2013

ESSAYS ON FRESH VEGETABLE PRODUCTION AND MARKETING PRACTICES

Michael Vassalos

University of Kentucky, michaelvassalos@outlook.com

Click here to let us know how access to this document benefits you.

Recommended Citation

ESSAYS ON FRESH VEGETABLE PRODUCTION AND MARKETING PRACTICES

_____

DISSERTATION

_____

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Agriculture at the University of Kentucky

By
Michael Vassalos

Lexington, Kentucky

Director: Dr. Carl Dillon, Professor of Agricultural Economics

Lexington, Kentucky

2013

ABSTRACT OF DISSERTATION

ESSAYS ON FRESH VEGETABLE PRODUCTION
AND MARKETING PRACTICES

Commercial fresh vegetable production is one of the most rewarding and risky farming activities. The price and yield variations throughout the production year, the special characteristics of fresh vegetable produce (i.e. perishability), and the changing consumer demands are some of the factors contributing to the increased uncertainty faced by vegetable producers.

This dissertation combined mathematical programming and econometric techniques to:
1) investigate the optimal production and marketing practices under different price distribution information scenarios, risk aversion levels and marketing outlets and
2) examine growers' preferences as well the effect of risk aversion levels and growers' risk perception on the choice of marketing contracts.

Specifically, the following three modeling approaches were adopted in order to achieve the dissertation objectives:
1) quadratic programming under a mean-variance framework,
2) discrete choice experiments and
3) a combination of quadratic and integer programming embodied in a mean-variance framework.

The findings indicate that optimal production practices and the resulting net returns are substantially influenced not only by the choice of marketing channel but also by growers' risk aversion levels as well as price knowledge. Furthermore, regarding the choice of marketing contracts, the results highlight the existence of heterogeneity in preferences and illustrate the importance of certification cost, in line with the previous literature. Lastly, the findings indicate that risk aversion and risk preferences do not play a significant role in the choice of contractual agreements by farmers.

KEYWORDS: Vegetable Marketing, Vegetable Production Practices, Integer Programming, Quadratic Programming, Choice Experiment, Marketing Contracts

_____

Student's Signature

_____

 Date

ESSAYS ON FRESH VEGETABLE PRODUCTION
AND MARKETING PRACTICES

By

Michael Vassalos

Director of Dissertation	

Director of Graduate Studies	

April 30, 2013	

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Successful commercial fresh vegetable production is a demanding task that requires a combination of production and marketing skills from the grower. This is a consequence of the special attributes of fresh produce. For instance, the perishability of fresh vegetables leads to fewer storage opportunities compared to other agronomic crops. As a result, growers are compelled to accept the market price close to, or during, their harvesting period. Furthermore, traditional risk mitigation options (i.e., future markets) do not exist for fresh vegetables. Thus, growers are more vulnerable to market fluctuations. Finally, growers need to operate in a changing market environment with greater demand for more varieties and quality (Dimitri et al., 2003). If the vegetable produced does not meet the required standards, then the grower has to sell at a lower price or not at all.

The aforementioned discussion illustrates the importance of selecting the most appropriate market outlet. Specifically, "which type(s) of market(s) to enter?" should be among the first decisions made by a fresh vegetable grower. Adequate examination of this topic requires consideration of several crops (herein tomatoes and sweet corn), different markets (herein wholesale or a combination of wholesale and marketing contracts), production practices (herein several transplanting/planting and harvesting periods), risk aversion levels and the competition for resources across enterprises.

Despite the extensive research regarding: i) growers' choices under uncertainty and ii) the factors affecting the use and selection of contracts (i.e., age, education, income, etc.) the literature sheds little light on: i) the interaction of production and marketing practices and how they are influenced by risk aversion and ii) growers'

preferences for contractual agreements. The present dissertation is an effort to help fill this gap.

Specifically, the dissertation has two general objectives. First, it attempts to answer the question of optimal marketing outlet and production timing for fresh vegetable growers aiming to maximize net returns. Second, it examines how growers' preferences, risk aversion levels and risk preferences affect their marketing choices. Two marketing options are examined in this case: 1) wholesale marketing and 2) a combination of wholesale and marketing contracts. The former has limited legal requirements from the growers. However, the prices offered are lower, compared to other options, and vary significantly throughout the production year. Participation in a marketing contract, on the other hand, is more demanding from the grower but offers more stable prices.

In order to achieve these objectives, mathematical programming and econometric techniques are employed. The present dissertation follows a three-essay format. Each manuscript can be considered as an extension of the previous one with increased complexity. Thus, although separate from each other, the three manuscripts are complementary. This approach allows the investigation of several aspects of fresh vegetable marketing and production practices. Furthermore, it enables comparison of results among different scenarios and estimation techniques. A discussion of the three manuscripts follows.

1.1 Chapter Initiatives

The second chapter has two main objectives. First, it investigates the effect of price variability, yield variability and risk aversion on the choice of optimal production

timing for wholesale marketing. Second, it examines the impact of price seasonality consideration on the optimal production practices and economic outcomes. The focus area is Fayette County, Kentucky (KY), one of the top vegetable producing counties in the state. Two crops are examined: 1) tomatoes and 2) sweet corn. These two are the top vegetables produced in KY both in terms of acres and number of farms. A hypothetical five-acre vegetable producer is used as the case study.

A combination of biophysical simulation and whole farm modeling is used to answer the research question. Specifically, a resource allocation mean-variance quadratic formulation is employed to examine the role of price, yield variability and growers' risk aversion on optimal production timing. Wholesale marketing is the examined market outlet.

The focus of the third chapter shifts to grower preferences for marketing contracts. Discrete choice modeling is employed to answer this research question. The main data source is a mail survey administered to 315 wholesale tomato growers in four states: 1) Illinois, 2) Indiana, 3) Kentucky and 4) Ohio. The effect of eight contract attributes (early price, peak price, late price, early volume requirements, late volume requirements, peak volume requirements, penalty, 3rd party safety cost), as well as the role of growers' risk aversion and risk preferences, are examined.

The fourth chapter provides a synthesis of the previous two under a mathematical programming formulation. Specifically, a combination of quadratic and integer programming, embodied in a mean-variance framework, is employed to examine the role of growers' risk aversion in the choice of optimal marketing mix. More precisely, growers' preferences between two marketing options (wholesale marketing versus a

combination of wholesale marketing and marketing contracts) under ten risk aversion levels are examined. Additionally, alterations in production practices required under the different market outlets and risk aversion levels are examined.

The final chapter of the dissertation provides a summary and discussion of the findings and methods used. Furthermore, the chapter discusses areas for future research.

Chapter 2: Optimal Land Allocation and Production Timing for Fresh Vegetable Growers under Price and Production Uncertainty

2.1 Introduction

Growers' decisions (i.e. choice of inputs, land allocation, production mix, etc.) in the uncertain environment created by production and price variability are a subject that has attracted scholars for more than five decades. Mapp et al. (1979) and Babcock et al. (1987) provide a discussion and review of the early research endeavors in this topic. Following the work of Chavas and Holt (1990), growers' risk behavior became an important element in the study of their allocation choices (i.e. Liang et al., 2011; Nivens et al., 2002; Wang et al., 2001).

In addition to the production and price variability, fresh vegetable growers face increased uncertainty due to the special characteristics of their product. For instance, the high perishability of most fresh produce results in limited storage opportunities; thus, the vegetable supply in the short run is highly inelastic (Sexton and Zhang, 1996; Cook, 2011). As a result, growers are compelled to accept the price during or close to the harvesting period. Consequently, plant and harvest timing plays an important role in the income received from vegetable production. Furthermore, the impact of quality on the prices of fresh vegetables should not be understated. Specifically, if the vegetable produced does not reach the quality standards expected by the buyer (i.e. consumers, retailers, intermediaries, etc.) then the growers have to accept a lower price (Hueth and Ligon, 1999).

Despite an abundance of research regarding growers' decisions under uncertainty and the increased risk faced by vegetable growers, the literature regarding how 1)

growers' risk aversion levels and 2) consideration of price seasonality[1] impact the

production decisions, particularly timing of planting and harvest, is limited[2]. The research

presented is an effort to fill this gap.

The objectives of this study are threefold. First, the study seeks to develop a dual

crop vegetable farm model with a land allocation and production timing decision

interface focusing on economic optimization. Second, it examins the effect of

price/production variability and of growers' risk preferences on their decisions regarding

the optimal production practices (land allocation, transplant timing). Third, the study

investigates potential alterations in optimal production practices and in the economic

results with and without considering seasonal price trends, a factor that may influence

growers' production timing decisions. Mathematical programming modeling in

conjunction with biophysical simulation techniques will be used to achieve these goals.

The focus area for the present paper is Fayette County, Kentucky. The following

two reasons dictated the selection of Fayette County as study region: i) it is among the

top vegetable producing counties in Kentucky (2007 Census of Agriculture) and ii) the

abundance and availability of weather and soil data. These data are essential requirements

for the biophysical simulation.

Kentucky was ranked 42 out of 50 states within the U.S.A. based on the 2010

value of farm cash vegetable receipts. However, the importance of vegetable crops in the

overall agricultural economy of the state is rising. Two facts highlight the growing role of

vegetable production in Kentucky. First, in contrast to the overall decline of farm

numbers in the state, there is an increase in the number of farms with some type of

---

[1] Price seasonality is defined as the price patterns occurring within a "crop marketing period"
[2] A notable exception is Simmons and Pomareda (1975)

vegetable crop from 1,086 (1997) to 2,123 in 2007 (2007 Census of Agriculture). Second, there is a steady growth in the annual farm cash receipts from $8.7 million (1997) to $24.7 million in 2007 (USDA/ERS Vegetables and Melon Outlook).

The latter fact indicates an additional opportunity for enhanced growth, since it represents a 51% increase in cash receipts per acre over a 10 year period, which annualizes to a modest growth of just over 4% annually or slightly more than the inflation rate. Looking at the demand side, the percentage of adults who consumed vegetables three or more times per day in Kentucky is higher than the national average (29.4% compared to 26%, Centers for Disease Control Prevention, 2010). This increased demand is coupled with growing interest among consumers for local products, due in part to the success of the Kentucky Proud program. These factors highlight a great range of opportunities for benefiting producers.

Tomatoes and sweet corn are the crops included in the whole farm economic model. These vegetables were selected because they are among the top vegetables produced in Kentucky, both in number of farms and in acres. Specifically, sweet corn was ranked first among vegetables in terms of acres and second in number of farms. Tomatoes were ranked first in terms of farm number and third in acres planted (2007 Census of Agriculture). In addition to their overall importance in the agricultural sector of Kentucky, tomatoes and sweet corn were selected because growers can easily rotate among them (Coolong et al., 2010).

The comparison of economic outcomes and the estimation of optimal production timing for vegetables, with and without consideration of seasonal price trends, constitute the main contribution of the study to the literature. Furthermore, it is among the first

research endeavors that utilize the Decision Support System for Agrotechnology Transfer (DSSAT) to overcome data limitations for economic studies that include multiple vegetables.

2.2 Data Collection and Yield Validation

The present section has the following three objectives: 1) discuss the biophysical simulation model used for the estimation of yield data, 2) illustrate how the biophysical simulation model was validated and 3) describe the sources of data used in the study.

2.2.1 Yield Data Estimation

One interesting strand of the applied economic/agricultural literature relates to efforts made by scholars with the goal of developing the most accurate possible model for yield forecasting. Two of the most widely cited techniques for yield forecasting are statistical regression equations and simulation methods (Walker, 1989; Kauffmann and Snell, 1997). The advantages and shortcomings of these two approaches have been widely discussed (Walker, 1989; Kaufmann and Snell, 1997; Tannura et al., 2008; Jame and Cutforth, 1996). Among the advantages of the biophysical simulation[3] are: i) that there is no need to specify a functional form, ii) it can provide yield data for different weather and production practices, iii) the use of biological principles for crop growth and iv) the use of shorter time periods to estimate growth. However, it is more difficult to use simulation techniques for large geographical areas and there is no incorporation of historical yield data.

A lack of yield data for the examined vegetables, the need to estimate the effects of different production practices and soil types on yields, the focus on a specific geographical area and the overall objective of using these data for economic modeling

---

[3] Biophysical simulation is a special case of the simulation models (Musser and Tew, 1984)

suggest the use of biophysical simulation as the most appropriate yield estimation technique for the present study (Dillon et al. 1991).

Biophysical simulation techniques have been extensively applied in the literature (e.g. Shockley et al., 2011; Deng et al., 2008; Archer and Gesch, 2003; Barham et al., 2011). Among the several biophysical models that have been developed and used, the present study will utilize the Decision Support System (DSSAT v 4.0, Hoogenboom et al., 2004; Jones et al., 2003). DSSAT was selected for the following reasons: i) it is well documented, ii) it has been used and validated in numerous studies over the last 15 years and iii) it is well suited for the present study since it incorporates modules for the two examined vegetables (tomatoes and sweet corn).

The minimum data set required in order to generate yield estimates using DSSAT include weather data, soil data and production practices information for the examined region (Fayette County, Kentucky). Daily weather data for 38 years (1971-2008)[4] were obtained from the University of Kentucky Agricultural Weather Center. The data set includes information regarding daily minimum/maximum temperature and rainfall. The weather data collection was finalized with the calculation of solar radiation from DSSAT weather module.

Soil data were gathered from the National Cooperative Soil Survey of NRCS. According to the soil maps the most common soil type in Fayette County is silt loams. Following Shockley (2010), the percent slopes from the soil maps are used as a criterion for distinguishing between deep and shallow soils. Specifically, if the slope is between 0% - 6% then the soil is characterized as deep. If the slope is between 6% - 20% then the soil is characterized as shallow. Based on these scales, 65% of the land is classified as

---

[4] These years of weather data were available when the biophysical model of the study was constructed

deep silt loam and 35% as shallow. Furthermore, the default soil types of DSSAT were modified to better depict the characteristics of Fayette County soil conditions. Soil color, runoff potential, drainage and percent soil slope were among the parameters modified. Table 2.1 reports the exact specifications of the used soil types. Last but not least, the seasonal analysis option of DSSAT is used for the yield simulation. Under this option the soil water conditions, nutrients and organic matter are reset to initial levels every year on January 1.

Information about the typical production practices for the vegetables considered in the study is obtained from the University of Kentucky Extension Service Bulletins (Coolong et al.; 2010). Tomatoes in the examined region are transplanted from early May (spring crop) through early August (fall crop). Regarding sweet corn, planting period extends from April 20 to July 20. In addition, 65 to 80 days after transplant and 70 to 95 days after planting are the typical harvest periods for tomatoes and sweet corn respectively. Including all the combinations of transplanting/planting days and harvesting periods requires modeling for 9,500[5] treatments, the inclusion and evaluation of such is beyond the scope of this study. The production practices examined here included eight bi-weekly transplanting days for tomatoes (starting May 1) and ten weekly planting days for sweet corn (starting April 25). Four, weekly harvest periods for each crop were initially included in the model[6].

---

[5] (120 transplanting days*15 harvesting days for tomatoes)+(120 planting days for sweet corn*25 harvesting days)* 2 for the 2 soil types examined

[6] 63, 70, 77, 84 days after transplant for tomatoes and 70, 77, 84 and 91 days after planting for sweet corn.

2.2.2 Yield Validation

Due to data limitations[7], two non-statistical validation methods were used in the present

paper. First, the estimated yields were presented to Dr. Timothy Coolong[8] and he was

asked whether or not they were a reasonable representation of expected yields in Central

Kentucky for the crops evaluated based on his observations and experience. Some

parameters of the biophysical model (i.e. fertilizer levels, irrigation, etc.) were modified

based on his recommendations. For instance, based on the simulated yield results and on

Dr. Coolong's suggestions, three harvest periods (63, 70, 77 days) for tomatoes and one

(84 days) for sweet corn are kept in the final model formulation[9] instead of the four

initially included. One cultivar was examined for each of the two crops because only one

was available from DSSAT v4. Detailed information regarding the production practices

included in the model is reported in Table 2.2. The simulated yields were considered

higher than what an average vegetable grower can achieve but not unreasonable for the

best producers. Table 2.3 reports summary statistics for the simulated yields.

Second, the simulated yields were compared with findings from previous studies.

Specifically, for tomatoes, consistent with past research (i.e. Hossain et al.; 2004,

Huevelink; 1999, Schweers and Grimes; 1976) the simulated yields are substantially

influenced by transplant period. Furthermore, consistent with the aforementioned studies

simulated yields had approximately a bell shaped form (Figure 2.1). Similarly, in

agreement with previous research for sweet corn (Williams, 2008; Williams and

Linquist, 2007), our findings illustrate that planting date plays an important role in

---

[7] The historical yield data available was too limited to do a validation through regression.

[8] Extension Vegetable Specialist, Assistant Extension Professor, University of Kentucky.

[9] 84 days harvest period for tomatoes and 70, 77 and 91 days for sweet corn are excluded from the final formulation since the simulated yields, for these periods, are not achievable in the examined area.

production, with yield decreasing substantially during later planting periods (Figure 2.2). There is no comparison of absolute values between the simulated yields and yields in the previous studies due to the differences in soil and weather conditions.

Finally, the simulated yields were compared with four experimental trials for tomatoes (Rowell et al.; 2004, Rowell et al., 2005; Rowell et al., 2006; Coolong et al., 2009) and one for synergistic sweet corn (Jones and Sears, 2005) conducted in Fayette County and Eastern Kentucky respectively. Regarding tomatoes, the biophysical simulation results compare favorably to the highest yielding cultivars. For sweet corn, the average simulated yields are slightly lower than the best yellow cultivar of the experimental trial.

2.2.3 Economic and Resource Data Estimation

In addition to the data requirements for the biophysical simulation model the following supplementary data were needed in order to achieve the objectives of the present study: 1) price data for the examined vegetables, 2) suitable field hours per day, 3) land availability, 4) input requirements and input prices.

Weekly price data for 13 years (1998-2010) were obtained from the USDA Agricultural Marketing Service (AMS). Specifically, the Atlanta terminal market prices are used. AMS terminal market reports are created using price data on vegetables traded at the local wholesale markets for 15 major cities. The price information is received by wholesalers for vegetables that are of "good merchantable quality" (USDA, 2012). The tomato data set used in the study includes information for different variety (mature greens, immature greens, vine-ripe), crop size (medium, large, extra-large) and package size (20 and 25 pound boxes). However, DSSAT v 4.0.2 does not differentiate yield

based on product variety and tomato size. In order to overcome this difficulty, following Dr. Coolong's recommendations, two assumptions are made: i) 90% of yield is assumed to be mature green (the rest 10% is immature greens or vine ripes) and ii) the simulated yield is divided in three sizes based on the following distribution: 15% medium, 60% large and 25% extra-large. The prices were transformed in a $/pound base. Considering that the price data set provides limited information regarding quality and the same is true for the biophysical simulation model, no specific quality assumptions are made. Thus, the whole harvest (after a 20% reduction for cull tomatoes) was considered of good merchantable quality. For sweet corn, prices are transformed in a $/dozen basis. The price set used is for yellow sweet corn.

Since there was a yearly trend detected in the price data set, in order to avoid overestimating the price variance, the Hodrick and Prescott (HP) filter is used to remove the trend movements. Following Ravn and Uhling (2002), a smoothing parameter (λ) of 6.25 is used. Table 2.3 reports summary statistics for the price data set. The combination of 13 years of price data with 38 years of simulated yield generates 494 (13*38) different states of nature. This approach for determining the underlying revenue distribution assumes a perfectly competitive environment wherein the producer does not impact prices received. Furthermore, it is consistent with low correlation between prices and yield calculated for the data used.

Field conditions dictate whether or not a given time is suitable for fieldwork. Following Shockley et al. (2011), the probability of not raining more than 0.15 inches per day over weekly periods for the 38 years of weather data available is first calculated. This probability was multiplied with the days worked in a week and the hours worked in a day

to determine expected suitable field hours per week. The land constrained was set at 5 acres based on information obtained from the 2010 Kentucky Produce Planting and Marketing Intentions Grower Survey and Outlook (Woods, 2010).

The Mississippi State Budget Generator (MSBG) is used to estimate weekly labor requirements and input cost per acre for tomatoes and sweet corn. MSBG is a software tool (Laughlin and Spurlock, 2007) developed by Mississippi State University that utilizes machinery costs, input prices (i.e. fertilizes, fuel etc.) and labor cost to calculate a per acre cost for a field operation (Ibendhal and Halich, 2010). For the present study, the 2012 vegetable budget files of MSBG were modified to depict the Fayette County specifications. In detail, input requirements and prices were modified following the suggestions of Dr. Coolong and the 2008 vegetable budget developed by the University of Kentucky extension service publications[10]. A detailed representation of the included costs is reported in Table 2.4.

2.3 Theoretical Framework

This section will provide the theoretical background for the economic model that will be implemented in the study. Whole farm economic analysis has been used by scholars to answer important questions such as: What is the optimal crop mix? Should I invest in new technologies? What is the best rotation strategy? A review of related work is presented by Lowe and Preckel (2004).

An interesting modeling aspect of the whole farm analysis is associated with the efforts made to incorporate risk in the objective function. Among the most frequently implemented techniques to cope with this issue is the mean-variance (E-V) formulation originally developed by Markowitz (1952). One of the following conditions must be

---

[10] Available at http://www.uky.edu/Ag/CDBREC/vegbudgets08.html

satisfied in order for the results of E-V analysis to be equivalent to expected utility theory: i) the utility function of the decision maker is quadratic, ii) normal distribution of outcomes (net returns), iii) Meyer's location-scale (L-S) condition (Dillon, 1992). The first two conditions are overly restrictive and have well documented theoretical deficiencies. For instance, quadratic utility functions have the unrealistic characteristics of wealth satiation and increasing absolute risk aversion (Bigelow, 1993).

Considering the previously mentioned limitations the more general L-S condition is adopted for the present study. Since yields and price for sweet corn and tomatoes are the stochastic elements of net returns it is sufficient to illustrate that they satisfy the L-S condition. Following Dillon (1992) a sufficient condition to meet the L-S requirements is for the ranked yields to be linear function of one another. The minimum correlation for the ranked yields was 97% and for ranked prices 87%. Thus, the use of mean variance analysis is considered legitimate for this study. Quadratic programming is commonly used to produce efficient E-V frontiers. The present study utilizes a formulation consistent with Freund (1956).

