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Logistics



Professor Marin Drinov Publishing House
of Bulgarian Academy of Sciences

Sofia 2026

UDC 65.012.34(075.8)

DOI <https://doi.org/10.5281/zenodo.21704822>

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Logistics: textbook. – Sofia: Professor Marin Drinov Publishing House of Bulgarian Academy of Sciences, 2026. – 195 p.

The textbook “Logistics” is intended for the study of the theoretical foundations and practical aspects of logistics and supply chain management in modern organizations. It systematically presents the conceptual framework of logistics, its objectives, principles, functions, and management models, as well as the management of material, information, and financial flows within enterprises. The publication is designed in accordance with modern approaches to higher education and competency-based learning. It combines academic theory with practical applications, allowing students to understand contemporary logistics processes and apply logistics tools to solve real business problems. The textbook is intended for undergraduate and graduate students studying Logistics, Supply Chain Management, Management, Marketing, Business Administration, International Business, Transportation, Economics, and related fields. It may also be useful for university lecturers, researchers, logistics professionals, and practitioners seeking to enhance their knowledge of modern logistics systems and supply chain management.

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The Bulgarian Academy of Sciences
Sofia, Bulgaria 2026

ISBN 978-619-245-654-2

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PREFACE

Logistics has become one of the most important disciplines in modern business and economic management. In an era of globalization, digital transformation, e-commerce expansion, and increasing customer expectations, organizations are required to manage material, information, and financial flows efficiently to remain competitive. The rapid development of Industry 4.0 technologies, artificial intelligence, the Internet of Things (IoT), automation, and sustainable logistics has significantly transformed supply chain operations and logistics management practices.

Modern enterprises recognize logistics not only as an operational function but also as a strategic management tool that creates customer value, reduces costs, improves service quality, and enhances overall organizational performance. Effective logistics management contributes to the resilience of supply chains, supports sustainable development, and enables companies to respond quickly to market changes and global disruptions. Therefore, studying logistics has become an essential component of higher education in business, management, economics, engineering, and related fields.

This textbook has been prepared to provide students with a comprehensive understanding of the theoretical foundations, practical applications, and current trends in logistics. It reflects international best practices and contemporary approaches to logistics management while integrating examples from leading global companies and modern digital technologies.

INTRODUCTION

Logistics has evolved into one of the most important fields of business management, playing a critical role in improving organizational efficiency, customer satisfaction, and competitive advantage. In today's global economy, characterized by digital transformation, international trade, rapidly changing consumer demands, and increasingly complex supply chains, logistics has become a strategic function that integrates procurement, production, transportation, warehousing, distribution, and information management.

The purpose of this textbook is to provide students with a comprehensive understanding of logistics as both a scientific discipline and a practical business activity. The textbook combines theoretical concepts with practical applications, enabling students to understand how logistics contributes to the effective management of material, information, and financial flows throughout the supply chain.

The primary objectives of the textbook are to:

- explain the conceptual foundations, principles, and categories of logistics;
- develop an understanding of logistics systems and supply chain management;
- examine the functional areas of logistics, including procurement, production, transportation, distribution, and warehouse logistics;
- familiarize students with modern logistics technologies, digital information systems, and automation tools;
- develop analytical, managerial, and problem-solving skills applicable to logistics decision-making;
- demonstrate the practical application of logistics concepts through case studies, role-playing activities, and business examples;
- prepare students to evaluate logistics performance and develop strategies that improve organizational competitiveness.

The textbook is organized into two interconnected modules that gradually introduce students to the conceptual foundations and functional areas of logistics.

Module 1 focuses on the theoretical basis of logistics, including its concepts, objectives, principles, management models, logistics flows, and the strategic role of logistics in creating competitive advantage.

Module 2 examines the major functional areas of logistics, including procurement, production, distribution, transportation, and warehouse logistics. Each chapter introduces modern logistics tools, digital technologies, performance indicators, and practical applications used by leading organizations worldwide.

Every chapter follows a unified structure consisting of:

- clearly defined learning content;
- questions for discussion to stimulate critical thinking;
- practical exercises for applying theoretical knowledge;
- test tasks for self-assessment and knowledge evaluation.

The textbook also includes role playing activities that simulate real business situations, success cases illustrating best practices of international logistics companies, a comprehensive glossary of logistics terminology, and a list of references for further study.

The textbook is intended primarily for undergraduate and graduate students studying Logistics, Supply Chain Management, Management, Marketing, Business Administration, International Economics, Transportation, and related disciplines. It may also be useful for doctoral students, university lecturers, researchers, logistics managers, procurement specialists, warehouse supervisors, transportation professionals, and business practitioners seeking to improve their knowledge of contemporary logistics management.

Upon successful completion of the textbook, students will possess both theoretical knowledge and practical competencies necessary for effective logistics and supply chain management in manufacturing, retail, transportation, service industries, and international business.

MODULE 1. CONCEPTUAL FOUNDATIONS OF LOGISTICS

Chapter 1

BASIC CATEGORIES AND CONCEPTUAL FRAMEWORK OF LOGISTICS

1.1. The essence of logistics as a scientific and practical activity

1.2. Main categories of logistics

1.3. Types of logistics and its role in the modern economy

1.1. The essence of logistics as a scientific and practical activity

Logistics, as both a science and a practical discipline, emerged at the intersection of military affairs, economics, and management. The term itself derives from the Greek word “logistikos” – the art of calculation.

Historically, logistics was actively applied in the military sphere to organize the supply of the army. Napoleon Bonaparte made a significant contribution to the development of military logistics, emphasizing that “an army marches on its stomach.”

In the 20th century, logistics approaches began to be actively used in business. Logistics underwent significant development after World War II, when the scale of production and international trade increased.

Stages of logistics development (Figure 1.1).

Logistics is the science and practice of managing the flow of physical resources, information, finances, and services to ensure their efficient movement from the source to the end user at minimal cost.

The modern interpretation of logistics involves:

- integrated management of flows;
- a focus on consumer needs;
- minimization of total costs;
- synchronization of supply, production, and sales processes.



Figure 1.1. Stages of logistics development

The object of logistics:

Material, information, financial, and service flows in economic systems.

The subject of logistics:

Methods and tools for managing flow processes.

Main tasks of logistics:

- resource planning;
- supply chain management;
- inventory management;
- transportation;
- warehousing;
- information support;
- cost minimization;
- improving customer service.

1.2. Main categories of logistics

The basic concepts of logistics include (definitions of the terms are provided in the glossary):

- logistics flow;
- logistics system;
- logistics chain;
- logistics channel;
- logistics operations;
- logistics costs;

- level of logistics service;
- logistics infrastructure.

Material Flow

The totality of material resources (raw materials, semi-finished products, finished goods) that move through time and space.

Characteristics:

- volume;
- product range;
- intensity;
- direction of movement;
- regularity.

Information Flow

Accompanies the material flow and ensures its management.

Financial Flow

The movement of funds associated with the procurement, production, and sale of products.

Service Flow

The provision of services related to the maintenance of goods.

Logistics system is a set of interconnected elements that ensure the management of resource flows.

Key elements:

- suppliers;
- production units;
- warehouses;
- transportation companies;
- intermediaries;
- consumers;
- information systems.

Global companies such as Amazon and DHL are building complex, integrated logistics systems that combine automated warehouses, transportation networks, and digital management platforms (Figure 1.2).

Logistics chain

The sequence of participants through which goods pass from the manufacturer to the consumer.

Logistics channel

The group of legal entities and individuals that facilitate the movement of goods.



Figure 1.2. Amazon and DHL’s Complex Integrated Logistics Systems

Example of a logistics chain (Figure 1.3).

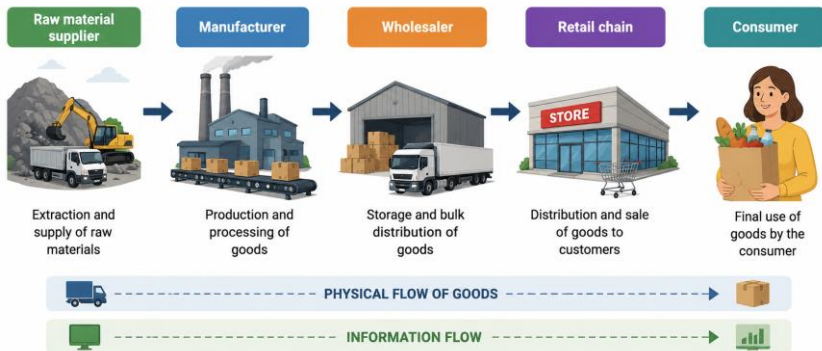


Figure 1.3. Logistics chain

1.3. Types of logistics and its role in the modern economy

Logistics is classified by area of activity as follows:

- procurement logistics;
- production logistics;

- distribution logistics;
- transportation logistics;
- warehouse logistics;
- information logistics;
- financial logistics;
- international logistics.

By management level, logistics is categorized as:

- micro-logistics (at the enterprise level);
- macro-logistics (at the regional, national, and international levels).

Logistics is a key factor in a company's competitiveness.

Modern concepts of logistics management include:

- Just-in-Time (JIT) – minimizing inventory;
- Supply Chain Management (SCM);
- digitalization of logistics;
- warehouse automation;
- the use of artificial intelligence.

Toyota was one of the pioneers in implementing the JIT system, which made it possible to reduce inventory, cut costs, and increase production flexibility.

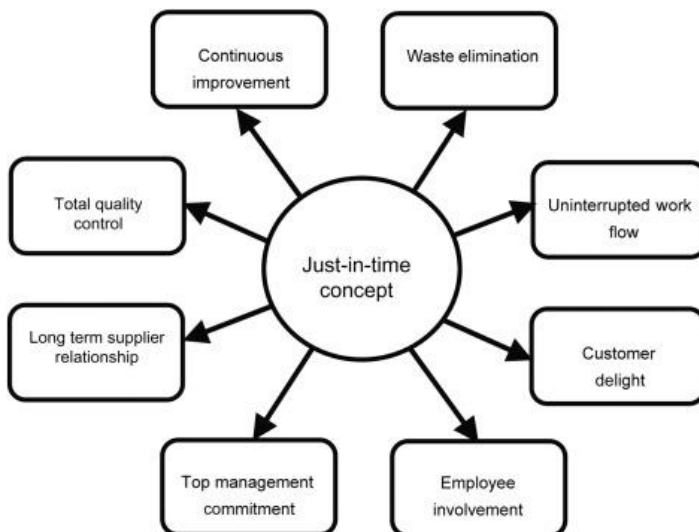


Figure 1.4. Just-in-Time (JIT)

Questions for discussion

1. What does the term “logistics” mean, and what is its historical origin?
2. What stages of logistics development can be identified?
3. What is the essence of logistics as a science?
4. What are the object and subject of study in logistics?
5. What are the main tasks of logistics within a company?
6. Define the concept of a “logistics flow.”
7. What types of logistics flows do you know?
8. What is a logistics system?
9. What elements make up a logistics system?
10. What is the difference between a logistics chain and a logistics channel?
11. Why is logistics considered an integrated management system?
12. How are material and information flows related?
13. What factors influence the efficiency of a logistics system?
14. Why is minimizing total costs a key principle of logistics?
15. What does a systems approach in logistics entail?
16. Explain the relationship between the level of logistics service and a company's costs.
17. How does micrologistics differ from macrologistics?
18. What risks arise when logistics flows are disrupted?
19. Give an example of material, information, and financial flows at a specific company.
20. How do digital technologies influence the development of logistics?
21. How does the role of logistics change in an unstable market?
22. Can a company be competitive without effective logistics?
Explain your answer.
23. What is more important for a company: minimizing costs or maximizing service levels?
24. Is logistics a strategic management function?
25. How does globalization affect logistics systems?
26. Will artificial intelligence change traditional approaches to logistics management?

Practical exercises

Practical exercise 1. Identifying logistics flows.

A juice manufacturing company receives fruit from farms, processes it, stores it in a warehouse, and sells it through retail chains.

Tasks:

1. Identify the material flows.
2. Identify the information flows.
3. Identify the financial flows.
4. Describe the service flow.

Practical exercise 2. Designing a logistics chain.

Design a logistics chain for a furniture manufacturer that purchases wood, manufactures products, and sells them through an online store.

Tasks:

- identify all participants in the chain;
- show the direction of the material flow;
- indicate where information and financial flows occur.

Practical exercise 3. Analysis of a company's logistics system.

The company has:

- 3 suppliers;
- 1 production facility;
- 2 warehouses;
- its own fleet of vehicles;
- 15 regular customers.

Tasks:

1. Identify the elements of the logistics system.
2. Describe possible “bottlenecks.”
3. Suggest two ways to improve efficiency.

Practical exercise 4. Case study (flow management).

The company is facing the following problems:

- delays in raw material deliveries;
- excess inventory;

- late deliveries to customers.

Tasks:

1. Identify which logistics principles have been violated.
2. Which flows are out of balance?
3. Propose a set of measures for optimization.

Practical exercise 5. Comparison of micro- and macro-logistics.

Give an example of:

- a micro-logistics system (at the enterprise level);
- a macro-logistics system (at the national or international level).

Explain the differences.

Practical exercise 6. Drawing a diagram of a logistics system.

Draw a diagram of the company's logistics system (in the form of a flowchart) that includes:

- suppliers;
- production;
- warehouse;
- transportation;
- customers;
- information links.

Practical exercise 7. Optimizing a company's logistics costs.

A trading company noticed that the share of logistics costs in revenue had risen from 18% to 28% over the course of the year.

The main reasons:

- rising fuel prices;
- inefficient delivery routes;
- an increase in the number of small orders.

Tasks

1. Which logistics functions need to be optimized?
2. What analysis methods should be used?
3. Should the company outsource its transportation services?
4. How can digitalization reduce costs?

Test tasks

1. As a science, logistics studies:

- a) only transportation processes;
- b) the management of a company's financial resources;
- c) the management of material, information, and financial resource flows;
- d) only warehousing.

2. The object of logistics is:

- a) a company's profit;
- b) ongoing processes in economic systems;
- c) marketing research;
- d) production equipment.

3. A material flow is:

- a) the flow of information about a product;
- b) the flow of funds;
- c) the movement of material resources in space and time;
- d) the process of serving customers.

4. Types of logistics flows include:

- a) material, information, financial, and service flows;
- b) production, commercial, and investment flows;
- c) marketing and advertising flows;
- d) tax and credit flows.

5. Logistics system is:

- a) a company's warehouses;
- b) a country's transportation network;
- c) a set of interconnected elements that ensure the management of flows;
- d) an accounting system.

6. Supply chain is:

- a) the sequence of participants in the movement of goods from the manufacturer to the consumer;
- b) set of means of transportation;
- c) list of suppliers;
- d) the internal structure of a company.

7. The main goal of logistics is:

- a) to increase the number of employees;
- b) to minimize total costs while maintaining a given level of service;
- c) to maximize inventory;
- d) to reduce production.

8. The principles of logistics include:

- a) fragmented management;
- b) systematic approach;
- c) isolation of departments;
- d) independence of flows.

9. Micro-logistics encompasses:

- a) flow management at the enterprise level;
- b) international transport corridors;
- c) the national economy;
- d) global supply chains.

10. The flow of information in logistics:

- a) exists independently of the flow of goods;
- b) accompanies the flow of goods and facilitates its management;
- c) pertains only to accounting;
- d) is related only to advertising.

2.1. Objectives and basic principles of logistics

2.2. Logistics functions

2.3. Current trends in logistics development

2.1. Objectives and basic principles of logistics

The main goal of logistics is to provide consumers with the goods they need:

- in the right quantity,
- in the right place,
- at the right time,
- of the right quality,
- at the lowest possible cost.

Strategic objectives:

1. Optimizing overall logistics costs.
2. Ensuring the company's competitiveness.
3. Establishing sustainable supply chains.
4. Improving the level of logistics service.
5. Integrating all logistics subsystems.

Operational objectives:

- timely delivery;
- maintaining optimal inventory levels;
- minimizing transportation costs;
- reducing order fulfillment time;
- reducing losses and damage.

Basic principles of logistics:

Systemic approach

Viewing logistics as a single, integrated system.

Comprehensiveness

Taking into account all elements of the logistics chain.

Optimization

Seeking the best balance between costs and results.

Continuity

Ensuring the uninterrupted flow of goods.

Flexibility

Adapting to market changes.

Reliability

Stability of supplies.

Information availability

Timely and accurate information for decision-making.

2.2. Logistics functions

Logistics functions are specific areas of activity aimed at managing flows.

Procurement Logistics

Organizing the supply of raw materials, materials, and components.

Main tasks:

- selecting suppliers;
- negotiating contracts;
- quality control;
- inventory management.

Production Logistics

Managing internal material flows within the enterprise.

Objectives:

- optimizing production inventory;
- minimizing work in progress;
- synchronizing processes.

Distribution Logistics

Organizing the movement of finished products to the consumer.

Objectives:

- selection of distribution channels;
- warehouse management;
- organization of transportation;
- customer service.

Transportation Logistics

Optimization of freight transportation using various modes of transport.

Objectives:

- selection of the mode of transport;

- route planning;
- Minimizing transportation costs.

Warehouse Logistics

Tasks:

- Optimizing the placement of goods;
- Inventory management;
- Automating inventory tracking.

Information Logistics

Tasks:

- Data processing;
- Integration of information systems;
- Supporting management decisions.

Logistics functions are closely interrelated:

- Purchasing affects the level of production inventory;
- Production affects delivery times;
- Transportation determines the speed of capital turnover;
- The warehousing system affects costs and service.

Logistics acts as an integrating system within the enterprise, coordinating the work of:

- production,
- marketing,
- finance,
- sales.

2.3. Current trends in logistics development

Modern logistics makes extensive use of:

- ERP systems

ERP systems provide complete visibility into inventory levels, customer orders, shipment status, supplier performance, and financial transactions. By eliminating isolated information systems and reducing manual data entry, organizations can minimize errors, improve coordination among departments, and respond more quickly to changing customer demands.

Implementing an ERP system provides several important benefits. Organizations achieve greater supply chain visibility, automate routine business processes, improve inventory accuracy, reduce operating costs, and accelerate order fulfillment. ERP systems also

support strategic decision-making through dashboards, analytics, and performance reporting. Furthermore, they facilitate compliance with regulatory requirements by maintaining accurate documentation and product traceability.

- WMS (warehouse management systems)

The core functions of a WMS include receiving and inspecting incoming goods, assigning optimal storage locations, monitoring inventory levels in real time, managing order picking and packing, generating shipping documentation, coordinating outbound shipments, and processing product returns. Advanced systems also support labor management, warehouse slotting optimization, cross-docking, cycle counting, and performance monitoring through key performance indicators.

Implementing a WMS provides numerous operational benefits. Organizations gain accurate inventory visibility, improved warehouse space utilization, faster order fulfillment, lower labor costs, and reduced inventory discrepancies. Automated workflows help eliminate manual errors, while real-time data enables managers to make informed operational decisions. As a result, businesses achieve higher warehouse productivity, lower logistics costs, and improved service quality.

- TMS (transportation management systems)

Organizations can significantly reduce transportation costs through optimized routing and carrier selection, improve on-time delivery performance, increase shipment visibility, and enhance customer satisfaction. Real-time tracking enables proactive management of delays, while automated reporting provides valuable insights into transportation costs and operational efficiency. In addition, TMS supports sustainability initiatives by optimizing vehicle utilization and reducing fuel consumption and carbon emissions.

- GPS tracking

Implementing GPS tracking provides numerous benefits for logistics companies. Real-time visibility enables managers to respond quickly to unexpected events such as traffic congestion, weather disruptions, or vehicle breakdowns. Optimized routing reduces fuel consumption and transportation costs while improving on-time delivery performance. GPS tracking also enhances cargo

security by enabling rapid location of stolen or lost assets and provides customers with accurate shipment updates, increasing transparency and customer satisfaction.

- Big Data

The main applications of Big Data in logistics include demand forecasting, inventory optimization, route planning, fleet management, warehouse automation, predictive maintenance, and real-time shipment tracking. Predictive analytics enables companies to anticipate customer demand, identify transportation bottlenecks, optimize warehouse operations, and minimize delivery delays. Data collected from connected vehicles and IoT devices also support proactive maintenance by detecting potential equipment failures before they occur, reducing downtime and maintenance costs.

