Research Article

Risk and Return Analysis of Open-Field Tomato Grown in Turkey: A Monte Carlo Simulation Approach

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Abstract | Agricultural production and crop choice decisions of the farmers are affected by the risk in price, cost, and yield outcomes. One of the products that are grown in irrigable lands and has high returns is tomato. The aim of this study is to analyze production costs, return and the risks associated with open-field tomato grown in Izmir province of Turkey in 2011-2017 period. Statistical data used in the study have been obtained from FAOSTAT, Turkish Statistical Institute and Turkish Ministry of Agriculture and Forestry. According to the results of the study, the average production costs of tomato was determined to be 4,940 US$ ha^{-1}. Average gross and net return were calculated to be 4,282 US$ ha^{-1} and 3,284 US$ ha^{-1}, respectively. Monte Carlo Simulation for tomato production was performed based on the values of input variables. According to results of these simulations, the gross return can be expected between 2,968 US$ and 5,912 US$ ha^{-1}, and net return can be expected between 1,483 and 5,384 US$ ha^{-1}. Risk factors that significantly influence the tomato production are the production amount, total costs and variable costs.

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Introduction

Tomato (*Lycopersicon esculentum Mill.*) is one of the most produced vegetable in the world. Tomato is important place in nourishment and human health. Tomatoes contain lots of vitamin C and vitamins B1, B2 and B6. In addition to minerals such as calcium, phosphate, potassium, iron and zinc, tomatoes also contain antioxidants like vitamin E, carotene and especially lycopene. Tomato is a product of economic importance in the world. According to data of FAOSTAT, 177 million tons of tomato was produced in the world in 2016. China is the largest producer by 31.81% of tomato production, followed by the USA (7.36%), Turkey (7.12%), Italy (3.64%), Spain (2.64%), Brazil (2.35%) and Mexico (2.29%) respectively (FAOSTAT, 2018).

Turkey is one of the world's leading producers of vegetables due to its climate and geography. In 2006-2017 period, tomato production per hectare of Turkey increased from 12.6 million tons to 12.8 million tons (TurkStat, 2018). Tomato is being carried out in almost all the part of Turkey. 80% of tomatoes produced by Mediterranean, Aegean and Marmara regions. Antalya, Izmir, Canakkale, and Mersin are also significant producer provinces. In same period, tomato production of Izmir province reached 240,432

tons by rising in the rate of 114.38% (TurkStat, 2018). The annual fresh tomato consumption in Turkey per capita is over 80 kg. 70% of total tomato production in Turkey is consumed fresh and the remainder is processed (Engindeniz and Cosar, 2013).

Growers make decisions by selecting one among many alternatives to diminish the negative economic effects of risky conditions. Additional information about uncertain factors and effective risk management strategies helps growers make better decisions (Asci *et al*., 2014). Growers should be aware of profitability and the cost of tomato production in different regions and adapt their production to obtain the highest possible net profit. For this purpose, they need guide research results (Engindeniz, 2007).

It is seen that many studies have been carried out on economic analysis of tomato production in different countries of the world (Brumfield *et al*., 1995; Baruah and Barman, 2000; Afolami and Ayinde, 2001; Obayelu *et al*., 2014; Wongnaa *et al*., 2014; Shende and Meshram, 2015; Jorwar *et al*., 2017; Ali *et al*., 2017; Paudel and Adhikari, 2018; Ahmed, 2018). It is seen on some of the additional study on the economic analysis of tomato production in Turkey. In some of these studies, cost and input using (Tanrıvermis, 2000; Tatlıdil *et al*., 2005; Engindeniz, 2006; Esengun *et al*., 2007; Cetin and Vardar, 2008; Keskin *et al*., 2010; Engindeniz and Cosar, 2013), marketing structure (Fidan and Tanrivermis, 2006; Erdal, 2006; Keskin, 2010; Erturk and Cirka, 2015; Aksoy and Kaymak, 2016; Kazak *et al*., 2018), and profitability level (Engindeniz and Tuzel, 2002; Engindeniz, 2007; Gunes, 2007; Gunduz and Esengun, 2007; Erdal *et al*., 2009; Engindeniz and Cosar, 2012; Sili and Gunduz, 2014) have been analyzed.

