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Review

Analysis of Contemporary Decision-Making Models in Farms

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Abstract: Individuals in organizations make decisions at all levels and in all business areas. It simply means that they need to select among several alternatives. However, the decision -making process is much more complex than the simple act of choice. There is a more rational approach to decision-making, but all authors agree that the process begins by identifying the problem and ends up evaluating applied solutions. This paper will deal with contemporary decision-making models, now available to all organizations who want to promote their business.

Key words: business analysis; decision models; diminishing returns; principle of marginality; opportunity costs.

1. Introduction

The analytical decision-making process begins with understanding what one wants to achieve with its decision. The quality of the decision will depend on how well the issues in question are understood [1]. It is necessary to make a list of all these issues, or "decision criterion". If, for example, one needs to decide between computer suppliers, not only their products, but also installation, training, and maintenance should be taken into consideration [2–4]. The cost is also an important criterion, although it is not always the best decision to buy the cheapest products if there are other criteria on the list [5]. Individuals in the company make decisions at all levels and in all areas of business. This simply means that they select between multiple alternatives. However, the decision-making process is much more complex than a simple act of choice [4,6]. There are several approaches to rational decision-making, but all authors agree that the process begins with the identification of the problem and ends with the evaluation of the applied solution [7,8]. Some of these principles that are intended to be analyzed in more detail in this paper are the principle of diminishing returns, the principle of marginality, the principle of limited capital and opportunity costs, and finally, the principle of combining the production structure [9].

2. Principle of diminishing returns

In production planning, the decision-maker uses different production resources (inputs) to reach the final product (output). In this process, individual inputs are variable, while other inputs are used as fixed or constant. With the change of variable costs in relation to fixed ones, there will be different

legal tendencies that occur on the input / output relation. The principle of diminishing returns is used to determine the efficiency of production, both the overall economy and individual producers [10]. The production function on the example of agricultural production is shown below. This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn.

Table 1. Production function [11].

Quantity of water for irrigation	Output	Fixed costs (land, seeds, fertilizer)	Variable costs (required quantity of water)	Total cost
0	0	30	0	30
1	50	30	10	40
2	90	30	20	50
3	120	30	30	60
4	140	30	40	70
5	150	30	50	80

In the example of the production function, it can be noticed that the law of diminishing returns assists managers in decision-making process, i.e. to what level it is worthwhile to invest some factors which would increase production (amount of water needed for irrigation), while constant factors (land) lead to each new investment, which reduces the mass of fixed capital [12]. Thus, investment in the same area of land increases. At one particular level, costs per unit of product begin to rise. The law of diminishing returns is also called the law of rising costs. In economic theory, Turgot stands out as the first theorist to set up the Law of Returns. Namely, Turgot, generalizing the opportunities in agriculture at that time, correctly concluded that an unlimited amount of products cannot be obtained on a limited land area, regardless of how much the applied work has increased, i.e. how much the investments have increased [13]. Turgot explained his teaching in the following way: "Seeds thrown on some fertile land, but without any cultivation, would represent an advance almost entirely lost." However, if only one tillage is conducted, the product will be larger, the second or third tillage may be able to double or triple the product. Therefore, the product will increase in a much larger proportion than the growth of advances, to a certain point where the return on advances will be as high as possible. Over that point, if the increase in advances continues, the products will increase even more at a declining rate until the increase in advances adds nothing to the product, since the fertility of nature is exhausted and the skill of the manager cannot assist." The conclusion that follows is that Turgot determined the highest return per unit of invested capital, as well as the additional return based on additional investments [14]. Turgot has precisely determined the point after which the additional variable input of fixed factors of production is justified, as long as the added or marginal return is greater than the additional (marginal) costs. Hereupon, additional investments cause increasing costs, so that the diminishing ones are manifested through rising costs. In order to achieve diminishing returns, a certain level of investment needs to be achieved. This means that diminishing returns start only at a certain level of investment in production. Therefore, managers have to be familiarized with the principles of diminishing returns, because they will be able to make the right decision at which point it is not worth investing in production anymore. This is the point when the cost of an investment is higher than the return that a particular investment brings. Namely, the first investment provides the highest return. It is the Law of rising returns, or the Law of constant returns, which is effective up to a certain point after which returns fall. It is important for the manager to determine the point from which diminishing returns arise in order to

