The Potential for Greenhouse Tomato Production Expansion in Florida

Serhat Asci[1]
Graduate Student
E-mail: sasci@ufl.edu

John J. VanSickle[1]
Professor

Dan Cantliffe[2]
Professor

[1]Food and Resource Economics Department,
[2]Horticultural Sciences Department,
University of Florida

The Potential for Greenhouse Tomato Production Expansion in Florida

Serhat Asci, John J. VanSickle and Dan Cantliffe[1]

[1]The authors are (respectively): Graduate Student and Professor, Food and Resource Economics Department and Professor, Horticultural Sciences Department,

University of Florida

Abstract

The U.S. fresh winter tomato industry and Mexican tomato production have been engaged in a trade conflict since the early1970s. Given that tomato is the highest valued fresh vegetable item, the fresh tomato market in the U.S. is open for rent seeking actions of importers and domestic producers. While importers try to increase their shares by lowering the prices, domestic producers attempt to keep tomato as a high-valued item and at the same time avoid any costly investment in production practices (such as greenhouse production). However, the competition with Mexican greenhouse tomato producers push winter tomato producers (particularly, in Florida) to search for new investment opportunities. This paper utilizes net present value and real option analysis to investigate whether it is beneficial for Florida tomato producers to invest in greenhouse production methods to stay competitive in the tomato market during the winter season.

Keywords: Risk in investment decision, greenhouse tomato, net present value, real option approach.

1. Introduction

Among all the vegetable crops in the U.S., the total value of production is the highest for tomato production (USDA-ERS 2012a). Moreover, the U.S. is the second largest fresh tomato producer in the world with 33.5 million cwt produced in 2010 (FAOSTAT 2012; USDA-ERS 2012b). Florida (12.3 million cwt) and California (10.4 million cwt) are the largest tomato producing states in the U.S. The tomato demand in the U.S. is high during all 12 months of the year (USDA-ERS 2012b). During the summer season most of U.S. states, Mexico and Canada produce tomatoes so the supply is high and prices are relatively low. All producers are able to compete for a relatively same tomato price, and US producers face fair competition. However, the dynamics are different during the winter season since the main tomato suppliers are the state of Florida and Mexico. Florida produces field-grown tomatoes, while producers in Mexico use greenhouse production technique to increase yield and decrease production risk, and possibly production cost. Therefore, Mexican producers are able to offer tomatoes at lower prices than the Florida winter tomatoes. Additionally, Mexico greenhouse production acreage increased to 30,000 acres in 2012, and 70% of these acreage is devoted to tomato production (SAGARPA 2013) while tomato planted land in Florida has been diminishing since 1990s and nowadays it is around 32,000 acres (USDA-ERS 2012b). Overall, competition with Mexican producers affects the profits of the Florida tomato producers that have traditionally benefited from the high prices at the winter tomatoes niche market.

This paper uses net present value and real option analysis to investigate whether it is worth for Florida producers to invest in greenhouse production methods to stay competitive in the tomato market during the winter season. Due to the difference between production methods, the costs for Mexican producers are significantly lower than those for US producers. Therefore, we also investigate how investment in greenhouse technology allows to reduce the costs of tomato production in Florida that might lead Florida producers to keep their market share.

2. Tomato Production in the US

Fresh tomatoes are harvested in California during all seasons except winter, while in Florida they are harvested from October to June with peak production from November to January. Most of Florida's winter production is shipped to the eastern U.S. while Mexico provides fresh tomatoes for the western part of U.S. (VanSickle et al. 2003). Overall, almost one-third of the total U.S. fresh tomato consumption is imported from Mexico and Canada during the off-season period, and around 40% of Mexican and the large majority of Canadian tomatoes are produced in greenhouses (USDA-FAS 2012). Other countries like the Netherlands and Spain also export greenhouse tomatoes to the U.S. in smaller quantities.