On the other hand, it is seen that there are many studies in different countries that carry out risk assessment with Monte Carlo Simulation in tomato production in the greenhouse and field (Uva *et al*., 2000; Tzouramani and Konstandinos, 2003; Soares *et al*., 2013; Asci *et al*., 2014; Bendlin *et al*., 2017; Neto *et al*., 2018; Ishag and Al Rawahy, 2018). In these studies, a Monte Carlo simulation was used to compare the profitability and risks of alternative investments. Fort this aim, production costs and expectations of return on investment and the risks associated with the production have been analysed. However, studies on economic analysis and risk analysis in tomato production should be continued in different regions. Data can be obtained for policies that can be implemented in this way, and it will also be a guide for growers and entrepreneurs who will invest in this field.

The aim of this study to analyze production costs, return and the risks associated with open-field tomato growing in Izmir province of Turkey in 2011-2017 period.

Materials and Methods

This study was carried out in Izmir province of Turkey (Longitude: 27°10'E, Latitude: 38°25'N) which has Mediterranean Climate Conditions. It is located in the Aegean Region, west of Turkey. Tomatoes are produced in 3,375 hectares in Izmir province (TurkStat, 2018). Statistical data for 2011-2017 used in the study have been obtained from FAOSTAT and Turkish Statistical Institute (TurkStat) and Turkish Ministry of Agriculture and Forestry (TMAF). In this study, basic economical data about tomato production obtained from Directorate of Izmir Province of Turkish Ministry of Agriculture and Forestry (TMAF, 2018). Since the 2011-2017 data of TMAF can be accessed, this period was taken as basis and annual data of field tomato production were used in the study.

Total variable costs are subtracted from the gross production value to calculate the obtained gross return from tomatoes. Total costs are subtracted from the gross production value to calculate the obtained net return from tomatoes. To calculate the gross production value obtained from tomato, the tomato production amount was multiplied by the tomato price. Tomato production costs consist of variable and fixed costs. The variable costs associated with tomato growing were all inputs related to the production of tomatoes and included labor, machine, fertilizer, pesticide, seed-seedling, electricity, etc. Fixed costs included administrative costs, interest on total variable costs and land rent. In this study, interest on total variable costs was calculated by charging a simple interest rate of 5%. Administrative costs were estimated 3% of total variable costs (Engindeniz, 2007; Engindeniz and Cosar, 2013). Trading commodity goods in the world in US dollars caused the data to be presented in dollars.

Monte Carlo Simulation was used for risk calculation. It is the method of computational algorythm based on random samplings to obtain numerical results (Doucet *et al*., 2001). It can be used in case, when several input variables can be considered as random, and can be described by statistical distributions. Distribution of random variable is usually chosen from family of statistical distributions, as the one which fits the best to already existing values of variable (Richardson *et al*., 2008). In this case were selected as random variable inputs price, production amount, total costs and variable costs. Variable price was defined as the random variable with triangular distribution, with parameters minimum, mode and maximum. Production was defined as the variable with uniform distribution, which is determined by maximum and minimum value, where all the values have equal probability of occurring. Total costs and variable costs are random variables with normal bell shaped distribution, determined by their mean values and standard deviations. All random variables were simulated using 1,000 of iterations. Variables considered as the output in this simulation were gross return and net return.

