Value Chains as the Leading Concept in the Agricultural Management Production Process

Tatyana Baranovskaya*
Federal State Budgetary Educational Institution of Higher Education
"Kuban State Agrarian University named after I. T. Trubilin"
Kalinina str. 13, 350044 Krasnodar
Russian Federation
e-mail: bartp_2@mail.ru

Valerii Loiko
Federal State Budgetary Educational Institution of Higher Education
"Kuban State Agrarian University named after I. T. Trubilin"
Kalinina str. 13, 350044 Krasnodar
Russian Federation
e-mail: loyko9@yandex.ru

Sergej Kurnosov
Federal State Budgetary Educational Institution of Higher Education
"Kuban State Agrarian University named after I. T. Trubilin"
Kalinina str. 13, 350044 Krasnodar
Russian Federation
e-mail: kurnosov_56@mail.ru

Abstract The paper presents the results of research on the process of production management in agriculture by presenting it in the form of a leading concept, namely the value chains. Two main chains were identified: and are the following: agricultural production and cyclical processing production. In this paper, we improved the flow control scheme with increased emphasis on financial value-adding flows. We also showed that the added value occurs during technological transformations of material flows in the links of value chains as necessary costs for technological transformations and their management.
The paper describes in detail the functions of one of the main blocks of value-added chains which is the storage, which receives the material flow of the created initial, original value (agricultural products). The volume of agricultural products in the storage should ensure the smooth functioning of the value-added chain of cyclical processing production. Our study also provides a mathematical description of financial and material flows in the given control scheme. A mathematical expression for the efficiency of the production process in agriculture has been obtained as well. We also derived a mathematical condition for the effectiveness and a formula for calculating the sale price of socially significant processed products. The paper considers a detailed description of time characteristics of the production process under study. It is shown that the time production intervals (periods) of the value added chain of agricultural production depend on the branch of agriculture that is used, and for the value added chain of cyclic processing production, there are two approaches to the organization of production and the establishment of the cycle time which are possible. In addition, we derived mathematical dependencies for calculating the time characteristics of cyclic processing production.

Keywords: *value chains, leadership, agricultural management, production process*

1 Introduction

The cost of food products in the market (in a store) is determined by the process of passing the initial agricultural products through the value-added chain (VAC) (Porter 2006) of the production process management scheme in agriculture, as shown in Figure 1 that follows (Khodos 2017). The following symbols are presented in the diagram:

d_1 **-** initial financial flow;
d_2 - returnable financial flow (market revenue);
d_{11} - financial flow that creates the initial value (agricultural products);
d_{12} - financial flow aimed at creating added values;

d_{121} - added value of agricultural production centers;
d_{122} - financial flow aimed at creating added value in the VAC of cyclical processing production;
d_{1221} - added value to the 1st link of the VAC of cyclic processing production;
d_{1222} - value added to the 2nd link of the VAC of cyclic processing production;
d_{122n} - added value in the n-th link of the VAC of cyclic processing production;

