	-	(5.16)	(2.10)

Figure 4.20 Risk Premiums Relative to RTWG With under the Minimum Price Contract Graph- Part 3

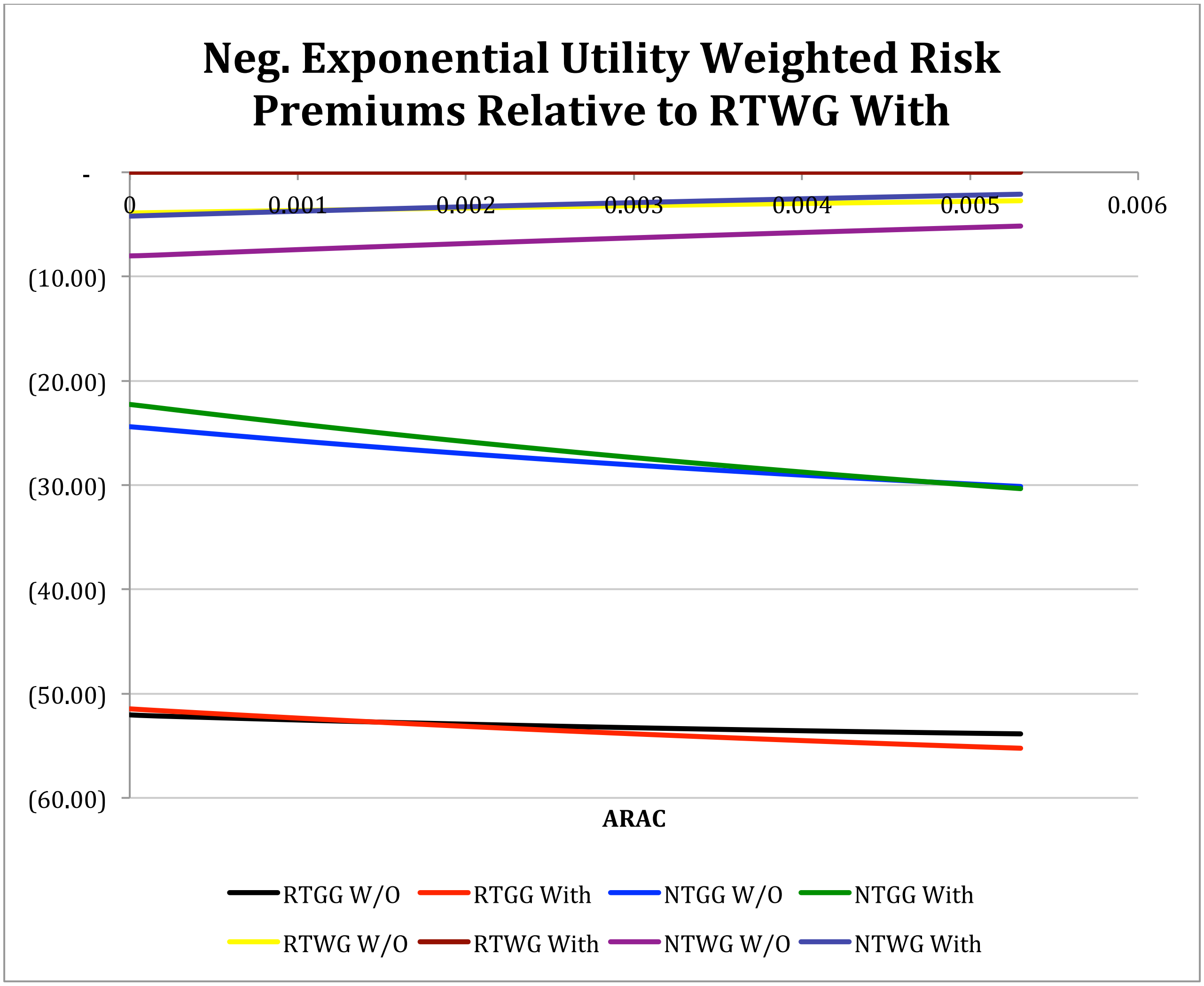


Table 4.22 Risk Premiums Relative to RTWG With under the BCAP Price Contract - Part 3

ARAC	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With
0.00000	(70.13)	(43.25)	(42.46)	(11.93)	(21.97)	-	(26.11)	(4.30)
0.00022	(70.16)	(43.51)	(42.69)	(12.45)	(21.83)	-	(25.89)	(4.17)
0.00044	(70.18)	(43.77)	(42.92)	(12.96)	(21.70)	-	(25.67)	(4.04)
0.00066	(70.20)	(44.02)	(43.14)	(13.46)	(21.56)	-	(25.45)	(3.91)
0.00088	(70.22)	(44.26)	(43.35)	(13.95)	(21.43)	-	(25.23)	(3.78)
0.00110	(70.24)	(44.50)	(43.56)	(14.43)	(21.30)	-	(25.02)	(3.65)
0.00133	(70.25)	(44.74)	(43.76)	(14.90)	(21.17)	-	(24.81)	(3.53)
0.00155	(70.26)	(44.97)	(43.96)	(15.36)	(21.04)	-	(24.60)	(3.41)
0.00177	(70.27)	(45.19)	(44.15)	(15.81)	(20.91)	-	(24.39)	(3.29)
0.00199	(70.28)	(45.42)	(44.33)	(16.25)	(20.78)	-	(24.19)	(3.17)
0.00221	(70.28)	(45.63)	(44.51)	(16.67)	(20.66)	-	(23.99)	(3.06)
0.00243	(70.29)	(45.84)	(44.68)	(17.09)	(20.53)	-	(23.80)	(2.94)
0.00265	(70.29)	(46.05)	(44.84)	(17.50)	(20.41)	-	(23.60)	(2.83)
0.00287	(70.29)	(46.26)	(45.00)	(17.91)	(20.29)	-	(23.41)	(2.72)
0.00309	(70.28)	(46.45)	(45.16)	(18.30)	(20.17)	-	(23.22)	(2.61)
0.00331	(70.28)	(46.65)	(45.31)	(18.68)	(20.05)	-	(23.03)	(2.51)
0.00353	(70.27)	(46.84)	(45.45)	(19.06)	(19.93)	-	(22.85)	(2.40)
0.00375	(70.26)	(47.03)	(45.59)	(19.42)	(19.81)	-	(22.67)	(2.30)
0.00398	(70.25)	(47.21)	(45.72)	(19.78)	(19.70)	-	(22.49)	(2.20)
0.00420	(70.24)	(47.39)	(45.85)	(20.13)	(19.58)	-	(22.31)	(2.10)
0.00442	(70.23)	(47.56)	(45.97)	(20.47)	(19.47)	-	(22.13)	(2.00)
0.00464	(70.21)	(47.73)	(46.09)	(20.81)	(19.36)	-	(21.96)	(1.90)
0.00486	(70.19)	(47.90)	(46.21)	(21.14)	(19.24)	-	(21.79)	(1.81)
0.00508	(70.17)	(48.06)	(46.32)	(21.46)	(19.13)	-	(21.62)	(1.71)
0.00530	(70.15)	(48.22)	(46.43)	(21.77)	(19.02)	-	(21.45)	(1.62)

Figure 4.21 Risk Premiums Relative to RTWG With under the BCAP Price Contract Graph- Part 3

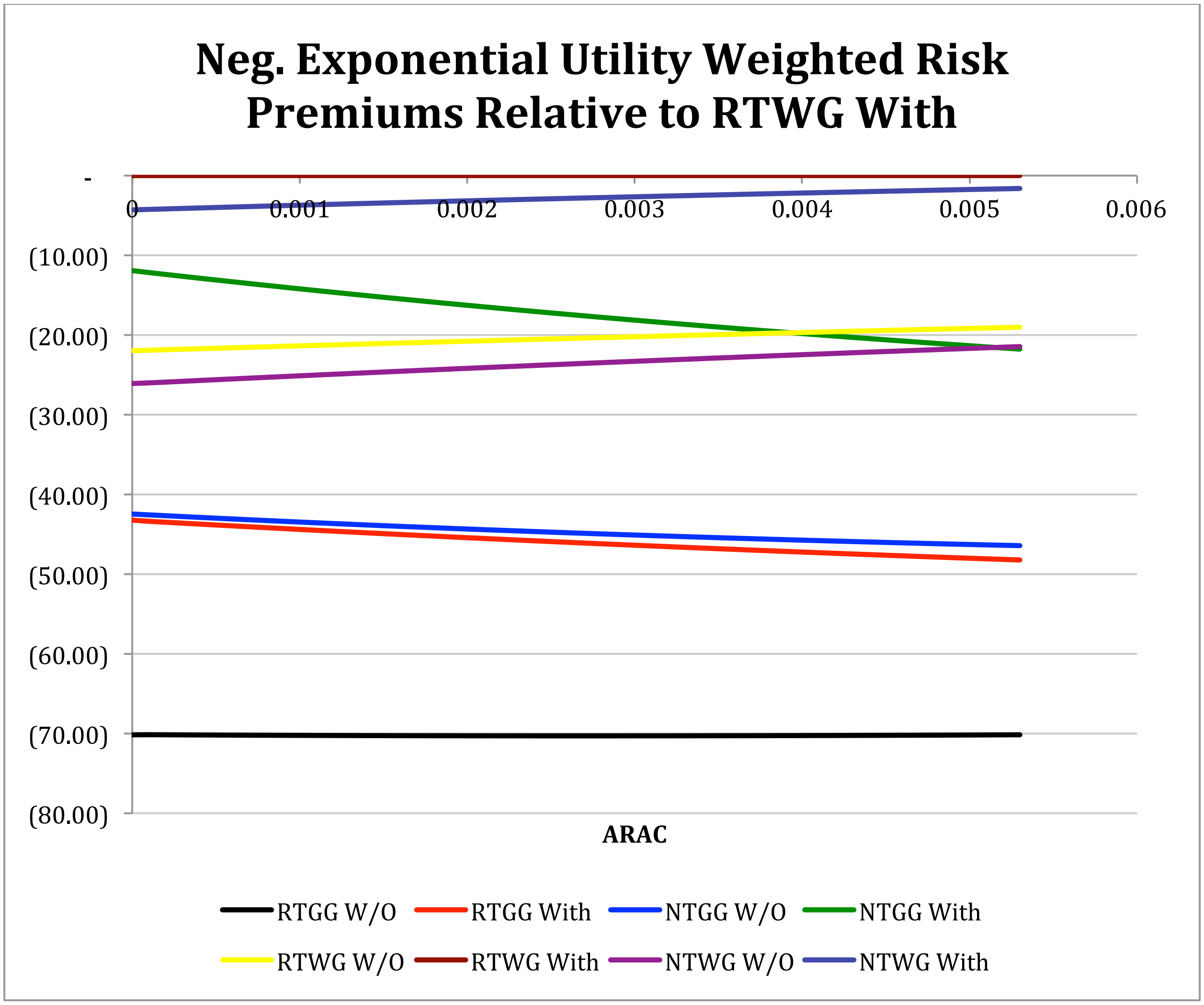


Table 4.23 Risk Premiums Relative to RTWG With under the 60% Gross Revenue Guarantee Contract - Part 3

ARAC	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With
0.00000	(51.50)	(52.42)	(23.83)	(23.35)	(3.34)	-	(7.48)	(4.83)
0.00022	(51.64)	(52.87)	(24.17)	(24.09)	(3.31)	-	(7.37)	(4.74)
0.00044	(51.77)	(53.31)	(24.51)	(24.81)	(3.28)	-	(7.25)	(4.65)
0.00066	(51.89)	(53.75)	(24.83)	(25.52)	(3.25)	-	(7.14)	(4.56)
0.00088	(52.02)	(54.18)	(25.15)	(26.21)	(3.23)	-	(7.03)	(4.48)
0.00110	(52.14)	(54.60)	(25.46)	(26.89)	(3.20)	-	(6.92)	(4.39)
0.00133	(52.26)	(55.01)	(25.77)	(27.56)	(3.17)	-	(6.81)	(4.31)
0.00155	(52.37)	(55.42)	(26.07)	(28.21)	(3.15)	-	(6.71)	(4.23)
0.00177	(52.49)	(55.82)	(26.36)	(28.85)	(3.12)	-	(6.61)	(4.16)
0.00199	(52.59)	(56.21)	(26.65)	(29.48)	(3.10)	-	(6.51)	(4.08)
0.00221	(52.70)	(56.60)	(26.92)	(30.10)	(3.08)	-	(6.41)	(4.01)
0.00243	(52.81)	(56.98)	(27.20)	(30.70)	(3.05)	-	(6.32)	(3.94)
0.00265	(52.91)	(57.35)	(27.46)	(31.29)	(3.03)	-	(6.22)	(3.86)
0.00287	(53.01)	(57.72)	(27.72)	(31.87)	(3.01)	-	(6.13)	(3.80)
0.00309	(53.10)	(58.08)	(27.98)	(32.44)	(2.99)	-	(6.04)	(3.73)
0.00331	(53.20)	(58.43)	(28.22)	(32.99)	(2.97)	-	(5.95)	(3.66)
0.00353	(53.29)	(58.78)	(28.47)	(33.54)	(2.95)	-	(5.87)	(3.60)
0.00375	(53.38)	(59.12)	(28.70)	(34.07)	(2.93)	-	(5.78)	(3.53)
0.00398	(53.47)	(59.46)	(28.93)	(34.59)	(2.91)	-	(5.70)	(3.47)
0.00420	(53.55)	(59.79)	(29.16)	(35.11)	(2.89)	-	(5.62)	(3.41)
0.00442	(53.63)	(60.11)	(29.38)	(35.61)	(2.87)	-	(5.54)	(3.35)
0.00464	(53.71)	(60.43)	(29.60)	(36.10)	(2.86)	-	(5.46)	(3.29)
0.00486	(53.79)	(60.75)	(29.81)	(36.58)	(2.84)	-	(5.39)	(3.24)
0.00508	(53.87)	(61.05)	(30.01)	(37.06)	(2.82)	-	(5.31)	(3.18)
0.00530	(53.94)	(61.35)	(30.21)	(37.52)	(2.81)	-	(5.24)	(3.13)

