Influence of different production methods on economic results of greenhouse vegetable production

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Abstract

The subject of research in this paper are investment models created by analyzing the characteristics of greenhouse vegetable production in Bosnia and Herzegovina. Five models were compiled based on data from family farms engaged in the production of vegetables in a protected area in partially controlled conditions. The main goal is to examine changes in the amount of economic results depending on the impact of sowing/planting, type and utilization of protected space in vegetable growing. The economic viability of the investment was determined using net present value, the internal rate of return, discounted payback period and profitability index. Model 4 (growing two vegetable species per year in high plastic tunnels) had the highest net present value (NPV = USD 125 322.18), while model 3 (growing two vegetable species per year in semi-high plastic tunnels) had the most favorable values of the internal rate of return (63.38%), discounted payback period (1.66 years) and profitability index (4.69). Justification of investments in risky business conditions indicates model 4 as the most favorable solution. Since the indicators used yielded conflicting conclusions about which model is the best solution, the ranking procedure was performed using the VIKOR method. Research results indicate that the model 3 represents the best compromise solution compared to the other models used.

Keywords: Investment analysis. VIKOR method. Decision making process.

1. Introduction

According to the Food and Agriculture Organization (FAO, 2019), the areas under vegetables in the world are constantly increasing in the period from the year of 2008 to 2017 and in 2017 this increase amounted to 19.40%, compared to the beginning of the observed period. The production of vegetables in a protected area, both in relation to other branches of plant production and in relation to the production of vegetables in the open field, brings numerous benefits to agricultural producers. It enables optimal use of production resources, but also growing vegetables in the off-season. The use of protected space reduces the risk of the impact of various adverse climate conditions throughout the year. It is also possible to increase the income of an agricultural producer as well as to overcome the restrictions concerning the land area required for horticultural production (Kuswardhani et al. 2014).

The productivity of vegetable species depends on the efficient use of both material and human resources used in the production process (Adeoye et al. 2016). Productivity also depends on the level and quality of production, the possibility of capitalization, but also production costs, which should be as low as possible (Pop et al. 2013). Determining production costs, achieved production results, and the selection of an appropriate production alternative are important activities that lead to maximizing profits on the farm (Oruc and Gözener, 2020). Production in a protected area significantly increases productivity, but also the quality of the finished product, creating, in an artificial way, optimal conditions for the growth of cultivated crops (Jadhav and Rosentrater 2017).

Unlike the production of vegetables in the open field, this type of production requires initial investments, the amount of which depends on the type of protected area and the level of control of microclimatic conditions. Even in the situation of plastic tunnels with natural ventilation without additional devices for microclimate control, investments involve the allocation of significant funds. Considering the above mentioned, and the fact that the invested funds will be captured for a significant period of time, it is necessary to make an economic assessment of such an investment and, based on the results obtained, to make decisions on its implementation.

The economic evaluation of investments in agricultural production has been the focus of research by numerous authors (Bodiroga et al. 2018; Navyatha et al. 2015, Sredojević et al. 2011, Tozer, 2009, Uzunöz and Akcay, 2006).

The process is essentially possible in two ways, but it is advised to take into account the time value of money, especially when it comes to projects that consider cash flows over a longer period of time.

The economic validity of investing in a protected area depends on a number of organizational, technical, technological factors, etc. In this regard, the aim of this paper was to show what kind of impact selected factors through five investment models - the type and utilization of protected space, sowing/planting structure, etc. - have on economic indicators of investment in the given conditions.

2. Literature Review

Numerous authors have analyzed the costs and production results achieved in the vegetable production process.

Thus, Bodiroga and Sredojević (2018) analyzed the economic and financial justification of investments in greenhouse production under different financing conditions using the production technology characteristic of the analyzed area. They applied dynamic indicators to analyze the economic viability of the investment (net present value, internal rate of return, payback period, etc.), while conducting a risk analysis using the Certainty equivalent method. The applied methods indicate that the investment in the greenhouse is justified both in the analyzed methods of financing and in risky business conditions. The liquidity problem can occur in years when maintenance costs are rising due to the replacement of foil on greenhouses, which can be solved by accumulating funds from the previous exploitation period.