stop further investments, because they do not contribute to increasing production. Knowledge of the production function enables the manager to narrow the range of possible choice options and decision-making [15]. In order to organize production, it is necessary to engage a certain amount of production factors (inputs) in order to achieve a certain amount of products (outputs). For example, the production function represents the relationship between food consumption and milk return in cows. This, in fact, shows how capable they are of "processing" animal feed into milk. In this case, the production function would help the farmer to determine how much the investment in the supply of animal feed affects milk production [16,17]. Through the production function, the farmer will determine to what extent it is profitable to increase the investment in animal feed, assessing it from the aspect of the achieved milk production [17]. Production function can be expressed in tabular form, graphical form, etc. In reality, diminishing returns determine the upper limit of production, after which the return will fall, despite the investment. For a manager in any economic activity, it is essential to never use more input than is necessary to achieve maximum return. In this way, the farmer or manager will save significant financial resources, especially if they correctly determine the point from which the diminishing returns begin. This will prevent unnecessary investment costs that will return zero or diminishing output. If one assumes that this is a large agricultural farm, with an intensive and diverse production structure, the decision of the manager who determined the limit of diminishing returns will be considered rational, which will signify great savings in input costs. Investing above this limit means creating unnecessary input costs with zero output.

3. Principle of marginality

The cost principle should indicate the relationship between fixed and variable costs and, based on their movement, it should also influence the making of economically rational decisions, because the movement of total costs depends on profit [14]. Namely, the movement of total costs per unit produced determines the profitability of a product. What the cost will be, whether constant or variable, depends on the decision made, provided that the fixed costs do not change regardless of whether they produce something or not. Variable costs are a function of changes in production. Specifically, variable costs change with the change in production levels. If production is not organized, there will be no variable costs. With the start of production and its increase, variable costs appear and change. When creating an alternative in planning, which is the basis for decision-making, the relationship between marginal costs and marginal returns is much more important. In order to make decisions about the level of production, it is very important to analyze the relationship between marginal costs and marginal returns, i.e. to determine the degree of increase in production in relation to the increase of additional (marginal) costs, for example how much an additional unit of new product affected additional costs. Based on that, a decision is made whether it is profitable to increase production, taking into account the movement of costs. An additional increase in production, for example for one unit (output), or for a unit of investment (input) is called the return-cost margin. For example, if the level of production does not affect the unit price of the product, which is the case in primary agricultural production in which the individual producer participates in the supply of total goods to a lesser extent, then the marginal return of additional output is constant. With reference to marginal return input, an additional unit, after a certain point, causes a decline, if one or more fixed factors of production are added. (Ibidem) Marginal production costs are calculated by dividing the growth of total income by the growth of return.

Table 2. Revenues / costs for the production of different quantities of corn [18].

Corn yields T/ha	Total fixed costs	Total variable costs per ha	Total costs per ha	Total average costs per ha	Marginal production costs	Marginal revenues (0.14$/kg)
1	2	3	4	5	6	7
6.3	617	267	884	0.140		
6.9	617	267	894	0.130	0.017	0.14
7.5	617	296	913	0.122	0.032	0.14
8.1	617	336	953	0.118	0.067	0.14
8.7	617	405	1022	0.117	0.115	0.14
9.3	617	504	1121	0.121	0.165	0.14
9.9	617	632	1249	0.126	0.213	0.14
10.5	617	790	1407	0.134	0.263	0.14