2.4 Empirical Framework

This section will discuss in detail the formulation of the economic model that is used in this paper. Specifically, an E-V formulation will be implemented to depict the economic environment of a hypothetical fresh vegetable farm in Fayette County, Kentucky. In line with Dillon (1999), the proposed model incorporates accounting variables as well as endogenous calculation of net returns variance instead of a variance-covariance matrix.

15

The objective of the grower is the maximization of net returns above selected variable costs less the risk aversion coefficient multiplied by the variance of net returns. The hypothetical farm is assumed to have five acres of cropland available and grow tomatoes and sweet corn in rotation with 50% of acres in any year devoted to each crop. This represents a two year crop rotation which is commonly followed by growers in the examined region (Coolong et al., 2010). This will lead to a maximum of 2.5 acres with tomatoes, which is close to the average acres cultivated with tomatoes in Kentucky reported from an unpublished survey of wholesale tomato growers (Vassalos et al., 2012). Rotation is required to prevent pathogen build up in the soil and control certain insects such as corn rootworms (Coolong et al., 2010). In addition to land limitation and rotation, the model includes the following constraints: i) labor resource limitation, ii) sales balance by crop and year, iii) input purchases by input, iv) net return balance and v) ratio of soil type. The final constraint guarantees that production practices will be distributed across both soil depths.

The model will be estimated for the following two scenarios: 1) the grower considers seasonal price trends and 2) the grower considers only annual price trends. The aforementioned scenarios do not necessarily reflect growers with different price information knowledge. They examine the conscious decision of a grower to adjust, or not, the production timing decisions based on the historical price trends. More precisely, the seasonal price trend scenario incorporates an interaction of seasonal price movement with yield differences associated with the alternative production practices examined.

The reason for examining these two scenarios vis-à-vis lies on the importance of production timing discussed earlier. Presumably, one of the factors that can drive optimal

timing decisions is whether or not the growers consider historical price trend information. This is especially true for fresh vegetable marketing which is characterized by substantial price seasonality (Figure 2.3).

The thirteen years of weekly price data for tomatoes and sweet corn from AMS are employed for the estimation of the first scenario (seasonal trends). A two-step experimentation process is adopted for the latter scenario (yearly trends). First, the optimal management decisions are identified when only considering the annual average price for each AMS year. Second, these optimal decisions are imposed in the optimization model with the complete weekly historical price information to ascertain actual economic outcome. It is important to mention that the model in the present study is a steady state equilibrium model and that the decision variables do not alter by state of nature under both scenarios.

In addition to the risk neutral case, the two specifications of the model (with and without full price information) were estimated for nine different risk aversion coefficients. These coefficients were calculated using the McCarl and Bessler (1989) approach. Based on this approach, a grower is said to maximize the lower limit from a confidence interval of normally distributed net returns. Each one of the nine examined levels in this study corresponds to a 5% increment from the previous level, starting from 50% (risk neutral) and ending with 95%. The mathematical specification of the model follows:

The grower's objective is to maximize net returns above selected variable costs less the risk aversion coefficient multiplied by the variance of net returns and is given by:

(2.1) $\bar{Y} - \Phi\sigma_y^2$

Subject to: land availability constraint, given by:

$$(2.2) \sum_C \sum_D \sum_H X_{C,D,H.S} \leq ACRES_s \ \forall \ S$$

Weekly labor resource limitation, given by:

$$(2.3) \sum_C \sum_D \sum_H \sum_S LAB_{C,D,H,WK} X_{C,D,H,S} \leq FLDDAY_{wk} \ \forall \ WK$$

Marketing balance:

$$(2.4) \sum_D \sum_H \sum_S YLD_{C,D,H,TS,S} X_{C,D,H,S} - SALES_{C,YR,WK,TS} = 0 \ \forall \ C, TS, WK, YR$$

Input purchases by input:

$$(2.5) \sum_C \sum_D \sum_H \sum_S REQ_{I,C} X_{C,D,H,S} - PURCH_{I,C} = 0 \quad \forall I$$

Soil depth ratio constraint:

$$(2.6) CSOILRATIO_{"shallow"} X_{C,D,H,"deep"} - CSOILRATIO_{"deep"} X_{C,D,H,"shallow"}$$

$$= 0 \; \forall C, D, H$$

Crop rotation constraint:

$$(2.7) \sum_C \sum_D \sum_H \sum_S ROTATE_C X_{C,D,H,S} \leq 0.5 \; ACRES_S \; \forall S$$

Net returns by year are given by:

$$(2.8) \sum_I IP_I PURCH_{I,C} - \sum_{WK} \sum_C \sum_{TS} P_{C,WK,TS} SALES_{C,YR,WK,TS} + Y_{YR} = 0 \; \forall YR$$

Expected profit balance is given by:

$$(2.9) \sum_{YR} \frac{1}{N} Y_{YR} - \bar{Y} = 0$$

Where, activities include:

$\bar{Y}$: Expected net returns above selected variable cost

$X_{C,D,H,S}$: Production of crop C, under transplanting/planting period D, harvesting period H and soil depth S

$PURCH_{I,C}$: Purchases of input I

Y_{YR}: Net returns above selected variable cost by year

$SALES_{C,YR,WK,TS}$: Tomato sales by size (medium, large, extra-large in pounds and sweet corn sales in dozens of ears by week and year respectively

Indices include:

C: Crop

S: Soil depth

TS: Tomato Size (medium, large, extra-large). There is only one size for sweet corn.

H: Harvesting period (1 for sweet corn)

YR: Year

D: Transplant date for tomatoes, Planting date for sweet corn

WK: Week

I: Input

N: State of Nature (13*38)

Coefficients include:

Φ: Risk aversion Coefficient

$P_{C,WK,TS}$: Weekly price for different tomato sizes in $/pound and for sweet corn in $ per ear

$YLD_{C,D,H,TS,S}$: Expected yield of tomatoes by size in pounds and of sweet corn by ears

$FLDDAY_{WK}$: Available field days per week

$ROTATE_C$: Rotation matrix by crop C

$P_{C,WK,TS}$: Weekly price in $/pounds per tomato size and in $/ear for sweet corn

$CSOILRATIO_{"S"}$: Ratio of total acres allocated to depth S

2.5 Results

      The results obtained from the mean-variance quadratic formulation, in conjunction with a discussion about them, are presented in this section. Tables 2.5 and 2.6 report results for three of those nine risk levels: low (65% significance level), medium (75% significance level) and high (85% significance level) risk aversion, as well as the risk neutral case. The selection of the above mentioned risk aversion attitudes was made in order to better depict the changes that take place in the optimal decisions (i.e. transplant/plant and harvest timing) and the economic outcomes as the risk aversion level increases.

2.5.1 Optimal Production Management Results

      In order to achieve the best possible economic outcome, and reduce their risk exposure (if they are risk averse), growers need to take into consideration production timing. This is especially true for fresh vegetable production where even the most basic decisions, such as when to plant, can lead to significant improvement or decline of economic results due to: i) the price variability and ii) the seasonal and perishable attributes of fresh produce. Table 2.5 reports the model results regarding three possible production strategies: i) land allocation/production mix, ii) planting schedule and iii) harvesting schedule.

      As far as land allocation choice is concerned, due to the rotation constraint, 50% of the available acres are devoted to tomato production and 50% to sweet corn for all risk aversion levels and for both scenarios examined. Furthermore, all the available acres (five) are used by the hypothetical farm.

Regarding the optimal transplant/plant and harvest timing, two strategies are observed from Table 2.5, depending on risk aversion levels. Under the seasonal price trend consideration scenario, a risk neutral grower who seeks to maximize expected net returns should focus on a combination of late tomato transplanting (July 10, July 24) and late sweet corn planting (June 21), as well as late tomato harvest (77 days after transplant). Under this plan the grower can receive higher prices, on average, for tomatoes and sweet corn.

As risk aversion levels increase and growers are willing to accept lower but more certain net returns, two risk mitigating strategies are suggested from the findings. First, risk averse growers should focus on an earlier tomato transplanting period compared to risk neutral farmers (June 12 instead of July 24). Specifically, the higher the risk aversion level the greater the transition to earlier period is observed in terms of acres cultivated with tomatoes (Table 2.5). This transition indicates a movement from a focus on higher prices to focus on higher yields and more stable prices. Specifically, the price coefficient of variation drops from 19% (July 24, 77 days harvest) to 10% (June 12, 77 days harvest) and the weighted average price declines from approximately $16.30 per 25 pound box to $13.40.

A Similar strategy (transition to earlier planting period for a risk averse grower compared to risk neutral) is observed for sweet corn (Table 2.5). In antithesis to tomato production, the land allocation for sweet corn does not change further with higher risk aversion levels. Besides reducing the price variation, an additional benefit of earlier planting for sweet corn is the reduced ear worm pressure.

In contrast to the first scenario, the second model formulation (where the grower has limited knowledge of the price set or consciously decided not to use the whole price information) findings indicate only minor changes in production schedule as risk aversion levels increase (Table 2.5). Specifically, tomato transplant and sweet corn planting periods remain the same across all four risk aversion level with a small increase of acres devoted to later transplanting periods (June 26) for higher risk coefficients. Last but not least, for both formulations the number of transplanting dates for tomatoes increases from two to three for the highest risk aversion level in seeking production practice diversification.

Regarding tomato harvesting, the model always recommends as the optimal schedule harvesting 77 days after transplant (Table 2.5). The higher yields and prices associated with these periods (in contrast with 63 and 70 days after transplant) explain this choice (Figures 2.1, 2.2).

2.5.2 Economic Results

The economic results associated with the previously mentioned production strategies are reported in this section. As can be seen from Table 2.6, the average net returns above selected variable costs, the coefficient of variation and the minimum possible net returns vary substantially between the different risk aversion levels and among the two model formulations.

Risk neutral growers under the full within season price distribution knowledge/consideration scenario have an average net return above selected variable costs of $85,382 combined with a coefficient of variation (C.V.) of 24.52%. As the level of risk aversion increases, in line with the underlying theory, a decline in both average

net returns and C.V. is noticed. For instance, the mean net returns for a highly risk averse grower correspond to 88% of the risk neutral case, while those for the low risk aversion scenario corresponded to 96%. However, the risk neutral case is associated with higher levels of standard deviations and coefficient of variation (almost 7% greater than the highly risk averse case).

The importance and impact of a farm manager's conscious consideration of price seasonality is investigated as a primary objective of this study. This is accomplished by calculating the economic outcomes that would result from a suboptimal solution ignoring the weekly fluctuation in prices. This depicts a more naïve production strategy that disregards within season price variation. Results provide evidence to support the importance of timing both in terms of enhanced profitability and greater potential for risk management.

As can be seen from Table 2.6, a risk neutral grower who schedules production timing with consideration of weekly price variation enjoys 15% higher expected net returns compared to one who disregards the ability to exploit production timing based on price information. Furthermore, a greater opportunity to manage risk is permitted for the former hypothetical grower. Specifically, under the first scenario the coefficient of variation (C.V.) ranges from 17% to 24.7%. On the other hand, under the second scenario, C.V. has a substantially reduced span from 17.14% to 17.56% with the interesting finding that higher risk aversion levels are associated with higher C.V. in contrast to the initial expectations. These findings validate the hypothesis that growers who decide to plan production without consideration of seasonal price variation have limited opportunities to manage risk.

Finally, a comparison of the estimated net returns above selected variable costs with a 2008 vegetable budget (Crop Diversification & Biofuel Research & Education, University of Kentucky) resulted in some thought provoking observations. Specifically, the estimated net returns (on a per acre basis) are from 1.5 (highly risk averse) to two times (risk neutral) greater than the ones reported on the 2008 vegetable enterprise budget. This difference can be attributed to the combination of the conservative price/yield estimations of the extension service in contrast to the higher prices (obtained from the Atlanta AMS) and yields (from the biophysical simulation) used in the study. However, the findings of the study are closer to the estimations of Rowell et al. (2006) who indicate that for the best tomato cultivars that season it is possible to achieve close to $16,000 per acre.

2.6 Conclusions

The present study combines biophysical simulation and mathematical programming modeling to develop and economic model that will provide some guidelines regarding the optimal production mix and planting decisions for vegetable production. The area of study was Fayette County, Kentucky and the enterprises of tomatoes and sweet corn were evaluated.

Considering the importance of production timing, due to the perishability of vegetable production, and the role that seasonal price trends consideration may play in optimal transplant/planting and harvesting schedules, two distinct scenarios are examined. Under the first, the hypothetical grower plans production timing considering weekly price variation, while, under the second one the grower chooses a simpler but less complete focus of annual price trends only. Three risk aversion levels are examined for

each scenario. The findings indicate that vegetable producers have the potential to improve their economic results if they follow a structured farm management plan. Specifically, under the first formulation (full price knowledge) growers can achieve average net returns that are from 4% to 15% higher than the ones from the second formulation (not full price knowledge). Furthermore, they have greater opportunity to manage risk.

Limitations of this study are primarily associated with the nature of the biophysical simulation model used. Specifically, yield estimations were made only for one variety and there are no calibrations for locally grown cultivars. Examination of different varieties may lead to different results, considering the different performance each variety has under different weather patterns and soil conditions. In addition to including more vegetables in the model, future work can investigate how the results are affected when multiple markets are examined simultaneously.

Figure 2.1: Simulated Tomato Yields[11]
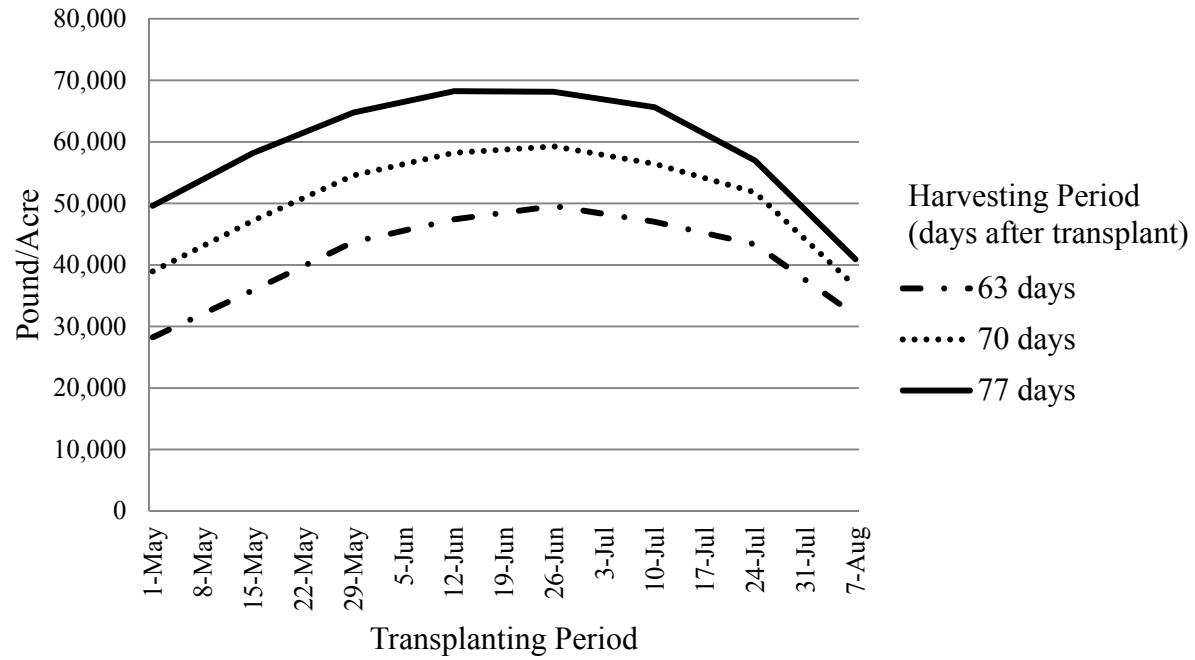
Source: Biophysical simulation results

---

[11] The graph depicts average tomato yields across years and soil types

Figure 2.2: Sweet Corn Yields[12]
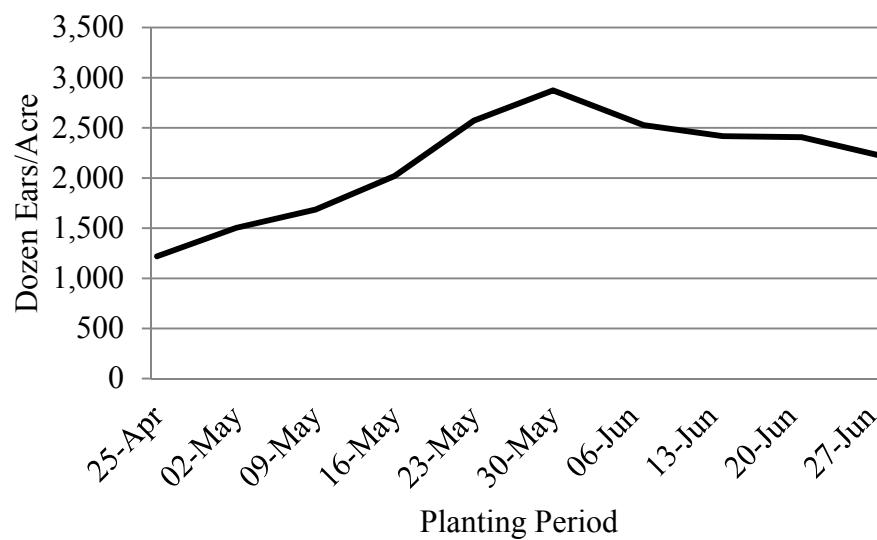
Source: Biophysical simulation results

---

[12] The graph depicts average sweet corn yields across years and soil types

Figure 2.3: Fresh Tomatoes Monthly Producer Price Index (1982=100)
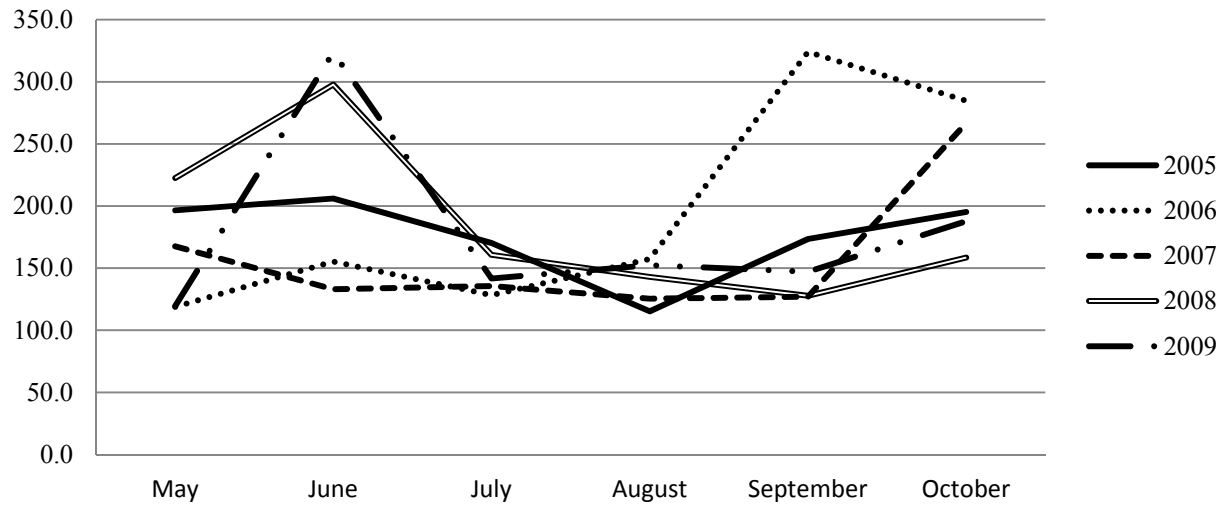
Source: USDA, ERS Fresh Tomato Monthly Producer Price Index, U.S. Tomato Statistics

Table 2.1: Soil Characteristics

Soil	Color	Drainage	Runoff Potential	Slope (%)	Runoff Curve #	Albedo	Drainage rate
Deep Silty Loam (65%)	Brown	Moderately Well	Lowest	3	64	0.12	0.4
Shallow Silty Loam (35%)	Brown	Somewhat Poor	Moderately Low	9	80	0.12	0.2

Source: Shockley, 2010

Table 2.2: Summary of Production Practices Used in the Biophysical Simulation Model

1) Tomato Production Practices	
Transplanting date	May 1, May 15, May 29, June 12, June 26, July 10, July 24, August 7
Harvesting period	63, 70, 77 days after transplant
Cultivar	BHN 66
Actual N/week (lbs/acre)	10
Irrigation	Drip irrigation, 1 inch water/week
Plant population (plants/acre)	5,000
Transplant age	42 days
Planting depth	2.5 inches
Assumptions	Dry Matter = 6%, Cull ratio = 20%
2) Sweet Corn Production Practices	
Planting Date	April 25, May 2, May 9, May 16, May 23, May 30, June 7, June 14, June 21, June 28
Harvesting Period	84 days after planting
Cultivar	Sweet corn cultivar of DSSAT v. 4
Actual N/week	2 applications of Ammonium Nitrate. One pre-plant (90 lb. actual N/acre) and a second 4 weeks after planting (50 lb. actual N/acre)
Irrigation	Drip irrigation, 1 inch water/week
Plant Population (plants/acre)	20,000
Planting Depth	2 inches
Assumptions	Dry matter =24%, Cull ratio= 3%, Ear weight = 0.661 pounds

Table 2.3: Price and Yield Summary Statistics[13]

