Synergistic effect in the management of agricultural production

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Abstract: Generally, when a certain type of agricultural production is optimized, an interaction is said to exist between two factors when the response (the yield of agricultural production) at the different levels of one factor is affected by the level of the other factor present. Thus, the combined effect of the two factors is not simply the sum of their separate effects, but either more than this sum (synergistic interaction) or less than this sum (antagonistic interaction). A 3 factor interaction between the factor f_1, f_2, and f_3 occurs when the nature of the interaction between f_1 and f_2 is different at the various levels of f_3. Higher order interactions can be similarly defined but these become increasingly more difficult to interpret. A disadvantage of this approach is that it explores each of the agricultural sub-process unrelated to the follow-up sub-process (e.g., this approach optimizes the process of fertilization without links to the crops distribution process and unrelated to the price optimization). This is because each sub-process has a different response unit that is the subject of optimization. Therefore, it is appropriate to investigate the interaction of agricultural production in its integrated form, through a universal response of variables (e.g., in the form of utility from the response). This new approach is introduced in the paper. Thus, the objective of the paper is to present a new method for the formal determination of synergistic effects of the agricultural enterprises management.

Key words: antagonistic effects, food production, input output model, interaction

Interaction is a kind of action that occurs as two or more objects have an effect upon one another (Sirvanci and Durmaz 1993). The idea of a two-way effect is essential in the concept of interaction, as opposed to a one-way causal effect. A closely related term is interconnectivity, which deals with the interactions of interactions within systems. Combinations of many simple interactions can lead to surprising emergent phenomena. An interaction has different tailored meanings in various sciences.

The answer to the question "What does synergism actually mean?" is generally vague, as it is obvious in the following concept definitions. "An interaction between two or more agents, entities, factors, or substances that produces an effect greater than the sum of their individual effects. Also called synergetic effect or synergistic effect, it is the opposite of antagonism" (Antony 2003). An example of antagonistic effect is the effect between the opposing actions of insulin and glucagon to the blood sugar level. While insulin lowers the blood sugar, glucagon raises it. Thus, regulating the major physiological function of these two chemicals is crucial in order to keep up a healthy level of glucose in blood.

In the natural world, synergistic phenomena are ubiquitous (Corning 2003). They range from physics to chemistry. An example of physics is the different combinations of quarks that produce protons and neutrons. A popular example of chemistry is water, a compound of hydrogen and oxygen. They also range from the cooperative interactions among the genes in genomes, the division of labour in bacterial colonies, the synergies of scale in multi-cellular organisms, as well as many different kinds of synergies produced by socially-organized groups, from the honeybee colonies to the wolf packs and human societies. Even the tools and technologies that are widespread in the natural world represent important sources of synergistic effects.

Marketing synergy refers to the promotion of the sale of products for varied use or off-market sales, as well as the development of marketing tools and in several cases the exaggeration of effects (Hertzberg and MacDonell 2002). It is usually based on a resource-management model, which is used to answer two research questions: (1) whether technological capability and marketing capability are complementary or supplementary capabilities; and

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(2) how technological capability and marketing capability can be used appropriately to respond to the environmental turbulence. Based on the model, we can see whether technological capability and marketing capability have *synergistic/antagonistic effects*.

The cause of the synergistic effect is due to each system having emergent properties. This means that no system can be understood by seeking to comprehend every individual component. When the elements interact with each other, there is a flow of energy between them, perhaps in the form of nutrients, water, food, or information. Synergy is when the sum of the whole system is greater than the sum of its parts; 1 + 1 = 3 (Macnamara 2012). We have the individual elements and we also have the relationship that adds a further complexity and characteristics. Many parents will identify with having to manage not only the demands of each child, but also the dynamic between them. This can create more work for the parents. Since we do not know what the relationship and flow of energy is between them or how that will influence each part, the whole is not predictable from looking at the parts. New properties will emerge from this synergy of interactions. We cannot predict the wetness of water from looking at the oxygen and hydrogen molecules separately. From neurons, the consciousness and creativity emerge. The number of possible relationships increases exponentially with the number of parts" (Macnamara 2012).

