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Determining the Optimum Production Portfolio in Agricultural Sector: Province of Denizli Case

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Abstract
Agriculture is a field which is critically important for the economy of every country. Countries pursue different agricultural production strategies in different regions in accordance with their needs. In this study, a production planning model was developed based on Modern Portfolio Theory for the production of summer and winter vegetables in Denizli, which has a significant agricultural production potential for the Aegean region. The historical data of the specified products were obtained from Turkish Statistical Institute (TUIK). As the analysis method, Markowitz mean variance model and efficient frontier concepts were used. The optimum production portfolios, which have different product ranges and through which the manufacturers can make maximum profit according to their risk appetite, were determined. This study serves as a guide way to the manufacturers for the cultivation plans in future seasons.

1. Introduction

In the world, agricultural sector keeps its economic and social industry-specific properties with its impact on manpower, its contribution to the national income and with the raw materials that it supplies to the industry sector. With the increasing world population, the need for agricultural products increases, but the cultivated areas decrease. Therefore, the significance of production planning intended for the growth of productivity provided from the cultivation areas is gradually increasing. 82% of the agricultural manufacturers in Turkey, own a land smaller than 100 decares and mostly the small family businesses are engaged in agriculture (Yavuz, 2005). These businesses that have a significant share in agricultural sector and that are engaged in small-scale production encounter many risks apart from the difficulties of agricultural production. Basically, risks are categorized systematic and non-systematic risk in finance literature. Here, some example of risks source are given. The risks such as not being able to fulfill the financial liabilities, having liquidity problems, losses caused by some operational mistakes, financial risks of agricultural market, and the non-financial risks such as manpower losses, technological deficiencies, climatic problems put these small businesses, which already have a limited land and capital structure, in a very difficult position. At that point, the most important thing for the manufacturers is to decide to which product to direct the limited resources in terms of production.

The province of Denizli, which is the subject of the study, was founded in six km north of the existing province between 261-245 BC. It exists in the southwest of Turkey. While the province is in the Aegean region due to its geographical location, it is located on an intersection among the Central Anatolia, Mediterranean and Aegean regions. Due to these characteristics, the province has a transition climate. While there is continental climate in the northern and higher regions, the Mediterranean climate is dominant in the southern and lower regions. The population of the province is 950.557 according to the address-based population registration system of 2012 (TUIK 2012). Mainly agriculture, industry and tourism sectors dominate the economy of the province. Denizli, which is the 21st biggest province of Turkey in terms of population, is the 15th province of Turkey with its vegetative production value of 1.965.415.000 TL. 40.4% of the total employment in the province takes place in agricultural sector. The status of the summer and winter vegetables in the province as of 2012 on the basis of cultivated area is given in Table 1.

Table 1. Agricultural Product Data of 2012 in Denizli (TUIK)

No	Product Name	Cultivated Area (Decare)	Production (Ton)	Output (Kg/Da)
1	Tomato (Table)	18,113	59,015	3,258
2	Cucumber (Table)	3,847	7,821	2,033
3	Eggplant	2,524	5,010	1,985
4	Green Pepper	6,866	11,383	1,658
5	Green Beans	5,013	4,154	829
6	Gumbo	2,284	474	208
7	Marrow	545	701	1,286
8	White Cabbage	1,145	2,810	2,454
9	Broccoli	35	70	2,000
10	Spinach	2,641	3,159	1,196
11	Cauliflower	286	500	1,748
12	Carrot	1,900	8,425	4,434
13	Celery	80	160	2,000
14	Lettuce (Heart)	1,408	1,637	1,163
15	Leek	1,622	3,304	2,037

When we look at Table 1, it is observed that a wide range of summer and winter vegetables grow as the transition climate dominates the province. When we check the data of 2008-2012, we see a growth of 25.7% in vegetable output in Denizli. If we use 2012 as a base, 1.4% of vegetable production in Turkey is carried out in Denizli.

At that point, it is very important to determine the level and type of the risks of prices and which product to plant in Denizli where there is a wide range of vegetable gardening. However, the agricultural market is an unsteady and complex, the prices are very ambiguous. The manufacturer usually makes a decision by taking the previous year's prices into consideration. This situation does not reflect the truth for future and misleads the manufacturer. According to Boussard (1999), risk is a notion to be avoided in agriculture. However, it is not very easy to avoid risk. Agriculture insurances are sufficient to cover the losses caused by natural disasters and pests. Of course, the insurance cost must be borne for this.