Figure 4.22 Risk Premiums Relative to RTWG With under the 60% Gross Revenue Guarantee Contract Graph- Part 3

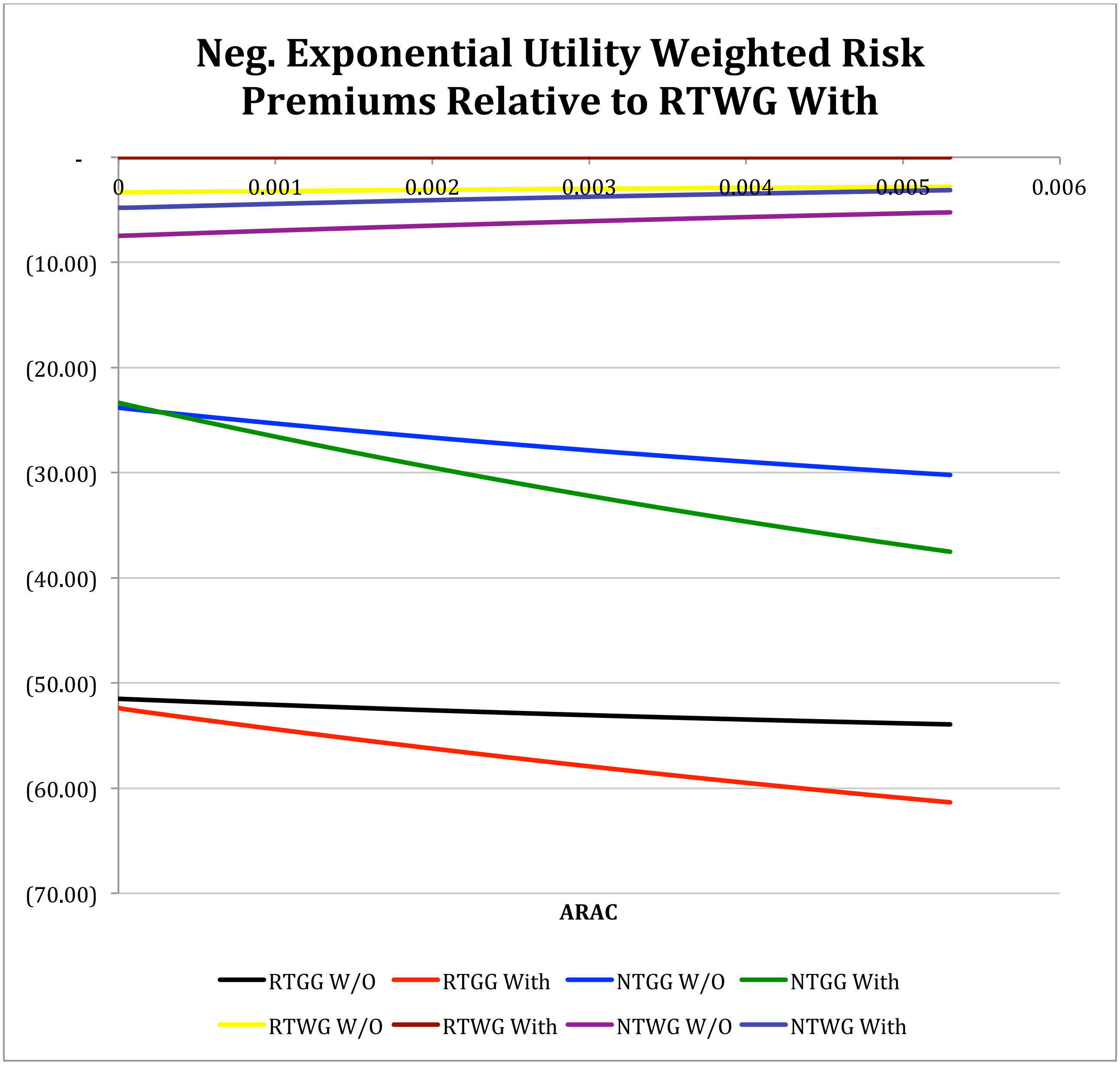


Table 4.24 Risk Premiums Relative to RTWG With under the 100% Gross Revenue Guarantee Contract - Part 3

ARAC	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With
0.00000	(59.78)	(49.48)	(32.10)	(19.06)	(11.61)	-	(15.76)	(5.74)
0.00022	(60.00)	(49.81)	(32.54)	(19.63)	(11.68)	-	(15.73)	(5.67)
0.00044	(60.23)	(50.13)	(32.97)	(20.19)	(11.74)	-	(15.71)	(5.61)
0.00066	(60.45)	(50.45)	(33.38)	(20.74)	(11.81)	-	(15.69)	(5.55)
0.00088	(60.66)	(50.76)	(33.80)	(21.28)	(11.87)	-	(15.67)	(5.48)
0.00110	(60.87)	(51.06)	(34.20)	(21.80)	(11.94)	-	(15.65)	(5.43)
0.00133	(61.08)	(51.36)	(34.60)	(22.31)	(12.00)	-	(15.64)	(5.37)
0.00155	(61.29)	(51.64)	(34.98)	(22.81)	(12.06)	-	(15.62)	(5.31)
0.00177	(61.49)	(51.92)	(35.36)	(23.29)	(12.13)	-	(15.61)	(5.26)
0.00199	(61.69)	(52.20)	(35.74)	(23.77)	(12.19)	-	(15.60)	(5.21)
0.00221	(61.88)	(52.47)	(36.10)	(24.23)	(12.26)	-	(15.59)	(5.16)
0.00243	(62.07)	(52.73)	(36.46)	(24.68)	(12.32)	-	(15.58)	(5.11)
0.00265	(62.26)	(52.98)	(36.82)	(25.12)	(12.39)	-	(15.58)	(5.06)
0.00287	(62.45)	(53.23)	(37.16)	(25.55)	(12.45)	-	(15.57)	(5.01)
0.00309	(62.63)	(53.48)	(37.50)	(25.97)	(12.51)	-	(15.57)	(4.97)
0.00331	(62.81)	(53.71)	(37.83)	(26.38)	(12.58)	-	(15.56)	(4.93)
0.00353	(62.98)	(53.95)	(38.16)	(26.78)	(12.64)	-	(15.56)	(4.88)
0.00375	(63.16)	(54.17)	(38.48)	(27.16)	(12.71)	-	(15.56)	(4.84)
0.00398	(63.33)	(54.39)	(38.79)	(27.54)	(12.77)	-	(15.56)	(4.80)
0.00420	(63.49)	(54.61)	(39.10)	(27.91)	(12.83)	-	(15.56)	(4.76)
0.00442	(63.66)	(54.82)	(39.41)	(28.28)	(12.90)	-	(15.56)	(4.73)
0.00464	(63.82)	(55.02)	(39.70)	(28.63)	(12.96)	-	(15.57)	(4.69)
0.00486	(63.98)	(55.22)	(39.99)	(28.97)	(13.03)	-	(15.57)	(4.65)
0.00508	(64.13)	(55.42)	(40.28)	(29.31)	(13.09)	-	(15.58)	(4.62)
0.00530	(64.28)	(55.61)	(40.56)	(29.64)	(13.15)	-	(15.58)	(4.58)

Figure 4.23 Risk Premiums Relative to RTWG With under the 100% Gross Revenue Guarantee Contract Graph- Part 3

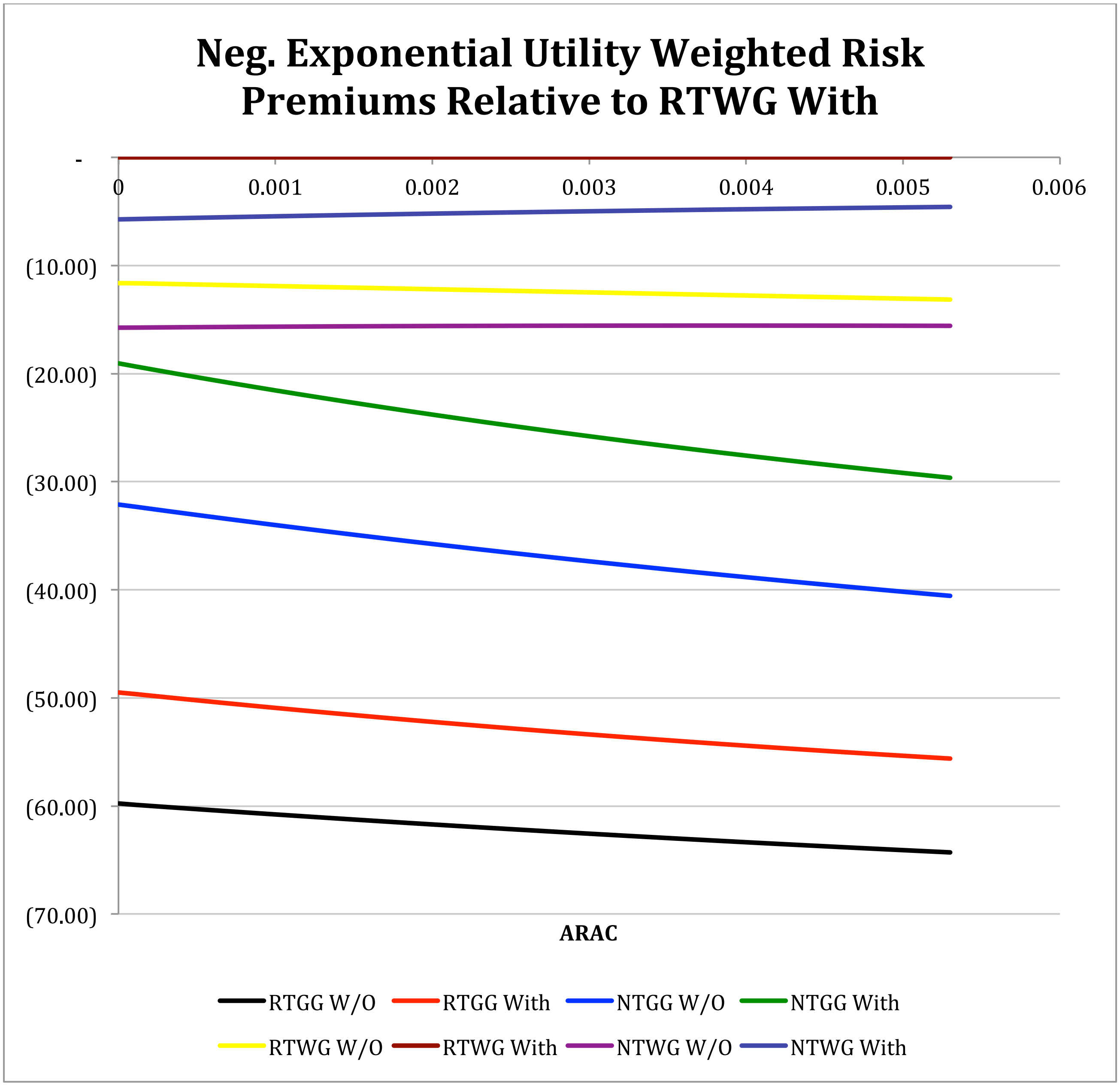


Table 4.25 Risk Premiums Relative to BCAP RTWG With under Contracts Comparison - Part 3

ARAC	SPOT-RTWG With	Min-RTWG With	BCAP-RTWG With	60%-RTWG W/O	100%-RTWG With
0.00000	(19.65)	(18.07)	-	(18.63)	(10.36)
0.00022	(19.56)	(17.99)	-	(18.52)	(10.16)
0.00044	(19.48)	(17.90)	-	(18.42)	(9.96)
0.00066	(19.39)	(17.82)	-	(18.31)	(9.76)
0.00088	(19.31)	(17.74)	-	(18.20)	(9.56)
0.00110	(19.23)	(17.66)	-	(18.10)	(9.36)
0.00133	(19.15)	(17.58)	-	(17.99)	(9.17)
0.00155	(19.06)	(17.51)	-	(17.89)	(8.97)
0.00177	(18.98)	(17.43)	-	(17.79)	(8.78)
0.00199	(18.90)	(17.35)	-	(17.68)	(8.59)
0.00221	(18.82)	(17.28)	-	(17.58)	(8.40)
0.00243	(18.75)	(17.20)	-	(17.48)	(8.21)
0.00265	(18.67)	(17.13)	-	(17.38)	(8.03)
0.00287	(18.59)	(17.06)	-	(17.28)	(7.84)
0.00309	(18.52)	(16.98)	-	(17.18)	(7.65)
0.00331	(18.44)	(16.91)	-	(17.08)	(7.47)
0.00353	(18.37)	(16.84)	-	(16.98)	(7.29)
0.00375	(18.29)	(16.77)	-	(16.89)	(7.11)
0.00398	(18.22)	(16.70)	-	(16.79)	(6.93)
0.00420	(18.15)	(16.63)	-	(16.69)	(6.75)
0.00442	(18.07)	(16.56)	-	(16.59)	(6.57)
0.00464	(18.00)	(16.49)	-	(16.50)	(6.39)
0.00486	(17.93)	(16.43)	-	(16.40)	(6.22)
0.00508	(17.86)	(16.36)	-	(16.31)	(6.04)
0.00530	(17.79)	(16.29)	-	(16.21)	(5.87)