At present, the phenomenon of synergy application is mainly used in the following disciplines.

Pharmaceutical research

Drug synergy occurs when the drugs can interact in ways that enhance or magnify one or more effects or side-effects of those drugs. This is sometimes exploited in the combination preparations, such as the codeine mixed with the acetaminophen or ibuprofen, to enhance the action of the codeine as a pain reliever. Negative effects of synergy are a form of contraindication. For example, the combination of depressant drugs that affect the central nervous system (CNS), such as alcohol and valium, can cause a greater reaction than simply the sum of the individual effects of each drug if they were used separately (Hideshima and Richardson 2011).

Human synergy

Human synergy relates to human interaction and teamwork, and it usually arises when two people with different complementary skills cooperate.

Biological sciences

Synergy of various kinds has been advanced by Corning (1983) as a causal agency that can explain the progressive evolution of complexity in living systems over the course of time. According to the Synergism Hypothesis, synergistic effects have been the drivers of cooperative relationships of all kinds and at all levels in living systems. In a nutshell, the thesis is that synergistic effects have often provided functional advantages (economic benefits) in relation to survival and reproduction that have been favoured by the natural selection.

If used in a *business application*, synergy means that the teamwork will produce an overall better result than if each person within the group were working toward the same goal individually. However, the concept of group cohesion needs to be considered (Phadke, 1989). Group cohesion is the property that is inferred from the number and strength of the mutually positive attitudes among the members of the group (Antony, 2001). As the group becomes more cohesive, its functioning is affected in a number of ways. One example is that the interactions and communication between members increase. Common goals and interests, as well as having a small size, all contribute to this. Another example is that the group member satisfaction increases as the group provides friendship and support against the outside threats (Buchanan and Huczynski 1997).

The term synergy was refined by Fuller (1975), who analyzed some of its implications more fully and coined the term Synergetics.

It means a dynamic state in which combined action is favoured over the difference of the individual component actions.

– Behaviour of whole systems unpredicted by the behaviour of their parts taken separately, known as the emergent behaviour.
– The cooperative action of two or more stimuli (or drugs), resulting in a different or a greater response than that of the individual stimuli.

OBJECTIVES AND METHODOLOGY

This paper objective is based on the input-output model of the food and agricultural products optimization and its interaction analysis. The objective of this paper is to present a new method for the formal determination of synergistic effects of the agricultural enterprises management.

The methodology for the purpose of obtaining the results from this paper (for designing, performing, and analyzing the following input-output model of agricultural business) was based on the linearization of the resource of inputs to agricultural production, as well as the total differential of the partial inputs.

RESULTS

In many cases of the organisational practice, it can be favourable to consider the organisation as a system and to investigate its related behaviour through the solution to the system task.

The subject of the research theory of the organisation are social systems (so-called mixed systems), consisting of both living and non-living elements (people and manufacturing components). The decisive task in these systems is always on the part of the human element, which decides on the final results of the mixed systems. *Also, the subject is to illustrate the importance of the interactions between the factors affecting food production and agricultural production. The following paper is a target definition of the organisational system* as the arrangement and the consequent use of the sources of the organisation system to *achieve the optimal value of the output product from the organisation transformation.*

It is evident from the diagram in Figure 1 that an agricultural or food organisation fulfils its objectives through the product offered (goods and services). This forms the output from the internal transformation process, which is implemented with the participation of all *available internal sources*: energy (E_I), material (H_I), information (I_I) and personnel (P). The system output is the response to the stimulus of the input impulses from the environment (external inputs, which are the inputs into the transformation process and have the character of fuel (H_E), energies (E_E) and information (I_E). The substances represent material and raw materials transformed into the form of the requested goods and services; energies are used to implement the transformation process and information shapes the transformation process so that the outputs are competitive. The open character of the agricultural system is achieved by its *interaction with the environment*, so the input/output behaviour of the system is causally unstable and depends on factors affecting the transformation process, as well as the effect from any variable factors (Hron 2012).