During the price making process of agricultural products, the role of the manufacturers and therefore costs are usually limited. Because the price of any product of any period is determined by the aggregate supply of that product, not the cost of that period. Due to the structure of the market, when manufacturers specify the product that they will produce the following year, they use the market prices of the current year as base rather than the possessed production facilities. As the output is formed according to the previous year's prices, it is inevitable that there will be instability in agricultural product supply. In other words, the agricultural product, which had a high unit price in the previous season and which earned money to the manufacturer, becomes an appealing product in the following season and the aggregate supply rate increases. This situation causes the decrease on the unit price of the product. The fact that the unit price falls despite the rise on the input costs of the product causes the farmer to incur losses. This case observes very often in agriculture productions. It is named Cobweb theory in Economic literature (Özgüven, 1983).

In the current situation, the agricultural manufacturers decide how much and which product to produce and how large a production area to allocate based on their past experiences. This situation is based on the simple diversification in traditional portfolio approach theory. According to the modern portfolio theory approach, in portfolio selection, an investor tries to determine the optimum portfolio that maximizes the return and that minimizes the risk in deciding which securities to buy in which ratios for the portfolios to be created based on profit and risk as data. While the investors like increase their expected returns, they also like to reduce the uncertainties regarding the profit that they may make. This situation is valid for the manufacturers operating in agricultural sector as well. As in the financial market, the price movements of past periods determine the course of production in agricultural sector as well.

In this study, the purpose is to maintain the availability of portfolio selection for the manufacturer in accordance with risk appetite in the intended risk level by product diversification in agriculture instead of producing single product. Rather than determining a general production policy for the sector, product portfolios were specified for the individual manufacturers, and during this process, the past price data of the last 5 years, not only the previous year, were used. The optimum portfolio model for the financial investment tools in the "Portfolio Selection" article of Markowitz based on mathematical model was applied for the vegetable farmers in Denizli.

A literature review was performed in the following chapter of the study. The mean variance model and methodology were explained in Chapter 3. The evidences were discussed on the 4th Chapter of the study. The results were presented in the last chapter.

2. Literature Review

According to the basic economic theory, individuals try to maximize their benefits. The basic assumption is that the person acts rationally while trying to gain this benefit. By its very nature, the future is ambiguous, and the people or institutions have to make a decision in this atmosphere of uncertainty. In this case, the investors can be classified in three groups according to their characteristics: aggressive, conservative and hybrid. Based on these characteristics of the investors, their attitude towards risk can be grouped as risk-lover, risk-avoider and risk neutral (Cologne, 1992). There are two main portfolio management approaches in financial literature. The first one is the traditional portfolio management approach. This approach was recognized in the financial field by the end of the World War II (Shenoy et. al., 1988). Traditional portfolio management is an approach mostly based on simple diversification. Investors reduce the risks by only increasing the number of the securities without examining the statistical relationships among the returns of the securities constituting the portfolio. The second portfolio management approach is the Modern Portfolio Theory that statistically includes the risk and profit concepts based on mathematical foundation. That the risk cannot be reduced only by portfolio diversification and that the direction and degree of the relationship among the investment tools in the portfolio have an impact on the risk reduction have been revealed with the Mean Variance Model developed by Markowitz (Markowitz, 1952). The main reference point of the model is that the risk-return relationship of the portfolio is important instead of the risk-profit status of each financial asset in the portfolio.

When Harry Markowitz came up with the optimum portfolio concept, which reduces risk by diversification, in 1952, Earl O. Heady proposed that there were two ways to reduce the volatility in his article "Minimization of Volatility and Diversification in Resource Allocation" in agriculture in the same year. First, the resources must be increased. Second, the usage and different use of resources must be changed if the resources are fixed.

In 1956, Rudolf J. Freund solved the diversification problem in a risky and risk-free environment by using the linear programming in a farm in North Carolina. It was observed that very different results in either situation.

In 1967, Freund and Heady researched how the agricultural portfolios could be applied in three different cases in their article "A Re-Examination of the Farm Diversification Problem". They made an analysis according to the portfolio theory suggested by Tobin

(1958). In this study, the implementation was carried out in a risk-free environment, in a risky market and in an environment where there were government incentives and additional limitations.