Figure 4.24 Risk Premiums Relative to BCAP RTWG With under Contracts Comparison Graph- Part 3

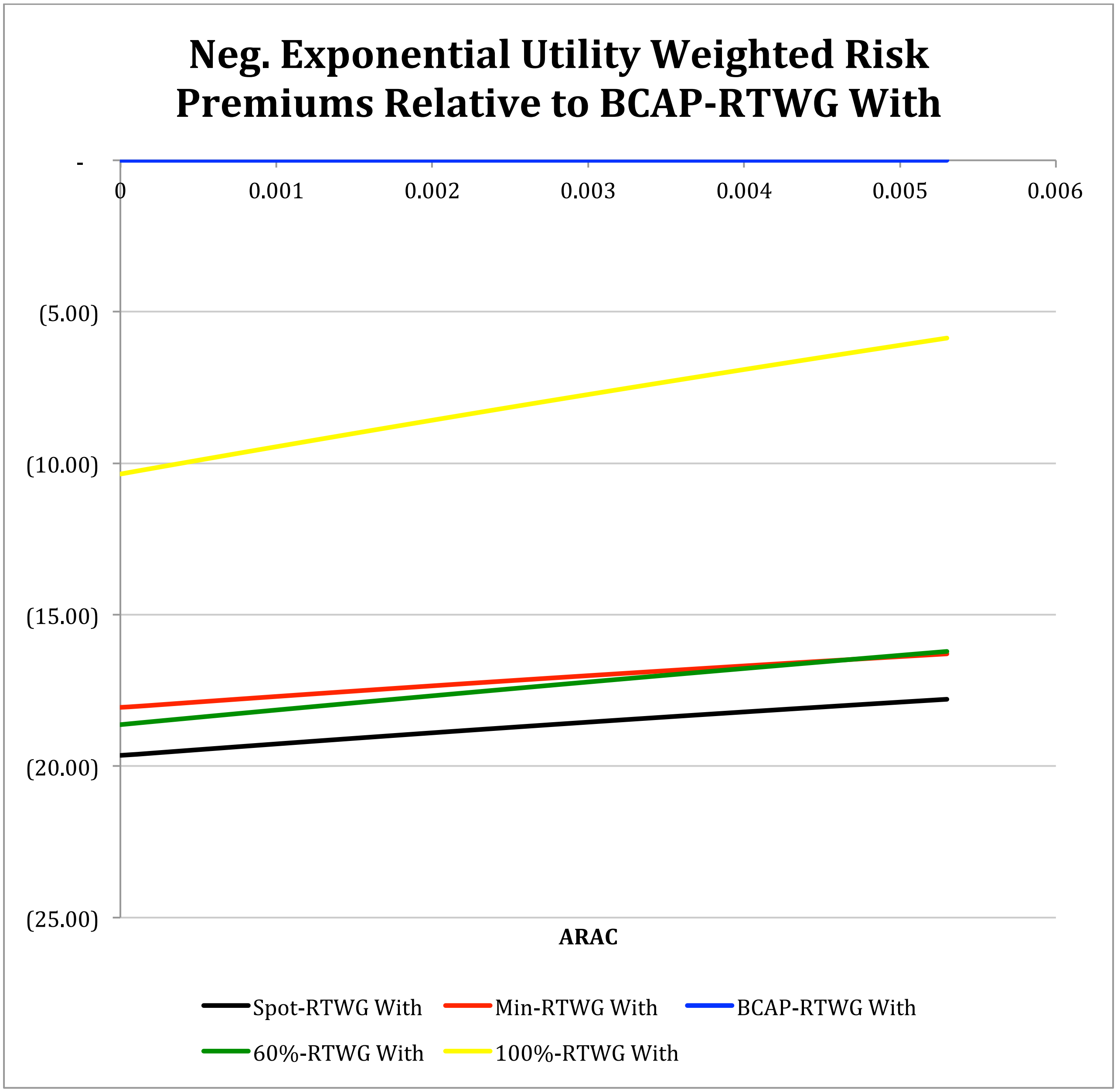


Table 4.26 StopLight Analysis Results– Contracts Comparison - Part 3

StopLight Analysis Results © 2011

Lower Cut-Off Value **$0.00** Upper Cut-Off Value **$153.13**

System	SPOT-RTWG With	Min-RTWG With	BCAP-RTWG With	60%-RTWG With	100%-RTWG With
Prob. (Unfavorable)	0.01	0.01	0.01	0.00	0.00
Prob. (Cautionary)	0.33	0.32	0.26	0.33	0.29
Prob. (Favorable)	0.67	0.67	0.73	0.67	0.71

Figure 4.25 StopLight Results Graph– Contracts Comparison - Part 3

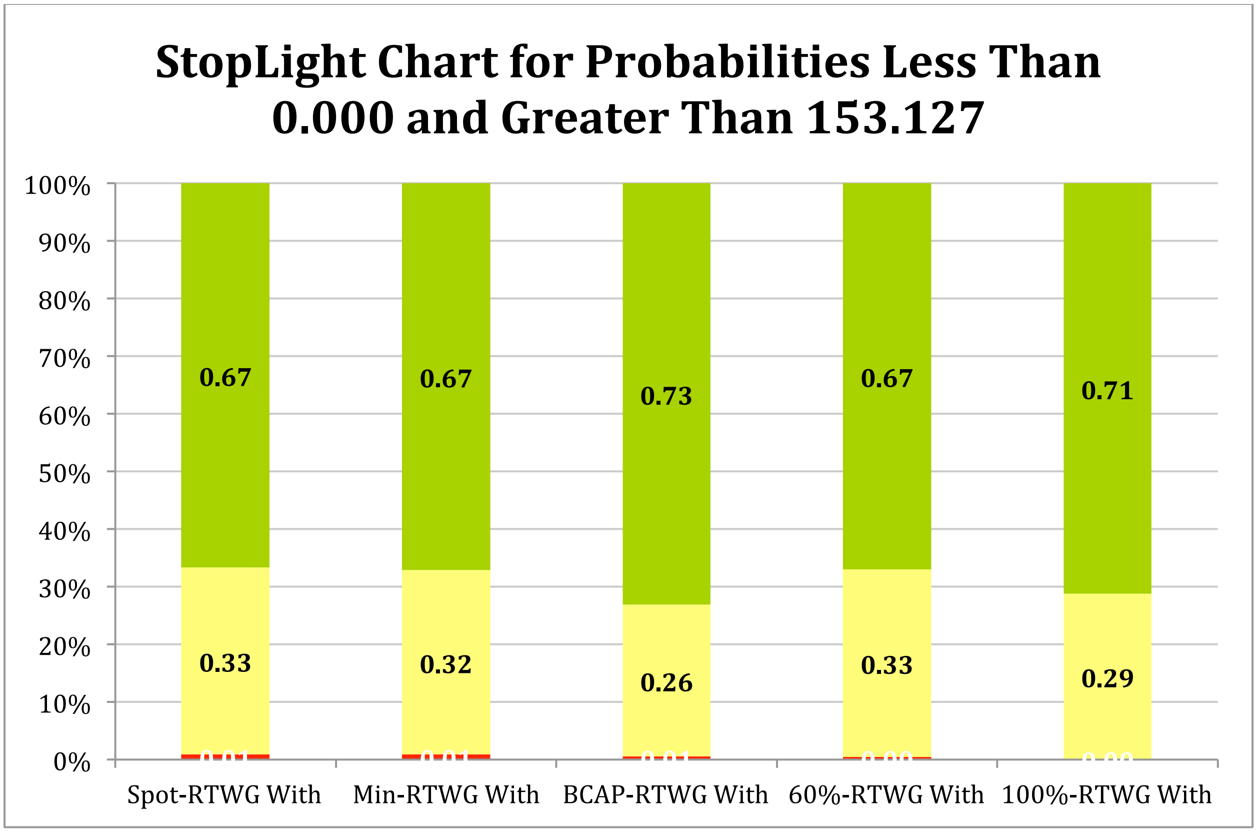


Table 4.27 Risk Premiums Relative to BCAP RTWG With under Contracts Comparison with $10/ton BCAP Payment - Part 3

ARAC	SPOT-RTWG With	Min-RTWG With	BCAP-RTWG With	60%-RTWG With	100%-RTWG With	BCAP 10-RTWG With
0.00000	(19.65)	(18.07)	-	(18.63)	(10.36)	(9.83)
0.00022	(19.56)	(17.99)	-	(18.52)	(10.16)	(9.78)
0.00044	(19.48)	(17.90)	-	(18.42)	(9.96)	(9.74)
0.00066	(19.39)	(17.82)	-	(18.31)	(9.76)	(9.69)
0.00088	(19.31)	(17.74)	-	(18.20)	(9.56)	(9.65)
0.00110	(19.23)	(17.66)	-	(18.10)	(9.36)	(9.61)
0.00133	(19.15)	(17.58)	-	(17.99)	(9.17)	(9.57)
0.00155	(19.06)	(17.51)	-	(17.89)	(8.97)	(9.52)
0.00177	(18.98)	(17.43)	-	(17.79)	(8.78)	(9.48)
0.00199	(18.90)	(17.35)	-	(17.68)	(8.59)	(9.44)
0.00221	(18.82)	(17.28)	-	(17.58)	(8.40)	(9.40)
0.00243	(18.75)	(17.20)	-	(17.48)	(8.21)	(9.36)
0.00265	(18.67)	(17.13)	-	(17.38)	(8.03)	(9.32)
0.00287	(18.59)	(17.06)	-	(17.28)	(7.84)	(9.28)
0.00309	(18.52)	(16.98)	-	(17.18)	(7.65)	(9.24)
0.00331	(18.44)	(16.91)	-	(17.08)	(7.47)	(9.20)
0.00353	(18.37)	(16.84)	-	(16.98)	(7.29)	(9.17)
0.00375	(18.29)	(16.77)	-	(16.89)	(7.11)	(9.13)
0.00398	(18.22)	(16.70)	-	(16.79)	(6.93)	(9.09)
0.00420	(18.15)	(16.63)	-	(16.69)	(6.75)	(9.05)
0.00442	(18.07)	(16.56)	-	(16.59)	(6.57)	(9.01)
0.00464	(18.00)	(16.49)	-	(16.50)	(6.39)	(8.98)
0.00486	(17.93)	(16.43)	-	(16.40)	(6.22)	(8.94)
0.00508	(17.86)	(16.36)	-	(16.31)	(6.04)	(8.91)
0.00530	(17.79)	(16.29)	-	(16.21)	(5.87)	(8.87)

Figure 4.26 Risk Premiums Relative to BCAP RTWG With under Contracts Comparison Graph with $10/ton BCAP Payment - Part 3

