MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
Faculty of Transport, Management and Logistics
Logistics Department

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«05» June 2020

BACHELOR THESIS

(EXPLANATORY NOTES)

OF GRADUATE OF ACADEMIC DEGREE

«BACHELOR»

THEME: **«Organization of logistics support for technobusiness»**

Speciality 073 «Management»

Educational Professional Program «Logistics»

Done by Volodymyr O. Kostiuk
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Kyiv 2020

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
Факультет транспорту, менеджменту і логістики
Кафедра логістики

ЗАТВЕРДЖУЮ
Завідувач кафедри логістики
_____ Григорак М.Ю.
(підпис, П.І.Б)
«05» червня 2020 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ

«БАКАЛАВР»

ТЕМА: «***Організація логістичного забезпечення технобізнесу***»

зі спеціальності 073 «Менеджмент»
(шифр і назва)

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Київ 2020

NATIONAL AVIATION UNIVERSITY
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Academic degree Bachelor

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Educational Professional Program «Logistics»

APPROVED
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«25» May 2020

TASK

FOR COMPLETION THE BACHELOR THESIS OF STUDENT

Volodymyr O. Kostiuk
(surname and name)

1. Theme of the master thesis: «Organization of logistics support for technobusiness» was approved by the Rector Directive №553/ст of May 04, 2020.

2. Term performance of thesis: from May 25, 2020 to June 21, 2020.

3. Date of submission work to graduation department: June 05, 2020.

4. Initial data required for writing the thesis: general information of techno-company Ajax System, statistical and financial data of techno-company Ajax System, literary sources on logistics, procurement logistics and inventory management, Internet source.

5. Content of the explanatory notes: introduction, the basics of logistics management of techno companies; systematization of procurement logistics tasks and definition of criteria that significantly affect the optimal procurement management; analysis the activity of techno-company Ajax System; identification of disadvantages in the procurement logistics and inventory management; recommendations of forecasting method using; recommendations of contractor selection order; recommendations of inventory management policy; calculation of the economic savings of the proposed measures; conclusions and appendix.

6. List of obligatory graphic matters: tables, charts, graphs, diagrams illustrating the current state of problems and methods of their solution.

7. Calendar schedule:

№	Assignment	Deadline for completion	Mark on completion
1	2	3	4
1.	Study and analysis of scientific articles, literary sources, normative legal documents, preparation of the first version of the introduction and the theoretical chapter	25.05.20-27.05.20	Done
2.	Collection of statistical data, timing, detection of weaknesses, preparation of the first version of the analytical chapter	28.05.20-29.05.20	Done
3.	Development of project proposals and their organizational and economic substantiation, preparation of the first version of the project chapter and conclusions	30.05.20-01.06.20	Done
4.	Editing the first versions and preparing the final version of the master thesis, checking by standards inspector	02.06.20-03.06.20	Done
5.	Approval for a work with supervisor, getting of the report of the supervisor, getting internal and external reviews, transcript of academic record	04.06.20	Done
6.	Submission work to Logistics Department	05.06.20	Done

Student_____
(signature)

Supervisor of the bachelor thesis _____
(signature)

8. Consultants of difference chapters of work:

Chapter	Consultant (position, surname and name)	Date, signature	
		The task was given	The task was accepted
Chapter 1	Associate Professor, Savchenko L.V.	25.05.20	25.05.20
Chapter 2	Associate Professor, Savchenko L.V.	28.05.20	28.05.20
Chapter 3	Associate Professor, Savchenko L.V.	30.05.20	30.05.20

9. Given date of the task May 25, 2020.

Supervisor of the master thesis: _____ Savchenko L.V.
(signature of supervisor) (surname and name)

Task accepted for completion: _____ Kostiuk V.O.
(signature of graduate) (surname and name)

ABSTRACT

The explanatory notes to the bachelor thesis «Organization of logistics support for techno business» comprises of 73 pages, 21 figures, 14 tables, 1 appendix, 58 references and 14 formulas.

KEY WORDS: HARDWARE COMPANY, PROCUREMENT LOGISTICS, INVENTORY MANAGEMENT, ECONOMIC ORDER QUANTITY, FIXED-TIME PERIOD SYSTEM

In the bachelor thesis was investigated the theoretical foundations and problems of logistics support of hardware company, especially procurement logistics and inventory management.

The analytical part is devoted to the study of the activities of Ajax Sysytems. The commercial and financial indicators have been analyzed, bottlenecks have also been identified in the procurement policy and inventory management processes.

In the project part is substantiated the feasibility of changing main component assembly contractor, because actual contractor shows a lag in delivery schedules.

Sales forecasts were made and frozen stocks of both devices and components were identified. It was proposed to change the inventory system to Fixed-Time Period System with Economic order quantity. All recommendations were economically justified.

Materials of the thesis are recommended for use during scientific research, in the educational process and in the practical work of specialists of logistics departments.

CONTENTS

NOTATION

DIY – Do It Yourself

IP – Inventory Position

CEO – Chief Executive Officer

MR – Material Resources

INTRODUCTION

A logistical approach using in the management of domestic companies is a necessary condition for improving the efficiency of management, competitiveness and intensification of their integration into the world economic system.

The search for ways to reduce costs goes in the direction of improving the management of procurement, sales, storage of goods and materials, improving cooperation between suppliers, consumers and contractors, changing the technology of material flows, and so on.

The special relevance of the use of logistics in Ukrainian enterprises is due to the following circumstances [54]:

– globalization and European integration processes, in which Ukrainian companies try to take an active part;

– multinational companies getting into the Ukrainian market;

– establishing stable relations with foreign partners who use new approaches in management;

– additional opportunities created by logistics for survival and development of enterprises in the conditions of vaguely forecasted economic results, narrowing of demand and crisis, etc.

The works of many scientists are devoted to the research of the problems of logistics management, for example, among Ukrainian scientists we can distinguish Grigorak M.Yu., Karpun O.V., Katerna O.K., Molchanova K.M., Savchenko L.V., Bakaev L.O., Krykavsky E.V., Chukhray N.I., Chornopyska N.V., Tyurina N.M., Skorobagatova T.M. and other.

Such CIS scientists as Anikin B.A., Gadzhinsky A.M., Dybskaya V.V., Lukinsky V.S., Mirotin L.B., Tishbayev I.E., Sergeev V.I. made a significant contribution and specialists from other foreign countries, in particular, Bauersocks D., Boucher J., Kloss D., Heskett J. and others.

The purpose of this thesis is to organize the logistics processes of the techno-business company.

In accordance with the purpose of the thesis were:

– study of the basics of logistics management of manufacturing companies, including hardware-company;

– systematization of procurement logistics tasks and definition of criteria that significantly affect the optimal procurement management;

– identification of advantages and disadvantages of large and small stocks in the company;

– identification of inventory management methods and consideration of basic inventory management systems;

– general analysis of Ajax Systems activity;

– commercial and financial indicators' analysis of company;

– logistics processes diagnostics;

– SWOT analysis of Ajax Systems;

– recommendations of forecasting method using;

– recommendations of contractor selection order;

– recommendations of inventory management policy.

The object of the study was the logistics support of techno-company processes.

Accordingly, the subject of the study was optimization inventory management of material flows, namely the components and devices on the one hand. On the other hand, searching and determining the optimal contractor for assembly microchips.

Writing thesis general scientific methods were used, such as abstraction, analysis and synthesis, induction and deduction – processing of scientific and educational literature, company analysis, identification of the problem area of research, identification of specific "bottleneck" in the supply and inventory management. And also special methods:

– expert evaluations – to determine the rank of criteria for evaluating potential suppliers;

– integrated score – to determine the rating of the supplier;

– inventory management methods – to determine the economic order quantity and inventory management policy in the project part of the thesis.

During the economic justification of the project decision, a comparative cost analysis was conducted.

In addition, “field” research was conducted in the divisions of Ajax Systems, namely interviews with:

– top-management for determination rank for contractors selection criteria;

– techno-specialists for determination of contractors by high quality of microchips;

– logistics managers for determination the logistics processes organization building.

The information base of the study consisted of: scientific and methodological developments of domestic and foreign logistics specialists, laws and regulations, statistical, financial and management reporting of Ajax Systems, as well as orders, directives, regulations and instructions relating to the logistics activity.

For information processing and project calculations, MS Excel used application packages such as MS Word and Visio for the design of the thesis.

CHAPTER 1
THEORETICAL BASIS OF LOGISTICS FOR TECHNOBUSINESS

1.1 Basis of hardware-company logistics

Some scientists consider the logistics activities of business entities as a practical implementation of complex logistics functions and basic operations. Complex logistics functions are divided into [37-41]:

– basic (supply, production, sales);

– key (maintenance of customer service standards, procurement management, transportation, inventory management, order procedure management, production procedure management, pricing, physical distribution);

– supporting (warehousing, cargo processing, protective packaging, ensuring the return of goods, providing spare parts and service, collection of returnable waste, computer information support).

The main components of logistics functions are loading, unloading, packing, freight forwarding, transportation and storage of goods, acceptance and release of goods from the warehouse, transshipment, sorting and assembly, consolidation of goods, collection, storage and transmission of cargo information, payments to suppliers, cargo insurance , transfer of ownership of goods, customs clearance and other logistics operations carried out at the enterprise [42,46,47].

Given the fact that the purpose of logistics is to harmonize the interests of producers, suppliers and consumers, we highlight its main directions on Fig. 1.1 [37,40,48].

Logistic activity of the techno-company can also be considered from the point of view of realization of the basic logistic processes like coordination [37-40]:

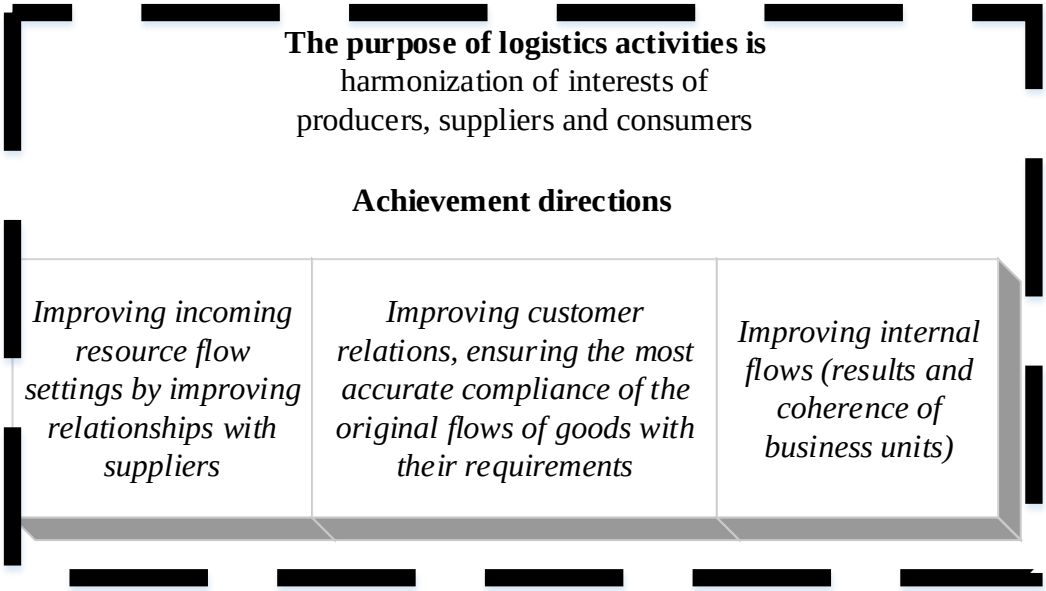


Figure 1.1 – The main achievement directions for logistics

– activities with an operational and calendar plan for the supply of raw materials, materials and semi-finished products, transport and warehousing with supplies;

– activities with a plan of physical distribution during production, in-plant movement of materials, raw materials, spare parts and finished products, loading and unloading operations, transport and warehousing operations for work in progress, etc;

– economic activity with a marketing plan during the sale of products, demand forecasting, service, operational and calendar planning, processing of customer orders, warehousing and transportation.

Thus, the implementation of logistics activities in techno-companies gives grounds to consider it as an integral part of logistics systems.

Most researchers consider logistics activities through the implementation of logistics functions, which in turn are divided into logistics processes and logistics operations. We give the definition of the latter according to the definitions of scientists [31,54,55].

The logistics process is a sequence of execution of logistics operations / functions organized in time, which implements the goals set in the planning period of the logistics system or its network (functional) units.

A logistical operation is any action (or set of actions) associated with the emergence or transformation of the main (associated) flows, which is not subject to further division (decomposition) in the management and controlling tasks of the existing or projected logistics system.

Transport operations are implemented mainly at the lower (operational) levels of management in the relevant functional units of the company and its partners in the supply chain. Logistics operations include, for example, actions performed on material resources or finished products, such as loading, unloading, packing, transportation, acceptance and release from storage, storage, transshipment from one mode of transport to another, assembly, sorting, consolidation, disaggregation, etc.

Logistics operations related to information and financial flows associated with the material can be the collection, storage, transmission of information about the material flow, reception and transmission of orders through information channels, settlements with suppliers, buyers of goods and logistics intermediaries, cargo insurance, customs operations registration of cargo, etc.

From the standpoint of business, the logistics function is a separate set of logistics operations, allocated to improve the efficiency of management in the implementation of logistics strategy / tactics of the firm.

However, the question arises as to how to manage logistics functions, processes and operations within and outside the enterprise. For more than the first decades, two approaches to enterprise logistics management have been considered: traditional and logistical.

According to fig. 1.2 consider the difference between traditional and logistical approaches within one enterprise.

In the traditional approach, the task of improving the integrated flow of materials, as a rule, is not a priority for any of these units. Indicators of material flow at the exit of the enterprise (point B) are random and far from optimal. In the logistics approach, the company is allocated a unit (usually the logistics service) and it receives significant rights, the priority of which is the management of end-to-end

material flow, ie flow coming from outside, passes warehouses, production shops, warehouses and then goes to consumer.