Stambaugh suggested in a study in 1996 that it was much more efficient to quantify the risk via scientific methods and to measure the value at risk with the industrialization in agriculture.

In 1981, Newberry and Stiglitz studied if price stability can be maintained in agriculture. It was deduced that it was possible to prevent fluctuation, but it was confirmed that the cost would be too high. They said that it was possible to maintain the income stabilization in futures market. It will be much more possible to maintain the income stabilization with the development of finance markets.

In 1990, Rodriguez created a portfolio for the wine makers in Spain by using the efficient portfolio theory of Markowitz. Similarly, Alaejos and Canas utilized the efficient portfolio theory of Markowitz in 1992. They made a study in order to obtain the most fruitful cultivation areas in the intended risk level in Bembezar region.

In 2002, it was suggested in Blank's study that the firms that made a diversification in agriculture firms reduced their risks by 9.4%. In his study between 1999 and 2001, it was presented that diversification in livestock industry reduced the risk by 5.4%.

Libbin, Kohler and Hawkes sought a solution to the diversification problem of the Mexican farmers by using the capital asset pricing model (CAPM) in their article published in 2004. They studied the optimum diversification with lowest risk and highest return for the farmers.

Segovia, Rambaud and Garcia pointed out that it was possible to maintain an efficient portfolio in the intended risk level for the farmers by using the portfolio theory of Markowitz in organic agriculture in Spain in 2005.

3. Methodology and Dataset

3.1 Methodology

Markowitz diversification is to create a portfolio with the first-class assets that have lower correlation than positive correlation in order to reduce the risk without reducing the portfolio returns. Markowitz model is an analytical method considering the correlation of the assets with one another. As the correlation among the assets decreases, the portfolio risk will decrease as well (Karan, 2013). The chance that an investment's actual return will be different than expected. Risk includes the possibility of losing some or all of the initial investment. Different versions of risk are usually measured by calculating the standard deviation of the historical returns of the investment. A high standard deviation indicates a high degree of risk. It is possible for the investor to create a vast number of portfolio in different profit and risk levels. Mean variance portfolio selection optimization model is recognized as the basis of the modern portfolio theory. The purpose is to determine the efficient asset combinations.

In the model, the purpose is to find the portfolio with minimum variance (minimum risk) that provides the targeted return constraint. The mathematical formulation of the model is as follows.

$$\min \sum_{i=1}^{n} \sum_{j=1}^{n} x_i x_j \sigma_{ij} \qquad (1)$$

Constraints:

$$\sum_{i=1}^{n} x_i \mu_i \geq R \qquad (2)$$

$$\sum_{i=1}^{n} x_i = 1 \qquad (3)$$

$$0 \leq x_i \leq 1 \qquad i = 1, 2, ..., n \qquad (4)$$

In the model,

- n represents the number of the existing assets,
- μ_i *i.* represents the expected return of the assets (*i*=1,2,…,*n*),
- σ_{ij} *i.* and *j.* represent the covariance values among the assets (*i*=1,2,…,*n*), (*j*=1,2,…,*n*), (if *i=j*, then, *i.* represents the variance value of the assets),
- R represents the targeted and expected return level,
- x_i *i*. represents the ratio of the assets within portfolio (*i*=1,2,…,*n*),
- x_j *j*. represents the ratio of the assets within portfolio (*i*=1,2,…,*n*).

In the model, x_i represents the decision variable, *i*. represents the ratio of the assets within portfolio. *R* is the targeted return ratio in the portfolio. The variance-covariance values among the assets take place in the objective function. In the mathematical model, the objective function is quadratic and the constraints are linear. The objective function is quadratic and the constraints are linear (Aygören, 2013).

The basic assumptions of the study include the prices of summer and winter vegetables, agricultural incentives, production losses due to natural disasters and climate changes, cultivation costs and all the other non-systematic risk factors. Also, product input-output from another region to the production region is free. Therefore, there is no minimum production condition on any product. Besides, all the products are produced under the farm conditions and in season. Lastly, it is assumed that the manufacturer has cultivated the whole existing field.

3.2 Dataset

The 5-year price data required for the study were obtained from the Turkish Statistical Institute (TUIK). The monthly prices are for May, the first delivery time of the product, until October, the last harvest time for summer vegetables, and for December-March for winter vegetables. 5-year (2008-2012) monthly closing prices were used.