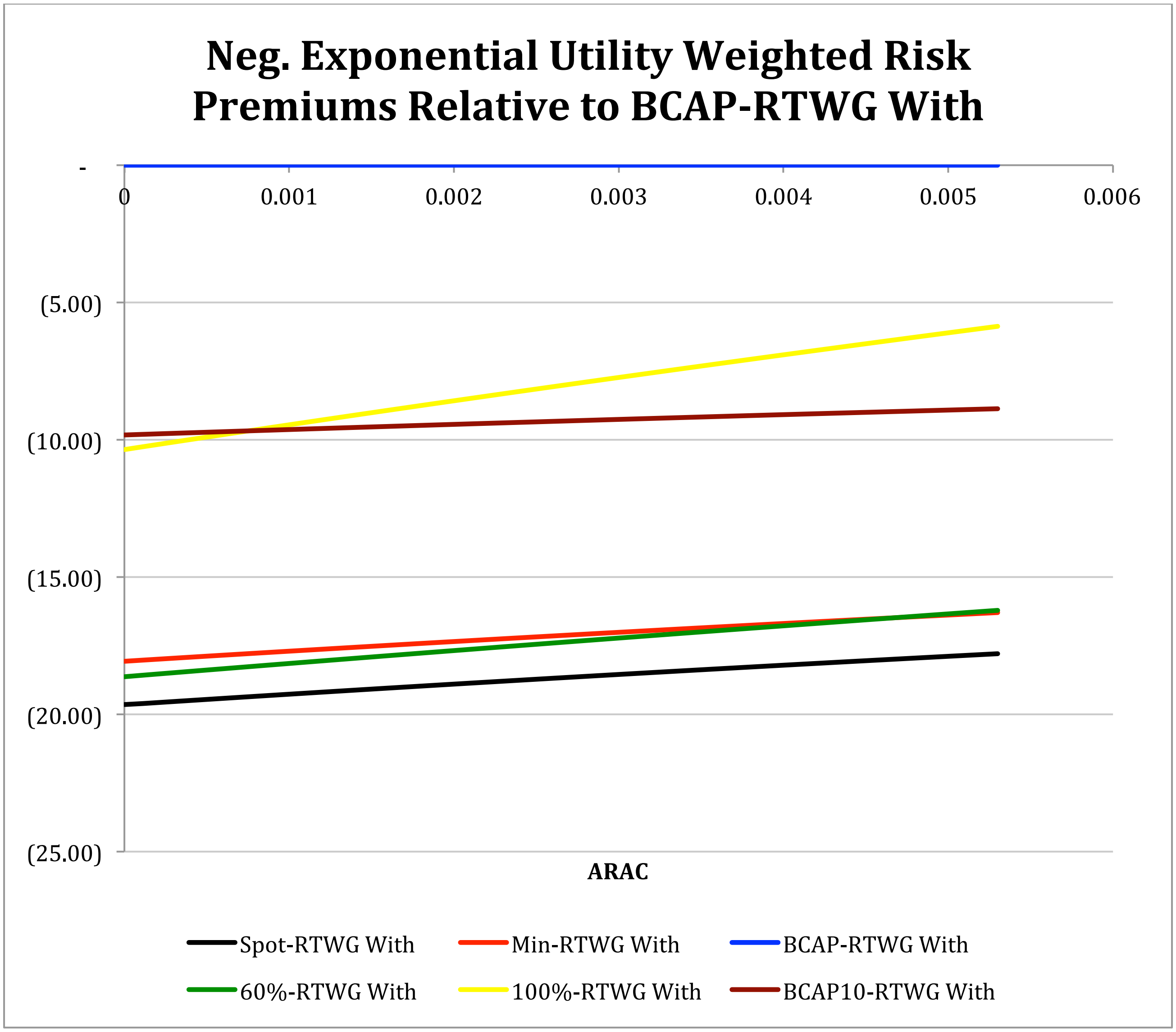
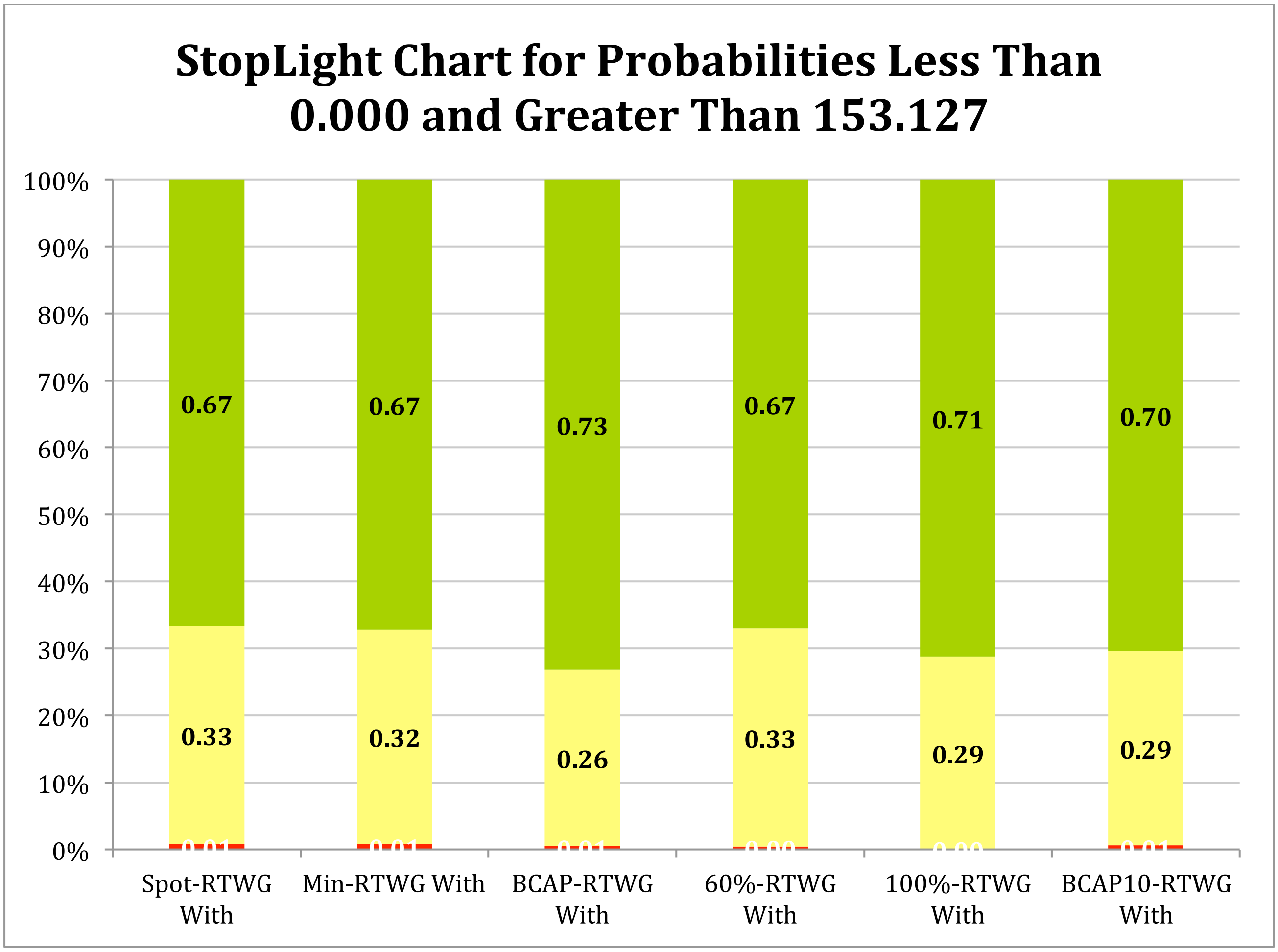


Table 4.28 StopLight Analysis Results– Contracts Comparison with $10/ton BCAP Payment - Part 3

StopLight Analysis Results	© 2011					
Lower Cut-Off Value	**$0.00**		Upper Cut-Off Value		**$153.13**	
System	**SPOT-RTWG With**	**Min-RTWG With**	**BCAP-RTWG With**	**60%-RTWG With**	**100%-RTWG With**	**BCAP 10-RTWG With**
Prob. (Unfavorable)	**0.01**	**0.01**	**0.01**	**0.00**	**0.00**	**0.01**
Prob. (Cautionary)	**0.33**	**0.32**	**0.26**	**0.33**	**0.29**	**0.29**
Prob. (Favorable)	**0.67**	**0.67**	**0.73**	**0.67**	**0.71**	**0.70**

Figure 4.27 StopLight Results Graph– Contracts Comparison with $10/ton BCAP Payment - Part 3



Chapter 5 – Discussions

5.1 Feasibility of Producing Sorghum With Biomass

While photoperiod sensitive sorghum produced the most biomass tons/acre, the dual-purpose sorghum produced the second highest amount of biomass. Grain sorghum produced the most grain bushels/acre. The costs of systems that produce biomass are higher than their rotation counterparts that do not produce biomass due to harvesting and fertilizer costs. NTWDPS W/O is the cheapest in costs and NTWPPS is the most expensive.

Based on results from the analysis including the 11 systems (Part 2) and the analysis including only 8 systems currently practiced in Central Kansas (Part 3), a crop system producing biomass is most preferred and displays higher net returns under the Spot, Minimum, BCAP, 60% and 100% Guarantee contracts according to the stochastic efficiency analysis. When comparing the contract scenarios side by side with the crop system most preferred, both systems produce biomass: NTWDPS With in Part 2 under the BCAP Price contract and RTWG With in Part 3 under the BCAP Price contract.

Because the systems that produce biomass cost more, revenue needs to be insured for the producer for them to decide to grow sorghum for biomass through use of contracts. When this is taken into consideration, it will also allow biorefineries to guarantee a feedstock supply that will allow their factory to run at an optimal level. Policy makers also need to be aware of the higher costs and the need for guaranteed revenue through contracts when deciding legislation to be put into place to create a functioning biofuel industry.

5.2 Feasibility of Producing Biomass Under Different Crop Rotations and Tillage Options

The crop systems that have a no-till option allow for the highest grain and biomass yields. The sorghum varieties produced more grain bushels and biomass tons when it was in rotation with wheat. Even though photoperiod sensitive sorghum produced the most biomass tons/acre, it has the highest amounts in production costs. The dual-purpose sorghum is more efficient than photoperiod sensitive sorghum because it produces grain and the second highest amount of biomass, but has lower production costs.

Crop systems rotated with wheat are more preferred because of higher net returns gained, whether comparing all 11 systems or when just the 8 south central rotations are analyzed. When all the varieties of sorghum are compared in the systems, the wheat and dual-purpose sorghum, no-till rotation with biomass production (NTWDPS With) is preferred. Under Part 3, the research finds that a reduced-till, wheat and grain sorghum rotation with biomass production (RTWG With) is highest in utility of net returns according to the SERF analysis. The least preferred system under Part 2 turns out to be the NTWPPS under the contract scenarios except the BCAP Price contract where RTGG W/O is the lowest in preference. Under Part 3 of Results, the RTGG With is least preferred within the Spot Market, Minimum Price, and 60% Gross Revenue Guarantee contracts. RTGG W/O is lowest in utility under SERF within the BCAP Price contract and the Gross Revenue Guarantee contract at the 100% level.

These results will benefit the producers when deciding what to grow and what tillage option to apply when considering growing for a biomass supply.

5.3 Feasibility of Producing Biomass Under Farmers' Risk Preferences

In Part 2 of the Results sections, all 11 cropping systems are compared. If a producer is offered the Spot Market contract, the Minimum Price contract, the BCAP Price contract, or the 60% or 100% Gross Revenue Guarantee contract, the NTWDPS With system is the most preferred regardless of risk preference when analyzed under SERF.

In Part 3 of the Results chapter, risk aversion doesn't seem to change the system that is most preferred by the producer within SERF. The most preferred system, regardless of risk preference or contract scenario used, is the reduced-till, wheat and grain sorghum rotation with biomass production (RTWG With).

Risk aversion is a factor biorefineries need to account for when going to local producers for biomass supply. The risk level of producers can change the amount of net returns they seek in order to negate the variability and risk associated with growing crops for biomass.

5.4 Feasibility of Producing Biomass Under Different Contract Scenarios

In Part 2 under the SERF results, the BCAP Price contract is highest in utility of net returns. When the net returns are calculated at the expected value of the inputs, yields, and costs, the NTWDPS With system under the BCAP Price contract has the highest net returns. The NTWPPS system has the lowest net returns overall under the Spot Market contract. The NTWDPS With is the highest in utility according to the SERF results under all 5 contract scenarios.

If a producer was allowed to select a contract based on the net returns obtained in Part 2, the most preferred is the BCAP Price contract when producing the NTWDPS With system. Under this contract, they would receive a $20/ton matching payment on biomass produced. When the matching payment was reduced by 50%, the new BCAP contract was still the highest in utility while producing NTWDPS With.

Under Part 3 within the SERF results, RTWG With is the highest in utility of net returns under the Spot Market contract, the Minimum Price contract, the BCAP Price contract, and the 60% and 100% Gross Revenue Guarantee contract.

When the contracts are compared together in Part 3, the BCAP Price contract producing RTWG With is the most preferred, irrespective of risk preference. To see if BCAP is still preferred when the matching payment is lowered, it is reduced to a $10/ton matching payment. The results still conclude that even at half of its original payment, it is still preferred more than the other contracts except if the producer is risk neutral. The 100% Gross Revenue Guarantee demonstrates a higher preference than the BCAP Price contract at $10/ton within a short range of the risk spectrum toward the lower bound.

Contracts can assist biorefineries entering an area to ensure a feedstock supply of biomass and gaining the confidence of the producers. The biofuel industry is still growing and has many risks associated with its growth and unfamiliarity. The BCAP Price contract, with its $20 matching payment per ton of biomass, is understandably most preferred. Even when reduced to $10/ton, a 50% reduction, it still places higher in utility majority of the time than the other contracts offered. This information may be of use to policymakers who want to help ensure the biofuel goals set in the Renewable Fuel Standard 2 (RFS2) under The Energy Independence and Security Act of 2007.

Chapter 6 – Conclusions

6.1 Overview

The purpose of this research is to evaluate and gain a better understanding of the economic feasibility of Kansas farmers growing energy sorghum for biofuel production. The specific objectives are to understand under which levels of net return and risk preferences farmers are willing to produce the sorghum for biomass use in Kansas under different contract scenarios. The findings also provide insight into what type of contract scenarios will be more preferred by Kansas sorghum farmers given their production characteristics, personal risk preferences, price risk, and yield variability. The need for more research in this area is generated by the increasing requirements for biofuel production and ongoing efforts to ensure an adequate supply of bioenergy crops and to facilitate development of sustainable biofuel supply chain driven by policy mandates. The focus on Kansas farmers and the farm-level analysis of this research make it a valuable addition to the growing body of literature examining energy crop supply.

Eleven cropping systems were analyzed for this research. They were either no-till or reduced-till and the rotation involved wheat, grain sorghum, dual-purpose sorghum, or photoperiod sensitive sorghum. The net returns were simulated using historical grain and biomass yields and prices. The net returns were calculated under 5 contract scenarios. The contract scenarios included the Spot Market contract, the Minimum Price contract, the BCAP Price contract, and 2 levels of the Gross Revenue Guarantee contract – 60% and 100%.