Results and Discussion

In this study, all the costs associated with the tomato production are given in Table 1. Costs of tomato production include variable and fixed costs. Average production cost was determined to be 4,940 US$ ha^{-1}. However, in a previous study conducted in Izmir province, total costs of processing tomato production was determined 3,410 US$ ha^{-1} (Engindeniz, 2007). In a similar study done in Ayas Districts of Ankara Province, tomato production costs were determined to be 4,123 US$ ha^{-1} (Tatlıdil *et al*., 2005). Average variable and fixed costs were calculated to be 3,942 US $ ha^{-1} and 998 US $ ha^{-1}, respectively. Share of variable cost in total production cost was 79.80%. Variable costs consist of both input and labor-machine costs. Share of input and labor-machine costs in variable costs were determined to be 42.09% and 57.91%, respectively. Most of these costs were seed-seedling, fertilizer and harvesting costs. Alternative cost is based on machine use and depreciation calculations are not made since the machine service is charged. Further, all the data vary according to the years. One of the most important reasons for this is the changes in the US $-Turkish Lira parity.

Table 1: *Total costs of tomato production (US$ ha^{-1}).*

Cost items	Years							Average	(%)
	2011	2012	2013	2014	2015	2016	2017		
Input costs									
Fertilizer	311	307	378	323	299	313	340	324	6.56
Pesticide	280	262	296	265	243	243	255	263	5.32
Seed-seediling	857	826	930	765	840	799	737	822	16.64
Irrigation	241	275	288	256	224	226	241	250	5.06
Total input costs (1)	1,689	1,670	1,892	1,609	1,606	1,581	1,573	1,659	33.58
Labor and machine costs									
Soil preparing	488	497	549	588	504	503	439	510	10.32
Fertilization	93	90	116	101	112	104	99	102	2.06
Planting	109	116	145	138	149	139	142	134	2.71
Pesticide application	112	110	128	115	104	104	99	110	2.23
Irrigation	186	180	186	161	187	139	127	167	3.38
Hoeing	236	233	262	230	224	208	227	232	4.70
Harvesting	994	965	988	816	690	660	623	820	16.60
Transport	217	209	233	230	187	198	184	208	4.21
Total labor and machine costs (2)	2,435	2,400	2,607	2,379	2,157	2,055	1,940	2,283	46.21
Total variable costs 1+2 = (A)	4,124	4,070	4,499	3,988	3,763	3,636	3,513	3,942	79.79
Interest on total variable costs (%5)	206	204	225	199	188	182	176	197	3.99
Administrative costs (%3)	124	122	135	120	113	109	105	118	2.39
Land rent	929	872	781	691	560	521	425	683	13.83
Total fixed costs (B)	1,259	1,198	1,141	1,010	861	812	706	998	20.21
Total costs (A+B)	5,383	5,268	5,640	4,998	4,624	4,448	4,219	4,940	100,00

Source: TMAF, 2018.

Table 2: *Gross ans net return obtained from tomato production.*

Years	Tomato production (kg ha^{-1})	Tomato price (US$ kg^{-1})	Gross production value (US$ ha^{-1}) (1)	Variable costs (US$ ha^{-1}) (2)	Total costs (US$ ha^{-1}) (3)	Gross return (US$ ha^{-1}) (1-2)	Net return (US$ ha-1) (1-3)
2011	41,000	0.19	7,790	4,124	5,383	3,666	2,407
2012	42,000	0.19	7,980	4,070	5,268	3,910	2,712
2013	42,000	0.20	8,400	4,499	5,640	3,901	2,760
2014	43,000	0.21	9,030	3,988	4,998	5,042	4,032
2015	46,000	0.19	8,740	3,763	4,624	4,977	4,116
2016	46,000	0.19	8,740	3,636	4,448	5,104	4,292
2017	43,000	0.18	7,740	3,513	4,219	4,227	3,521
Average	43,286	0.19	8,224	3,942	4,940	4,282	3,284

Source: TMAF, 2018.

Average gross return and net return of tomato production are given Table 2. Average production amount was 43,286 kg ha^{-1}. Average price of tomatoes received by the growers was 0.19 US $ kg^{-1}. Average gross production value and gross return are calculated 8,224 US $ ha^{-1} and 4,282 US$ ha^{-1} respectively. Net return calculated to be 3,284 US $ ha^{-1}. In a previous studies in Izmir province, net return of tomatoes was determined to be 1,794 US$ ha^{-1} (Engindeniz, 2007) and 2,817 US $ ha^{-1} (Engindeniz and Cosar, 2013).