TOMATO YIELDS BY SIZE (simulated)			
	MEDIUM	LARGE	EXTRA LARGE
Average (pounds/acre)	6,580	26,321	10,967
Standard Deviation	1,976.92	7,907.67	3,294.86
Coefficient of Variation	30.00	30.00	30.00
Maximum Yield	10,425	41,700	17,375
Minimum Yield	0	0	0
TOMATO PRICES			
	MEDIUM	LARGE	EXTRA LARGE
Average ($/25 pound boxes)	$15.04	$15.56	$16.31
Standard Deviation	3.12	3.48	3.84
Coefficient of Variation	20.00	22.00	23.00
Maximum Price ($/25 pound box)	29.55	30.58	30.70
Minimum Price ($/25 pound box)	8.99	9.77	9.68
SWEET CORN YIELD (simulated, one size)			
Average (ears/acre)	12,687		
Standard Deviation	6,140		
Coefficient of Variation	47.00		
Maximum Yield	28,579		
Minimum Yield	903		
SWEET CORN PRICE			
Average ($/crate)	$13.04		
Standard Deviation	3.94		
Coefficient of Variation	30.00		
Maximum Price($/crate)	33.78		
Minimum Price($/crate)	6.56		

Source: DSSAT model yield results, Atlanta Agricultural Market Station prices

---

[13] The maximum and minimum yields reported on the table refer to different production practices, thus one is not expected to add the maximum yield of medium, large and extra-large to obtain maximum yield per acre

Table 2.4: Production Costs per Acre

Tomato Expenses		Sweet Corn Expenses	
Type of Expense	Cost($)	Type of Expense	Cost ($)
Fertilizer	319.67	Fertilizer	194.16
Herbicide	2.33	Herbicide	21.16
Insecticide	97.47	Insecticide	208.10
Seed & planting supplies	1575.08	Seed & planting supplies	126.00
Labor	3688.26	Labor	116.58
Machinery expenses	139.69	Machinery expenses	66.76
Other expenses (i.e. boxes)	1600.00	Other expenses (i.e. crates)	580.00
Interest on capital	76.00	Interest on capital	10.58
Irrigation supplies	627.00	Irrigation supplies	410.00

Table 2.5: Summary of Optimal Production Practices by Risk Attitude

		Model 1: Seasonal Price Trend				
		Tomatoes[14]			Sweet Corn	
Risk Levels	Transplanting Date	Acres (% of total)		Planting Day	Acres (% of total)	
		DSL[a]	SSL[b]		DSL	SSL
Risk Neutral	July 10	27.0%	14.7%	June 21	32.5%	17.5%
	July 24	5.2%	2.8%			
Low Risk Aversion	June 12	5.4%	3.0%	May 23	32.5%	17.5%
	July 10	27.0%	14.6%			
Medium Risk Aversion	June 12	16.6%	9.0%	May 23	32.5%	17.5%
	July 10	16.0%	8.6%			
High Risk Aversion	June 12	23.0%	12.4%	May 23	32.5%	17.5%
	July 10	8.4%	4.4%			
	July 24	1.2%	0.6%			
		Model 2: Yearly Trend				
		Tomatoes			Sweet Corn	
Risk Levels	Transplanting Date	Acres (% of total)		Planting Day	Acres (% of total)	
		DSL	SSL		DSL	SSL
Risk Neutral	June 12	26.8%	14.4%	May 30	32.5%	17.5%
	June 26	5.7%	3.0%			
Low Risk Aversion	June 12	15.0%	8.2%	May 30	32.5%	17.5%
	June 26	17.4%	9.4%			
Medium Risk Aversion	June 12	14.4%	7.8%	May 30	32.5%	17.5%
	June 26	18.0%	9.8%			
High Risk Aversion	June 12	14.2%	7.6%	May 30	32.5%	17.5%
	June 26	16.8%	9.0%			
	July 10	1.4%	0.8%			

Source: Economic Model Results
[a] DSL stands for Deep Silty Loam
[b] SSL stands for Shallow Silty Loam

---

[14] Optimal harvesting period for tomatoes, for all the risk aversion levels and for both models, is 77 days after tranplanting.

Table 2.6: Net Returns by Risk Attitude

Model 1: Seasonal Price Trend				
Economic Results	Risk Neutral	Low Risk Aversion	Medium Risk Aversion	High Risk Aversion
Mean ($)	84,573	81,492	77,192	74,391
Min ($)	42,064	48,676	48,216	46,497
Standard Deviation ($)	20,939	16,914	14,120	12,816
Coefficient of Variation	24.76	20.76	18.29	17.13
Model 2: Yearly Trend				
Economic Results	Risk Neutral	Low Risk Aversion	Medium Risk Aversion	High Risk Aversion
Mean($)	71,827	71,429	71,407	71,994
Min($)	41,807	40,282	40,202	40,970
Standard Deviation ($)	12,453	12,562	12,582	12,783
Coefficient of Variation	17.34	17.59	17.62	17.76

Source: Economic Model Results

Chapter 3: Fresh Vegetable Growers' Risk Perception, Risk Preference and Choice of Marketing Contracts: A Choice Experiment

3.1 Introduction

Fresh vegetable production is a high risk farming activity. Fresh vegetable growers, in addition to the traditional sources of risk associated with farming (i.e., production, price, and financial risk), face increased uncertainty due to the characteristics of their products (Cook, 2011; Ligon, 2001; Hueth and Ligon, 1999). Some of those characteristics include: i) the perishability of fresh vegetable products, ii) the lack of traditional policy measures (i.e., price and income support programs) and futures markets, and iii) the importance of quality of production.

Fresh vegetable growers have limited opportunities to mitigate this risk. A possible option towards this goal is the adoption of marketing contracts. Marketing contracts typically refer to a written or oral agreement between a grower and a buyer who set a price and possible price adjustments, including quality specifications, a delivery period schedule, and other terms of transaction (MacDonald et al., 2004; Katchova and Miranda, 2004). Under this type of agreement, producers assume all risk related to production (yield, quality, etc.) and input prices, but share risk related to output market price with the buyer (MacDonald et al., 2004).

A number of arguments have been presented in the literature to explain the increased use of contractual arrangements. First, contract agreements help both parties to better manage risk (Wolf et al., 2001; MacDonald, 2004). Second, the incentives/penalties embodied in a contractual agreement may act as catalysts to induce a particular behavior, i.e. provide better product quality (Hueth and Ligon, 1999; Wolf et al., 2001). Calvin et al. (2001) highlighted several reasons that shippers have for

contracting. Among the most important ones, according to ERS marketing study interviews (Calvin et al., 2001) are the secured markets and the maintenance of future relationships with buyers. Last but not least, contractual arrangements can help growers and buyers in their resource allocation decisions due to the predictability introduced into production (Hueth et al., 1999).

Although extensive research has been conducted regarding several aspects of contractual agreements in agriculture, the literature regarding estimation of growers' preferences and their willingness to accept/pay for different marketing contracts attributes is limited. A notable exception is Hudson and Lusk (2004), who used discrete choice experiments (DCE) to estimate the marginal values of six attributes (expected income, price risk shifted, autonomy, asset specificity, provision of inputs, length of contract) of hypothetical contracts using a sample of 49 growers from Mississippi and Texas. The findings of their study indicate that risk avoidance and transaction costs play a major role in the choice of contractual agreement. Furthermore, the study highlights the heterogeneity of preferences among growers.

DCE analysis refers to a broad range of survey-based statistical techniques used by scholars in order to draw inferences for important questions such as: i) consumers' preferences, ii) tradeoffs that consumers are willing to make in order to enjoy specific attributes, iii) how consumers may react to introduction of new products or changes in existing ones, and iv) market-share predictions (Green et al., 2001; Louviere et al., 2010)[15]. Since marketing contracts can be described in terms of several distinct attributes, using DCE analysis in order to estimate the marginal value of them to growers is justifiable.

---

[15] Discrete choice experiments (DCE) are referred in Green et al. (2001) as choice based conjoint analysis.

The objective of the study is twofold. First, the study seeks to examine growers'
preferences for a number of marketing contract attributes. Second, it investigates the
effect of growers' risk perceptions and risk preferences on the choice of a marketing
contract agreement.

The marketing contract attributes examined include different levels of price,
volume requirements, transaction costs, and penalties. Elicitation of growers' risk
preference is achieved with the use of a "multiple price lists" design where growers are
presented with several lottery choices and are asked to select one (Binswanger, 1980;
Bisnwanger, 1981). Growers' risk perception is determined through a number of Likert
scale questions.

A mail survey questionnaire was used to gather data from tomato producers and
consisted of five sections. Supplementary data used included tomato prices and yields in
order to design reasonable contract options for the choice experiment. Those data were
obtained from the USDA Agricultural Marketing Service Atlanta Terminal Market and
with the use of biophysical simulation, respectively. Growers' preferences toward
marketing contracts are estimated using mixed-logit modeling. This approach allows the
relaxation of the restrictive independence from irrelevant attributes assumption and
accounts for heterogeneity in preferences.

The use of DCE techniques to examine preferences for fresh vegetable marketing
contracts is a primary contribution of this study to the literature. In comparison with
Hudson and Lusk (2004), the present study focuses on a specific crop (tomatoes) and
group of growers (wholesale tomato growers), but the results have implications for both
growers and a broader range of stakeholders who can benefit from the insights offered by

this study. These specifications allow the evaluation of more concrete contractual

agreements. Last but not least, it is the first effort to examine how growers' risk

perceptions affects their choice of contracts.

The findings of the study can provide useful insights both to policy makers and to

the vegetable production industry. This is so for several reasons. Consumer interest in

locally-sourced foods has increased dramatically, and marketing contracts are one

method for commercial scale buyers and retailers to develop a reliable supply of local

produce. Thus, a better understanding of farmers' preferences can increase the adoption

of mutually beneficial contracts. Second, information regarding farmers' acceptance and

perceived tradeoffs between the different attributes in interaction with their risk

perception and risk preferences levels will provide useful intuition in better

understanding how different producers view this emerging market. Finally, the study will

further examine the importance of transaction costs in contractual agreements, which may

give guidance to relevant policy.

3.2 Data Collection and Survey Design

The main data source for the study is a mail survey. The survey was administered

to a sample of wholesale tomato producers in four states: Kentucky, Illinois, Ohio and

Indiana. Growers who direct market the majority of their produce were excluded from the

sample since they are less likely to operate under contractual agreements (MacDonald et

al., 2004). Mailing information for the growers was gathered from the Market Maker web

sites within these respective states, after obtaining permission to use the data base of the

site. A total of 315 mailing addresses were retrieved.

From the 315 surveys, ten were returned for insufficient or wrong addresses and five were no longer farmers, leading to an effective survey group of 300 growers. In order to mitigate non-response bias problems, the three wave survey design (survey - reminder - survey) proposed by Dillman (1978) was implemented. A monetary incentive ($25) was offered with the intention of boosting the response rate. The overall response rate was 18.3% (55 returned surveys) with an effective response rate of 16.3% (49 usable surveys). The sample size and the response rates for each state are presented in Table 3.1. Descriptive statistics are reported in Table 3.2.

The study sample includes a greater percentage of women operators and slightly younger growers compared to 2007 Census of Agriculture (Table 3.2). Furthermore, the average acres with tomatoes in the study compare closely to the average of total harvested acres with tomatoes from the 2007 census of agriculture. The final form of the survey questionnaire (i.e., wording, ordering of questions, etc.) is the result of several focus group discussions with vegetable growers, extension specialists and persons involved with marketing of fresh vegetables. Two of the major focus groups took place during the 2011 Kentucky Farm Bureau Convention and the 2012 Kentucky Fruit and Vegetable Trade Show.

The survey questionnaire consisted of five sections. First, general questions about the characteristics of the farm were solicited. The next section incorporated questions regarding growers' perceptions and experience with marketing contracts. The third section asked questions related to growers' risk comfort levels. The choice experiment is included in the fourth section. The survey concluded with questions on demographic characteristics.

The importance of various factors in growers' decisions to participate, or not, in a marketing contract agreement is also examined in the second section of the survey instrument. More than 50% of growers indicated reduced price risk and secure income among the most important reasons for participating in a marketing contract agreement (Table 3.3). Considering the price volatility of fresh vegetable production, those preferences are not surprising. Conversely, 28 out of 49 respondents indicated unsatisfying price terms among the most important factors that may discourage them from participating in marketing contracts. Furthermore, a significant portion of respondents indicated that the difficulty of satisfying the quality and quantity requirements imposed in a marketing contract may discourage them from participating in such an agreement (Table 3.4).

Two types of questions were used to elicit growers' risk comfort levels (third section of the questionnaire). The first type of question was based on expected utility and the second type consisted of a self-rating. The former approach is based on an allocation game suggested by Gneezy and Potters (1997), Charness and Gneezy (2010) and Binswanger (1980, 1981). This approach is used to elicit growers' risk preference. The latter is a series of Likert- scale questions based on Pennings and Garcia (2001). This approach is used to elicit growers' risk perception.

3.2.1 Conjoint Experiment and Selection of Attributes

One of the first steps required in order to conduct a DCE analysis is the choice of product attributes and their corresponding levels that will be used in the study (Green et al., 2001). The following includes a discussion regarding the selection of contract attributes used in the study and of their levels.

The focus of the study on marketing contracts and on fresh vegetable production, in conjunction with previous literature and the discussions that took place during the focus groups, are the main factors that influenced the selection of attributes for the choice experiment. Under a marketing contract, in contrast to production contracts, growers bear all the risk associated with production (yield, quality) and input prices and share some or all of the output price risk (MacDonald et al., 2004; Ligon, 2001; Vavra, 2009). This is depicted in the choice experiment with the inclusion of volume and quality requirements and by eliminating possible requirements regarding varieties, production practices, etc.

In detail, the choice profiles used in the study consisted of the following eight attributes: early period price, peak period price, late period price, early period volume, peak period volume, late period volume, certification cost, and penalties. The first seven attributes have three levels each and the penalties four levels. A description of these attributes and their levels is reported in Table 3.5. In addition to the previously mentioned contract attributes, an important requirement of the examined contracts relates to quality of tomatoes. Specifically, the examined contracts refer to U.S.D.A. number 1 grade tomatoes.

Based on the number of attributes and their levels, a full factorial design corresponds to 8,748 (or $3^7 \times 4$) profiles. In order to reduce this number, a fractional factorial design was implemented. The fractional factorial design corresponds to a sample of the full factorial that retains the main and first order interaction effects (Louviere et al., 2000). The *%mktex* macro algorithm in SAS returned 18 choice sets of two choices. In order to minimize the time to complete the questionnaire and mitigate the fatigue of the participants, those 18 sets were randomly distributed in groups of 6 to 3 versions taking

care not to include a clearly superior choice. In addition to the two choices, a third "no contract" choice was added. A sample choice experiment is reported in Figure 3.1. Each respondent was assigned to only one version of the survey (differ only in choice sets) and made 6 choices. As a result, a total of 49*6=294 choices are represented in the data.

The price attribute refers to the monetary amount that the contractors should pay the growers during or before the payment deadline. Among the several price mechanisms suggested in the literature (Hueth and Ligon, 1998; Hueth and Melkonyan, 2004; Hueth and Ligon, 2002; Katchova and Miranda, 2004), a price per pound contingent on quality and period of the year is adopted for the examined contracts. Following Hueth and Ligon (1999) and Hueth and Melkonyan (2004), the payment offered depends on the tomato price of a downstream market. Specifically, USDA-AMS tomato prices from the Atlanta Terminal Market were used in the study as base prices. In order to capture the seasonal price variability of tomatoes and achieve a constant supply flow, three different time periods are used. Early period refers approximately to the period up to July 4, the peak period covers July and August and the late period spans September and October. Following the focus group discussion three different price levels are used for each period (Table 3.5). The range of prices provided to growers is abstract due to the lack of data from actual contractual agreements.

Regarding volume requirements, the scarcity of detailed yield data leads to the use of biophysical simulation techniques. Specifically, tomato yields for thirty-eight years under different production practices (transplant days and harvesting days) were estimated with the use of the Decision Support System for Agrotechnology Transfer (DSSAT v.4, Hoogenboom et al., 2004). Validation of the simulated yields was made based on

previous literature (Ciardi et al., 1998; Heuvelink, 1999) and expert opinion for fresh

market tomatoes grown in Kentucky. Specifically, the model parameters and the

simulated yields were evaluated with Dr. Timothy Coolong, Extension Vegetable

Specialist at the University of Kentucky. The estimated yields were considered higher

than what an average producer may achieve but would be expected for experienced

wholesale growers. Since growers do not generally contract all of their production

(Katchova and Miranda, 2004), the volume requirements specified on the choice profiles

correspond to 10%, 15% and 20% of the average yield calculated by DSSAT for each of

the three periods (early, peak and late). Similarly with the price per pound, the range of

volume requirements is theoretical due to the lack of actual data from real contractual

agreements.

   One of the most important provisions in a contractual agreement is related to the

cost that growers have to face in case they fail to meet their obligations. A grower may

face a penalty under the following two circumstances: i) failure to provide the agreed

volume and ii) failure to provide the required quality. Analogous to price mechanisms, a

number of different cost structures (penalties) have been suggested in the literature (Wolf

et al., 2001; Hueth et al., 1999). In the context of the present study, the penalties are

reported as price reductions. Four different penalty levels are used in the discrete choice

experiment of the survey: 5%, 10% and 15% of price and terminate contract. The last

option (terminate) indicates that the contract will no longer be valid and the grower will

have to sell his production in the spot market.

   Considering that the price and penalty mechanisms of the examined contracts

depend on the quality of the supplied tomatoes, a quality measurement instrument is

required in order to eliminate possible disputes among growers and buyers. A number of different quality validation options have been suggested in the literature (Hueth and Ligon, 1999; Wolf et al., 2001).

The certification cost attribute corresponds to the payments that growers may have to provide for third party food-safety audits, one of the possible quality control options. Hatanaka et al. (2005) provide a review regarding the development of third party audits, their benefits and the challenges associated with those. Third party audits can be an expensive quality assurance function that larger buyers may require of their fresh produce suppliers as buyers try to manage food safety risks. Part of the challenge for growers is the variation in certification requirements among buyers. In any case, such audits have become a central element to the discussion regarding marketing arrangements between growers and buyers (Hatanaka et al., 2005; Mahshie, 2009). Actual certification costs can vary, depending on the 3rd party auditor and the buyer requirements. We used three levels of $0 (no requirement), $500 and $1000 to represent possible associated certification expenses based on direction from the growers in the focus groups.

As far as the expected signs are concerned, Hudson and Lusk (2004) illustrated that increases in the expected income from contracts are positively related with the probability of contract adoption. On the other hand, higher transactions cost lead to lower probability of contracting. In the context of this study, the higher the price per pound offered, the higher the expected income for the grower. Thus, the *a priori* expectation is to have a positive sign associated with price per pound. Penalties and certification cost represent the transaction costs in the examined contracts. The higher they are, the more costly the contract enforcement, suggesting a negative influence in the adoption

probability. Finally, the higher the volume requirements are, the more difficult it will be for growers to satisfy the contract agreement, indicating a greater possibility of penalties. Thus, the initial expectation regarding volume requirements is that they will negatively influence the adoption probability.

3.3 Econometric Models

The conceptual foundation of DCE models lies on the seminal work of Lancaster (1966). In detail, Lancaster's theory of demand posits that consumers gain utility from the characteristics that a good possesses rather than the "actual" good. Additionally, McFadden's (1974) random utility theory (RUT) provides the theoretical background that connects consumers' selection of an alternative and their utility (Louviere et al., 2000). Specifically, based on RUT, an individual's (i) utility from choosing an alternative j in the t-th choice set can be expressed as a combination of two elements: one deterministic and one stochastic. This can be denoted as:

$$(3.1)\ U_{ijt} = X_{ijt}\beta + \varepsilon_{ijt}$$

where β is a vector of unobserved parameters that will be estimated, X_{ijt} is a vector of observed variables, and ε_{ijt} is the random error term. The individual (i) will choose the alternative j that will generate the highest utility.

The selection of the most appropriate statistical technique for the analysis of the data (i.e., conditional logit, multinomial probit, nested logit, etc.) depends on the assumptions that the researcher will make regarding the error term and on the experimental design of the DCE.

Specifically, under the assumption that the error term is independent and identically distributed, with an extreme value Type I distribution, then the probability that the individual (i) will choose the j alternative can be formulated as:

$$(3.2)\ P_{ijt} = \frac{e^{X_{ijt}\beta}}{\sum_{k=1}^{j} e^{X_{ikt}\beta}}$$

This corresponds to the conditional logit model (MacFadden, 1974). One important restriction associated with the conditional logit model is the assumption of independence of irrelevant alternatives (IIA) (Louviere et al., 2000).

The mixed logit model (or random parameters logit) is an extension of the basic multinomial logit model (Train, 2003) that allows the relaxation of the restrictive IIA assumption. Furthermore, a number of additional desirable properties of mixed logit formulation have been discussed in the literature. First, the model accounts for heterogeneity in preferences (Louviere et al., 2000). Second, it allows for correlation of unobserved factors over time (Train, 2003). Third, the model does not restrict the distribution of random components to normal. A number of other distributions can be used, depending on the analysts' assumptions. Lastly, the mixed logit model allows researchers to consider the panel data nature of most repeated choice data such as in this study.

In contrast to conditional logit, in a mixed logit model, the unobserved vector of coefficients β varies in the population following a distribution function $f(\mu, v)$, with μ representing the mean and v the variance of the distribution. The objective of the mixed logit is the estimation of μ and v instead of β. As shown in Train (2003), the unconditional choice probability of mixed logit is expressed as:

$$(3.3) \; P_{ijt} = \int \frac{e^{x_{ijt}\beta}}{\sum_{k=1}^{j} e^{x_{ikt}\beta}} h(\beta)d(\beta)$$

where, $h(\beta)$ is the density function for the random parameters β. Due to the fact there is no closed form solution for equation (3), the integral is calculated using simulation techniques.

3.4 Empirical Results

The results obtained from the econometric estimation in conjunction with a discussion of them are presented in this section. In addition to the main effects estimation, both for conditional and mixed logit models, interaction terms between contract attributes and growers' risk perception and risk preferences are estimated. Two approaches are used for the interpretation of the results. First, the statistical significance and the signs of the coefficients are discussed. Second, a monetary interpretation based on marginal values is provided. Following Hu et al. (2009), the marginal value (MV) in a mixed logit model is calculated as:

$$(3.4) \; MV = - \frac{\beta_{attribute} + \beta_{attribute*D}D}{\beta_{price} + \beta_{attribute*D}D}$$

where $\beta_{attribute}$ and β_{price} are the coefficients associated with a contract attribute and a price (early, peak, late season) respectively. D is a vector of risk preference or risk perception variables, and $\beta_{attribute*D}$ is estimated coefficient of the interaction term between attributes and the estimated risk variables. Under the marketing contract framework examined, MV can be generally interpreted as the amount by which the price per pound offered should be increased or decreased in order for a grower to accept a marginal increment in one of the contract attributes (eg. 1% increase in the penalty levels).