Among these periods, *R* represents the term interest, P_t represents the maturity value and P_{t-1} represents the opening value. Accordingly, the term interests are calculated via the following Formula 5.

$$R = (P_t - P_{t-1}) / P_{t-1} \qquad (5)$$

The average returns for each vegetable as per the seasons were calculated by using the following Formula 6.

$$\mu_i = \frac{\sum_{i=1}^{n} R_i}{n} \qquad (6)$$

The variance-covariance matrices were created by using the vegetable prices in the seasons. The calculated values of summer vegetables are shown in Table 2 and Table 3, and the calculated values of winter vegetables are shown in Table 4 and Table 5.

Table 2. Average Return of Summer Vegetables

	Tomato	Cucumber	Eggplant	Green Pepper	Green Beans	Gumbo	Marrow
Average Return (%)	5.34	2.22	8.31	3.62	2.78	2.60	3.35

Table 3. Variance-Covariance Matrix of Summer Vegetable Returns

	Tomato	Cucumber	Eggplant	Green Pepper	Green Beans	Gumbo	Marrow
Tomato	1574.01	852.68	-167.33	432.80	417.03	-10.40	549.90
Cucumber	852.68	777.06	-53.80	378.21	407.39	-46.69	435.48
Eggplant	-167.33	-53.80	1919.20	715.37	142.23	480.55	-342.19
Green Pepper	432.80	378.21	715.37	1241.07	489.09	189.01	-168.68
Green Beans	417.03	407.39	142.23	489.09	645.35	189.01	-50.73
Gumbo	-10.40	-46.69	480.55	189.01	189.01	455.25	-181.36
Marrow	549.90	435.48	-342.19	-168.68	-50.73	-181.36	1341.61

Table 4. Average Return of Winter Vegetables

	White Cabbage	Broccoli	Spinach	Cauliflower	Carrot	Celery	Lettuce	Leek
Average Return (%)	-0.07	1.53	1.58	0.38	1.77	1.64	1.64	2.49

Table 5. Variance-Covariance Matrix of Winter Vegetable Returns

	White Cabbage	Broccoli	Spinach	Cauliflower	Carrot	Celery	Lettuce	Leek
White Cabbage	98.30	31.02	48.35	-2.51	-5.57	3.91	18.14	84.72
Broccoli	31.02	272.95	82.60	65.93	30.05	6.07	60.50	56.55
Spinach	48.35	82.60	266.64	38.69	3.66	14.91	129.87	249.03
Cauliflower	-2.51	65.93	38.69	305.77	57.60	35.02	-48.45	-78.33
Carrot	-5.57	30.05	3.66	57.60	359.29	-2.32	-33.86	-50.58
Celery	3.91	6.07	14.91	35.02	-2.32	198.50	-5.46	11.77
Lettuce	18.14	60.50	129.87	-48.45	-33.86	-5.46	244.62	173.44
Leek	84.72	56.55	249.03	-78.33	-50.58	11.77	173.44	537.20

As shown in the data in the Variance-Covariance tables, while some values are positive, some values are negative. In other words, while some of the vegetable returns increase, some of them decrease within the same period. As a result, the portfolio risk may be lower than the risk of each vegetable.

4. Evidence

Mathematically denoted Markowitz mean variance selection model was resolved by using the GAMS software interface. GAMS software is a program that involves resolving software developed for different types of problems in order to use for the solution of optimization problems in especially Operational Research field. The model is a non-linear quadratic problem, and CONOPT, which was developed for the solution of the non-linear problems, was chosen as the resolving software (https://www.gams.com/help/index.jsp?topic=%2Fgams.doc%2Fsolvers%2Fconopt%2Findex.html).