Table 3: *Results of Monte Carlo Simulation.*

Statistic	Gross return	Net return
Number of observations	1000	1000
Minimum	2,968.4927	1,483.3128
Maximum	5,912.5618	5,384.0814
Range	2,944.0690	3,900.7686
Median	4,470.9591	3,461.0970
Mean	4,467.5095	3,469.6875
Standard deviation (n)	483.9823	641.9951
Variation coefficient	0.1083	0.1850
Skewness (Pearson)	-0.0411	-0.0518
Kurtosis (Pearson)	-0.4408	-0.3464

Table 3 shows result of Monte Carlo simulation, with descriptive statistics of resulting variable. Based on these simulations can be expected, that gross return will be most likely expected between 2,968 US$ ha^{-1} and 5,912 US$ ha^{-1}, and net return 1,483 US$ ha^{-1} and 5,384 US$ ha^{-1}. Range of net return is wider 3,900 US$ ha^{-1}, range of gross return is 2,944 US$ ha^{-1}. Average value of simulated gross return values was 4,467 US$ ha^{-1} and net return 3,469 US$ ha^{-1}. Expected variability measured by variation coefficient was higher in case of net return 18.50%, in case of gross return it was 10.83%. In case of both variables was negative skewness, which means that most of the expected values will be higher than median. Also kurtosis was negative in both cases, which suggests flat distributions with higher variability, where values are less centered around mean.

Figure 1 shows histogram of gross return. Most probable value of gross return will be around 4,467 US$ ha^{-1}, expected distribution of this variable is normal. Similar result can be seen also on the Figure 2, which shows empirical cumulative distribution function of gross return.

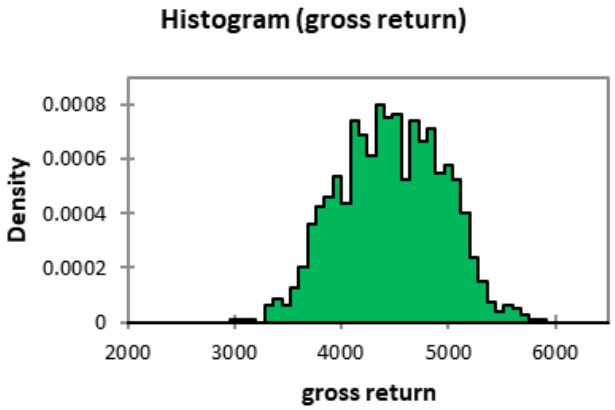

Figure 1: *Distribution of gross return.*

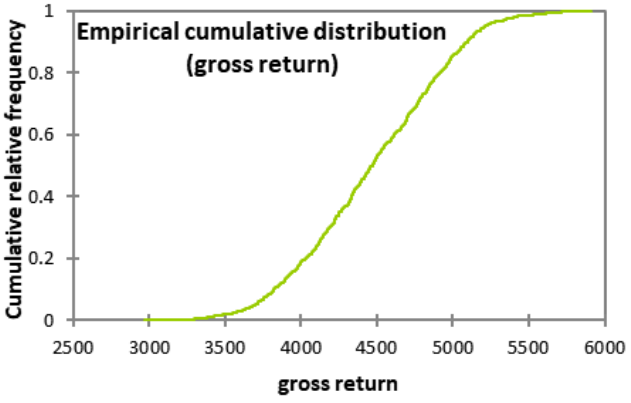

Figure 2: *Distribution of simulated gross return.*

Figure 3 shows contribution of input variables to gross return, where can be seen that most important factor influencing positively gross return is the production, negative influence on gross return was recorded in case of variable costs and total costs. In general can be concluded, that simulation results correspond to what was expected. According to analysis result is gross return mostly positively influenced by production, and main factor influencing gross return in negative way was total cost. Similar result was recorded also in case of variable cost. Result of sensitivity analysis can be found on the Figure 3.