Risk analysis was performed on the simulated net returns through use of the Excel add-in SIMETAR©. Stochastic efficiency analysis was used to evaluate the systems based on the net returns and risk preferences, defined using the absolute risk aversion coefficients (ARACs). Within each contract scenario, the systems were analyzed to determine which system was the most preferred. Next, the production under various contracts scenarios was examined to find the contract that had the highest utility under the SERF results dependent upon a decision maker's risk preferences. It was also determined what additional net returns per acre were required for a system or a contract to be equally preferred to the one with highest utility. When the contracts were compared, a BCAP Price contract with a \$10/ton matching payment was included as a way to perform sensitivity analysis.

There are several key findings that emerge from the research. First, the contract that provides the highest average net returns for the grower is the BCAP Price contract with a matching payment of \$20 per ton of biomass produced. Even when the matching payment is reduced by 50%, the BCAP Price contract is still most preferred majority of the time. Second, when the analysis includes wheat and the three varieties of sorghum, the crop system with the highest preference in the SERF analysis is the one with a no-till option, wheat and dual-purpose sorghum rotation and with biomass production (NTWDPS With). When the analysis only involves wheat and grain sorghum rotations, the reduced-till option with biomass production has the most preferred based on the analysis of the 8 systems currently practiced in South Central Kansas. Third, the risk preference does affect the manager's decision under SERF, but not as significantly as initially thought. Originally, the assumption was risk preference would give noteworthy differences in the crop system and contract scenario that had the highest utility. This could potentially be accounted by the risk aversion representation in SIMETAR©.   The absolute risk aversion coefficients

(ARACs) represent the risk preferences from risk neutral to risk adverse. If risk loving was included in the analysis, then the results may differ.

6.2 Contributions

The findings from the research will contribute to the development of the biofuel industry, particularly in Kansas. It will benefit the decision making process that biofuel processors are undergoing who are planning to develop or expand their feedstock base to the region. The additional insight could prove advantageous in informing policy decisions focused on enhancing biofuel supply and facilitating development of biofuel industry to help meet the goals set by the government.

Fossil fuels are a non-renewable source and the reserves are expected to last between 41 to 700 years (Goldemberg and Johansson 2004; Goldemberg 2007). Policy is in place to increase the amount of renewable energy with goals of biomass tons specified for the coming years (*H.R. 6 (110th): Energy Independence and Security Act of 2007* 2007). The need for increased biofuel production is evident as researchers look to find a competent renewable resource to replace fossil fuels. Increasing the knowledge concerning biofuel production can help in advancing the knowledge that can be used by producers, processors, and policymakers.

6.3 Limitations

While wheat and sorghum rotations are common in South Central Kansas, soybeans and corn production are typical of that area too, but are not usually grown in rotation with sorghum. The analysis in this research does not include systems with corn and soybean rotations. As noted in Pachta (2010) and Brammer (2014), the agronomic study in Hesston, KS that the grain yields were extracted from was not done for economic analysis purposes. The experiment was performed to see how certain factors affect yields. This could alter the results when choosing the system with highest utility in the SERF analysis because corn and soybeans will affect the costs and net returns of the crop systems available. It can also affect the rotations available for selection. Crop system preference could change when performing the stochastic efficiency analysis.

Another limitation of the research was the availability of biomass yields data. That information was only available from 2007 to 2011 while the grain yields were used from 10 years worth of data. Having a recent, accurate, and representative data collection is needed when performing research that is made to represent real-life scenarios. Because of the short span of biomass yield data, it may not reflect the most recent yields. This in turn could affect farmers' preferences for crop rotations.

6.4 Future Research

This research helps expand the farm-level literature available on farmer's willingness to grow biomass. It also adds to the literature involving farmers' preference to grow biomass in Kansas, one of the top 10 states in agricultural production. The area in Kansas observed is the south central region.

One area of future research is to expand the geography of the study to other regions of Kansas or across the whole state. The results could then be compared to the results found in South Central Kansas. This research only focused on rotations that included sorghum, whether it was rotated with wheat or it was a continuous sorghum rotation. By including other crop rotations that may or may not involve sorghum, the research can be expanded and compared to other crops such as corn and soybeans. If corn is included, the grain and biomass prices for corn can be used for comparison reasons.

Future research could also be accomplished by surveying producers for crop data and risk preferences. Biorefinery preferences could also be included because this research is also meant for biorefineries who wish to gain their supply from local sources.

Additional contracts could be included or analyzed to discover contract preference. A sensitivity analysis could be performed on the spot market price in the Spot Market contract for biomass. Also, an in-depth look at the organizational structure of biomass production could be worked into the research to help farmers determine what their costs and net returns could potentially be if there are middle-men between the producers and the biorefineries. The middlemen could be entities that harvest, store, and/or haul the biomass produce. Biorefineries also need to take this into account when deciding how they want to secure a biomass supply and allocate their finances.

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Appendix A – Budgets

The costs of the budget systems are the same across the contract scenarios. The prices, gross returns, and net returns will differ. A table will first be presented with the costs associated with the system, then smaller subsets of those tables will follow only containing the prices, gross returns, and net returns associated with the respective budgets.

Table A.1 RTGG With and RTGG W/O Costs ($/acre)

RTGG-M

Grain Sorghum

Nov or Dec. Chisel	1	application	$12.99
April Mulch Tread	0.75	application	$7.26
May Sweep Tread	1.25	application	$12.10
May Herbicide application	1	application	$6.01
Dual 2 Mag	1.33	pt./ac	$20.78
Atrazine 4L	1.75	pt./ac	$3.47
Atrazine 90 DF	0.275	lb./ac	$0.96
Pre-plant Nitrogen application	1	application	$5.95
Urea (46-0-0)	101.66	lbs. N/ac.	$61.33
Mid May Planted G. Sorghum	1	application	$16.59
Concept & Poncho treated GS seed	42	1000s seeds/ac.	$10.50
DAP (18-46-0) banded	80	lbs.	$24.20
Mid Sept. G.Sorghum Harvest	77.04	bu./ac.	$33.44
Interest	0.07	%	$7.55
Total Cost without Biomass			$223.12
Harvest (Biomass)	1	application	
Swath	1	acre	$18.00
Rake	0	acre	
Bale (Lrg Sqr @ approx. 1100 lbs.)	2.60	bale/ac	$36.40
Stacking	2.60	bale/ac	$10.40
Fertilizer for Stover			
Urea (46-0-0)	14.43	lbs. of N	$8.70
TSP (0-46-0)	2.13	lbs. of P	$1.42
Potash (0-0-60)	45.60	lbs. of K	$22.94
Lime	0	lbs.	
Interest	0.07	%	$3.43
Total Cost with Biomass			$324.41

Table A.2 RTGG With and RTGG W/O Gross Returns and Net Returns under the Spot Market Contract ($/acre)

Gross Return without Biomass						
Grain Sorghum	77.04	bu.	$4.90	$/bu.	$/ac.	$377.31
Net Return without Biomass						**$154.19**
Gross Return with Biomass						
Grain Sorghum	77.04	bu.	$4.90	$/bu.		$377.31
Biomass	1.43	ton/ac	$69.58	$/ton		$99.49
Total						$476.80
Net Return with Biomass						**$152.39**
Net From Biomass						**$(1.80)**

Table A.3 RTGG With and RTGG W/O Gross Returns and Net Returns under the Minimum Price Contract ($/acre)

Gross Return without Biomass						
Grain Sorghum	77.04	bu.	$4.90	$/bu.	$/ac.	$377.31
Net Return without Biomass						**$154.19**
Gross Return with Biomass						
Grain Sorghum	77.04	bu.	$4.90	$/bu.		$377.31
Biomass	1.43	ton/ac	$70.00	$/ton		$100.09
Total						$477.40
Net Return with Biomass						**$153.00**
Net From Biomass						**$(1.19)**

Table A.4 RTGG With and RTGG W/O Gross Returns and Net Returns under the BCAP Price Contract ($/acre)

Gross Return without Biomass						
Grain Sorghum	77.04	bu.	$4.90	$/bu.	$/ac.	$377.31
Net Return without Biomass						**$154.19**
Gross Return with Biomass						
Grain Sorghum	77.04	bu.	$4.90	$/bu.		$377.31
Biomass	1.43	ton/ac	$89.58	$/ton		$128.08
Total						$505.40
Net Return with Biomass						**$180.99**
Net From Biomass						**$26.80**

Table A.5 RTGG With and RTGG W/O Gross Returns and Net Returns under the Gross Revenue Guarantee – 60% Contract ($/acre)

Gross Return without Biomass						
Grain Sorghum	77.04	bu.	$4.90	$/bu.	$/ac.	$377.31
Net Return without Biomass						**$154.19**
Gross Return with Biomass						
Grain Sorghum	77.04	bu.	$4.90	$/bu.		$377.31
Biomass	1.43	ton/ac	$69.58	$/ton		$99.49
Biomass Revenue Guarantee						$59.39
Total						$476.80
Net Return with Biomass						**$152.39**
Net From Biomass						**$(1.80)**

Table A.6 RTGG With and RTGG W/O Gross Returns and Net Returns under the Gross Revenue Guarantee – 100% Contract ($/acre)

Gross Return without Biomass						
Grain Sorghum	77.04	bu.	$4.90	$/bu.	$/ac.	$377.31
Net Return without Biomass						**$154.19**
Gross Return with Biomass						
Grain Sorghum	77.04	bu.	$4.90	$/bu.		$377.31
Biomass	1.43	ton/ac	$69.58	$/ton		$99.49
Biomass Revenue Guarantee						$98.99
Total						$476.80
Net Return with Biomass						**$152.39**
Net From Biomass						**$(1.80)**

Table A.7 NTGG With and NTGG W/O Costs ($/acre)

NTGG-M			
Grain Sorghum			
Nov. Herbicide application	0.5	application	$3.01
2,4-D LVE	8	oz./ac	$1.53
COC	16	oz./ac	$1.78
Atrazine 90 DF	0.4175	lbs./ac	$1.46
Atrazine 4L	0.75	pt./ac	$1.49
April/May Herbicide application	1	application	$6.01
Glyphosate	24.04	oz./ac	$5.50
ProPak	4.75	oz./ac	$1.65
AMS	1.725	lbs./ac	$0.59
Dual 2 Mag	0.665	pts./ac	$10.39
Atrazine 90 DF	0.4175	lbs./ac	$1.46
2,4-D LVE	4.75	oz./ac	$0.91
May Herbicide application	0.75	application	$4.51
Dual 2 Mag	0.665	pts./ac	$10.39
Atrazine 4 L	1.625	pts./ac	$3.22
Pre-plant Nitrogen application	1	application	$5.95
Urea (46-0-0)	101.66	lbs. N/ac.	$61.33
Mid May Planted G. Sorghum	1	application	$18.05
Concep & Poncho treated GS seed	42	1000s seeds/ac.	$10.50
DAP (18-46-0) banded	80	lbs. 18-46-0	$24.20
Mid Sept. G.Sorghum Harvest	81.14	bu./ac.	$34.38
Interest	0.07	%	$7.29
Total Cost without Biomass			$215.59
Harvest (Biomass)	1	application	
Swath	1	acre	$18.00
Rake	0	acre	$0.00
Bale (Lrg Sqr @ approx. 1100 lbs.)	2.81	bale/ac	$39.30
Stacking	2.81	bale/ac	$11.23

Fertilizer for Stover			
Urea (46-0-0)	15.58	lbs. of N	$9.40
TSP (0-46-0)	2.30	lbs. of P	$1.54
Potash (0-0-60)	49.24	lbs. of K	$24.77
Lime	0	lbs.	$0.00
Interest	0.07	%	$3.65
Total Cost with Biomass			$323.47

Table A.8 NTGG With and NTGG W/O Gross Returns and Net Returns under the Spot Market Contract ($/acre)

Gross Return without Biomass						
Grain Sorghum	81.14	bu.	$4.90	$/bu.	$/ac.	$397.39
Net Return without Biomass						**$181.80**
Gross Return with Biomass						
Grain Sorghum	81.14	bu.	$4.90	$/bu.		$397.39
Biomass	1.54	ton/ac	$69.58	$/ton		$107.43
Total						$504.82
Net Return with Biomass						**$181.35**
Net From Biomass						**$(0.45)**

Table A.9 NTGG With and NTGG W/O Gross Returns and Net Returns under Minimum Price Contract ($/acre)

Gross Return without Biomass						
Grain Sorghum	81.14	bu.	$4.90	$/bu.	$/ac.	$397.39
Net Return without Biomass						**$181.80**
Gross Return with Biomass						
Grain Sorghum	81.14	bu.	$4.90	$/bu.		$397.39
Biomass	1.54	ton/ac	$70.00	$/ton		$108.08
Total						$505.47
Net Return with Biomass						**$182.00**
Net From Biomass						**$0.20**

Table A.10 NTGG With and NTGG W/O Gross Returns and Net Returns under the BCAP Price Contract ($/acre)

Gross Return without Biomass						
Grain Sorghum	81.14	bu.	$4.90	$/bu.	$/ac.	$397.39
Net Return without Biomass						**$181.80**
Gross Return with Biomass						
Grain Sorghum	81.14	bu.	$4.90	$/bu.		$397.39
Biomass	1.54	ton/ac	$89.58	$/ton		$138.31
Total						$535.70
Net Return with Biomass						**$212.23**
Net From Biomass						**$30.43**

Table A.11 NTGG With and NTGG W/O Gross Returns and Net Returns under the Gross Revenue Guarantee – 60% Contract ($/acre)