The analysis of the production of different quantities of corn, with the production function as the basis, starts from three variable inputs, while the others are constant. Also, the analysis assumes that "when achieving each individual level, a combination with the lowest price of water, fertilizer and seeds for sowing is applied." These three inputs are shown in Table 2, column three - total variable costs per hectare [17]. The total fixed costs per hectare include all costs necessary for growing corn, except for the price of water, nitrogen and seeds for sowing. Otherwise, total costs include total variable costs and fixed costs ($ 617 in the example). Fixed costs are constant ($ 617 in the example), regardless of changes in production volume. These costs include: depreciation, investments, interest, taxes, insurance, salaries, as well as other costs related to production. Maximizing income, i.e. increasing profits, means that a unit increase in production must bring higher revenue than costs for a unit increase in production. That is, it is profitable to make a decision to increase production only on the assumption that it brings higher income in relation to costs. "Marginal production cost is one that results from an increase in the unit measure of the total increase in production costs, and marginal revenue is the result of an increase in total revenue. Marginal revenue is equal to the price if the price remains independent depending on the quantity of goods sold (0,14 $)." The maximum revenue will be achieved under the assumption that the equality MP=MR is achieved, as shown by the data in Table 2, where the return of 8,7 T/ha is the maximum. Namely, if the marginal revenue, i.e. the price of 140$/T of the product, is more than the value of 115$ of marginal product. However, if production is increased by an additional 600kg, the marginal production cost will be $ 165, which is more than the $ 140 of marginal revenue. If the ideal level of production per hectare was 8.7 tons of final product, it can be calculated at each production level - per hectare, by deducting total expenditures from total revenue. The key to the manager's decision is that the average total profit is achieved in such a way that the calculated prices will be significantly higher than the total average costs. This can be reported (from Table 2) as follows: for production of 8.7T / ha, the total average cost is $ 117 / T, and the profit is $ 83 / T. Assuming a price reduction to $ 100 / T, the farmer will decide to reduce production to 8.1T / ha, because, at this level, a marginal revenue of $ 0.115 would be higher than a marginal production cost of 0.067. Such low prices would not make a profit, since the total average cost is $ 120, and the farmer will try to reduce the loss in various ways, in the short term. The eventual decision of the farmer on the production of corn in the following period depends on the level of price movements. Only the price of corn, which brings the farmer a profit, will be his motive to continue with production. Otherwise, the farmer will refocus to a culture that will bring him more profit. If the price of a certain product is not adjusted upwards soon, the farmer will either start growing another crop or lease the land, and may even sell it. Assuming that there was an increase in prices to 167 $ / t, in that case production would increase to 9.3T / ha, where the marginal return is higher than the marginal production costs, i.e. $ 165. This higher level of production will cause a total average cost of $ 121 / T. Thus, profit is maximized when total average costs increase.

This attitude deviates from the established notion that profit grows at a lower cost per unit of output. Profits can increase because a larger quantity of a product is more valuable than the inputs invested in the production of that product. That is, the manager (or farmer) does not aim to produce at the lowest price per unit of product, but when the marginal production costs are equal to the marginal revenue (MP=MR) [17].

4. Principle of limited capital and opportunity costs

The principle applies since most small business owners have limited capital and input sources. Hence, it is necessary to decide what and how much to produce when the value of marginal revenue and marginal input costs cannot be equalized. The producer can grow more than one crop, regardless of whether he has limited funds for the supply of mineral fertilizers and other inputs. In reference to limited sources of input, the principles of equal marginal revenue must be respected, and limited inputs must be distributed where they will generate the most income. Namely, when preparing an alternative, for example, for the use of mineral fertilizers, a decision must be made to distribute a certain amount of fertilizer equally among crops, or to invest that capital for other purposes, instead of buying a fertilizer. When input sources (funds and labor) are limited, resources must be distributed so that "the last units that fall to the value of marginal revenue are always equal." The hypothetical example (Table 3) represents the application of mineral fertilizers and their influence on the cultivation of three crops. The following is an example for clarification. The farm covers an area of 48 hectares, which indicates that each crop occupies 16 hectares (48 hectares: 3 crops = 16 hectares). Since the amount of mineral fertilizer is limited to 9 tons, this amount should be divided into three crops, per hectare, when the assumed prices of crops A, B and C are as follows: A = $ 0.132 / kg, B = $ 0.110 / kg, and C = $ 0.044 / kg. The price of mineral fertilizer of $ 0.44 / kg is also known. First, the marginal income must be calculated to increase the used mineral fertilizer by 56 kg, with the appropriate price, and thus the value of the marginal revenue is obtained. The distribution of mineral fertilizer into three crops is conducted in such a way that the most is invested in the crop that brings the higher income. As each crop has 16 hectares of land, which has already been stated, the increase in mineral fertilizer by 56 kg / ha corresponds to 0.9 tons of the total amount, or 9 tons. "The first and second tons belong to plants B and C, where the value of the marginal revenue is $ 49 / ha. The third and fourth tons will be scattered on plants A and C, where the value of the marginal revenue is 44 $ / ha. This process is extended until all 9 tons of mineral fertilizer are depleted" [10]. In the hypothetical example, the best decision is if the mineral fertilizer is used in the following way:

1. 112 kg/ha - for crop A,

2. 168 kg/ha - for crop B and

3. 280 kg/ha – for crop C.

There are other additional methods that can be implemented to increase revenue. For example, if another ton of mineral fertilizer is available, then 56 kg / ha could be added to crop B at a $ 30.80 marginal revenue value, creating a marginal cost value of $ 24.60.

Table 3a. Presumed correlation between the use of mineral fertilizers and income in the case of growing three types of crops [17].

	Mineral fertilizer kg / ha	**Total income kg / ha**	**Marginal income kg / ha**	**Marginal revenue value in $**
Crop A. cost price 0.132$/kg	0	1345		
	56	1681	336	44.35
	112	1962	281	37.09
	168	2186	224	29.57
	224	2354	168	22.18
	280	2466	112	14.78
	336	2522	56	7.39
	392	2572	56	7.39
	448	2606	28	3.70
	504	2606	0	0
	560	2578	-28	-3.70
Crop B, cost price 0.110$/kg	0	1345		
	56	1794	449	44.39
	112	2186	392	43.12
	168	2522	326	36.96
	224	2802	280	30.80
	280	3027	225	24.75
	336	3195	168	18.48
	392	3335	140	15.40
	448	3447	112	12.32
	504	3475	28	3.05
	560	3475	0	0

Table 3b. Presumed correlation between the use of mineral fertilizers and income in the case of growing three types of crops [17].

	Mineral fertilizer kg / ha	**Total income kg / ha**	**Marginal income kg / ha**	**Marginal revenue value in $**
Crop C, cost price 0.132$/kg	0	2368		
	56	3489	1121	49.32
	112	4497	1108	44.35
	168	5394	897	39.47
	224	6179	785	34.54
	280	6908	729	32.08
	336	7580	672	29.57
	392	8085	505	22.22
	448	8421	336	14.78
	504	8520	99	4.36
	560	8526	56	2.64

When making decisions, the farmer is often faced with a dilemma: whether to opt for greater diversification, or specialization of production [19]. Decisions on a full specialization of production (i.e. production of only one product) are rarely made. Normally, the specialization is reduced to two to three products, with a certain number of products being produced, but in extremely small quantities. Farmers' capital is limited, which means that they usually have to invest in the crops from which they expect the greatest profit, taking into account the natural properties of the land when selecting them. Optimal solutions are reached by applying the principle of opportunity costs. "The application of this principle ensures the creation of the highest profit, provided that each unit of labor, capital and land is used where it brings the highest additional (marginal) revenue, and not the

highest average revenue. The opportunity cost of using a resource in a certain way represents a lost value concerning the disuse of a resource in the most cost-effective way offered by possible alternatives." Opportunity costs refer to lost revenue due to inadequate resource allocation [20]. Hence, the return on these resources must be at least at the level of their opportunity costs. This means that returns on resources are in the most favorable allocation, if they are at the level of their opportunity costs. However, this means that opportunity costs exceed the amount of achieved value, created by the choice of resource allocation, and that the potential revenue is lost.