Figure 1 shows that the relationship between the value and the financial concept of food and agricultural management is evident. The relation is such that due to the influence of information, we can consider

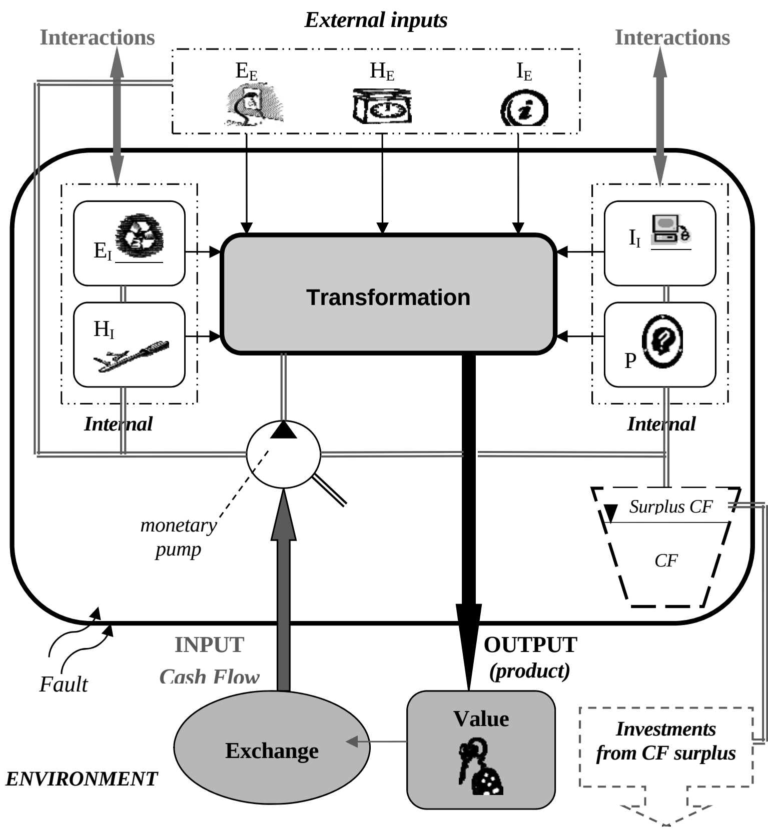

Figure 1. System concept of the functioning of the organisation

financial resources to be the equivalent of the other external sources (energy, material and information). The management of financial flows in Figure 1 is implemented by an imaginary monetary pump (in an organisation, this role is usually occupied by the financial manager) which, using the distributor, pushes the cash-flow generated by the turnover process into the organisation along with the running costs. The cash-flow must be distributed into the transformation process which implements the conversion of inputs into the output-product. In addition, the requirement to pay suppliers for external inputs must be covered by the internal financial resources.

Input – output model in the case of omitted interactions

In a stable condition when the interaction of internal sources with the environment does not affect these sources, it is valid that *the change in the value of inputs in the time* E_E (pursuant to the value functioning of the organisation) can be expressed by the total differential consisting of the partial differential equations. In accordance with Figure 1, the total change in the value of external inputs E_E is the sum of the partial changes in external inputs (energy, material and information). For a relatively short time period when the external input values only have low change values, it is possible to linearize the dependent variable function (one partial input) depending on a relatively small time change (Ellekjaer and Bisgaard 1998). This will cause only a small deviation from the real functional value (Figure 2).