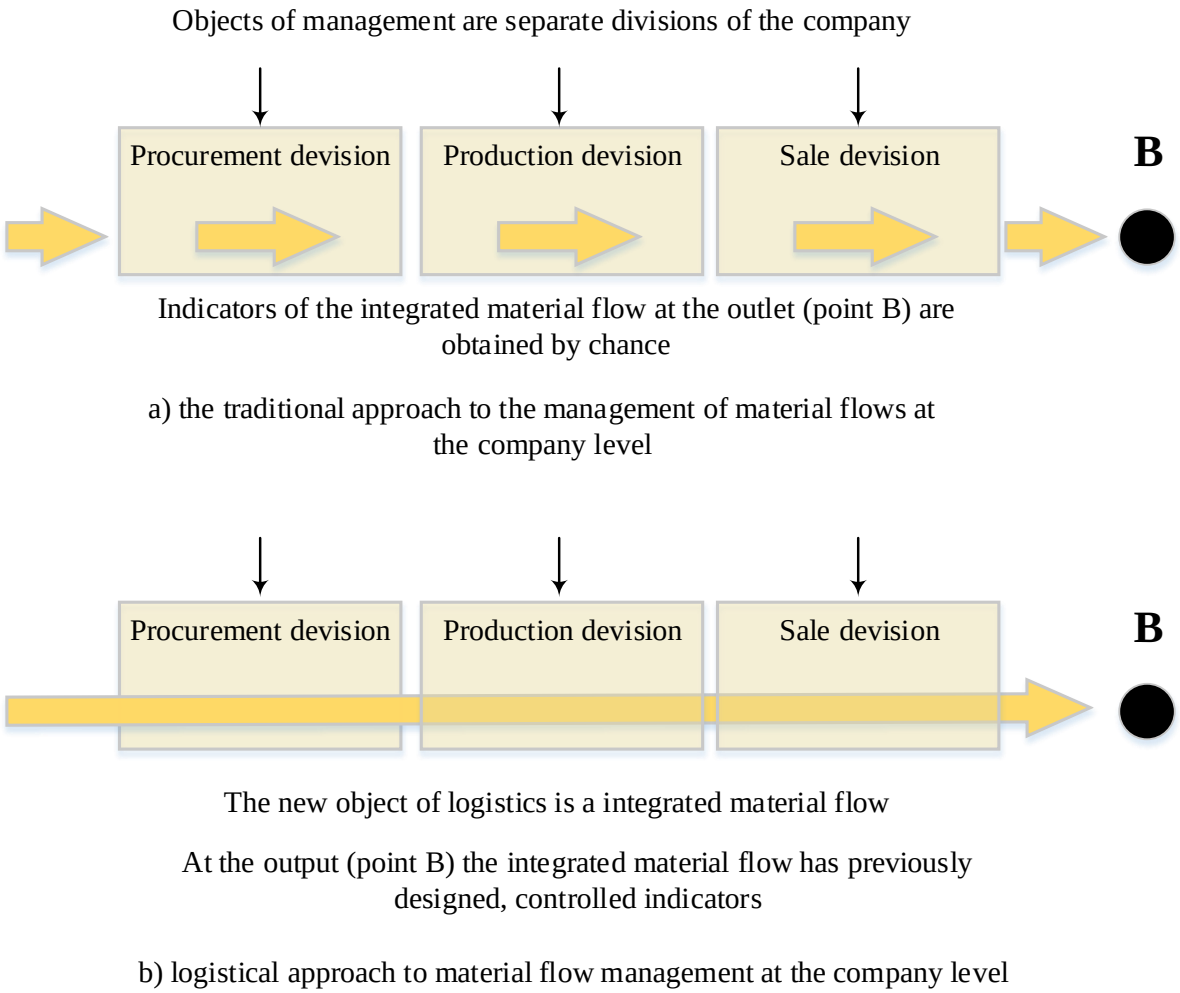


Figure 1.2 – Traditional and logistical approach to company management

As a result, the indicators of material flow at the exit of the enterprise become manageable for using logistical approach to company management.

1.2 Procurement logistics and inventory management

The activity of any company, both public and private, depends on the availability of raw materials, supplies and services provided by other company.

The supply process is the entrance to the logistics system, so the implementation of the principles of logistics at this stage is the key to the efficiency of the entire system.

The main purpose of applying a logistic approach to supply management is to meet the needs of production in material resources (MR) with the maximum possible economic efficiency [27,40].

Based on this, we formulate the main tasks of supply logistics on Fig. 1.3, while the first sign is required to ensure the smooth operation of the enterprise.

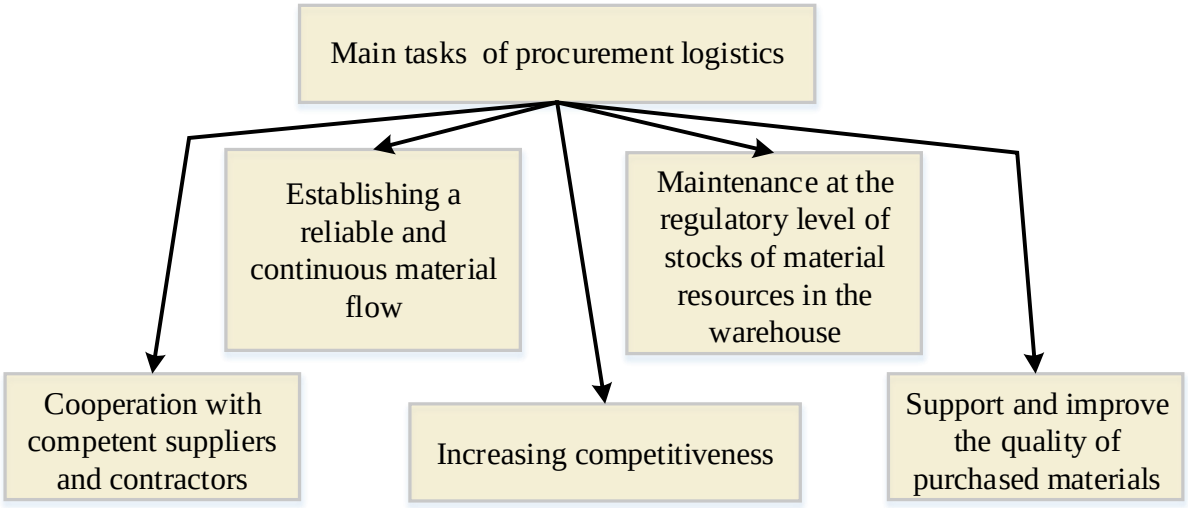


Figure 1.3 – Main tasks of procurement logistics

Cooperation with suppliers, which includes their search, selection and close cooperation with them to agree on the lowest total cost while maintaining the appropriate level of quality, quantity, delivery terms and service.

Maintaining and improving the quality of purchased materials means that the production of goods or services must be carried out with a certain level of quality,

otherwise the final product or service will not meet the accepted requirements and will not be able to ensure the competitiveness of goods and services.

As well as increasing competitiveness. Control over all costs of the supply network allows you to identify operations that do not bring profit or require additional time, increase the competitiveness of the organization as a whole.

The object of supply logistics - the flow of material resources and services circulating in the functional cycle of supply.

Thus, supply logistics is derived from the production logistics model. And these logistics activities in procurement management should be combined with a single policy of relations with major suppliers of material resources [27,40].

The main criteria for the development of logistics policy for procurement and the formation of a common supply system are [27,40]:

- optimal frequency (time) of deliveries;
- optimal structure of material flows;
- minimum total logistics supply costs.

Right organization of supply involves not only minimizing the cost of time and material resources, but also eliminating the need to attract additional workers to perform operations related to the delivery of materials. Therefore, a number of mandatory requirements are set for delivery, the main of which are orderliness, continuity, rhythm and economy.

Planning involves the delivery of material resources on fixed schedules at the most rational frequency of delivery. Systematic organization of supply provides a wide and durable range of MR, economic use of labor, warehouses and vehicles, contributes to the normalization of stocks.

Uninterrupted supply involves regular delivery of the required amount of material resources in the required range to ensure continuous production.

Rhythmicity implies uniform and timely delivery of MR, which guarantees uninterrupted production, avoids accumulation in warehouses of excess inventories, and so on. However, rhythmicity should not be equated with regularity, as the rhythm of supply may vary depending on production programs.

Cost-effectiveness as a principle of rational supply implies economical spending of funds associated with the delivery, processing and storage of MR. This is achieved through the efficient use of transport, mechanization of loading and unloading operations, development of unified technological solutions for delivery, assembly and packaging of materials in containers and more.

When deciding on the choice of the most economical schemes for the supply of material resources should be based on the need to achieve the greatest results at minimum cost. For this purpose it is necessary to provide rhythmic and uninterrupted supply, to establish standards of material stocks at the minimum transport, operational and other expenses.

According to statistics provided by Hayser J. and Render B. [57, p.506], surplus stocks account for more than 50% of invested capital, and therefore inventory management is a critical point and requires increased attention of managers. Such statistics may suggest that small stocks should be kept, not large ones. However, as shown on Fig. 1.4 (built on [34]) the creation of large stocks and small stocks is characterized by its advantages and disadvantages.

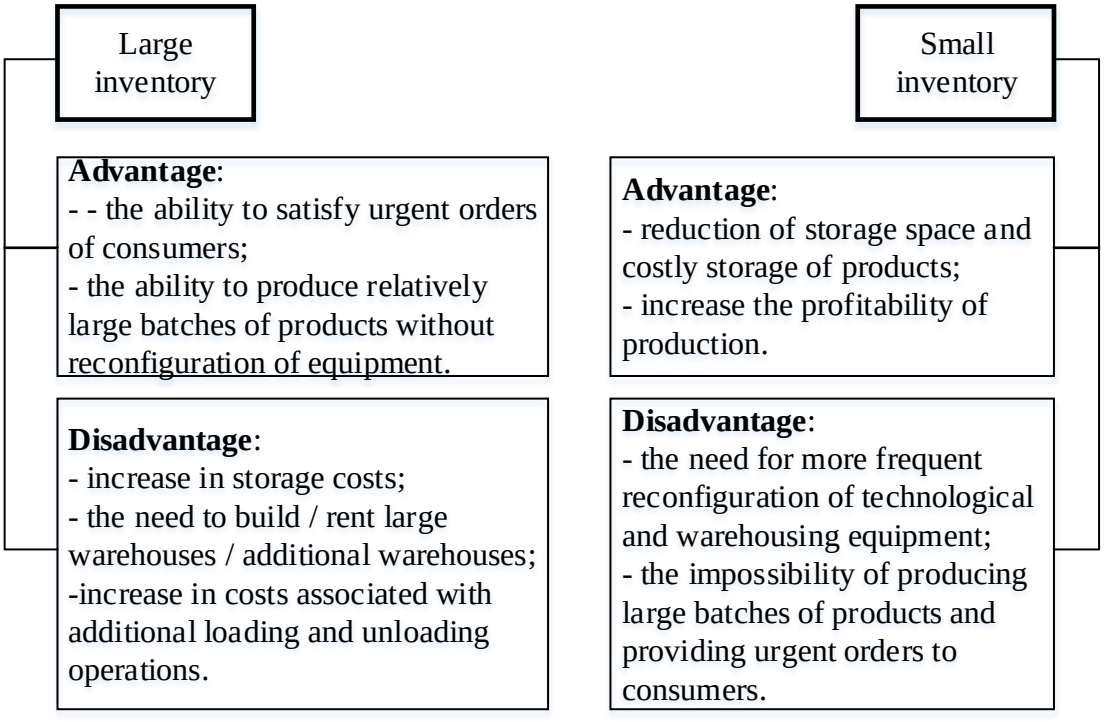


Figure 1.4 – Advantages and disadvantages of large and small inventory

Based on this, it is worth noting that determining the quantity of stocks in the company becomes an urgent task and needs to be optimized. It is this issue that deals with the direction of operational management and logistics - inventory management. The most detailed definition of the purpose of inventory management was given by Schreibfeder J. [58, p.13]: “Effective inventory management allows the organization to meet or exceed consumer expectations, creating stocks of each product that maximize net profit”.

Analyzing scientific sources [3-5,8,12,13,16] it can be argued that "push" and "pull" systems are designed for comprehensive logistics management (including inventory management), while inventory systemization methods and inventory replenishment planning systems are purely for inventory management in terms of inventory. technical support (Fig. 1.5).

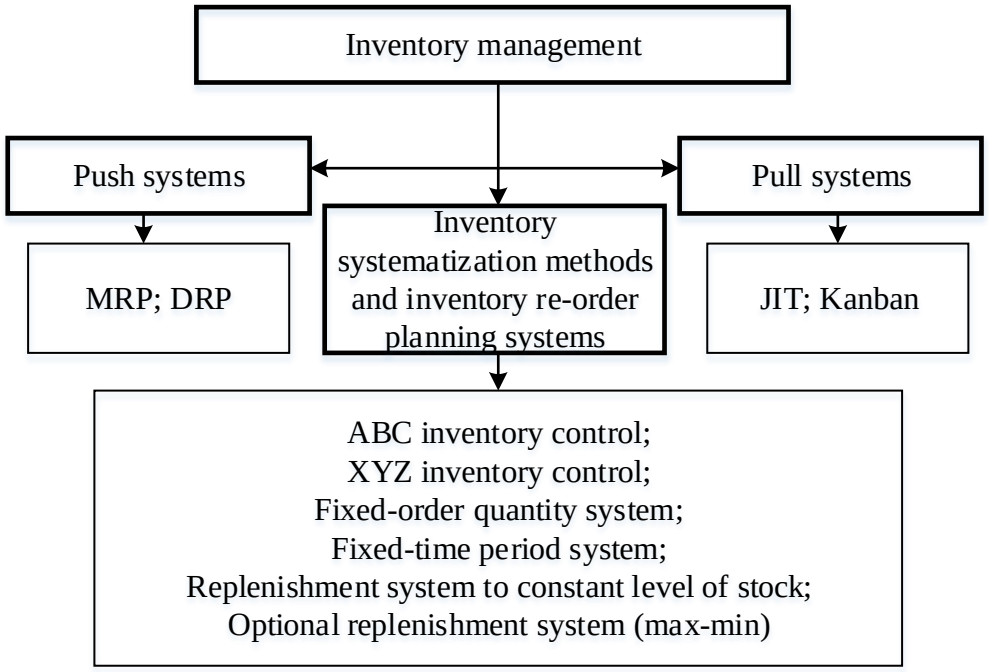


Figure 1.5 – Inventory management

Based on the above, we can conclude that inventory management is one of the components of the logistics system and requires integrated management in terms of management of the entire logistics system of the enterprise, while we can identify management tools aimed at planning and management stocks.

Optimal inventory management is based on determining the economic order quantity (formula (1.1)):

$$EOQ = \sqrt{\frac{2 \times c_0 \times Q}{c_1 \times i \times \theta}} \quad or \quad EOQ = \sqrt{\frac{2 \times c_0 \times Q}{c_2 \times \theta}}, \tag{1.1}$$

де EOQ – economic order quantity, pcs;

Q – demand, pcs per year;

c_0 – ordering cost, currency unit per order;

c_1 – unit price, currency unit per pcs;

i – the share of holding cost from the unit price;

θ – planning period in days per year;

c_2 – unit holding cost, currency unit per pcs.

Here are the assumptions when using the model based on the calculation of the optimal order size [11, p.41-42; 52]:

– used for one inventory article;

– consumption intensity is a priori known and constant value, demand is satisfied completely and instantly;

– the capacity of the warehouse on which the stock is delivered is unlimited;

– the delivery time of the order and the time between deliveries of the order are known and constant values;

– the ordering cost does not depend on the size of the order and is constant during the planning period;

– lack of stock is unacceptable;

– the cost of stock acquisition is fixed throughout the observation period.

The economic order quantity is aimed at minimizing the total cost of inventory management, which reduces the growth of consumer prices, thereby positively affecting the competitiveness of the company. This formula is based on the choice of

such an order quantity, which would minimize the total cost of inventory management, which in turn is divided into the ordering cost and holding cost. Graphically, the dependence of total costs on the order quantity is presented on Fig. 1.6.