Testa et al (2014) analyzed the profitability of cherry tomato production in greenhouses without heating. The authors point out that for adequate positioning on the market, it is necessary to analyze the costs and profitability of production. Based on the conducted research, the authors state that variable costs (78.1%) have a dominant share in the total production costs (USD 247,121.67 ha), and that labor costs have a significant impact on the profitability of production. The authors state a small net profit in production (0.01 USD kg^{-1}), and that even a slight reduction in yield or selling price can lead to a negative financial result. They see the association of agricultural producers as a solution to problems such as limited sales to local and regional markets, the absence of an agreed sales price, a low degree of mechanization and the like.

Mohamad et al (2017) analyzed the economic feasibility of producing organic vegetables (tomatoes and peas) and fruits (strawberries) in different production systems. In all production systems, tomatoes and peas had a positive gross margin. In the selling price of organic tomatoes, the incentive (premium) participates with 39%. The authors conclude that due to the lower realized yield compared to conventional production, a stimulus (premium) is necessary for profitable production.

Mariyono (2018) points out vegetable production as a sector whose greater representation could increase the income of poor producers in rural areas. Analyzing vegetable production, it is concluded that the volume of production and market prices have a significant impact on profits, but that blue eggplant and large chili peppers from cultivated species were only on the verge of profitability (break-even point) with a decrease of 40%. Variables such as age of farmers, education, number of family members, location and existing customers did not influence the choice of farmers to switch from subsistence to commercial production, while variables such as experience in vegetable production, number of plots and their distance from the market, had significant negative impacts.

The application of MCDM methods (MCDM - Multi-criteria Decision Making) is of great importance when it comes to decision-making in vegetable production. Thus, for example Rezaeiniya et al. (2012), state that the decision on the choice of greenhouse location can be a multi-criteria problem because numerous, often conflicting factors can affect it (access to electricity, opportunities to increase production area under greenhouses, availability of raw materials, land lease costs, availability of specialized labor, etc). The authors combined the ANP and COPRAS-G method to break down the problem into simpler parts and select the appropriate alternative.

Then Vico et al (2017) used in their research two types of criteria of economic effectiveness and two types of criteria of economic efficiency, as well as three indicators of nutritional quality for ranking different technologies of winter lettuce cultivation. Using two methods of multi-attribute decision-making, they ranked four different technologies for growing winter lettuce in a protected area. They presented the ranking results based on both methods used, SAW and TOPSIS and three scenarios that differ by weighting coefficients. Production technology involving mulch + agrotextile has proven to be the best alternative when using both methods and all scenarios. The SAW method proved to be more sensitive to changes in weight coefficients compared to the TOPSIS method.

3. Materials and Methods

The research was conducted on the teritory of the Bosnia and Herzegovina (Area of Bijeljina) on a sample of 32 family farms. During the three years (2016-2018), data were collected on the type of individual crops and achieved economic results in the production, but also the type of protected area, the use of protected area, and the like. The data obtained were used to create 5 investment models, cash flow projection and determine business results for each of the investment alternatives. For the economic evaluation of the investment, the indicators were used: net present value of investments, internal rate of return, Discounted payback period and profitability index.

Assuming that annual incomes and expenses are incurred at the end of the year and taking into account all individual incomes and expenses during the operating period, the net present value of investment models is calculated using the form:

$$NPV = \left(\frac{CF_1}{(1+i)^1} + \frac{CF_2}{(1+i)^2} + \cdots \frac{CF_n}{(1+i)^n}\right) - A_0 \quad [1]$$

Where is:

$CF_1, CF_2, ... CF_n$- net cash flow in the first, second, ... n-th year of the exploitation period

A_0- total investment

i- discount rate

The internal rate of return was calculated by the interpolation method using the expression:

$$i_e = i_1 - NPV_1 \frac{i_2 - i_1}{NPV_2 - NPV_1} \quad [2]$$

Where is:

i_1- selected discount rate at which the net present value of $NPV_1>0$

i_2- selected discount rate at which the net present value $NPV_2<0$ and $i_2> i_1$