According to Figure 2, it is possible to express the change in the value of energy input E_E for the time interval Δt as the direction of the function $E_E = \mathrm{f}(t)$ in the point E_0 (derivation of the function in the point) multiplied by the time interval Δt, i.e.:

$$\Delta E_E = \frac{d(E_0)}{dt} \cdot \Delta t \tag{1}$$

If expressing this change in the value of the energy flow depending on the *volume supplied* in a certain time period, the linearization of the incremental value ΔE_E will be determined by the change in the volume of the supplied energy Δq_E during this time period:

$$\Delta E_E = \frac{d(E_0)}{dq_E} \cdot \Delta q_E \tag{2}$$

In the same way, further input values could be linearized depending on the volume of the supplied input during a certain time unit. Then relations can be created whereby it is possible to describe the behaviour of the food or agricultural organisation system. The financial view of the organizational system is in the cardinal equation:

$$\textit{Output cost} - \textit{input cost} = \textit{profit} \tag{3}$$

The financial view puts the economic result (profit/loss) into the relation with the evaluated outputs-sales and costs generated. From the value view, three types of processes arranged in order of effect can be distinguished:
– value input process,
– value output process,
– value transformation process insulated from the external input.

To express the change of the input value (external sources), then the fact that the input inflow during a certain time period is equal to the sum of the partial changes for the individual types of the external inputs used. This concerns changes in fuel E_E, material H_E and information I_E inputs. A change in the value of the input ΔH_E during a certain time period can be expressed by the Equation (4):

$$\Delta H_E = f_1(E_E, H_E, I_E) \tag{4}$$

If linearizing the individual inputs according to Figure 1, it is possible *to express the change in the value of inputs* H_E by the total differential Eq. (5):

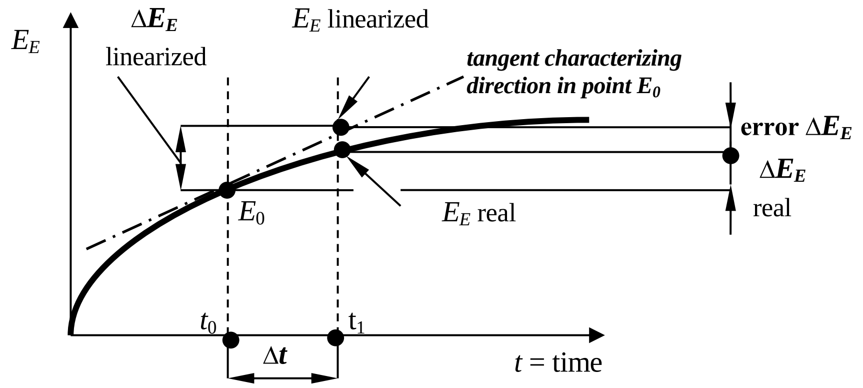

Figure 2. Ilustration of the principle of linearization of the energy input into the organisation

$$\Delta H_E = \left(\frac{\partial E_E}{\partial q_E}\right)\cdot \Delta q_E + \left(\frac{\partial H_E}{\partial q_H}\right)\cdot \Delta q_H + \left(\frac{\partial I_E}{\partial q_I}\right)\cdot \Delta q_I \tag{5}$$

The Equation (5) shows how the change in the value of inputs relates to the partial changes in the components which comprise the inputs. In a similar manner, it is possible to express the change in the value of input ΔH_V, which is stated by the direction (speed of growth of the function) $\left(\frac{\partial H_V}{\partial q_V}\right)$ and the value of the volume of output Δq_V during a certain period, see Eq. (6):

$$\Delta H_V = \left(\frac{\partial H_V}{\partial q_V}\right)\cdot \Delta q_V \tag{6}$$

In a situation in which the company only operates with internal sources, the transformation is given by changing of the internal inputs:

$$\Delta H_I = f_1(E_P\ H_P\ I_P\ P_I) \tag{7}$$

If linearizing the individual internal inputs according to Figure 2, it is possible to characterize the change in the value of transformation by the Equation (8).

$$\Delta H_I = \left(\frac{\partial E_I}{\partial q_E}\right)\cdot \Delta q_E + \left(\frac{\partial H_I}{\partial q_H}\right)\cdot \Delta q_H + \left(\frac{\partial I_I}{\partial q_I}\right)\cdot \Delta q_I + \left(\frac{\partial P}{\partial q_P}\right)\cdot \Delta q_P \tag{8}$$