- Artificial intelligence

The main applications of AI in logistics include demand forecasting, inventory optimization, route planning, warehouse automation, predictive maintenance, intelligent fleet management, and real-time shipment tracking. Machine learning algorithms analyze historical and real-time data to forecast customer demand, optimize inventory levels, and recommend the most efficient transportation routes. AI-powered warehouse systems improve picking accuracy, automate sorting operations, and coordinate autonomous mobile robots (AMRs), increasing productivity while reducing human error.

- The growth of e-commerce

One of the most significant impacts of e-commerce is the growing importance of fulfillment centers strategically located near major consumer markets. Unlike traditional distribution systems, e-commerce logistics requires processing thousands of small customer orders rather than large bulk shipments. Modern fulfillment centers use automated storage systems, robotics, artificial intelligence, and Warehouse Management Systems to improve order accuracy and reduce processing time.

- Green logistics

The main practices of green logistics include route optimization to reduce travel distances and fuel consumption, load consolidation to maximize vehicle utilization, the use of electric and alternative-fuel vehicles, energy-efficient warehouses powered by renewable

energy, sustainable packaging, recycling and waste reduction, and reverse logistics for product returns, refurbishment, and recycling.

- The globalization of supply chains

The primary objective of global supply chain management is to coordinate the efficient flow of goods, information, and financial resources across international partners. A typical global supply chain involves suppliers, manufacturers, logistics providers, distributors, retailers, and customers located in different countries. Effective coordination requires advanced information systems, standardized business processes, and strong collaboration among all participants to ensure timely deliveries, product quality, and cost efficiency.

- The development of omnichannel systems

Omnichannel logistics is an integrated logistics approach that provides customers with a seamless shopping and delivery experience across multiple sales channels, including physical stores, e-commerce websites, mobile applications, social media platforms, and marketplaces. Unlike traditional multichannel systems, where each sales channel operates independently, omnichannel logistics synchronizes inventory, order management, warehousing, transportation, and customer service across all channels through a unified logistics network.

Digitalization makes it possible to:

- ✓ reduce costs by 10–30%;
- ✓ reduce inventory by 20–40%;
- ✓ improve the accuracy of demand forecasting.

Questions for discussion

1. What is the main goal, strategic objectives, and operational objectives of logistics within a company?
2. List the basic principles of logistics.
3. What does the principle of a systematic approach in logistics entail?
4. What functions does logistics perform within a company?
5. How is the principle of flexibility implemented in an unstable market?
6. Explain the relationship between procurement and production logistics.
7. How does transportation logistics affect capital turnover?
8. What is the strategic importance of logistics for a company's competitiveness?
9. Is effective logistics possible without modern information systems? Justify your answer.
10. How does logistics affect a company's financial results?
11. How is globalization changing the goals and principles of logistics?
12. Is it advisable to outsource logistics functions?
13. What environmental aspects should modern logistics take into account?
14. How do crises (economic, military, pandemic) affect logistics systems?

Practical exercises

Practical exercise 1. Analysis of a company's supply chain.

Assignment:

Select a manufacturing company.

Tasks:

1. Draw a diagram of the logistics chain.
2. Identify material, information, and financial flows.
3. List the main logistics functions at each stage.
4. Identify potential “bottlenecks.”

Practical exercise 2. Analysis of logistics principles.

Problem statement:

The company faces the following problems:

- delayed deliveries;
- excess inventory;
- lack of information sharing between departments;
- high transportation costs.

Requirements:

1. Identify which logistics principles have been violated.
2. Propose specific management solutions.
3. Estimate the potential economic impact.

Practical exercise 3. Violation of the principle of systematicity.

At the company, the procurement department focuses on the lowest price and purchases large batches.

The warehouse is overloaded.

The finance department complains of a shortage of working capital.

Tasks:

1. Explain the conflict between the departments.
2. Identify the violated principles of logistics.
3. Propose an integrated management model.
4. Estimate the economic benefit of reducing inventory by 20% (assuming inventory is 3 million EUR).

Practical exercise 4. Integration of logistics functions.

The company has separate procurement, warehousing, and transportation departments that do not coordinate their activities.

Requirements:

1. Identify the consequences of this lack of integration.
2. Propose a model for a centralized logistics system.
3. Describe the expected results of implementation.

Practical exercise 5. Developing a logistics strategy.

The company is entering a new regional market.

Requirements:

1. Define the strategic logistics objectives.
2. Select a distribution model (direct/indirect).
3. Propose KPIs to evaluate effectiveness.

Practical exercise 6. Calculating logistics costs.

The company has the following monthly expenses:

- transportation costs – 120,000 EUR;
- warehousing costs – 80,000 EUR;
- inventory management costs – 50,000 EUR;
- IT support – 30,000 EUR.

Requirements:

1. Determine the total logistics costs.
2. Calculate the cost structure (%).
3. Propose measures to optimize these costs.

Test tasks

1. Logistics is:

- a) the process of manufacturing goods;
- b) the management of material, information, and financial flows;
- c) method of marketing research;
- d) accounting system.

2. The main goal of logistics is to:

- a) maximize inventory;
- b) minimize the number of suppliers;
- c) provide consumers with the necessary goods at the lowest possible cost;
- d) raise product prices.

3. The “7R Logistics” concept includes:

- a) 7 stages of production;
- b) 7 principles of personnel management;
- c) ensuring the right product, in the right quantity, at the right place, and at the right time;
- d) 7 modes of transportation.

4. The principles of logistics include:

- a) isolation of departments;
- b) a systematic approach;
- c) market monopolization;
- d) increased costs.

5. Procurement logistics is responsible for:

- a) selling finished products;
- b) organizing the supply of materials;
- c) developing an advertising campaign;
- d) financial analysis of the company.

6. *Production logistics is aimed at:*

- a) optimizing internal material flows;
- b) identifying new markets;
- c) managing credit;
- d) determining the product mix.

7. *Distribution logistics involves:*

- a) purchasing raw materials;
- b) delivering finished products to consumers;
- c) budget planning;
- d) advertising activities.

8. *Information logistics ensures:*

- a) product quality control;
- b) cash flow;
- c) the collection, processing, and transmission of data for flow management;
- d) staff recruitment.

9. *The principle of continuity in logistics means:*

- a) the absence of changes in the system;
- b) the constant flow of goods without delays;
- c) the elimination of inventory;
- d) the consistency of suppliers.

10. *The integration of logistics functions makes it possible to:*

- a) increase the company's costs;
- b) reduce the level of service;
- c) lower total costs and improve efficiency;
- d) eliminate transportation operations.

3.1. Basic concepts of logistics management

3.2. Integrated logistics and Supply Chain Management

3.3. Logistics management models

3.1. Basic Concepts of Logistics Management

The “Total Cost” concept

This concept aims to minimize total logistics costs:

$$C_{\log} = C_{\text{trans}} + C_{\text{warehouse}} + C_{\text{inventory}} + C_{\text{information}}$$

where:

C_{trans} – transportation costs;

$C_{\text{warehouse}}$ – warehousing costs;

$C_{\text{inventory}}$ – inventory holding costs;

$C_{\text{information}}$ – information costs.

The “Just-in-Time” (JIT) concept

Developed by Toyota.

Just-in-Time (JIT) is a logistics concept for managing production and supply, under which materials, components, and finished products arrive exactly when needed, in the right quantity, and at the right place, without creating excess inventory.

The main goals of JIT:

- minimizing inventory;
- shortening the production cycle;
- reducing storage costs;
- increasing production flexibility;
- eliminating waste (muda).

Principles of JIT:

1. Production based on actual demand.
2. Minimal safety stock.
3. Short production cycles.

4. High-quality processes.
5. Close cooperation with suppliers.
6. Pull system.

How JIT works

Production is initiated by an actual customer order, not by a forecast.

The tool used to implement this is the Kanban system – cards or electronic signals that regulate the flow of materials.

The impact of JIT on logistics flows

Material flow:

- reduction in inventory levels;
- more frequent deliveries in small batches;
- reduction in warehouse space.

Information flow:

- requires high accuracy and speed of data transmission;
- automation of orders;
- synchronization with the production schedule.

Financial flow:

- freeing up working capital;
- reducing inventory holding costs;
- improving the cash-to-cash ratio.

Advantages of JIT:

- reduced logistics costs;
- shorter production cycle;
- improved product quality;
- rapid response to changes in demand;
- increased capital turnover.

Disadvantages and risks:

- dependence on suppliers;
- risk of production stoppages due to delays;
- vulnerability to fluctuations in demand;
- need for a stable information system.

Conditions for effective implementation:

- stable demand;
- reliable suppliers;
- short logistics cycle;
- automated information system;
- standardized processes.

Key JIT performance indicators:

- inventory turnover;
- service level;
- production cycle time;
- share of logistics costs;
- defect rate.

The MRP concept

MRP (Material Requirements Planning) is a system for planning material requirements that ensures the timely delivery of raw materials and components in accordance with the production plan.

MRP answers three key questions:

1. What needs to be produced?
2. How much is needed?
3. When is it needed?

Key elements of MRP

MRP is based on three data sets:

- Master Production Schedule (MPS).
- Bill of Materials (BOM)
- Inventory Status File.

How MRP Works:

Demand for finished products → calculation of component requirements → generation of purchase orders → monitoring of delivery dates.

Algorithm for calculating requirements

Main Steps:

1. Determining gross demand.
2. Subtracting current inventory.
3. Calculating net demand.
4. Planning orders taking lead time into account.

Formula for Net Demand:

$$\text{Net Demand} = \text{Gross Demand} - \text{Current Inventory} + \text{Safety Stock}$$

Advantages of MRP:

- reduction of excess inventory;
- reduction of material shortages;
- increased planning accuracy;

- improved production coordination.

Disadvantages of MRP:

- dependence on data accuracy;
- complexity of implementation;
- need for an automated information system;
- sensitivity to sudden changes in demand.

The MRP II concept

Expanding the capabilities of MRP

MRP II is an advanced manufacturing resource planning system that covers not only materials but also:

- production capacity;
- labor resources;
- finance;
- production schedules;
- monitoring of plan execution.

MRP II integrates material, information, and financial flows into a single system.

Features of MRP II:

- closed-loop system;
- monitoring of plan execution;
- variance analysis;
- production budgeting.

Impact on logistics flows

Material flow:

- accurate procurement planning;
- reduction of shortages.

Information flow:

- requires a centralized database;
- high level of automation.

Financial flow:

- improved expense planning;
- reduction in tied-up capital.

The DRP (Distribution Requirements Planning) concept

DRP (Distribution Requirements Planning) is a system for planning product distribution requirements within a logistics network, which ensures timely replenishment of inventory at

warehouses of various levels (central, regional, and retail).

DRP is a logical extension of the MRP concept, but it is applied at the sales stage rather than the production stage.

The main objectives of DRP:

- ensuring the required service level;
- optimizing inventory in distribution channels;
- coordinating shipments between warehouses;
- reducing logistics costs.

The object of DRP planning

Unlike MRP, where the object is materials and components, in DRP the object is:

- finished goods;
- inventory in the distribution network;
- inter-warehouse transfers.

Key elements of DRP:

- demand forecast at the warehouse level;
- inventory data;
- safety stock;
- lead time;
- delivery schedule.

DRP algorithm:

1. Determining forecast demand at each distribution level.
2. Calculating gross demand.
3. Accounting for inventory on hand.
4. Calculating net requirements.
5. Creating a replenishment schedule.

Net requirements formula:

$$\text{Net requirements} = \text{Forecast demand} - \text{Current inventory} + \text{Safety stock}$$

The impact of DRP on logistics flows

Material flow:

- optimization of transfers between warehouses;
- reduction of excess inventory;
- avoidance of shortages.

Information flow:

- requires accurate demand forecasting;

- centralized database;
- automated data exchange.

Financial flow:

- reduction of tied-up capital;
- lower storage costs;
- improved inventory turnover.

Advantages of DRP:

- improved service levels;
- reduced safety stock;
- optimized transportation routes;
- improved cash flow planning.

Disadvantages and Risks:

- dependence on the accuracy of demand forecasting;
- complexity of coordinating a multi-level network;
- need for automation.

Lean Logistics concept

Lean Logistics is a concept for managing logistics processes aimed at eliminating waste, reducing costs, and creating maximum value for the customer.

The concept is based on Lean manufacturing and is a component of the Toyota Production System, developed by Toyota Motor Corporation.

The core idea of Lean Logistics

All logistics operations must create value for the customer.

Anything that does not create value is waste and must be eliminated.

Types of waste in logistics (7 types of waste):

- excess inventory;
- waiting (delays);
- excessive transportation;
- overprocessing;
- unnecessary movement;
- defects and returns;
- overproduction.

Principles of Lean Logistics:

- focus on customer value;
- Value Stream Mapping;

- continuous flow;
- pull system;
- continuous improvement (Kaizen).

Lean Logistics Tools:

- Value Stream Mapping (VSM);
- 5S (workplace organization);
- Kaizen;
- Kanban;
- Just-in-Time;
- process standardization;
- visual management.

The impact of Lean Logistics on flows

Material flow:

- reduction in inventory;
- route optimization;
- shorter cycle times.

Information flow:

- process transparency;
- minimization of errors;
- rapid decision-making.

Financial flow:

- reduction in logistics costs;
- improved capital turnover;
- reduction in tied-up funds.

Key performance indicators for Lean Logistics:

- logistics cycle time;
- inventory level;
- inventory turnover;
- percentage of logistics costs;
- service level;
- defect rate.

Advantages of Lean Logistics:

- reduction in total costs;
- increased flexibility;
- shorter lead times;
- increased competitiveness;
- improved quality of logistics services.

Disadvantages and risks:

- requires a change in corporate culture;
- complexity of implementation;
- dependence on staff discipline;
- risks associated with unstable demand.

3.2. Integrated logistics and Supply Chain Management

Supply Chain Management (SCM) is the integrated management of material, information, and financial flows throughout the entire supply chain – from raw material suppliers to the end consumer.

SCM encompasses the coordination of activities among:

- suppliers;
- manufacturers;
- logistics operators;
- distributors;
- retail chains;
- consumers.

Supply Chain: structure

A typical supply chain includes:

- raw material supplier;
- manufacturer;
- warehouse / distribution center;
- retailer;
- consumer.

SCM ensures coordination among all participants in the system.

The main objectives of SCM:

- minimizing total costs in the supply chain;
- improving service levels;
- reducing delivery times;
- increasing flexibility and adaptability;
- creating a competitive advantage.

Key flows in SCM:

Material flow:

the movement of goods from the supplier to the consumer.

Information flow:

the transmission of orders, forecasts, reports, and inventory data.

Financial flow:

payments, credit, and settlements between supply chain

participants.

Principles of SCM:

- integration of supply chain participants;
- transparency of information;
- focus on the end consumer;
- optimization of total costs;
- long-term partnerships.

Functional Areas of SCM:

- procurement management;
- production planning;
- inventory management;
- transportation;
- warehouse logistics;
- demand management;
- partner relationship management.

Levels of Integration in SCM:

- internal integration (between company departments);
- interorganizational integration;
- global integration.

Benefits of SCM:

- reduction in overall logistics costs;
- reduction in inventory throughout the supply chain;
- improved service levels;
- faster capital turnover;
- reduced risks.

Risks and challenges of SCM:

- dependence on partners;
- information disruptions;
- fluctuations in demand;
- global risks (crises, wars, pandemics).

3.3. Logistics management models

The *Push model* is a system for managing material flows in which production and product delivery are based on demand forecasts, and products are “pushed” through the supply chain to warehouses and distribution centers.

It is based on the following principle: first, we produce → then

we sell.

How the Push model works:

- a demand forecast is developed;
- a production plan is developed;
- materials are procured;
- products are manufactured;
- products are moved to warehouses;
- from warehouses – to the customer.

This is a typical Make-to-Stock (MTS) system – production “for stock.”

Characteristic features of the Push model:

- focus on forecasting;
- centralized planning;
- large production batches;
- significant safety stock;
- longer logistics cycle.

Impact on logistics flows:

Material flow

- high inventory levels;
- potential overproduction;
- increased warehousing costs.

Information flow

- dependence on forecast accuracy;
- need for planning calculations.

Financial flow

- significant funds tied up in inventory;
- slower capital turnover.

Advantages of the Push model:

- production stability;
- economies of scale;
- ability to plan capacity utilization;
- reduced risk of product shortages.

Disadvantages of the Push Model:

- risk of overproduction;
- high inventory costs;
- tied-up working capital;
- slow response to changes in demand.

When the Push model is appropriate:

- stable demand;
- long product life cycle;
- mass production;
- low product variety.

Examples: food industry, basic consumer goods, construction materials.

The *Pull model* is a system for managing material flows in which production and supply are driven by actual customer demand rather than by forecasts.

The basic principle: order first → then production.

How the pull model works:

1. The customer places an order.
2. The information is sent to the manufacturer.
3. Production of the required quantity of products begins.
4. The products are delivered directly to the customer or to the distribution channel.

This is a typical Make-to-Order (MTO) system – production “on demand.”

Characteristic features of the Pull model:

- focus on actual demand;
- minimal inventory;
- small production batches;
- short production cycles;
- high flexibility;
- use of Kanban signals.

Impact on logistics flows:

Material flow

- reduced inventory;
- lower risk of overproduction;
- more frequent deliveries in small batches.

Information flow

- the speed of information transfer is critical;
- automated management systems;
- supply chain transparency.

Financial flow

- reduction in tied-up capital;
- acceleration of cash turnover;
- improvement in the cash-to-cash ratio.

Advantages of the Pull model:

- minimization of inventory;
- reduction of logistics costs;
- high adaptability to changes in demand;
- lower risk of product write-offs;
- improved capital turnover.

Disadvantages and risks:

- dependence on supplier stability;
- risk of supply disruptions;
- potential production downtime;
- complexity of process coordination.

When the Pull model is appropriate:

- unstable or customized demand;
- short product life cycles;
- high level of competition;
- ability to produce quickly.

Examples: automotive manufacturing, furniture industry, IT equipment, customized products.

The *EOQ (Economic Order Quantity) model* is a classic economic-mathematical model for inventory management that determines the optimal order quantity that minimizes the total costs of inventory storage and order processing.

The economic essence of EOQ

The main idea of the model is to find an order quantity at which:

- inventory holding costs;
- order processing costs are minimized in total.

Cost trade-off:

- large batches → fewer orders, but higher storage costs;
- small batches → lower storage costs, but more orders.

EOQ strikes a balance between these costs.

Optimal Order Quantity Model:

$$EOQ = \sqrt{\frac{2DS}{H}}$$

where:

D – annual demand;

S – order processing cost;

H – unit storage cost.

Key assumptions of the Model:

1. Demand is constant and known.
2. Lead time is constant.
3. Stockouts are not allowed.
4. The unit price does not depend on quantity.
5. Orders are received instantly.

Advantages of EOQ:

- ease of use;
- clear analytical formula;
- cost minimization;
- foundation for modern inventory management systems.

Disadvantages:

- does not account for fluctuations in demand;
- does not account for volume discounts;
- does not account for the risk of supply disruptions;
- limited flexibility.

ABC inventory management model

Based on the Pareto principle:

- A – 20% of items → 80% of value;
- B – middle category;
- C – low-value items.

The economic logic of the model.

The ABC model allows you to:

- focus control on key items;
- differentiate inventory management policies;
- optimize warehouse resources;
- minimize tied-up capital.

Management decisions for different groups:

Group A

- daily monitoring;
- minimal safety stock;
- accurate forecasting;

- use of JIT or MRP.

Group B

- periodic monitoring;
- standard planning methods;
- moderate safety stock.

Group C

- simplified monitoring;
- large purchase batches;
- possible use of EOQ.

Advantages of the ABC model:

- ease of implementation;
- high practical value;
- focus on key resources;
- improved inventory turnover.

Disadvantages:

- does not account for demand stability;
- does not account for the criticality of the production process;
- requires regular data updates.