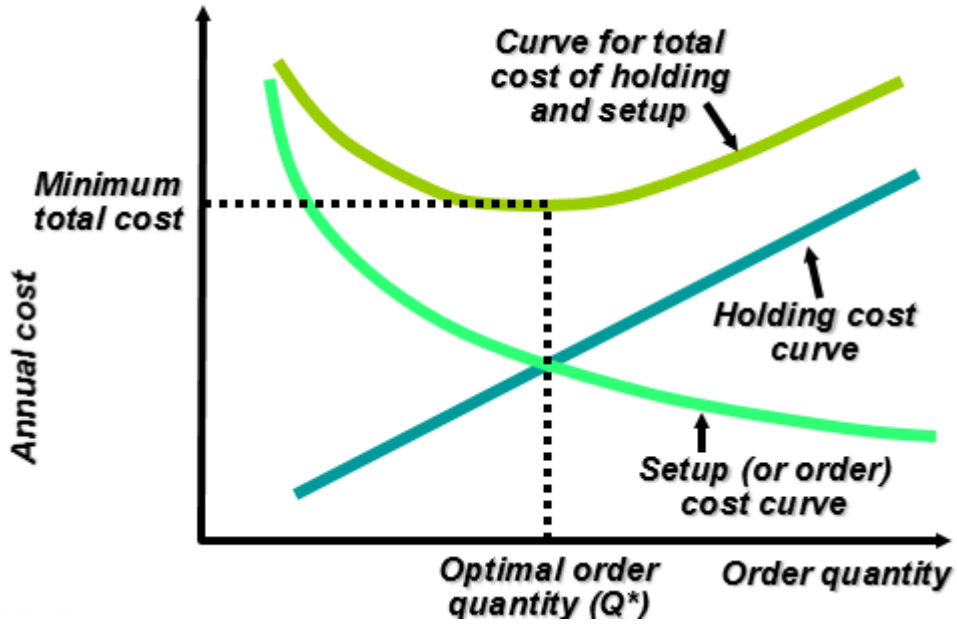


Figure 1.6 –Dependence of total costs on the order quantity

Based on the Fig. 1.6 we can specify certain patterns:

– total ordering costs decrease with increasing order volume;

– total holding costs increase with increasing order quantity;

– holding costs generally increase as the order quantity increases, but are offset by a decrease in losses due to lack of inventory.

The classic EOQ formula can be used in the conditions of purchasing goods in large batches and receiving wholesale discounts. The logic of using this modification of the model is to compare the amount of total costs for inventory management under different cost conditions and choose the best option by the criterion of minimizing the total costs.

Inventory systems are a set of rules and methods for regulating the level of inventory, i.e. to determine which levels should be maintained, what order quantity should be re-order and when to place orders.

The first policy choice is through a system called a fixed-order quantity system. Therefore, two variables define this system and answer the two basic questions of when to order and how much. The first is an order quantity, Q, and the second is a reorder point, ROP. As the name suggests, the quantity ordered with this system is constant or fixed and is denoted by Q. An order is placed when the inventory position drops to some predetermined level. This predetermined level is called the reorder point and is usually noted as ROP. Together these variables specify when to place an order: when inventory reaches the ROP. They also specify how much to order: the quantity Q.

A graphical presentation of this model is shown on Fig. 1.7. Notice that the system assumes a constant demand rate of d by which the inventory position (IP) is reduced. When the IP reaches the ROP, an order is placed for the quantity Q. When goods arrive, the inventory is replenished, and all at once the inventory position is increased by Q. However, inventory cannot arrive the moment an order is placed as there is a certain amount of lead time, L, during which we have to wait for the order.

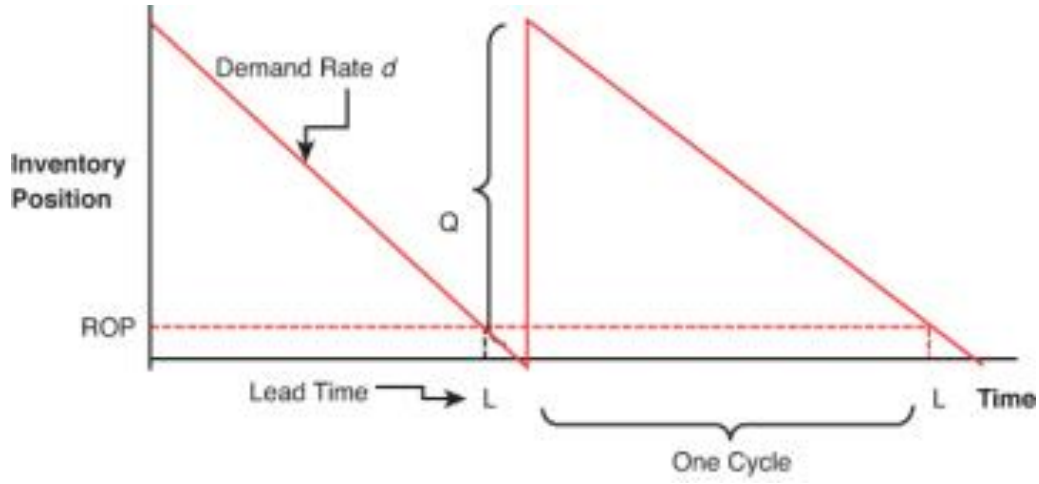


Figure 1.7 – Fixed-order quantity system

The second inventory policy is determined by a system called a fixed-time period system shown on Fig. 1.8. This system checks inventory levels in fixed time intervals labeled as T. The result is that the quantity ordered varies based upon the inventory position when the system is checked.

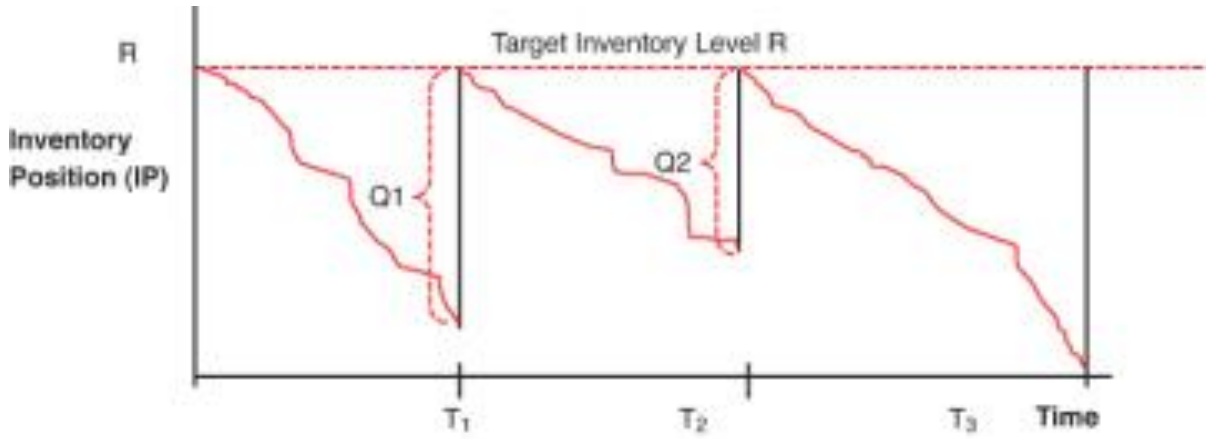


Figure 1.8 – Fixed-time period system

The system sets a target inventory level it wants to maintain, say R. Inventory is checked every T intervals, say every week or every two weeks, and an order is placed to restore the inventory level back to R. Based on the inventory level at time period T, the amount of inventory that needs to be ordered will be some quantity Q that varies from period to period. This quantity Q is the difference between the target inventory R and how much inventory is in stock now – inventory position (IP) at time T. Sometimes this system is called the periodic review system to indicate that the inventory level is checked periodically, rather than continuously.

The fixed-period order system requires carrying more safety stock inventory. The reason is that with this system we do not check the IP on a regular basis, and a sudden surge of demand could lead to a stockout. This system, however, allows more organized purchasing as inventory levels are checked in set time intervals. Orders can be bundled and quantity discounts obtained more easily, which can provide an advantage. In a fixed-order quantity system different items may reach reorder points at different times generating many orders at random intervals. On the other hand, a fixed-period system could ensure that inventory levels are checked on a regular basis for all items—say every two weeks. Then the orders for all the items could be bundled.

Optional Replenishment system (“minimum-maximum”), i.e. (s, S System) where ‘s’ denotes reorder point while ‘S’ is for desired inventory level, is applicable

in situations where the cost of reviewing the inventory and the cost of ordering play a very significant role.

Inventory is ordered in fixed time periods, T, and if the position has dropped to (or below) a predetermined level and the quantity ordered varies in order to cover expected needs.

The order quantity is calculated by subtracting the on-hand inventory from the maximum inventory, as the result falls below the minimum quantity. The min-max system is used commonly for low dollar volume items ("C" parts). It prevents ordering items in very small quantities. It is also useful when periods of low demand are anticipated or where it is desirable to use up current quantities of stock before replenishing, such as for items subject to spoilage or deterioration. The main advantage of this system is its simplicity.

Replenishment system to constant level of stock. Inventory is ordered in fixed time periods, T, and the quantity ordered varies or when inventory drops to a reorder point, ROP and the quantity ordered is fixed quantity, Q.

1.3 Chapter 1 summary

In the theoretical part of the bachelor thesis the main issues of logistics management in hardware companies were considered. It should be noted that for hardware companies (that are manufacturing companies) there are general aspects of logistics management in manufacturing companies. The main idea of which is integrated material flow management, i.e. the transition from the traditional approach to company management to the logistics approach. Integrated material flow management means coordinated management of procurement, production and distribution processes. The most vulnerable places in this management are inventory management of both finished products and raw materials and components.

CHAPTER 2
ANALYSIS OF LOGISTICS SUPPORT FOR TECHNOBUSINESS

2.1 Main points of techno-company Ajax

Ajax Systems is an international technology company headquartered in Kyiv. The company develops wireless security systems and has its own full-cycle production. It was founded in 2011 in Kyiv by Oleksandr Konotopsky.

The main product is the professional wireless security system Ajax. By 2020, the system consists of 27 devices for protecting the premises and surrounding areas, fire safety, flood protection, as well as devices for home automation equipment. The sensors work for up to 7 years from complete batteries. The system devices developed by the company use two-way radio protocol Jeweler developed by the company. It has a range of up to 2,000 meters and transmits alarms in 0.15 seconds [30].

Products are designed and manufactured in Ukraine. Monthly production of 220,000 devices. The team of 800+ employees [19,49].

Ukrainian Ajax Systems, in addition to its native country, is already sold in more than 93 countries, mainly the EU: Italy, France, Spain, Sweden, Norway, Denmark and the Netherlands, Germany and the UK [51].

The company received a $ 1 million investments in 2015 and $ 10 million in 2019 because Ajax is the most successful hardware start-up [24,49].

All company history can be divided on such periods as prehistory (2008-2011), establishment and development (2011-2014) and improvement and expansion (2014-nowadays).

Prehistory (2008-2011): Oleksandr Konotopsky and Yevhen Humeniuk founded Secur in 2008, a company that imported security alarms and video surveillance systems from China to Ukraine [33].

Establishment and development (2011-2014): Ajax Systems was established in 2011 with a starting capital of $ 50,000. The first products were Ajax sensors for motion detection WS-301, opening doors and windows WS-401, breaking glass WS-601, movement and breaking glass WS-302GB, smoke WS-501, WS-101 keychain, WS-102 wireless keyboard and WS-201 street light siren. These wireless devices used a programmable Ajax RR-104 receiver to communicate with security companies.

To communicate with the detectors, the receiver used the company's one-way radio protocol Conquiztador with a range of up to 500 m (security systems from other manufacturers worked on average at a distance of up to 150 m). Ajax devices operated for 3-5 years on batteries and cost 30% less than the cheapest Polish counterparts [33].

The first entry into the international market was in 2012 and it failed, but it also set new requirements for the product to remake it: make it more technologically advanced, work on design and marketing packaging. Ajax Systems decided to create a completely new product with a mobile application, backup support, encryption and its own long-range radio technology.

Improvement and expansion (2014-nowadays). In 2015, production of the second generation of security devices began: MotionProtect motion detector, DoorProtect opening detector, GlassProtect glass breakage detector and key fob with alarm button to control the SpaceControl system (Fig. 2.1) [51]. The new product line had technical improvements, improved software, more modern design of white and black plastic cases.

The Ukrainian SMRK fund invested $ 1 million in Ajax venture capital in exchange for a company's stake in 2015 [24].

The company adds new devices in 2016, offering a comprehensive security system for self-monitoring with the ability to connect to the security company's console. Hub (see Fig. 2.1), Ajax Cloud server and Ajax Security System applications for iOS and Android smartphones are presented. New sensors have been developed: the CombiProtect combined motion and glass break detector, the infrared motion

detector with the optional MotionProtect Plus microwave detector, the FireProtect fire and smoke temperature detector, the LeaksProitect Street flow detector [33,35].

Figure 2.1 – StarterKit (second generation intelligent control panel, wireless motion detector, wireless opening detector, wireless key fob)

A new operating system OS Malevich for the hub was created in 2017, as well as a door opening sensor with tilt and impact sensor DoorProtect Plus, a fire sensor with carbon monoxide sensor FireProtect Plus, a HomeSiren room siren and a KeyPad touch keyboard. It is now possible to connect CCTV cameras to the security system via RTSP. A module for integrating third-party sensors Transmitter (eg, street detectors) into the Ajax system was also developed.

OS Malevich was updated in 2018. It has the ability to create security groups and personal keyboard codes. A new model of intelligent control panel Hub Plus with four communication channels (Ethernet, Wi-Fi, two SIM-cards), as well as a street sensor MotionProtect Outdoor motion with digital LISA counter-algorithm was released. In addition to the power relay, a low-current Relay relay with a dry contact for remote control of equipment (for example, solenoid valves and electric locks) has been created.

Ajax PRO Desktop application has been created for PCs. Large security and service companies can access the API for integrating Ajax technologies into their own ecosystems from the end of 2018.

New devices were released in 2019: Button, ReX, Hub2 and MotionCam.

Ninety percent of the security device market is formed by professional structures, such as security companies and integrators of specialized solutions in 2015. At that time, Ajax Systems focused on them, but the product of the Ukrainian company was created with the aim of combining better features of professional and DIY security systems. Ajax Systems reached its goal already in 2019 with the share of 59% of professional structures and 41% at self-monitoring of customers (Fig. 2.2).

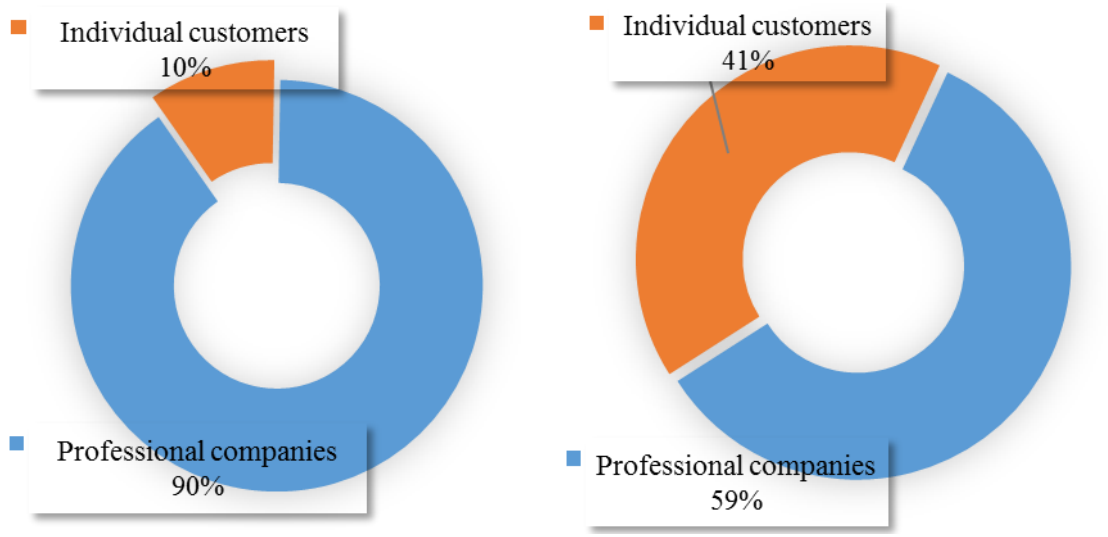


Figure 2.2 – Clients of Ajax Systems in 2015 and 2019

The professional companies in Ajax devices are attracted by technical aspects: the working distance between wireless sensors and the hub is up to 2 km versus 500 meters from competitors; gadget battery life – up to 7 years (about 2 years in the market) thanks to Jeweller's own energy-efficient communication protocol; encryption, anti-tampering functions.