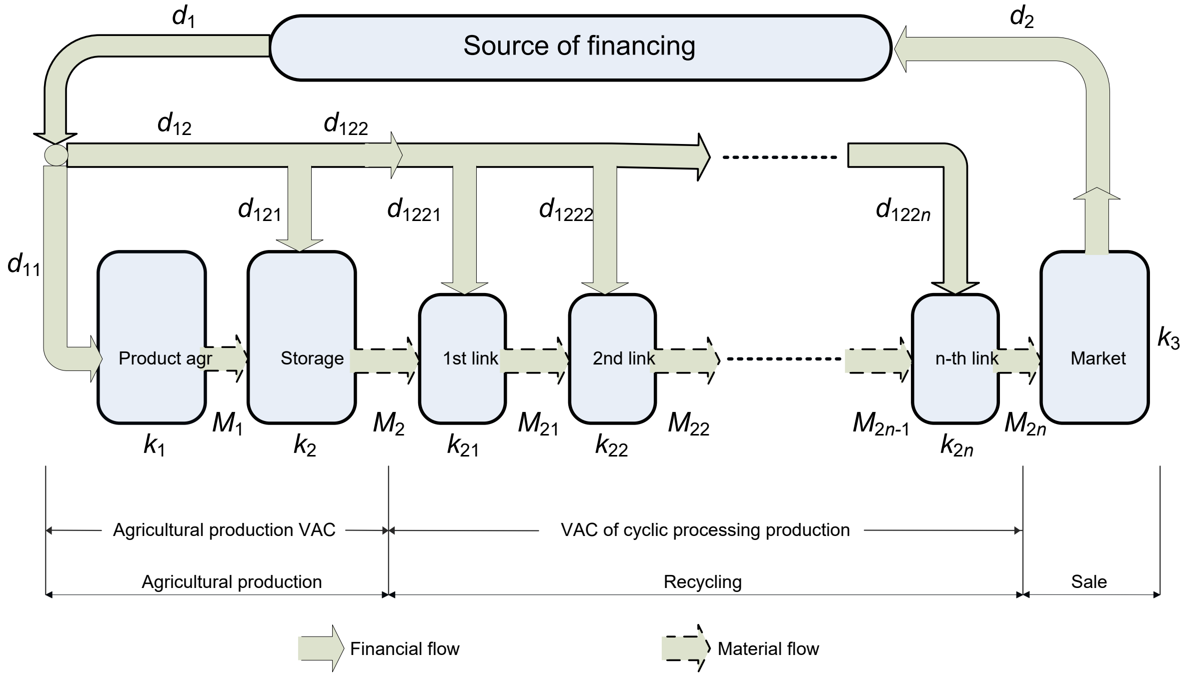

Fig. 1. Scheme of production process management in agriculture
Source: Own results

M_1 - initial material flow of agricultural products (initial cost);
M_2 - part of the volume of agricultural production output from the Storage, sufficient for the necessary loading of the 1st link of the VAC of cyclic processing production;
M_{21} - technologically converted value-added M_2 stream;
M_{22} - technologically converted value-added M_{21} stream;
M_{2n-1} - technologically converted value-added M_{2n-2} stream;
M_{2n} - technologically converted value-added M_{2n-1} stream;

k_1 - coefficient of conversion of d_{11} financial flow to agricultural products (M_1 flow);
k_2 - technological coefficient of conversion of agricultural products to the Storage;
k_{21} - technological conversion coefficient in the 1st link of the VAC of cyclic processing production;
k_{22} - technological conversion coefficient in the 2nd link of the VAC of cyclic processing production;
k_{2n} - technological conversion coefficient in the n-th link of the VAC of cyclic processing production;
k_3 - the market coefficient for converting the finished product of a cyclical processing production (M_{2n} flow) into the d_2 returnable financial flow (market revenue).

2. Methodology

Similar to Loyko (2020), we find a detailed mathematical description of the movement of financial and material flows in the flow scheme developed by them. This work focuses on value added chains and the time characteristics of production processes that occur in them.

Using the d_{11} financial flow, the initial value is created - the material flow of agricultural products, which is sent to the Storage before processing. This is necessary, since agriculture has a pronounced seasonal character, while human consumption of food products is all-season. An elevator can act as the Storage facility in crop production, a refrigerator - in livestock production, and so on. For food products (bread, meat, sausage, cereals, pasta, flour, various types of canned food, etc.) to appear on the market, it is necessary to process the initial cost - agricultural products (Takhumova 2018a; or Takhumova 2018b).