Gross Return without Biomass						
Grain Sorghum	81.14	bu.	$4.90	$/bu.	$/ac.	$397.39
Net Return without Biomass						**$181.80**
Gross Return with Biomass						
Grain Sorghum	81.14	bu.	$4.90	$/bu.		$397.39
Biomass	1.54	ton/ac	$69.58	$/ton		$107.43
Biomass Revenue Guarantee						$64.14
Total						$504.82
Net Return with Biomass						**$181.35**
Net From Biomass						**$(0.45)**

Table A.12 NTGG With and NTGG W/O Gross Returns and Net Returns under the Gross Revenue Guarantee – 100% Contract ($/acre)

Gross Return without Biomass						
Grain Sorghum	81.14	bu.	$4.90	$/bu.	$/ac.	$397.39
Net Return without Biomass						**$181.80**
Gross Return with Biomass						
Grain Sorghum	81.14	bu.	$4.90	$/bu.		$397.39
Biomass	1.54	ton/ac	$69.58	$/ton		$107.43
Biomass Revenue Guarantee						$106.91
Total						$504.382
Net Return with Biomass						**$181.35**
Net From Biomass						**$(0.45**

Table A.13 RTWG With and RTWG W/O Costs ($/acre)

RTWG			
Wheat			
Sept. Herbicide Application	0.5	application	$3.01
Glyphosate	10.83	oz./ac	$2.48
AMS	1.075	lbs./ac	$0.37
2,4-D LVE	5	oz./ac	$0.96
Pre-plant Nitrogen application	1	application	$5.95
Urea (46-0-0)	107.44	lbs. N/ac.	$64.81
Mid Oct. Planted Wheat	1	application	$17.40
Wheat Seed	90	lbs./ac.	$15.30
DAP (18-46-0) in furrow	73.75	lbs. 18-46-0	$22.31
Late June Wheat Harvest	48.27	bu.	$29.42
Grain Sorghum			
July V-Blade	0.75	application	$6.82
Fall and spring Sweep	3.75	application	$36.30
March Herbicide Application	0.25	application	$1.50
Glyphosate	4.25	oz./ac	$0.97
AMS	0.25	lbs./ac	$0.09
May Herbicide Application	1	application	$6.01
Atrazine 4L	1.125	pts./ac	$2.23
Dual 2 Mag	1.33	pts./ac	$20.78
Atrazine 90 DF	0.2075	lbs./ac	$0.73
Pre-plant Nitrogen application	1	application	$5.95
Urea (46-0-0)	101.66	lbs. of N needed	$61.33
Mid-May Planted G. Sorghum	1	application	$16.59
Concep & Poncho treated GS seed	42	1000s seeds/ac.	$10.50
DAP (18-46-0) banded	80	lbs.	$24.20
Mid Sept. G. Sorghum Harvest	96.22	bu./ac.	$37.85
Interest	0.07	%	$13.78
Total Cost without Biomass			$407.63

Harvest (Biomass)	1	application	
Swath	1	acre	$18.00
Rake	0	acre	$0.00
Bale (Lrg Sqr @ approx. 1100 lbs.)	3.57	bale/ac	$49.99
Stacking	3.57	bale/ac	$14.28
Fertilizer for Stover			
Urea (46-0-0)	19.82	lbs. of N	$11.95
TSP (0-46-0)	2.93	lbs. of P	$1.95
Potash (0-0-60)	62.63	lbs. of K	$31.50
Lime	0	lbs.	$0.00
Interest	0.07	%	$4.47
Total Cost with Biomass			$539.79
Total Cost / Acre of rotation			$269.89

Table A.14 RTWG With and RTWG W/O Gross Returns and Net Returns under the Spot Market Contract ($/acre)

Gross Return without Biomass						
Wheat	48.27	bu.	$7.06	$/bu.	$/ac.	$340.77
Grain Sorghum	96.22	bu.	$4.90	$/bu.	$/ac.	$471.26
Net Return without Biomass						**$202.20**
Gross Return with Biomass						
Wheat	48.27	bu.	$7.06	$/bu.	$/ac.	$340.77
Grain Sorghum	96.22	bu.	$4.90	$/bu.	$/ac.	$471.26
Biomass	1.96	ton/ac	$89.58	$/ton	$/ac.	$136.64
Total/acre of rotation						$474.34
Net Return with Biomass						**$204.44**
Net From Biomass						**$2.24**

Table A.15 RTWG With and RTWG W/O Gross Returns and Net Returns under the Minimum Price Contract ($/acre)

Gross Return without Biomass						
Wheat	48.27	bu.	$7.06	$/bu.	$/ac.	$340.77
Grain Sorghum	96.22	bu.	$4.90	$/bu.	$/ac.	$471.26
Net Return without Biomass						**$202.20**
Gross Return with Biomass						
Wheat	48.27	bu.	$7.06	$/bu.	$/ac.	$340.77
Grain Sorghum	96.22	bu.	$4.90	$/bu.	$/ac.	$471.26
Biomass	1.96	ton/ac	$70.00	$/ton	$/ac.	$137.47
Total/acre of rotation						$474.75
Net Return with Biomass						**$204.86**
Net From Biomass						**$5.32**

Table A.16 RTWG With and RTWG W/O Gross Returns and Net Returns under the BCAP Price Contract ($/acre)

Gross Return without Biomass						
Wheat	48.27	bu.	$7.06	$/bu.	$/ac.	$340.77
Grain Sorghum	96.22	bu.	$4.90	$/bu.	$/ac.	$471.26
Net Return without Biomass						**$202.20**
Gross Return with Biomass						
Wheat	48.27	bu.	$7.06	$/bu.	$/ac.	$340.77
Grain Sorghum	96.22	bu.	$4.90	$/bu.	$/ac.	$471.26
Biomass	1.96	ton/ac	$89.58	$/ton	$/ac.	$175.92
Total/acre of rotation						$493.97
Net Return with Biomass						**$224.08**
Net From Biomass						**$43.77**

Table A.17 RTWG With and RTWG W/O Gross Returns and Net Returns under the Gross Revenue Guarantee – 60% Contract ($/acre)

Gross Return without Biomass						
Wheat	48.27	bu.	$7.06	$/bu.	$/ac.	$340.77
Grain Sorghum	96.22	bu.	$4.90	$/bu.	$/ac.	$471.26
Net Return without Biomass						**$202.20**
Gross Return with Biomass						
Wheat	48.27	bu.	$7.06	$/bu.	$/ac.	$340.77
Grain Sorghum	96.22	bu.	$4.90	$/bu.	$/ac.	$471.26
Biomass	1.96	ton/ac	$69.58	$/ton	$/ac.	$136.64
Biomass Revenue Guarantee						$81.60
Total/acre of rotation						$474.34
Net Return with Biomass						**$204.44**
Net From Biomass						**$2.25**

Table A.18 RTWG With and RTWG W/O Gross Returns and Net Returns under the Gross Revenue Guarantee – 100% Contract ($/acre)

Gross Return without Biomass						
Wheat	48.27	bu.	$7.06	$/bu.	$/ac.	$340.77
Grain Sorghum	96.22	bu.	$4.90	$/bu.	$/ac.	$471.26
Net Return without Biomass						**$202.20**
Gross Return with Biomass						
Wheat	48.27	bu.	$7.06	$/bu.	$/ac.	$340.77
Grain Sorghum	96.22	bu.	$4.90	$/bu.	$/ac.	$471.26
Biomass	1.96	ton/ac	$69.58	$/ton	$/ac.	$136.64
Biomass Revenue Guarantee						$136.00
Total/acre of rotation						$474.34
Net Return with Biomass						**$204.44**
Net From Biomass						**$2.25**

Table A.19 NTWG With and NTWG W/O Costs ($/acre)

NTWG				
Wheat				
Sept. Herbicide Application	0.5	application		$3.01
Glyphosate	10.83	oz./ac		$2.48
AMS	1.075	lbs./ac		$0.37
2,4-D LVE	5	oz./ac		$0.96
Pre-plant Nitrogen application	1	application		$5.95
Urea (46-0-0)	107.44	lbs. N/ac.		$64.81
Mid Oct. Planted Wheat	1	application		$17.40
Wheat Seed	90	lbs./ac.		$15.30
DAP (18-46-0) in furrow	73.75	lbs.		$22.31
April Herbicide Application	0.25	application		$1.50
Surfactant	1.6	oz./ac		$0.40
Everest	0.15	oz./ac		$3.04
Late June Wheat Harvest	51.10	bu.		$30.07
Grain Sorghum				
July Herbicide Application	1	application		$6.01
Glyphosate	23.21	oz./ac		$5.31
ProPak	9.5	oz./ac		$3.29
2,4-D Amine	4.75	oz./ac		$0.69
Banvel	3.25	oz./ac		$2.08
AMS	0.75	lbs./ac		$0.26
Select	2	oz./ac		$1.64
Superb COC	3.25	oz./ac		$0.67
Sept. Herbicide application	1	application	93.07372283	$6.01
Glyphosate	18.94	oz./ac		$4.34
ProPak	4.75	oz./ac		$1.65
2,4-D Amine	5	oz./ac		$0.73
AMS	1.2	lbs./ac		$0.41
Nov. Herbicide application	0.75	application		$4.51
Glyphosate	4	oz./ac		$0.92
AMS	0.125	lbs./ac		$0.04
COC	16	oz./ac		$1.78
2,4-D LVE	8	oz./ac		$1.53

Atrazine 90 DF	0.4175	lbs./ac	$1.46
Atrazine 4L	0.75	pts./ac	$1.49
Spring Herbicide Application	1	application	$6.01
Glyphosate	19.63	oz./ac	$4.49
ProPak	4.75	oz./ac	$1.65
AMS	1.3	lbs./ac	$0.44
Banvel	1.375	oz./ac	$0.88
May Herbicide Application	1	application	$6.01
COC	8	oz./ac	$0.89
2,4-D LVE	1.5	oz./ac	$0.29
Banvel	0.5	oz./ac	$0.32
Dual 2 Mag	1.1675	pts./ac	$18.24
Glyphosate	8.25	oz./ac	$1.89
AMS	1.075	lbs./ac	$0.37
Atrazine 90 DF	0.2075	lbs./ac	$0.73
May Herbicide Application	0.25	application	$1.50
Atrazine 4L	0.375	pts./ac	$0.74
Dual 2 Mag	0.3325	pts./ac	$5.20
Pre-plant Nitrogen application	1	application	$5.95
Urea (46-0-0)	101.66	lbs. of N needed	$61.33
Mid-May Planted G. Sorghum	1	application	$18.05
Concep & Poncho treated GS seed	42	1000s seeds/ac.	$10.50
DAP (18-46-0) banded	80	lbs. 18-46-0	$24.20
Mid Sept. G. Sorghum Harvest	95.92	bu./ac.	$37.78
Interest	0.07	%	$14.70
Total Cost without Biomass			$434.56
Harvest (Biomass)	1	application	
Swath	1	acre	$18.00
Rake	0	acre	$0.00
Bale (Lrg Sqr @ approx. 1100 lbs.)	3.56	bale/ac	$49.78
Stacking	3.56	bale/ac	$14.22
Fertilizer for Stover			
Urea (46-0-0)	19.73	lbs. of N	$11.90
TSP (0-46-0)	2.91	lbs. of P	$1.95

Potash (0-0-60)	62.36	lbs. of K	$31.37
Lime	0	lbs.	$0.00
Interest	0.07	%	$4.45
Total Cost with Biomass			$566.22
Total Cost / Acre of rotation			$283.11

Table A.20 NTWG With and NTWG W/O Gross Returns and Net Returns under the Spot Market Contract ($/acre)

Gross Return without Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Grain Sorghum	95.92	bu.	$4.90	$/bu.	$/ac.	$469.77
Net Return without Biomass						**$197.97**
Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Grain Sorghum	95.92	bu.	$4.90	$/bu.	$/ac.	$469.77
Biomass	1.96	ton/ac	$69.58	$/ton	$/ac.	$136.06
Total/acre of rotation						$483.27
Net Return with Biomass						**$200.16**
Net From Biomass						**$2.20**

Table A.21 NTWG With and NTWG W/O Gross Returns and Net Returns under the Minimum Price Contract ($/acre)

Gross Return without Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Grain Sorghum	95.92	bu.	$4.90	$/bu.	$/ac.	$469.77
Net Return without Biomass						**$197.97**
Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Grain Sorghum	95.92	bu.	$4.90	$/bu.	$/ac.	$469.77
Biomass	1.96	ton/ac	$70.00	$/ton	$/ac.	$136.88
Total/acre of rotation						$483.69
Net Return with Biomass						**$200.57**
Net From Biomass						**$2.60**

Table A.22 NTWG With and NTWG W/O Gross Returns and Net Returns under the BCAP Price Contract ($/acre)

Gross Return without Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Grain Sorghum	95.92	bu.	$4.90	$/bu.	$/ac.	$469.77
Net Return without Biomass						**$197.97**
Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Grain Sorghum	95.92	bu.	$4.90	$/bu.	$/ac.	$469.77
Biomass	1.96	ton/ac	$89.58	$/ton	$/ac.	$175.17
Total/acre of rotation						$502.83
Net Return with Biomass						**$219.72**
Net From Biomass						**$21.75**

Table A.23 NTWG With and NTWG W/O Gross Returns and Net Returns under the Gross Revenue Guarantee – 60% Contract ($/acre)