The results of the basic estimation, without any interaction terms, for the

conditional and mixed logit models are reported in Table 3.6. Following the *a priori*

expectations and in line with Hudson and Lusk (2004), the early price ($/lb.) attribute has

a statistically significant and positive coefficient. Thus, *ceteris paribus*, growers show

preference for contracts offering higher price for tomatoes expecting to reach the market

early in the season (before July 4). Taking into account the greater yield risk associated

with early planting, due to weather conditions, this finding is not surprising.

The penalty and certification cost variables represent the transaction costs (cost of

monitoring and enforcement) of the examined contracts. The highly statistically

significant negative coefficients of these two attributes indicate the considerable negative

impact they have on growers' utility. Specifically for certification cost, this negative

impact on utility can be attributed to two factors. First, growers seek to avoid higher

transaction costs, since this will result in reduced income. Second, it may indicate

growers' reluctance to increase their dependence on quality determination from the buyer

or third party audits. Especially if there is no scientific base for this quality verification[16],

the penalties may be activated easily, which would result in reduction of growers' income

or even termination of the contract. Lastly, these findings provide further empirical

validation for the transaction cost theory (Allen and Lueck, 1995).

The random variable "no contract" represents the third alternative in the choice

sets. It is selected by growers if they would rather not choose any of the two contract

alternatives offered. For both model estimations (conditional and mixed logit), the

variable "no contract" is not statistically significant. This finding indicates that, on

average, growers do not suffer utility loss if they do not have the option to participate in a

---

[16] i.e. it is not uncommon to have multiple demands placed in to growers (Mahshie, 2009)

marketing contract agreement. However, under the mixed logit formulation, the standard deviation estimate of this coefficient is statistically significant. This result, in agreement with Hudson and Lusk (2004), indicates unobserved preference heterogeneity among growers.

Regarding volume requirements, none of those described in this experiment (early, peak, late period volume) had a significant impact on growers' utility (Table 3.6). Considering that the volume requirements included in the examined contracts do not exceed 20% of possible yield per acre, this finding is not surprising.

The mixed logit formulation provided a slightly better fit as measured by the McFadden R^2. The incorporation of the random variable (no contract) which indicated the existence of unobserved heterogeneity in growers' preferences can explain this increase.

Estimated marginal values (MV) resulting from the mixed logit formulation indicate that, in order to accept a 1% increase in penalty levels, growers must be compensated by $0.3/ lb. higher early price (Table 3.7). Considering the range of offered early price in the present study is $0.62/lb. - $0.72/lb., on average, growers want 0.4%-0.5% higher early price to accept 1% increase in penalty levels. Similarly, the average MV of $0.0004 for certification cost (Table 3.7) indicated that growers must be offered a 0.05% - 0.06% higher early price in order to accept a $1 increase in the expenditures associated with certification cost.

3.4.1 Growers' Risk Perception, Risk Preferences and Choice of Contracts

The second objective of the study is to investigate how growers' risk perception and risk preferences affect their selection of marketing contracts. The present section

discusses the techniques used to elicit growers' risk preferences and risk perception as well as the results from the subsequent econometric estimation.

An interesting strand of the contract literature refers to the examination of growers' risk preferences and whether or not these affect the choice of contracts. Thus far, research findings regarding this issue are mixed. For instance, Ackerberg and Botticini (2002) and Hudson and Lusk (2004) indicate that risk is an important determinant of contract choice. On the other hand, findings from Allen and Lueck (1995, 1999) illustrate that risk preferences do not have significant impact on the choice of contracts.

Growers' wealth, yield coefficient of variation, and risk transferred to the buyer are among the proxies used in the aforementioned studies to estimate growers' risk preferences. The present paper uses a multiple price list design, following previous work (Binswanger, 1980; Binswanger, 1981; Gneezy and Potters, 1997; Charness and Gneezy, 2010) in order to draw inferences regarding growers' risk preferences. Specifically, in this experiment, growers were asked to select among two different hypothetical tomato plant varieties. The two plants have different levels of resistance to disease and, depending on whether or not the disease occurs, different economic returns. The probability that a disease will occur is 50%. Growers were presented with a set of six possible payoffs and were asked to select one (Figure 3.2).

In accordance with Binswanger (1980), higher expected returns were offered at the cost of higher variance. The corresponding risk classification levels and the estimated partial risk aversion coefficient are reported at Table 3.8. Under the assumption that

growers' exhibit constant partial risk aversion, the partial risk aversion coefficient can be estimated using a utility function of the following form (Binswanger, 1980):

$$(3.5)\ U = (1 - S)M^{1-s}$$

Where M is the certainty equivalent and S is the approximate partial risk aversion coefficient[17]. In line with Lusk and Coble (2005), the measure used in the analysis as an individual's risk aversion coefficient (S) is the midpoint of the possible minimum and maximum range of S[18]. Another alternative is to use the geometric average; however both approaches gave similar results.

In addition to growers' risk preferences, their risk perception is also required in order to elicit optimal risk behavior (Lusk and Coble, 2005). Three Likert-scale questions from Pennings and Garcia (2001) were used to elicit growers risk perception (Table 3.9). A measure of growers' risk perception is obtained by the sum of responses to questions 1-3 (Lusk and Coble, 2005).

After the elicitation of growers' general risk perception and risk preferences, three specifications of the mixed logit framework were estimated (Table 3.10). In contrast to the main effects model, discussed previously, these specifications include grower-specific information that will provide a better interpretation of their preferences. In detail, growers' general risk perception (Model 1), risk preference (Model 2), and an interaction term between risk preferences and risk perception (Model 3) are included in the

---

[17] In order to calculate S (Table 8) we have to solve for the indifference point among two consecutive choices using equation 5. For instance, for choices A and B the S is calculated from the following equation: $50^{(1-s)} + 50^{(1-s)} = 40^{(1-s)} + 70^{(1-s)}$. This equation can be solved in Excel or in Mathematica after graphing the equations to estimate where the functions crosses the x-axes.

[18] Following Binswanger (1981), for the regression analysis alternative F (Table 3.8) was given a value near zero (0.18) and the value for alternative A was set to 2.47

estimation as interaction terms. In all the three model formulations, the "no contract" attribute is assumed to have a random coefficient.

The results of the three estimated models are consistent with the findings of conditional logit and main effects mixed logit formulations, discussed previously. In detail, certification cost and penalty have negative impact on growers' utility, while growers show preference for contracts with higher early price.

Furthermore, findings from Model 1 illustrate that certification cost has a higher negative impact on utility of growers with higher general risk perception (RP) as indicated by the highly statistically significant, negative coefficient of the interaction term "certification cost*RP". If selection of contracts is primarily driven by growers' general risk perception then, in line with Hanaka's (2005) suggestions, educational or financial assistance can be an important element in altering growers' behavior in favor of marketing contract agreements.

As can been seen from Model 2 findings (Table 3.10), growers' risk aversion (RA) did not have any significant impact on their preferences regarding marketing contracts. However, when the interaction term between growers' risk perception and risk aversion is included in the estimation (Model 3, Table 3.10), the interaction between this term and the certification cost is statistically significant with the expected negative sign.

Marginal values based on the three previously mentioned models are also calculated. In order to gain a better understanding of how different growers' value different contract attributes two levels of risk perception and risk preferences are examined. For risk perception these values are -2 and 2 representing risk seeking and risk averse growers. For risk aversion the selected levels are 0.5 and 2. For comparison

purposes, marginal values are also estimated for the average levels of risk aversion and risk preferences.

Table 3.11 reports only the statistically significant results of these estimations. In contrast to the results from Model 1, none of the marginal values estimations for the risk perception interaction term are statistically significant. This finding indicates that the effects may not be large enough to have a perceptible value. On the other hand, the higher the growers' risk aversion coefficient, the greater compensation (in terms of early price) they should be offered to accept a 1% increase in penalty or a $1 increase in certification cost.

3.5 Conclusions

The present study used discrete choice experiments in conjunction with estimation of random utility models to investigate: i) how growers' value different attributes of marketing contracts and ii) how growers' risk perception and preferences affect their selection of marketing contracts. The main data source is a mail survey administrated to 315 wholesale tomato growers in 4 states: Kentucky, Illinois, Ohio and Indiana. Fresh vegetable growers were selected as the sample of the present study due to the increased sources of risk they face and the limited opportunities they have to reduce this uncertainty.

The empirical results in line with the initial hypothesis and with previous literature (i.e. Hudson and Lusk; 2004, Allen and Lueck; 1995) highlight the role of transaction costs as an important determinant of contract choice. Specifically, the findings indicate that certification cost requirements (or third party audits) have a significant negative impact on growers' utility concerning the selection of contracts.

Furthermore, the findings indicate the existence of unobserved heterogeneity regarding growers' preferences for marketing contracts.

The effect of risk on the selection of contracts is a widely discussed topic in the literature; however, no common consensus has been reached. The present study used a multiple price risk game and a number of Likert scale questions to elicit growers' risk aversion and risk perception, respectively. In contrast with Hudson and Lusk (2004), the results indicate that growers' risk aversion and risk preferences have a limited impact on growers' selection of marketing contracts. Last but not least, buyers who wish to enter into marketing contracts with growers need to provide a high early price, as well as improve the determination of quality criteria, thus reducing the third party audit costs.

Future research may include larger samples and different geographic areas where the use of marketing contracts is more common than in the examined region. If the importance of third party audit cost in these regions, where growers are more familiar with contracts, is lower and risk perception is still a significant determinant of choices, then it may indicate that education can alter growers' preferences.

Figure 3.1: Example Choice Set

	Option A				Option B				Option C
Delivery Period	Price ($/lbs)	Volume (pounds/ acre/ week)	Penalty	Certification Cost	Price ($/lbs)	Volume (pounds/ acre/ week)	Penalty	Certification Cost	
Early	$ 0.74	2,200/acre/week	5%	$1000	$0.62	2,600/acre/week	15%	$500	I will not
Peak	$ 0.53	6,000/acre/week	5%	$1000	$0.55	5,000/acre/week	15%	$500	Choose either A
Late	$ 0.70	5,100/acre/week	5%	$1000	$0.77	4,300/acre/week	15%	$500	or B

Please choose only <u>one</u> option   ☐ Option A   *or* ↔   ☐ Option B   *or* ↔   ☐ Option C

Figure 3.2: Risk preferences elicitation question

Please consider the choice you would make in the following hypothetical situation:
You will be given 150 tomato plants (in 5 bundles of 30 plants each) for free, to use in

the coming season. There are two types of plants, A and B, and you can choose any

combination of the two that totals 5 bundles.

The A and B plants have different levels of resistance to tomato diseases. The A plants

have potentially higher harvests but are more vulnerable to disease. If disease does not

occur, the A plants will produce a harvest worth $30 per bundle. However if disease

occurs (50% of the time), the A plants' harvest is worthless ($0 per bundle). The B plants

are disease-resistant and always produce a harvest worth $10 per bundle.

The following table illustrates the different combinations of type A and B plants that you

could receive, and the value of their combined harvests based on the weather. Please

check one box to indicate which combination of plants you would choose.

I choose (check one of the six combinations A-F below)	Bundles of 30 type A plants	Bundles of 30 type B plants	If disease does not occur (50%)	If disease occurs (50%)
o A	0	5	$50	$50
o B	1	4	$70	$40
o C	2	3	$90	$30
o D	3	2	$110	$20
o E	4	1	$130	$10
o F	5	0	$150	$0

Table 3.1: Registered Commercial Tomato Growers and Usable Response Rate by State

State	Registered Growers	Usable Responses	% Usable Response Rate
Illinois	116	17	14.6 %
Indiana	53	12	22.6 %
Kentucky	50	12	24.0 %
Ohio	81	8	9.8 %
n	300	49	16.3%

Source: Market Maker, survey questionnaire

Table 3.2: Descriptive Statistics Associated with Commercial Tomato Growers

Variable	Average	Std.	Min.	Max.
Gender (1=female)	0.24 (0.17)[a]	0.43	0	1
Age	49. 2 (56)[a]	12.43	30	70
Experience with contracts (1=yes)	0.36	0.48	0	1
Household size	2.4	1.28	1	6
Household income	71,480	33,169	20,000	137,500
Education	15	2.5	5	19
Off farm employment (1= yes)	0.42	0.49	0	1
Acres with Tomatoes n=49	17.5 (17)[a]	85.5	0.125	600

Source: Survey questionnaire
[a] Numbers in parenthesis come from 2007 census of agriculture for vegetables, potatoes and melons.

Table 3.3: Factors that Encourage Growers Participation in Marketing Contracts

		Importance levels (4=most important)			
Factor	Freq.	1	2	3	4
Reduced price risk	29	10.3%	20.7%	31.0%	37.9%
Secured income	39	2.6%	12.8%	41.0%	43.6%
No need to worry about supply channels	23	26.0%	39.1%	8.7%	26.1%
Access new market opportunities	31	25.8%	25.8%	25.8%	22.6%
Bonuses for better quality	19	43.4%	10.5%	10.5%	10.5%
Opportunity to sell higher volumes	30	33.3%	20.0%	20.0%	23.3%
Prior experience with contracts	8	62.5%	12.5%	12.5%	0.0%
Lower distribution cost	13	46.1%	7.7%	7.7%	15.4%
Maintenance of future relationships with buyers	18	44.4%	16.0%	16.7%	5.6%
Other	2	50.0%	0.0%	0.0%	50.0%

Source: Survey questionnaire

Table 3.4: Factors that Discourage Growers From Participating in Marketing Contracts

| | | Importance levels (4=most important) | | | |
Factor	Freq.	1	2	3	4
Difficult to satisfy quality requirements	32	21.8%	28.1%	21.9%	28.1%
Unhappy with price terms	28	10.7%	10.7%	32.1%	46.4%
Severe penalties	19	15.8%	26.3%	15.8%	42.1%
Inflexibility to pursue other markets	23	34.8%	26.1%	17.4%	21.7%
Cost of enforcement	11	9.0%	36.4%	18.2%	36.4%
Bad previous experience with contracts	12	25.0%	50.0%	16.7%	8.3%
Unhappy with quality terms	19	5.3%	43.4%	26.3%	21.0%
Delivery time	17	23.5%	41.2%	17.6%	17.6%
Method of payment	12	50.0%	16.7%	25.0%	8.3%
Not enough information about contracts	18	16.7%	22.2%	22.2%	38.9%
Difficult to satisfy volume requirements	28	39.3%	14.3%	17.9%	28.6%
Not enough land	12	33.3%	16.7%	16.7%	33.3%
Other	1	100%	0.0%	0.0%	0.0%

Source: Survey questionnair

Table 3.5: Choice Based Experiment Attributes and Their Levels

Variable	Description	Levels			
		1	2	3	4
Early Price	Price offered for late June-Early July ($/lb)	0.62	0.68	0.74	
Peak Price	Price offered for July-August ($/lb)	0.53	0.55	0.58	
Late Price	Price offered for September – October ($/lb)	0.70	0.77	0.84	
Early Volume	Volume requirements for Late June- Early July (lbs./acre)	2,200	2,400	2,600	
Peak Volume	Volume requirements for July- August (lbs./acre)	5,000	5,500	6,000	
Late Volume	Volume requirements for September- October (lbs./acre)	4,300	4,700	5,100	
Penalties	Price reduction if the contract agreements are not satisfied (% of price)	5%	10%	15%	Terminate
Certification Cost	3rd party audit cost	0	500	1000	

Table 3.6: Main Effect Conditional and Mixed Logit Estimations

	Conditional Logit		Mixed Logit	
	Coefficient	Std. Error	Coefficient	Std. Error
Early Price	3.546*	1.960	3.683*	2.125
Peak Price	3.902	4.748	5.138	5.317
Late Price	0.569	1.690	1.427	1.891
Early Volume	-0.000	0.000	-0.000	0.000
Peak Volume	0.000	0.000	0.000	0.000
Late Volume	0.000	0.000	0.000	0.000
Certification Cost	-0.001***	0.000	-0.002***	0.000
Penalty	-1.228***	0.288	-1.44***	0.320
No Contract	5.140	4.34	6.50	4.909
No Contract S.D.			3.208***	0.628
McFadden R^{2a}	0.118		0.128	
Adj. McFadden R^2	0.090		0.089	
n=49				

*, ** and *** indicate 10%, 5% and 1% significance level respectively.
[a] McFadden R^2 is given by one minus the ratio of unrestricted to restricted log likelihood values

Table 3.7: Marginal Values Under Mixed Logit Model

	Early Price		Peak Price		Late Price	
	Mean	Std. Error[a]	Mean	Std. Error	Mean	Std. Error
Early Volume	0.000	0.000	0.000	0.000	0.000	0.000
Peak Volume	0.000	0.000	0.000	0.000	0.000	0.000
Late Volume	0.000	0.000	0.000	0.000	0.000	0.000
Certification Cost	0.0004*	0.0002	0.000	0.000	0.001	0.001
Penalty	0.393*	0.238	0.282	0.303	1.015	1.351
No Contract	-1.8	1.4	-1.3	0.95	-5.3	6.86

* Indicates 10% significance level

[a] The standard errors are estimated using the delta method.

Table 3.8: The Payoffs and Corresponding Risk Classification

Choice	Low Payoff (Disease occurs)	High Payoff (No disease)	Risk Aversion Class[a]	Approximate Partial Risk Aversion Coefficient (S)	Percentage of Choices in Experiment
A	50	50	Extreme	∞ to 2.48	16.3%
B	40	70	Severe	2.48 to 0.84	22.45%
C	30	90	Intermediate	0.84 to 0.5	34.69%
D	20	110	Moderate	0.5 to 0.33	18.37%
E	10	130	Slight to Neutral	0.33 to 0.19	6.12%
F	0	150	Neutral to Negative	0.19 to $-\infty$	2.04%

[a] Based on Binswanger (1980) classification

Table 3.9: Growers' Risk Perception: Response to Scale Questions
 (-4= strongly Disagree, 4= Strongly Agree)

Question	Definition	Mean
1	With respect to the conduct of business I avoid taking risk	0 (2.00)[a]
2	With respect to the conduct of business I prefer certainty to uncertainty	1.5 (1.7)
3	I like "playing it safe"	0.8 (1.8)

n=49

[a] Number in parentheses are standard deviations

Table 3.10: Mixed Logit Estimations Including Growers' Risk Perception and Risk Preferences Interaction

	Model 1[a]			Model 2[b]			Model 3[c]	
	Coeff.	Std. Error		Coeff.	Std. Error		Coeff.	Std. Error
Early Price	3.439	2.200	Early Price	4.049*	2.168	Early Price	2.864	2.251
Peak Price	7.247	5.540	Peak Price	6.171	5.437	Peak Price	7.757	5.600
Late Price	1.257	1.923	Late Price	1.739	1.917	Late Price	1.612	1.943
Early Volume	-0.000	0.000	Early Volume	-0.001	0.001	Early Volume	-0.000	0.000
Early Volume* RP	0.000	0.000	Early Volume* RA	0.001	0.000	Early Volume* RARP	0.000	0.000
Peak Volume	0.000	0.000	Peak Volume	0.000	0.000	Peak Volume	0.000	0.000
Peak Volume*RP	-0.000	0.000	Peak Volume*RA	-0.000	0.000	Peak Volume*RARP	-0.000	0.000
Late Volume	0.000	0.000	Late Volume	0.000	0.000	Late Volume	0.000	0.000
Late Volume *RP	0.000	0.000	Late Volume *RA	-0.000	0.000	Late Volume *RARP	0.000	0.000
Certification Cost	-0.001***	0.000	Certification Cost	-0.001**	0.000	Certification Cost	-0.001***	0.000
Certification Cost*RP	-0.000**	0.000	Certification Cost*RA	-0.000	0.000	Certification Cost*RARP	-0.000	0.000
Penalty	-1.429***	0.334	Penalty	-0.922*	0.581	Penalty	-1.455***	0.346
Penalty*RP	-0.053	0.627	Penalty*RA	-0.635	0.0559	Penalty*RARP	0.039	0.601
No Contract	7.186	5.027	No Contract	6.774	4.997	No Contract	6.528	5.079
No Contract S.D.	3.138***	0.624	No Contract S.D.	3.218***	0.629	No Contract S.D.	3.104***	0.620
McFadden R^{2d}	0.14			0.139			0.148	
Adj. McFadden R^2	0.089			0.082			0.009	
n=49								

*, **, *** Indicate 10%, 5% and 1% significance level respectively

[a] Model 1 includes interaction terms with growers risk preference levels (RP)

[b] Model 2 includes interaction terms with growers risk aversion levels (RA)

[c] Model 3 includes as an interaction term a combination of risk aversion and risk preference levels (RARP)

[d] McFadden R^2 is given by one minus the ratio of unrestricted to restricted log likelihood values

Table 3.11: Marginal Value Estimates Under Mixed Logit Models

Marginal values associated with Risk Aversion (Model 2)

	R.A. levels	Early Price ($/pound.)	Std.Error
Certification Cost	0.5	0.0003*	0.0002
	1	0.0004*	0.0002
	2	0.0005*	0.0003
	R.A. levels		
Penalty	0.5	0.306	0.191
	1	0.384*	0.215
	2	0.541*	0.315

* Indicates statistical significance at 10% level

Chapter 4: Risk Aversion and Production Uncertainty as Parameters Influencing Growers Marketing Choice: A Mathematical Programming Approach

4.1 Introduction

Following the pioneering work of Coase (1937), Cheung (1969) and Stiglitz (1974) numerous empirical studies have used either mathematical programming or econometric techniques to model growers' choices regarding contractual agreements. The first group of research primarily utilized whole farm economic analysis to evaluate the selection of the optimal marketing mix (eg. Barry and Willmann, 1976; Buccola and French, 1977; Buccola and French, 1979; Miller, 1986; Bailey and Richardson, 1985). Studies in the second group of research used a wide variety of econometric techniques such as: i) limited dependent variable models (Goodwin and Schroeder, 1994; Musser et al., 1996; Katchova and Miranda, 2004; Sartwelle et al., 2000), ii) binary variable models (Paulson et al., 2010; McLeay and Zwart, 1998) and iii) discrete choice experiments (Hudson and Lusk, 2004). The questions that these studies answered included: i) what factors influence the choice of contracts, ii) how much production to sell under contracts, and iii) what tradeoffs are growers willing to make in order to participate in contractual agreements?