For the implementation of the above process, we have proposed the scheme of Fig. 1, which includes the Source of financing, the Value-Added Chain of agricultural production, the VAC of cyclic processing production, and the market. The added value occurs during technological transformations of material flows in the VAC links as necessary expenses for technological transformations and their management. Therefore, to the d_{11} original cost we add the d_{12} cost, which consists of d_{121}, i.e. the sum of the agro-production storage costs in the Storage (in the quantity necessary for the smooth functioning of the VAC in cyclic processing production) and the d_{122} cost, representing the cost of technological transformation and management in the links of the VAC in cyclic processing production. That is, in mathematical language, the d_{12} total value added in the scheme of Fig. 1 may be written as:

$$d_{12} = d_{121} + d_{122}, \tag{1}$$

and the d_1 total financial flow of production costs will be:

$$d_1 = d_{11} + d_{12}. \tag{2}$$

It should be noted here, that the d_{121} added value in (1) refers to keeping in the Storage for the entire specified period, while the work of the VAC in processing production occurs in cycles in the m amount for the storage period. Therefore, the 1st link of the specified VAC is loaded with a part of the volume of agricultural production from the Storage, enough to work in one cycle. At the end of the cycle, the part of the agricultural production volume that is enough to work in one cycle can be loaded from the Storage again, and it happens the same way for m cycles. It means, that in formula (1) d_{122} is the added cost for all m cycles. The volume of the material flow entering the 1st link of the VAC processing, should be mathematically written as:

$$M_2 = \frac{1}{m} k_2 M_1. \tag{3}$$

and the M_1 volume as:

$$M_1 = \frac{d_{11}}{C_a}, \tag{4}$$

where C_a is the cost of production of a weight unit of agricultural production (specific costs), and $\frac{1}{C_a} = k_1$ is the conversion coefficient of the d_{11} financial flow to agricultural products (M_1 flow).

In this case, d_2^c revenue per one cycle will depend directly on the product of the technological coefficients of the VAC links, the P_p sales price, the input financial flow per d_{11}/m cycle and inversely on the unit costs of C_a agricultural production:

$$d_2^c = k_2 \cdot k_{21} \cdot k_{22} \cdots k_{2n} \frac{P_p}{mC_a} d_{11}, \tag{5}$$

where $P_p = k_3$ is the market selling price of a unit of processed products.

If all m cycles are completed, then d_2 revenue for the entire period will be:

$$d_2 = k_2 \cdot k_{21} \cdot k_{22} \cdots k_{2n} \frac{P_p}{C_a} d_{11}. \tag{6}$$

Next, we evaluate the efficiency of the production process in agriculture according to the scheme Figure 1. We will consider Э the efficiency of the production process, as the ratio of the profit received on the d_2 market from the sale of products produced during the period to the d_1 total costs made during the same period for the production of goods, i.e.

$$Э = \frac{d_2}{d_1}.$$

We use the expression from (2) instead of d_1:

$$Э = \frac{d_2}{d_{11} + d_{12}}$$

Now, let's divide the numerator and denominator by the amount of the financial flow to create the main value of d_{11}, where we get:

$$Э = \frac{\frac{d_2}{d_{11}}}{1 + \frac{d_{12}}{d_{11}}}$$

In the denominator of this expression, the second term is nothing more than a fraction of the value added relative to the size of the d_{11} financial flow. Let's denote this fraction by μ, i.e.

$$\mu = \frac{d_{12}}{d_{11}} \tag{7}$$

Then the expression for the Э efficiency of the production process will look like the following:

$$Э = \frac{d_2}{d_{11}(1 + \mu)}. \tag{8}$$

Now substituting the expression for d_2 from (6) in (8) and performing the transformations, for the efficiency of Э we get:

$$Э = \frac{k_2 \cdot k_{21} \cdot k_{22} \cdots k_{2n} P_p}{C_a(1 + \mu)} \tag{9}$$

Let's indicate the composition of technological coefficients before P_p in the numerator of the expression (9) using k_0 :

$$k_0 = k_2 k_{21} k_{22} \cdots k_{2n}$$

Then, finally, for the Э efficiency of the production process, we may use:

$$Э = \frac{k_0 P_p}{C_a(1 + \mu)} \tag{10}$$

It be easily seen, that the Э efficiency of the production process depends directly on the P_p value of the market price, and vice versa, i.e. on the C_a unit cost of production of agricultural products and the μ value of the share of value added.