Questions for discussion

1. What is the essence of the “Total Cost” concept?
2. List the main principles of the Just-in-Time (JIT) concept.
3. What is MRP, and what are its main functions?
4. How does MRP differ from MRP II?
5. What is the purpose of DRP?
6. Explain the essence of Lean Logistics.
7. What is Supply Chain Management (SCM)?
8. What is the difference between the Push and Pull models of logistics management?
9. Under what conditions is it appropriate to use the Push model?
10. In what situations is the Pull model more effective?
11. What are the advantages of the hybrid Push–Pull model?
12. Explain the economic rationale behind the EOQ formula.
13. What factors influence the optimal order quantity?
14. Explain the Pareto principle in ABC analysis.
15. Why does the ABC model require regular review?
16. What risks arise when implementing JIT?
17. Which KPIs are appropriate for evaluating the effectiveness of a logistics model?
18. How does demand volatility affect the choice of a logistics model?
19. What conditions are critical for the successful integration of SCM?
20. How can ABC analysis and EOQ be combined into a single inventory management system?

Practical exercises

Practical exercise 1. Calculating the EOQ (Economic Order Quantity).

The company's annual demand is 12,000 units.

The cost of processing a single order is 500 EUR.

The annual storage cost per unit is 20 EUR.

Requirements:

1. Determine the optimal order quantity (EOQ).
2. Calculate the number of orders per year.

Practical exercise 2. ABC analysis of inventory.

The company has the following inventory items:

Product	Annual Volume (units)	Price (EUR)
A	1,000	500
B	3,000	100
C	5,000	20
D	500	1,000
E	2,000	50

Tasks:

1. Calculate the annual cost of each item.
2. Determine each item's share of the total cost.
3. Classify the products into categories A, B, and C.

Practical exercise 3. Choosing a logistics model (Push or Pull).

The company produces:

1. Standard building materials with predictable demand.
2. Custom-made furniture.

Tasks:

1. Justify the choice of management model (Push or Pull).
2. Explain the risks associated with the chosen approach.

Practical exercise 4. Calculation of total logistics costs (Total Cost).

Data:

- transportation costs – 200,000 EUR;
- warehouse costs – 150,000 EUR;
- storage costs – 100,000 EUR;
- order processing costs – 50,000 EUR.

Requirements:

1. Determine the total logistics costs.
2. Propose ways to optimize these costs.

Practical exercise 5. Analysis of the JIT model.

The company plans to implement the Just-in-Time (JIT) system, which was first introduced by Toyota.

The following is required:

1. Assess the benefits of implementing JIT.
2. Identify potential risks to the company in an unstable market.
3. Propose measures to minimize these risks.

Practical exercise 6. Combining models.

The company has three product groups:

- high-value strategic components;
- mass-market standard products;
- rare spare parts.

The following is required:

1. Propose a combination of models (ABC + EOQ + Push/Pull).
2. Justify the choice for each group.

Test tasks

1. What is the main objective of the “Total Cost” concept?

- a) minimizing transportation costs;
- b) minimizing warehousing costs;
- c) minimizing total logistics costs;
- d) maximizing inventory levels.

2. The Just-in-Time (JIT) concept involves:

- a) building up large safety stocks;
- b) delivering resources exactly when needed;
- c) purchasing materials once a year;
- d) relying exclusively on demand forecasts.

3. The main function of an MRP system is:

- a) planning transportation routes;
- b) planning material requirements;
- c) managing warehouse staff;
- d) analyzing financial statements.

4. The Push model is based on:

- a) an actual customer order;
- b) a demand forecast;
- c) zero inventory;
- d) ABC analysis.

5. The Pull model involves:

- a) production “for inventory”;
- b) production based on forecasts;
- c) starting production after receiving an order;
- d) building up excess inventory.

6. The EOQ formula is used to determine:

- a) the optimal delivery route;
- b) the optimal order quantity;
- c) the service level;
- d) the break-even point.

7. In ABC analysis, category A includes:

- a) items with the lowest value;
- b) items of medium value;
- c) items that account for the largest share of inventory value;
- d) all of the company's items.

8. Lean Logistics aims to:

- a) increase inventory;
- b) eliminate waste in logistics processes;
- c) maximize order fulfillment time;
- d) increase the number of suppliers.

9. SCM (Supply Chain Management) involves:

- a) managing only warehouse operations;
- b) coordinating all participants in the supply chain;
- c) managing exclusively financial flows;
- d) optimizing only transportation costs.

10. The hybrid push-pull model is characterized by:

- a) a complete lack of forecasting;
- b) the use of JIT alone;
- c) a combination of forecasting and responding to actual demand;
- d) a focus exclusively on inventory.

4.1. Material flows

4.2. Information flows

4.3. Financial flow

4.4. Integration of flows and indicators in the logistics system of enterprise

4.1. Material flows

Material flow is the movement of raw materials, components, semi-finished goods, and finished products throughout the supply chain, from suppliers to manufacturers, warehouses, distribution centers, retailers, and finally to customers. It is one of the core elements of logistics, ensuring that the right products are delivered to the right place, at the right time, in the right quantity, and at the lowest possible cost.

The material flow begins with the procurement of raw materials from suppliers. These materials are transported to manufacturing facilities, where they are transformed into finished products. After production, the products are stored in warehouses or distribution centers until customer orders are received. The goods are then picked, packed, and transported to retailers or directly to end customers. In some cases, material flow also includes reverse logistics, where returned products, recyclable materials, or defective goods are transported back for repair, recycling, or disposal.

The primary objectives of material flow management are to reduce transportation and storage costs, improve inventory turnover, shorten order fulfillment time, and increase customer satisfaction. Companies also aim to eliminate unnecessary movements, reduce waste, and ensure a continuous flow of materials throughout the supply chain. Concepts such as Just-in-Time (JIT), Lean Logistics, and Supply Chain Management (SCM) support these objectives by

synchronizing production, inventory, and transportation activities.

Effective material flow provides numerous benefits, including lower operating costs, improved resource utilization, higher inventory accuracy, better production planning, and faster response to customer demand. It also enhances supply chain flexibility, allowing organizations to adapt quickly to market changes, seasonal demand, and unexpected disruptions.

In today's global business environment, efficient material flow has become a key competitive advantage. Companies that successfully manage the movement of materials through integrated logistics systems can improve operational efficiency, strengthen supply chain resilience, and deliver superior customer service while maintaining sustainable and cost-effective logistics operations.

4.2. Information flows

Information flow in logistics refers to the movement, exchange, and management of data that supports the planning, execution, and control of logistics activities throughout the supply chain. It connects suppliers, manufacturers, warehouses, transportation providers, distributors, retailers, and customers by providing accurate and timely information needed for decision-making. Effective information flow is essential for ensuring that material and financial flows operate efficiently and that supply chain partners remain well coordinated.

Types of information flows:

- proactive (orders, forecasts);
- supporting (invoices, certificates);
- reactive (reports, complaints).

Requirements for information flows:

- accuracy;
- timeliness;
- completeness;
- efficiency.

Information flows begin with customer demand and continue throughout every stage of the supply chain. Customer orders, inventory levels, production schedules, transportation plans, warehouse operations, delivery status, and financial transactions are

continuously exchanged among supply chain participants. This information enables companies to forecast demand, plan procurement, schedule production, manage inventory, optimize transportation, and monitor order fulfillment in real time.

The main objectives of information flow management are to improve communication, increase supply chain visibility, reduce uncertainty, support faster decision-making, and enhance coordination among logistics partners. Accurate information helps organizations avoid inventory shortages, reduce excess stock, improve transportation planning, and respond quickly to disruptions or changing customer demand.

Efficient information flows provide numerous benefits, including improved inventory accuracy, faster order processing, better demand forecasting, lower operating costs, and higher customer satisfaction. Real-time access to logistics information also enables managers to monitor key performance indicators, identify operational problems, and implement corrective actions before they affect customer service.

In today's digital economy, information has become one of the most valuable resources in logistics. Companies that effectively manage information flows through integrated digital systems can build more transparent, agile, and resilient supply chains. By ensuring that the right information reaches the right people at the right time, organizations can improve operational efficiency, strengthen collaboration with supply chain partners, and gain a sustainable competitive advantage in the global marketplace.

4.3. Financial flow

Financial flow in logistics refers to the movement and management of money associated with the flow of goods and services throughout the supply chain. It includes all financial transactions between suppliers, manufacturers, logistics providers, distributors, retailers, and customers. Financial flow ensures that payments, invoices, transportation costs, inventory expenses, customs duties, taxes, and other logistics-related costs are accurately managed and coordinated with material and information flows.

Financial flow categories:

- prepayments to suppliers;
- transportation costs;
- storage costs;
- receipts from customers.

Financial flow begins when a customer places an order and continues through every stage of the supply chain. Companies purchase raw materials from suppliers, pay transportation providers for freight services, finance warehouse operations, and receive payments from customers after products are delivered. These financial transactions support the continuous movement of goods while ensuring that every participant in the supply chain is compensated for the value they provide.

Effective management of financial flow requires accurate planning, monitoring, and control of logistics costs. Major components include procurement costs, transportation expenses, warehousing costs, inventory holding costs, packaging costs, insurance, customs duties, taxes, and payment processing. Organizations continuously analyze these costs to improve profitability while maintaining high levels of customer service.

The primary objectives of financial flow management are to minimize logistics costs, improve cash flow, optimize working capital, accelerate payment processing, and support informed financial decision-making. Effective financial management enables companies to negotiate better supplier contracts, optimize transportation expenditures, reduce inventory carrying costs, and improve overall supply chain profitability.

Efficient financial flows provide significant benefits, including lower operating costs, improved cash management, faster invoice processing, greater financial transparency, and stronger relationships with suppliers and customers. They also enable organizations to monitor logistics performance, evaluate investment decisions, and respond more effectively to market changes and economic uncertainty.

Key ratios:

1. Inventory turnover:

$$K_{\text{turnover}} = \text{Sales} / \text{Average inventory}$$

2. Inventory turnover period:

$$T = 365 / K_{\text{turnover}}$$

In today's global business environment, financial flow is a critical component of integrated logistics management. When financial, material, and information flows are effectively coordinated, organizations can achieve greater operational efficiency, enhance supply chain resilience, improve profitability, and maintain a sustainable competitive advantage in increasingly complex global markets.

4.4. Integration of flows and indicators in the logistics system of enterprise

A logistics system is effective only when these three flows are coordinated. Interrelationships:

- the material flow initiates the financial flow;
- the information flow coordinates the material flow;
- the financial flow provides resource support.

A mismatch in these flows leads to:

- excess inventory;
- cash flow gaps;
- delivery delays;
- rising costs.

Logistics management performance metrics:

- service level (%);
- order fulfillment rate;
- logistics cycle time;
- inventory turnover;
- share of logistics costs in cost of goods sold;
- cash-to-cash cycle = DIO + DSO – DPO:

DIO (Days of Inventory Outstanding): Average inventory / (COGS / 365).

DSO (Days Sales Outstanding): Average accounts receivable / (Total sales / 365).

DPO (Days Payable Outstanding): Average Accounts Payable / (COGS / 365).

Questions for discussion

1. Define a material flow and list its main parameters.
2. What stages does a material flow go through in a company's logistics system?
3. Define an information flow and describe its types.
4. What requirements are placed on information flows in logistics?
5. What is a financial flow in a logistics system?
6. What indicators characterize the efficiency of financial flows?
7. Explain the relationship between material, information, and financial flows.
8. What is the integration of flows within a logistics system?
9. What consequences can arise from a lack of coordination between material and information flows?
10. How does the speed of information processing affect the efficiency of the material flow?
11. Why is optimizing total logistics costs more important than minimizing the costs of individual departments?
12. How does inventory turnover affect a company's financial condition?
13. What risks arise when minimizing inventory?
14. What components make up a company's total logistics costs?
15. What metrics should be analyzed to evaluate the effectiveness of a logistics system?
16. What measures can be proposed to synchronize flows within a company?

Practical exercises

Practical exercise 1. Calculating material flow rate.

A company ships 2,400 units of product in 8 hours.

Determine:

1. The material flow rate.
2. How the flow rate will change if the time is reduced to 6 hours.

Practical exercise 2. Inventory Turnover.

The cost of goods sold for the year is 3,600,000 EUR.

The company's average inventory is 600,000 EUR.

Tasks:

1. Calculate the inventory turnover ratio.
2. Determine the inventory turnover period (in days).

Practical exercise 3. Analysis of the cash-to-cash cycle.

Company data:

- inventory turnover period – 40 days;
- accounts receivable collection period – 30 days;
- accounts payable payment period – 25 days.

Tasks:

1. Calculate the cash-to-cash cycle.
2. Analyze the financial implications of the result.

Practical exercise 4. Synchronizing flows.

The company has:

- excess inventory;
- delivery delays;
- frequent cash flow gaps.

The following is required:

1. Identify which flow is operating inefficiently (material, information, or financial).
2. Propose a set of measures to synchronize the flows.

Practical exercise 5. Optimizing the logistics cycle.

The logistics cycle time consists of:

- order processing – 2 days;
- production – 5 days;
- transportation – 4 days;
- warehousing – 3 days.

Tasks:

1. Determine the total logistics cycle.
2. Propose ways to shorten it.
3. Assess the impact of shortening the cycle on cash flow.

Practical exercise 6. Excess inventory and “frozen” funds.

A furniture manufacturing company has increased its purchases of raw materials by 25% over the past year. At the same time:

- sales volume increased by only 5%;
- average inventory levels increased by 40%;
- inventory turnover decreased from 8 to 5 turns per year;
- cash flow gaps have emerged.

The finance department accuses the purchasing department of “overstocking” the warehouse.

Tasks:

1. Which flow is operating inefficiently?
2. What is the cause of the imbalance?
3. How should the inventory management policy be changed?
4. Which metrics should be monitored monthly?
5. Propose a set of measures to synchronize the flows.

Practical exercise 7. Cash-to-cash.

The company has the following metrics:

- DIO – 55 days; DSO – 45 days; DPO – 30 days.

Management is concerned about a shortage of working capital.

Tasks:

1. Calculate the cash-to-cash cycle.
2. Explain the financial implications of this metric.
3. Suggest ways to shorten the cycle.
4. Which cash flow requires priority adjustment?

Test tasks

1. The logistics approach involves:

- a) managing only physical inventory;
- b) optimizing warehouse operations;
- c) integrated management of physical, information, and financial flows;
- d) minimizing transportation costs.

2. The intensity of a material flow is defined as:

- a) the ratio of time to volume;
- b) the volume of output divided by time;
- c) the product of time and volume;
- d) the difference between demand and inventory.

3. The parameters of the material flow include:

- a) quality of information;
- b) return on sales;
- c) volume, speed, and intensity;
- d) the company's liquidity.

4. The flow of information in logistics serves the following purpose:

- a) solely to control costs;
- b) to coordinate material flows;
- c) to increase inventory;
- d) to generate profit.

5. The inventory turnover ratio is calculated as:

- a) average inventory / cost of goods sold;
- b) 365 / average inventory;
- c) cost of goods sold / average inventory;
- d) profit / inventory;

6. The JIT concept is aimed at:

- a) increasing safety stock;
- b) delivering materials exactly when needed;
- c) accumulating products in the warehouse;
- d) minimizing information flows.

7. The cash-to-cash cycle metric characterizes:

- a) the time between paying suppliers and receiving payment from customers;
- b) the duration of transportation;
- c) the profitability of products;
- d) the speed of information processing.

8. Total logistics costs include:

- a) transportation costs only;
- b) warehousing costs only;
- c) transportation, warehousing, inventory, and information costs;
- d) production costs only.

9. A mismatch between physical and information flows leads to:

- a) increase in inventory turnover;
- b) reduction in costs;
- c) delivery delays and excess inventory;
- d) increase in profit.

10. The main goal of integrating flows is to:

- a) minimize the costs of an individual department;
- b) maximize production inventory;
- c) ensure coordination and improve the efficiency of the entire logistics system;
- d) increase the number of suppliers.

5.1. The role of logistics in the competitive advantage system

5.2. Logistical factors influencing competitiveness

5.3. Logistics strategies and their impact on a company's market position

5.1. The role of logistics in the competitive advantage system

In today's economy, competition takes place not between individual companies, but between supply chains. Logistics is evolving from a support function into a strategic factor in value creation.

The concept of the value chain was proposed by Michael Porter. He identified primary and support activities, among which logistics (inbound and outbound) plays a key role in creating added value.

Logistics ensures:

- cost reduction;
- faster capital turnover;
- a high level of service;
- increased customer loyalty.

One of the primary ways logistics contributes to competitive advantage is through cost leadership. Effective management of transportation, warehousing, inventory, and procurement reduces total logistics costs. Companies that optimize their supply chains can minimize waste, improve resource utilization, and lower production and distribution expenses. These savings can be transferred to customers through lower prices or reinvested in innovation and business development.

Logistics also supports differentiation strategies by providing superior customer service. Fast order processing, accurate deliveries, flexible shipping options, and reliable product availability enhance customer satisfaction and loyalty. Businesses that consistently deliver products on time and in perfect condition build a strong

reputation and gain an advantage over competitors. Modern logistics systems also enable customized services, allowing companies to respond quickly to changing customer demands.

Another important aspect is time-based competition. Speed has become a critical competitive factor in many industries. Efficient logistics reduces order cycle time, shortens lead times, and enables rapid response to market changes. Technologies such as real-time tracking, warehouse automation, predictive analytics, and artificial intelligence help companies improve visibility across the supply chain and make faster, data-driven decisions.

Logistics is a strategic function that creates value throughout the entire supply chain. By reducing costs, improving service quality, increasing operational flexibility, supporting digital innovation, and promoting sustainability, logistics strengthens a company's competitive position. Organizations that effectively manage their logistics systems are better equipped to respond to market changes, satisfy customer needs, and achieve long-term competitive advantage in both domestic and global markets.

5.2. Logistical factors influencing competitiveness

A company's competitiveness is shaped by a number of logistical factors.

Order fulfillment speed

Order cycle time includes:

- order processing;
- picking;
- transportation;
- delivery.

Reducing this time increases customer satisfaction and capital turnover.

Delivery reliability

The OTIF (On Time in Full) metric demonstrates the rate at which orders are fulfilled without delays or errors.

Level of logistics costs

Logistics costs can account for 10–30% of the cost of goods sold. Optimizing them creates a pricing advantage.

System flexibility

Flexibility means the ability to respond quickly to:

- fluctuations in demand;
- supply disruptions;
- crisis situations.

Information integration

The digitization of logistics enables:

- real-time tracking of shipments;
- demand forecasting;
- automated inventory management.

5.3. Logistics strategies and their impact on a company's market position

Logistics strategies are long-term plans that guide how organizations manage the flow of materials, information, and financial resources throughout the supply chain. A well-designed logistics strategy enables companies to improve operational efficiency, reduce costs, enhance customer satisfaction, and strengthen their competitive position. As markets become increasingly global and customer expectations continue to rise, logistics has become a strategic function that directly influences business success.

One of the most widely used logistics strategies is the *cost minimization strategy*, which focuses on reducing transportation, warehousing, inventory, and distribution expenses. Companies achieve this through route optimization, warehouse automation, efficient inventory management, and economies of scale. Lower logistics costs enable businesses to offer competitive prices, improve profitability, and increase their market share.

Another important approach is the *customer service strategy*, which prioritizes fast, reliable, and flexible deliveries. Businesses implementing this strategy invest in efficient order processing, real-time shipment tracking, accurate inventory management, and responsive customer support. High service quality improves customer satisfaction and loyalty, strengthens brand reputation, and creates a sustainable competitive advantage in highly competitive markets.

The *time-based strategy* emphasizes speed throughout the supply chain. Companies seek to reduce order cycle times, shorten lead times, and accelerate product delivery. This strategy is especially valuable in industries such as e-commerce, fashion, healthcare, and electronics, where rapid response to customer demand is essential. Faster logistics operations enable organizations to react quickly to market changes and outperform slower competitors.

A growing number of organizations implement *flexibility and agility strategies*. Agile logistics systems allow companies to adapt rapidly to fluctuations in customer demand, supply chain disruptions, and changing market conditions. Flexible transportation options, multiple sourcing strategies, digital supply chain visibility, and responsive inventory management help organizations maintain business continuity while reducing operational risks.