Despite this abundance of research there is no general consensus of the role of risk aversion in contract choices. The following three possibilities have been suggested in previous research: 1) risk aversion is an important parameter in contract choice (i.e. Ackerberg and Botticini, 2002; Parcell and Langmeir, 1997; Zheng et al., 2008), 2) to a greater extent, it is the transaction cost or the provision of incentives that dictates the choice of contracts (i.e. Allen and Lueck, 1999; Allen and Lueck 1995; Predergast, 1999; Aggarwal, 2007) and 3) both transaction costs and risk aversion are significant

determinants of contract choice (i.e. Hudson and Lusk, 2004; Fukunaga and Huffman, 209).

The objective of the present study is to investigate the role of growers' risk aversion in the choice of optimal marketing mix. Specifically, growers' preferences between two marketing options (wholesale marketing and combination of wholesale marketing and marketing contracts) under ten risk aversion levels are examined.

The contribution of the study to the literature is threefold. Specifically, it is the first research endeavor, to the authors' knowledge that: i) utilizes integer programming and biophysical simulation techniques to model contract choices, ii) discusses changes in optimal production practices induced by the participation in a contractual agreement and iii) compares the results of a mathematical programming formulation with findings from discrete choice experiments. Specifically, the results of this study were compared with the findings of Vassalos et al. (2013) who used a choice experiment to examine wholesale tomato growers' preferences for marketing contracts. The following sections provide a detailed discussion regarding the hypothetical farm of the study, the marketing options, the economic model and the production practices examined.

4.2 The Hypothetical Farm

The hypothetical vegetable farm of the study is located in Fayette County, Kentucky (KY). Three reasons dictated the selection of this region. First, Fayette County is among the top vegetable producing counties in the state. Second, Fayette County includes Lexington, a regional urban center with a relative large number of restaurants. Moreover, the increased demand for local products among wholesale buyers and commercial buyers indicates an opportunity to exploit marketing contracts in the area as

an alternative market option (Cable, 2011; Ernst and Woods, 2011). Third, there is an abundance of soil and weather data for Fayette County. These data are essential requirements for the biophysical simulation model as discussed later.

Based on the average size of operation observed in the 2010 Kentucky Produce Planting and Marketing Intentions survey (Woods, 2010), the hypothetical farm is assumed to have five acres of cropland available and grow tomatoes and sweet corn in a rotation with 50% of acres in any year devoted to each crop. The choice of these vegetables is driven by two factors. First, in terms of acres and number of farms tomatoes and sweet corn are the top two vegetables produced in KY (2007 Census of Agriculture). Second, growers can easily rotate among these two crops (Coolong, 2010).

The 2012 vegetable budget files of Mississippi State Budget Generator (Laughlin and Spurlock, 2007; Ibendhal and Halich, 2010) were modified for Fayette County (KY) conditions[19] and used to estimate the selected variable costs. A detailed presentation of these costs is reported in Table 4.1.

An important first step for the success of a commercial vegetable farm is the selection of a marketing channel (Rowell, Woods, Mansfield, 1999). For the purposes of the present study the following two marketing options are available: i) wholesale market or ii) a combination of marketing contracts and wholesale marketing. Detailed discussion for these two options is provided in the following section.

---

[19] The required modifications were based on the 2008 vegetable budget developed by University of Kentucky Extension Service and on personal communication with Dr. T. Coolong.

4.3 Marketing Channels

4.3.1 Wholesale Market

Under this option, an intermediary initially buys from the grower and afterwards

sells to a retailer or the consumer. Wholesale markets have limited legal requirements for

the grower and there is no need for advertisement. On the other hand, the price offered is

lower compared to other market outlets such as farmers markets.

To represent the wholesale marketing option, price data for tomato and sweet

corn is obtained from the USDA Agricultural Marketing Service (AMS). The AMS

terminal market price data set is based on vegetable sales taking place at the local

wholesale markets for 15 major cities. The prices reported are those received by

wholesalers for products that are of "good merchantable quality" (USDA, 2012). Prices

from the Atlanta terminal market in proximity to Kentucky markets are used in this study.

Specifically, the data set utilized includes 13 years (1998-2010) of weekly price

data for yellow sweet corn and for three different sizes (medium, large, extra-large) of

mature green tomatoes. The Hodrick and Prescott (HP) filter is used to remove the

observed yearly trend of the price data. Following Ravn and Uhling (2002) a smoothing

parameter (λ) of 6.25 is used. Finally, the prices were transformed to $/pound and

$/dozen ears for tomatoes and sweet corn respectively.

4.3.2 Contract Design

The second marketing option available for the hypothetical grower represents a

combination of marketing contracts for large tomatoes[20] and wholesale marketing. A

marketing contract is defined as an oral or written agreement between a grower and a

---

[20] Only large tomatoes are examined in order to better imitate the conjoint experiment in Vassalos et al. (2013)

buyer (wholesaler, restaurant, grocery store, etc.) who sets some quantity/quality

requirements, a price for the product coupled with possible price adjustments, and

delivery period requirement (McDonald et al., 2004; Katchova and Miranda, 2004).

Marketing contract agreements can act as a tool to coordinate the market, achieve a

constant supply of local vegetables, and possibly improve the economic outcome of

producers.

Three mutually exclusive marketing contracts (contract 1, contract 2, and contract

3) are defined for this study utilizing different levels of the following eight attributes:

early period price, peak period price, late period price, early period volume requirements,

peak period volume requirements, late period volume requirements, penalty and

certification cost. Early period, refers approximately to the period up to July 10, the peak

period covers July and August, and the late period includes September and October.

Selection of these time periods is based on focus group discussions with buyers.

Definitions for each attribute are reported in Table 4.2.

The present study employs a price per pound mechanism contingent on the quality

of the product and the delivery period. The USDA-AMS tomato prices from Atlanta

Terminal Market are used as base prices and are modified accordingly following

comments from focus groups. Specifically, following the feedback from the focus group,

the examined contracts offer the highest price range levels for late period production

($0.70 to $0.84 per pound) followed by early period production ($0.62 to $0.74 per

pound) and peak period production ($0.53 to $0.58 per pound) . For comparison

purposes, the average AMS prices for large tomatoes are $0.67, $0.57, $0.53 for the late,

early and peak period respectively.

Regarding volume requirements, the scarcity of detailed yield data leads to the use of biophysical simulation techniques. Since growers do not generally contract all of their production (Katchova and Miranda, 2004), the volume requirements specified on the contract profiles correspond to 10%, 15% and 20% of the average yield calculated by DSSAT, evenly distributed among the three periods (early, peak and late).

If the grower fails to satisfy the requirements of the contract then a penalty clause is activated. The literature examines several possible penalty structures (Wolf et al., 2001; Hueth et al., 1999). For the purposes of the present study, the penalties are defined as a percentage of the full contract price. Specifically, three penalty levels are used in the study: 5%, 10% and 15% of the price. In line with the price determination, the final selection of penalty levels is made following the feedback from the focus groups.

The certification cost attribute refers to lump sum payments that growers have to provide for third party audits conducting quality control. The importance of such costs in the choice of contractual agreements has been mentioned earlier. Based on feedback from the focus groups three levels of certification cost were used: $0 (no certification cost), $500 and $1000. Finally, the volume requirements of the three contracts correspond to 10%, 15% and 20% of the average yields estimated through the biophysical simulation model (discussed in the next section) for each of the three periods (early, peak and late).

Contract 1 consists of a combination of the minimum values of each attribute. Contract 2 includes a combination of the medium levels of each one of the eight attributes. Finally, contract 3 incorporates a combination of the highest price, highest volume requirements, highest penalty levels and highest certification cost (Table 4.2). The selection of these combinations for the examined contracts is made in order to avoid

the existence of a clearly superior contract (i.e. high price, low penalties, zero certification cost).

4.4 Economic Model

The economic environment of the hypothetical wholesale vegetable farm is modeled with a combination of quadratic and integer programming formulation embodied in a mean-variance framework (E-V). Two reasons justify the use of integer programming (IP). First, the contractual agreements offered in the study are mutually exclusive and non-negotiable. This is required in order to imitate the discrete choice experiment environment. IP enables an efficient modeling of such constraints. Second, IP is a powerful and efficient tool when multiple choice sets are considered simultaneously (Danok et al., 1980).

The objective of the model is the maximization of net returns above selected variable costs less the risk aversion coefficient multiplied by the variance of net returns. The risk aversion coefficients are estimated using the McCarl and Bessler (1989) approach. This technique assumes that a grower maximizes the lower limit from a confidence interval of normally distributed net returns. Based on this approach, nine levels of risk aversion are estimated. Each one of these levels corresponds to a 5% increment from the previous one starting from 50% (risk neutral) up to 95% (extreme risk aversion).

Regarding the model formulation, the present essay expanded the model introduced in the second chapter of the dissertation to include the following additions:

$$(4.1) \sum_{CONTR} PICK_{CONTR} \leq 1$$

$$(4.2)\ SHORTAGE_{CONTR,WK,YR} - M * FAIL_{CONTR,WK,YR} \leq 0, \forall\ CONTR, WK, YR$$

$$(4.3)\ CONTRSALES_{CONTR,WK,YR} + M * FAIL_{CONTR,WK,YR} \leq M, \forall\ CONTR, WK, YR$$

$$(4.4)\ \sum_{CONTR} \sum_{WK} CONTRSALES_{CONTR,WK,YR} - M * SATISFY_{YR} \leq 0, \forall\ YR$$

$$(4.5)\ \sum_{CONTR} \sum_{WK} PENSALES_{CONTR,WK,YR} - M * SATISFY_{YR} \leq 0, \forall\ YR$$

$$(4.6)\ \sum_{CONTR} \sum_{WK} FAIL_{CONTR,WK,YR} + M * SATISFY_{YR} \leq M + 2, \forall\ YR$$

$$(4.7)\ CONTRSALES_{CONTR,WK,YR} + PENSALES_{CONTR,WK,YR} + SHORTAGE_{CONTR,WK,YR}$$
$$- CONTRVOL_{CONTR,WK} * PICK_{CONTR} = 0 \ \forall\ CONTR, WK, YR$$

where SATISFY$_{YR}$, FAIL$_{CONTR,WK,YR}$, PICK$_{CONTR}$ are binary variables and M is a number larger than the highest number of pounds that can be sold under contract (Danok et al., 1980). SHORTAGE$_{CONTR,WK,YR}$ is a continuous variable defined as the difference between the contract volume requirements for the different weeks and the large tomato pounds actually produced during those weeks for each of the production years examined.

The first constraint (equation (4.1)) insures that only one, if any, contract will be selected. This approach enables the simulation of the choice experiment described by Vassalos et al. (2013)[21], which is one of the objectives of the present study.

If a contract option is selected then the grower will either 1) satisfy the weekly (WK) volume requirements specified by the examined contracts each production year (YR) or 2) fail to satisfy the volume requirements. Under the former option the grower will sell the required amount of tomatoes (CONTSALES) at the original contract price.

---

[21] Under the choice experiment, the growers were asked to select one and only one option from three choices: two distinct marketing contract formulations and the option of "I will not choose any of the offered contracts".

Under the latter case the grower will sell the amount of tomatoes produced (PENSALES) under a reduced penalty price.

The aforementioned options are formulated with the use of either/or constraints (Equations (4.2) and (4.3)) and with the use of Boolean logical conditions specified in the model (Equations (4.4) and (4.5)). For instance, if $FAIL_{CONTR,WK,YR} = 0$ then the constraint (4.3) holds and the grower will be able to meet the contract requirements.

Marketing contracts frequently include disclaimers that allow the buyer to terminate the contractual agreement if the grower repeatedly fails to meet the agreed terms. Equation (4.6) models such a disclaimer. Specifically, it establishes that the contract agreement will be terminated if the grower fails to meet the requirements more than two weeks during that year. Lastly, equation (4.7) establishes the balance requirement for the contract volume. The complete mathematical formulation is presented at appendix B.

In order to estimate whether a given period is suitable for fieldwork, the approach used in Shockley et al. (2011) is employed. Specifically, the probability of not raining more than 0.15 inches per day is calculated based on weather data from 1971 to 2008. This probability was multiplied with the days worked in a week and the hours worked in a day to determine expected suitable field hours per week. Daily weather data for the 38 year period are obtained from the University of Kentucky Agricultural Weather Center.

The model is estimated under two scenarios. In the first one, the grower is able to select some combination among two marketing channels: 1) wholesale marketing only and 2) wholesale marketing and contractual agreements (for large tomatoes). Under the second scenario, sensitivity analyses tests were conducted to examine the effect of price

alterations on the choice of marketing outlet. This approach will help to identify changes in economic performance production practices resulting from the participation in marketing contracts.

4.5 Production Environment and Biophysical Simulation Model

Statistical regression equations and simulation models are the two main techniques used in the literature to overcome yield data limitations (Walker, 1989). The present study employs a special case of simulation modeling known as biophysical simulation (Musser and Tew, 1984). Specifically, yield data for tomatoes and sweet corn are estimated using the Decision Support System for Agrotechnology Transfer (DSSAT v. 4.0) a biophysical simulation model (Hoogenboom et al., 2003; Jones et al., 2003). The selection of DSSAT is based on the following three reasons: i) it is well documented, ii) it has been validated in numerous studies over the last 15 years and iii) it incorporates modules for tomatoes and sweet corn.

The minimum data requirements to generate yield estimates using DSSAT include: i) soil data, ii) daily weather data and iii) production practices information for the region and crops under consideration. These data sets are obtained from the National Cooperative Soil Survey of NRCS, the University of Kentucky Agricultural Weather Center and the University of Kentucky Extension Service Bulletins (Coolong et al., 2010) respectively.

Based on the soil maps the most common soil type in Fayette County (KY) is silt loams with 65% of the soil classified as deep silt loams and 35% as shallow. This distinction is based on the percent slopes from the soil maps. Specifically, following Shockley (2010), soils with slopes less than 6% are characterized as shallow and soils

with slopes between 6% and 20% as deep. In order to better simulate the soil conditions of the examined region, the default soil types of DSSAT were modified. The parameters altered include soil color, runoff potential, drainage and soil slope. The exact soil specifications are reported at Table 4.3.

The weather data set used in the study includes daily climate information (minimum/maximum temperature, precipitation) for 38 years (1971-2008). The data set was finalized with the estimation of solar radiation from the DSSAT v. 4.0 weather module.

The production practices data set contains information for transplanting period (tomatoes), planting period (sweet corn), harvesting period, irrigation requirements, plant population, planting depth, fertilization requirements and cultivar types. In the examined region, tomato transplant extends from early May (spring crop) through early August (fall crop) and sweet corn is planted from April 20 to July 20. Tomatoes are typically harvested 65 to 80 days after transplant and sweet corn is usually harvested 70 to 95 days after planting.

4.5.1 Yield Estimates and Validation

Yield estimation for all the possible combinations of transplanting/planting and harvesting periods requires coding of more than 9500 treatments[22] in DSSAT which is beyond the scope and objectives of the present essay. In order to reduce the number of treatments, the examined production practices include eight bi-weekly transplanting days for tomatoes (starting May 1), nine weekly planting days for sweet corn (starting April

---

[22] ((120 transplanting days* 15 harvesting days for tomatoes)+(120 planting days *25 harvesting days for sweet corn)*2 for the 2 soil types

25) and four weekly harvest periods for each crop. One cultivar is examined for each crop since only one is available in DSSAT v 4.0.

One of the most important aspects in biophysical simulation modeling is the validation of the estimated yields. Considering the lack of yield data in the examined region (Fayette County, KY) the following two non-statistical validation methods are employed: i) expert's opinion and ii) comparison with findings from previous studies.

Specifically, for the former approach, the initial yield estimations were presented to Dr. Timothy Coolong[23] and he was asked whether or not they were a reasonable representation of yields in Central Kentucky for tomatoes and sweet corn. Following Dr. Coolong's recommendations, three harvesting periods for tomatoes (63, 70, 77 days) and one for sweet corn (84 days) are kept in the final model formulations. The simulated yields were considered as higher than what an average vegetable grower can achieve but not unreasonable for the best producers. Yields estimated for harvesting periods 84 days after transplanting for tomatoes and 70, 77 and 91 days after planting for sweet corn are removed from the yield data set since they were considered as not achievable in the examined area. Tables 4.4 and 4.5 provide detailed information regarding the production practices examined and summary statistics for the simulated yields respectively.

For the latter approach trends observed in previous research were compared with trends in the simulated yield data set. As such, in line with Hossain et al. (2004), Huevelink (1999) and Schweers and Grimes (1976), the simulated tomato yields had approximately a bell shaped form and are substantially influenced by the transplanting period (Figure 4.1). Regarding sweet corn, consistent with Williams (2008) and Williams and Linquist (2007) planting period plays an important role in production (Figure 4.2).

---

[23] Extension Vegetable Specialist, Assistant Extension Professor, University of Kentucky

Since the weather conditions and soil data in Fayette County (KY) are different from the ones in the previously mentioned studies, absolute yield values are not compared. However, in order to provide further validation, the simulated yields for tomatoes and sweet corn are compared with experimental trials that conducted in Central and Eastern Kentucky. For tomatoes, the simulated yields compare favorably to the highest yielding cultivars in the experimental trials (Rowell et al., 2004; Rowell et al., 2005; Rowell et al., 2006; Coolong et al., 2009). Regarding sweet corn, the average simulated yields are slightly lower than the best yellow cultivar of the experimental trials ((Jones and Sears, 2005).

4.6 Results

The findings of the mathematical programming formulation indicate that wholesale marketing is preferred, over a combination of wholesale marketing and marketing contracts, for all risk aversion levels (Table 4.6). This result are in line with Vassalos et al. (2013) who illustrated that, on average, wholesale growers do not suffer utility loss if a contract option is not available to them. The primary reason for not selecting a mix of wholesale marketing and contracts lies in the yield losses associated with the earlier production, required by a marketing contract agreement (Figure 4.1). In agreement with the underlying theory, as risk aversion levels increase growers' trade off expected net returns for lower variance. For instance, the net returns for an extremely risk averse grower (level 9) correspond to 80% of the maximum possible net returns coupled with a reduction in coefficient of variation (C.V.) from 24.52% to 16.18% (Table 6).

Compared to other agronomic crops, fresh vegetables have fewer storage opportunities and therefore an inelastic supply at a given time period. Consequently, in

order to satisfy the requirements of the selected market outlet and achieve the optimal

economic outcome growers have to carefully plan their planting and harvesting activities.

Table 4.7 reports the optimal production schedule and land allocation for four of

the examined risk aversion levels. The findings indicate that the optimal schedule for a

risk neutral grower, seeking to maximize net returns, includes a combination of late

transplanting/harvesting period for tomatoes and late planting for sweet corn.

Specifically, July 10 and July 24 are selected as optimal transplanting periods for

tomatoes and June 21 as optimal planting for sweet corn. Regarding tomato harvesting,

77 days after transplant is the time selected as optimal (Table 4.7). All the available five

acres are utilized.

The following three alterations are adopted as risk aversion levels increase: 1)

gradually shift focus towards earlier transplanting periods for tomatoes (June 12 instead

of July 10), 2) earlier planting for sweet corn (from June 21 to May 23) and 3) expand the

number of optimal transplanting periods from two to three for the highest risk aversion

level level (Table 4.7). These strategies help to reduce the variation in net returns, which

is an objective for risk averse growers. The reduction in C.V. results from a reduced price

variation. Specifically, the price coefficient of variation drops from 19% (July 24, 77

days harvest) to 10% (June 12, 77 days harvest). Similarly to the risk neutral case, all five

acres are utilized.

The results from Vassalos et al. (2013) indicated that growers are more likely to

participate in a marketing contract agreement if the early price offered is higher.

Consequently, an intriguing research question is to examine the impact of higher contract

prices, ceteris paribus, on the choice of optimal marketing outlet in the mathematical

programing framework. In order to answer this question sensitivity analyses were conducted. Specifically, for the risk neutral case, the following four scenarios are examined: i) increase only in the early period price, ii) increase only in the peak period price, iii) increase only in the late period price and iv) increase all prices simultaneously. The findings indicate that the combination of wholesale and marketing contracts is preferred, for the first time, when all three prices increase simultaneously by 70%. The contract selected as optimal under this scenario is contract 3.

If the model formulation "enforces" participation in a marketing contract agreement, by increasing the contract prices, then the optimal production practices are significantly altered compared to those under only wholesale marketing. Specifically, two major changes occur under this scenario for a risk neutral grower: 1) Harvesting 70 and 77 days after transplanting is preferred, instead of after 77 days only and 2) transplanting occurs all eight of the examined weeks between May 1 and August 7 (Table 4.8). However, transplanting at July 10 and harvesting 77 days later is still the period with the greater number of acres with tomatoes. No alteration is realized for sweet corn production practices (Table 4.8). The aforementioned changes are required in order to satisfy the volume requirements of the contract and receive the higher prices.

4.7 Conclusions

The present study employed a whole farm modeling approach to investigate optimal marketing strategies for fresh vegetable growers, under different risk aversion levels. Specifically, a combination of integer and quadratic programming are used to model the economic environment of a vegetable farm located at Fayette County,

Kentucky. Two marketing options, wholesale marketing only and a combination of wholesale marketing with marketing contracts, are examined.

The former approach is characterized by greater volatility in prices, but provides increased freedom to the grower regarding the choice of production practices. The latter option provides higher and more stable prices but requires constant production throughout the year, additional cost in the form of third party audits and reduced yield compared to wholesale marketing only.

The findings of the study indicated that wholesale marketing is preferred over a combination of wholesales and marketing contracts. Risk aversion levels influenced the selection of optimal production practices but not the choice of marketing outlet. Furthermore, findings from a sensitivity analysis illustrated that when all three contract prices (early, peak, late) are increased simultaneously, from the base price scenario, a risk neutral grower will prefer the combination of wholesale marketing and contracts over only wholesale marketing.

