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Optimization of stocks in animal husbandry through digitalization opportunities in the planning of deliveries

N. Petrova, N. Kostadinova, G. Aleksiev*

Department of Management., Faculty of Economics, Trakia University, 6000 Stara Zagora, Bulgaria

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Abstract. *Bulgarian animal husbandry has undergone several transformations since the country's accession to the EU. The declining levels of institutional support in recent years have necessitated the optimization of activities and the rational use of available resources. This requires the introduction of modern digital management methods for livestock farms. The aim of the present study is to assess the digitalization in supply planning for optimization of stocks in animal husbandry. To achieve this goal it is necessary to solve the following tasks: to analyze the problems in the cyclical supply of feed stocks; to study the models for optimization of stocks in animal husbandry; to assess the possibilities for digitalization of the processes of supply and management of feed stocks. The expectations from the research are that digitalization of the processes will optimize the supplies and stocks in animal husbandry, which is a prerequisite for efficiency and continuity of the production process. The results of the study show that consistently optimizing the existing, warranty, and preparatory stock is crucial for enhancing efficiency on any animal husbandry farm. Integrating digital technologies to monitor, analyze, optimize, and schedule these stocks can enhance farm efficiency, mitigate risks, and safeguard the environment.*

Keywords: agriculture, efficiency, feed, management, stocks, digitalization

Introduction

"Digital agriculture refers to tools that digitally collect, store, analyze and share electronic data and/or information along the agricultural value chain." (European Commission, 2013)

According to the Strategy for Digitization of Agriculture and Rural Areas of the Republic of Bulgaria, the accelerated digitalization of Bulgarian agriculture is a necessary process to reduce the bureaucratic burden, optimize production processes, increase farmers' incomes and yields, achieve a sustainable bio-industry, maintain food safety in conditions of increased industrialization and new, unproven technologies, a drastic increase in competitiveness and increased demand for Bulgarian products on the single European market and on world markets. Digitalization allows the agricultural economy to realize its high potential and reap the same successes as the high-tech spheres of the economy: increasing productivity, adding value, improving quality and safety, and thus income and quality of life, drastically reducing

pollution to sustainable levels, flexible and quick response to market trends.

The implementation of intelligent systems improves the welfare of animals by monitoring their health, administering drugs and overall improvement of welfare and care according to Jiang et al. (2023) and Gehlot et al. (2022).

Feeding farm animals by using intelligent systems includes automation, sensors, data analysis, which significantly improve the precision of feeding animals and allow providing the right amount of feed with the appropriate composition for each animal. The benefits of this approach are presented by Place et al. (2022) and are improved animal health, increased productivity and increased profitability.

Intelligent feeding systems aim to improve animal feeding programs by providing nutrients according to the exact nutritional needs of individual animals based on real-time feedback obtained from sensors. Any feeding issues are monitored and corrective action is taken if necessary.

These systems reduce labor costs and increase productivity, allow refinement of feed composition and reduce adverse environmental impacts (Hernandez-Patlan et al., 2023).

Material and methods

The methods used to achieve the goal and solve the tasks are analysis and synthesis, induction and deduction, axiomatic method, structural-functional approach, systematic approach.

Inventories and work in progress in animal husbandry in economic literature are divided among a number of key types of inventories that should be clearly distinguished in order to improve their management and thus the farms' efficiency.

For the production of finished products, the availability of raw materials is essential, such as fodders for livestock, basic and auxiliary materials, semi-finished products and fuels. These elements are the major determinant of productive resources of the enterprise. For each element of these a current and guarantee stock is determined.

Current stock

The current stock ensures appropriate rhythm and continuity of the production process. The levels of current stock should be closely monitored and optimized in order to avoid potential losses. On a theoretical level the current stock is determined in natural values by the formula:

$$\mathbf{Z_{ti} = R_d \,.\, T_d}$$

where:

Z_{ti} – Current stock of the i-th material;

R_d - Consumption of the i-th material per day;

T_d - Interval in days between two deliveries.