Many companies also adopt *green logistics strategies*, integrating environmental sustainability into their logistics operations. These strategies include optimizing transportation routes, reducing fuel consumption, using environmentally friendly packaging, increasing recycling, and lowering greenhouse gas emissions. Sustainable logistics not only reduces environmental impact but also enhances corporate reputation, meets regulatory requirements, and attracts environmentally conscious customers and investors.

Questions for discussion

1. What is the role of logistics in creating a company's competitive advantages?
2. How does logistics influence the creation of added value according to Michael Porter's concept?
3. How does operational logistics differ from strategic logistics?
4. What are the main logistics factors that influence a company's competitiveness?
5. Can a company be competitive without effective logistics in the context of globalization?
6. Which logistics strategy is more effective: cost minimization or service differentiation?
7. Can logistics create unique competitive advantages that are difficult to replicate?
8. How does the instability of transportation infrastructure affect companies' competitiveness?
9. How does the OTIF metric characterize the level of service?
10. How does inventory level affect a company's financial results?
11. Why is the flexibility of a logistics system important in an unstable market?
12. What factors should be considered when choosing a logistics strategy?
13. What is cross-docking, and what are its advantages?
14. What are the advantages and disadvantages of logistics outsourcing (3PL)?
15. What metrics characterize the level of logistics service?
16. Why is it important to analyze the share of logistics costs in the cost structure?
17. How is the digitization of logistics changing the competitive environment?
18. What logistics factors are most critical for companies under martial law?

Practical exercises

Practical exercise 1. Selecting a logistics strategy.

The company operates in the highly competitive FMCG market.

Characteristics:

- high level of competition;
- price-sensitive customers;
- frequent changes in demand;
- high storage costs.

Tasks:

1. Justify the choice of a logistics strategy (cost minimization, differentiation, integrated SCM, Lean).
2. Identify the main logistics risks.
3. Propose a KPI system.

Practical exercise 2. Implementation of JIT.

Manufacturing company plans to implement a JIT system.

Tasks:

1. Identify the conditions for successful implementation.
2. Assess potential risks (supply disruptions, market volatility).
3. Analyze the impact on competitiveness indicators (by type of company resource).

Practical exercise 3. Logistics outsourcing (3PL).

The company is considering outsourcing its transportation operations to a third-party company.

Tasks:

1. Define the criteria for selecting a 3PL partner.
2. Justify the expected economic benefits and efficiency gains.
3. Analyze the risks of losing control.

Practical exercise 4. Route optimization.

The company makes deliveries to 10 retail locations.

Total mileage is 480 km per day.

Tasks:

1. Propose an approach to route optimization.
2. Assess the impact of reducing mileage on costs.
3. Identify additional competitive advantages.

Practical exercise 5. Company facing instability.

The company is operating amid supply disruptions and rising transportation costs.

Tasks:

1. Propose a crisis-response logistics strategy.
2. Identify short-term and long-term solutions.
3. Develop a system of metrics to monitor effectiveness.

Test tasks

1. A company's logistics are aimed at:

- a) maximizing production volumes;
- b) optimizing material and information flows;
- c) increasing the number of employees;
- d) minimizing marketing expenses.

2. According to Michael Porter's concept, logistics is:

- a) support function;
- b) core activity that creates value;
- c) form of management control;
- d) marketing tool.

3. OTIF metric refers to:

- a) transportation costs;
- b) on-time and complete order fulfillment;
- c) inventory turnover;
- d) warehouse utilization rate.

4. Cost-minimization strategy involves:

- a) increasing inventory levels;
- b) optimizing routes and reducing logistics costs;
- c) expanding the warehouse network without analyzing costs;
- d) increasing delivery times.

5. The Just-in-Time (JIT) concept involves:

- a) building up large safety stocks;
- b) delivering resources exactly when they are needed;
- c) centralizing marketing activities;
- d) reducing the product range.

6. *Cross-docking allows you to:*

- a) extend the shelf life of goods;
- b) minimize warehousing costs through rapid transshipment;
- c) increase production inventory levels;
- d) reduce the number of suppliers.

7. *Inventory turnover characterizes:*

- a) the number of the company's warehouses;
- b) the rate at which inventory is replenished;
- c) the level of transportation costs;
- d) the number of the company's customers.

8. *Lean logistics aims to:*

- a) increase production inventory;
- b) eliminate waste in logistics processes;
- c) centralize finances;
- d) expand warehouse staff.

9. *An integrated SCM strategy involves:*

- a) isolated transportation management;
- b) coordination of all supply chain participants;
- c) minimizing information systems;
- d) avoiding digitalization.

10. *Logistics performance indicators include:*

- a) return on advertising;
- b) the proportion of logistics costs in total revenue;
- c) the percentage of administrative staff;
- d) the average length of service of employees.

MODULE 2. FUNCTIONAL AREAS OF LOGISTICS

Chapter 6

PROCUREMENT LOGISTICS

6.1. Concepts, role, goals and objectives of procurement logistics

6.2. Classification and the procurement process

6.3. Methods and tools for procurement optimization

6.1. Concepts, role, goals and objectives of procurement logistics

Procurement logistics is a key component of supply chain management that focuses on planning, organizing, and controlling the flow of materials, components, and services from suppliers to the organization. Its primary purpose is to ensure that the right materials are delivered in the right quantity, at the right quality, to the right place, at the right time, and at the lowest possible total cost. Procurement logistics serves as the link between suppliers and production or business operations, ensuring the uninterrupted availability of resources needed for organizational success.

The concept of procurement logistics extends beyond the simple purchasing of goods. It includes supplier selection, demand forecasting, purchasing, transportation planning, inventory management, receiving, quality inspection, and coordination of information and financial flows. Modern procurement logistics emphasizes strategic supplier relationships, digital procurement systems, risk management, and sustainability.

The role of procurement logistics is vital because it directly influences production continuity, product quality, customer satisfaction, and overall business profitability. Efficient procurement logistics reduces procurement costs, minimizes production delays caused by material shortages, and improves coordination between suppliers and internal departments. It also supports long-term partnerships with reliable suppliers, ensuring stable supply even during periods of market uncertainty or supply chain disruptions.

The primary goal of procurement logistics is to provide the organization with the required resources while minimizing the total cost of procurement and maintaining the desired level of service. Rather than focusing solely on obtaining the lowest purchase price, procurement logistics seeks to optimize the total cost of ownership, including transportation, storage, handling, inventory carrying costs, and supplier performance. Achieving this balance enables companies to remain competitive while maintaining operational efficiency.

The main objectives of procurement logistics include accurate forecasting of material requirements, selecting qualified and reliable suppliers, negotiating favorable purchasing contracts, maintaining optimal inventory levels, ensuring timely deliveries, and monitoring supplier performance. Additional objectives include reducing procurement lead times, minimizing inventory holding costs, improving product quality, enhancing supply chain visibility, and ensuring compliance with legal, ethical, and environmental standards.

6.2. Classification and the procurement process

Procurement can be classified according to various criteria:

Criterion	Types of procurement	Characteristics
By purpose	Raw materials, materials, components, finished goods	For production or sale
By frequency	Regular, one-time, seasonal	Frequency of purchases
By volume	Bulk, batch, small-scale	Volume of delivery
By strategic importance	Strategic, routine, critical	Impact on the business

The procurement process consists of several interconnected stages. The first stage is “Identification of needs”, where departments determine the quantity and specifications of required materials or services. Accurate demand forecasting helps prevent shortages and excessive inventory.

The second stage is “Supplier search and evaluation”. Potential suppliers are identified and assessed based on criteria such as price,

product quality, delivery performance, financial stability, production capacity, sustainability practices, and reputation. Organizations often use supplier scorecards and qualification systems to compare alternatives.

The third stage involves “Requesting quotations and negotiating contracts”. Procurement specialists invite suppliers to submit bids or proposals and negotiate prices, payment terms, delivery schedules, warranties, and service conditions. The objective is to achieve the best overall value rather than simply the lowest purchase price.

Once an agreement is reached, the organization issues a “Purchase order”, which formally authorizes the supplier to deliver the required goods or services. The supplier then prepares and ships the order according to the agreed schedule.

Upon delivery, the receiving department performs “Inspection and quality control” to verify that the goods meet the required quantity, quality, and specifications. Any discrepancies or defects are reported and resolved with the supplier before acceptance.

The final stage is “Payment and supplier performance evaluation”. After successful inspection, invoices are processed, and payments are made according to the contract. Organizations continuously evaluate supplier performance using indicators such as delivery reliability, product quality, responsiveness, and cost efficiency. This information supports future procurement decisions and helps build long-term supplier relationships.

6.3. Methods and tools for procurement optimization

VMI (Vendor Managed Inventory) – the supplier manages inventory. VMI is an inventory management system in which the supplier independently controls inventory levels at the customer’s warehouse or points of sale. The supplier is responsible for replenishing inventory based on actual consumption. The customer receives materials or goods automatically, without having to plan each order on an ongoing basis (Figure 6.1).

The goals of VMI:

- to reduce the risk of stockouts;
- to optimize storage and procurement costs;
- to improve supply chain efficiency.

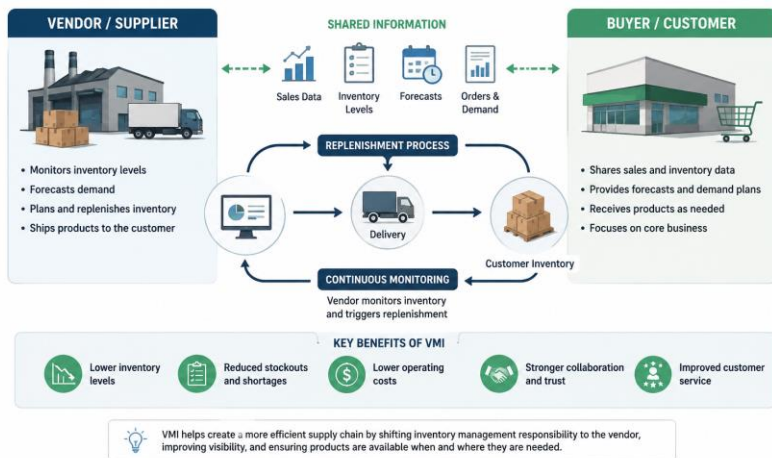


Figure 6.1. VMI (Vendor Managed Inventory)

How VMI works:

1. The customer provides the supplier with access to inventory and sales data (via an ERP system or a dedicated platform).
2. The supplier analyzes the data and determines the optimal delivery schedule and volume.
3. The supplier handles delivery independently, maintaining the required inventory level.
4. The customer monitors only the result – ensuring sufficient product availability.

Benefits of VMI:

- reduced costs for the customer: less manual work, less downtime due to shortages;
- inventory optimization: the supplier knows actual consumption and can plan deliveries more accurately;
- improved customer service: reduced risk of stockouts;
- close collaboration with the supplier (strategic partnerships).

Drawbacks and risks:

- dependence on the supplier: risk of shortages if the supplier fails to meet its targets;
- need for accurate consumption data and an accounting system;
- potential increase in costs for the supplier, which could affect the price.

E-procurement systems – automation of the procurement process. E-procurement refers to digital platforms and software solutions that automate the procurement process, from planning needs to paying suppliers. They integrate data on inventory, orders, budgets, and suppliers. They allow you to manage the entire procurement chain online.

The goals of e-procurement systems:

- to reduce manual work and paperwork;
- to optimize procurement and inventory management processes;
- to increase transparency and cost efficiency.

Key functions of e-procurement:

1. Procurement planning – automatic generation of purchase requests based on production or sales needs.
2. Supplier search and evaluation – comparison of prices, delivery times, and supplier ratings.
3. Order placement and tracking – online ordering, delivery status tracking, and schedule changes.
4. Electronic auctions and tenders – conducting competitions and auctions among suppliers.
5. Budget and expense control – automated expense analysis, report generation, and procurement KPIs.
6. Integration with ERP and warehouse systems – synchronization with company inventory and financial data.

Benefits of e-procurement:

- cost reduction – automation cuts administrative costs and minimizes errors;
- process transparency – all stages of the procurement process are tracked within the system;
- speed and efficiency – reduced time spent on order processing;
- analytics and forecasting – the system generates reports and helps plan purchases;
- risk reduction – monitoring of delivery times and suppliers.

Inventory management in procurement:

- minimizing storage costs;
- determining the safety stock and reorder point.

Safety stock is an additional supply of materials or goods held in inventory to protect against unpredictable fluctuations in demand or delivery delays.

Objectives:

- prevent material shortages;
- ensure continuity of production or sales;
- reduce the risk of downtime due to force majeure.

Factors in determining safety stock:

1. Demand variability (unstable or seasonal demand).
2. Supplier reliability and delivery times.
3. Cost of shortage (lost profits or production stoppages).

Reorder Point (ROP) is the inventory level at which a new order should be placed so that the replenishment arrives before inventory runs out.

Formula for calculating ROP:

$$\text{ROP} = (\text{Average Daily Demand} \times \text{Lead Time}) + \text{Safety Stock}$$

Kanban is a method of visual control and management of material and production flows that ensures “just-in-time” delivery and inventory optimization. It originates from the Toyota Production System. It uses signals (cards, labels, electronic signals) to trigger the restocking process (Figure 6.2).

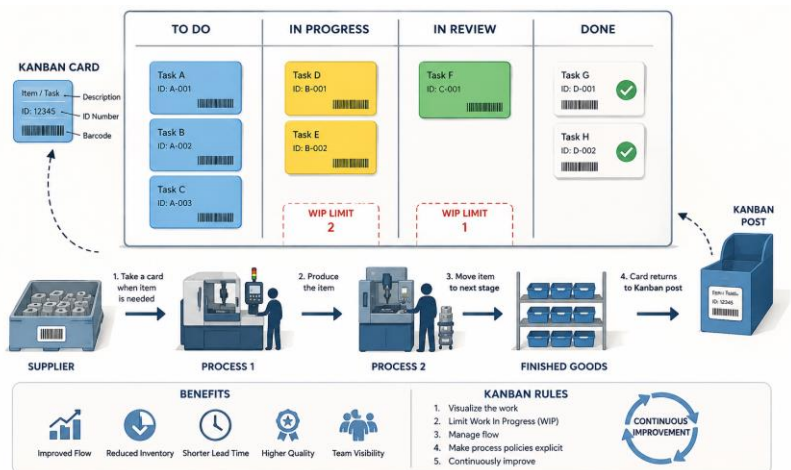


Figure 6.2. Kanban

Objectives:

- minimize excess inventory;
- increase production flexibility;
- ensure a continuous flow of materials and products.

How Kanban works:

1. Visual signals (Kanban cards) – each batch of materials or components has a card that signals the need for replenishment.
2. Replenishment only after a signal – materials are ordered only when the existing inventory has been used up.
3. Continuous flow – Kanban allows production and supply to operate as a single cycle.
4. Inventory limits – the maximum number of units is determined in advance to avoid excess inventory.

Advantages of Kanban:

- reduced inventory and storage costs;
- increased production flexibility and responsiveness to demand;
- visual control – it's easy to track the status of inventory and processes;
- improved efficiency and transparency in cross-departmental collaboration.

Disadvantages and risks:

- requires clear process organization and employee discipline.
- not suitable for situations with unstable or unpredictable demand unless there are additional safety stocks.
- dependence on the accuracy of signals – delays or errors in the cards can lead to shortages.

Questions for discussion

1. What is procurement logistics, and what is its role in a company's logistics system?
2. What are the main objectives of procurement logistics?
3. List the main tasks of procurement logistics within a company.
4. What factors influence a company's demand for material resources?
5. By what criteria are purchases classified?
6. What stages does the procurement process include?
7. What sources of information are used to find suppliers?
8. List the main criteria for selecting suppliers.
9. What methods of supplier evaluation are used in modern logistics?
10. What are the advantages and disadvantages of the Just-in-Time system in procurement logistics?
11. What are the reorder point and safety stock?
12. What costs arise in the procurement process?
13. What role do information systems (ERP, SCM) play in procurement logistics?
14. What are the main risks involved in a company's procurement activities?
15. What risk minimization methods are used in procurement logistics?
16. How is procurement logistics related to production and distribution logistics?
17. What are the current trends in the development of procurement logistics in the context of the digital economy?

Practical exercises

Practical exercise 1. Procurement planning.

A company plans to produce 1,000 units per month. To produce one unit, the following are required:

- raw material A – 2 kg;
- raw material B – 3 kg.

Suppliers offer the following prices:

- raw material A – 50 EUR/kg;
- raw material B – 40 EUR/kg.

Tasks:

1. Calculate the monthly demand for materials.
2. Determine the total cost of purchasing materials.
3. Justify the optimal order quantity, taking into account potential savings from ordering in bulk.

Practical exercise 2. Selecting a supplier.

The company is considering three suppliers of raw materials:

Supplier	Price per kg (EUR)	Delivery time (days)	Reliability (%)
X	45	5	90
Y	42	10	70
Z	48	3	95

Tasks:

1. Select the best supplier, taking into account a balance of price, delivery times, and reliability.
2. Explain your choice.

Practical exercise 3. Inventory management.

The company uses material at an average rate of 100 kg per day. Delivery time is 5 days. The safety stock is 200 kg.

Tasks:

1. Calculate the reorder point.
2. Determine the minimum and maximum inventory levels, given that the maximum order quantity is 1,000 kg.

Practical exercise 4. Procurement risks.

A raw materials supplier is delaying delivery due to force majeure. The company risks having to halt production.

Tasks:

1. Identify the type of procurement logistics risk.
2. Suggest three ways to minimize this risk.

Practical exercise 5. The Impact of digital technologies.

A company plans to implement an ERP system for procurement and inventory management.

Tasks:

1. Describe which stages of procurement process can be automated.
2. Give an example of how analytics can help forecast material needs.

Practical exercise 6. Scenario: “Negotiations with a supplier”.

The supplier is offering a 5% discount for orders over 10,000 kg, but the delivery time will be extended by 2 weeks.

Tasks:

1. Analyze whether this offer is beneficial for the company.
2. Prepare arguments for negotiations regarding the optimal price and delivery terms.

Practical exercise 7. Comparison of alternatives.

A company can purchase materials locally (expensive, fast) or import them (cheaper, longer).

Tasks:

1. Create a table comparing costs and risks.
2. Develop a recommendation for a procurement strategy.

Practical exercise 8. Preparing a purchasing plan.

You are a purchasing manager for one month. You need to ensure the production of 500 units of a product using three types of raw materials.

Tasks:

1. Develop a procurement plan taking into account the EOQ and safety stock.
2. Justify the order intervals and the quantity of each batch.

Test tasks

1. What is the main objective of procurement logistics?

- a) maximizing sales profit;
- b) ensuring uninterrupted production at minimal cost;
- c) controlling the quality of finished products;
- d) increasing inventory levels.

2. Which of the following is NOT part of the procurement process?

- a) determining material needs;
- b) entering into contracts with suppliers;
- c) manufacturing finished products;
- d) monitoring delivery performance.

3. Which of the following is a criterion for selecting a supplier?

- a) cost and payment terms;
- b) number of employees at the company;
- c) office size;
- d) presence of a corporate logo;

4. Which method helps determine the economic order quantity?

- a) ABC analysis;
- b) EOQ;
- c) VMI;
- d) JIT.

5. Which procurement method involves the supplier managing the company's inventory?

- a) Just-in-Time;
- b) EOQ;
- c) VMI;
- d) ABC analysis.

6. What is a “safety stock” in procurement logistics?

- a) the minimum quantity of products needed to maintain production;
- b) the maximum warehouse capacity;
- c) the amount of money allocated for purchases;
- d) the quantity of goods ordered from a supplier;

7. Which of the following procurement logistics risks is associated with delivery delays?

- a) financial;
- b) operational;
- c) legal;
- d) reputational.

8. Which tool allows you to classify goods by importance and purchase volume?

- a) EOQ;
- b) ABC analysis;
- c) VMI;
- d) Kanban.