When the grower selects a combination of wholesale marketing and contractual agreements as a market outlet two main changes in production practices are noticed compared to wholesale marketing only. First, transplanting dates cover the whole period allowed. Second, harvesting occurs during multiple time periods.

The findings of the study may act as a guide for the growers. In particular, the results highlight the importance of a carefully scheduled production plan in order to achieve the best possible economic outcome for commercial fresh vegetable production.

Limitations of this study are related with the use of biophysical simulation modeling to overcome yield data limitations. Specifically, DSSAT v 4.0 includes only

one variety for tomatoes and sweet corn that are not commonly used in Kentucky.

Finally, future work may investigate how the results change if i) the model is utilized in areas where marketing contracts are a more common practice, or, ii) with the inclusion of a farmers' market option if the required price data are available.

Figure 4.1: Simulated Tomato Yields[24]
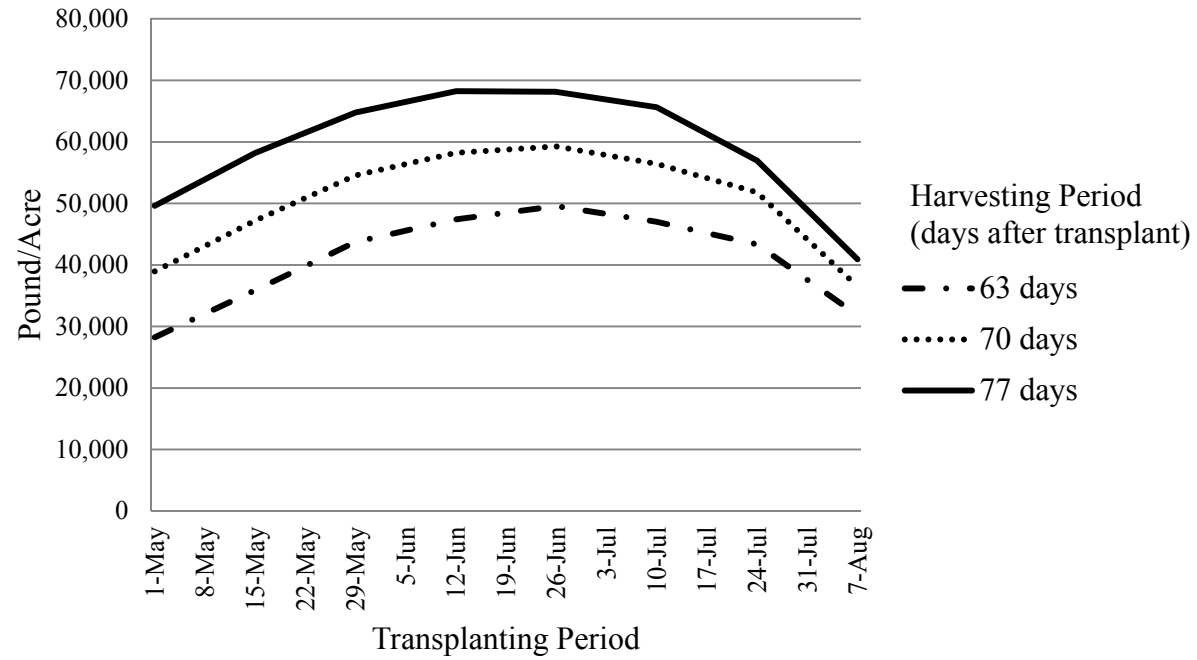
Source: Biophysical simulation results

---

[24] The graph depicts average tomato yields across years and soil types

Figure 4.2: Sweet Corn Yields[25]
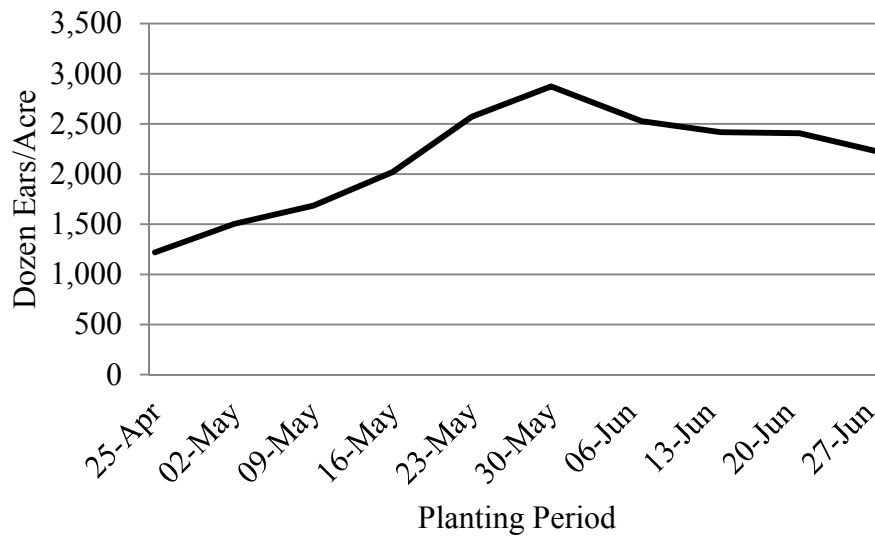
Source: Biophysical Simulation Results

---

[25] The graph depicts average sweet corn yields across years and soil types. Harvesting period is 84 days after planting.

Table 4.1: Production Costs per Acre

Tomato Expenses		Sweet Corn Expenses	
Type of Expense	Cost ($)	Type of Expense	Cost($)
Fertilizer	319.67	Fertilizer	194.16
Herbicide	2.33	Herbicide	21.16
Insecticide	97.47	Insecticide	208.10
Seed & planting supplies	1575.08	Seed & planting supplies	126.00
Labor	3688.26	Labor	116.58
Machinery expenses	139.69	Machinery expenses	66.76
Other expenses (i.e. boxes)	1600.00	Other expenses (i.e. crates)	580.00
Interest on capital	76.00	Interest on capital	10.58
Irrigation supplies	627.00	Irrigation supplies	410.00

Table 4.2: Contract Attributes and their Levels

Variable	Description	Levels		
		1	2	3
Early Price	Price offered for late June- Early July ($/lb)	0.62	0.68	0.74
Peak Price	Price offered for July-August ($/lb)	0.53	0.55	0.58
Late Price	Price offered for September – October ($/lb)	0.70	0.77	0.84
Early Volume	Volume requirements for Late June- Early July (lbs./week)	323	353	382
Peak Volume	Volume requirements for July- August (lbs./week)	753	809	882
Late Volume	Volume requirements for September- October (lbs./week)	632	691	735
Penalties	Price reduction if the contract agreements are not satisfied (% of price)	5%	10%	15%
Certification Cost	3rd party audit cost ($)	0	500	1000

Table 4.3: Soil Characteristics

Soil	Color	Drainage	Runoff Potential	Slope (%)	Runoff Curve #	Albedo	Drainage rate
Deep Silty Loam (65%)	Brown	Moderately Well	Lowest	3	64	0.12	0.4
Shallow Silty Loam (35%)	Brown	Somewhat Poor	Moderately Low	9	80	0.12	0.2

Source: Shockley, 2010

Table 4.4: Summary of Production Practices Used in the Biophysical Simulation Model

1) Tomato Production Practices	
Transplanting date	May 1, May 15, May 29, June 12, June 26, July 10, July 24, August 7
Harvesting period	63, 70, 77 days after transplant
Cultivar	BHN 66
Actual N/week (lbs/acre)	10
Irrigation	Drip irrigation, 1 inch water/week
Plant population (plants/acre)	5,000
Transplant age	42 days
Planting depth	2.5 inches
Assumptions	Dry Matter = 6%, Cull ratio = 20%

2) Sweet Corn Production Practices	
Planting date	April 25, May 2, May 9, May 16, May 23, May 30, June 7, June 14, June 28
Harvesting period	84 days after planting
Cultivar	Sweet corn cultivar of DSSAT v. 4
Actual N/week	2 applications of Ammonium Nitrate. One pre-plant (90 lb. actual N/acre) and a second 4 weeks after planting (50 lb. actual N/acre)
Irrigation	Drip irrigation, 1 inch water/week
Plant population (plants/acre)	20,000
Planting depth	2 inches
Assumptions	Dry matter =24%, Cull ratio= 3%, Ear weight = 0.661 pounds

Table 4.5: Summary Statistics[26]

Tomato Yields by Size (simulated)			
	Medium	Large	Extra Large
Average (pounds/acre)	6,580	26,321	10,967
Standard Deviation	1,976.92	7,907.67	3,294.86
Coefficient of Variation	30.00	30.00	30.00
Maximum Yield	10,425	41,700	17,375
Minimum Yield	0	0	0
Tomato Prices			
	Medium	Large	Extra Large
Average ($/25 pound boxes)	$15.04	$15.56	$16.31
Standard Deviation	3.12	3.48	3.84
Coefficient of Variation	20.00	22.00	23.00
Maximum Price ($/25 pound box)	29.55	30.58	30.70
Minimum Price ($/25 pound box)	8.99	9.77	9.68
Sweet Corn Yield (simulated, one size)			
Average (ears/acre)	12,687		
Standard Deviation	6,140		
Coefficient of Variation	47.00		
Maximum Yield	28,579		
Minimum Yield	903		
Sweet Corn Price			
Average ($/crate)	$13.04		
Standard Deviation	3.94		
Coefficient of Variation	30.00		
Maximum Price($/crate)	33.78		
Minimum Price($/crate)	6.56		

Source: DSSAT model yield results, Atlanta Agricultural Market Station prices

---

[26] The maximum and minimum yields reported on the table refer to different production practices, thus one is not expected to add the maximum yield of medium, large and extra-large to obtain maximum yield per acre

Table 4.6: Net Returns Above Variable Costs

Risk Levels[a]	Optimal Market Outlet	Mean Net returns	% of Max. net returns	Standard Deviation	Coefficient of Variation (%)
Risk neutral	Wholesale	85,382	100 %	20939	24.52
1 (z= 55%)	Wholesale	85,288	99.8 %	20747	24.33
2 (z= 60%)	Wholesale	83,779	98.0 %	18452	22.02
3 (z= 65%)	Wholesale	82,301	96.2 %	16914	20.55
4 (z= 70%)	Wholesale	80,066	93.3 %	15363	19.19
5 (z= 75%)	Wholesale	78,001	90.5 %	14120	18.10
6 (z= 80%)	Wholesale	76,581	88.5 %	13399	17.50
7 (z= 85%)	Wholesale	75,200	86.4 %	12816	17.04
8 (z= 90%)	Wholesale	73,231	83.4 %	12098	16.52
9 (z= 95%)	Wholesale	71,591	80.7 %	11581	16.18

[a] Following McCarl and Bessler (1989), under the assumption of normal distribution, the risk levels are given by: $r(X)= 2z_a/\sigma_y$

Table 4.7: Summary of Optimal Production Practices by Risk Attitude

	Tomatoes[27]			Sweet Corn		
Risk Levels	Transplanting Date	Acres (% of total)		Planting Day	Acres (% of total)	
		DSL	SSL		DSL	SSL
Risk Neutral	July 10	27.0%	14.7%	June 21	32.5%	17.5%
	July 24	5.2%	2.8%			
3 (z=65%)	June 12	5.4%	3.0%	May 23	32.5%	17.5%
	July 10	27.0%	14.6%			
5 (z= 75%)	June 12	16.6%	9.0%	May 23	32.5%	17.5%
	July 10	16.0%	8.6%			
7 (z=85%)	June 12	23.0%	12.4%	May 23	32.5%	17.5%
	July 10	8.4%	4.4%			
	July 24	1.2%	0.6%			

---

[27] Optimal harvesting period for tomatoes, for all the risk aversion levels and for both models, is 77 days after transplanting.

Table 4.8: Production Practices Under Contract (Risk Neutral Only)

Tomatoes				Sweet Corn		
Transplanting Date	Harvesting Period	Acres (% of total)		Planting Day	Acres (% of total)	
		DSL	SSL		DSL	SSL
May 1	70	0.32	0.18	June 21	32.5%	17.5%
May 15	70	0.52	0.28			
May 29	70	0.48	0.26			
June 12	70	0.44	0.24			
June 26	70	0.42	0.22			
July 10	70	0.38	0.20			
July 24	70	0.40	0.22			
August 7	70	0.68	0.36			
May 1	77	0.24	0.12			
May 15	77	0.42	0.22			
May 29	77	0.38	0.20			
June 12	77	0.38	0.20			
June 26	77	0.36	0.20			
July 10	77	26.74	14.4			
July 24	77	0.36	0.18			
August 7	77					

Chapter 5: Conclusions and Future Work

The present dissertation combined mathematical programming and discrete choice experiment techniques in a three essays format to investigate: 1) fresh vegetable growers' choice of optimal production practices and market outlet under different risk aversion levels, ii) the impact of season price versus annual price trend consideration on the optimal choice and iii) growers' preferences for marketing contracts.

Four main data sets are used to achieve the research objectives. First, biophysical simulation modeling is employed to overcome yield data limitations. This approach facilitated the development of an extensive data set, for tomatoes and sweet corn, that includes yield information for different production practices, soil and weather conditions. Second, primary data are used to evaluate growers' preferences for marketing contracts. Third, the required price data for the analysis are obtained from the USDA agricultural market stations (Atlanta). Lastly, production practice data (for example tomato transplanting periods, sweet corn planting periods, and fertilizer requirements) are obtained from University of Kentucky Extension Service production guideline bulletins.

The contribution of this dissertation to the literature is threefold. Specifically, it is the first research endeavor that: i) examines the interaction among production practices, market timing and risk aversion for vegetable production, ii) investigates growers' preferences for marketing contracts as well as the effect of risk perception on the contract choices and iii) employs biophysical simulation for an economic study on vegetables.

The second chapter of the dissertation investigates the role of risk aversion and price distribution knowledge on the choice of optimal production practices for a hypothetical wholesale vegetable grower in Fayette County, Kentucky. Two scenarios are examined: 1) the grower considers seasonal price trends and 2) the grower considers only

annual price trends. Quadratic programming formulation, embodied in a mean-variance framework, is used to model the economic environment of the hypothetical farm. This approach enabled consideration of competition among resources for the two crops (tomatoes and sweet corn) and permitted the examination of ten different risk aversion levels.

The findings indicate that a risk neutral grower, aiming to maximize net returns, should primarily focus on late production both for sweet corn and tomatoes (June 21 and July 10 respectively). As the risk aversion level increases a couple of alterations in production practices are highlighted to reduce growers' risk exposure. First, growers' should shift focus to earlier planting/transplanting periods, and thus earlier marketing periods. Second, for high risk averse growers, the number of optimal transplanting periods is increased (from two to three). Moreover, in line with the initial expectations, the findings indicate that if the grower knows considers seasonal price variation then he/she can substantially improve the expected net returns and better manage risk.

Besides modifying production practices, growers can mitigate risk with participation in marketing outlets that offer more stable prices throughout the season compared to a wholesale only option. An example of such an outlet is the use of marketing contract agreements. Despite the very rich literature regarding factors affecting participation in contracts (i.e., age, education, etc.) the research regarding growers' preferences for marketing or productions contracts is rather limited.

The third chapter of the dissertation is an effort to fill this gap. Specifically, with the use of a discrete choice experiment, the manuscript identifies fresh vegetable growers' preferences for eight marketing contract attributes and the role of risk

perception as well as the role of risk preferences in the choice of contracts. The attributes examined are early period price, late period price, peak period price, early period volume requirements, peak period volume requirements, late period volume requirements, penalty and certification cost.

The main data set used in the manuscript is obtained from a mail survey administrated to 315 wholesale tomato growers in Kentucky, Illinois, Ohio and Indiana. Conditional logit and mixed logit models are used to analyze preferences. Both models indicate that growers prefer contracts with higher early price offered coupled with lower penalties and certification cost. The mixed logit formulation revealed that, on average, growers do not suffer from utility loss if they do not have a contract choice offered. However, the results also indicate heterogeneity in preferences among growers. Lastly, the findings indicate that risk aversion and risk preferences have a minimal impact on the choice of contract agreements.

Chapter four combines the previous two chapters. Specifically, the model formulation of chapter two is extended, with the use of integer programing, in order to enable the inclusion of a combination of wholesale marketing and marketing contracts as an alternative to wholesale only. Three marketing contracts and ten risk aversion levels are examined. The findings indicate that, irrespectively of risk aversion, wholesale marketing is preferred over the combination of wholesale marketing and marketing contracts. Although risk aversion levels do not influence the choice of marketing outlet, the findings indicate that they affect the choice of optimal production practices. This finding is in line with the results of the second chapter. Furthermore, sensitivity analyses findings illustrated that a combination of wholesale marketing and marketing contracts is

preferred when the prices for all periods (early, peak, and late) are increased. This finding differs from the results in chapter 3 indicating that growers prefer contracts with higher early price.

In summary, the findings of the dissertation provide valuable insights both to growers and to buyers. More precisely, the results identified critical aspects that can help mitigate the risk associated with fresh vegetable production and achieve the optimal economic outcome. For instance, consideration of seasonal price information and appropriate selection of production timing, based on the risk levels of the grower, are two of these factors. Furthermore, the information regarding growers' preferences for marketing contracts can be utilized by buyers in order to create contracts that can attract greater participation of growers.

As far as future research endeavors are concerned, a number of possibilities exist. First, if the required price data sets are available, inclusion of additional marketing options (i.e. farmers' market, CSA marketing, etc.) can be incorporated in the model to examine how growers' optimal marketing decisions are modified. Furthermore, the findings of the study can be compared with either choice experiments or mathematical programming formulations examining preferences for locations where marketing contracts are more commonly used and fresh vegetable farming is more popular. Lastly, an intriguing topic may be the inclusion of more than two crops in the examined model formulations.

Last but not least, without doubt there will be errors, omissions and over-simplifications for which I take absolute responsibility, while hoping that the rest of the

material will be enough to stimulate new trains of thought into the economics of fresh

vegetable production and marketing.

Appendices

Appendix 1: Survey Questionnaire

<div align="center">

University Of Kentucky

Tomato Marketing Study

</div>

Thank you for agreeing to participate in this research. In this survey, we are interested in your opinions and choices of possible marketing contracts for fresh tomatoes. You will need about 15-20 minutes to complete the survey. We appreciate your time.

We would like to start the survey by learning about the characteristics of your farm. The person who answers the survey should be the one that is primarily involved in the management of the farm.

A1. Where is your farm business located?   State: _____

County: _____

Zip Code: _____

A2. What is your total farm size?
- ☐ 0.1 to 0.9 acres
- ☐ 1 to 4.9 acres
- ☐ 5 to 14.9 acres
- ☐ 15 to 24.9 acres
- ☐ 25 to 49.9 acres
- ☐ 50 to 99.9 acres
- ☐ More than 100 acres

A3. How many acres are dedicated to field grown production?
- ☐ 0.1 to 0.9 acres
- ☐ 1 to 4.9 acres
- ☐ 5 to 14.9 acres
- ☐ 15 to 24.9 acres
- ☐ 25 to 49.9 acres
- ☐ 50 to 99.9 acres
- ☐ More than 100 acres

A4. Are you involved with any greenhouse or protected tomato production?

☐ No   ☐ Yes

A5. Are you in a position to expand your operation to grow more tomatoes if the right opportunity came along?

☐ No   ☐ Yes

A6. Over the last three years, your tomato production has:

☐ Decreased   ☐ Stayed the   ☐ Increased
                              same

A7. Do you have experience growing grain crops?

☐ No   ☐ Yes

A8. What marketing channel(s) are you using for your <u>vegetable crops</u> (check all that apply)?

☐ Direct marketing (i.e. farmer's market, on farm sales, CSA's, u-pick etc.)
☐ Local Wholesalers (i.e. local grocers, DSDs or restaurants)
☐ Regional Wholesalers (i.e. chain store distribution centers, terminal markets, brokers etc.)
☐ Marketing Cooperatives
☐ Produce Auctions
☐ Other _____

A9. For the field grown tomatoes on your farm, please provide the following information

Acres with field grown tomatoes: _____ acres

Average yield (lbs. /acre or # of 25 pound boxes) the last 3 years: _____ (units)

Typical transplanting periods (dd/mm): _____

_____

_____

_____

Now, we would like to know a bit more about your perception and your experience with **marketing contracts**.

Marketing contracts, in the context of this survey, refer to a written agreement between a producer and a buyer that sets a price and possible price adjustments (i.e. penalties for bad quality) as well as an outlet for the vegetables produced before harvest or before the commodity is ready to be marketed. The grower assumes all risk related to amount produced, but shares risk related to market price with the buyer.

B1. Have you ever participated in a marketing contract agreement for any kind of agricultural product?

☐ No ☐ Yes

B2. Would you be interested in participating in produce marketing contract agreements?

☐ No ☐ Maybe, depending on the terms ☐ Yes

B3. Please, rank the top four reasons that would <u>encourage</u> you to use a marketing contract (1= the least important and 4 = the most important reason)

_____ Reduce price risk   _____ Opportunity to sell higher volume
_____ Secure income   _____ Prior experience with contracts
_____ No need to worry about supply   _____ Lower distribution cost
       channels
_____ Access new market opportunities   _____ Maintenance of future relationship
                                                  with buyers
_____ Bonuses for better quality   _____ Other (Specify):
                                           _____

B4. Please, rank the top four reasons that would <u>discourage</u> you from using marketing contracts for your vegetable production (1= the least important and 4= the most important reason)

_____ Difficult to satisfy quality   _____ Unhappy with the quality terms
       requirements
_____ Unhappy with the price terms   _____ Delivery time
_____ Severe penalties   _____ Method of payment
_____ Inflexibility to pursue other markets _____ Not enough information about
                                                  contracts
_____ Cost of enforcement   _____ Difficult to satisfy volume
                                                  requirements
_____ "Bad" previous experience   _____ Not enough land
_____ Other: (Specify)_____

C1. With the following questions we would like to learn a bit more about your risk comfort levels.

Please consider the choice you would make in the following hypothetical situation:

You will be given 150 tomato plants (in 5 bundles of 30 plants each) for free, to use in the coming season. There are two types of plants, A and B, and you can choose any combination of the two that totals 5 bundles.