In the last decade, U.S. greenhouse tomato production increased two-fold (from 2.7 million cwt in 2000 to 5.4 million cwt in 2011), although its share in the total fresh tomato production is still relatively low (approximately 15 percent). However, for retail market specifically, more than 40% of tomatoes are produced using greenhouse technologies (USDA-ERS 2012b). California and Arizona have become the key states for greenhouse production since the competition with Mexican greenhouse tomato producers drove them to switch into niche market during the winter season when the tomato price is at peak level.

Florida supplies tomatoes largely for winter while California supplies in spring and summer. Florida producers get higher prices for their product because they produce in the off-season, when lower winter supplies result in higher prices. The average price of fresh tomatoes was $72.50 per cwt in 2010 in Florida, while the average price in California was $33.10 per cwt (USDA ERS, 2012b). However, fresh tomato prices are known to be sensitive to the instabilities of supply which lead to the price volatility. Florida's biggest winter tomato competitor Mexican greenhouse production has anywhere between threefold and twenty-fold more productivity (on per-acre basis) than Florida field production. Although greenhouse production cost is high, it is competitive in revenue and the quality can be better than that of field-grown tomatoes. Hence, imported greenhouse tomatoes have more opportunities to

increase their market share in the U.S. (Cantliffe and VanSickle 2009). Overall, the increased interest in greenhouse tomato production in Southwestern states, as well as increasing competition from imported Mexican greenhouse tomatoes can subsequently decrease winter tomato prices, and hence the profits of the Florida producers.

Aforementioned, investment and operating costs for greenhouse tomato production are higher than those of field production, and as a result, greenhouse production is often perceived by Florida producers as more risky (Cook and Calvin 2005). Moreover, greenhouse production is very energy-intensive (Singh et al. 2003). Nevertheless, the investment in the greenhouse production systems may a viable option for growers in Florida, since this technology yields much greater yields and high quality and a more stable market for their products than of current production technique.

3. Literature Review

To explore investments decision made by for growers, the risk-based model are widely used by academics and business consultants. In this study, we develop an investment decision model and employ simulation approach for including risk to examine the investment decision in the greenhouse production systems in Florida. Below, we review existing studies focused on (a) agricultural decision-making under the risk and uncertainty, and (b) application of simulation methods for risk based analysis. Overall, we show how investment decision includes risk and how simulation is used to address the risk in the analysis.

There are numerous empirical studies of risk and agricultural decision-making. The risk analysis methodologies proposed in the studies can be summarized chronologically: initially, risk programming was applied by Hazell (1971) to examine risky decisions; later, Anderson et al. (1977) focused on the role of producers' risk attitudes; further, an empirical analysis on effective educational programs to facilitate risky decision-making was provided by Nelson and Harris (1978). Then, Young (1984) improved the methods of measuring risk. More general efficiency criteria for ordering risky choices

were introduced by King and Robison (1981), and stochastic simulation was proposed by Mapp and Helmers (1984). More applications of risk analysis in production, marketing, and finance are also published by various researchers (Robison and Brake 1979; Sonka and Patrick 1984).

Collins and Barry (1986) evaluated two approaches for using a single-index model in portfolio analysis for agricultural firms. The single-index model offers a summary measure of risk for individual assets or enterprises that accounts for the combined effects of the asset's own variance, as well as covariance with other assets. When used in portfolio analysis to derive risk-efficient sets of decision choices, the single-index model offers a computationally efficient way to use quadratic programming that accounts for a full constraint set and for the covariance relationships among the decision choices.

Williams et al (1990) examined risk-based decisions in the context of stochastic dominance of two tillage systems, conventional tillage and no-tillage, for five crop rotations, wheat-fallow, grain sorghum-fallow, continuous wheat, continuous grain sorghum, and wheat-grain sorghum-fallow, shows that risk-averse managers prefer a conventional tillage wheat-sorghum-fallow system.