9. What is the advantage of the Just-in-Time system in procurement logistics?

- a) reduced inventory and storage costs
- b) increased safety stock
- c) increased number of suppliers
- d) automation of supplier evaluation

10. How do digital technologies affect procurement logistics?

- a) they enable demand forecasting and automate procurement;
- b) they increase manual labor in the warehouse;
- c) they reduce the quality of materials;
- d) they do not affect the procurement process.

7.1. The nature and significance, objectives, and functions of production logistics

7.2. Logistics flows in an enterprise's production system and the organization of production processes in the logistics system

7.3. Logistics tools for production optimization and performance indicators for production logistics

7.1. The nature and significance, objectives, and functions of production logistics

Production logistics is a subsystem of a company's logistics that ensures the effective planning, organization, and management of material flows during the production process.

Its main objectives are:

- synchronizing production processes;
- shortening the production cycle;
- minimizing inventory;
- improving resource efficiency.

Production logistics ensures the continuous flow of materials, semi-finished products, and components between production units.

Key characteristics of production logistics:

1. Focus on flows, not just functions.
2. Integration of production with procurement and sales.
3. Ensuring the synchronization of operations.
4. Reducing production costs.

The main tasks of production logistics include:

1. Production planning

Determining production volumes and the optimal use of resources.

2. Material flow management

Organizing the movement of:

- raw materials;
- components;
- semi-finished products;

- finished products.

3. Shortening the production cycle

Production logistics aims to minimize the time between receiving raw materials and releasing the finished product.

4. Inventory optimization

Inventory control:

- raw materials;
- work in progress;
- finished goods.

5. Coordination of Production Processes

Ensuring coordination between:

- departments;
- equipment;
- personnel.

7.2. Logistics flows in an enterprise's production system and the organization of production processes in the logistics system

Several types of flows exist in production logistics.

Material flow – the movement of materials in the production process.

Example: raw materials → processing → assembly → quality control → finished products.

Information flow – the transfer of information regarding:

- orders;
- production plans;
- inventory;
- production operations.

Financial flow – the movement of funds related to:

- purchases;
- labor costs;
- production costs.

Service flow – support for production:

- equipment maintenance;
- logistics services;
- repairs.

The organization of production processes determines the efficiency of logistics.

Main types of production:

1. *Custom manufacturing* – the production of individual items.

Example:

- shipbuilding;
- construction.

2. *Batch production* – the production of goods in batches.

Example:

- machine building;
- furniture manufacturing.

3. *Mass production* – production of large quantities of identical products.

Example:

- automotive manufacturing;
- electronics.

7.3. Logistics tools for production optimization and performance indicators for production logistics

MES (Manufacturing Execution System) is a system for managing manufacturing operations in real time.

It provides a link between manufacturing equipment, personnel, and the company's information systems, such as ERP and MRP.

The main goal of MES is to monitor and optimize manufacturing processes in real time, thereby improving production efficiency and product quality.

MES performs several key functions:

1. Monitoring of production processes – tracking the status of equipment and the progress of production in real time.

2. Production order management – monitoring the execution of production tasks according to the plan.

3. Materials and resources management – tracking the availability of materials, components, and tools.

4. Quality control – recording quality parameters at every stage of production.

5. Data collection and analysis – automatically generating statistics on equipment, production cycles, scrap, and productivity.

6. Integration with ERP/MRP – synchronizing production operations with enterprise resource planning.

Levels of MES integration. MES is positioned between the ERP system and production equipment:

- ERP – strategic enterprise resource planning;
- MES – real-time production management;
- PLC/SCADA/ IoT – equipment control and process automation.

This enables a complete production management cycle, from planning to execution and monitoring.

Benefits of MES:

- real-time production control;
- reduced production cycle time;
- improved product quality;
- reduced production losses;
- accurate tracking of equipment and resource usage;
- integration with ERP/MRP to optimize resource management.

MES in production logistics. MES provides:

- optimization of production flows;
- control of material and component inventories;
- reduction of equipment downtime;
- improved efficiency of production processes;
- data collection for further analysis and planning.

APS (Advanced Planning and Scheduling) is a modern system for advanced planning and optimization of production processes that allows you to:

- optimize production planning;
- coordinate resources and production capacity;
- account for equipment, personnel, and material constraints;
- respond quickly to changes in demand or supply.

The primary goal of APS is to achieve maximum efficiency in production processes while minimizing costs and delays.

Key features of APS:

1. Production Schedule Optimization. Automatically determine the most efficient production schedule.

2. Management of Limited Resources. Allocate equipment, working hours, personnel, and materials.

3. Scenario Planning. The ability to simulate different plan scenarios to select the optimal one.

4. Production Demand Forecasting. Incorporating demand forecasts into production planning.

5. Integration with ERP and MES. Ensures synchronization of strategic planning, operational management, and production execution.

Benefits of APS:

- shorter production cycles;
- reduced inventory and storage costs;
- increased equipment utilization;
- optimized use of production resources;
- rapid response to changes in orders or supply;
- integration with ERP and MES for full production control.

APS modules:

1. Production Planning.
2. Scheduling Optimization.
3. Resource Management.
4. Demand Forecasting.
5. What-if Analysis.

APS in Production Logistics enables you to:

- integrate strategic and operational planning;
- minimize delays and equipment downtime;
- reduce logistics and production inventory costs;
- increase production flexibility in changing conditions.

Production logistics performance metrics. The following metrics are used to assess performance:

1. Production cycle time – the time from the start of production to the release of the product.
2. Inventory level – the volume of inventory in production.
3. Labor productivity – the amount of output per employee.
4. Defect rate – the proportion of defective products.
5. Equipment utilization rate – indicates the efficiency of production capacity utilization.

Questions for discussion

1. What is the essence of production logistics, and what is its role in a company's overall logistics system?
2. What are the main differences between production logistics and supply and distribution logistics?
3. What role does production logistics play in improving a company's operational efficiency?
4. What types of flows operate within a company's production logistics system? How are they interrelated?
5. What are the main tasks of production logistics in a modern company?
6. What are the distinctive features of organizing material flows in production?
7. What factors influence the effectiveness of production flow management?
8. What modern information systems are used to manage production logistics?
9. How does digitalization affect the development of production logistics?
10. What metrics are used to evaluate the effectiveness of production logistics?
11. What logistics approaches can help shorten the production cycle?
12. How does inventory optimization affect production efficiency?
13. What role does production logistics play in ensuring a company's competitiveness?
14. What challenges may arise when implementing logistics systems in production?
15. How does the integration of logistics and production management affect a company's performance?
16. What are the prospects for the development of production logistics in the context of the digital economy and Industry 4.0?

Practical exercises

Practical exercise 1. Analysis of a company's production flows.

The company manufactures household appliances. The production process includes the following stages:

1. Supply of raw materials.
2. Machining of parts.
3. Assembly of products.
4. Quality control.
5. Packaging of finished products.

Tasks:

1. Identify the material flows that occur in the production process.
2. Identify the information flows that accompany production.
3. Explain how the movement of material flows can be optimized.

Practical exercise 2. Optimization of the production cycle.

At the company production cycle lasts 12 days and consists of:

- preparatory operations – 2 days;
- part processing – 4 days;
- assembly – 3 days;
- quality control – 2 days;
- packaging – 1 day.

Tasks:

1. Determine the total duration of the production cycle.
2. Propose logistics measures to shorten the production cycle.
3. Indicate which logistics tools can be used.

Practical exercise 3. Analysis of production inventories.

The company has the following inventories:

- raw materials – 5,000 units;
- work in progress – 2,000 units;
- finished goods – 3,000 units.

The average daily production volume is 1,000 units.

Tasks:

1. Determine the total inventory.
2. Determine how many days of production the inventory will cover.

3. Propose logistics measures to optimize inventory.

Practical exercise 4. Identifying waste in the production process.

The following problems have been observed at the company:

- excess inventory;
- equipment downtime;
- delays in material deliveries;
- product defects.

Tasks:

1. Identify the types of waste present in production.
2. Explain how the concept of Lean Production can help eliminate them.
3. Propose specific optimization measures.

Practical exercise 5. Calculating production productivity.

The company employs 50 workers. Over the course of a month, 10,000 units of product were manufactured.

Tasks:

1. Determine the labor productivity per worker.
2. Propose logistical measures to increase productivity.

Practical exercise 6. Analysis of equipment utilization efficiency.

At the company, the equipment operates:

- 16 hours a day;
- actual operating time – 12 hours.

Tasks:

1. Determine the equipment utilization rate.
2. Suggest ways to improve equipment utilization efficiency.

Test tasks

1. *Production logistics is:*

- a) system for managing product sales;
- b) system for managing a company's financial flows;
- c) system for managing material flows in the production process;
- d) system for managing marketing processes.

2. *The main goal of production logistics is:*

- a) to increase advertising volume;
- b) to optimize production processes and material flows;
- c) to increase the number of employees;
- d) to increase warehouse inventory.

3. *Which type of production involves the manufacture of large quantities of the same product?*

- a) custom;
- b) batch;
- c) mass;
- d) individual.

4. *Which system is designed for planning material requirements?*

- a) ERP;
- b) MRP;
- c) CRM;
- d) SCM.

5. *Which metric characterizes the time from the start of production to the release of finished products?*

- a) inventory turnover;
- b) production cycle;
- c) demand level;
- d) profit level.

6. *Work in progress is:*

- a) finished goods in inventory;
- b) products currently undergoing production;
- c) products sold to consumers;
- d) products to be scrapped.

7. *Which of the following indicators characterizes the efficiency of equipment utilization?*

- a) equipment utilization rate;
- b) inflation rate;
- c) marketing expenses;
- d) advertising volume.

8. *The main tasks of production logistics include:*

- a) organizing material flows in production;
- b) managing advertising campaigns;
- c) brand building;
- d) managing market share.

9. *The flow of information in production logistics is related to:*

- a) the movement of raw materials;
- b) the transfer of data on production and inventory;
- c) the transportation of products;
- d) the payment of invoices.

10. *The main advantage of the logistics approach in manufacturing is:*

- a) an increase in production costs;
- b) a reduction in production time and optimization of resources;
- c) an increase in inventory levels;
- d) an increase in the number of operations.

8.1. The nature, significance, purpose, objective, and functions of distribution logistics

8.2. Managing goods flows in the distribution system and logistics strategies for sales

8.3. Current trends in the development of distribution logistics and an assessment of the effectiveness of sales logistics

8.1. The nature, significance, purpose, objective, and functions of distribution logistics

Distribution (sales) logistics is the part of a company's logistics system that ensures the planning, organization, management, and control of the movement of finished products from the manufacturer to the end consumer.

Key aspects:

- management of material flows after production;
- organizing the distribution network;
- delivering goods to the right place at the right time;
- meeting customer needs.

Significance:

- improves customer service;
- reduces transportation and storage costs;
- provides competitive advantages;
- impacts the company's profitability.

Objective: to ensure that products are delivered to consumers efficiently, at minimal cost, and with the highest level of service.

Main tasks:

- establishing distribution channels;
- sales planning;
- managing finished goods inventory;
- organizing transportation;
- selecting warehouses and logistics centers;
- providing information support for the process.

Functions:

- transportation – moving goods;
- warehousing – storage and handling;
- distribution – placing products in sales channels;
- information – data processing and transmission;
- service – customer service.

8.2. Managing goods flows in the distribution system and logistics strategies for sales

Key elements of the system:

- transportation;
- warehouses (distribution centers);
- inventory;
- information systems.

Key management processes:

- supply volume planning;
- inventory management;
- delivery route optimization;
- coordination of supply chain participants.

Management methods:

- Just-in-Time (JIT) – inventory minimization;
- Cross-docking – transshipment without storage;
- DRP – distribution requirements planning.

Principles:

- cost minimization;
- delivery speed;
- supply reliability;
- flexibility.

Main types of strategies:

1. Push strategy – the manufacturer actively promotes the product through distribution channels. Focus on intermediaries.
2. Pull strategy:
 - focus on the end consumer;
 - demand drives product movement.
3. Omnichannel strategy:
 - integration of online and offline channels;
 - consistent customer experience.
4. Lean logistics:

- elimination of waste;
 - process optimization.
5. Agile logistics:
- rapid adaptation to changes in demand;
 - flexibility in decision-making.

8.3. Current trends in the development of distribution logistics and an assessment of the effectiveness of sales logistics

Key trends:

- Digitalization of logistics (ERP, WMS, CRM, TMS systems);
- Warehouse automation (robots, conveyor belts, sorting systems);
- E-commerce logistics (express delivery, last-mile logistics);
- Big Data and analytics (demand forecasting);
- Artificial intelligence (route optimization, inventory management);
- Green logistics (environmental sustainability, reduction of CO₂ emissions).

Key performance indicators:

- customer service level;
- order fulfillment time;
- logistics costs;
- inventory turnover;
- delivery accuracy.

Evaluation methods:

- ABC analysis – identifying key products;
- XYZ analysis – demand stability;
- KPI analysis;
- Benchmarking – comparison with competitors.

Performance criteria:

- minimum costs;
- maximum speed;
- high level of service;
- system flexibility.

Questions for discussion

1. What role does distribution logistics play in a company's overall logistics system?
2. What are the main goals and objectives of distribution logistics?
3. List and describe the main functions of distribution logistics.
4. How important is distribution logistics for a company's competitiveness?
5. What is a goods flow in a distribution system?
6. What are the main elements of a goods flow management system?
7. What principles underlie goods flow management?
8. What is cross-docking, and what are its advantages?
9. What role do information systems play in managing flows?
10. What is the essence of Agile logistics' flexibility?
11. What are the main current trends in the development of distribution logistics?
12. What role does digitalization play in logistics?
13. How does e-commerce affect the distribution system?
14. What metrics are used to evaluate the effectiveness of sales logistics?
15. What is the level of logistics service?
16. How can costs in distribution logistics be optimized?
17. Why is delivery speed becoming a critical factor in ensuring competitiveness?
18. How are digital technologies changing the distribution system?
19. What risks can arise in distribution logistics?

Practical exercises

Practical exercise 1. Selecting a distribution channel.

The company manufactures plumbing fixtures and plans to enter a new market.

Conditions:

- mid-range products;
- wide sales geography;
- limited financial resources.

Requirements:

1. Select a distribution channel type.
2. Justify the choice.
3. Propose a channel structure.

Practical exercise 2. Optimization of goods flows.

The company has:

- 1 central warehouse;
- 3 regional warehouses;
- 10 retail locations.

A problem has arisen: delivery delays and high costs.

The following is required:

1. Identify possible causes of the problems.
2. Propose ways to optimize operations.
3. Select a logistics technology (JIT, cross-docking, DRP).

Practical exercise 3. Selecting a logistics sales strategy.

The company operates in an environment of unstable demand.

Tasks:

1. Select an appropriate logistics strategy (Push/Pull/Agile/Lean).
2. Justify your choice.
3. Describe the possible outcomes of implementation.

Practical exercise 4. Developing a distribution plan.

A confectionery manufacturer is entering the national market.

The following is required:

1. Develop a distribution logistics plan.
2. Determine the number of warehouses.
3. Select the mode of transportation.
4. Take into account costs and delivery speed.

Practical exercise 5. The Impact of e-commerce on logistics.

A company is transitioning to online sales.

Requirements:

1. Identify changes to the logistics system.
2. Describe new delivery requirements.
3. Propose solutions for last-mile logistics.

Practical exercise 6. Comprehensive analysis of sales logistics.

The company is facing the following challenges:

- high logistics costs;
- slow delivery times;
- customer dissatisfaction.

The following steps are required:

1. Conduct an analysis of the situation.
2. Identify key issues.
3. Propose a set of logistics solutions.
4. Select a sales strategy.
5. Define KPIs to measure effectiveness.

Practical exercise 7. Expanding the sales market.

The company is entering the international market.

Tasks:

1. Identify logistics risks.
2. Select a distribution model.
3. Propose a logistics network diagram.

Test tasks

1. *Distribution logistics is:*

- a) the management of production processes;
- b) the management of financial flows;
- c) the management of the movement of goods from the manufacturer to the consumer;
- d) human resources management.

2. *The main goal of distribution logistics is:*

- a) to increase production;
- b) to minimize production costs;
- c) to efficiently deliver goods to the consumer;
- d) to increase wages.

3. *The functions of distribution logistics include:*

- a) production planning;
- b) product transportation;
- c) human resources management;
- d) accounting.

4. *Which of the following is an element of a distribution system?*

- a) marketing research;
- b) transportation;
- c) human resources policy;
- d) advertising.

5. *Cross-docking is:*

- a) long-term storage of goods;
- b) transshipment of goods without warehousing;
- c) production;
- d) packaging of goods.

6. Service level refers to:

- a) the number of employees;
- b) the quality of customer service;
- c) production volume;
- d) advertising expenses.

7. ABC analysis is used for:

- a) personnel evaluation;
- b) classifying products by importance;
- c) production planning;
- d) product advertising.

8. XYZ analysis allows you to determine:

- a) the cost of goods;
- b) the stability of demand;
- c) the number of warehouses;
- d) salary levels.

9. What affects distribution efficiency?

- a) climate;
- b) logistics costs and delivery speed;
- c) the color of the packaging;
- d) website design.

10. Agile logistics means:

- a) stability without change;
- b) flexibility and rapid adaptation;
- c) reducing personnel costs;
- d) abandoning technology.

- 9.1. *The nature, role, objective and functions of transportation logistics***
- 9.2. *Modes of transportation, organization of transportation processes, selection of mode of transportation and carrier, combination of transportation modes***
- 9.3. *Transport flow management, documentation for transportation, modern technologies in transportation logistics, challenges and prospects for the development of transportation logistics***

9.1. The nature, role, purpose, objectives, and functions of transportation logistics

Transportation logistics is a subsystem of logistics that ensures the movement of material flows (raw materials, goods, finished products) from the supplier to the consumer at minimal cost and within specified time frames.

Key aspects:

- physical movement of goods;
- route optimization;
- minimizing transportation costs;
- ensuring timely delivery.

The role of transportation logistics:

- connects all elements of the logistics chain;
- affects the cost of goods (often 20–50%);
- determines the level of customer service.

Objective – to ensure the efficient, uninterrupted, and cost-effective movement of goods.

Main tasks:

- selecting the optimal mode of transportation;
- route planning;
- transportation management;
- reducing transportation costs;
- ensuring cargo safety.

Functions:

- transportation planning;
- organizing transportation;
- control and monitoring of delivery;
- coordinating transportation participants.

9.2. Modes of transportation, organization of transportation processes, selection of mode of transportation and carrier, combination of transportation modes

Modes of transportation and their characteristics:

1. Road transport

Advantages:

- high flexibility;
- door-to-door delivery.

Disadvantages:

- high cost over long distances.

2. Rail transport

Advantages:

- efficient for bulk shipments;
- low cost.

Disadvantages:

- limited flexibility.

3. Maritime transport

Advantages:

- the cheapest option for international shipments.

Disadvantages:

- long delivery times.

4. Air transport

Advantages:

- the fastest mode of delivery.

Disadvantages:

- very high cost.

5. Pipeline transport

- used for liquids and gases.

The transportation process includes:

1. Cargo preparation.
2. Loading.

3. Transportation.
4. Unloading.
5. Storage (if necessary).

Basic principles:

- continuity;
- regularity;
- efficiency;
- reliability.

Selecting mode of transportation and carrier.

Selection criteria:

- transportation cost;
- delivery speed;
- reliability;
- distance;
- type of cargo.

Selection methods:

- cost comparison;
- minimum cost method;
- multi-criteria analysis.

Combination of transportation is the organization of freight transportation using two or more modes of transport within a single logistics chain.

Objectives:

- to reduce costs;
- to increase transportation efficiency;
- to optimize delivery times.

Main types of combination transportation:

1. *Intermodal transportation:*

- different modes of transport are used;
- the cargo remains in a single transport unit (container).

2. *Multimodal transportation:*

- single operator is responsible for the entire route;
- single contract of carriage.

3. *Mixed transportation:*

- different modes of transport without a single operator;
- multiple contracts.

Main Combinations of Transport Modes:

- road + rail;

- road + sea;
- rail + sea;
- road + air.