The A and B plants have different levels of resistance to tomato diseases. The A plants have potentially higher harvests but are more vulnerable to disease. If disease does not occur, the A plants will produce a harvest worth $30 per bundle. However if disease occurs (50% of the time), the A plants' harvest is worthless ($0 per bundle). The B plants are disease-resistant and always produce a harvest worth $10 per bundle.

The following table illustrates the different combinations of type A and B plants that you could receive, and the value of their combined harvests based on the weather. Please **check one box** to indicate which combination of plants you would choose.

I choose (check one of the six combinations A-F below)	Bundles of 30 type A plants	Bundles of 30 type B plants	If disease does not occur (50%)	If disease occurs (50%)
o A	0	5	$50	$50
o B	1	4	$70	$40
o C	2	3	$90	$30
o D	3	2	$110	$20
o E	4	1	$130	$10
o F	5	0	$150	$0

C2. With respect to the conduct of business, I avoid taking risk (select one):

I strongly disagree   I Strongly Agree

   o -4   o -3   o -2 o -1 o 0 o 1 o 2 o 3   o 4

C3. With respect to the conduct of business, I prefer certainty to uncertainty (select one):
I strongly disagree   I Strongly Agree

   o -4   o -3   o -2 o -1 o 0 o 1 o 2 o 3   o 4

C4. I like "playing it safe" (select one):
I strongly disagree   I Strongly Agree

    o -4   o -3   o -2   o -1   o 0   o 1   o 2   o 3   o 4

Suppose you have the opportunity to enter a marketing contract agreement for fresh tomatoes. In the following choice situations you will be presented with a series of options for marketing contracts. Each choice situation contains three options described by their characteristics. Please select the option that is better for you. Please, bear in mind that:

- Please choose ONLY ONE OPTION in each situation
- Marketing contracts A and B given in each situation are identical in all other features not specifically listed
- Assume that the options in EACH situation are the ONLY ones available
- Do NOT compare options in different situations

In the following six choice situations you will be considering marketing contracts for **Large Tomatoes US #1. Average Prices** from Agricultural Market Service (Atlanta Terminal Market) for the period 1998-2010 were: **$ 0.54/lb** for June, **$0.53** for July-August and **$0.64** for September- October.

Delivery Period: 1) early refers to late June early July (approximately 3 weeks up until 4th of July), peak period refers to July and August (approximately 8 week period) and, 3) late refers to September and October (approximately 8 week period).

Penalties refer to price reduction in case that the producer fails to deliver the agreed volume and quality. The terminate contract option means that the contract is no longer valid and the producer has to sell the production in the spot market

Options A and B correspond to two different possibilities of marketing contract arrangements. Under the no contract option the producer will receive market price.

Certification Cost refers to a dollar amount that the producer has to pay to a third agency that will verify the quality of production (3rd party audit).

Once again, suppose you are making these choices in real life. Please, try to select the options that would be closest to what you would do in real life.

SITUATION 1[28]

Delivery Period	Contract A				Contract B				No Contract
	Price / Pound	Volume (pounds/ acre/ week)	Penalty	Certification Cost	Price / Pound	Volume (pounds/ acre/ week)	Penalty	Certification Cost	
Early	$ 0.62	2,200/acre/week	Terminate[29]	$0	$ 0.74	2,600/acre/week	5%	$1000	I will not Choose either A or B
Peak	$ 0.55	5,500/acre/week	Terminate	$0	$0.53	6,000/acre/week	5%	$1000	
Late	$ 0.70	5,100/acre/week	Terminate	$0	$0.77	4,300/acre/week	5%	$1000	

Please choose only option: ☐ Contract A *OR* ↔ ☐ Contract B *OR* ↔ ☐ No Contract <u>one</u>

---

[28] Penalties refer to a price reduction if the producer fails to deliver the required quantity/ quality of tomatoes

[29] Terminate contract means that the contract will no longer be valid if the grower fails to deliver the required quality/quantity of tomatoes. Thus, production will be sold in the spot market

SITUATION 2

Delivery Period	Contract A				Contract B				No Contract
	Price / Pound	Volume (pounds/ acre/ week)	Penalty	Certification Cost	Price / Pound	Volume (pounds/ acre/ week)	Penalty	Certification Cost	I will not Choose either A or B
Early	$ 0.62	2,400/acre/week	Terminate	$1000	$0.74	2,200/acre/week	15%	$500	
Peak	$ 0.53	5,500/acre/week	Terminate	$1000	$0.55	5,000/acre/week	15%	$500	
Late	$ 0.77	5,100/acre/week	Terminate	$1000	$0.70	4,700/acre/week	15%	$500	

Please choose only <u>one</u> option: ☐ Contract A $\overset{OR}{\leftrightarrow}$ ☐ Contract B $\overset{OR}{\leftrightarrow}$ ☐ No Contract

SITUATION 3

Delivery Period	Contract A				Contract B				No Contract
	Price / Pound	Volume (pounds/ acre/ week)	Penalty	Certification Cost	Price / Pound	Volume (pounds/ acre/ week)	Penalty	Certification Cost	I will not Choose either A or B
Early	$ 0.74	2,200/acre/week	5%	$1000	$0.62	2,600/acre/week	15%	$500	
Peak	$ 0.53	6,000/acre/week	5%	$1000	$0.55	5,000/acre/week	15%	$500	
Late	$ 0.70	5,100/acre/week	5%	$1000	$0.77	4,300/acre/week	15%	$500	

Please choose only <u>one</u> option: ☐ Contract A $\overset{OR}{\leftrightarrow}$ ☐ Contract B $\overset{OR}{\leftrightarrow}$ ☐ No Contract

SITUATION 4

Delivery Period	Contract A					Contract B				No Contract
	Price / Pound	Volume (pounds/ acre/ week)	Penalty	Certification Cost	Price / Pound	Volume (pounds/ acre/ week)	Penalty	Certification Cost		I will not Choose either A or B
Early	$ 0.68	2,400/acre/week	10%	$500	$0.62	2,600/acre/week	15%	$1000		
Peak	$ 0.55	6,000/acre/week	10%	$500	$0.53	5,500/acre/week	15%	$1000		
Late	$ 0.77	5,100/acre/week	10%	$500	$0.84	4,300/acre/week	15%	$1000		

Please choose only <u>one</u> option: ☐ Contract A *OR* ↔ ☐ Contract B *OR* ↔ ☐ No Contract

SITUATION 5

Delivery Period	Contract A					Contract B				No Contract
	Price / Pound	Volume (pounds/ acre/ week)	Penalty	Certification Cost	Price / Pound	Volume (pounds/ acre/ week)	Penalty	Certification Cost		I will not Choose either A or B
Early	$ 0.68	2,600/acre/week	Terminate	$1000	$0.62	2,200/acre/week	5%	$ 0		
Peak	$ 0.53	5,000/acre/week	Terminate	$1000	$0.58	6,000/acre/week	5%	$ 0		
Late	$ 0.70	4,700/acre/week	Terminate	$1000	$0.84	4,300/acre/week	5%	$ 0		

Please choose only one option: ☐ Contract A *OR* ↔ ☐ Contract B *OR* ↔ ☐ No Contract

SITUATION 6

| Delivery Period | Contract A | | | | Contract B | | | | No Contract |
	Price / Pound	Volume (pounds/ acre/ week)	Penalty	Certification Cost	Price / Pound	Volume (pounds/ acre/ week)	Penalty	Certification Cost	
Early	$ 0.68	2,600/acre/week	Terminate	$1000	$0.74	2,400/acre/week	10%	$1000	I will not Choose either A or B
Peak	$ 0.58	6,000/acre/week	Terminate	$1000	$0.58	5,500/acre/week	10%	$1000	
Late	$ 0.84	4,300/acre/week	Terminate	$1000	$0.70	4,700/acre/week	10%	$1000	

Please choose only   □ Contract A   *OR* ↔   □ Contract B   *OR* ↔   □ No Contract   <u>one</u> option:

Finally, we would like to know a bit more about you

D1. Gender:
☐   Male
☐   Female

D2. Age Group:
☐   15-   ☐   26-   ☐   36-   ☐   46-   ☐   56-   ☐   66+
       25   35   45   55   65

D3. What is your annual <u>household</u> income?
☐   Under $ 15,000   ☐ $ 50,000 – 74,999
☐ $ 15,000 - $ 24,999   ☐ $ 75,000 – 99,999
☐ $ 25,000 - $34,999   ☐ $ 100,000 - $125,000
☐ $ 35,000 - $49,999   ☐   Above $ 125,000

D4. What percentage of your household income is your farm income?
☐   Under 10%   ☐   50%-90%
☐   10%-20%   ☐   More than 90%
☐   20%-50%

D5. What is your education level?
☐   Some classes of primary school   ☐   Graduated high school
☐   Completed primary school   ☐   Completed technical school
☐   Some classes of secondary school   ☐   Some college no degree
☐   Completed secondary school   ☐   Completed college
☐   Some classes of high school   ☐   Completed graduate school

D6. How many members are in the household, including you? _____

D7. Are there any children under 18 in your household?
Yes   ☐   No

D8. What is your current marital status?
☐ Married   ☐ Widow/widow   ☐ Divorce   ☐ Separated   ☐ Never Married
                      er   d

D10. Do you have off farm employment?
☐   No   ☐ Yes, but less than my farm   ☐   Yes, more than my farm income
                      income

Thank You!!

Please use the following space to express any comments/ questions you may have about the survey.

Appendix 2: Mathematical Specification of the Economic Model for Chapter 4

The grower's objective is to maximize net returns above selected variable costs less the

risk aversion coefficient multiplied by the variance of net returns and is given by:

$$(A.1) \ \bar{Y} - \Phi \sigma_y^2$$

Subject to: land availability constraint, given by:

$$(A.2) \sum_C \sum_D \sum_H X_{C,D,H.S} \leq ACRES_S \ \forall \ S$$

Weekly labor resource limitation, given by:

$$(A.3) \sum_C \sum_D \sum_H \sum_S LAB_{C,D,H,WK} X_{C,D,H,S} \leq FLDDAY_{wk} \ \forall \ WK$$

Marketing balance:

$$(A.4) \sum_D \sum_H \sum_S YLD_{C,D,H,TS,S} X_{C,D,H,S} - SALES_{C,YR,WK,TS}$$

$$- \sum_{CONTR} CONTRSALES_{CONTR,WK,YR} - PENSALES_{CONTR,WK,YR}$$

$$= 0 \ \forall \ C,TS,WK,YR$$

Input purchases by input:

$$(A.5) \sum_C \sum_D \sum_H \sum_S REQ_{I,C} X_{C,D,H,S} - PURCH_{I,C} = 0 \ \forall \ I$$

Soil depth ratio constraint:

$$(A.6) CSOILRATIO_{"shallow"} X_{C,D,H,"deep"} - CSOILRATIO_{"deep"} X_{C,D,H,"shallow"}$$

$$= 0 \ \forall \ C,D,H$$

Crop rotation constraint:

$$(A.7) \sum_C \sum_D \sum_H \sum_S ROTATE_C X_{C,D,H,S} \leq 0.5 \ ACRES_S \ \forall \ S$$

Contract choice given by:

$$(A.8) \sum_{CONTR} PICK_{CONTR} \leq 1$$

Either or constraints given by:

$$(A.9)\ SHORTAGE_{CONTR,WK,YR} - M * FAIL_{CONTR,WK,YR} \leq 0, \forall\ CONTR, WK, YR$$

$$(A.10)\ CONTRSALES_{CONTR,WK,YR} + M * FAIL_{CONTR,WK,YR} \leq M, \forall\ CONTR, WK, YR$$

Boolean logical constraints given by:

$$(A.11) \sum_{CONTR} \sum_{WK} CONTRSALES_{CONTR,WK,YR} - M * SATISFY_{YR} \leq 0, \forall\ YR$$

$$(A.12) \sum_{CONTR} \sum_{WK} PENSALES_{CONTR,WK,YR} - M * SATISFY_{YR} \leq 0, \forall\ YR$$

Terminate contract disclaimer given by:

$$(A.13) \sum_{CONTR} \sum_{WK} FAIL_{CONTR,WK,YR} + M * SATISFY_{YR} \leq M + 2, \forall\ YR$$

Balance requirement for contract volume

$$(A.14)\ CONTRSALES_{CONTR,WK,YR} + PENSALES_{CONTR,WK,YR} +$$

$$+\ SHORTAGE_{CONTR,WK,YR} - CONTRVOL_{CONTR,WK} * PICK_{CONTR}$$

$$= 0\ \forall\ CONTR, WK, YR$$

Net returns by year are given by:

$$(A.15) \sum_I IP_I PURCH_{I,C} - \sum_{WK} \sum_C \sum_{TS} P_{C,WK,TS} SALES_{C,YR,WK,TS} -$$

$$\sum_{CONTR} \sum_{WK} CONTRREVENUE_{CONTR,WK,YR} -$$

$$- \sum_{CONTR} \sum_{WK} PENREVENUE_{CONTR,WK,YR} + Y_{YR} = 0 \ \forall \ YR$$

Contract Revenue given by:

$$(A.16) CONTRREVENUE_{CONTR,WK,YR}$$

$$= CONTRSALES_{CONTR,WK,YR} * CONTRPRICE_{CONTR,WK}, \forall \ CONTR, WK, YR$$

Penalty Revenue given by:

$$(A.17) PENREVENUE_{CONTR,WK,YR}$$

$$= PENSALES_{CONTR,WK,YR} * PENPRICE_{CONTR,WK}, \forall CONTR, WK, YR$$

Expected profit balance is given by:

$$(A.18) \sum_{YR} \frac{1}{N} Y_{YR} - \bar{Y} = 0$$

Where, activities include:

$\bar{Y}$: Expected net returns above selected variable cost

$X_{C,D,H,S}$: Production of crop C, under transplanting/planting period D, harvesting period H and soil depth S

$PURCH_{I,C}$: Purchases of input I

Y_{YR}: Net returns above selected variable cost by year

$SALES_{C,YR,WK,TS}$: Tomato sales by size (medium, large, extra-large in pounds and sweet corn sales in dozens of ears by week and year respectively

$CONTRSALES_{CONTR,WK,YR}$: Large tomato sales requirement under contract by week and year when the volume requirements are met

$PENSALES_{CONTR,WK,YR}$: Large tomato sales under contract if volume requirements are not met, by week and year

$PICK_{CONTR}$, $FAIL_{CONTR,WK,PY}$, $SATISFY_{CONTR,WK,PY}$: Binary integer decision variables

Coefficients include:

Φ: Risk aversion Coefficient

$P_{C,WK,TS}$: Weekly price for different tomato sizes in $/pound and for sweet corn in $ per ear

$YLD_{C,D,H,TS,S}$: Expected yield of tomatoes by size in pounds and of sweet corn by ears

$FLDDAY_{WK}$: Available field days per week

$ROTATE_C$: Rotation matrix by crop C

$P_{C,WK,TS}$: Weekly price in $/pounds per tomato size and in $/ear for sweet corn

$CSOILRATIO_{"S"}$: Ratio of total acres allocated to depth S

$CONTRPRICE_{CONTR,WK}$: Price paid to the grower if the contract requirements are met by contract and week

$PENALTYPRICE_{CONTR.WK}$: Price paid to the grower if a contract is selected and the volume requirements are not met

M: A large number (Big M)

Indices include:

C: Crop

S: Soil depth

TS: Tomato Size (medium, large, extra-large). There is only one size for sweet corn.

H: Harvesting period (1 for sweet corn)

YR: Year

D: Transplant date for tomatoes, Planting date for sweet corn

WK: Week

I: Input

N: State of Nature (13*38)

CONTR: Contract

References

Ackerberg, A. and M. Botticini. "Endogenous Matching and the Empirical Determinants of Contract Form" *Political Economy* 110(2002): 564-591.

Aggarwal, R.M. "Role of Risk Sharing and Transaction Costs in Contract Choice: Theory and Evidence from Groundwater Contracts." *Journal of Economic Behavior and Organization* 63(2007): 475-496.

Allen, D.W. and D. Lueck. "Risk Preferences and the Economics of Contracts" *American Economic Review* 85(1995): 447-451.

Allen, D.W. and D. Lueck. "The Role of Rick in Contract Choice" *Law, Economics, & Organization* 15, 3(1999): 704-736.

Archer, D.W. and R.W. Gesch. "Value of Temperature-Activated Polymer-Coated Seed in the Northern Corn Belt" *Journal of Agricultural and Applied Economics* 35, 3(2003):625-637.

Babcock, C.A., J.A. Chalfant and R.N. Collender. "Simultaneous Input Demands and Land Allocation in Agricultural Production under Uncertainty" *Western Journal of Agricultural Economics* 12, 2(1987):207-215.

Bailey, D.V., and J.W. Richardson. "Analysis of Selected Marketing Strategies: A Whole-Farm Simulation Approach." *American Journal of Agricultural Economics* 67(1985):813-820.

Barham, E., H. Bise, J.R.C. Robinson, J.W.Richardson, and M.E. Rister. ''Mitigating Cotton Revenue Risk through Irrigation, Insurance, and Hedging.'' Journal of Agricultural and Applied Economics 43, 4(2011):529–40.

Barry, P.J., and D.R. Willmann. "A Risk-Programming Analysis of Forward Contracting With Credit Constraints " *American Journal of Agricultural Economics* 58(1976):62-70.

Bigelow, J.P. "Consistency of Mean-Variance Analysis and Expected Utility Analysis A Complete Characterization." *Economics Letters* 43(1993):187-192.

Binswanger, H.P. "Attitudes Toward Risk: Theoretical Implications of an Experiment in Rural India" *Economic Journal* 91(1981): 867-890.

Binswanger, H.P. "Attituted Toward Risk: Experimental Measurement in Rural India" *American Journal of Agricultural Economics* 62 (1980): 395-407.

Buccola, S.T., and B.C. French. "An E-V Analysis of Pricing Alternatives for Long- Term Marketing Contracts." *Southern Journal of Agricultural Economics* 9(1977):17-23.

Buccola, S.T., and B.C. French. "Long- Term Marketing Contracts: Intra-Firm Optima and Inter-Firm Agreement." *American Journal of Agricultural Economics* 61(1979):648-656.

Cable, S. "Locally grown produce a strength for Kentucky, Tennessee." *The Packer*, 2011. Internet site: http://www.thepacker.com/fruit-vegetable-news/shipping-profiles/kentucky-tennessee-produce/Locally-grown-produce-a-strength-for-Kentucky-Tennessee-124799869.html

Calvin, L. R. Cook, M. Denbaly, C. Dimitri, L. Glacer, C. Handy, M. Jekanowski, P. Kaufman, B. Krissoff, G. Thomson and S. Thornsburry. 2001. *U.S. Fresh Fruit and Vegetable Marketing.* Washington D.C.: U.S. Department of Agriculture, ERS, Agr. Econ.Rep. 795, January.

Centers for Disease Control and Prevention. "State Specific Trends in Fruit and Vegetable Consumption Among Adults – United States 2000-2009" *Morbidity and Mortality Weekly Report* September 10, 2010 / 59(35):1125-1130

Charness, G. and U. Gneezy. "Portfolio Choice and Risk Attitudes: An Experiment". *Economic Inquiry* 48, 1(2010): 133-146.

Chavas, J.P. and M.T. Holt. "Acreage Decisions Under Risk: The Case of Corn and Soybeans" *American Journal of Agricultural Economics* 72, 3(1990):529-538.

Cheung, S.N.S."Transaction Costs, Risk Aversion and the Choice of Contractual Arrangements." *Journal of Law and Economics* 12(1969):23-42.

Ciardi, J.A., C.S. Vavrina and M.D. Orzolek. "Evaluation of Tomato Transplant Production Methods for Improving Establishment Rates". *Horrtscience* 33(1998): 229-232.

Coase, R.H."The Nature of the Firm." *Economica* 4(1937):386-405.

Cook, R. "Fundamental Forces Affecting U.S. Fresh Produce Growers and Marketers" *Choices: The Magazine of Food, Farm and Resource Issues* 26, 4(2011) 4th quarter.

Coolong, T., J. Pfeiffer, D. Slone and A.L. Poston. "Fresh Market Tomato Variety Performance in 2009". University of Kentucky, 2009. Internet site: http://www.hort.purdue.edu/fruitveg/rep_pres/2009-10/mvt_2009_pdf/12-13_tomato_coolong_09.pdf

Coolong, T., R. Bessin, T. Jones, J. Strang and K. Seebold. "2010-11 Vegetable Production Guide for Commercial Growers". University of Kentucky, Extension Service Bulletins (ID-36), 2010.

Crop Diversification & Biofuel Research & Education, University of Kentucky. Internet site: http://www.uky.edu/Ag/NewCrops/budgets.html

Danok, A.B., B.A. McCarl, and T.K. White."Machinery Selection Modeling: Incorporation of Weather Variability." *American Journal of Agricultural Economics* 62(1980):700-708.

Deng, X., B.J. Barnett, G. Hoogenboom, Y. Yu, and A.G. Garcia. "Alternative Crop Insurance Indexes" *Journal of Agricultural and Applied Economics* 40, 1 (2008):223-237.

Dillman, D.A. *Mail and Telephone Surveys: The Total Design Method.* New York: John Wiley & Sons, 1978.

Dillon, C.R. "Production Practice Alternatives for Income and Suitable Field Day Risk Management" *Journal of Agricultural and Applied Economics* 31, 2 (1999):247-261.

Dillon, C.R., J.W., Mjelde, and B.A. McCarl. "Biophysical Simulation Models: Recommendations for Users and Developers" *Computers and Electronics in Agriculture* 6, 3(1991):213-224.

Dimitri, C., A. Tegene and P.R. Kaufman. *U.S. Fresh Produce Markets. Marketing Channels, Trade Practices and Retail Pricing Behavior.* Washington D.C. U.S. Department of Agriculture, ERS, Agricultural Economic Report Number 825, September, 2003.

Ernst, M., and T. Woods. *Marketing Fresh Produce to Restaurants.* Internet site: http://www.uky.edu/Ag/CDBREC/marketing/restaurants.pdf, University of Kentucky, Cooperative Extension Service (2011).