The Discounted payback period is determined by applying the method of linear interpolation using the form:

$$k = t_1 - \frac{NPV_{t1}}{NPV_{t2} - NPV_{t1}} \quad [3]$$

Where are:

t_1 and t_2 are two selected trial periods for which net present values are calculated for which $t_1 < t_2$ and NPV_{t1} is negative and NPV_{t2} is positive or >0

The profitability index was determined using the form:

$$I_p = \frac{NPV}{A_0} \quad [4]$$

In each of the models, the justification of the investment in risky business conditions was checked using the scenario analysis method. The scenario analysis takes into account the key risk factors of a project, the sensitivity of such a project to their changes as well as the probability of such a change (Brzaković et al. 2016). The expected net present value in this procedure was calculated using the form:

$$EV = \sum_{i=1}^{n} V_i P_i \qquad [5]$$

where is:

V_i- net present value of individual outcome-scenarios

P_i- probability of realization of individual outcomes-scenarios

The standard deviation and the coefficient of variation in the scenario analysis procedure were determined using the following forms:

$$\sigma = \sqrt{\sum_{x=1}^{n} (V_i - EV)^2 P_i} \qquad [6]$$

$$CV = \frac{\sigma}{EV} \qquad [7]$$

Given that investment valuation indicators favored individual investment models differently, a compromise ranking was made and the best alternative was selected using the VIKOR method (Zheng and Wang 2020, Gao et al. 2019, San Cristóbal 2011). The value of the Qi indicator on the basis of which the ranking list was created was determined using the expression:

$$Q_i = v \cdot QS_i + (1 - v) \cdot QR_i \qquad [8]$$

Where is:

v- weight strategies to meet most criteria which can be in the range of 0-1, taken 0.5 as a compromise between maximum group benefit and minimum regret

QS_i- measure of deviation expressing the requirement for maximum group benefit

QR_i- measure of deviation which expresses the request to minimize the maximum distance of an action from the ideal.

QS_i and QR_i values were calculated using the expressions:

$$QS_i = \frac{S_i - S^*}{S^- - S^*} \qquad [9]$$

$$QR_i = \frac{R_i - R^*}{R^- - R^*} \qquad [10]$$

Where is:

S^*-min S_i, and S^-maxS$_i$ and R^*-min R_i, and R^- maxR_i, while the values for the pessimistic solution (S_i) and the expected solution (R_i) were calculated using the expressions:

$$S_i = \sum_{i=1}^{n} w_i(x_i^* - x_i)/(x_i^* - x_i^-) \qquad [11]$$

$$R_i = max[w_i(x_i^* - x_i)/(x_i^* - x_i^-] \qquad [12]$$

where:

x_i^* represents the highest and x_i^- the minimum value of a certain criterion in all observed alternatives (vegetable production models), while x_i denotes the values of all other criteria in the observed sequence.

The values of w_i represent weight coefficients which give the selected criteria a certain significance, that is relative weight.

4. Results and Discussions

Bijeljina is one of the leading regions when it comes to vegetable production in Bosnia and Herzegovina. The results of the survey show that there are two types of protected space in the study area: semi-high tunnels of 100 m^2 and high tunnels of 400 m^2, and different construction solutions. In both cases there are greenhouses without heating. Although producers are familiar with modern vegetable production systems, high investments in them, low selling prices of vegetables, and thus a higher risk prevents them from modernizing the existing method of production. The holdings surveyed produce a maximum of two vegetable species per year in a protected area where the main crop is cucumber, then bell pepper, and tomatoes are in third place in terms of representation. The reason for the largest production of these vegetable species is in their economic validity. For the mentioned vegetable species, the following table shows the cost structure and the achieved production results.