Advantages of combining transport modes:

- reduced logistics costs;
- route optimization;
- ability to deliver over long distances;
- increased flexibility;
- reduced strain on individual modes of transport.

Disadvantages:

- complexity of organization;
- need for coordination;
- additional transshipments;
- risk of delays.

Principles of combination transportation:

- unity of the transport process;
- minimization of transshipments;
- coordination of schedules;
- economic feasibility.

9.3. Transport flow management, documentation for transportation, modern technologies in transportation logistics, challenges and prospects for the development of transportation logistics

Transport flow management involves:

- route planning;
- transport loading optimization;
- transport schedule management.

Main approaches:

- centralized management;
- decentralized management.

Documentary support for transportation. Main documents:

- waybill (TTN);
- bill of lading (for sea transportation);
- air waybill;
- CMR (international road transportation).

Modern technologies in transport logistics. Key technologies:

- GPS-transport monitoring;
- TMS (Transport Management Systems);
- RFID-technology is a technology for automatic identification of objects using radio waves. It allows:

- to identify cargo;
- to track the movement of goods;
- to automate logistics processes;
- route automation.

Digitalization allows:

- to reduce costs;
- to increase delivery accuracy;
- to improve control.

Problems and prospects for development.

Problems:

- infrastructure failure;
- high fuel costs;
- border delays;
- environmental problems.

Prospects:

- development of “green logistics”;
- transport automation;
- use of drones;
- development of multimodal transportation.

Questions for discussion

1. What is the main goal and objectives of transport logistics?
2. Name the main functions of transport logistics.
3. What factors influence the organization of transportation?
4. What is the transport process and what stages does it include?
5. Compare the main types of transport according to efficiency criteria.
6. What are the key criteria for choosing a carrier?
7. What is the compromise between cost and speed of delivery?
8. What risks arise when transporting goods?
9. How to develop an optimal transportation route?
10. What methods are used to optimize transport costs?
11. How to assess the effectiveness of transport logistics of an enterprise?
12. What are the models of transport flow management?
13. How to organize interaction between participants in the transport process?
14. What logistics strategies are used in the transport sector?
15. What modern information systems are used in transport logistics?
16. How does digitalization affect transportation efficiency?
17. What are the advantages of automating transport processes?
18. What are the main problems of transport logistics in Ukraine?
19. How does the state of infrastructure affect transportation efficiency?
20. How do wars or global crises affect transport chains?

Practical exercises

Practical exercise 1. Choosing mode of transport.

Choose the optimal mode of transport for the following situations:

1. Delivery of fresh flowers over a distance of 1500 km.
2. Transportation of metal over a distance of 800 km.
3. Delivery of electronics from China to Ukraine.
4. Transportation of oil.

Justify your choice based on the following criteria:

- speed;
- cost;
- reliability.

Practical exercise 2. Choosing the best transportation option.

The company needs to deliver goods (10 tons) over a distance of 1000 km.

Options:

Type of transport	Cost (EUR/t)	Delivery time
Road	1200	2 days
Rail	900	4 days
Air	3000	1 day

Tasks:

- calculate the total costs;
- choose the best option;
- justify the decision.

Practical exercise 3. Calculation of transportation costs.

Transportation cost:

- rate: 25 EUR/km
- distance: 600 km
- additional costs: 3000 EUR

Calculate the total transportation cost.

Practical exercise 4. Route optimization.

The company delivers goods to 4 cities:

- Berlin (Germany);

- Prague (Czech Republic);
- Vienna (Austria);
- Bratislava (Slovakia).

Tasks:

- build an optimal route;
- minimize costs and distance;
- explain the choice.

Practical exercise 5. Logistics situation analysis.

The company has frequent delivery delays.

Tasks:

- identify possible causes;
- suggest 5 solutions;
- evaluate the effectiveness of the proposed measures.

Practical exercise 6. International transportation.

The company exports furniture from Poland to Germany.

Tasks:

- choose a mode of transport;
- determine the route;
- make a list of documents;
- assess the risks.

Practical exercise 7. Logistics solution.

The company wants to reduce transportation costs by 15%.

Tasks:

- propose at least 5 measures;
- assess their impact;
- determine the most effective.

Practical exercise 8. Force majeure.

During the transportation of goods, there was a delay at the border.

Task:

- suggest actions for the logistician;
- minimize losses;
- provide customer service.

Test tasks

1. *The main purpose of transport logistics:*

- a) production of products;
- b) storage of goods;
- c) movement of goods;
- d) packaging of goods.

2. *Which mode of transport is the most flexible?*

- a) rail;
- b) road;
- c) sea;
- d) pipeline.

3. *The fastest mode of transport:*

- a) sea;
- b) road;
- c) air;
- d) rail.

4. *The cheapest mode of transport for international transportation:*

- a) road;
- b) air;
- c) sea;
- d) rail.

5. *What document is used in international road transportation?*

- a) bill of lading;
- b) consignment note;
- c) CMR;
- d) certificate.

6. What is the main criterion for choosing a mode of transport?

- a) color of the vehicle;
- b) transportation costs;
- c) car brand;
- d) country of manufacture.

7. What system is used for transport management?

- a) ERP;
- b) CRM;
- c) TMS;
- d) HRM.

8. What does the transport process include?

- a) only transportation;
- b) only loading;
- c) a set of operations (loading, transportation, unloading);
- d) only storage.

9. What factor most influences the choice of transport?

- a) form of cargo;
- b) distance of transportation;
- c) name of the product;
- d) advertising.

10. What is multimodal transport?

- a) transportation by one mode of transport;
- b) transportation by different modes of transport;
- c) transportation only by sea;
- d) transportation without documents.

10.1.The nature, role, functions, and objectives of warehouse logistics

10.2.Classification of warehouses, organization of warehouse operations, warehouse technologies and equipment

10.3.Warehouse inventory management, automation of warehouse logistics, efficiency of warehouse systems

10.1. The nature, role, functions, and objectives of warehouse logistics

Warehouse logistics is a system for managing material flows within a warehouse and between the warehouse and other elements of the logistics chain.

Main objectives:

- ensuring uninterrupted supply;
- minimizing costs;
- optimizing inventory;
- improving customer service.

Role in logistics. The warehouse serves as:

- buffer between production and consumption;
- center for consolidating goods;
- element of inventory management.

Main functions:

- receiving goods;
- storage;
- order fulfillment;
- shipping;
- data processing.

Objectives:

- ensuring the safety of goods;
- optimizing warehouse operations;
- reducing order processing time;
- minimizing losses and damage.

10.2. Classification of warehouses, organization of warehouse operations, warehouse technologies and equipment

Classification of warehouses:

By Purpose:

- manufacturing;
- distribution;
- transit;
- customs.

By ownership:

- owned;
- leased;
- logistics operators (3PL).

By degree of mechanization:

- manual;
- mechanized;
- automated.

By storage conditions:

- standard;
- refrigerated;
- specialized.

Organization of warehouse processes.

Main processes:

1. Receiving goods.
2. Put-away.
3. Storage.
4. Picking.
5. Packing.
6. Shipping.

Organizational principles:

- FIFO, LIFO.

FIFO (First In – First Out)

The goods that arrived at the warehouse first are shipped first.

Features:

- prevents spoilage of goods;
- ensures proper inventory turnover;
- is used for goods with expiration dates.

Applications:

- food products;
- pharmaceuticals;
- cosmetics.

Advantages:

- minimizes losses from spoilage;
- up-to-date inventory levels;
- accurately reflects the actual flow of goods.

Disadvantages:

- more complex to organize (requires zoning);
- may require more handling.

LIFO (Last In – First Out)

The goods that arrived last are shipped first.

Features:

- used where there is no risk of spoilage;
- often used in stacked storage.

Applications:

- building materials;
- raw materials;
- fuel resources.

Advantages:

- ease of implementation;
- lower handling costs;
- suitable for bulk goods.

Disadvantages:

- risk of old inventory becoming obsolete;
- not suitable for perishable goods.

Warehouse technologies and equipment.

Main equipment:

- racking systems;
- forklifts;
- conveyors;
- automated storage and retrieval systems (AS/RS).

Technologies:

- barcoding;
- RFID:

RFID (radio-frequency identification) is a technology for contactless identification of objects using radio waves. It allows for the automatic identification and tracking of goods without direct

contact or line of sight (unlike barcodes).

Advantages:

- contactless reading;
- ability to scan multiple items simultaneously;
- high processing speed;
- reduction in human error;
- real-time tracking of goods.

Disadvantages:

- high implementation cost;
- complex integration;
- potential interference (metal, liquids);
- requires specialized equipment.

Applications in warehouse logistics:

- goods receipt;
- inventory;
- movement tracking;
- shipping;
- loss prevention.

Pick-by-Light (PBL) is a visual order-picking assistance system that uses light indicators on racks or shelves to help pick the correct items. Main objective – to increase the speed and accuracy of order picking in the warehouse.

How Pick-by-Light works:

1. The WMS (Warehouse Management System) identifies the items to be picked.
2. An LED indicator lights up on the shelf where the required item is located.
3. The worker retrieves the required quantity of the item.
4. The worker presses the confirmation button on the light panel.
5. The system automatically records the operation and moves on to the next item.

System components:

- LED panels / indicators on the shelves;
- confirmation buttons (Pick Confirm);
- WMS / software;
- signal lights / displays for operators.

Advantages:

- increased order picking speed (up to 2–3 times);

- fewer picking errors;
- convenience for operators;
- easy integration with automated warehouses;
- suitable for e-commerce and small-item picking.

Disadvantages:

- high implementation cost (led panels, wms integration);
- requires system configuration for a specific warehouse;
- more difficult to scale with a large number of skus without

additional panels.

Voice Picking (VDP, Voice-Directed Picking) is a system for picking orders in a warehouse using voice instructions:

- the worker receives tasks through a headset;
- voice commands indicate what to pick, where it is, and in what

quantity;

- the worker confirms completion by voice or by pressing a button.

goal:

- to enable hands-free/eyes-free picking and increase speed and accuracy.

How the Voice Picking System works:

1. The WMS (Warehouse Management System) sends tasks to the voice system.

2. The worker hears a voice instruction: “Go to section A, shelf 12, and pick 3 units of item X.”

3. The worker completes the task and confirms it.

4. The system updates the order status and issues the next command.

System components:

- headset;
- microphone and voice receiver;
- WMS / software;
- voice command server.

Advantages of Voice Picking:

• hands-free and eyes-free—the operator can work with both hands;

- accuracy increases to 99.5–99.9%;
- order picking speed increases by 10–30%;
- easy integration with WMS;

- suitable for large warehouses and a high number of SKUs;
- reduction in errors and returns.

Disadvantages:

- cost of equipment and licenses;
- need for staff to adapt to voice commands;
- background noise can affect accuracy;
- limited effectiveness in very noisy production environments.

10.3. Warehouse inventory management, automation of warehouse logistics, efficiency of warehouse systems

Warehouse inventory management. Main models:

- EOQ (Economic Order Quantity);
- Just-in-Time (JIT);
- Safety stock.

Safety stock (SS) is additional inventory held in the warehouse beyond the average demand to protect against unforeseen fluctuations in demand and supply delays.

Objectives:

- to avoid stockouts;
- to ensure consistent order fulfillment;
- to improve supply chain reliability.

Reasons for use:

1. Demand uncertainty (seasonal fluctuations, promotional campaigns).
2. Supply delays (transportation issues, production stoppages).
3. Forecasting errors.
4. Internal operational risks (equipment breakdowns, staff shortages).

$$SS=(D_{\max}-D^-)\times LT$$

Average demand D^-

Maximum demand $D_{\max}$

Lead time LT

Key metrics:

- inventory turnover;
- service level;
- warehouse fill rate.

Automation of warehouse logistics. Key Systems:

- WMS (Warehouse Management System);

Warehouse Management System (WMS) is a software application designed to manage, control, and optimize warehouse operations. It supports the efficient movement and storage of goods within a warehouse, from receiving and put-away to inventory management, order picking, packing, and shipping. WMS provides real-time visibility of inventory, improves warehouse productivity, reduces operational costs, and enhances order accuracy.

Key functions of a WMS:

- receiving and inspecting incoming goods;
- inventory tracking and stock control in real time;
- optimizing storage locations (slotting);
- order picking and packing management;
- shipping and dispatch coordination;
- barcode and RFID integration;
- labor and workforce management;
- warehouse performance reporting and analytics.

Benefits of WMS:

- increased inventory accuracy;
- faster order fulfillment;
- reduced warehouse operating costs;
- improved space utilization;
- lower picking and shipping errors;
- enhanced customer satisfaction;
- better visibility and traceability throughout warehouse operations.

- ERP integration;

ERP Integration in warehouse is the process of connecting an Enterprise Resource Planning (ERP) system with a Warehouse Management System (WMS) to ensure the seamless exchange of information between warehouse operations and other business functions. This integration enables real-time synchronization of inventory, orders, procurement, production, sales, and financial data, improving the efficiency and accuracy of warehouse management.

When goods are received, stored, picked, packed, or shipped, the warehouse system automatically updates the ERP system. As a result, inventory levels, purchase orders, customer orders, and

financial records remain accurate across the entire organization. Warehouse employees can access up-to-date information, while managers gain real-time visibility into stock availability and warehouse performance.

Key functions of ERP Integration in warehouse:

- automatic synchronization of inventory data;
- integration of receiving, storage, picking, packing, and shipping processes;
- real-time order processing and fulfillment;
- purchase order and supplier management;
- barcode and RFID data exchange;
- inventory forecasting and replenishment;
- financial and accounting updates;
- warehouse performance monitoring and reporting.

Benefits of ERP Integration in Warehouse

- improved inventory accuracy and visibility;
- faster order fulfillment and reduced processing time;
- elimination of duplicate data entry;
- lower operational costs and fewer human errors;
- better coordination between warehouse, procurement, sales, and finance;
- enhanced customer service through accurate stock information;
- greater productivity and warehouse efficiency;
- data-driven decision-making with real-time reporting.
- IoT in warehouses;

IoT (Internet of Things) in warehouses refers to the use of internet-connected devices, sensors, and smart equipment to monitor, automate, and optimize warehouse operations in real time. IoT technology enables continuous communication between warehouse assets, inventory, equipment, and management systems, improving operational efficiency, inventory accuracy, and decision-making.

IoT devices collect and transmit data from various warehouse activities, including inventory movement, equipment performance, environmental conditions, and employee operations. This data is integrated with Warehouse Management Systems (WMS) and Enterprise Resource Planning (ERP) systems, allowing managers to monitor warehouse performance and respond quickly to operational issues.

Key applications of IoT in warehouses:

- real-time inventory tracking using RFID tags and smart sensors;
- monitoring the location and condition of goods;
- automated stock level monitoring and replenishment;
- tracking forklifts, pallets, and warehouse equipment;
- monitoring temperature and humidity for sensitive products;
- predictive maintenance of warehouse machinery;
- energy management and warehouse security;
- integration with WMS and ERP systems for real-time data exchange.

Benefits of IoT in warehouses:

- improved inventory accuracy and visibility;
- faster warehouse operations and order fulfillment;
- reduced inventory losses and picking errors;
- lower operating and maintenance costs;
- better utilization of warehouse space and equipment;
- enhanced product quality through environmental monitoring;
- increased employee productivity and workplace safety;
- data-driven decision-making through real-time analytics.

Warehouse system efficiency. Warehouse KPIs:

- picking accuracy (%);
- order fulfillment time;
- cost per unit;
- staff productivity.

Methods for improving efficiency:

- route optimization;
- automation;
- staff training;
- implementation of lean logistics.

Questions for discussion

1. What is warehouse logistics?
2. What is the role of a warehouse in the logistics supply chain?
3. What are the main functions of a warehouse?
4. What is the difference between a warehouse and a distribution center?
5. What are the main tasks of warehouse logistics?
6. What is material flow in a warehouse?
7. What types of warehouse operations are you familiar with?
8. What is warehouse infrastructure?
9. What factors influence warehouse organization?
10. What does efficiency in warehouse logistics mean?
11. Why is it important to optimize warehouse processes?
12. What is the FIFO principle, and where is it applied?
13. What are the benefits of using ABC analysis in a warehouse?
14. How does warehouse zoning affect operational efficiency?
15. Explain the differences between a manual and an automated warehouse.
16. How does the level of mechanization affect warehouse productivity?
17. Why is it important to monitor warehouse inventory?
18. What risks arise from improper storage of goods?
19. How does warehouse logistics affect customer service levels?
20. What are the advantages and disadvantages of owned versus leased warehouses?
21. How does the implementation of a WMS affect a company's operations?
22. Which key performance indicators (KPIs) are most important for evaluating a warehouse?
23. How can warehouse operating costs be reduced?
24. What factors determine the choice of a warehouse location?
25. How is digitalization changing warehouse logistics?
26. How can a warehouse be adapted to crisis conditions (war, pandemic)?

Practical exercises

Practical exercise 1. Warehouse classification.

The company's warehouse:

- stores frozen products;
- uses automated racking systems;
- serves retail chains.

Task:

Classify the warehouse by:

- purpose;
- storage type;
- level of automation.

Practical exercise 2. Analysis of warehouse processes.

Delays are occurring in order fulfillment at the warehouse.

Tasks:

- identify possible causes;
- propose 3–5 measures to optimize the process.

Practical exercise 3. Safety stock.

Given:

- average demand – 100 units/day;
- maximum demand – 140 units/day;
- lead time – 5 days.

Task: calculate the safety stock.

Practical exercise 4. Warehouse layout.

Task:

Develop a layout diagram (explanatory diagram) of the warehouse, taking into account:

- receiving areas;
- storage areas;
- picking areas;
- shipping areas.

Present the diagram in the form of a flowchart.

Practical exercise 5. Equipment selection.

The company plans to open a 2,000 m² warehouse.

Tasks:

- identify the necessary equipment;
- justify the selection (racking, machinery, IT systems).

Practical exercise 6. Warehouse optimization.

The company has a high error rate in order fulfillment (15%).

Tasks:

- identify the causes;
- propose solutions (process-related and organizational).

Practical exercise 7. WMS Implementation.

The warehouse operates manually, resulting in a high number of errors and delays.

Tasks:

- justify the feasibility of implementing a WMS;
- describe the expected results.

Practical exercise 8. Lean warehouse.

Propose measures for implementing Lean principles in the warehouse:

- reducing waste;
- optimizing processes;
- improving efficiency.

Test tasks

1. *The main function of a warehouse:*

- a) production;
- b) storage;
- c) advertising;
- d) transportation.

2. *What does the FIFO principle mean?*

- a) last in, first out;
- b) first in, first out;
- c) random selection;
- d) first out, most expensive goods.

3. *Which system is used for warehouse management?*

- a) CRM;
- b) ERP;
- c) WMS;
- d) MRP.

4. *Warehouse operations include:*

- a) production;
- b) order fulfillment;
- c) marketing;
- d) advertising.

5. *What is ABC analysis?*

- a) method of transportation;
- b) classification of goods by importance;
- c) method of packaging;
- d) method of warehousing.

6. Which metric characterizes the speed at which goods move through a warehouse?

- a) service level;
- b) inventory turnover;
- c) profit;
- d) number of employees.

7. What is a WMS?

- a) transportation management system;
- b) warehouse management system;
- c) financial system;
- d) marketing system.

8. Which type of warehouse is designed for rapid distribution of goods?

- a) manufacturing;
- b) distribution center;
- c) customs;
- d) reserve.

9. The main goal of warehouse automation is:

- a) to increase the number of employees;
- b) to reduce errors;
- c) to increase warehouse space;
- d) to reduce the product range.

10. Which inventory management method aims to minimize inventory levels?

- a) EOQ;
- b) JIT;
- c) FIFO;
- d) ABC.

ROLE PLAYING ACTIVITIES FOR MODULE 2

To Chapter 6

Negotiations with suppliers and procurement optimization

Students are divided into groups (5–7 people in each).

Participant roles:

1. Company Procurement Manager – responsible for procurement planning, supplier selection, and inventory management.
2. Suppliers – offer various delivery terms (price, lead time, reliability, discounts).
3. Company's financial manager – evaluates procurement costs and the procurement budget.
4. Logistics manager – evaluates delivery options and warehousing costs.