Freund, R.J. "The Introduction of Risk into a Programming Model" *Econometrica* 24, 3(1956):253-263.

Fukunaga, K., and W.E. Huffman."The Role of Risk and Transcation Costs in Contract Design: Evidence from Farmland Lease Contracts in U.S. Agriculture." *American Journal of Agricultural Economics* 91, 1(2009):237-249.

Gneezy, U. and J. Potters. "An Experiment on Risk Taking and Evaluation Periods". *Quarterly Journal of Economics* vol. 112(1997): 631-645.

Goodwin, B.K., and T.C. Schroeder."Human Capital, Producer Education Programs, and the Adoption of Forward-Pricing Methods." *American Journal of Agricultural Economics* 76, 4(1994):936-947.

Green, P.E., A.M. Krieger and Y. Wind. "Thirty Years of Conjoint Analysis: Reflections and Prospects". *Interfaces* 31(2001): s56-s73.

Hatanaka, M., C. Bain and L. Busch. "Third- Party Certification in the Global Agrifood System". *Food Policy* 30(2005): 354-369.

Heuvelink, E. "Evaluation of a Dynamic Simulation Model for Tomato Crop Growth and Development". *Annals of Botany* 83(1999):413-422.

Hoogenboom, G., J.W. Jones, C.H. Porter, P.W. Wilkens, K.J. Boote, W.D. Batchelor, L.A. Hunt, and G.Y. Tsuji. Decision Support System for Agrotechnology Transfer Version 4.0. University of Hawaii, Honolulu, HI, 2003.

Hossain, M.M., K.M. Khalequzzaman, Md.A Hossain, M.R.A. Mollah and M.A. Sique. "Influence of Planting Time on Extension of Picking Period of Four Tomato Varieties" *Journal of Biological Sciences* 4(2004):616-619.

Hu, W., T. Woods and S. Bastin. "Consumer Acceptenace and Willingness to Pay for Blueberry Products with Non Conventional Attributes". *Journal of Agricultural and Applied Economics* 41(2009):47-60.

Hudson, D., and J. Lusk. "Risk and Transactions Cost ini Contracting: Results from a Choice Based Experiment." *Journal of Agricultural & Food Industrial Organization* 2(2004):Article 2.

Hueth, B. and E. Ligon. "Estimation of an Efficient Tomato Contract". *European Review of Agricultural Economics* 29(2002): 237-253.

Hueth, B. and E. Ligon. "Quality Measurement and Risk-Sharing in Contracts for California Fruits and Vegetables". Paper presented at AAEA annual meeting, Salt Lake City, Utah 2-5 August, 1998.

Hueth, B. and T. Melkonyan. "Identity Preservation, Multitasking and Agricultural Contract Design". *American Journal of Agricultural Economics* 86(2004): 842-847.

Hueth, B., and E. Ligon. "Producer Price Risk and Quality Measurement" *American Journal of Agricultural Economics* 81, 3(1999):512-524.

Hueth, B., E. Ligon and S. Wolf. "Incentive Instruments inf Fruit and Vegetable Contracts: Input Control, Monitoring, Measuring and Price Risk". *Review of Agricultural Economics* 21(1999): 374-389.

Heuvelink, E. "Evaluation of a dynamic simulation model for tomato crop growth and development" *Annals of Botany* 83, 4(1999):413-422.

Ibendahl, G.A. and G. Halich. "How to Estimate Custom Machinery Rates" *Journal of the ASFMRA* 2010 Collection 30(2010):8-10.

Jame, Y.W., and H.W. Cutforth. "Crop Growth Models for Decision Support Systems" *Canadian Journal of Plant Science* 76, 1(1996):9-19.

Jones, J.W., G. Hoogenboom, C.H. Porter, K.J. Boote, W.D. Batchelor, L.A. Hunt, P.W. Wilkens, U. Singh, A.J. Gijsman, and J.T. Ritchie. "The DSSAT Cropping System Model." *European Journal of Agronomy* 18 (2003):235-265.

Jones, T., and A. Ferguson Sears. "Synergistic Sweet Corn Evaluations in Eastern Kentucky". Department of Horticulture, 2005. Internet site:

http://www.hort.purdue.edu/fruitveg/rep_pres/2005-6/mvvt_2005_pdf/sc_ky-east_05.pdf

Katchova, A., and M. Miranda."Two Step Econometric Estimation of Farm Characteristics Affecting Marketing Contract Decisions." *American Journal of Agricultural Economics* 86, 1(2004):88-102.

Kaufmann, R.K., and S.E. Snell. "A Biophysical Model of Corn Yield: Integrating Climatic and Social Determinants" *American Journal of Agricultural Economics* 79, 1(1997): 178-190.

Lancaster, K. "A New Approach to Consumer Theory". *Journal of Political Economy* 74(1966): 132-157.

Laughlin, D.H. and S.R. Spurlock. *Mississippi State Budget Generator v6.0.* Department of Agricultural Economics, Mississippi State University. Mississippi State, Mississippi, 2007.

Liang, Y., J.C. Miller, A.Harri and K.H. Coble. "Crop Supply Response Under Risk: Impacts of Emerging Issues on Southeastern U.S. Agriculture" *Journal of Agricultural and Applied Economics* 43, 2(2011): 181-194.

Ligon, E. "Contractual Arrangements for Fresh Produce in California". *Agricultural and Resource Economics Update* 5(2001): 1-2.

Louviere, J.J., D.A. Hensher and J.D. Swait. *Stated Choice Methods: Analysis and Application.* Cambridge, UK: Cambridge University Press, 2000.

Louviere, J.J., T.N. Flynn and R.T. Carson. "Discrete Choice Experiments are Not Conjoint Analysis" *Journal of Choice Modeling* 3(2010): 57-72.

Lowe, T.J., and P.V. Preckel. "Decision Technologies for Agribusiness Problems: A Brief Review of Selected Literature and a Call for Research" *Manufacturing and Service Operations Management* 6, 3(2004):201-208.

Lusk, J.M. and K.H. Coble. "Risk Perceptions, Risk Preference and Acceptance of Risky Food" *American Journal of Agricultural Economics* 87(2005): 393-405.

MacDonald, J., J. Perry, M. Ahearn, D. Banker, W. Chambers, C. Dimitri, N. Key, K. Nelson and L. Southard. *Contracts, Markets and Prices: Organizing the Production and Use of Agricultural Commodities.* Washington D.C.: U.S. Department of Agriculture, ERS, Agr. Econ.Rep. 837, November, 2004.

Mahshie, A. "Industry Calls for Change to Third- Party Audits" The Packer, 2009 internet site: http://www.thepacker.com/fruit-vegetable-news/fresh-produce-handling-distributing/industry_calls_for_changes_to_third-party_audits_122077334.html

Mapp, H.P.Jr., M.L. Hardin, D.L. Walker and T. Persaud. "Analysis of Risk Management for Agricultural Producers" American *Journal of Agricultural Economics* 61, 5(1979):1071-77.

Markowitz, H. "Portfolio Selection" *The Journal of Finance* 7, 1(1952):77-91.

McCarl, B.A. and D. Bessler. "Estimating an Upper Bound on the Pratt Risk Aversion Coefficient When the Utility Function is Unknown" *Australian Journal of Agricultural Economics* 33, 1(1989):56-63.

McFadden, D. "Conditional Logit Analysis of Qualitative Choice Behavior." *Frontiers in econometrics* 8(1974): 105–142.

McLeay, F., and T. Zwart."Factors Affecting Choice of Cash Sales Versus Forward Marketing Contracts." *Agribusinness* 14, 4(1998):299-309.

Miller, S.E."Forward Contracting Versus Hedging Under Price and Yield Uncertainty." *Southern Journal of Agricultural Economics* 18(1986):139-146.

Musser, W.N., and B.V. Tew. "Use of Biophysical Simulation in Production Economics." *Southern Journal of Agricultural Economics* 16(1984):77-86.

Musser, W.N., G.F. Patrick, and D.T. Eckman."Risk and Grain Marketing Behavior of Large-Scale Farmers " *Review of Agricultural Economics* 18, 1(1996):65-77.

Nivens, H.D., T.L. Kastens and K.C. Dhuyvetter. "Payoffs of Farm Management: How Important is Crop Marketing?" *Journal of Agricultural and Applied Economics* 34, 1(2002):193-204.

Parcell, J.L., and M.R. Langemeier."Feeder-Pig Producers and Finishers: Who Should Contract? ." *Canadian Journal of Agricultural Economics* 45, 3(1997):317-327.

Paulson, N.D., A. Katchova, and S.H. Lence."An Empirical Analysis of the Determinants of Marketing Contract Structures for Corn and Soybeans." *Journal of Agricultural & Food Industrial Organization* 8(2010):Article 4.

Pennings, J.M.E. and P. Garcia. "Measuring Producers Risk Preferences: A Global Risk- Attitude Construct". *American Journal of Agricultural Economics* 83(2001): 993-1009.

Prendergast, C."The Provision of Incentives in Firms." *Journal of Economic Literature* 37(1999):7-63.

Ravn, M.O. and H. Uhlig. "Notes on Adjusting the Hodrick- Prescott Filter for the Frequency of Observations" *The Review of Economics and Statistics* 84, 2(2002):371-380.

Rowell, B., A. Satanek and J.C. Snyder. "Yield, Income, Quality and Blotchy Ripening Susceptibility of Staked Tomato Cultivars in Central Kentucky." Department of Horticulture, University of Kentucky, 2004. Internet site: https://www2.ag.purdue.edu/hla/fruitveg/MidWest%20Trial%20Reports/tomatoes_centralKY_04.pdf.

Rowell, B., A. Satanek. K. Bale and J.C. Snyder. "Yield, Income and Quality of Staked Tomato Cultivars in Central Kentucky." University of Kentucky, 2005. Internet site: http://www.hort.purdue.edu/fruitveg/rep_pres/2005-6/mvvt_2005_pdf/tom_ky-cent_05.pdf

Rowell, B., J. Pfeiffer, T. Jones, K. Bale and J.C. Snyder. "Yield, Income and Quality of Staked Tomato Cultivars in Central Kentucky". University of Kentucky, 2006. Internet site: http://www.hort.purdue.edu/fruitveg/rep_pres/2006-7/mvvt_2006_pdf/TomatoTrialRptPurdue 06jcs.pdf.

Rowell, B., T. Woods, and J. Mansfield. "Marketing Options for Commercial Vegetable Growers", University of Kentucky, 1999. Internet site: http://www.ca.uky.edu/agc/pubs/id134/id134.pdf

Sartwelle, J.I., D. O'Brien, W. Tierney, and T. Eggers. "The Effect of Personal and Farm Characteristics Upon Grain Marketing Practices." *Journal of Agricultural and Applied Economics* 32, 1(2000):95-111.

Schweers, V.H. and D.W. Grimes. "Drip and Furrow Irrigation of Fresh Market Tomatoes on a Slowly Preamble Soil: Part 1 Production" *California Agriculture* 30(1976): 8-10.

Sexton, R.J. and M. Zhang. "A Model of Price Determination for Fresh Produce with Application to California Iceberg Lettuce" *American Journal of Agricultural Economics* 78, 4(1996): 924-934.

Shockley, J.M. "Whole Farm Modeling of Precision Agricultural Technologies". Unpublished Ph.D dissertation. University of Kentucky, Dept. of Agricultural Economics, 2010.

Shockley, J.M., C.R. Dillon, and T.S. Stombaigh. "A Whole Farm Analysis of the Influence of Auto-Steer Navigation on Net Returns, Risk and Production Practices" *Journal of Agricultural and Applied Economics* 43, 1(2011):57-75.

Simmons, R.L. and C. Pomareda. "Equilibrium Quantity and Timing of Vegetable Exports" *American Journal of Agricultural Economics* 57, 3(1975):472-479.

Stiglitz, J.E. 1974. "Incentives and Risk Sharing in Sharecroping." *The Review of Economic Studies* 41(1974):219-225.

Tannura, M.A., S.H. Irwin, and D.L. Good. "Weather, Technology and Corn and Soybean Yields in the U.S. Corn Belt." Marketing and Outlook Research Report 2008-01, Department of Agricultural and Consumer Economics, University of Illinois, 2008.

Train, K. *Discrete Choice Methods With Simulation.* Cambridge University Press, 2003.

U.S. Department of Agriculture - Natural Resources Conservation Service. Web Soil Survey internet site: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

U.S. Department of Agriculture- Economic Research Service. Internet Site: http://www.ers.usda.gov/data-products/vegetables-and-pulses-data/outlook-tables.aspx

U.S. Department of Agriculture, National Agricultural Statistics Service. *2007 Census of Agriculture.* Washington DC, 2010.

U.S. Department of Agriculture. *Fruit and Vegetable Market News User Guide.* Agricultural Marketing Service, Fruit and Vegetable Programs. Washington DC, April, 2012.

University of Kentucky, College of Agriculture –UKAg weather center. Internet site: http://wwwagwx.ca.uky.edu

Vassalos, M., W. Hu, T. Woods, J. Schieffer and C.R. Dillon. "Marketing Contracts for Fresh Market Tomato Production: A Choice Based Experiment." Poster presented at the AAEA annual meeting, Seattle, Washington, August 12-14, 2012

Vassalos, M., W. Hu, T. Woods, J. Schieffer, and C. Dillon. "Fresh Vegetable Growers' Risk Perception, Risk Preference and Choice of Marketing Contracts: A Choice Experiment." Paper presented at Southern Agricultural Economics Association Annual Meeting. Orlando, FL, February 3-5, 2013.

Vavra, P. *Role, Usage and Motivation for Contracting in Agriculture.* OECD Food, Agriculture and Fisheries Working papers, No. 16, OECD publishing, Quality Measurement and Risk-Sharing in Contracts for California Fruits and Vegetables, 2009.

Walker, G.K. "Model for Operational Forecasting of Western Canada Wheat Yield" *Agricultural and Forest Meteorology* 44(1989):339-351.

Wang, X., J.H. Dorfan, J.McKissick and S.C. Turner. "Optimal Marketing Decisions for Feeder Cattle Under Price and Production Risk" *Journal of Agricultural and Applied Economics* 33, 3(2001):431-443

Williams M.M. "Sweet Corn Growth and Yield Responses to Planting Dates of the North Central United States". *HortScience* 43, 6(2008):1775-1779.

Williams, M.M., and J.L. Lindquist. "Influence of Planting Date and Weed Interference on Sweet Corn Growth and Development" *Agronomy Journal* 99(2007):1066-1072.

Wolf, S., B. Hueth and E. Ligon. "Policing Mechanisms in Agricultural Contracts". *Rural Sociology* 66(2001): 359-381.

Woods, T. "2010 Kentucky Produce Planting and Marketing Intentions Grower Survey and Outlook" AEC Extension Publication 2010-05, University of Kentucky Cooporative Extension Service, 2010. Internet Site:

http://www.uky.edu/Ag/NewCrops/plantingsurvey2010.pdf

Zheng, X., T. Vukina, and C. Shin. "The Role of Farmers' Risk Aversion for Contract Choice in the U.S. Hog Industry." *Journal of Agricultural & Food Industrial Organization* 6(2008):Article 4.

VITA – MICHAEL VASSALOS

EDUCATION

- Ph.D. in Agricultural Economics

University of Kentucky, Lexington, KY.   GPA: 3.85/4   Expected to be awarded August 2013
DISSERTATION: "Essays on Fresh Vegetable Production and Marketing Practices".

- M.Sc. in Agricultural Economics

University of Kentucky, Lexington, KY.   GPA: 3.82/4   December 2008
THESIS: "Common Agricultural Policy, Greek Agriculture and Multifunctionality".

- 5-year Ptyxio (M.Sc. equivalent) in Agricultural Economics

Agricultural University of Athens   GPA: 7.31/10   November 2005
THESIS: "North Amorgos: Agricultural Income, Viability of Agricultural Enterprises and Growth Prospects".

FIELDS OF SPECIALIZATION

- Primary: Agribusiness/Farm Management

- Secondary: Production Economics and Local Development

- Research Interest: Grower's Decisions Under Risk and Uncertainty, Risk Management, Precision Agriculture and Agricultural Policy

COLLABORATION ON FUNDED GRANTS

2.Xi, A.(PI), P. Lue, C.R.Dillon, W. Hu (Co-PI), Y. Zhang, M. Vassalos and B. Li. *Impact of Agricultural Insurance on Production Decisions: Empirical and Simulated Evidence from Shanghai, Zhejiang, Anhui and Sichuan*. National Natural Science Foundation of China, approx. $27,000, 2011-2013.

1. Dillon, C.R. (PI), M.Vassalos (Co-PI), T. Woods, T. Coolong, W.Hu, J. Schieffer. *Optimal Production and Marketing Decisions for Kentucky Vegetable Producers*. Kentucky Department of Agriculture, Specialty Crop Block Grant Program, approx. $65,000, submitted, not funded.

REFEREED JOURNAL ARTICLES

3. Vassalos, M., C.R. Dillon and P. Childs. 2012. "Empirically Testing for the Location-Scale Condition: A Review of the Economic Literature". *Journal of Risk Model Validation* 6(3):51-66.

2. Vassalos, M., C.R. Dillon and A. Pagoulatos. 2012. "A Hedonic Price Analysis of Corn and Soybean Herbicides". *Food Economics* 9(1-2): 117-128.

1. Vassalos, M., C.R. Dillon, D. Freshwater and P. Karanikolas. 2010. "Modeling Multifunctionality of Agriculture at a Farm-Level: The Case of Kerkini District, Northern Greece". *Applied Studies in Agribusiness and Commerce* 4(3-4): 59-64.

MANUSCRIPTS UNDER REVIEW

2.Vassalos, M., C.R. Dillon and T. Coolong. "Optimal Land Allocation and Production Timing for Fresh Vegetable Growers Under Price and Production Uncertainty." Being revised for third review, Journal of Agricultural and Applied Economics.

1. Vassalos, M., W. Hu, T. Woods, J, Scheiffer and C.R. Dillon. "Marketing Contracts for Fresh Market Tomato Production: A Choice Based Experiment". Being Revised for first review, Journal of Agricultural and Resource Economics.

COMPETITIVE PRESENTATIONS

8. Vassalos, M., W. Hu, T. Woods, J. Schieffer and C.R. Dillon. "Fresh Vegetable Growers' Risk Perception, Risk Preference and Choice of Marketing Contracts: A Choice Experiment". Selected Paper, Southern Agricultural Economics Association Annual Meeting, Orlando, FL, February 2-5, 2013.

7. Vassalos, M. W. Hu, T. Woods, J.Schieffer and C.R. Dillon. "Marketing Contracts for Fresh Market Tomatoes: A Choice Based Experiment". Selected Poster, part of the poster tour, Agricultural and Applied Economic Association Annual Meeting, Seattle, WA, August 12-14, 2012.

6. Dillon, C.R. and M. Vassalos. "A Heuristic Optimization Model for Vegetable Production and Marketing Decisions". Selected Poster, Agricultural and Applied Economic Association Annual Meeting, Seattle, WA, August 12-14, 2012.

5. Vassalos, M. and C.R. Dillon. "Choice of Optimal Planting and Marketing Decisions for Fresh Vegetable Producers: A Mathematical Programming Approach". Selected Paper, Southern Agricultural Economics Association Annual Meeting, Birmingham, Al, February 4-7, 2012.

4. Vassalos, M. and C.R. Dillon. "Going Organic or Conventional? A Case Study for the Farm Specific Factors Affecting the Transition to Organic Farming in Lake Kerkini: Greece". Selected Paper, 4th Annual International Symposium on Agriculture, Athens Institute for Education and Research, Athens, Greece, July 18-19, 2011.

3. Vassalos, M. and C.R. Dillon. "A Hedonic Price Analysis of Corn and Soybean Herbicides". Selected paper, 120th European Association of Agricultural Economists seminar, Chania-Crete, Greece, September 2-4, 2010.

2. Vassalos, M., C.R. Dillon and P. Karanikolas. "Farm Decision Making in a Multifunctional Context: The Case of Lake Kerkini District, Greece". Selected paper, 113th European Association of Agricultural Economists seminar, Belgrade, Serbia, December 9-11, 2009.

1. Karanikolas, P., M. Vassalos, N. Martinos and K. Tsiboukas. "Economic Viability and Multifunctionality of Agriculture: The Case of North Amorgos" (in Greek). Selected paper, 5th National Conference of Greek Metsobian Polytechnical Institute, Metsobo, Greece, September 27-30, 2007.

AWARDS

● $ 400 travel award from University of Kentucky Graduate School in order to attend AAEA 2012 annual meeting.   August 2012.

PROFESSIONAL EXPERIENCES

Research Assistant, Department of Agricultural Economics, University of Kentucky
2006-Present

- ➢ Research Assistant, Agricultural University of Athens, Department of Ag. Economics
  Spring 2005
- ➢ Internship, Greek Ministry of Rural Development and Food, Athens-Greece   July-August 2004
- ➢ Internship, Greek Ministry of Rural Development and Food, Athens-Greece
  August 2003

SERVICES

5. Reviewer for Canadian Journal of Agricultural Economics   2013.

4. Co-coordinator of the seminar series for the Department of Agricultural Economics, University of Kentucky, with Dr. C.R. Dillon and Dr. T. Woods.   2011-2012.

3. Moderator of "Industrial Organization/ Supply Chain Management – Poster Tour Session", Agricultural and Applied Economic Association Annual Meeting, Seattle, WA. August 12-14, 2012.

2. Chair of session XIII for the 4th Annual International Symposium on Agriculture, Athens Institute for Education and Research, Athens, Greece.   July 18-19, 2011.

1. Elected President of the Agricultural Economics Graduate Student Organization   2010-2011.

PROFESSIONAL ORGANIZATIONS

- Agricultural and Applied Economic Association
- European Association of Agricultural Economists
- Southern Agricultural Economic Association
- Athens Institute for Education and Research (ATINER)
- GAMMA SIGMA DELTA Honored Society of Agriculture
- Golden Key International Honored Society

COMPUTING SKILLS

- Advanced User: MS Word, Excel, PowerPoint
- Experienced User: SPSS, STATA, GAMS, LaTeX, DSSAT
- Limited Exposure: R, ArcGIS