Coefficients of technological transformations are generally less than one (for example, "grain to flour" or "meat to sausage") and they slightly reduce the numerator. For the production process to break even, it is necessary that the efficiency is not less than one unit:

$$Э \geq 1$$

When producing socially significant processed products, such as bread, it is important to determine the minimum selling price of products on the market, at which production still remains break-even. Obviously, by equating the right part of the expression (10) to one, we can obtain a formula for calculating the minimum break-even price, taking into account the values of production parameters:

$$P_{p\min} = \frac{C_a(1+\mu)}{k_0} \tag{11}$$

3. Results and discussion

Next, we will consider the time characteristics of the studied production process in more detail. In the agricultural production process shown in Fig. 1, time production intervals (periods) of agricultural production VAC and the chains of cyclical processing production can differ very much. This may be explained by the biological features of agricultural production facilities.

If we consider crop production, the terms of growing crops in this industry are not very long. For example, in vegetable growing of an open ground, the time of cultivation lie in the range from two to four months. In fruit growing, fruits ripen in a period of one to two and a half months; and in field farming, for example, grain-growing takes from three to six months from sowing to harvesting. But, unfortunately, the seasonality in the field of crop production so far remains insurmountable. Therefore, in crop production, the duration of the production period is one calendar year (Gribskov 2015) .

The situation is simpler with frequency in the livestock industry. In this industry, seasonal dependence is not that acute. In cattle breeding, bulls grow up to be ready for slaughter in eight to nine months, and heifers are even two months faster: six or seven months. In pig farming, pigs reach a mass of 100 kg in six to eight months and are thus ready for sale. In poultry farming, it takes an average of four to five months for a turkey to be suitable for slaughter. If the young birds are fattened for meat, then it is required the next age limits: eight to nine weeks for broiler chickens, seven to eight weeks for ducklings and nine weeks for goslings. In rabbit breeding, it takes three months to fatten a rabbit (Bogomolova 2019).

Thus, the frequency of VAC in agricultural production, and, consequently, the volume of loading in the Storage, for the crop industry are annual, and for the livestock industry, the frequency and volume of stock in the Storage will be the maximum as indicated above.

There are two possible approaches to organizing production and setting the cycle time for VAC of a cyclic processing center.

In the first approach, the processing time of parts of the volume of agricultural production output from the Storage sufficient to work in one cycle is defined as the sum of the processing times of the material flow in the links of the VAC of cyclic processing production, multiplied by their number:

$$t_ц = m\sum_{i=1}^{n} t_i \ , \tag{12}$$

where:

$t_ц$ - the processing time of the material flow in all n links of the VAC of cyclic processing production;

i - number of the VAC link;

m - the number of processed parts of the volume of agricultural production from the Storage, sufficient to work in one cycle.