Tables listing suppliers and delivery terms:

Supplier	Price per kg	Delivery time	Reliability	Discount for large orders
A	45 EUR	5 days	90%	0%
B	42 EUR	10 days	70%	5% for orders over 10,000 kg
C	48 EUR	3 days	95%	0%

Information about the company's needs:

- the company needs to produce 5,000 units per month.
- it takes 2 kg of raw materials to produce 1 unit.

Storage costs: 2 EUR/kg per month.

Safety stock: 500 kg.

Possible scenarios:

- one of the suppliers is unable to deliver the goods on time due to force majeure;
- it is necessary to purchase several types of raw materials simultaneously;
- limited procurement budget;
- possibility of using a VMI or Just-in-Time system.

Expected outcomes:

- learn to evaluate suppliers and delivery terms;
- learn to balance price, lead times, reliability, and risks;
- practice negotiation and strategic decision-making in procurement logistics.

To Chapter 7

Optimization of the company's production process

The company manufactures household appliances. Recently, the following problems have arisen:

- delays in production;
- a buildup of work in progress;
- excess inventory;
- uneven utilization of equipment;
- delays in the delivery of materials.

The company's management decided to hold a meeting to optimize production logistics.

Roles of participants:

Students are divided into 5–6 roles.

1. Director

Responsibilities:

- coordinates the discussion;
- makes the final decision;
- sets strategic directions for development.

2. Production manager

Responsibilities:

- organizing the production process;
- utilizing production capacity;
- planning production.

Task:

- propose measures to shorten the production cycle.

3. Logistics manager

Responsible for:

- managing material flows;
- optimizing inventory;
- coordinating between departments.

Tasks:

- propose logistics tools (JIT, Kanban, Lean).

4. Procurement manager

Responsible for:

- purchasing raw materials;

- working with suppliers;
- organizing procurement.

Task:

- propose solutions for a stable supply of materials.

5. Financial manager

Responsible for:

- company expenses;
- financial efficiency of production.

Task:

- assess the economic efficiency of the proposed solutions.

6. Quality control manager

Responsible for:

- product quality;
- reducing defects.

Task:

- propose measures to improve production quality.

Questions for discussion after the game:

1. What were the main logistics challenges identified?
2. Which solutions proved to be the most effective?
3. What logistics tools could be implemented at the company?
4. How does coordination between departments affect production efficiency?

To Chapter 8

Distribution system optimization: strategic decision for the company

Objectives:

- develop practical skills in sales logistics management;
- learn to make logistics decisions;
- develop analytical thinking and teamwork skills.

Game plot. You are the top management team of the company facing problems in its distribution system:

- delivery delays;
- rising costs;
- customer dissatisfaction.

The company plans to overhaul its logistics system, drawing on the experience of leading global companies.

Company options (selected by groups). Each group works on the business model of one company:

- Amazon – fast delivery;
- Zara – quick response to demand;
- IKEA – cost minimization.

Roles of team members in each team.

1. Logistics manager
 - responsible for the flow of goods and delivery.
2. CFO
 - monitors expenses.
3. Marketing specialist
 - represents the interests of customers.
4. Warehouse manager / Operations manager
 - is responsible for warehouses and inventory.
5. CEO
 - makes the final decision.

Tasks:

1. Select a logistics strategy
(Push / Pull / Agile / Lean / Omnichannel)
2. Propose:
 - a distribution channel structure;
 - a warehouse layout;
 - delivery methods;
 - last-mile solutions.
3. Propose innovations:
 - digital systems;
 - automation;
 - cost optimization.

Additional challenges:

- sharp increase in demand;
- transportation delays;
- rising fuel prices;
- logistics system failure.

To Chapter 9

Organizing transportation services

Objectives:

- develop practical skills in making logistics decisions;
- teach participants how to work under resource constraints;
- develop negotiation and teamwork skills.

The manufacturing company needs to deliver products (select product type) from a warehouse in Ukraine to a customer in Europe.

Several constraints arise during the process:

- a limited budget;
- delivery deadlines;
- risks (delays, damage, customs procedures).

Roles of participants. Students are divided into groups:

1. Manufacturer:

- defines requirements (price, deadline, volume);
- selects a carrier;
- monitors the process.

2. Logistics company:

- plans transportation;
- proposes routes;
- optimizes costs.

3. Carriers (3 groups):

- road transport;
- rail transport;
- multimodal transport.

Each group:

- proposes its own terms;
- argues its advantages.

4. Customs service:

- checks documents;
- may cause delays.

5. Client

- evaluates delivery quality;
- sets requirements.

Task – to organize transportation:

- quickly;
- inexpensively;
- reliably.

Specific tasks:

- select a mode of transportation;
- plan a route;
- justify costs;
- assess risks;
- agree on terms between the parties.

Force majeure

Possible situations:

- delays at the border;
- vehicle breakdown;
- increase in fuel costs;
- damage to cargo.

Participants must:

- make decisions quickly;
- change the route or mode of transport.

Expected outcomes

Students should:

- understand real-world logistics processes;
- learn to make decisions under conditions of uncertainty;
- develop analytical thinking.

To Chapter 10

Effective warehouse management

Objectives:

- develop practical warehouse management skills;
- teach participants how to make logistics decisions;
- foster teamwork and analytical thinking.

Situation:

The company is facing problems in the warehouse:

- delays in order processing;
- picking errors;
- warehouse overload;
- rising costs.

Task:

- optimize warehouse operations.

Roles of participants:

1. Warehouse manager:
 - is responsible for operational activities;
 - oversees staff and processes.
2. Logistics specialist:
 - analyzes the flow of goods;
 - proposes process optimizations.
3. Financial manager:
 - evaluates expenses;
 - monitors the budget.
4. IT specialist:
 - is responsible for automation;
 - proposes WMS solutions.
5. Customer / Sales representative:
 - raises complaints;
 - sets service requirements.
6. Warehouse operator (optional):
 - describes real-world problems “from the inside.”

Variations:

Option 1: “Limited budget”:

- the financial manager sets a limit;
- the team must choose only 2–3 solutions.

Option 2: “Crisis”:

- sharp increase in orders (e-commerce);
- the warehouse is overloaded.

Option 3: “Automation vs. people”:

- part of the team supports automation;
- part of the team supports process optimization without investment.

Expected outcomes

Students:

- understand the real-world challenges facing the warehouse;
- are able to make logistics decisions;
- work as a team;
- apply theory to practice.

SUCCESS CASES OF COMPANIES IN LOGISTICS

To Chapter 2

Enterprise Resource Planning (ERP) systems have transformed logistics by integrating procurement, inventory management, warehousing, transportation, production, sales, and finance into a single information system. Many global companies have successfully implemented ERP solutions to improve supply chain efficiency, reduce costs, and enhance customer satisfaction.

One of the most successful examples is *Amazon*. The company uses an integrated ERP environment together with advanced warehouse management systems to coordinate millions of customer orders every day. Real-time inventory tracking, automated procurement, and optimized order processing enable Amazon to deliver products quickly while maintaining high inventory accuracy and efficient warehouse operations.

Another notable example is *DHL*, one of the world's leading logistics providers. DHL has implemented ERP systems to integrate transportation management, warehouse operations, procurement, and financial management across its global network. The system provides complete visibility of shipments, improves communication between departments, reduces transportation costs, and supports faster decision-making.

In the automotive industry, *Toyota* combines ERP systems with Lean Manufacturing and Just-in-Time (JIT) principles. ERP supports production planning, supplier coordination, inventory management, and material requirements planning (MRP). As a result, Toyota maintains low inventory levels, minimizes waste, improves production efficiency, and ensures reliable product delivery.

Walmart is another excellent example of successful ERP implementation. The retailer integrates procurement, inventory management, distribution, and supplier collaboration through its ERP platform. This integration enables accurate demand forecasting, rapid inventory replenishment, reduced stock shortages, and lower logistics costs while ensuring products are available when customers need them.

Warehouse Management Systems (WMS) have become an essential technology for logistics companies seeking to improve warehouse efficiency, inventory accuracy, and customer service. By automating warehouse operations and integrating them with transportation, procurement, and enterprise resource planning systems, WMS enables organizations to optimize the flow of goods throughout the supply chain. Several global logistics companies have successfully implemented WMS solutions and achieved significant operational improvements.

One of the best-known examples is *DHL*. The company operates thousands of warehouses and distribution centers worldwide, handling millions of shipments each day. DHL implemented advanced WMS solutions that integrate barcode scanning, RFID technology, and real-time inventory tracking. The system optimizes receiving, storage, order picking, packing, and shipping processes while providing managers with complete visibility of warehouse operations. As a result, DHL has improved inventory accuracy, reduced order processing time, increased warehouse productivity, and enhanced customer satisfaction through faster and more reliable deliveries.

Another successful example is *FedEx*. To support its global distribution network, FedEx uses WMS technologies integrated with automated sorting systems and transportation management software. Real-time inventory updates and automated warehouse workflows allow the company to process large volumes of parcels efficiently while minimizing handling errors. The implementation of WMS has improved shipment visibility, optimized warehouse space utilization, and reduced operational costs.

DB Schenker has also adopted modern WMS solutions across its global warehouse network. The company uses digital warehouse management, barcode technology, and automated inventory control to support customers in industries such as automotive, healthcare, and consumer goods. The WMS enables accurate inventory tracking, faster order fulfillment, and seamless integration with transportation management systems, allowing customers to monitor inventory and shipments in real time.

Another leading logistics provider, *Kuehne+Nagel*, has implemented cloud-based WMS solutions that support omnichannel

distribution and e-commerce logistics. The system automates warehouse processes, improves labor productivity, and provides advanced analytics for inventory optimization. Integration with ERP and transportation systems enables efficient coordination between suppliers, warehouses, and customers, resulting in faster deliveries and improved supply chain performance.

Transportation Management System (TMS) is a software solution that helps organizations plan, execute, monitor, and optimize the movement of goods. It supports route planning, carrier selection, shipment tracking, freight cost management, and delivery scheduling. Many global logistics companies have successfully implemented TMS solutions to improve transportation efficiency, reduce logistics costs, and enhance customer service.

One of the leading examples is *DHL*. DHL uses advanced TMS solutions to coordinate road, air, sea, and rail transportation across more than 220 countries and territories. The system integrates transportation planning with warehouse operations and Enterprise Resource Planning (ERP) systems, allowing the company to optimize delivery routes, monitor shipments in real time, and improve communication with customers. As a result, DHL has reduced transportation costs, increased vehicle utilization, and achieved faster, more reliable deliveries.

Another successful example is *UPS*. UPS developed an advanced transportation management and route optimization system that analyzes traffic conditions, delivery locations, fuel consumption, and vehicle capacity. The system helps drivers follow the most efficient routes while reducing unnecessary mileage and delivery time. This technology has enabled UPS to lower fuel consumption, improve on-time delivery performance, and reduce greenhouse gas emissions while maintaining a high level of customer service.

FedEx also relies on an integrated TMS to manage its global transportation network. The system provides real-time shipment visibility, automated carrier management, and predictive delivery planning. Customers can track shipments throughout the transportation process, while logistics managers use analytics to improve delivery performance and resource utilization. The implementation of TMS has increased operational efficiency, reduced transportation delays, and strengthened customer

confidence.

Another excellent example is *Maersk*. As one of the world's largest shipping and logistics providers, Maersk uses TMS to coordinate multimodal transportation involving ships, trucks, railways, and ports. The system optimizes container movements, improves scheduling, and integrates transportation data with warehouse management and customs documentation. This has resulted in better supply chain visibility, lower transportation costs, and improved coordination across global logistics operations.

GPS tracking has become a fundamental technology in modern logistics, enabling companies to monitor vehicle locations, optimize delivery routes, improve fleet management, and provide real-time shipment visibility. By integrating GPS tracking with Transportation Management Systems (TMS), Enterprise Resource Planning (ERP), and fleet management software, logistics companies can reduce transportation costs, improve delivery reliability, and enhance customer satisfaction.

One of the most successful examples is *DHL*. DHL uses GPS tracking across its global fleet to monitor the real-time location of trucks and delivery vehicles. The technology enables dispatchers to optimize routes, respond quickly to traffic disruptions, and provide customers with accurate delivery estimates. GPS tracking also improves vehicle utilization, reduces fuel consumption, and enhances driver safety. As a result, DHL has achieved greater operational efficiency and more reliable delivery services.

Another leading example is *UPS*. UPS combines GPS tracking with advanced route optimization software to manage millions of deliveries every day. Dispatchers continuously monitor vehicle locations and adjust routes based on traffic conditions, weather, and delivery priorities. Real-time GPS data helps reduce unnecessary mileage, improve on-time delivery performance, and lower fuel consumption. Customers also benefit from accurate shipment tracking and estimated delivery times.

FedEx has integrated GPS tracking into its global transportation network to provide end-to-end shipment visibility. Vehicles transmit location data continuously, allowing logistics managers to monitor delivery progress and respond quickly to unexpected delays. Customers can track their shipments in real time through online

platforms, improving transparency and confidence in the delivery process. GPS tracking has also helped FedEx improve fleet utilization and reduce transportation costs.

Another successful implementation can be found at *Amazon*. The company uses GPS technology to monitor delivery vehicles and support its last-mile logistics operations. Drivers receive optimized navigation instructions, while customers can track deliveries in real time through Amazon's mobile application. GPS integration allows Amazon to improve route planning, reduce delivery times, and increase the efficiency of its rapidly expanding logistics network.

Big Data has become a strategic asset in modern logistics, enabling companies to analyze massive volumes of information from transportation networks, warehouses, customers, suppliers, GPS devices, and IoT sensors. By transforming data into actionable insights, logistics companies can optimize operations, predict demand, reduce costs, and improve customer service. Many global logistics providers have successfully implemented Big Data technologies to strengthen their supply chain performance.

One of the leading examples is *DHL*. DHL uses Big Data analytics to monitor millions of shipments, analyze transportation performance, and predict potential delivery disruptions. Data collected from vehicles, warehouses, weather reports, and traffic systems are processed in real time to optimize delivery routes and improve warehouse operations. By using predictive analytics, DHL can identify bottlenecks before they occur, reduce transportation delays, and enhance supply chain visibility.

Another successful implementation is found at *UPS*. UPS analyzes large volumes of operational data generated by its vehicles, drivers, customers, and delivery routes. Big Data supports route optimization, vehicle maintenance scheduling, and fuel consumption analysis. Predictive analytics helps the company reduce operating costs, improve delivery reliability, and increase fleet efficiency. The continuous analysis of transportation data also enables UPS to make faster and more informed operational decisions.

Amazon is another excellent example of Big Data implementation in logistics. The company collects enormous amounts of data from customer orders, warehouse operations, supplier performance, and delivery networks. Advanced analytics are used to forecast demand,

optimize inventory levels, improve warehouse productivity, and support personalized customer services. By analyzing purchasing behavior and seasonal trends, Amazon can position products closer to customers, reducing delivery times and logistics costs.

Maersk also relies on Big Data to improve global shipping operations. The company collects data from ships, ports, weather systems, cargo containers, and fuel consumption sensors. These data are analyzed to optimize shipping routes, improve vessel scheduling, reduce fuel usage, and increase supply chain transparency. Big Data enables *Maersk* to make better operational decisions while improving the reliability of international freight transportation.

Artificial Intelligence (AI) is transforming the logistics industry by improving decision-making, automating routine tasks, and optimizing supply chain operations. AI technologies such as machine learning, computer vision, predictive analytics, and intelligent automation help logistics companies forecast demand, optimize transportation routes, improve warehouse operations, and enhance customer service. Many global logistics providers have successfully implemented AI to increase efficiency and reduce operating costs.

One of the leading examples is *DHL*. *DHL* uses AI to optimize transportation planning, predict shipment delays, and improve warehouse operations. Machine learning algorithms analyze real-time data from vehicles, weather conditions, traffic, and customer orders to recommend the most efficient delivery routes. AI also supports demand forecasting and warehouse automation, enabling *DHL* to improve delivery reliability, reduce transportation costs, and enhance overall supply chain performance.

Another successful example is *Amazon*. *Amazon* applies AI throughout its logistics network, from demand forecasting and inventory optimization to robotic warehouse operations and last-mile delivery planning. AI analyzes customer purchasing patterns to predict future demand, allowing products to be positioned closer to customers before orders are placed. Intelligent robots assist warehouse employees by transporting inventory, while AI-powered route optimization helps delivery drivers reduce travel time and improve delivery accuracy.

UPS has also integrated AI into its transportation management processes. The company combines artificial intelligence with GPS

tracking and predictive analytics to optimize delivery routes based on traffic conditions, weather forecasts, package volumes, and vehicle capacity. AI continuously evaluates transportation data and recommends operational improvements, helping UPS reduce fuel consumption, improve fleet utilization, and increase on-time delivery performance.

Another important example is *FedEx*. FedEx uses AI to enhance shipment tracking, customer support, and predictive maintenance of its transportation fleet. Machine learning models analyze equipment performance to identify potential mechanical failures before they occur, reducing vehicle downtime and maintenance costs. AI-powered analytics also improve delivery planning and provide customers with more accurate estimated delivery times.

The rapid growth of **e-commerce** has transformed the logistics industry by increasing demand for fast, accurate, and flexible delivery services. To meet customer expectations, logistics companies have invested in advanced technologies such as automated warehouses, Transportation Management Systems (TMS), Warehouse Management Systems (WMS), artificial intelligence (AI), and real-time shipment tracking. These innovations have enabled companies to process millions of online orders efficiently while improving customer satisfaction.

One of the most successful examples is *Amazon*. Amazon has built one of the world's most advanced e-commerce logistics networks, consisting of highly automated fulfillment centers, regional distribution hubs, and last-mile delivery services. The company uses AI-powered demand forecasting, robotic warehouse systems, and real-time inventory management to process millions of customer orders every day. Customers can track their shipments in real time, while optimized delivery routes help ensure fast and reliable service. These innovations have enabled Amazon to offer same-day and next-day delivery in many markets.

Another leading example is *DHL*, which has expanded its logistics services to support the rapid growth of online retail. DHL provides warehousing, order fulfillment, international shipping, and returns management for e-commerce businesses of all sizes. By integrating WMS, TMS, and AI technologies, DHL helps online retailers improve inventory accuracy, optimize delivery routes, and

provide customers with real-time shipment visibility. These solutions have significantly reduced delivery times and improved overall supply chain performance.

Alibaba has also revolutionized e-commerce logistics through its smart logistics network. By combining cloud computing, Big Data, AI, and automated warehouses, Alibaba manages millions of online transactions during major shopping events such as Singles' Day. Advanced logistics technologies enable the company to forecast demand, optimize inventory distribution, and coordinate deliveries across an extensive network of logistics partners, ensuring rapid and reliable order fulfillment.

Another successful example is *FedEx*, which has adapted its global transportation network to meet the growing demands of e-commerce. FedEx offers integrated fulfillment, express delivery, shipment tracking, and returns management services for online retailers. Real-time tracking systems, automated sorting facilities, and predictive analytics enable the company to handle increasing parcel volumes while maintaining high delivery reliability and customer satisfaction.

Green logistics focuses on reducing the environmental impact of transportation, warehousing, packaging, and supply chain operations while maintaining high levels of efficiency and customer service. Logistics companies are increasingly adopting sustainable practices such as electric vehicles, alternative fuels, energy-efficient warehouses, route optimization, and carbon emission monitoring. These initiatives not only support environmental protection but also reduce operating costs and improve corporate reputation.

One of the leading examples is *DHL*. DHL has implemented a comprehensive green logistics strategy that includes electric delivery vehicles, bicycle couriers in urban areas, and warehouses powered by renewable energy. The company also uses artificial intelligence and transportation management systems to optimize delivery routes, reducing fuel consumption and greenhouse gas emissions. In addition, DHL monitors its carbon footprint and offers customers carbon-neutral shipping options, helping businesses achieve their sustainability goals.

Another successful example is *UPS*. UPS has invested heavily in alternative-fuel vehicles, including electric, hybrid, and compressed

natural gas (CNG) trucks. The company also uses advanced route optimization software to minimize unnecessary driving distances and fuel consumption. These initiatives have reduced carbon emissions, improved fuel efficiency, and lowered transportation costs while maintaining reliable delivery services.