Simulation is a widely covered subject; however, most of the existing studies are not written for agricultural economists and do not relate to agricultural firm-level models (e.g., Law and Kelton, Savage, Vose, Ragsdale and Winston). Simulation as a tool for analyzing risky decisions was suggested by Anderson et al. (1977). The types of equations and identities have been used to construct the Farm Level Income and Policy Simulation Model, as described in Richardson and Nixon (1986; 1999); however, the methods for simulating the random variables were not discussed.

Risk analysis of adopting any of four commonly used zero runoff sub-irrigation systems in greenhouse operations was described on different crop categories by Uva et al. (2000) with a Monte Carlo Simulation approach. Richardson *et al* (2000) used an applied procedure for estimating and simulating probability distributions in farm-level risk assessment and clearly describe the procedure on how to

analyze risk by this method. Moreover, Ramirez (2000) and, Featherstone and Kastens (2000) uses parametric techniques for modeling and simulating correlated variables. Iwai and Emerson (2008) implied risk analysis with a Monte Carlo Simulation by calculating NPV and real options price to assess sugarcane mechanization investment in Florida. In the lieu of previous studies, the goal of this paper is to use the agricultural decision-making under the risk and uncertainty, and to apply simulation methods for risk based analysis on greenhouse tomato investment decision in Florida.

4. Data and Model

The patriot model on greenhouse tomato production in Florida (VanSickle 2011) and University of Florida interactive budget tables for Florida field grown tomato (UF-FRED 2012) are used to estimate revenue and cost for tomato production. Although the patriot model uses 120,000 sq. m (29.7 acres) greenhouse area for a feasible investment, the comparison between field grown and greenhouse production is done on one acre basis.

Table 1 shows the cost of tomato production for the two production techniques; field grown and greenhouse. The table indicates that greenhouse production requires approximately 30 times more capital than field production. The largest expense of the greenhouse production is growing cost since much more seedlings and chemicals are required for this intense production than field grown. However, higher yield in greenhouse production leads to the lower per-unit sales costs, as compared with the field grown production. Greenhouse production is more energy dependent method; and hence, energy cost is significantly higher for the greenhouse production than for field grown production. Since energy is the only acre dependent expenditure, it is examined separately while other cost items are aggregated.

Table 1. Tomato production budget models in Dollars (for 1 acre)

	Field Grown		Greenhouse	Cost Share		
Seasons	**07-08**	**08-09**	**09-10**			
Initial Investment			976303.88			
Growing costs	3517.59	3671.71	258795.15	21.90%	21.26%	46.64%
Energy costs	1138.54	1916.75	94239.57	7.09%	11.10%	16.98%
Labor Costs	3971.40	3986.25	130368.88	24.73%	23.08%	23.49%
Other growing costs	1389.29	1422.44	5446.13	8.65%	8.24%	0.98%
Sales costs	5235.00	5385.00	41553.88	32.60%	31.18%	7.49%
Maintenance	807.05	886.07	24481.68	5.03%	5.13%	4.41%
Total Cost (w/o initial cost)	16058.87	17268.22	554885.28	100.00%	100.00%	100.00%

Source: Calculated by authors from Patriot model and interactive budgets.

Despite its limitations, net present value (NPV) framework is a commonly used to evaluate agricultural investment. In this analysis, expected free cash flows (FCF) are calculated for the span of ten years; present value is found by discounting for the cost of capital. NPV was obtained by subtracting the initial investment cost from the present value. The investment cost items are converted into revenue-cost table in Table 2, and free cash flows are calculated. Tax rate on EBIT is taken as 29% since average tax rate of agricultural production firms is calculated from corporate tax data for the last ten years (IRS 2012).