Gross Return without Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Grain Sorghum	95.92	bu.	$4.90	$/bu.	$/ac.	$469.77
Net Return without Biomass						**$197.97**
Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Grain Sorghum	95.92	bu.	$4.90	$/bu.	$/ac.	$469.77
Biomass	1.96	ton/ac	$69.58	$/ton	$/ac.	$136.06
Biomass Revenue Guarantee						$81.24
Total/acre of rotation						$483.27
Net Return with Biomass						**$200.16**
Net From Biomass						**$2.20**

Table A.24 NTWG With and NTWG W/O Gross Returns and Net Returns under the Gross Revenue Guarantee – 100% Contract ($/acre)

Gross Return without Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Grain Sorghum	95.92	bu.	$4.90	$/bu.	$/ac.	$469.77
Net Return without Biomass						**$197.97**
Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Grain Sorghum	95.92	bu.	$4.90	$/bu.	$/ac.	$469.77
Biomass	1.96	ton/ac	$69.58	$/ton	$/ac.	$136.06
Biomass Revenue Guarantee						$135.39
Total/acre of rotation						$483.27
Net Return with Biomass						**$200.16**
Net From Biomass						**$2.20**

Table A.25 NTWPPS Costs ($/acre)

NTWPPS			
Wheat			
Sept. Herbicide Application	0.5	application	$3.01
Glyphosate	10.83	oz./ac	$2.48
AMS	1.075	lbs./ac	$0.37
2,4-D LVE	5	oz./ac	$0.96
Pre-plant Nitrogen application	1	application	$5.95
Urea (46-0-0)	107.44	lbs. N/ac.	$64.81
Mid Oct. Planted Wheat	1	application	$17.40
Wheat Seed	90	lbs./ac.	$15.30
DAP (18-46-0) in furrow	73.75	lbs. 18-46-0	$22.31
April Herbicide Application	0.25	application	$1.50
Surfactant	1.6	oz./ac	$0.40
Everest	0.15	Oz./ac	$3.04
Late June Wheat Harvest	51.10	bu.	$30.07
Grain Sorghum (Photoperiod Sensitive)			
Herbicide #1	1	application	$6.01
Bicep II Magnum	1.6	qt./ac	$16.93
Fertilizer-Broadcast	1	application	$5.95
Fertilizer for Grain			
Urea (46-0-0)	43	lbs. of N	$25.94
TSP (0-46-0)	41	lbs. of P	$27.39
Fertilizer for Stover			
Urea (46-0-0)	93.32	lbs. of N	$56.29
TSP (0-46-0)	20.22	lbs. of P	$13.51
Lime with application	0	lbs.	$0.00
Planting No-till	1	application	$18.05
PS Seed	4.67	lbs./ac	$16.81
Fertilizer for Grain			
Potash (0-0-60)	0	lbs. of K	$0.00
Fertilizer for Stover			
Potash (0-0-60)	264.86	lbs. of K	$133.22

Herbicide #2	1	application	$6.01
Buctril + Atrazine	2	pt./ac	$12.68
Grain Sorghum Harvest (no grain)	0	bu./ac.	$0.00
Harvest (Biomass)	1	application	$0.00
Swath	1	acre	$18.00
Rake	1	acre	$7.00
Bale (Lrg Sqr @ approx. 1100 lbs.)	17.94	bale/ac	$251.09
Stacking	17.94	bale/ac	$71.74
Interest	0.07	%	$29.90
Total Cost / Acre of rotation			$442.06

Table A.26 NTWPPS Gross Returns and Net Returns under the Spot Market Contract ($/acre)

Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Biomass	9.86	ton/ac	$69.58	$/ton	$/ac.	$686.34
Total/acre of rotation						$523.53
Net Return with Biomass						**$81.47**

Table A.27 NTWPPS Gross Returns and Net Returns under the Minimum Price Contract ($/acre)

Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Biomass	9.86	ton/ac	$70.00	$/ton	$/ac.	$690.51
Total/acre of rotation						$525.61
Net Return with Biomass						**$83.55**

Table A.28 NTWPPS Gross Returns and Net Returns under the BCAP Price Contract ($/acre)

Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Biomass	9.86	ton/ac	$89.58	$/ton	$/ac.	$883.63
Total/acre of rotation						$622.17
Net Return with Biomass						**$180.11**

Table A.29 NTWPPS Gross Returns and Net Returns under the Gross Revenue Guarantee – 60% Contract ($/acre)

Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Biomass	9.86	ton/ac	$69.58	$/ton	$/ac.	$686.34
Biomass Revenue Guarantee						$409.72
Total/acre of rotation						$523.53
Net Return with Biomass						**$81.47**

Table A.30 NTWPPS Gross Returns and Net Returns under the Gross Revenue Guarantee – 100% Contract ($/acre)

Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Biomass	9.86	ton/ac	$69.58	$/ton	$/ac.	$686.34
Biomass Revenue Guarantee						$682.87
Total/acre of rotation						$523.53
Net Return with Biomass						**$81.47**

Table A.31 NTWDPS With and NTWDPS W/O Costs ($/acre)

NTWDPS			
Wheat			
Sept. Herbicide Application	0.5	application	$3.01
Glyphosate	10.83	oz./ac	$2.48
AMS	1.075	lbs./ac	$0.37
2,4-D LVE	5	oz./ac	$0.96
Pre-plant Nitrogen application	1	application	$5.95
Urea (46-0-0)	107.44	lbs. N/ac.	$64.81
Mid Oct. Planted Wheat	1	application	$17.40
Wheat Seed	90	lbs./ac.	$15.30
DAP (18-46-0) in furrow	73.75	lbs. 18-46-0	$22.31
April Herbicide Application	0.25	application	$1.50
Surfactant	1.6	oz./ac	$0.40
Everest	0.15	oz./ac	$3.04
Late June Wheat Harvest	51.10	bu.	$30.07
Grain Sorghum (Dual Purpose)			
Herbicide #1	1	application	$6.01
Bicep II Magnum	1.6	qt./ac	$16.93
Fertilizer-Broadcast	1	application	$5.95
Fertilizer for Grain			
Urea (46-0-0)	43	lbs. of N	$25.94
TSP (0-46-0)	41	lbs. of P	$27.39
Planting No-till	1	application	$18.05
DS Seed	4.67	lbs./ac	$16.81
Fertilizer for Grain			
Potash (0-0-60)	0	lbs. of K	$0.00
Herbicide #2	1	application	$6.01
Buctril + Atrazine	2	pt./ac	$12.68
Harvest Grain Sorghum	73.11	bu./ac	$32.54
Interest	0.07	%	$11.76

Total Cost without Biomass			$347.66
Harvest (Biomass)			
Swath	1	acre	$18.00
Rake	0	acre	$0.00
Bale (Lrg Sqr @ approx. 1100 lbs.)	8.44	ton/ac	$214.83
Stacking	8.44	ton/ac	$61.38
Fertilizer for Stover			
Urea (46-0-0)	53.09	lbs. of N	$32.02
TSP (0-46-0)	9.11	lbs. of P	$6.09
Potash (0-0-60)	183.23	lbs. of K	$92.16
Lime	0	lbs.	$0.00
Interest	0.07	%	$14.86
Total Cost with Biomass			$787.00
Total Cost / Acre of rotation			$393.50

Table A.32 NTWDPS With and NTWDPS W/O Gross Returns and Net Returns under the Spot Market Contract ($/acre)

Gross Return without Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Sorghum	73.11	bu.	$4.90	$/bu.	$/ac.	$358.07
Net Return without Biomass						**$185.57**
Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Sorghum	73.11	bu.	$4.90	$/bu.	$/ac.	$358.07
Biomass	8.44	ton/ac	$69.58	$/ton	$/ac.	$587.22
Total/acre of rotation						$653.00
Net Return with Biomass						**$259.50**
Net From Biomass						**$73.94**

Table A.33 NTWDPS With and NTWDPS W/O Gross Returns and Net Returns under the Minimum Price Contract ($/acre)

Gross Return without Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Sorghum	73.11	bu.	$4.90	$/bu.	$/ac.	$358.07
Net Return without Biomass						**$185.57**
Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Sorghum	73.11	bu.	$4.90	$/bu.	$/ac.	$358.07
Biomass	8.44	ton/ac	$70.00	$/ton	$/ac.	$590.78
Total/acre of rotation						$654.79
Net Return with Biomass						**$261.29**
Net From Biomass						**$75.72**

Table A.34 NTWDPS With and NTWDPS W/O Gross Returns and Net Returns under the BCAP Price Contract ($/acre)

Gross Return without Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Sorghum	73.11	bu.	$4.90	$/bu.	$/ac.	$358.07
Net Return without Biomass						**$185.57**
Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Sorghum	73.11	bu.	$4.90	$/bu.	$/ac.	$358.07
Biomass	8.44	ton/ac	$89.58	$/ton	$/ac.	$756.01
Total/acre of rotation						$737.40
Net Return with Biomass						**$343.90**
Net From Biomass						**$158.33**

Table A.35 NTWDPS With and NTWDPS W/O Gross Returns and Net Returns under the Gross Revenue Guarantee – 60% Contract ($/acre)

Gross Return without Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Sorghum	73.11	bu.	$4.90	$/bu.	$/ac.	$358.07
Net Return without Biomass						**$185.57**
Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Sorghum	73.11	bu.	$4.90	$/bu.	$/ac.	$358.07
Biomass	8.44	ton/ac	$69.58	$/ton	$/ac.	$587.22
Biomass Revenue Guarantee						$350.62
Total/acre of rotation						$653.00
Net Return with Biomass						**$259.50**
Net From Biomass						**$73.94**

Table A.36 NTWDPS With and NTWDPS W/O Gross Returns and Net Returns under the Gross Revenue Guarantee – 100% Contract ($/acre)

Gross Return without Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Sorghum	73.11	bu.	$4.90	$/bu.	$/ac.	$358.07
Net Return without Biomass						**$185.57**
Gross Return with Biomass						
Wheat	51.10	bu.	$7.06	$/bu.	$/ac.	$360.71
Sorghum	73.11	bu.	$4.90	$/bu.	$/ac.	$358.07
Biomass	8.44	ton/ac	$69.58	$/ton	$/ac.	$587.22
Biomass Revenue Guarantee						$584.36
Total/acre of rotation						$653.00
Net Return with Biomass						**$259.50**
Net From Biomass						**$73.94**

Appendix B – Correlation Matrices

Table B.1 Correlation Matrix of Grain Yields

Linear Correlation Matrix

	W/GS RT	W/GS NT	GS/W RT	GS/W NT	GS/GS RT	GS/GS NT
W/GS RT	1.000	0.742	0.003	-0.048	0.024	0.055
W/GS NT		1.000	-0.056	-0.102	-0.052	0.042
GS/W RT			1.000	0.985	0.971	0.982
GS/W NT				1.000	0.975	0.967
GS/GS RT					1.000	0.986
GS/GS NT						1.000

Table B.2 P-Values of Correlation of Grain Yields

Correlation statistic two-tailed p-values (approx.). **Bold values** indicate statistical significance at the 95% confidence level.

Significance 0.95

	W/GS RT	W/GS NT	GS/W RT	GS/W NT	GS/GS RT	GS/GS NT
W/GS RT		**0.014**	0.992	0.896	0.947	0.879
W/GS NT			0.878	0.779	0.887	0.908
GS/W RT				**1.903E-07**	**3.060E-06**	**4.682E-07**
GS/W NT					**1.671E-06**	**4.8112E-06**
GS/GS RT						**1.7017E-07**
GS/GS NT						

Table B.3 Correlation Matrix of Photoperiod Sensitive Sorghum and Dual-Purpose Sorghum Yields

Linear Correlation Matrix			
	PSS Biomass	**DPS Grain**	**DPS Biomass**
PSS Biomass	1.000	0.656	0.291
DPS Grain		1.000	-0.351
DPS Biomass			1.000

Table B.4 P-Values of Correlation of Photoperiod Sensitive Sorghum and Dual-Purpose Sorghum Yields

Correlation statistic two-tailed p-values (approx.). **Bold values** indicate statistical significance at the 95% confidence level.			
Significance	0.95		
	PSS Biomass	**DPS Grain**	**DPS Biomass**
PSS Biomass		0.230	0.635
DPS Grain			0.563
DPS Biomass			

Table B.5 Correlation Matrix of Grain Prices

Linear Correlation Matrix		
	Wheat	**Sorghum**
Wheat	1.000	0.693
Sorghum		1.000

Table B.6 P-Values of Correlation of Grain Prices

Correlation statistic two-tailed p-values (approx.). **Bold values** indicate statistical significance at the 95% confidence level.