For individual clients, Ajax Systems gadgets are interesting in design, simple installation and management through a mobile application.

Another advantage in foreign markets is the price. Systems of this class are many times more expensive. It is profitable to have development and production in Ukraine, and the latter has already become cheaper than in China. So, the basic Ajax StarterKit in Ukraine costs 6,000 UAH. Similar kits of the international manufacturer Visonic are sold on Amazon for $ 500, Essence's one are sold for $ 400.

The security market reaches hundreds of millions of dollars a year in these countries. The process of testing devices to obtain the necessary certificates in Ukraine and Europe is no different, but from a legal point of view, these are different documents. Each country has its own minor requirements. For example, Ajax Systems had to obtain a separate fire safety certificate in Norway. The Danes had enough instructions in English and the documentation had to be translated into local languages in France, Italy and Spain.

Ajax Systems raised $ 10 million from Horizon Capital investment company in March 2019. Horizon Capital received a minority stake. The fund bought part of the Ajax Systems stake from the first investor, SMRK, and also part of the shares from the company's management [23].

Ajax Systems enters new markets primarily through participation in specialized exhibitions. During its operation, the company has received a number of awards, including largest profile awards [19,33,50]:

– April 2017 – Ajax Hub received Best Debut and Best Innovative Product at the exhibition of technical means and equipment for safety and fire protection MIPS Securika (Moscow);

– November 2017 – Security Alarm of the Year, IFSEC International Exhibition;

– September 2018 – finalist in the Intersec security exhibition competition;

– October 2018 – second place at the Expoprotection Awards, category Safety and Fire Fighting for the innovative system.

The company has 5 patents [23]. The soft technologies of Ajax Systems are [19]:

– Jeweler is a two-way radio communication technology operating at frequencies of 868.0–868.6 MHz with a communication range of up to 2000 m. It has automatic signal power control (up to 25 mW) and uses the TDMA time division method (device pings of 12-300 seconds depending on the settings). The technology provides addressing of devices and block encryption of information with a dynamic key. Delivery of the alarm takes no more than 0.15 seconds;

– SmartDetect is an infrared sensor signal processing algorithm for hazard detection used by MotionProtect, MotionProtect Plus and CombiProtect infrared motion sensors. Recognizes people and ignores animals and false alarms.

– OS Malevich is a real-time operating system (RTOS), which manages Hub, Hub Plus, Hub 2 and ReX radio repeater. It has a similar Linux processor allocation mechanism and modularity, supports communication with a cloud server on several channels, manages a system of 150 devices, is able to simultaneously send alarm messages via IP channels, call and send SMS, supports automation devices and scripts. It has systems to counteract software crashes and cyberattacks, is invulnerable to viruses. Updated automatically.

– LISA is a two-stage algorithm for preventing false alarms of the MotionProtect Outdoor street motion detector. Analyzes signals from two infrared sensors, comparing the similarity of their forms. If the system is not sure that the operation is man-made, a spectral analysis is performed (comparison of the frequency components of the signals of the two sensors)

– HazeFlow is an algorithm for recognizing fire by smoke, temperature limit or a sharp rise in temperature. The system combines all fire detectors that signal danger synchronously with built-in sirens, notifications in applications, via SMS and calls.

– Smart Bracket is mount for installing sensors without the need to disassemble the case. The perforated part on the mount activates the tamper in the event of an alarm disassembly attempt.

The hardware technologies of Ajax Systems are [19]:

– Hub 2 is a control panel that coordinates the operation of security devices with alarm photo verification, maintains communication with the cloud server,

transmits alarms to users (push notifications in the application, SMS and calls) and security company (Contact ID and SIA protocols). If the building is without electricity, the control panel will be able to operate for up to 16 hours from a backup battery. Connects to the Internet via Ethernet and 2G / 3G (2 SIM slots);

– Button is wireless "alarm" button. Works in two modes: alarm (security call) and control (the button is adjusted to open / close electric locks, shutters, gates, control of lighting and heating, etc.). Operates at a distance of up to 1300 m from the power plant. Battery life up to 5 years;

– ReX is a radio repeater that increases the range of security devices. ReX manages the connected devices, allowing them to be placed at a considerable distance from the hub: in a multi-storey office, in buildings that stand alone, or in a large production. Up to five such devices can be used in the system;

– MotionCam is motion detector with camera for alarm verification. Sends a series of photos from the scene, giving the opportunity to understand what caused the alarm. It has infrared illumination for shooting in the dark, can work up to 4 years from the battery at a distance of up to 1700 meters from the hub. Transmits the first photo in less than 9 seconds, and alarms instantly. MotionCam requires a Hub 2 control panel.

From a local hardware startup, Ajax Systems transformed into one of the largest European manufacturers of security systems in just 4 years. Yet Ajax Systems's goal remains immutable and is to provide people with the comfort of safe living.

2.2 Commercial and financial indicators' analysis of company

The year 2016 turned out to be year of launching new products and entering the international markets.

After an impressive 2016, many "experts" predicted "the syndrome of the second season" for Ajax in 2017. But company have invited top specialists into their

team, increased production, expanded their presence on the international market, and received one of the most important award in the field of security.

In 2018, Ajax Systems has been developing at a self-threatening pace: the production volume has increased, the staff has grown, and the extent of market presence has expanded. Such massive-scale changes often lead to an uncontrolled chain reaction resulting in the collapse of processes and decrease in the quality of services. In order to avoid chaos, Ajax have reduced the pace of new product development and redirected the efforts concentrating on process optimization.

Restructuring of the manufacturing process was the second step implemented by us: we changed the hierarchical structure, reformed the motivation program, expanded the middle line of lead masters, and formed functional teams whose composition is tightly controlled. The latter has enabled Ajax to increase productivity in an environment where production volumes increase faster than new hands appear at the assembly line.

Along with the transformation of the manufacturing process, Ajax are improving the principles of staff recruitment: Ajax select those who share the principles of Ajax Systems, invest in their development, and create own professionals while practising internal rotation within the company. All Ajax Systems employees undergo mandatory training and testing: they get acquainted with the approach to operation of the company.

Improvement of quality should be emphasized separately. In 2018, the company has successfully passed two audits. First, we have received an ISO 9001:2015 certificate of compliance that confirms our fanatical commitment to all aspects of the business: recruitment, working with suppliers, and quality control of products. The auditors, by the way, have been extremely surprised by the fact that we test absolutely every Ajax device. Additionally, the company has been awarded Grade 2 under the 5th scheme meaning that company produce a serial product with consistently high quality. If random samples of detectors from batches for Europe and Ukraine are tested in the laboratory, both of them will correspond to the stringent standards.

The main figure of Ajax Systems is represented in Table 2.1. So, number of employees increased in 2 times and more year by year (Fig.2.3). Ajax attracts talented people. On average, company receive a few dozens responses to each job vacancy. Specialists are attracted by the ambitious challenges they will face, and the freedom they will have to make decisions. This independence allows us to solve problems more effectively.

Table 2.1 – Main commercial and financial indicators of Ajax

No.	Characteristics	2015	2016	2017	2018	2019
1.	The number of employees	49	125	230	405	807
2.	- increased in n-times	-	2.55	1.84	1.76	1.99
3.	Product Line	5	13	18	28	37
4.	Production, psc/month	4000	12000	44000	108000	22000
5.	Languages offered by Ajax apps	3	3	17	25	25
6.	Languages offered by Ajax site	3	3	3	3	7
7.	Growth of sales, in times	n/a	n/a	5	2.5	3.1
8.	Markets, countries	n/a	45	67	77	93
9.	Issues solved by technical support	n/a	2057	7865	n/a	n/a
10.	Ukrainian security companies that are connected Ajax Hub to the monitoring console	n/a	20	67	n/a	n/a
11.	International cooperation queries	n/a	658	810	n/a	n/a

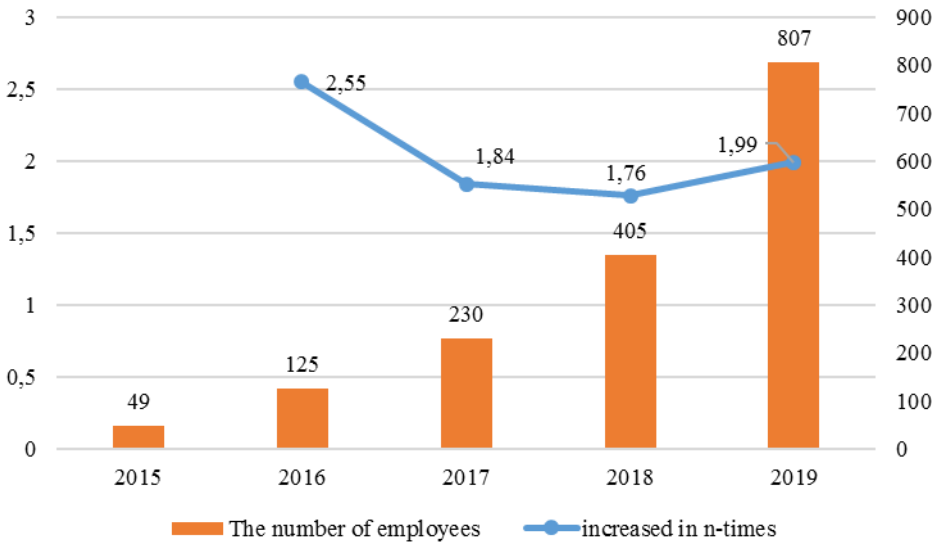


Figure 2.3 – Dynamics of employee number growth

In many ways, dynamic of employee number growth has been affected by the expansion of the geography of presence and the soaring demand for Ajax Systems. Moreover, this year company has doubled our R&D team and put the new office in Kharkiv, the city known for its engineering schools. By attracting new specialists to the team, we've accelerated the development of the new products.

The dynamic of device number in the product line is shown on Figure 2.3. Ajax finish with 13 devices in the product line in 2015: Ajax Cloud and mobile iOS, Android and web applications. In the summer 2016 Ajax released a brand new operating system – Hub OS Malevich. This has been like a tectonic shift for Ajax ecosystem. Malevich allows Ajax to easily and quickly develop and launch new features that extend the functionality of the security system. Thanks to the new OS, Ajax have already implemented two important features – the integration of video cameras and street detectors. In 2018, Ajax have set a goal to launch devices to the market that will help Ajax develop niches of street protection and smart homes. The launch of a low-current relay Relay represented the first release. With the advent of automatic scripts in 2019, it made life easier for many Ajax owners.

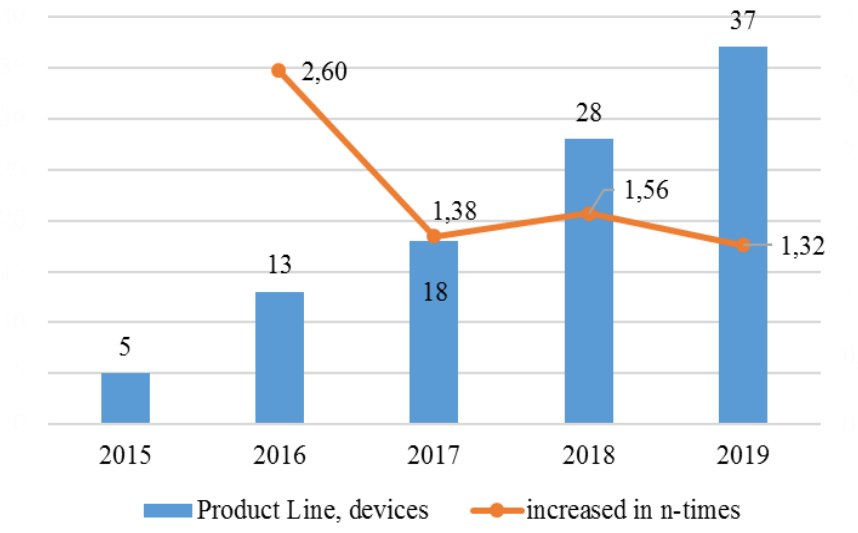


Figure 2.4 – Dynamics of device number growth in the product line

The production capacity increase in two and more times year by year, as we see on Figure 2.5. In September 2018, Ajax Systems reached a significant milestone –

one million devices produced. It took us 3 years to achieve that. The current production volume has exceeded two hundred thousand detectors per month; therefore, the second millions of devices came off the assembly line in the first half of 2019.

In terms of scaling the mass production, 2019 was the most challenging year so far. Ajax Systems has minimized the time for assembling, testing, and packaging by increasing the number of assembly lines from 2 to 8 and reinforcing workstations with robots. As a result, Ajax Systems began to produce 220 000 units per month while still testing every single device.

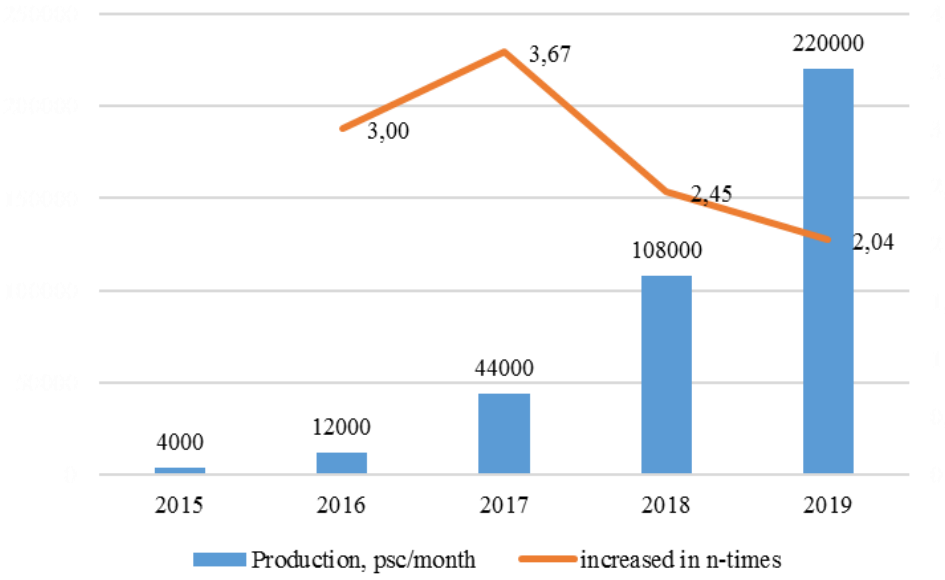
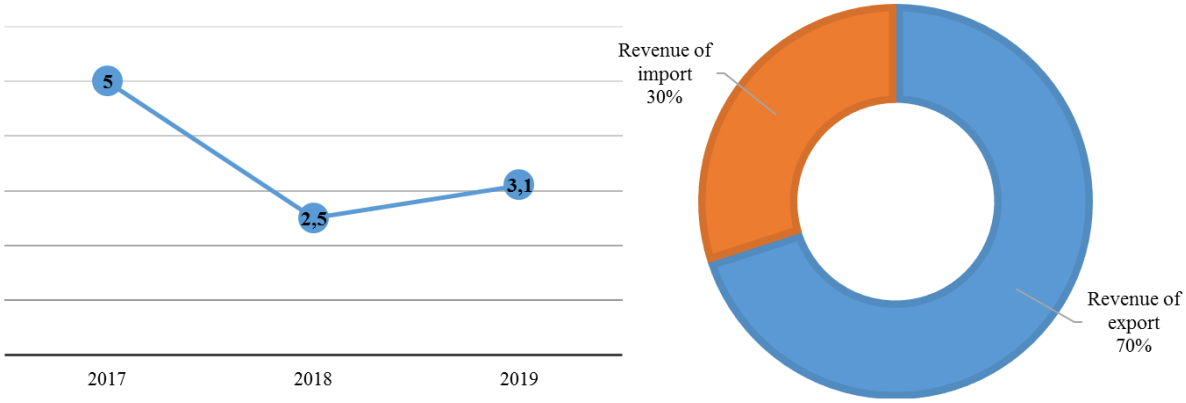


Figure 2.5 – Dynamics of production capacity growth

Ajax Systems is growing at a very fast pace, with over 70% of revenue coming from export sales and the growth of sales increased in two and more times every year, as we shown in Figure 2.6.