During the stable condition, without the existence of the interaction of the individual inputs, the change in the value of the output is in balance with the change in the value of the input and the change in the value of the insulated transformation. So, it is therefore valid:

$$\Delta H_{V0} = \Delta H_{E0} + \Delta H_{I0} \tag{9}$$

where the index "$_0$" means the stable condition. The individual variables ΔH_{V0}, ΔH_{E0}, ΔH_{I0} are replaced by their linearized components stated by the Equations (5), (6), (8) resulting in Equations (10).

If modifying the expression (10) so that the individual addend from both square brackets is merged on the right side of the equation, it results in the expression (11), in which there is a generic grouping of the individual sources (Equations (11)).

From the expression (11), the importance of the efficient use of personnel sources in an organization is seen as an important and irreplaceable role within the source relations of the organisation. This is expressed in the expression (11) by the fact that the direction $\frac{\partial P}{\partial q_P}$ is unrelated to any external source.

Optimising (maximizing) of the partial derivation of the value of the personnel contribution of human resources according to the volume of this source $\left(\frac{\partial P}{\partial q_P}\right) = MAX$ is a key issue in the conditions of the so-called diffusion competition, which is characterized by the proportional allocation of internal sources for all competitors in the stated industry with the same accessibility to external sources. This means that no competitor has an easier access to any source. Under this situation, the only source of the competitive advantage is a more effective use of the human potential in the organisation, which is represented in the Equation (11) by the expression $\frac{\partial P}{\partial q_P}$.

Input/output model with the considered input factors interaction

Leaving the idealized situation of the stationary influence of source interactions on the organisation system where the behaviour of the system in a stable condition was derived, then in a real situation, the internal sources at the time are modified by the interaction with the environment, i.e. the principle of the equifinality value of the output is broken. In addition, in accordance with the business reality, there is a phenomenon which is indicated as a reserve of the finished products. In the diagram of the source system (Figure 1), this status is reflected so that each consumer source is not converted into an output value.

Therefore, the value of all inputs consumed by the enterprise is not equal to the output value (the stationary condition of the enterprise in which it is assumed that there is no interaction between the internal and external sources was left). In the case that the production capacity is designed in relation to the real demand, it is possible to express this value difference as follows:

$$\left(\frac{\partial H_V}{\partial q_V}\right)_0 \cdot \Delta q_V = \left[\left(\frac{\partial E_E}{\partial q_E}\right)_0 \cdot \Delta q_E + \left(\frac{\partial H_E}{\partial q_H}\right)_0 \cdot \Delta q_H + \left(\frac{\partial I_E}{\partial q_I}\right)_0 \cdot \Delta q_I\right] + \left[\left(\frac{\partial E_I}{\partial q_E}\right)_0 \cdot \Delta q_E + \left(\frac{\partial H_I}{\partial q_H}\right)_0 \cdot \Delta q_H + \left(\frac{\partial I_I}{\partial q_I}\right)_0 \cdot \Delta q_I + \left(\frac{\partial P}{\partial q_P}\right)_0 \cdot \Delta q_P\right] \tag{10}$$

$$\left(\frac{\partial H_V}{\partial q_V}\right)_0 \cdot \Delta q_V = \left(\frac{\partial E_E}{\partial q_E} + \frac{\partial E_I}{\partial q_E}\right)_0 \cdot \Delta q_E + \left(\frac{\partial H_E}{\partial q_H} + \frac{\partial H_I}{\partial q_H}\right)_0 \cdot \Delta q_H + \left(\frac{\partial I_E}{\partial q_I} + \frac{\partial I_I}{\partial q_I}\right)_0 \cdot \Delta q_I + \left(\frac{\partial P}{\partial q_P}\right)_0 \cdot \Delta q_P \tag{11}$$