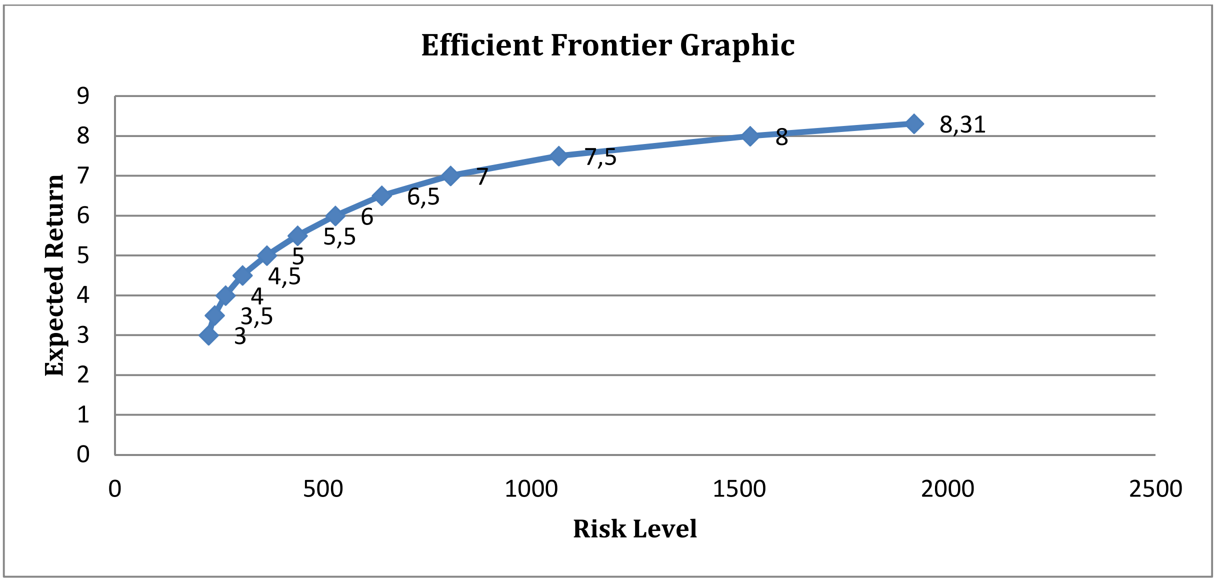
When the mean variance model is resolved for the different expected return levels, efficient portfolios will be obtained for each return level. The curve that unites the targeted return levels and the efficient portfolios of those return levels is called "efficient frontier". Risk levels are categorized 3 groups namely low, medium and high.

Table 6. Expected Return and Risk Levels of Summer Vegetables

Portfolio No	Risk Group	Expected Return	Risk Level
1	low	3	224.49
2		3.5	239.57
3		4	265.15
4		4.5	306.42
5		5	364.23
6	medium	5.5	438.58
7		6	529.47
8		6.5	640.35
9		7	806.17
10		7.5	1065.81
11		8	1525.33
12	high	8.31	1919.20

Each production portfolio on the efficient frontier consisting of different ratios for summer vegetables is an optimum portfolio for different risk levels. These are the portfolios that have the lowest risk in a specific return level or the highest risk in a specific risk level. When we look at Table 6, the expected return of the manufacturer in different risk levels will be between 3% and 8.31%. There are 12 portfolios within this range. When the manufacturer plans a production with low risk level, the expected return will be 3%. As the risk level to be borne increases, the expected return will rise to 8.31% in high risk level.

Figure 1. Efficient Frontier Graphic for Summer Vegetables



The portfolio risk and the returns can be viewed through the graphic in Figure 1. When the risk levels to be borne for each return were combined on the graphic, the efficient frontier graphics were obtained for the data ranges. The variance values of the portfolio represent the portfolio risk. The manufacturer can invest on any portfolio according to the risk approach, in other words, according to the risk appetite, on the efficient frontier.

Table 7. Production Ratio of Summer Vegetables in Optimum Portfolios

Risk Group	Tomato	Cucumber	Eggplant	Green Pepper	Green Beans	Gumbo	Marrow	Total
low	0%	11%	4%	4%	11%	48%	22%	100%
	4%	4%	10%	2%	17%	40%	24%	100%
	9%	0%	17%	0%	18%	33%	24%	100%
	13%	0%	24%	0%	16%	25%	24%	100%
	17%	0%	31%	0%	13%	17%	23%	100%
medium	20%	0%	38%	0%	11%	9%	22%	100%
	24%	0%	45%	0%	8%	1%	22%	100%
	30%	0%	51%	0%	0%	0%	18%	100%
	34%	0%	60%	0%	0%	0%	6%	100%
	27%	0%	73%	0%	0%	0%	0%	100%
	10%	0%	90%	0%	0%	0%	0%	100%
high	0%	0%	100%	0%	0%	0%	0%	100%