Nowadays Ajax Systems sold up to 2-3 thousand devices every month and occupies 35-40% of the Ukrainian market of wireless detectors for security systems.

Numbers of languages offered by Ajax apps and Ajax site are represented on Figure 2.7.



Dynamics of sale growth Proportion of revenue from type of sales

Figure 2.6 –Dynamics of sale growth and proportion of revenue from type of sales

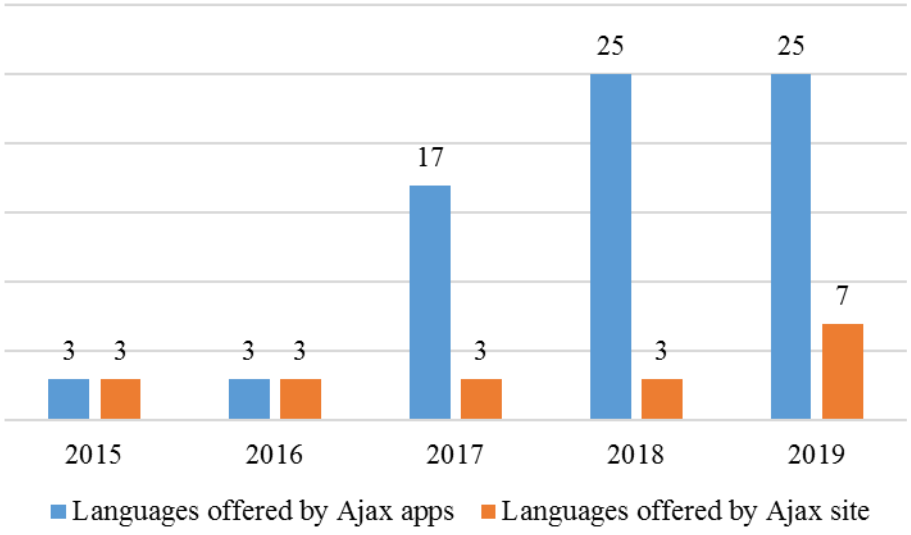


Figure 2.7 –Dynamics of languages offered by Ajax apps and Ajax site

Apps are an important part of providing security systems, for their ease of use by consumers in different countries, the company has increased the number of languages to 25. To boost product recognition and support the efforts of Ajax regional partners, Ajax has translated the core marketing and educational Ajax materials (i.e. website, blog, support section, manuals, video tutorials) to 4 new languages in 2019. In 2018, company have completely updated Ajax official website. Nowadays, this is an information platform featuring an option that enables Ajax customers to quickly select individualized Ajax security system solutions. The

amount of content has increased 10 times when compared with the old site. The support section has expanded to 324 articles with detailed instructions and step-by-step recommendations for operating Ajax. Company will start offering this megaplatform in other languages for European customers in 2020.

For partners and independent installers, Company opened Ajax Academy in three languages: Ukrainian, Russian, and English. The learning process currently consists of 26 lessons that help to understand the intricacies of operation of their products. For many partners, the Ajax Academy serves as a free tool for internal employee training and knowledge control. After completion of all the lessons, a student receives a certificate. Today, over 1,000 people in Ukraine and abroad have received such certificates.

We can see quantity country growth on Figure 2.8. Year by year the quantity of countries where is sold Ajax products are increased.

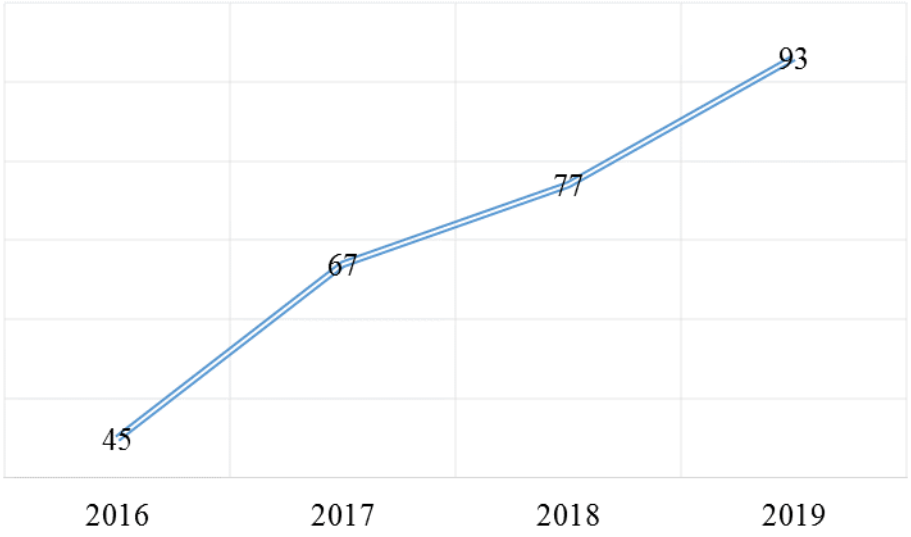


Figure 2.8 – Dynamics of quantity country growth

If first years focused on speed, then in last four years the focus was on quality. Partners who believed in Ajax strength were impressed with the results of Ajax sales at home. And now Italy, Spain, Norway, Sweden and Denmark have become the markets in which Ajax is growing at a fast pace and volumes are increasing quarterly.

After a rapid horizontal growth across many markets through strategic partnerships with local distributors in 2016-2018, Ajax began to establish a stronger presence in each region in 2019. Localization of Ajax experience involves solving local business problems and communicating with partners in their native languages.

On the one hand, to dig deeper into the local markets, Ajax has connected closely with the regional security service providers: installers and alarm response companies that communicate with users of security equipment daily.

Ajax has restructured and expanded their business development team from 12 to 32 people. Now it's a multi-language division that helps partners in 93 countries to grow their business.

2.3 Logistics processes diagnostics

Schematically we presented R&D, production and logistics processes on Figure 2.9 and 2.10.

In 2018, the process of product development has been automated turning it into a pipeline that creates hardware using the principles of software development. Nowadays, the development of a new device starts simultaneously in all departments: design development is launched, selection of components begins, production processes are established, a marketing strategy is developed, and a logistics scheme is contemplated. This level of coordination helps to avoid downtime and missed deadlines, and a distributed version control system minimizes human error.

The demand for goods is so great that sometimes in Ukraine company need to wait until it appears in stock.

The components are applied to the printed circuit boards in the "Maiak", then a special team assembles everything and tests. By maintaining control over production, the company managed to reduce the number of defects to less than 1%. If this was done in China, the marriage would exceed 10% or even 20% [35].

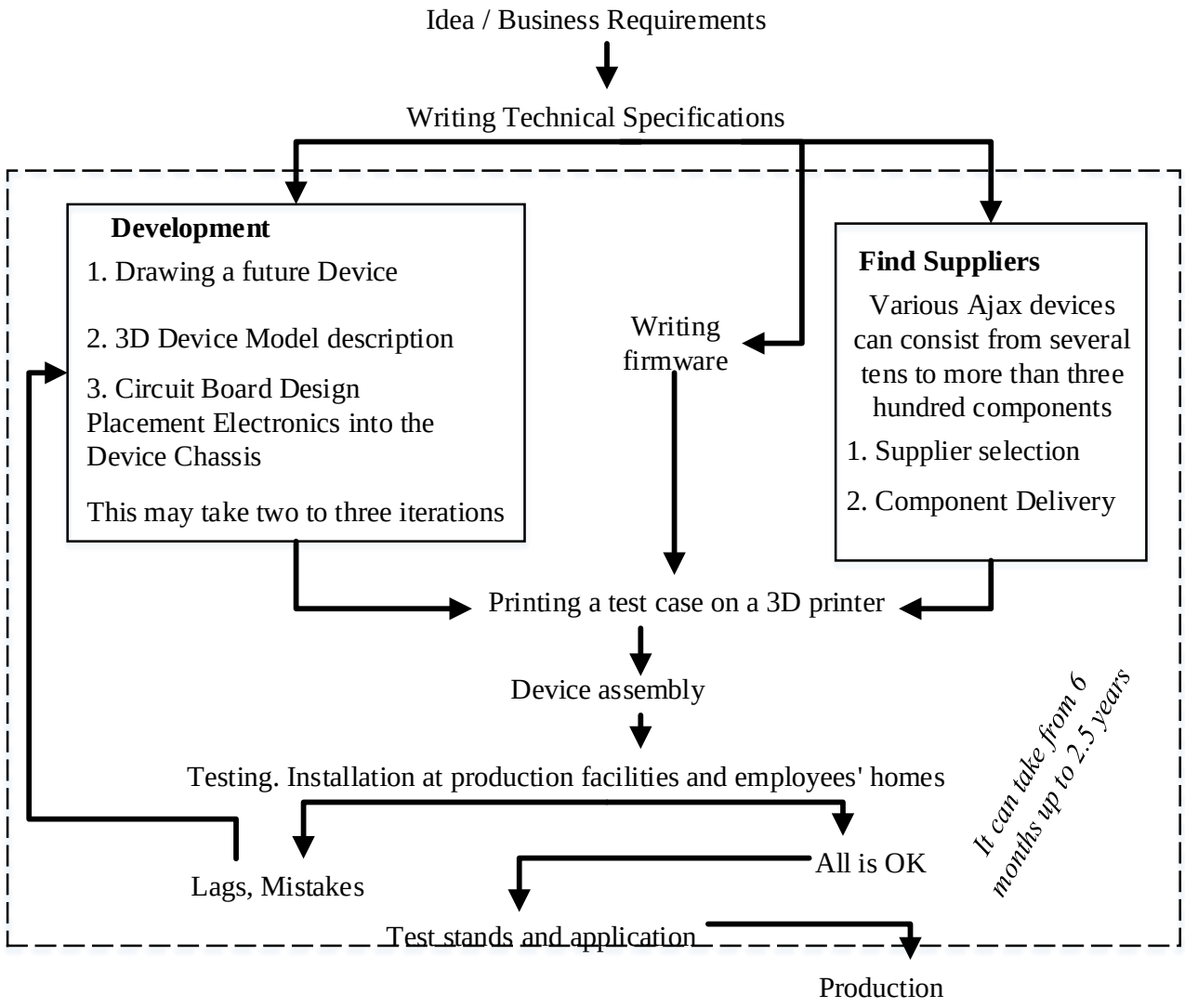


Figure 2.9 – R&D and Logistics Processes

Work on each device begins with business requirements, with the idea, for example, that the company's portfolio should have a wireless keyboard that will be thin, beautiful and touch-sensitive. R&D's engineers draw up technical specifications with a description of its functions and design. After that, the development process begins. Each device is created from zero. First, the industrial designer draws what the future device will look like. The designer describes it in 3D models. Hardware engineers design boards trying to squeeze the necessary electronics into the device chassis. Depending on the complexity of the device, this may take two to three iterations.

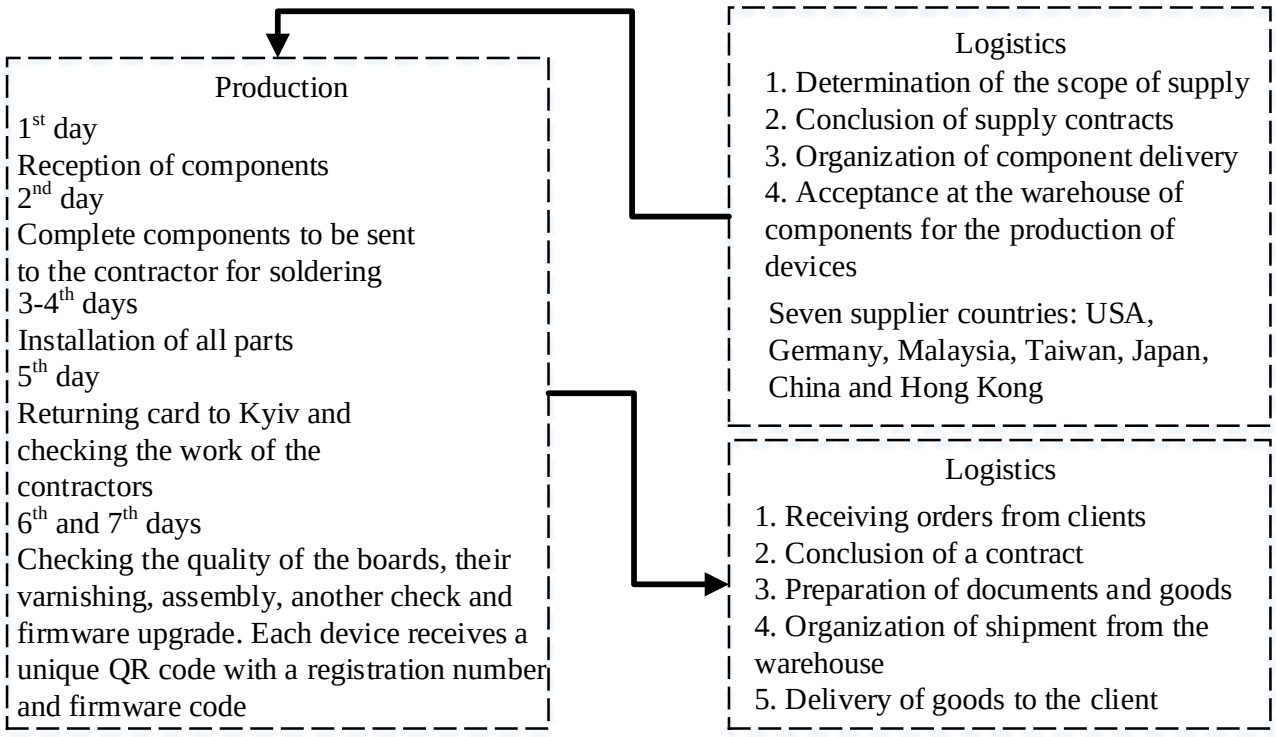


Figure 2.10 – Production and Logistics Processes

At this time, work is also underway to find suppliers. In various Ajax devices, from several tens to more than three hundred components. For example, to find a supplier of suitable magnets for an opening detectors, fifty samples had to be tested.