The main conclusion from this method of determining current stock is that there are two main factors for its volume - material consumption of a certain kind per day and the number of days between two deliveries. The number of days between two consecutive deliveries are influenced by the following factors: remoteness of the enterprise or its subsidiaries from the suppliers of raw materials; duration of the unloading, transport to warehouses, sorting, creating documents, etc.; as well as the time to prepare materials for their entry in the production process

The warranty reserve

The warranty reserve includes the minimum amount of raw materials, which ensures the continuity of the production process when the normal course of supply is disrupted. The volume of this stock is defined as percentage of the average of current stocks in number of days depending on the frequency of deliveries. The smaller the number of suppliers, the greater the percentage of the guarantee stock. Some farms diversify their suppliers of feeding materials in order to mitigate the risks and lower the warranty reserve levels. Disruptions in the supply chain nonetheless are a common occurrence and farmers rely on their experience when optimizing the warranty reserve. We should also note that a high amount of warranty reserve can lead to significant inefficiency in the use of available resources. The warranty reserve can be determined and based on research and analysis of deviations in supply from the previous

reporting period by individual types of materials. It depends largely on the type of production, the distance between supplier and consumer, forms of supply, organization of supply and production.

Preparatory stock

It is implemented only in cases when the technology requires a preliminary preparation of the raw materials - drying, aging, sorting, stacking and the like. Its value is determined similarly to the current stock, but here the number of days needed for preparation are taken in to account, instead of the number of days between two consecutive deliveries.

In practice, three additional types of standards for inventories are used:

- Maximum stock - the sum of the current and warranty reserve

Zmax = Zcurr. + Zwarr.

- Average stock – half of the current

- Minimum stock – equals the warranty

Zmin = Zwarr.

In animal husbandry the largest volume of stocks are the fodder stocks, followed by equipment, materials and others. The need for fodder is almost continuous and their organization must be coordinated in the terms of delivery with regard to the consumption. Through these inventories, an enterprise ignores the supply disruptions and ensures a normal production process. The main causes for these disruptions in practice can be summarized as:

• poor organization of the procurement process - delayed delivery;

• inability of the contractor to fulfill supply obligations for objective reasons - production causes, accidents, etc.;

• problems with transportation;

• poor organization of loading and unloading;

• increase of purchase prices.

Several factors lessen the trend of increasing stock volumes:

• stocks are not directly involved in the production process, thus delaying the turnover and reducing the possibility of profit;

• slowing the rate of expansion of production;

• creating artificial scarcity on the market;

• losses arising from deterioration;

• increasing the costs for protection of stocks (to maintain storage, security, special arrangements

Production stocks in animal husbandry

➢ current stocks – they provide for the everyday needs of production. Determined by the daily needs in rational dimensions by the intervals of supply. They are calculated as follows:

$C_S = q.t$

C_s – current stocks

q – scientifically justified rate of consumption

t – rational delivery interval

➢ insurance guarantee stock - by its means the farm is protected against supply disruptions.

➢ Stocks of finished goods - they occur when difficulties in the marketing and distribution of production is evident.

➢ work in progress - before they become finished goods, stocks go into a phase of work in progress. To speed up the turnover of funds, it is necessary to shorten the duration of this phase.

Results and discussion

In order for a company to achieve maximum profit, it is necessary to use its resources efficiently, including its inventories.

The maintenance of material stocks by any company aims for:

- the production or activity to remain constant and not to suffer interruptions caused by lack of raw materials or delays in receiving ordered goods;

- planning purchases from wholesalers, which allows obtaining better prices for a larger batch of goods;

- use of discounts in the prices of transport services when transporting larger quantities;

- overcoming inconsistencies resulting from uneven delivery related to the seasonality of supply;

- overcoming a speculative rise in commodity prices;

It is in the interest of manufacturing to keep material stocks as large as possible to avoid situations of production process stoppages due to shortages and to ensure lower procurement costs. On the other hand, in order to increase the profitability of capital investments in inventories, it is necessary to reduce assets and increase the turnover of inventories. These conflicting relations can be overcome only when adopting an integrated approach to inventory management with clear corporate goals according to Rakovska (2015).