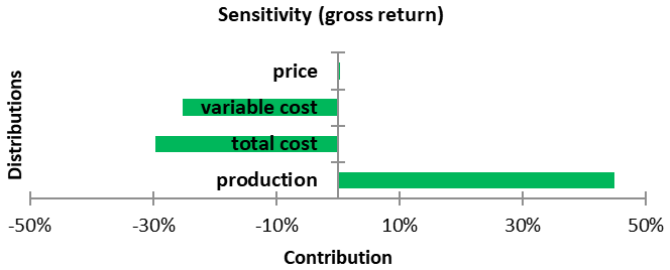

Figure 3: *Sensitivity analysis for gross return.*

Figures 4 and 5 shows that distribution of simulated results for net return was very similar to gross return. Variability of this distribution was slightly higher than in case of gross return. Most probable value for net return will be around its mean value 3,469 US$ ha^{-1}. Range of possible values of net return is wider than it was in case of gross return. Net return can be expected in the interval from 1,483 US$ ha^{-1} to 5,384 US$ ha^{-1}.

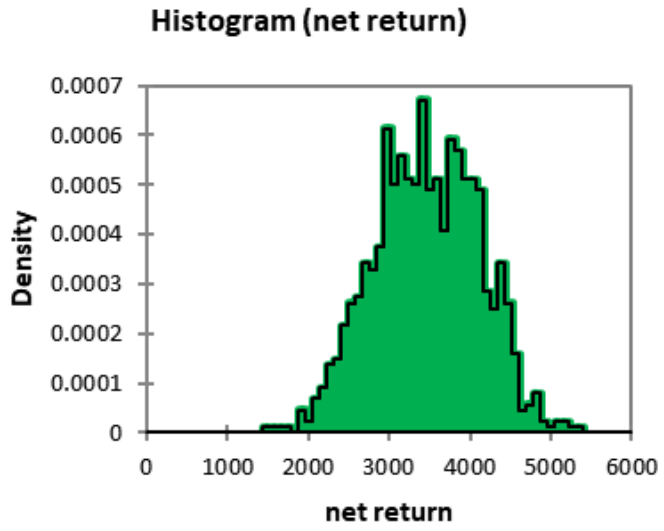

Figure 4: *Distribution of net return.*

Comparison of sensitivity analysis results of net return and gross return, that net return is more sensitive to production and total costs influence than gross return. Otherwise is the effect of these variables to net return very similar (Figure 6).