After all the components are selected, a test case for the device is printed on a 3D printer, assembled and accepted for testing. Plastic until the last stage remains "homemade." This is the most expensive thing in production (a mold costs $ 10,000 - $ 30,000), so it is ordered when there is complete confidence that nothing will change in the device.

In parallel with the preparation for production, firmware is being written so that engineers can check the operation of the hardware. Here, all second-generation gadgets have a common part – the core. This is a piece of code that ensures their operation over the air and interaction with the hub. The rest of the code is individual and works with the direct functionality of the sensor. When the firmware is ready, the devices are installed on test objects: Ajax Systems production facilities and employees' homes. The developers of the company look at the logs, check for errors and all the teams reach. When everything works properly, the firmware is transferred

to production. For each device, a separate test bench and software for testing performance is developed. With the advent of a new device in the lineup, it is also necessary to update the hub, applications and the server side.

The development time of each device varies. So, work on the home siren started in April, and in July Ajax Systems already ordered molds. Three and a half months is the fastest device. And if the device is new, then it will take about a year to launch it.

If we talk about new product, we can understand that development of design and applications from first step to retail can take from 6 months up to 2.5 years in Ajax [38].

If the development can take about a year, then the production cycle of one device lasts about eight days. The first day goes to the reception of components.

At the production warehouse there are racks full of various parts: cards, transceivers in coils, antennas and other components (Fig.2.11). They come from seven countries: USA, Germany, Malaysia, Taiwan, Japan, China and Hong Kong.

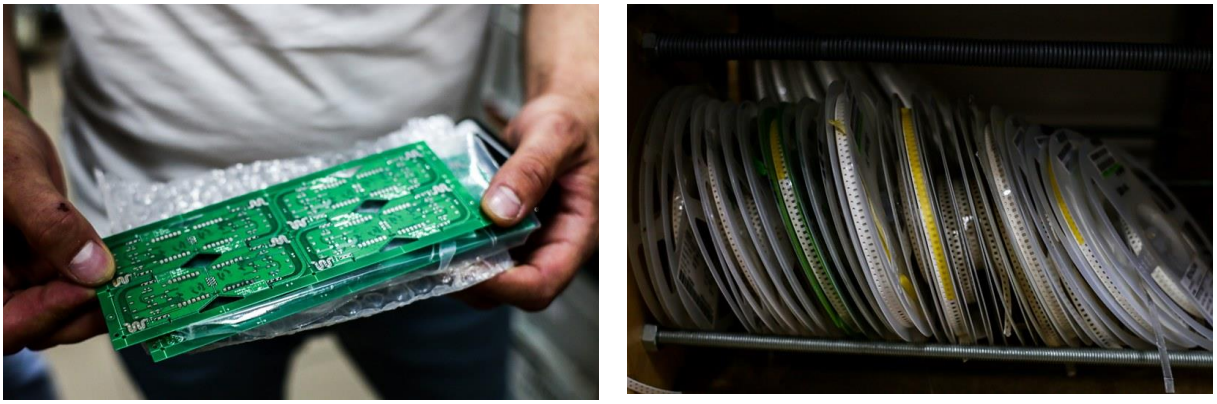


Figure 2.11 – Components of Ajax Systems finished goods

After receiving the parts, one day is required to complete them to be sent to the contractor for soldering. Another day is spent on sending and receiving components in contract manufacturing. Installation of all parts takes about two days. The fifth day is reserved for returning fees to Kyiv and checking the work of the contractor. At the second production line of Ajax Systems on the left bank in Kyiv, it takes another day to solder the output contacts. The final two days are taken by checking the quality of the cards, their varnishing, assembly, another check and firmware upgrade. In the

process, each device receives a unique QR code with a registration number and firmware code, which leads the device until it is installed on the site using a mobile application.

There are four main stages of quality control in production (there are seven for the hub), and 5% of the batch of each collector per day is completely disassembled and reassembled. This approach allows Ajax Systems to keep production defects at 0.2% versus several percent for contracted Chinese manufacturers.

2.4 Chapter 2 summary

Ajax Systems is an international technology company headquartered in Kyiv which founded in 2011. Nowadays, the team of 800+ employees and monthly production of 220,000 devices. Ajax Systems clients are b2b (59%) and b2c (41%).

In many ways, dynamic of employee number growth has been affected by the expansion of the geography of presence and the soaring demand for Ajax Systems. Ukrainian Ajax Systems, in addition to its native country, is already sold in more than 93 countries, mainly the EU: Italy, France, Spain, Sweden, Norway, Denmark and the Netherlands, Germany and the UK.

The company has 5 patents and such technologies as: Jeweler, SmartDetect, OS Malevich, LISA, HazeFlow, Smart Bracket, Hub2, Button, ReX, MotionCam.

Indicators and their dynamics testify to positive trends in the development of the company and its expansion. However, this affects the configuration of not only production processes (number of assembly lines is 8 and reinforcing workstations with robots now), but also the configuration of logistics processes.

An analysis of the configuration processes showed the difficulties in logistics associated with forecasting the quantity of finished products, the selection of contractors and inventory management. It is displayed in the SWOT analysis of the company (appendix A).

CHAPTER 3
PRACTICAL RECOMMENDATIONS FOR IMPROVING THE LOGISTICS OF AJAX SYSTEMS

3.1 Recommendations of contractor selection order

The most vulnerable place in working with contractors is the late execution of orders. The modern selection system takes into account only the technical aspects of the contractor's work and is focused on the high quality of the final product. However, it does not take into account its financial standing of a company, company experience, logistics characteristics such as just in time delivery, transport cost and others.

The process of selecting suppliers and contractors can be carried out on the basis of an integrated score of the following indicator group [27,45]:

1. Relay-type indicators are characterized by answer options “yes” or “no”. Relay-type indicators are the presence of the necessary permits: ISO certificates for quality management, license to operate. All contractors have the above permits in our case, they will all be accepted for consideration.

2. Quantitative indicators are characterized by an assessment that has a digital dimension. Quantitative reliability of the supplier: the percentage of deliveries on time, the relevance of the goods, the cost of purchasing goods, deadlines for orders, customer service (level of service) and business experience in years.

3. Qualitative indicators are characterized by the scale of the desirability function (Table 3.1).

Qualitative indicators will be the distance of the supplier from the consumer (location), the financial standing of the contractors, the relationship with the customer and business initiative.

Today, the company has one contractor for the microchip assembly of devices in Kyiv, namely Electro Garant. A search for other contractors showed that there are also 3 companies on the market (Electro Schema, Centr Schem, Umna Schema) that can provide microchip collection assembly for devices.

Table 3.1 – Quality assessments and corresponding standard assessments

No.	Evaluation of the quality indicator	Evaluation on a desirability scale	
		range	average value
1.	Excellent / close	more 0,950	0,975
2.	Very good / close enough	0,875-0,950	0,913
3.	Good / not very close	0,690-0,875	0,782
4.	Satisfactory / far enough	0,367-0,690	0,530
5.	Bad / far	0,066-0,367	0,285
6.	Very bad / very far	0,0007-0,066	0,033

Due to the fact that the company is expanding and the final assembly of devices is carried out not only in Kyiv, but also in Kharkiv, it is necessary to consider the contractors for microchip assembly also near Kharkiv. Three companies providing such services were found, namely Micro Electonika, Micro Electro Svit, Svit Micro Schem.

We selected samples and provided them to technical specialists to provide a final expertise on the quality of products of real and potential contractors. In addition, we evaluated other criteria. Just-in-time delivery: for real companies were calculated according to the company's data, for potential companies were determined on the basis of reported data from these companies minus error of five percent. The lead time for ordering microchips for devices has been determined in accordance with agreements with real contractors and in accordance with reports of potential contractors. Unit transport costs were determined in accordance with contracts with real contractors and in accordance with the value provided by potential contractors. Qualitative indicators such as financial standing, business initiative and location of the contractor were determined by us independently. For example, a business

initiative is its own assessment after talking on the phone with a sales manager and being active about the possibility of cooperation.

The initial data for the selection of the contractors are presented in Table 3.2 (Kyiv) and Table 3.3 (Kharkiv).

Table 3.2 – The initial data for the selection of the contractors in Kyiv

No.	Characteristics	Electro Garant	Electro Schema	Centr Schem	Umna Schema
1.	Required documents	yes	yes	yes	yes
2.	Just-in-time delivery, %	88	95	95	95
3.	Lead time, days	3	2	2	2
4.	Unit transport costs, uah	1.67	1.25	1.82	1.51
5.	Business experience, years	4	2	3	2.5
6.	Financial standing	excellent	excellent	good	good
7.	Business initiative	good	very good	excellent	good
8.	Location	not very close	close enough	close	not very close

Table 3.3 – The initial data for the selection of the contractors in Kharkiv

No.	Characteristics	Micro Electonika	Micro Electro Svit	Svit Micro Schem
1.	Required documents	yes	yes	yes
2.	Just-in-time delivery, %	95	95	95
3.	Lead time, days	4	3	5
4.	Unit transport costs, uah	1.21	1.16	1.10
5.	Business experience, years	1	1.5	0.5
6.	Financial standing	excellent	excellent	good
7.	Business initiative	very good	good	excellent
8.	Location	not very close	close enough	close

It is proposed to evaluate contractors according to the supplier selection algorithm by defining an integrated score in five steps [27,44]:

Step 1. At a choice of the contractors first of all check relay-type indicators. Among contractors, those that have a relay-type value of “no” are further excluded. In our case, all contractors have a status of “yes”, so they all remain for further analysis and final selection.

Step 2. The next step is to calculate the weights for quantitative and qualitative indicators by formula (3.1).

$$Wi = \frac{2 \times (K - r + n)}{K \times (K + n)}, \quad (3.1)$$

where *Wi* is the weighting factor of the *i*-th indicator, *i є [1; K]*;

K is the total number of indicators that are taken into account when determining the integrated assessment (relay-type indicators are not taken into account), in our case this is seven one;

r is the value of the rank of the i-th indicator, *i є [1; K]*, (the higher the rank, the less important for us is the presence of this indicator in the contractor);

n is the number of relay-type indicators, in our case 1.

The value of the rank of each indicator was determined by a survey of top management, namely the CEO, Chief Accountant and Production Director, the results of which are given in table. 3.4.

Table 3.4 – Determining the rank of each indicator to select a contractor

No.	Indicator	Rank determined by the top manager			Average value	The final value of the rank
		CEO	Chief Accountant	Production Director		
1	Just-in-time delivery, %	4	5	2	3,67	3
2	Lead time, days	1	4	1	2,00	1
3	Unit transport costs, uah	2	1	5	2,67	2
4	Business experience, years	3	3	6	4,00	4
5	Financial standing	5	2	7	4,67	5
6	Business initiative	6	7	4	5,67	7
7	Location	7	6	3	5,33	6

For example, the weight for indicator “Just-in-time” for Micro Electronika: are calculated as *W1* = 2 × (7 - 3 + 1)/ 7 × (7+1) = 10 / 56 = 0,179. Other weight for indicators are calculated in a similar manner.

Step 3. For each quantitative indicator it is established which extreme value is the most attractive at the corresponding estimation. That is, it is necessary to determine what the maximum (*max*) or minimum value (*min*) should be. So, we take minimum value for indicators “Just-in-time delivery”, “Lead time” and “Unit transport costs”. We take maximum value for indicator “Business experience”.

Then for each indicator among all contractors we choose the best value for a certain extreme. This is the reference value.

The calculation of the value of the quantitative indicators *Zj* (*j* ϵ *[1; m]*, where *m* is the number of contractors) is carried out by formulas (3.2) and (3.3), namely:

- at the extremum "*max*":

$$Zj = \frac{K\ fact\ j}{K\ ref}, \tag{3.2}$$

- at the extremum "*min*":

$$Zj = \frac{K\ ref}{K\ fact\ j}, \tag{3.3}$$

where *K ref* is reference value for this indicator;

K fact j – the actual value for the *j*-th contractor.

For example, the value of the quantitative indicator “Just-in-time” for Micro Electronika: are calculated as *Z11* = 95 / 95 = 1.00; *Z12* = 3 / 4 = 0.75; *Z13* = 1.1 / 1.21 = 0.909; *Z14* = 1 / 1.5 = 0.66. Other value of the quantitative indicators is calculated in a similar manner.

Step 4. The calculation of the value of quantitative and qualitative characteristics *Di* taking into account the weight for each indicator is carried out according to the formula (3.4).

$$Di = Zj \times Wi. \quad (3.4)$$

Therefore, for the indicator “Just-in-time” for Micro Electronika: D11 = 0.179 × 1.00 = 0.179, for the indicator “Lead time” is D12 = 0.25 × 0.75 =0.188 and so on.

Step 5. The value of the integrated score for each contractor is defined as the sum of the values of *Di*.

As an example, we show the calculations for the company Micro Electronika: integrated score are 0.179 + 0.188 + 0.195+ 0.095+0.104+0.033 + 0.056 = 0.849.

Therefore, all calculations will be performed in MS Excel according to the algorithm described above and summarize the results in Table 3.5 for Kyiv contractors and Table 3.6 for Kharkiv contractors.

The final values of the integrated score indicate that the highest rating was received by company Umna Schema with a score of 1.115, the second place is occupied by company Electro Schema with a score of 0.977, the third place is company Electo Garant with a score of 0.844 (this is real contractor). As conclusion we can say that optimal contractor for the microchip assembly in Kyiv is company Umna Schema, for which quality of their final product is equal quality of one by Electo Grant, but taking into account other indicators company Umna Schema has advantage before Electo Grant.

The final values of the integrated score indicate that the highest rating was received by company Micro Electro Svit with a score of 0.972, the second place is occupied by company Micro Electronika with a score of 0.849 (this is real contractor), the third place is company Svit Micro Schem with a score of 0.779. As conclusion we can say that optimal contractor for the microchip assembly in Kharkiv is company Micro Electro Svit.