Table 1: Calculation of the production of the most common types of vegetables (USD ha^{-1})

Indicator	*Tomato*	*Bell Pepper*	*Cucumber*
A. Production Value	92 596.62	59 714.16	55 036.97
B. Production Costs (1+2+3+4+5)	52 313.54	44 320.86	38 601.66
1. Cost of materials	23 007.06	18 282.50	12 894.85
Planting material	7 021.71	6 654.64	4 025.94
Fertilizer	8 655.77	5 825.77	5 328.45
Pesticides	5 150.84	3 635.19	1 373.56
Other material	2 178.74	2 166.90	2 166.90

2. *Machinery operating costs (services of other persons)*	603.89	603.89	603.89
3. *Depreciation and Interest expenses*	9 176.78	9 176.78	9 176.78
4. *Labor costs*	18 874.55	15 606.44	15 144.64
5. *Other costs (irrigation, etc)*	651.26	651.26	781.51
C. Selling expenses	4 475.90	1 385.40	1 302.51
D. Total costs (B+C)	56 789.44	45 706.26	39 904.17
E. Financial result (A-D)	35 807.18	14 007.90	15 132.80
F. Cost per unit (USD kg^{-1})	0.43	0.37	0.32

**according to the exchange rate for 13.09.2021, 1EUR = 1.1841 USD*
Source: authors' survey

The production value was determined by multiplying the average yield by the average market price. The largest share in the costs of materials in the production of tomatoes and cucumbers had the fertilizer, while in the case of bell peppers, that position belonged to the costs of planting material. Cucumber hybrids that are most often used for production in a protected area are Opalit and Monolit, in tomatoes Rally and Pink Rock, and in bell peppers Vedrana, Barbie, Blondy, Blancina, etc. Other material costs included one-year elements of the irrigation system, mulch foil, binding rope and the like. The costs of mechanization were determined under the assumption that the services of other persons are used for land preparation, because it is not profitable to procure our own tillage machines for the planned production areas. Depreciation costs included depreciation of greenhouses and irrigation systems. Sales costs were determined under the assumption that sales are made on the green market, which is the most common way of selling in the analyzed area. They included the costs of packaging for packaging and transport (crates, mesh and nylon bags), removal, transport of goods and fees for sale at the market. It can be seen from the table that the lowest costs per kilogram of cucumber produced, then bell peppers, while tomatoes with 0.43 USD kg^{-1} had the highest value. However, the average selling price was higher than the cost per kilogram for both tomatoes ($ 0.70) and peppers ($ 0.47) and cucumbers ($ 0.44) and thanks to the above, the financial result was achieved as in table 1.

When it comes to the subsequent crops, capia-type peppers are most often produced, then there are lettuce, spinach and green beans. According to the obtained results, four of the investment models that were created implied the type of protected space and the method of production that is represented in practice, while the fifth model implied an investment alternative in which the protected space was used in full. Each of the investment models had common assumptions:

- The investment object includes unheated greenhouses with a total area of 4 000 m^2
- Four family members are fully engaged in the vegetable production process
- Expiration date of foil on greenhouses is four years
- Cash flows are determined on the assumption that cash revenues and expenses occur at the end of the year
- The investment was financed by combining (in equal amounts) its own funds and funds obtained from loans from commercial banks. The discount rate is determined as a weighted average of the interest rate on the used credit funds and the rate on the funds from the equity of the producer / investor, as an opportunity cost (3,84%)
- Both calculations and cash flows are determined on the assumption that subsidies are not used, because the amount can vary significantly depending on the available funds at both the state and local level.
- Since it is not profitable to invest money in the necessary mechanization with an investment of this volume, it is planned to use the services of other persons.
- Model 1 and model 3 involve investment in 40 semi-high tunnels with a total area of 4 000 m^2 while investment in models 2,4 and 5 involves the purchase of 10 high tunnels of the same total area.

Individual assumptions for investment models:

Model 1

- The annual production cycle includes the cultivation of 1 vegetable crop per year by growing tomatoes on 50% of the area under the protected area and cucumbers on the other 50%.
- Cucumber is planted from 15.03-20.03 and remains in the protected area until 01.08-15.08.
- Tomatoes are planted from 01.04-05.04, while the harvest of plants is done in the period from 01.08-15.08.

Model 2

This model has the same space utilization as well as the time of planting and harvesting vegetable crops while the difference is in the type of protected space.