Inventory management is a process by which various actions are performed in order for a company to improve matters related to the organization, planning and control of its entire product inventory. Proper inventory management contributes to business profitability by identifying and correcting weaknesses in resource utilization.

Models are used to analyze the impact of various factors in the environment and make it possible to predict possible situations that may arise in the immediate or long-term perspective. Due to the complexity of determining the level of material stocks, so-called optimization models are used in theory and practice. They help determine the size of the order and the number of deliveries during the period (month, year), etc. The models include various solutions that attempt to optimize material lot sizes by minimizing total annual supply chain costs.

The main model used is the Economic Order Quantity Model (EOQ).

The prerequisites of the basic inventory management model are:

- uniform and homogeneous stock is considered;
- the demand is uniform and constant;
- the model does not allow for the existence of a deficit, i.e. the consumption of the stock is always equal to its demand;
- the warehouse and the delivery vehicle have unlimited capacity;
- the delivery time (fulfillment of the order) is permanent;
- the same quantity is ordered every time - the optimal order size.

The optimal size of the batch of delivered goods, and accordingly the optimal frequency of delivery depends on the following factors: the volume of demand; transportation, delivery, and storage costs.

The minimum amount of transport and delivery costs and storage costs are chosen as optimality criteria. Transport and delivery costs decrease as the size of the order increases, as purchases and transport of goods are made in larger quantities and, therefore, less frequently. Storage costs increase in direct proportion to order size. To solve this problem, it is necessary to minimize the function representing the sum of the transportation and delivery costs and the storage costs. In order to achieve such optimization, the following formula can be used:

$$TC(q) = TC_0(q) + TC_1(q),$$

Where q is the volume of delivery, $TC_0(q)$ is the total cost of all deliveries during the considered period, $TC_1(q)$ is the total cost of keeping the stock, and $TC(q)$ is the total cost of forming and keeping the stock.

The annual demand for the stock is D units, and one delivery is q units, then the number of deliveries will be $D/$, and C_0 is the cost per delivery. Since the inventory is depleted uniformly, $q/2$ will be the average amount of inventory held in the warehouse and C_1 is the storage cost per unit of inventory for one year. For the objective function of the base model results are obtained by calculating:

$$(q) = C_0 D/q + C_1 q/2$$

Solving the model consists in finding the optimal delivery volume q where the total cost is minimal.

$$q = \sqrt{2C_0D/C_1}$$

This model is known as the Economic Order Quantity (EOQ) model because the most economical order size is established. It is one of the oldest classic supply planning models developed by Ford W. Harris in 1913, but Wilson is credited for the application and in-depth analysis of this model, and in economics the EOQ formula is known as Wilson's formula and was additionally proven by Kumar (2016).

Economic order quantity is an inventory management technique that helps make efficient decisions by determining the optimal amount of

inventory a company should purchase to meet its demand while minimizing its shipping and storage costs.

Method ABC analysis

The essence of this method is expressed in determining a criterion according to which stocks are distributed by degree of importance into three groups, and for each group specific methods of optimal management are applied, considered suitable for the specified group. The ABC analysis method is based on the Pareto rule known in economics or the 80/20 rule. In terms of inventory, the 80/20 rule can be interpreted in the following ways: 20% of the types of inventory maintained are associated with 80% of the total cost of purchasing all types of inventory; 20% of the inventory types maintained are associated with 80% of the total cost of managing all inventory types; 20% of the stock types maintained occupy 80% of the total warehouse space, and so on as it was presented by Milkova (2019).

Possibilities for digitalization of the processes of supply and management of feed stocks

Data-driven solutions in the supply chain have become seamlessly implemented using tools and techniques developed by big data analysts. Better and faster solutions can help businesses by analyzing and understanding real-time results that deal with large data sets that describe integrity, volume, variety and velocity according to Alkahtani et al. (2021). Organizations can also improve the supply chain by reducing costs and mitigating risk. A combination of data technologies and agri-food projects are critical to creating new knowledge by expanding farmers' data, advanced services, processes and software. It also plays a role in adapting factories of the future and information and communication technologies and related agricultural and big data models.