Table 3.5 – Selection of contractors according to the highest integrated score in Kyiv

No.	Indicator	Electro Garant	Electro Schema	Centr Schem	Umna Schema	Extremum	Rank, *r*	Ref. data, *Kref*	Weight, *Wi*	Electro Garant		Electro Schema		Centr Schem		Umna Schema	
										Z1	*D1*	*Z2*	*D2*	*Z3*	*D3*	*Z4*	*D4*
1.	Just-in-time delivery	95	95	95	95	min	3	95	0,179	1,000	0,179	1,000	0,179	1,000	0,179	1,000	0,179
2.	Lead time	4	3	5	2	min	1	3	0,250	0,750	0,188	1,000	0,250	0,600	0,150	1,500	0,375
3.	Unit transport costs	1,21	1,16	1,1	1,51	min	2	1,1	0,214	0,909	0,195	0,948	0,203	1,000	0,214	0,728	0,156
4.	Business experience	1	1,5	0,5	2,5	max	4	1,5	0,143	0,667	0,095	1,000	0,143	0,333	0,048	1,667	0,238
5.	Financial standing	0,975	0,975	0,782	0,782		5		0,107	0,975	0,104	0,975	0,104	0,782	0,084	0,782	0,084
6.	Business initiative	0,782	0,913	0,975	0,782		7		0,036	0,782	0,028	0,913	0,033	0,975	0,035	0,782	0,028
7.	Location	0,782	0,913	0,975	0,782		6		0,071	0,782	0,056	0,913	0,065	0,975	0,070	0,782	0,056
8.	Integrated score									0,844		0,977		0,779		1,115	

Table 3.6 – Selection of contractors according to the highest integrated score in Kharkiv

No.	Indicator	Micro Electonika	Micro Electro Svit	Svit Micro Schem	Extr.	Rank, *r*	Ref. data, *Kref*	Weight *Wi*	Micro Electonika		Micro Electro Svit		Svit Micro Schem	
									Z1	*D1*	*Z2*	*D2*	*Z3*	*D3*
1.	Just-in-time delivery	95	95	95	min	3	95	0,179	1,000	0,179	1,000	0,179	1,000	0,179
2.	Lead time	4	3	5	min	1	3	0,250	0,750	0,188	1,000	0,250	0,600	0,150
3.	Unit transport costs	1,21	1,16	1,1	min	2	1,1	0,214	0,909	0,195	0,948	0,203	1,000	0,214
4.	Business experience	1	1,5	0,5	max	4	1,5	0,143	0,667	0,095	1,000	0,143	0,333	0,048
5.	Financial standing	0,975	0,975	0,782		5		0,107	0,975	0,104	0,975	0,104	0,782	0,084
6.	Business initiative	0,913	0,782	0,975		7		0,036	0,913	0,033	0,782	0,028	0,975	0,035
7.	Location	0,782	0,913	0,975		6		0,071	0,782	0,056	0,913	0,065	0,975	0,070
8.	Integrated score								0,849		0,972		0,779	

3.2 Recommendations of forecasting method using

One of the key areas of using mathematical methods in logistics is the development of forecasting of supply volumes, as forecasting dynamics of supply volumes is the basis for decision-making on logistics in operational, tactical and strategic planning and administration. The accuracy and reliability of the forecast determines the efficiency of logistics operations and functions.

When developing a forecast from the point of view of synchronization of supply volumes in logistics, the degree of inertia is of the greatest importance. Inertia in logistics is manifested in two ways: first, as the inertia of relationships, ie the preservation of the main features of the mechanism of formation of the phenomenon (preservation of arguments); secondly, as inertia in the development of individual aspects of processes, i.e. the degree of preservation of their nature, pace, direction, changes in key quantitative indicators over relatively long chronological periods.

The presence of inertia does not mean that the phenomenon in its development will strictly follow the existing trend, various factors will to a greater or lesser extent affect the phenomenon, leading to deviations from the trend. In some cases, it is advisable to use different methods to determine and extrapolate the prevailing trend, using to predict the relationship between indicators and patterns of change. The use of statistical approaches to forecasting is natural [53].

Tactical planning involves the regulation of consumption and the allocation of resources over a planning period of several months to a year. As indicated in [43], the main issue of tactical logistics planning is profit maximization. When maximizing net revenues, the tactical planning model should include constraints that reflect long-term factors, such as maintaining market share by offering different product lines, maintaining optimal customer service, or maintaining product quality by creating strategic alliances with key suppliers.

Tactical planning in the Ajax Systems network includes planning: sales, production of devices, stocks of raw materials, inventories to meet seasonal demand

or regulate unexpected changes in demand, transport operations, distribution of goods, synchronization of plans and optimization and balancing of plans.

There is often an imbalance of supply and demand, which creates a number of problems for the business organization: short lead times, loss of customers in case of lost sales, high overall costs. Therefore, the synchronization of demand, sales plan and supply plan is an urgent task of logistics planning for Ajax Systems (Fig. 3.1).

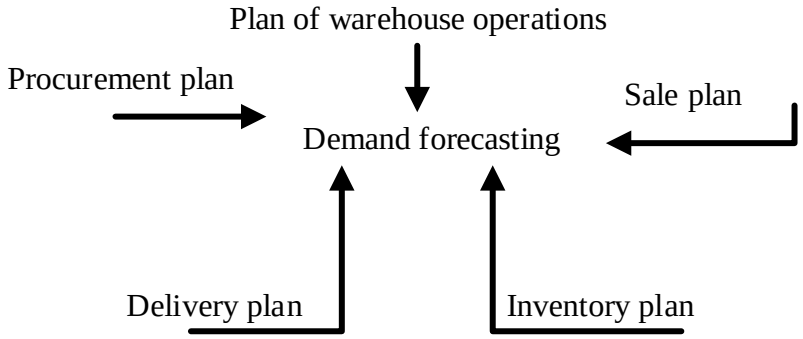


Figure 3.1 – Synchronization of demand forecast with plans of Ajax Systems

We use the Holt-Winters method to predict total demand [25,26,45]. The Holt-Winters model is an extension of the Holt method to three-parameter exponential smoothing. This model takes into account not only the smoothing of a number of general levels and trends, but also the seasonal components in the data.

This means that the method is characterized by three parameters that must be selected to obtain a forecast. The choice of these parameters can be made by a simple search.

The advantage of this method is the ability to make a forecast for a long period. But in order to make a forecast, for example, for 1 year, we will need data for at least 2 full years, and preferably for 3-5 full years.

The system of equations describing the Holt-Winters method is as follows:

- the smoothing of data:

$$L_t = \alpha \cdot \frac{y_t}{s_{t-s}} + (1-\alpha) \cdot (L_{t-1} + T_{t-1}) . \quad (3.5)$$

- the smoothing of trend (trend estimate):

$$T_t = \beta \cdot (L_t - L_{t-1}) + (1-\beta) \cdot T_{t-1}. \quad (3.6)$$

- seasonal estimate:

$$S_t = \gamma \cdot \frac{y_t}{L_t} + (1-\gamma) \cdot S_{t-s}. \quad (3.7)$$

- forecasting on p periods forward:

$$y^*_{t+p} = (L_t + p \cdot T_t) \cdot S_{t-s+p}, \quad (3.8)$$

where L_t – the smoothing of data;

α – data smoothing parameter;

y_t – the actual value of the indicator for the period t;

β – smoothing parameter to estimate the trend;

T_t – trend estimate;

γ – smoothing parameter to estimate seasonality;

S_t – seasonal estimate;

p – the number of periods for which the forecast is based;

s – the duration of the period of seasonal fluctuations, in this case equal to twelve months.

The fraction in equation (3.5) serves to exclude seasonality from y_t. After excluding seasonality, the algorithm works with “pure” data, in which there are no seasonal fluctuations. Its appears in the final forecast, when the “net” forecast, calculated almost by the Holt method, is multiplied by the seasonal factor.

Smoothing parameters must meet the conditions:

$$0 \le \alpha \le 1;\ 0 \le \beta \le 1;0 \le \gamma \le 1. \quad (3.9)$$

Before using formulas (3.5) - (3.9) it is necessary to set the initial conditions. There are two options for choosing the initial conditions in the Winters model. In the thesis, the choice of initial conditions is as follows: the initial value for the smoothed series (L_{t-1}) is equal to the average value for the first s observations.

Then the initial conditions for the trend (T_{t-1}) are determined by the slope of the line formed by these observations ($y_t^{'} = a_0 + a_1 \cdot t$). The trend line is selected by the method of least squares:

$$a_1 = \frac{N \cdot \sum y_i \cdot t_i - \sum y_i \cdot \sum t_i}{N \sum t_i^2 - \left(\sum t_i\right)^2}$$
$$a_0 = \frac{\sum y_i \cdot \sum t_i^2 - \sum t_i \cdot \sum y_i \cdot t_i}{N \cdot \sum t_i^2 - \left(\sum t_i\right)^2} \ \text{or} \ a_0 = \overline{y} - a_1 \cdot \overline{t}, . \quad (3.10)$$
$$\text{where} \ \overline{y} = \frac{1}{n}\sum_{i=1}^{n} y_i \ \text{and} \ \overline{t} = \frac{1}{n}\sum_{i=1}^{n} t_i.$$

or using the MS Excel function “Add a trendline”.

We use the function LINEAR (known_y’s; known _x’s; const; statistics) to determine a_1: where “known_y’s” are indicators of demand for 2017-2019; “known _x’s” is the time period for which there are actual indicators of demand, i.e. from 1 to 36); “Const” is equal to one, which shows that the equation has $y = a_1x + a_0$ is a constant a_0, which indicates a general case of trend construction; “Statistics” is a unit that indicates the need to take into account all indicators in the calculation.

Seasonality coefficients for the initial conditions are calculated by next formula:

$$S_t = y_t / L_s, \quad (3.11)$$

where L_s is initial condition for data smoothing (the average value for the all years is chosen as initial conditions for data smoothing);

y_t is the actual value of the indicator for the period t (i.e. t = 1, 2, 3, 4… 12).

All calculations are performed in MS Excel. So, let's define the initial conditions:

The initial data for a smoothed data is $L_{12} = \overline{y_{(1;36)}}$ = 90596.89 pcs.

The initial data for a smoothed trend is T_{12} = 3327.51 pcs.

Seasonal coefficients for initial data are: S_1 = 0.941; S_2 = 0.964; S_3 = 1.201; S_4 = 1.229; S_5 =1,011; S_6 = 0.966; S_7 = 0.943; S_8 = 0.946; S_9 = 0.966; S_{10} = 0.946; S_{11} = 0.942; S_{12} = 0.946.

After determining the initial data, we make calculations according to formulas (3.5) - (3.9).

To determine the accuracy of the forecasting, we must first calculate the error by formula (3.12) and the average absolute error in%. This error estimates how large the errors are compared to the value of the series. This method is used to estimate the accuracy of the forecast (forecast accuracy = 1 - MAPE) by formula (3.13).

$$e_t = y_t - \bar{y}_t . \tag{3.12}$$

$$MAPE = \frac{1}{n}\sum_{i=1}^{t}\frac{e_t}{y_t} . \tag{3.13}$$

To increase the accuracy of the forecast, use the Solver tab to optimize the values of α, β and γ. To do this, in the window of Solver set the target cell that contains the value of the accuracy of the forecast, the variable data include cells where the values of α, β and γ and set the limits specified in formula (3.9). Thus, during the start of Solver the values of smoothing parameters are determined taking into account the reduction of the forecast error. Forecasting calculations are presented in table. 3.7, it was obtained that the data smoothing parameters should have the following values α = 0.808, β = 0.059 and γ = 1.000. The obtained data indicate a

small average error equal to 0.03%, we present the graphically obtained results on Fig. 3.2. and in Table 3.8.

Table 3.7 – Sales forecasting of Ajax Systems

Period, t	Date	Fact data, pcs	Smoothing data, Lt	Trend smoothing, Tt	Seasonal coefficient, St	Forecast data, psc
1	2	3	4	5	6	7
1.	Jan-17	40054	-	-	0,941	-
2.	Feb-17	41021	-	-	0,964	-
3.	Mar-17	51121	-	-	1,201	-
4.	Apr-17	52324	-	-	1,229	-
5.	May-17	43027	-	-	1,011	-
6.	Jun-17	41108	-	-	0,966	-
7.	Jul-17	40143	-	-	0,943	-
8.	Aug-17	40254	-	-	0,946	-
9.	Sep-17	41124	-	-	0,966	-
10.	Oct-17	40251	-	-	0,946	-
11.	Nov-17	40102	-	-	0,942	-
12.	Dec-17	40253	90596,89	3327,51	0,946	-
13.	Jan-18	79663	86436,91	2884,43	0,922	88383
14.	Feb-18	84458	87960,66	2803,91	0,960	86081
15.	Mar-18	108840	90651,04	2797,19	1,201	109009
16.	Apr-18	114965	93508,75	2800,77	1,229	114873
17.	May-18	97401	96346,70	2802,97	1,011	97354
18.	Jun-18	95798	99185,31	2805,08	0,966	95755
19.	Jul-18	96228	102025,83	2807,18	0,943	96187
20.	Aug-18	99178	104864,72	2809,05	0,946	99141
21.	Sep-18	104064	107703,74	2810,83	0,966	104028
22.	Oct-18	104545	110547,76	2812,79	0,946	104506
23.	Nov-18	106848	113401,21	2815,20	0,942	106801
24.	Dec-18	109977	116279,24	2818,92	0,946	109903
25.	Jan-19	105236	115127,99	2583,97	0,914	109765
26.	Feb-19	110580	115654,88	2462,24	0,956	113025
27.	Mar-19	141287	117760,40	2441,13	1,200	141817
28.	Apr-19	148327	120559,28	2462,30	1,230	147783
29.	May-19	125044	123562,04	2494,29	1,012	124368
30.	Jun-19	122392	126592,27	2526,00	0,967	121751
31.	Jul-19	122338	129595,55	2554,25	0,944	121781
32.	Aug-19	128481	135137,79	2731,06	0,951	124983
33.	Sep-19	134143	138649,30	2777,25	0,967	133210
34.	Oct-19	134169	141787,04	2798,58	0,946	133747
35.	Nov-19	136606	144907,77	2817,64	0,943	136230
36.	Dec-19	140138	148083,51	2838,84	0,946	139719

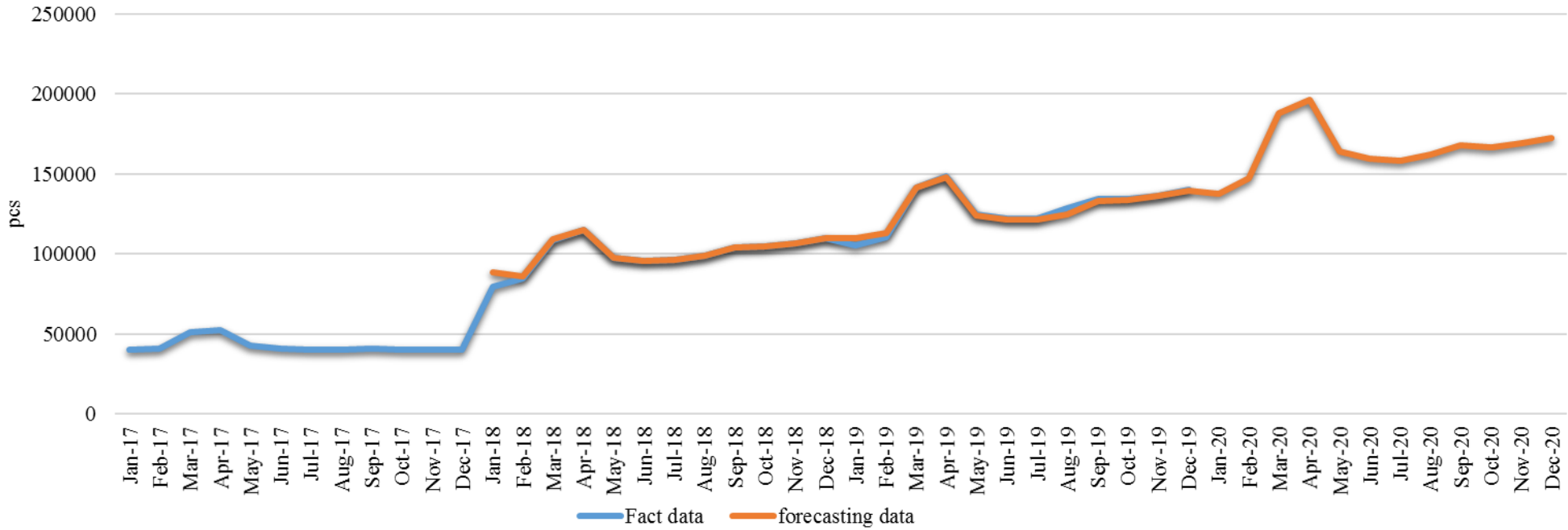


Figure 3.2 – Sales forecasting of Ajax Systems

Table 3.8 – Sales forecast data of Ajax Systems in 2020

No.	Month, year	Forecasting data
1.	Jan-20	137955
2.	Feb-20	147014
3.	Mar-20	187886
4.	Apr-20	196161
5.	May-20	164224
6.	Jun-20	159638
7.	Jul-20	158550
8.	Aug-20	162381
9.	Sep-20	167990
10.	Oct-20	166990
11.	Nov-20	169038
12.	Dec-20	172376

According to the sales data obtained are forecast to increase by 1.29 times. Ajax Systems must have reliable contractors for normal and stable production of devices and inventory management needs to be improved to optimize logistics costs. In addition, it is necessary to establish inventory management taking into account a more accurate forecast compared to the actual stocks in warehouses.