$$\left(\Delta H_E + \Delta H_I\right) - \Delta H_V = \frac{\partial\left(\Delta hz\right)}{\partial t} \cdot \Delta q_V \tag{12}$$

where the expression $\frac{\partial\left(\Delta hz\right)}{\partial t}$ is the immediate change of the accumulated value from the transformation process Δhz in time. Paradoxically, a positive value represents the dominant occurrence of antagonistic interactions between the sources because the interaction caused the output product to be of a lower benefit than that required by the clients (customers). It is physically reflected as an unsalable reserve of final products (e.g. food) – at the stated price. The negative value of the variable Δhz signals the dominant occurrence of synergic interactions between the sources. In the case of the integration of this expression according to the time, the accumulation of the unused output value could be ascertained for a certain time period. If completing the stationary description of the value system of the organisation by changing the cumulated value of the output from the transformation process in time, it results in the dynamic Equation (13).

$$\left(\frac{\partial\left(\Delta hz\right)}{\partial t}\right) \cdot \frac{d\left(\Delta q_v\right)}{dt} + \left(\frac{\partial H_V}{\partial q_V}\right) \cdot \Delta q_V = \left(\frac{\partial E_E}{\partial q_E} + \frac{\partial E_I}{\partial q_E}\right) \cdot \Delta q_E +$$

$$+ \left(\frac{\partial H_E}{\partial q_H} + \frac{\partial H_I}{\partial q_H}\right) \cdot \Delta q_H + \left(\frac{\partial I_E}{\partial q_I} + \frac{\partial I_I}{\partial q_I}\right) \cdot \Delta q_I + \left(\frac{\partial P}{\partial q_P}\right) \cdot \Delta q_P \tag{13}$$

Replace the respective input and output values:

$$y = \Delta q_v; \quad a_1 = \frac{\partial h_z}{\partial q_v}; \quad a_0 = \frac{\partial H_v}{\partial q_v}; \; b_0 = \left(\frac{\partial E_E + \partial E_I}{\partial q_E}\right);$$

$$b_1 = \left(\frac{\partial H_E + \partial H_I}{\partial q_H}\right); \; b_2 = \left(\frac{\partial I_E + \partial I_I}{\partial q_I}\right); \; b_3 = \left(\frac{\partial P}{\partial q_P}\right)$$

$$u_0 = \Delta q_E; \; u_1 = \Delta q_H; \; u_2 = \Delta q_I; \; u_3 = \Delta q_P \tag{14}$$

After replacing (14) in the Equation (13) this results in:

$$a_1 \cdot \dot{y} + a_0 \cdot y = b_0 \cdot u_0 + b_{10} \cdot u_1 + b_2 \cdot u_2 + b_3 \cdot u_3 \tag{15}$$

CONCLUSION

The purpose of this paper is to illustrate a new method of the factor interaction analysis for the agricultural businesses doing process.

The Equation (15) is the first order differential equation. The explicit solution results in an equation that would characterize the type of dominant interaction between the individual inputs (important interactions are usually second order interactions). The development of the resulting (dominant) interaction depends on:

(1) change in the value of output product;
(2) change of energy inputs in interactions with the change in material inputs;
(3) change in material inputs in interactions with the information flow;
(4) and on the interaction of the information flow with the change in the use of personnel potential.

The Equation (15) shows *the importance of the role which the system of behaviour of the agricultural organisation represents in terms of achieving the accumulated output value of its production.* Most business industries report a certain level of uncertainty in information about the future product demand. Due to this uncertainty regarding the future development, it is necessary to arrange the organisation sources so that when used they can react to the deviations in demand and also easily adapt to the changes in the industry trends. This is with the help of the synergic effect which originates during the dominant effect on positive interactions between the sources. Therefore, the efficient arrangement of sources is a necessary precondition for the origination of a synergic effect that can only be achieved due to the organisation intervention and coordinating the consistency of the designated managers in the organisation. The enforcement of organisational change, required by the development of the environment of the organisation, is solely in the area of human resources.

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