The latest innovations in warehouse logistics and automation, digital and robotic solutions are transforming modern warehouses from conventional physical objects into connected and intelligently functioning ecosystems. In the age of global communications, e-business and online shopping, the supply chain is more complex than ever, and large companies increasingly establish and maintain warehouses and distribution centers in different and remote geographical locations. There are a number of problems and challenges facing the effective management of modern farms' warehouse, which, however, find a common solution - automation. With the help of visionary technological concepts such as IoT as presented by Mo (2011), Big Data, artificial intelligence, mobile robots, specialized warehouse management software, etc., facility managers in the field of warehousing and logistics manage to not only keep up with the dynamics of the supply chain, but also to secure competitive advantages, as was also researched by Kamilaris et al. (2019). Among them are improved efficiency, security and safety, faster and more accurate processing of orders, greater capacity. In addition, the automation of operational activities such as packing, sorting and tracking allows the release of intellectual power and its redirection to more critical tasks of a tactical and strategic nature was proven by Büyüközkan and Göçer (2018).

From the introduction of the first means of automation in the warehouse operation up to present day, managers are frantically looking for the potential for additional automation of processes in order to work faster, more efficiently and more reliably. And while humans are still indispensable in the performance of certain tasks, performing heavy and repetitive activities for too long of a period of time can create serious health risks and worsen overall performance. The main factors in favor of automated systems are guaranteed safety for personnel, savings in labor costs, higher speed and precision, as well as a more sustainable quality of work in the long term based on previous research from Panetto et al. (2020).

Specialized warehouse management software packages are designed to strictly manage the day-to-day activities of warehouse, logistics and distribution centers and usually include a rich variety of tools and functional modules, some of which we have displayed in this paper. Some of them are dedicated to inventory control tools, others to tracking, manual and automated order fulfillment, and still others to preparatory operations to finalize

deliveries based on results presented by Dadi et al. (2021).

Food safety, security, traceability concerns in the food industry must be anticipated and prevented rather than reactive and responsive as people are more health conscious these days. Digitalization remains a perfect solution to all these problems of reducing human intervention and providing food supply chain monitoring that is unachievable with only human labor. Therefore, there is a need for science-based decision-making and the use of advanced technologies that make supply chains, especially food, safer and more secure, with better traceability and accountability. Digital technologies are helping to develop efficient agri-food supply chains in various ways.

Conclusion

Warehouse management systems promote a holistic and centralized approach to warehouse management. Activities that fall into the potential automation categories are planning, organizing, directing and controlling the utilization of available resources, managing material flows, and personnel. The most modern products in the segment offer real-time, historical and even predictive monitoring and diagnostics capabilities of all integrated warehouse processes and operations – from the moment an object enters the warehouse until it leaves for production. Among the most distinct benefits of digitalizing warehouse and logistics operations through the implementation of a specialized management software solution are the significant increase in efficiency, the elimination of human errors, and the introduction of paperless business administration.

RFID technology can be used to sense the food environment; big data can help analyze vast amounts of information in fractions of seconds; IoT is a combination of different technologies; robots can automate work. Robots can reduce human intervention; AI can think independently and respond to changing conditions adequately. The use and generalization of such high-tech technologies are necessary in the food industry sector.

The constant optimization of the current, warranty and preparatory stock is key for improving the efficiency in any animal husbandry farm. The implementation of digital technologies to monitor, analyze, optimize and schedule these stocks can lead to improvements of the farms efficiency as well as reduce risks and protect the environment. In the age of digitalization of agriculture and parallel to Industry 4.0, more and more researchers are focusing on Agriculture 4.0, Bulgarian farmers are faced with a serious problem, they must implement digital technologies or risk to be left behind and diminish their competitiveness on the global markets.

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