5. Principle of combining production structure in agriculture

The principle of combining the production structure is inevitable in agriculture, especially when determining the relationship between plant and livestock production. Every farmer is constantly faced with the dilemma of the extent to which he should opt for plant or livestock production. With the lowest possible production costs, the farmer sets the production that provides the optimal output, which represents the establishment of adequate relationship between plant production and livestock. There are a large number of combinations of different types of products or substitutions of one product for another. The substitution of products in plant production is determined by natural conditions. The branch connection between barley and alfalfa, for example, is different from barley and wheat. Also, the influence of plant crops (not only between them) on livestock production should be observed [14].

Previous linkage may be independent, competitive, supplementary and complementary. There are few producers in agriculture who opt for products that are independent of each other. Such production can only be afforded by producers who are not limited by capital, and there are few of them. However, even in such conditions (when sufficient capital is available), supplementary and complementary relations are important when making a decision on the structure of production. Competitive relations represent the competition of two products, if the increase of one reduces the quantity of the other product, and they compete for the same input (land, for example). Thus, a farmer who has 260 ha of arable land can sow the entire area with barley or wheat, and he may also combine. Since barley and wheat require the same land, the same tillage machines, the same season, these two products are therefore competitive. Supplementary relations do not disturb the return or quality of products on certain land, wheat or barley for example, and after the end of the harvest of these crops, fodder plants that have a shorter vegetation period should be sown. Namely, the second sowing is the one that enables the use of the land even after the harvest of wheat or barley. In this way, in addition to the fact that the land is used for a longer period of the year, the remains of fodder plants also improve the quality of the land with the assistance of plowing, and the labor force is used on the farm for a longer period of the year. For example, the workforce is engaged in the production of grain, and when this is complete, it is used for winter activities. The aim is that the workforce is engaged throughout the year, and the production of grain has a positive impact, which is reflected in the fact that the production of one product affects the growth of another. A complementary relationship occurs with a limited resource, where the production of one product contributes to the increase of another product. Thus, for example, "winter grazing of sheep is well organized on the alfalfa plot, which will bring an increase in the amount of seeds per hectare next season." Plants such as alfalfa bind nitrogen in the soil, which will improve the yield of corn, for instance. The previous relations are shown in Table 4 (data are hypothetical) [14]. In the previous case, the decision-maker will concentrate all energy sources on the product that brings maximum profit. If this decision is followed by a certain restriction in the realization of the product with the highest profit (for example, a certain amount of product is determined by the contract), that product is produced to a certain extent, and the farmer invests the rest of resources in another product. It can also be noticed (Table 4)

that alfalfa replaces grain in an increased amount, i.e. an increasing amount of wheat is replaced by the same amount of excess alfalfa produced.

Table 4. Complementary products, products that are independent of each other, or are competitive and marginally interchangeable in size [17].

Branch base of products	Grain production	Alfalfa production	Marginal interchangeable scale
Complementary products	7000	0	-320/+320= –1.00
	7200	320	
Independent products	7320	640	+0/+320= +0
Competitive products	7000	960	+320/+320= +1.00
	6500	1280	+500/+320= +1.56
	5800	1600	+700/+320= +2.19
	4200	1920	+1600/320= +5.00

6. Conclusion

In the decision-making process, managers face various constraints. The goal of most organizations is to maximize profits, and that goal is limited by the fact that managers are limitedly informed. As a rule, limitations in managerial decisions include legal, moral, contractual, financial, and technological issues. Legal constraints include a number of state and local regulations that must be obeyed by all citizens, both individuals and corporations. Areas in which managers may have difficulties with laws include environmental issues, employment, illegal dismissals, etc. Moral constraints refer to activities that are not illegal, but are not in accordance with generally accepted norms of behavior and are considered inappropriate. Contractual constraints bind the company based on an earlier contract - leasing, rent, unions, etc. In the decision-making process, technological and financial constraints play a major role, especially when managers are tasked with the obligation to maximize production in order to meet the set budget. Technological limitations are evident, because the volume of production, for example, in a certain time interval directly depends on the capacity of machines or the productivity of workers.

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