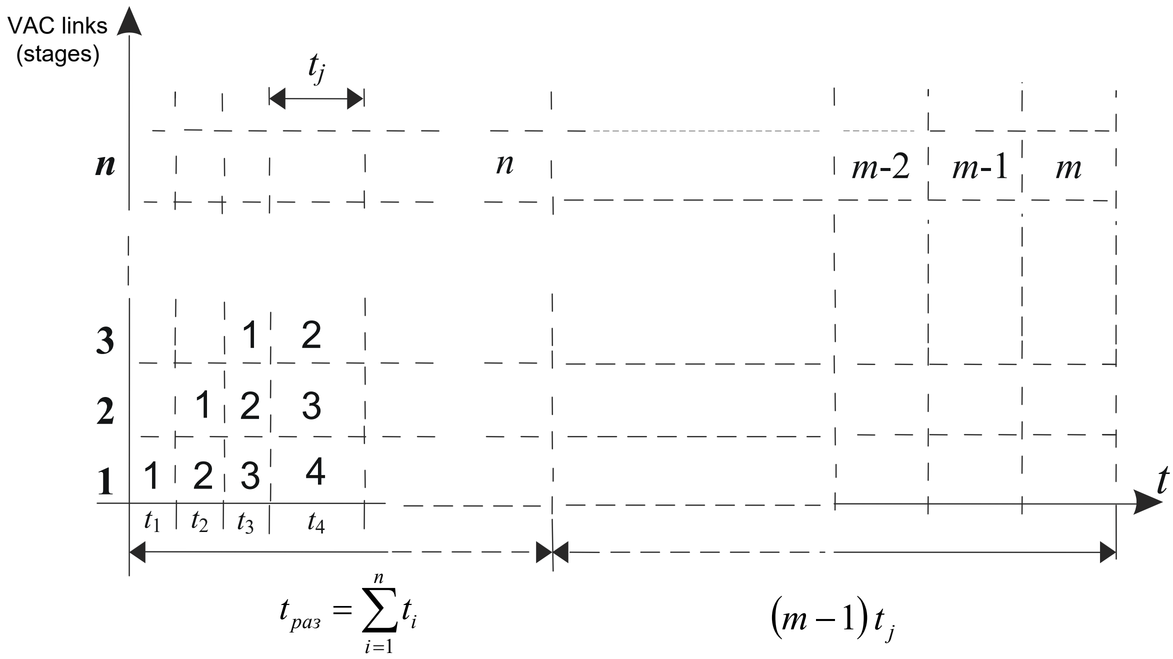

Fig. 2. Diagram of the VAC conveyor operation of a cyclic processing production center with *n* links (stages) and *m* parts of the processing volume (tasks)
Source: Own results

In the second approach, the VAC of cyclic processing production is considered as a sequential production pipeline (see Fig. 2). In this case, the cycle duration is defined as the sum of the acceleration time $t_{раз}$ and the conveyor time $t_к$.

The acceleration time is the time when the first part of the volume of agricultural production output from the Storage is sufficient to work in a single cycle (see formula (3)), through all the links in the value added chain of cyclic processing production:

$$t_{раз} = \sum_{i=1}^{n} t_i \; . \tag{13}$$

The conveyor time, which is $t_{к,}$ can be defined as the product of the number of *m* parts of the processing volume (tasks), reduced by one (since one task was already completed during acceleration), by the duration of processing the material flow in the slowest t_j link, i.e., in the link which the conversion was performed in, longer than in the other links.

$$t_к = (m-1)t_j \tag{14}$$

Therefore, the total time for $t_{цк}$ conveyor processing can be written as:

$$t_{цк} = \sum_{i=1}^{n} t_i + (m-1)t_j \; . \tag{15}$$

When using pipelining, there is a noticeable acceleration in processing and an improvement in the use of production capacity. Dividing (12) by (15), we get the next formula to speed up processing:

$$U = \frac{m\sum_{i=1}^{n} t_i}{\sum_{i=1}^{n} t_i + (m-1)t_j} \; . \tag{16}$$

If we assume that all the links have the same processing time, i.e. $t_j = t_i$, then (16) can be simplified

$$U = \frac{mn}{n+m-1}. \tag{17}$$

Let's assume that $m = 100$, $n = 4$. Then, using these values in (17), we get

$$U \approx 4$$

In other words, we have accelerated the production process by four times approximately.

4. Conclusions

Overall, our results demonstrate that the flow control scheme has been improved, with increased emphasis on financial value-adding flows. The study describes in detail functions of one of the main blocks of value-added chains, which is the storage.

In this study, we derived and provided the mathematical description of financial and material flows in the scheme of production process management in agriculture. Moreover, we have as well obtained a mathematical expression for the efficiency of the production process in agriculture. A mathematical break-even condition and a formula for calculating the sale price of socially significant processed products have been derived. These tools might become amazingly effective and useful in planning, executing and assessing the productions processes in agriculture.

Last but not least, our study also derived mathematical dependencies for calculating the time characteristics of cyclic processing production. This might also be a very useful or even the leading item in production planning and calculation.

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