Table 2 shows that operating cash flow (OCF) is 7.72 times higher given greenhouse production method, as compared with field grown production (on per-acre basis). However, production amount is 15.44 times higher in greenhouse production technique. FCF ratio drops to 5.55 times after depreciation and tax items are included into equation.

$$OCF = Revenue - Cost \qquad\qquad (1)$$

$$EBIT = OCF - Depreciation \qquad\qquad (2)$$

$$FCF = EBIT - Tax \qquad\qquad (3)$$

Table 2. Free Cash Flow Calculations

	Field Grown		Greenhouse	Ratio (Greenhouse /Field Grown)
Seasons	07-08	08-09	09-10	
Production Amount (lbs)	37500.00	37500.00	578991.88	15.44
Revenue	54600.00	54600.00	843012.17	15.44
Energy Cost	1138.54	1916.75	94239.57	49.17
Other Costs	14920.33	15351.47	460645.71	30.01
Operating Cash Flow	38541.13	37331.78	288126.89	7.72
Depreciation	201.76	221.52	82174.08	
EBIT	38339.36	37110.26	205952.81	
Tax on EBIT (%29)	11118.42	10761.98	59726.32	
Free Cash Flow	27220.95	26348.29	146226.50	5.55

Monte Carlo simulation is used for forecasting field grown tomato yield and tomato prices. Greenhouse tomato yield is assumed to be constant for the seasons beyond 2010-2011. The data for tomato yield and prices are collected from ERS tomato statistics (USDA-ERS 2012b). The methodology developed by Richardson et al. (2000) was used in Simetar© software by simulating interdependent price and yield.

Non-random components are found as a function of linear trend and trend square.

$$\hat{X}_{it} = \hat{a} + \hat{b} \cdot \text{Trend}_t + \hat{c} \cdot \text{Trend}_t{}^2 \tag{4}$$

Random components are calculated by the difference of actual and predicted values ($\hat{X}_{ik}$).

$$\hat{e}_{it} = X_{it} - \hat{X}_{it} \tag{5}$$

Relative variability of observations is measured as a fraction of random components to predicted values.

$$D_{it} = \frac{\hat{e}_{it}}{\hat{X}_{it}} \tag{6}$$

After the relative variability is sorted for each observation, correlation matrix is calculated by the probabilities of occurrence for the deviates. The intra temporal correlation matrix for price and yield variables is found as below.

$$\rho_{ij} = \begin{bmatrix} 1 & 0.14 \\ 0 & 1 \end{bmatrix} \qquad (7)$$

Correlated standard normal deviates (CSND$_{ik}$) are found by using this correlation matrix and independent standard normal deviates (R_{ik}) for ten-year simulation time span (with years indexed by k). Thus, we calculate empirical distribution for each variable using correlated uniform deviates.

$$CUD_{ik} = normdist(R_{ik} - CSND_{ik}) \rightarrow CFD_{ik} \qquad (8)$$

At last, stochastic simulation ($\tilde{X}_{ik}$) is found by the multiplication of predicted values and MVE distribution. The relative risk expansion in the model is given as (E_{ik}) which is not included in this simulation.

$$\tilde{X}_{ik} = \hat{X}_{ik} \cdot (1 + CFD_{ik} \cdot E_{ik}) \qquad (9)$$

End-user fuel prices are used for estimating growth rate of the energy cost. The data is collected from 1978 to 2011 (US-EIA 2012). The growth rate of energy cost was calculated as 7% from the average annual growth rate. Moreover, the growth of other costs is assumed as 3%, based on inflation rate.

Following the simulation methodology developed by Richardson et al. (2000) for yield and prices, and accounting for the growth rate for the cost items, forecasted FCF for field grown and greenhouse tomato production is given in Table 3.