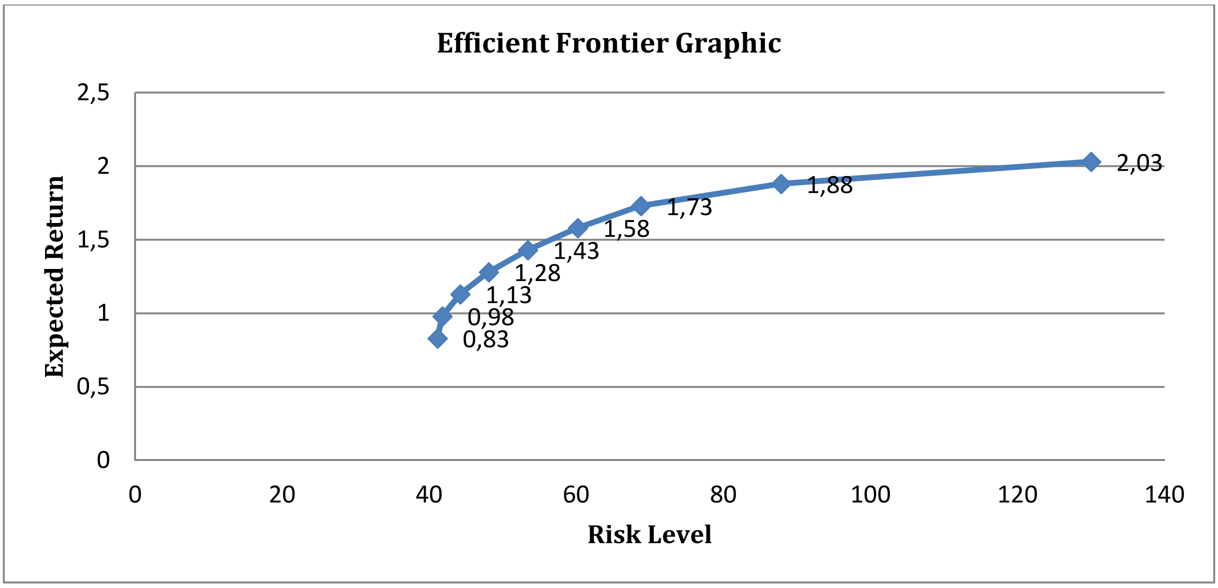
When we look at Table 7, the ratio of the summer vegetables that the manufacturer will produce on the entire land that he owns for each risk level is seen. In minimum risk level, the manufacturer must not plant tomato, and the cultivation area to be allocated for cucumber must be 11%, for eggplant must be 4%, for green pepper must be 4%, for green beans must be 11%, for gumbo must be 48% and for marrow must be 22% in Denizli. For the manufacturers with medium-level risk appetite, these ratios must be 20% for tomato, 38% for eggplant, 11% for green beans, 9% for gumbo and 22% for marrow respectively. If we look closely, the manufacturers with medium risk level must not produce cucumber and green pepper. The manufacturers with the highest risk perception must produce only eggplant. The reason is that the product with the highest average return among the summer vegetables is eggplant. As the risk perception of the manufacturer increases in summer vegetables, while the cucumber, green pepper, green beans, gumbo and marrow production in their portfolio decreases, the eggplant production ratio significantly increases. In different risk levels, there are product groups where there is no production at all. However, by assumption, there will be no situation like not satisfying the demand of the consumer as products can enter the region from other territories.

Table 8. Return and Risk Levels of Winter Vegetables

Portfolio No	Risk Group	Expected Return	Risk Level
1	low	0.83	41.11
2		0.98	41.78
3		1.13	44.21
4		1.28	48.08
5		1.43	53.41
6	medium	1.58	60.19
7		1.73	68.78
8		1.88	87.84
9		2.03	129.99
10		2.18	204.78
11		2.33	325.23
12	high	2.48	521.07

Considering the average return of winter vegetables, the expected return of the manufacturer in different risk levels will be between 0.83% and 2.48%. There are 12 portfolios in these return and risk levels.

Figure 2. Efficient Frontier Graphic for Winter Vegetables



In Figure 2, the optimum production portfolios in efficient frontier with different risk levels for winter vegetables can be seen. The manufacturer may choose to invest on each point on the efficient frontier according to the risk appetite.