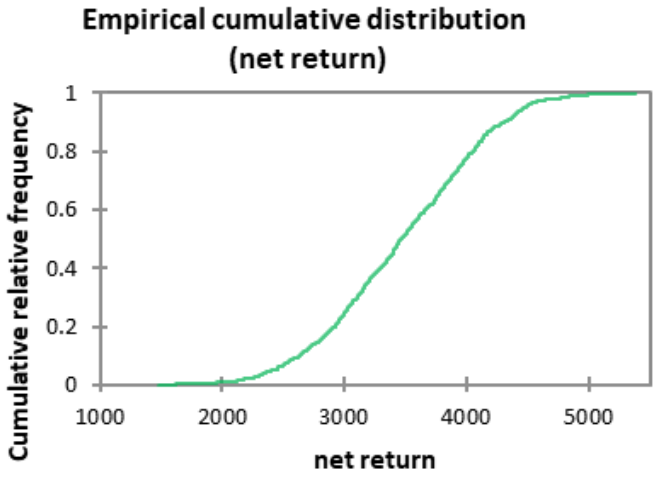

Figure 5: *Cumulative distribution function of net return.*

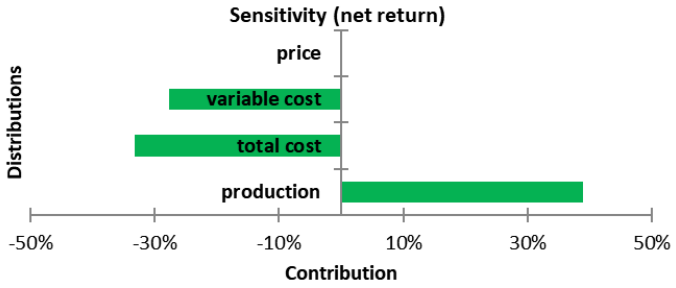

Figure 6: *Sensitivity analysis of net return.*

The main risk factors for tomato production can be identified as yield, price, and cost risks (Engindeniz and Tuzel, 2002). Yield can be affected by climate change. The source of price risk lies in the supply and demand relationship. Cost risk comes from input and labor expenses. However, cost risk is relatively lower in open-field production than in greenhouse production (Engindeniz, 2007; Asci *et al*., 2014). Tomato growers should be aware of the risks to increase their per unit revenue, to reduce their production costs and to keep their market share But, some tomato growers do not consider marketing and cost interaction and thus results in economic failure (Engindeniz and Cosar, 2013).

Growers risk preferences play an important role in determining their production decisions (Engindeniz, 2006). In some previous studies, the risks faced by the growers in the greenhouse and field crop tomato production and their investment preferences were examined (Uva *et al*., 2000; Tzouramani and Konstandinos, 2003; Asci *et al*., 2014; Ishag and Al Rawahy, 2018). According to the results of these studies, the investment decision preferences change

with an increase in a grower's risk-aversion coefficient. The increase in greenhouse investment shows that some growers are beginning to take more risk because they find greenhouse investment as a way to compete better in the market (Engindeniz and Tuzel, 2002).

This study aims to incorporate yield, price and cost risks in open-field tomato growing. The results of this study indicate that a grower would choose to continue with open-field tomato production due to high option value and risk aversion. These results are consistent with what has been witnessed in tomato production in Izmir province. However, policies or market conditions such as an increase in credit availability, decreased input prices, reduced tomato price fluctuation, and/or facilitating effective risk management strategies would make open-field tomato production preferable for growers.

Conclusions and Recommendations

Tomatoes provide significant economic contribution at regional and national level in Turkey. It is the most produced and exported vegetable in Turkey. According to the results of this study, tomato production can be sustained economically. Most significant risk factors which can influence its profitability are production amount and total costs. In case of agricultural production are these factor mostly influenced by natural conditions. In further research it could be suggested to simulate net return and gross return values in relation to natural conditions. Production and market risks both affect the profitability and economic viability of tomatoes. Growers should gather all the economic data about the tomato production and market conditions before making a decision. Also growers should make investigations on other enterprises and determine if tomatoes can be profitable. Although, cost and return estimates are believed to be typical and realistic, individual growers should adjust these values to their own specific situations and circumstances. Success in tomato growing depends on how well the grower can manage the crop and make the right decisions at the right time.

With these results, both in Izmir, Turkey has both benefits in taking some measures related to the production of tomatoes in general. By making agricultural production planning in which regions of the tomato, how much It must be determined that it will be produced. For this purpose Turkey's tomato map should be created. Crop after harvest in tomato losses are around 15-35%. Therefore farmers should be informed on proper harvesting methods, classification and storage methods. In areas where tomato production is common both input use and new production agricultural techniques in terms of adaptation consultancy system should be developed. Financial support for tomato farmers programs that can provide should be transferred to the application. Role in tomato production and marketing cooperative and farmer unions establishment and operation should be encouraged and financial support should be provided in this direction. For this purpose, first of all, cooperative education should be expanded. In addition, the necessary incentives for the establishment of farmer associations and a leader who will lead by training farmers should be determined.

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Novelty Statement

As researchers in Turkey and Slovakia, we wanted to collaborate. First, we prepared an econometric study with institutional data in Izmir province of Turkey. In this study, we planned to anticipate the economic sustainability of tomato production in the open-field.

Authors's Contribution

Sait Engindeniz designed the study, wrote comments, problems and recommendations. Kubilay Ucar collected institutional data and prepared tables and figures. Jozef Palkovic performed Monte Carlo Simulation and evaluated it. All authors read and approved the final manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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