Significance	0.95	
	Wheat	**Sorghum**
Wheat		**2.73074E-13**
Sorghum		

Appendix C – StopLight Analysis Results

Table C.1 StopLight Analysis Results– Minimum Price Contract

StopLight Analysis Results © 2011

Lower Cut-Off Value **$0.00** Upper Cut-Off Value **$152.33**

System	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With	NTWPPS	NTWDPS W/O	NTWDPS With
Prob. (Unfavorable)	0.05	0.06	0.03	0.04	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Prob. (Cautionary)	0.49	0.48	0.42	0.41	0.33	0.32	0.34	0.32	0.87	0.39	0.09
Prob. (Favorable)	0.46	0.46	0.55	0.56	0.66	0.68	0.65	0.67	0.12	0.61	0.91

Figure C.1 StopLight Analysis Graph – Minimum Price Contract

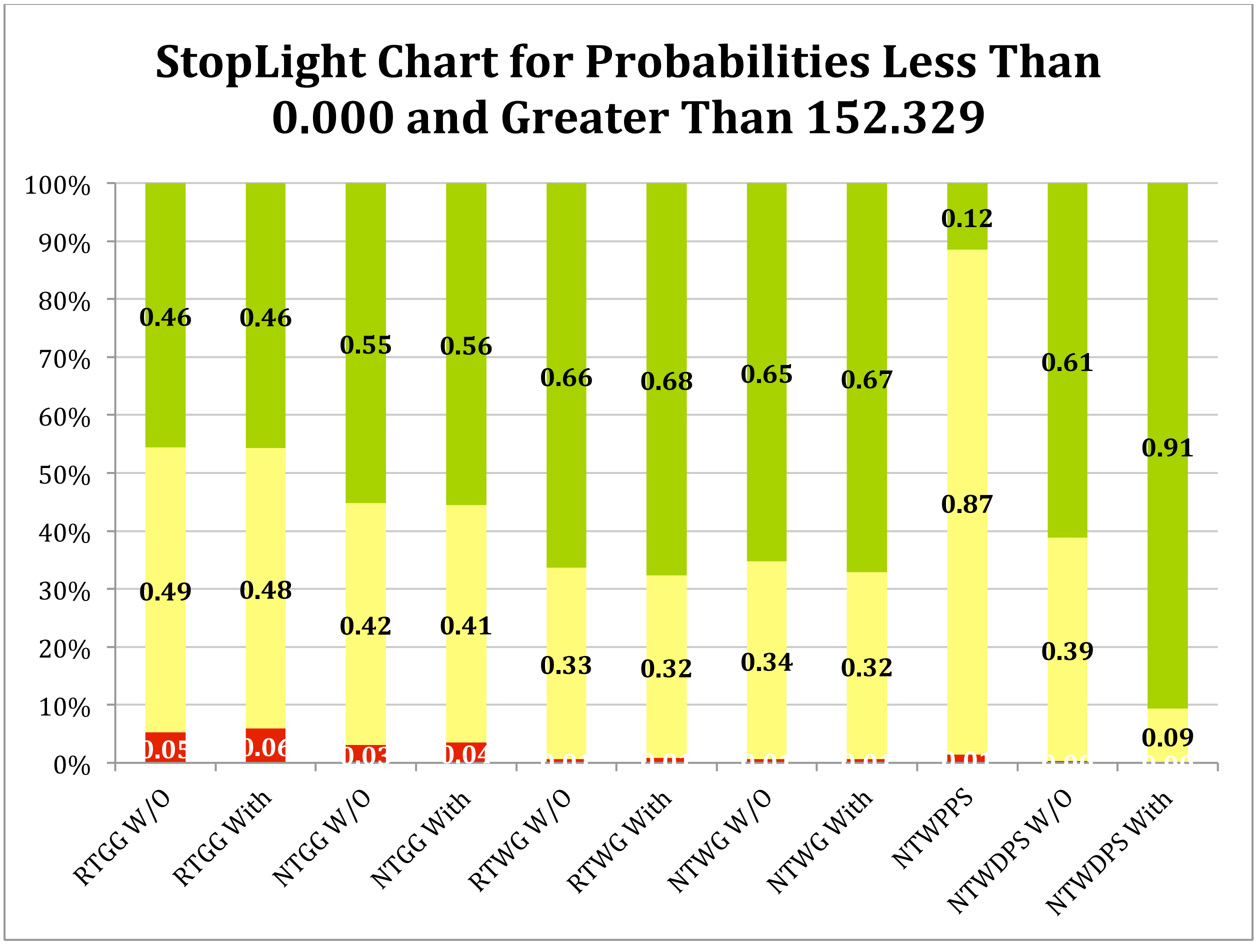

Table C.2 StopLight Analysis Results– BCAP Contract

StopLight Analysis Results © 2011

Lower Cut-Off Value	**$0.00**			Upper Cut-Off Value		**$152.33**					
System	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With	NTWPPS	NTWDPS W/O	NTWDPS With
Prob. (Unfavorable)	0.05	0.04	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Prob. (Cautionary)	0.49	0.41	0.42	0.34	0.33	0.26	0.34	0.26	0.33	0.39	0.00
Prob. (Favorable)	0.46	0.55	0.55	0.65	0.66	0.73	0.65	0.74	0.67	0.61	1.00

Figure C.2 StopLight Analysis Graph – BCAP Contract

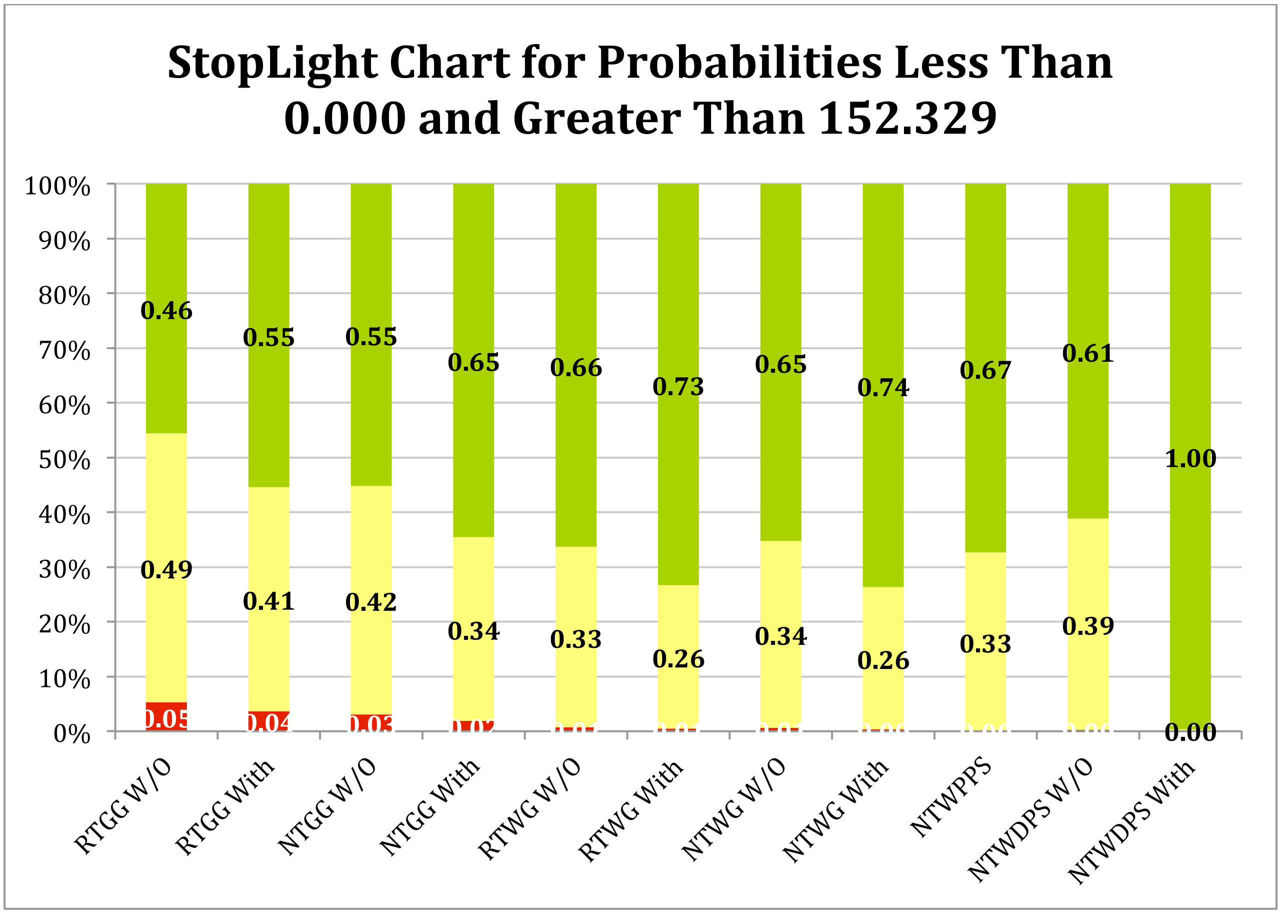

Table C.3 StopLight Analysis Results– Gross Revenue Guarantee – 60% Contract

StopLight Analysis Results © 2011

Lower Cut-Off Value	$0.00		Upper Cut-Off Value			$153.13					
System	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With	NTWPPS	NTWDPS W/O	NTWDPS With
Prob. (Unfavorable)	0.05	0.08	0.03	0.05	0.01	0.00	0.01	0.01	0.11	0.00	0.00
Prob. (Cautionary)	0.49	0.47	0.42	0.41	0.33	0.33	0.34	0.34	0.76	0.39	0.12
Prob. (Favorable)	0.45	0.45	0.55	0.54	0.66	0.67	0.65	0.66	0.14	0.61	0.89

Figure C.3 StopLight Analysis Graph – Gross Revenue Guarantee – 60% Contract

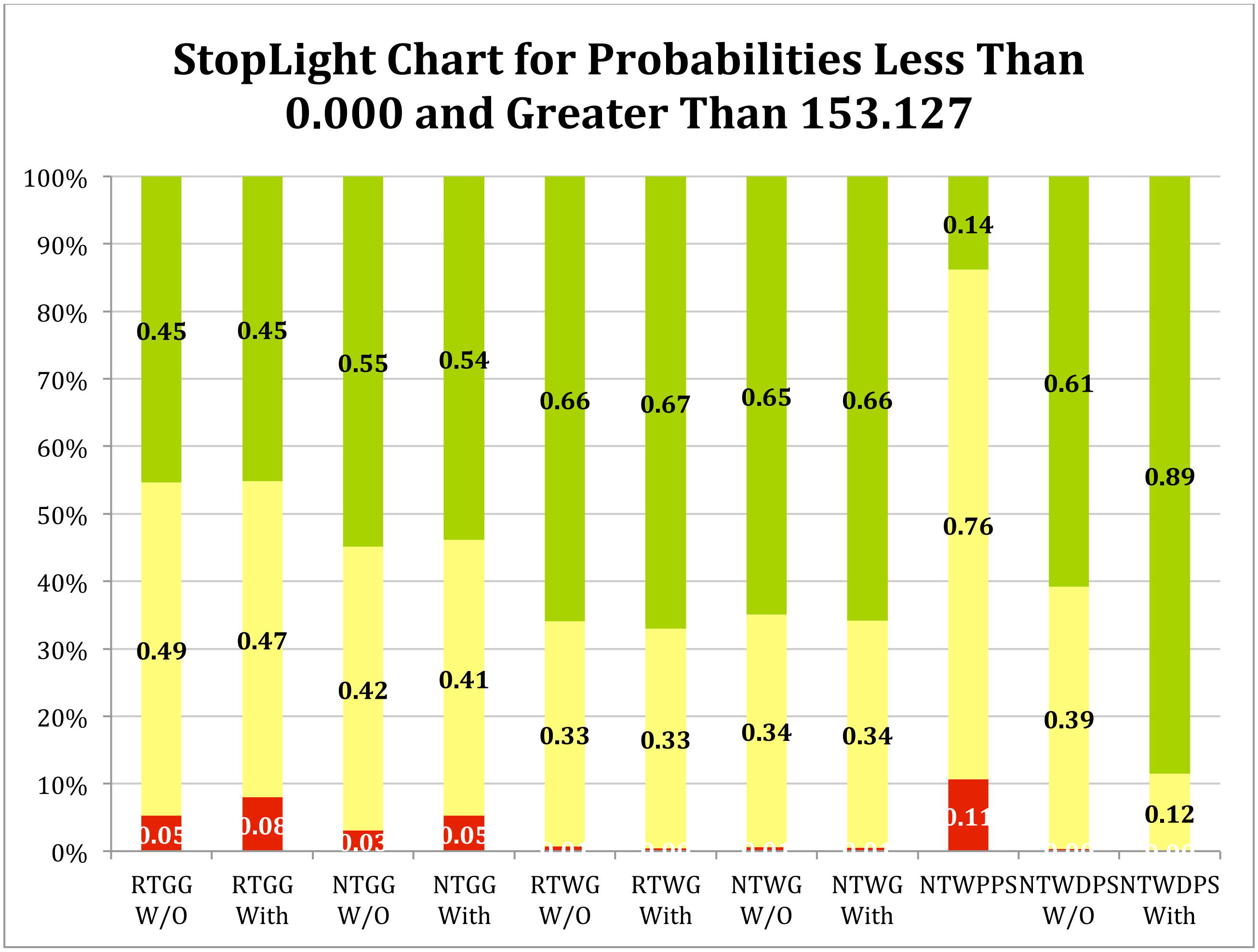

Table C.4 StopLight Analysis Results– Gross Revenue Guarantee – 100% Contract

StopLight Analysis Results

Lower Cut-Off Value **$0.00** Upper Cut-Off Value **$153.13**

System	RTGG W/O	RTGG With	NTGG W/O	NTGG With	RTWG W/O	RTWG With	NTWG W/O	NTWG With	NTWPPS	NTWDPS W/O	NTWDPS With
Prob. (Unfavorable)	0.05	0.04	0.03	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00
Prob. (Cautionary)	0.49	0.48	0.42	0.40	0.33	0.29	0.34	0.30	0.81	0.39	0.08
Prob. (Favorable)	0.45	0.48	0.55	0.58	0.66	0.71	0.65	0.70	0.19	0.61	0.92

Figure C.4 StopLight Analysis Graph – Gross Revenue Guarantee – 100% Contract