Model 3

- The annual production cycle involves the cultivation of two vegetable species in such a way that 50% of the area under the protected area is planted with cucumber, and then lettuce, and the other 50% of the area with tomatoes, and then spinach.
- Cucumber is planted from 15.03-20.03, the plants are harvested from 01.08-15.08, and then the lettuce is planted, which remains in the greenhouses until 30.11.
- Tomatoes are planted from 01.04-05.04, grown in greenhouses until 01.08-15.08. After that, spinach is sown in the period from 01.09-15.09, while the harvest is done around 15.01.

Model 4

This model differs from model 3 only when it comes to the type of protected space. It involves same production of vegetables but in high tunnels.

Model 5

- The annual production cycle includes the cultivation of three vegetable species per year (high tunnels) by growing tomatoes, green beans and spinach on 50% of the area, and cucumbers, capia-type peppers and lettuce on the other 50% of the area.
- Cucumber is planted from 15.03-20.03, the plants are harvested until 15.07, then the capia-type peppers are planted and grown until 15.11. After that, lettuce is planted and grown in greenhouses until 01.04.
- Tomatoes are planted from 01.04-05.04, the harvesting of plants is done until 15.07, then green beans are planted and grown until 01.11, and the third crop is spinach, which is planted after this period and it remains in a protected area until 10.03.

Considering that the type of protected area and the number of cultivated crops differ in the models used, the amount of investment is different, which consists of investments in investment facilities, irrigation equipment and permanent working capital (Table 2).

Table 2: Structure of investments in the observed models (USD)

Investment model	*Investment in facilities*	*Investments in irrigation equipment*	*Investments in permanent working capital*	*Total investment*
Model 1 *Model 3*	15 137,89	1 008,02	6 649,91	22 795,82
Model 2 *Model 4*	33 538,02	1 008,02	6 990,93	41 536,97
Model 5	33 538,02	1 008,02	5 480,01	40 026, 06

Source: authors' survey

Investments in facilities consist of the costs of metal construction, foil for greenhouses, installation, painting of greenhouses, transportation and the like. Investments in permanent working capital are determined by the method of the number of days of the technological process of production, while investments in irrigation equipment include the costs of perennial elements of this system (pumps, alkaten pipes, taps, couplings, semi-couplings, etc.). It can be seen from the table that the lowest investments are required by models 1 and 3, then by model 5, while the largest amount should be set aside for investing in high tunnels of the mentioned area. Taking into account the above data on the amount of investment, but also data are projected on average income, costs and yields of individual crops obtained by the survey, revenues and expenses for the used models and then the net cash flow is determined (Table 3).

Table 3: Net cash flow for the observed investment models (USD)

Years	*Net cash flow by model*				
	Model 1	Model 2	Model 3	Model 4	Model 5
0.	-22 795.82	-41 536.97	-22 795.82	-41 536.97	-40 026.06
1.	11 357.89	14 371.58	14 692.22	18 692.94	16 763.84
2.	10 874.77	13 760.02	14 067.21	17 897.49	16 050.49
3.	11 711.93	14 819.65	15 150.22	19 275.74	17 286.50
4.	7 966.87	8 879.00	11 514.03	13 476.19	11 423.96
5.	12 729.08	16 106.34	16 465.88	20 949.32	18 787.37
6.	12 801.31	16 197.16	16 559.19	21 067.46	18 893.31
7.	11 353.15	14 365.52	14 686.07	18 685.06	16 756.78
8.	8 564.84	9 635.87	16 404.47	14 460.66	12 306.82
9.	12 322.93	15 591.66	11 823.46	20 279.89	18 187.02
10.	26 134.45	38 837.08	29 632.28	43 369.82	39 835.28

Source: authors' survey

The data given in the table indicate that all models have a positive net cash flow during the observed exploitation period with the lowest values during the fourth and eighth year, which is a consequence of the replacement of foil on greenhouses. The final value of the investment is added to the income in the last year of the observed period and it is calculated as the sum of the unamortized value of the facility and equipment from the value of permanent working capital. After defining the net cash flows, the assessment of the economic validity of each of the investment models was determined, using the previously mentioned indicators for that purpose (Table 4).