Table 3. Forecasted FCF for field grown and greenhouse tomato production

Seasons	Field Grown	Greenhouse
10-11	20481.18	48759.52
11-12	19613.49	71851.77
12-13	19569.40	72767.68
13-14	23018.03	53539.07
14-15	50078.78	173636.65
15-16	41828.13	191658.70
16-17	37496.77	228051.41
17-18	38104.23	84340.45
18-19	25572.67	64558.32
19-20	28617.58	38629.12

Table 4 shows the NPV results of field grown and greenhouse production practices. The table indicates that NPV of greenhouse investment is bigger than field grown, so this production method is economical for Florida tomato producers.

$$PV_t = \sum_{t=2010}^{n=2020} E(FCF_t)/(1 + WACC)^{n-t} \qquad (10)$$

$$NPV_t = PV_t - I \qquad (11)$$

Table 4. Net Present Values for field grown and greenhouse tomato production

	Present Values	Initial Investment	NPV
Field Grown	229601.8		229601.8
Greenhouse	895424.3	488151.9	407272.4

The NPV analysis has the following limitations (1) only current information available at the time of the decision is used, (2) after the initial decision made, the future decisions cannot be included and (3) just a single discount rate is used (as opposed to allowing the rate to change over time). Hence, the high NPV result is not sufficient to explain why U.S. growers still do not switch to the greenhouse tomato production. The next step in this research is to use real options approach (ROA) to evaluate viability of greenhouse tomato production in Florida. ROA allows including the future value of agricultural investment. Second, ROA controls for the irreversibility of investment in analysis. Third, ROA allows modeling dynamic decision making process. Forth, ROA allows for the flexibility of agricultural investment by including the non-linear distribution of the cash flow or the eventual risk profile changes. The main difference in the concept of NPV and ROA could be shown precisely as

$$NPV: MAX(at\ t = 0)[0, E_0 V_t - X] \qquad (12)$$

$$ROA: E_0 MAX(at\ t = T)[0, V_t - X] \qquad (13)$$

To estimate the uncertainty for staying in field grown production, 10,000 sets of FCF are generated by simulating cost and revenue terms. We obtain the volatility from the standard deviation of annual rate of return defined as $z = \ln(PV_1 + FCF_1) - \ln(PV_0)$. The procedure mentioned by Copeland and Antikarov (2001) is followed for the multiplicative stochastic process to calculate ROA.

References

Anderson, J. R., J. L. Dillon, and J. B. Hardaker. 1977. Agricultural Decision Analysis. Ames: Iowa State University Press.

Bredahl M. A. Schmitz and J.S. Hillman. 1987. Rent Seeking in International Trade: The Great Tomato War. *American Journal of Agricultural Economics*, 69(1): 1-10.

Cantliffe D.J. and J.J. VanSickle. 2003. Competitiveness of the Spanish and Dutch Greenhouse Industries with the Florida Fresh Vegetable Industry, UF EDIS Publication #HS918.

Collins R.A. and P.J. Barry. 1986. Risk Analysis with Single-Index Portfolio Models: An Application to Farm Planning. *American Journal of Agricultural Economics*, 68(1): 152-61.

Cook R. and L. Calvin. 2005. Greenhouse Tomatoes Change the Dynamics of the North American Greenhouse Tomato Industry, Economic Research Service (ERS), USDA.

Featherstone A.M. and T.L. Kastens. 2000. Non-Parametric and Semi-Parametric Techniques for Modeling and Simulating Correlated, Non-Normal Price and Yield Distributions: Applications to Risk Analysis in Kansas Agriculture. *Journal of Agricultural and Applied Economics*, 32(2): 267-281.

Hazell, P. B. R. 1971. A Linear Alternative to Quadratic and Semivariance Programming for Farm Planning under Uncertainty. *American Journal of Agricultural Economics*, 53(1): 53-62.

Iwai N. and R.D. Emerson. 2008. Labor Cost and Sugarcane Mechanization in Florida: NPV and Real Options Approach. Immigration Reform: Implications for Farmers, Farm Workers, and Communities Conference, Washington, DC. May 8-9, 2008.

King, R. P., and L. J. Robison. 1981. An Interval Approach to the Measurement of Decision Maker Preference. *American Journal of Agricultural Economics*, 63(1): 510-20.