Table 9. Production Ratio of Winter Vegetables in Optimum Portfolios

Risk Group	White Cabbage	Broccoli	Spinach	Cauliflower	Carrot	Celery	Lettuce	Leek	Total
low	39%	2%	0%	12%	11%	18%	17%	0%	100%
	32%	4%	0%	10%	13%	21%	20%	0%	100%
	25%	6%	0%	9%	15%	23%	20%	2%	100%
	18%	7%	0%	8%	17%	26%	20%	5%	100%
	11%	9%	0%	7%	18%	28%	20%	7%	100%
medium	4%	10%	0%	6%	20%	30%	20%	9%	100%
	0%	12%	0%	2%	22%	32%	19%	12%	100%
	0%	8%	0%	0%	25%	31%	10%	25%	100%
	0%	2%	0%	0%	29%	28%	0%	42%	100%
	0%	0%	0%	0%	29%	12%	0%	59%	100%
	0%	0%	0%	0%	22%	0%	0%	78%	100%
high	0%	0%	0%	0%	1%	0%	0%	99%	100%

In Table 9, the ratio of winter vegetables that the manufacturer will produce in the intended risk level can be seen. Accordingly, the ratio of the cultivated areas that the manufacturer will allocate in the low risk level must be 39% for white cabbage, 2% for broccoli, 12% for cauliflower, 11% for carrot, 18% for celery and 17% for lettuce. In this level, the spinach and leek production is not rational for the manufacturer. In the medium risk level, the production ratio is 4% for white cabbage, 10% for broccoli, 6% for cauliflower, 20% for carrot, 30% for celery, 20% for lettuce and 9% for leek. Lastly, in the highest risk level, the manufacturer will generate the maximum return in 1% carrot and 99% leek cultivation. If we look closely, as the risk level increases, while the white cabbage and cauliflower cultivation significantly decreases, the carrot and leek cultivation area increases. Also, according to the results obtained from the model, the spinach production is not rational independently from the risk.

5. Conclusion and Recommendation

In this study conducted within the frame of modern portfolio theory, a production plan was put forward for the agricultural manufacturers via determining the optimum production portfolios. A production plan was prepared for the manufacturers at the end of the examinations made on a product group consisting of the vegetables which are commonly produced in Denizli. The majority of the manufacturers operating in agricultural production make decision based on experiences and current year's prices rather than scientific resources in both the selection and use of production facilities and selection of the product to be produced. This situation results to the detriment of the manufacturer who already has limited facilities. According to the analyses put forward with this model, production must be planned for the realization of profit motive, which is one of the most important expectations of manufacturers, and for the sustainability of this situation, and scientific methods must be used in this planning. The mathematical model created based on Markowitz's "Modern Portfolio Theory" was resolved by using the GAMS software interface and optimum results were obtained. From this point of view, for the businesses operating in the province of Denizli, a production plan was put forward for the following year by analyzing the past 5-year prices of the selected products on a monthly basis, and it was determined how to distribute the limited production facilities to which product groups in different risk levels; in other words, the product portfolios were specified.

At the end of the study, these can be determined regarding the production of summer vegetables in Denizli; the risk-free manufacturers can be recommended with gumbo, marrow, green beans and cucumber cultivation respectively according to the production volume. As the risk level increases, the most important product for the manufacturers will be eggplant. In fact, the manufacturers must direct all the production facilities, which they have at maximum risk, to this product. Green pepper is an uneconomical product for all the risk levels in terms of production. Lastly, while tomato is a product, the ratio of which must be initially increased within the production portfolio as the risk level increases, its ratio will have to be reduced in high risk levels. For winter vegetables, white cabbage, celery, lettuce and cauliflower production respectively constitute the most suitable production portfolio for manufacturers in low risk level. As the risk appetite of manufacturers rises, it will be reasonable to direct the production facilities to leek and carrot. In maximum risk level, the ratio of the portfolio must be leek at 99%. Spinach is a product which is irrational to produce in all risk levels.

The optimum production portfolios in different risk levels were specified for summer and winter vegetables in Denizli by analyzing the data. This model can be applied for all the agricultural products in different regions. In the selection of the products to be cultivated, manufacturers can create portfolios that will provide maximum benefit in any risk level by utilizing the limited production facilities thanks to this model.

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