Table 4: Indicators of economic justification of investments in the observed models

Investment model	*NPV (USD)*	*IRR (%)*	*PBP (year)*	I_p

Model 1	78 086.40	48.50	2.17	3.43
Model 2	88 147.48	32.43	3.22	2.12
Model 3	106 882.92	63.38	1.66	4.69
Model 4	125 322.18	43.49	2.40	3.02
Model 5	109 200.78	40.10	2.58	2.73

Source: authors' survey

It can be seen in the table that the indicators used indicate that all models have economic validity, because the net present values are positive, internal rates of return are lower than the calculated interest rate, Discounted payback period is shorter than the observed exploitation period and profitability index is higher than 1. There are significant differences between the achieved values of the indicators. Investments in Model 4 had the highest net present value, while the internal rate of return, discounted payback period and profitability index had the most advantageous values when investing in Model 3.

The achieved values of cash flow in practice often digress from the projected results due to a number of factors that have an influence on them. Having in mind the above mentioned, it is necessary to take into account the risk of this type when assessing the investment and after its quantification to make a decision on economic validity. As one of the factors are increasing variations in entry prices that lead to an increase in the risk faced by farmers. (Adanacioglu and Yercan, 2012). Risk consideration in practice is very rare and if there is any, pessimistic and optimistic variants are most often presented during the risk analysis, which try to present the results in extreme conditions (Sojkovà and Adamičkovà 2011). Accordingly, the risk analysis of the investment models used was conducted using the scenario analysis method, where the change in the values of key variables was observed through three possible scenarios. The key variables are: the amount of investment, income from investments during the exploitation period and expenses that occur during the exploitation period. The most probable scenario is the one in which there are no changes in the stated parameters with a probability of realization of 50%. The optimistic scenario assumes an improvement in the value of selected parameters in such a way that the amount of investment reduces by 15%, expenses during the exploitation period by 10%, and that income increases its value by 5%. Deterioration of the value of selected parameters is predicted in the pessimistic scenario, in such a way that investments increase their value by 20%, the expenses during exploitation by 15% and that income from investments reduces its value by 10%. It is predicted that the probability of realization of the optimistic and pessimistic scenario is equal and amounts to 25% (Table 5).

Table 5: Risk analysis by scenario analysis method

Indicator	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*
The most likely scenario NPV (USD)	78 086.40	88 147.48	106 882.92	125 322.18	109 200.78
Optimistic scenario NPV(USD)	107 173.97	121 990.43	143 744.36	167 204.06	157 035.71
Pessimistic NPV(USD)	29 065.52	31 658.01	44 425.64	54 816.03	28 990.08
Expected NPV(USD)	73 103.08	82 485.85	100 483.96	118 166.11	101 106.84
Standard deviation	28 061.54	32 435.28	35 692.75	40 374.41	45 988.82
CV	0.38	0.39	0.36	0.34	0.45

Source: authors' survey

The data in the table indicate that the producer will have an economically justified investment regardless of the chosen production model, even in risky business conditions, because the expected net present values remain positive. The investment in Model 4 had the highest expected net present value and the lowest value of the coefficient of variation, and, taking this indicator into account, it can be considered the most favorable solution.

In a situation when the used criteria are contradictory, as well as when there may be different interests of the subjects conducting the decision-making process, it is necessary to find a compromise solution by applying the method of multi-criteria decision-making (Brožovà, 2004). Since the indicators used favor different models used in the further research, a multicriteria compromise ranking procedure (VIKOR) was conducted in order to select a compromise solution with maximum benefit and minimum regret. The used models were ranked using the following 6 criteria:

- Investment amount (K_1)
- Net present value (K_2)
- Internal rate of return (K_3)
- Discounted payback period (K_4)
- Profitability index (K_5)
- Expected net present value (K_6)