Mapp, H. P., and G. A. Helmers. 1984. Methods of Risk Analysis for Farm Firms. Risk Management in Agriculture, ed. P. J. Barry. Ames: Iowa State University Press, pp. 116-28.

Nelson, A. G., and T. D. Harris. 1978. Designing an Instructional Package: The Use of Probabilities in Farm Decision Making. *American Journal of Agricultural Economics*, 60(1): 993-97.

Ramirez O.A. 2000. Parametric Modeling and Simulation of Joint Price-Production Distributions under Non-Normality, Autocorrelation and Heteroscedasticity: A Tool for Assessing Risk in Agriculture. *Journal of Agricultural and Applied Economics*, 32(2): 283-297.

Richardson, J.W. 2008. Simetar: Simulation and Econometrics to Analyze Risk. Simetar Inc. College Station, Texas.

Richardson, J.W., Klose, S.L and A.W. Gray. 2000. An applied procedure for estimating and simulating multivariate empirical (MVE) distribution in farm-level risk assessment and policy analysis. *Journal of Agricultural and Applied Economics*, 32(2): 299-315.

Robison, L. J., and J. R. Brake. 1979. Application of Portfolio Theory to Farmer and Lender Behavior. *American Journal of Agricultural Economics*, 61(1): 158-64.

Singh H, D. Mishra, N.M. Nahar and M. Ranjan. 2003. Energy use pattern in production agriculture of a typical village in arid zone India: part II. Energy Conversion Manage. 44(7): 1053–67.

Sonka, S. T., and G. F. Patrick. 1984. Risk Management and Decision Making in Agricultural Firms. Risk Management in Agriculture, ed. P. J. Barry. Ames: Iowa State University Press, pp. 95-115.

Uva W.L., Weiler T.C., Milligan R.A., Albright L.D. and D.A. Haith. 2000. Risk Analysis of Adopting Zero Runoff Subirrigation Systems in Greenhouse Operations: A Monte Carlo Simulation Approach, *Agricultural and Resource Economics Review*. 29(2): 229-239.

VanSickle J. J. 2011. Patriot Model for Greenhouse Tomato Production. Unpublished.

VanSickle J.J., E.A. Evans and R.D. Emerson. 2003. U.S.-Canadian Tomato Wars: An Economist Tries to Make Sense Out of Recent Antidumping Suits, *Journal of Agricultural and Applied Economics*. 35(2): 283-96.

Williams J.R., R.V. Llewelyn and G.A. Barbany. 1990. Risk Analysis of Tillage Alternatives with Government Programs. *American Journal of Agricultural Economics*, 72(1): 172-81.

Young, D. L. 1984. Risk Concepts and Measures for Decision Analysis. Risk Management in Agriculture, ed. P. J. Barry, Ames: Iowa State University Press, pp. 31-42.

FAOSTAT. 2012. Access date: December 2012. http://faostat.fao.org/.

IRS. 2012. Corporation-Data-by-Sector-or-Industry. Access date: December 2012. http://www.irs.gov/uac/SOI-Tax-Stats---Corporation-Data-by-Sector-or-Industry#_bm2.

SAGARPA. 2013. Protected Agriculture. Access date: January 2013 http://houseofproduce.com/news/production/?storyid=141.

Smith S., and J.J. VanSickle. 2009. Interactive Budgets. June 2012.
http://www.fred.ifas.ufl.edu/iatpc/ibudgets09.php.

USDA-ERS. 2012a. Vegetables and Pulses Data. Access date: December 2012
http://www.ers.usda.gov/data-products/vegetables-and-pulses-data.aspx.

USDA-ERS. 2012b. U.S. Tomato Statistics. Access date: September 2012
http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1210.

USDA-FAS. 2012. Fresh & Processing Tomatoes: World Markets & Trade and Global Agricultural
Trade System (GATS). Access date: December 2012
http://www.fas.usda.gov/data.asp.

US-EIA. 2012. Data Tools and Models. Access date: December 2012
http://www.eia.gov/tools/models/.