3.3 Recommendations of inventory management policy

According to the actual results of demand for devices and the sales forecast for them, we've checked the balances of devices in the company's warehouses during 2018 and 2019 (Table 3.9).

Explain data. Planned inventory on the end of month were calculated as the inventory of the end of first month plus inventory in column difference between fact and forecast. Actual inventory on the end of month were taken from company data.

As we can see, the difference between inventories of devices amounted to 3 584 pcs, which in turn froze in inventories by more than UAH 25 million.

Таблиця 3.9 – Planned and actual inventory of devices on the end of month, pcs

No.	Date	Fact	Forecast	Difference	Planned inventory on the end of month	Actual inventory on the end of month
1	2	3	4	5	6	7
1.	Jan-18	79663	88383	8720	14557	15711
2.	Feb-18	84458	86081	1623	16180	17434
3.	Mar-18	108840	109009	169	16349	17503
4.	Apr-18	114965	114873	-92	16257	12542
5.	May-18	97401	97354	-47	16210	17364
6.	Jun-18	95798	95755	-43	16168	17322
7.	Jul-18	96228	96187	-41	16126	17280
8.	Aug-18	99178	99141	-37	16089	12543
9.	Sep-18	104064	104028	-36	16053	17207
10.	Oct-18	104545	104506	-39	16015	17169
11.	Nov-18	106848	106801	-47	15967	17121
12.	Dec-18	109977	109903	-74	15894	17048
13.	Jan-19	105236	109765	4529	20422	21576
14.	Feb-19	110580	113025	2445	22867	24021
15.	Mar-19	141287	141817	530	23397	24551
16.	Apr-19	148327	147783	-544	22853	24007
17.	May-19	125044	124368	-676	22176	23330
18.	Jun-19	122392	121751	-641	21536	22690
19.	Jul-19	122338	121781	-557	20979	22133
20.	Aug-19	128481	124983	-3498	17481	18635
21.	Sep-19	134143	133210	-933	16548	17702
22.	Oct-19	134169	133747	-422	16126	18280
23.	Nov-19	136606	136230	-376	15750	17004
24.	Dec-19	140138	139719	-419	15331	18915
25.	Difference between inventories, pcs					3584
26.	Average price of devices, uah					7000
27.	Total frozen assets, uah					25 088 000

In addition, cash was frozen not only in stocks of devices, but also components that are also stored in the company's warehouses. Consider a similar period, taking

into account the planned number of components for the manufacture of devices according to the calculated demand forecast (Table 3.10).

Таблиця 3.10 – Planned and actual inventory of components on the end of month, pcs

No.	Date	Fact	Forecast	Difference	Planned inventory on the end of month	Actual inventory on the end of month
1	2	3	4	5	6	7
1.	Jan-18	2230564	2474731	244167	250004	251158
2.	Feb-18	2364824	2410267	45443	295447	296701
3.	Mar-18	3047520	3052245	4725	300172	301326
4.	Apr-18	3219020	3216442	-2578	297594	12542
5.	May-18	2727228	2725925	-1303	296291	297445
6.	Jun-18	2682344	2681151	-1193	295099	296253
7.	Jul-18	2694384	2693226	-1158	293941	295095
8.	Aug-18	2776984	2775944	-1040	292901	12543
9.	Sep-18	2913792	2912789	-1003	291898	293052
10.	Oct-18	2927260	2926172	-1088	290810	291964
11.	Nov-18	2991744	2990416	-1328	289482	290636
12.	Dec-18	3079356	3077297	-2059	287423	288577
13.	Jan-19	2946608	3073410	126802	414225	415379
14.	Feb-19	3096240	3164688	68448	482674	483828
15.	Mar-19	3956036	3970879	14843	497516	498670
16.	Apr-19	4153156	4137914	-15242	482274	483428
17.	May-19	3501232	3482298	-18934	463340	464494
18.	Jun-19	3426976	3409037	-17939	445401	446555
19.	Jul-19	3425464	3409864	-15600	429801	430955
20.	Aug-19	3597468	3499536	-97932	331869	333023
21.	Sep-19	3756004	3729872	-26132	305737	306891
22.	Oct-19	3756732	3744918	-11814	293923	296077
23.	Nov-19	3824968	3814449	-10519	283404	284658
24.	Dec-19	3923864	3912127	-11737	271667	276215

The end of Table 3.10

1	2	3	4	5	6	7
25.	Difference between inventories, pcs					4548
26.	Average price of devices, uah					100
27.	Total frozen assets, uah					454 800

As we can see, the difference between inventories of components amounted to 4 548 pcs, which in turn froze in inventories by more than UAH 454 000.

So, if Ajax Systems will use the forecasting method of Holt-Winters, it will provide an opportunity to return the assets in the company's turnover and direct them to the R&D of new devices.

According to practical and theoretical data, the most optimal option among inventory management systems for production company is the Fixed-Time Period System.

To ensure timely production of components, we calculate the economic order quantity and other important indicators for the above system (table 3.11). We've used next initial data:

Table 3.11 – Component data of Fixed-Time Period System

No.	Parameter	Data
1.	Demand, pcs	43 348 992
2.	Economic order quantity ,pcs	1 989 677
3.	The interval between orders, days	16
4.	Order Lead Time, days	5
5.	Delay Order Lead Time /possible time for delay delivery/, days	1
6.	Daily Usage Rate /expected daily consumption/, pcs /day	118 765
7.	Expected inventories consumption during delivery, pcs	356 293
8.	Maximum inventories consumption during delivery, pcs	593 822
9.	Safety stocks, pcs	237 529
10.	The maximum volume of inventories / Target Inventory , pcs	2 227 206
11.	Order quantity	2 583 498 - IP

– the annual demand quantity of components is 43 348 992 pcs;

– ordering cost (not a per unit cost, but the cost associated to the operation of ordering and shipping) is UAH 50 000;

– unit holding cost is UAH 0.03;

– period of control is 365 days.

We compare the results of inventory management costs under the old inventory management scheme with deliveries once every two months and with the proposed inventory management system with intervals between orders of 16 days (Table 3.12).

Table 3.12 - Comparison of component inventory management costs for the old and new inventory systems

No.	Parameter	Old scheme	New scheme
1.	Demand, pcs	43 348 992	43 348 992
2.	Ordering quantity, order	1	3
3.	Ordering cost, uah	50 000	150 000
4.	Holding cost, uah	216 745	72 248
5.	Total cost, uah	266 745	222 248
6.	Difference of cost, uah	44 497	
7.	Annual difference of cost, uah	533 960	

We've taken for comparison the costs for two months. We received an three orders for the new inventory system with an order interval of sixteen days for the Fixed-Time Period System. When calculating the holding cost, we've taken the average storage costs for these two months. The obtained result testifies to the advantage of using the new inventory system and gives additional revenue of more than UAH 44 000 on two months and annual additional revenue of more than UAH 533 000. The calculated savings are summarized in Table 3.13.

Table 3.13 – The calculated savings of the proposed improvements, UAH

No.	Parameter	Data
1.	Frozen assets (devices stocks)	25 088 000
2.	Frozen assets (components stocks)	454 800
3.	Difference of cost of inventory systems	533 960
4.	Total savings	26 076 760

Thus, in the case of the proposed improvements, namely the use of the Holt-Winters method in forecasting sales demand and the use of Fixed-Time Period System with Economic order quantity in the amount of 1 989 677 pcs, we can achieve a total annual benefit of UAH 26 076 760.

3.4 Chapter 3 summary

In this chapter of the thesis, recommendations were given to improve the logistics of Ajax Systems, which consisted of:

– Holt-Winters predictions were made. This method through the use of smoothing factors provides the most accurate forecast for further inventory management planning;

– identified the most optimal contractor for the microchips assembly in both Kyiv and Kharkiv. At the first stage, only those contractors were identified who fully provided quality components from a technical point of view. In the second stage, the selection was made using the method of integrated score of the choice of supplier;

– calculated and compared costs for the balances of stocks of devices and components in comparison with actual data and forecast data. The results showed significant savings when using the Holt-Winters method in forecasting;

– calculated and compared costs for component inventory management in case of changes in the approach to inventory management and the use of Fixed-Time Period System with Economic order quantity.

CONCLUSIONS AND RECOMMENDATIONS

The theoretical part of the thesis was devoted to the analysis of scientific and methodical literature on the logistics of production companies, namely the logistics of procurement and inventory management.

Procurement logistics is related to other functional areas, as evidenced by the researched literature sources, which are reviewed at the beginning of the theoretical part. First of all, the company should be considered as a single organism, the successful operation of which depends on the coordinated work of all departments. This is the manifestation of the logistical approach to the management of production company.

Given that the thesis will focus on issues related to the procurement of MR, the issues of supply were considered in more detail, the task of which is to establish a reliable and uninterrupted material flow through competent and reliable suppliers / contractors through which we can get quality procurement materials, maintain their stock and accordingly increase the competitiveness of their enterprise.

That is why the stages of organization of MR supply, procurement methods and the procedure of EOQ calculation and inventory systems were examined in detail, as well as the main assumptions and limitations, which were subsequently taken into account in the project part.

Identification of advantages and disadvantages of large and small stocks in the company are given understanding of necessary calculation of inventory level.

General analysis of Ajax Systems activity is shown that Ajax Systems is an international technology company headquartered in Kyiv. The company develops wireless security systems and has its own full-cycle production and was founded in 2011 in Kyiv. Products are designed and manufactured in Ukraine. Monthly production of 220,000 devices. The team of 800+ employees. All company history can be divided on such periods as prehistory (2008-2011), establishment and development (2011-2014) and improvement and expansion (2014-nowadays).

Ajax Systems has the share of 59% of professional structures and 41% at self-monitoring of customers. In addition, the company is in great demand in foreign markets, so in general you can find Ajax Systems products in 95 countries.

Advantage in foreign markets is the price. Systems of this class are many times more expensive. It is profitable to have development and production in Ukraine, and the latter has already become cheaper than in China. So, the basic Ajax StarterKit in Ukraine costs 6,000 UAH. Similar kits of the international manufacturer Visonic are sold on Amazon for $ 500, Essence's one are sold for $ 400.

Commercial and financial indicators' analysis of company has showed that the company occupies a stable position in the market of security systems, the demand for the company's devices is growing, which leads to a stable financial position, in addition, the company receives investments from investors aimed at further development of the company and its improvement.

Logistics processes diagnostics showed that Ajax Systems has logistics of R&D (where the main part is searching and procurement of components) and logistics of production and distribution (where we can emphasis procurement logistics, inventory management and distribution logistics).

SWOT analysis of Ajax Systems has showed such:

– opportunities: possibility to open new markets, increased demand for the security device markets, new technologies;

– threats: Covid-19 pandemic, economic and political instability in the Ukraine, outflow of personnel abroad, government decisions;

– strength: strong brand name, good reputation at the global stage, large clients base in different counties, high level of employees, specific employees training, attracting to investment companies;

– weaknesses: order of contractor selection, demand forecasting, inventory management.

These characteristics give us next conclusions:

– using opportunities of market and strengths of company we can development of new markets and new devices;

– using opportunities of market and eliminating weaknesses of company we can increase the level of logistics management;

– eliminating threats of market and using strengths of company we can improvement personnel motivation, disinfection to prevent infection on production zone and office;

– eliminating threats of market and weaknesses of company we can reduce logistics cost.

In the project part it was proposed method of Holt-Winters for sale forecasting which will determine future sales with minimal error. Because the old version of the forecast did not fit and created excess stocks, which froze funds in stocks.

Thus, the calculated forecast provided an error of 0.03%, which indicates a high level of forecasting accuracy. It was determined that future sales should increase by 1.29 times, respectively, it is necessary to provide production with the necessary components to respond in a timely manner to customer demand.

In this regard, the order for microchip assembly contractor selection was first determined, as the actual contractor, although providing high quality components for production, showed a lag in delivery schedules. Therefore, a search for potential contractors was conducted to determine the most optimal quality both in Kyiv and in Kharkiv. Prototypes were provided to technical engineers to determine the product quality of these potential contractors. After selecting the contractors with the highest rating for the quality of their products, other indicators were also considered: just-in-time delivery, lead time, unit transport costs, business experience, financial standing, business initiative.

To determine the rank of each indicator to select a contractor, a top management survey was conducted, namely the CEO, Chief Accountant and Production Director.

The final values of the integrated score indicate that the highest rating was received by company Umna Schema with a score of 1.115, the second place is occupied by company Electro Schema with a score of 0.977, the third place is company Electo Garant with a score of 0.844 (this is real contractor). As conclusion we can say that optimal contractor for the microchip assembly in Kyiv is company

Umna Schema, for which quality of their final product is equal quality of one by Electo Grant, but taking into account other indicators company Umna Schema has advantage before Electo Grant.

The final values of the integrated score indicate that the highest rating was received by company Micro Electro Svit with a score of 0.972, the second place is occupied by company Micro Electronika with a score of 0.849 (this is real contractor), the third place is company Svit Micro Schem with a score of 0.779. As conclusion we can say that optimal contractor for the microchip assembly in Kharkiv is company Micro Electro Svit.

To change inventory management systems, frozen inventories were identified in both quantitative and monetary units. The data showed that at the end of 2019, the difference between inventories of devices amounted to 3,584 pcs, which in turn froze in inventories by more than UAH 25 million.

Similar calculations of balances in component warehouses showed the difference between inventories of components amounted to 4,548 pcs, which in turn froze in inventories by more than UAH 454,000.

According to practical and theoretical data, the most optimal option among inventory management systems for production company is the Fixed-Time Period System.

We've taken for comparison the costs for two months. We received an three orders for the new inventory system with an order interval of sixteen days for the Fixed-Time Period System. When calculating the holding cost, we've taken the average storage costs for these two months. The obtained result testifies to the advantage of using the new inventory system and gives additional revenue of more than UAH 44 000 on two months and annual additional revenue of more than UAH 533 000.

Thus, in the case of the proposed improvements, namely the use of the Holt-Winters method in forecasting sales demand and the use of Fixed-Time Period System with Economic order quantity in the amount of 1 989 677 pcs, we can achieve a total annual benefit of UAH 26 076 760.

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Appendix A

SWOT-analysis of Ajax Systems

	Strengths: - Strong brand name - Good reputation at the global stage - Large clients base in different counties - High level of employees, specific employees training - Attracting to investment companies	**Weaknesses:** - Order of contractor selection - Demand forecasting - Inventory management
Opportunities: - Possibility to open new markets - Increased demand for the security device markets - New technologies	- Development of new markets and new devices	- Increase the level of logistics management
Threats: - Covid-19 pandemic - Economic and political instability in the Ukraine - Outflow of personnel abroad - Government decisions	- Personnel motivation - Disinfection to prevent infection on production zone and office	- Cost reduction