Therefore, the starting matrix was of the order of 5x6, and then for each of the models used, its distance from the ideal value was determined, i.e. the Q_i indicator was calculated. The ranking was conducted through three scenarios in which different values of weight coefficients were used. The scenarios show the different wishes of the investors. Thus, the first scenario was created for an investor to whom all the criteria used are equally important, and the weighting coefficients, which have the task of presenting the importance of the criteria (Triantaphyllou and Sánchez 1997), were equal to:

$$w_1 + w_2 + w_3 + w_4 + w_5 + w_6 = 0.167$$

The second scenario was created for an investor whose economic effect will be given priority over risk:

$$w_2 = w_3 = w_5 = 0.25 \quad w_1 = w_4 = w_6 = 0.083$$

The third scenario corresponds to the investor who gives more importance to less risky investments, i.e. those investments that require less investment and faster return on funds, so the weighting coefficients are formed accordingly:

$$w_2 = w_3 = w_5 = 0.083 \quad w_1 = w_4 = w_6 = 0.25$$

In accordance with the above mentioned, investment models are ranked in all three scenarios, which is shown in Table 6.

Table 6: Ranking list of investment projects according to different scenarios

Investment model	*Scenario 1*	*Scenario 2*	*Scenario 3*
	Qi	*Qi*	*Qi*
Model 1	0.76	0.80	0.73
Model 2	1.00	1.00	1.00
Model 3	0.00	0.00	0.00
Model 4	0.71	0.41	0.72
Model 5	0.74	0.61	0.74

Source: authors' survey

The results shown in the table indicate that investment model 3 is best ranked according to all scenarios used, while the last position belonged to investment in model 2. In order for such a ranking list to be accepted as final, it is necessary to fulfill certain conditions (Chatterjee and Chakraborty 2016). First, it is necessary that there is an acceptable advantage that is determined for (v = 0.5) using the expression:

$$Q(A_{II})-Q(A_I)\geq DQ \qquad [13]$$

Where:

AII- second-ranked alternative

AI- first-ranked alternative

DQ = 1 / m-1

m-number of alternatives

The second condition implies the existence of acceptable stability in decision-making that will exist if the first-ranked alternative retains its position with a change in the "v" value, ie fulfills one of the following conditions:

- The first-ranked is when QRi values are taken into account
- The first-ranked is when QSi values are taken into account
- The first-ranked is according to Qi values when v = 0.25 and when v = 0.75

Considering that the difference between the Qi values of the second-ranked and first-ranked alternatives is higher than the DQ in all scenarios, the first condition is fulfilled. Investment model 3 is also ranked first when it comes to QSi values, thus fulfilling the second condition, and model 3 remains the best ranked model (Table 7)

Table 7: Ranking list of investment projects (QSi values)

Investment model	*Scenario 1*	*Scenario 2*	*Scenario 3*
	QSi	*QSi*	*QSi*
Model 1	0.52	0.59	0.46
Model 2	1.00	1.00	1.00
Model 3	0.00	0.00	0.00
Model 4	0.41	0.40	0.43
Model 5	0.62	0.61	0.62

Source: authors' survey

5. Conclusion

Vegetable production in a protected area has economic validity when performed in a protected area without heating in the way defined by the investment models. Although all investment models have economic validity according to the indicators used, the type of protected area as well as the number of cultivated vegetables had a significant impact on the achieved production results. By investing in high tunnels and producing two vegetable crops per year (model 4), a larger accumulation of funds during the exploitation period is achieved in relation to semi-high tunnels, as well as the cultivation of a smaller number of crops. The same choice between the used models is indicated by the analysis of economic validity in risky business conditions. On the other hand, when observing Discounted payback period, the amount of invested funds as well as the realized net present value per unit of investment, the best results have investments in semi-high tunnels and cultivation of two crops per year (model 3). When all the criteria are taken into account with equal impact on the selected result (scenario 1), the investment in model 3 proves to be the best compromise solution. Also, the same investment is best ranked in the other two scenarios with different impact of the criteria used on the ranking results. Although model 5 implies full utilization of space during the year, it did not prove to be the most economically viable solution. The reason for this is in the fact that it requires a shorter period of growing the main crop in the greenhouse compared to other models that achieves more favorable economic results compared to previous and subsequent crops.

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