Maersk is a global leader in sustainable maritime logistics. The company is investing in low-emission vessels powered by green methanol and other alternative fuels to reduce greenhouse gas emissions from ocean transportation. *Maersk* also uses digital technologies and data analytics to optimize shipping routes, improve fuel efficiency, and reduce idle time at ports. These innovations contribute to more sustainable and efficient global supply chains.

Another important example is *DB Schenker*. The company has introduced electric trucks, energy-efficient warehouses, and environmentally friendly rail freight solutions to reduce the environmental impact of logistics operations. *DB Schenker* also applies digital transportation planning systems that improve vehicle utilization and decrease empty trips, helping lower fuel consumption and carbon emissions while maintaining high service quality.

The globalization of supply chains has enabled companies to source materials, manufacture products, and distribute goods across multiple countries and continents. Modern logistics companies support global supply chains by integrating transportation, warehousing, customs management, digital technologies, and real-time information systems. As international trade continues to grow, logistics providers play a critical role in ensuring that products move efficiently, safely, and cost-effectively around the world.

One of the best examples is *DHL*. *DHL* operates one of the world's largest international logistics networks, serving more than 220 countries and territories. The company integrates air, sea, road, and rail transportation with warehousing, customs brokerage, and supply chain management services. By using advanced digital platforms, real-time shipment tracking, and predictive analytics, *DHL* provides customers with complete visibility across global supply chains. This integrated approach enables businesses to reduce transportation delays, improve inventory management, and respond quickly to changes in global demand.

Another leading example is *Maersk*. As one of the world's largest

container shipping companies, Maersk connects manufacturers, suppliers, ports, and customers through an extensive global transportation network. The company has expanded beyond ocean shipping by offering integrated logistics services, including warehousing, inland transportation, customs clearance, and supply chain visibility. Digital technologies allow customers to monitor shipments in real time, optimize transportation schedules, and improve coordination across international markets.

Kuehne+Nagel has also successfully implemented global supply chain solutions for industries such as automotive, healthcare, aerospace, and consumer goods. The company combines multimodal transportation, warehouse management, inventory optimization, and digital tracking systems to coordinate complex international logistics operations. Its integrated logistics platform provides customers with end-to-end visibility, helping them reduce costs, improve delivery performance, and manage global risks more effectively.

Another successful example is *DB Schenker*, which manages international supply chains through a worldwide network of logistics centers, distribution facilities, and transportation services. The company uses cloud-based logistics platforms, artificial intelligence, and data analytics to optimize cross-border transportation, improve customs processes, and increase supply chain resilience. These technologies enable businesses to adapt quickly to disruptions such as changing market demand, transportation delays, and geopolitical challenges.

The development of **omnichannel systems** has transformed modern logistics by integrating physical stores, online platforms, mobile applications, and distribution networks into a single, seamless customer experience. Logistics companies support omnichannel strategies by ensuring that inventory, transportation, warehousing, and order fulfillment are synchronized across all sales channels. Advanced technologies such as Warehouse Management Systems (WMS), Transportation Management Systems (TMS), Enterprise Resource Planning (ERP), and artificial intelligence (AI) enable companies to deliver products quickly and efficiently regardless of where customers place their orders.

One of the most successful examples is *Amazon*. Amazon operates a highly integrated omnichannel logistics network that

combines online shopping, fulfillment centers, physical retail stores, and last-mile delivery services. The company uses AI-powered demand forecasting, real-time inventory management, and automated warehouses to ensure that products are available across multiple sales channels. Customers can order through the website or mobile application and receive fast home delivery or collect products from designated pickup locations, creating a seamless shopping experience.

Another leading example is *Walmart*. Walmart has successfully integrated its physical stores, e-commerce platform, and distribution centers into a unified omnichannel system. Customers can purchase products online, choose home delivery, or use Buy Online, Pick Up In Store (BOPIS) services. Advanced WMS, ERP, and TMS technologies synchronize inventory across stores and warehouses, ensuring accurate stock information and efficient order fulfillment. This integration has improved customer convenience, reduced delivery times, and increased operational efficiency.

DHL supports omnichannel retail by providing integrated warehousing, transportation, order fulfillment, and returns management services for businesses worldwide. DHL's digital logistics platform connects suppliers, warehouses, online marketplaces, and retail stores, allowing companies to manage inventory and customer orders through a single system. Real-time shipment tracking and advanced analytics improve supply chain visibility and enable faster responses to changing customer demand.

Another excellent example is *Zara*. Zara has developed an omnichannel logistics model that links its stores, online platform, and distribution centers through centralized inventory management. Customers can check product availability online, order items for home delivery, or collect purchases from stores. The company's integrated logistics system enables rapid inventory replenishment and flexible order fulfillment, helping Zara respond quickly to changing fashion trends while maintaining high customer satisfaction.

To Chapter 3

The **Total Cost** concept in logistics focuses on minimizing the overall cost of supply chain operations rather than reducing the cost of a single activity. Instead of optimizing transportation, warehousing, inventory, or packaging independently, companies evaluate the combined impact of all logistics costs on overall business performance. This approach helps organizations make balanced decisions that improve efficiency, customer service, and long-term profitability.

One of the best examples is *Amazon*. Amazon invests heavily in automated warehouses, robotics, and advanced information systems. Although these technologies require significant initial investment, they reduce labor costs, improve inventory accuracy, accelerate order fulfillment, and lower long-term operating expenses. By evaluating the total cost of logistics rather than focusing only on warehouse expenses, Amazon has created one of the world's most efficient distribution networks while maintaining rapid delivery services.

Another successful example is *Walmart*. Walmart applies the Total Cost concept by integrating transportation, inventory management, supplier collaboration, and distribution planning. The company uses centralized distribution centers and advanced forecasting systems to reduce inventory holding costs while ensuring products remain available in stores. Although Walmart invests heavily in technology and logistics infrastructure, the resulting savings in transportation, inventory, and operational efficiency significantly reduce total supply chain costs.

DHL also applies the Total Cost approach in its global logistics operations. Instead of selecting the lowest-cost transportation option for each shipment, DHL evaluates factors such as delivery time, fuel consumption, warehouse capacity, customer service, and environmental impact. The company uses Transportation Management Systems (TMS), Warehouse Management Systems (WMS), and artificial intelligence to optimize the entire logistics network. This integrated approach reduces operational costs while improving delivery reliability and customer satisfaction.

Another important example is *Toyota*. Toyota combines the Total Cost concept with Lean Logistics and the Just-in-Time (JIT) production system. By maintaining low inventory levels, improving supplier coordination, and reducing waste throughout the supply chain, Toyota minimizes total logistics costs rather than focusing only on production expenses. The company achieves higher efficiency, lower storage costs, and improved product quality through integrated logistics planning.

The **Just-in-Time (JIT)** logistics concept focuses on delivering materials and products exactly when they are needed in the production or distribution process. Instead of maintaining large inventories, companies coordinate closely with suppliers and transportation partners to minimize stock levels while ensuring continuous operations. JIT reduces inventory holding costs, improves production efficiency, and increases supply chain flexibility. Many global companies have successfully implemented JIT principles to achieve competitive advantages.

One of the most well-known examples is *Toyota*, the pioneer of the Just-in-Time production system. Toyota coordinates thousands of suppliers to deliver components precisely when they are required on the assembly line. The company integrates JIT with Enterprise Resource Planning (ERP), Material Requirements Planning (MRP), and supplier collaboration systems to synchronize procurement, production, and logistics activities. As a result, Toyota maintains low inventory levels, reduces warehouse costs, minimizes waste, and improves production efficiency while maintaining high product quality.

Another successful example is *Dell Technologies*. Dell applies the JIT concept in its build-to-order manufacturing model. Instead of producing computers for inventory, the company assembles products only after receiving customer orders. Suppliers deliver components directly to production facilities according to real-time demand forecasts, allowing Dell to reduce inventory costs, avoid product obsolescence, and respond quickly to changing customer requirements. This flexible supply chain has become one of Dell's major competitive advantages.

BMW has also successfully implemented JIT logistics across its global manufacturing network. Components are delivered to

assembly plants according to precise production schedules, reducing storage requirements and improving production flow. Advanced logistics technologies, supplier integration, and real-time transportation monitoring ensure that parts arrive exactly when needed. This approach reduces operating costs while increasing manufacturing efficiency and product quality.

Another excellent example is *Honda*, which uses Just-in-Time logistics to coordinate suppliers, production facilities, and distribution centers. Through close collaboration with suppliers and advanced production planning systems, Honda minimizes inventory while ensuring uninterrupted manufacturing operations. Continuous monitoring of supplier performance and transportation schedules enables the company to respond rapidly to fluctuations in demand and maintain efficient production processes.

Material Requirements Planning (MRP) is a computer-based planning system that helps companies determine what materials are needed, in what quantities, and when they should be available for production. By integrating inventory data, production schedules, and purchasing activities, MRP improves material availability, reduces inventory costs, and ensures efficient production planning. Many global manufacturing and logistics companies have successfully implemented MRP systems to optimize their supply chains.

One of the best-known examples is *Toyota*. Toyota integrates MRP with its Just-in-Time (JIT) production system to coordinate the delivery of thousands of components from suppliers. The MRP system analyzes production schedules and inventory levels to determine material requirements for each manufacturing stage. This enables Toyota to maintain low inventory levels while ensuring that all necessary parts are available when needed, reducing production delays and improving operational efficiency.

Another successful example is *Boeing*. The production of commercial aircraft requires millions of components supplied by manufacturers around the world. Boeing uses MRP systems to plan material purchases, schedule deliveries, and coordinate production across multiple facilities. By accurately forecasting material requirements, Boeing improves supplier coordination, minimizes production interruptions, and manages complex global supply chains more effectively.

Siemens also applies MRP to support its global manufacturing operations. The company integrates MRP with Enterprise Resource Planning (ERP) systems to manage procurement, inventory control, and production planning. Real-time analysis of inventory levels and production schedules enables *Siemens* to optimize purchasing decisions, reduce excess inventory, and improve resource utilization. This integrated approach increases production efficiency while lowering operating costs.

Another excellent example is *Nestlé*. *Nestlé* uses MRP to manage the procurement of raw materials, packaging materials, and production resources across its manufacturing facilities worldwide. The system calculates material requirements based on production forecasts and customer demand, ensuring that ingredients are available when required while minimizing inventory carrying costs. MRP also improves supplier coordination and supports consistent product availability in global markets.

Manufacturing Resource Planning (MRP II) is an advanced planning system that extends Material Requirements Planning (MRP) by integrating production planning with inventory management, purchasing, finance, capacity planning, and human resources. MRP II enables organizations to coordinate all manufacturing and logistics activities through a single information system, improving efficiency, reducing costs, and supporting better decision-making. Many global companies have successfully implemented MRP II to optimize their supply chains and manufacturing operations.

One of the leading examples is *Toyota*. *Toyota* combines MRP II with its Lean Manufacturing and Just-in-Time (JIT) principles to coordinate production schedules, supplier deliveries, inventory management, and resource planning. The system provides managers with real-time information on production capacity, material availability, labor requirements, and financial performance. This integrated approach enables *Toyota* to reduce inventory costs, improve production efficiency, and maintain a highly responsive supply chain.

Another successful implementation can be found at *Siemens*. *Siemens* uses MRP II to integrate manufacturing, procurement, warehouse operations, financial management, and production

scheduling across its global facilities. The system supports capacity planning, inventory optimization, and supplier coordination, ensuring that production resources are used efficiently. As a result, Siemens has improved production planning, reduced manufacturing costs, and enhanced supply chain visibility.

Boeing also relies on MRP II to manage the production of commercial aircraft. Manufacturing an aircraft requires thousands of suppliers and millions of individual components. MRP II integrates engineering data, procurement, production planning, inventory control, and financial management into a unified system. This enables Boeing to coordinate complex manufacturing processes, improve material availability, reduce production delays, and optimize resource utilization across its global operations.

Another excellent example is *Caterpillar*. Caterpillar uses MRP II to manage production resources across its worldwide manufacturing network. The system integrates demand forecasting, purchasing, production scheduling, inventory management, and financial planning. By coordinating these activities, Caterpillar improves equipment availability, reduces inventory levels, increases manufacturing efficiency, and responds more effectively to changing customer demand.

Distribution Requirements Planning (DRP) is a logistics planning system that determines when, where, and in what quantities products should be distributed throughout a supply chain. DRP helps companies manage inventory across distribution centers, warehouses, and retail locations by forecasting demand and coordinating replenishment. By integrating transportation, inventory management, and distribution planning, DRP improves product availability while reducing inventory costs. Many global companies have successfully implemented DRP to optimize their distribution networks.

One of the leading examples is *Walmart*. Walmart uses DRP to coordinate inventory replenishment across thousands of retail stores and distribution centers. The system analyzes sales data, inventory levels, and demand forecasts to determine when products should be shipped from distribution centers to stores. By integrating DRP with Enterprise Resource Planning (ERP) and Warehouse Management Systems (WMS), Walmart maintains high product availability while minimizing excess inventory. This approach reduces logistics costs

and ensures that customers can consistently find products on store shelves.

Another successful example is *Procter & Gamble*. The company uses DRP to manage the distribution of thousands of consumer products to retailers around the world. DRP enables Procter & Gamble to forecast regional demand, optimize inventory levels at distribution centers, and coordinate replenishment with manufacturing facilities. This integrated planning system improves product availability, reduces transportation costs, and supports efficient collaboration with retail partners.

Coca-Cola has also implemented DRP to coordinate product distribution across its extensive bottling and distribution network. The system analyzes customer demand, seasonal sales patterns, and inventory levels to schedule replenishment efficiently. By synchronizing production with distribution requirements, Coca-Cola minimizes stock shortages during periods of high demand while reducing excess inventory and improving transportation efficiency.

Another excellent example is *Nestlé*. Nestlé uses DRP to manage the global distribution of food and beverage products from manufacturing plants to regional warehouses and retail customers. The system integrates demand forecasting, inventory management, transportation planning, and warehouse operations, allowing the company to respond quickly to market changes while maintaining high service levels. DRP helps Nestlé improve inventory accuracy, reduce distribution costs, and increase supply chain responsiveness.

Lean Logistics is a management approach that focuses on eliminating waste, improving process efficiency, reducing costs, and creating value for customers throughout the supply chain. By minimizing unnecessary transportation, excess inventory, waiting time, and inefficient warehouse operations, Lean Logistics helps organizations achieve faster deliveries and higher operational performance. Many global logistics and manufacturing companies have successfully implemented Lean Logistics principles to strengthen their competitive advantage.

One of the most recognized examples is *Toyota*, the pioneer of Lean Manufacturing and Lean Logistics. Toyota applies Lean principles throughout its supply chain by combining Just-in-Time (JIT) delivery, continuous improvement (Kaizen), and close

collaboration with suppliers. Materials are delivered only when needed for production, reducing inventory levels and warehouse costs. Standardized processes and continuous monitoring eliminate waste and improve production efficiency, enabling Toyota to maintain high product quality while minimizing logistics costs.

Another successful example is *DHL*. DHL has adopted Lean Logistics practices across its warehousing and transportation operations to improve productivity and reduce operational waste. The company uses value stream mapping, process standardization, and continuous improvement programs to optimize warehouse layouts, shorten order processing times, and eliminate unnecessary movements. Combined with digital technologies such as Warehouse Management Systems (WMS) and Transportation Management Systems (TMS), Lean practices have helped DHL increase warehouse efficiency, reduce transportation costs, and improve customer service.

Amazon also applies Lean Logistics principles in its highly automated fulfillment centers. The company continuously analyzes warehouse processes to reduce unnecessary handling, optimize picking routes, and improve inventory management. Robotics, artificial intelligence, and data analytics support lean operations by minimizing delays, reducing errors, and increasing order fulfillment speed. These improvements allow Amazon to process millions of customer orders quickly while maintaining high operational efficiency.

Another excellent example is *IKEA*. IKEA has implemented Lean Logistics throughout its global distribution network by optimizing packaging, warehouse layouts, transportation planning, and inventory management. Flat-pack packaging reduces transportation and storage costs, while efficient warehouse design minimizes handling time and maximizes space utilization. Lean principles also support close cooperation with suppliers and distribution centers, ensuring reliable product availability and efficient replenishment.

Supply Chain Management (SCM) is the coordinated management of the flow of materials, information, and finances from suppliers to manufacturers, distributors, retailers, and final customers. Effective SCM integrates procurement, production, warehousing, transportation, and customer service to improve

efficiency, reduce costs, and increase customer satisfaction. Many global logistics companies have successfully implemented SCM strategies to build resilient and highly efficient supply chains.

One of the most successful examples is *DHL*. DHL provides integrated supply chain solutions for companies across industries such as healthcare, automotive, retail, and technology. Its SCM platform combines transportation management, warehouse management, customs services, inventory control, and real-time shipment tracking. By using digital technologies, artificial intelligence, and predictive analytics, DHL improves supply chain visibility, optimizes inventory levels, and reduces delivery times. This integrated approach enables customers to respond quickly to changing market conditions and improve overall operational performance.

Another leading example is *Amazon*. Amazon has built one of the world's most advanced supply chain networks by integrating suppliers, fulfillment centers, transportation systems, and last-mile delivery services. The company uses artificial intelligence, robotics, cloud computing, and real-time inventory management to forecast demand, optimize warehouse operations, and coordinate deliveries. Its SCM strategy enables rapid order fulfillment, efficient inventory management, and exceptional customer service, making Amazon a global leader in e-commerce logistics.

Maersk has transformed its business from a shipping company into an integrated supply chain provider. Maersk offers end-to-end logistics services, including ocean freight, inland transportation, warehousing, customs clearance, and digital supply chain management. Through advanced SCM platforms, customers can monitor shipments in real time, manage inventory, and coordinate international logistics activities across multiple countries. This integrated model improves supply chain transparency, reduces transportation delays, and increases operational efficiency.

Another excellent example is *Unilever*. Unilever manages a complex global supply chain that connects thousands of suppliers, manufacturing facilities, distribution centers, and retail partners. The company uses integrated SCM systems to improve demand forecasting, procurement planning, production scheduling, and distribution management. Advanced analytics and digital

technologies help optimize inventory levels, reduce waste, and support sustainable supply chain practices while ensuring product availability in markets worldwide.

The **Push model** is a supply chain strategy in which products are manufactured and distributed based on demand forecasts rather than actual customer orders. Companies using the Push model rely on historical sales data, market trends, and demand forecasting to produce goods in advance and distribute them to warehouses or retail stores before customer purchases occur. This approach is particularly effective for products with stable and predictable demand.

One of the best-known examples is *Procter & Gamble*. The company manufactures household and personal care products based on demand forecasts and distributes them to regional warehouses and retail stores worldwide. Advanced forecasting systems analyze historical sales data and seasonal demand patterns, allowing Procter & Gamble to maintain high product availability while supporting efficient large-scale production. The Push model helps the company reduce manufacturing costs and ensure that retailers receive products before customer demand peaks.

Another successful example is *Coca-Cola*. Coca-Cola uses the Push model to produce and distribute beverages to distributors, supermarkets, and retail outlets before periods of high demand, such as holidays and summer seasons. Production planning is based on sales forecasts, weather conditions, and market trends. This proactive distribution strategy ensures that products are readily available to customers while supporting efficient transportation and warehouse utilization.

Unilever also applies the Push model across its global supply chain. The company forecasts demand for food, home care, and personal care products and manufactures goods in advance to maintain inventory at regional distribution centers. Integrated Enterprise Resource Planning (ERP) and Supply Chain Management (SCM) systems support production scheduling, inventory management, and distribution planning. As a result, Unilever maintains high service levels while reducing production interruptions.

Another important example is *Nestlé*. Nestlé uses demand forecasting and distribution planning to manufacture products before

customer orders are received. Products are delivered to warehouses and retail partners to ensure continuous product availability. By combining the Push model with advanced inventory management systems, Nestlé achieves efficient production planning, stable product supply, and lower unit manufacturing costs.

The **Pull model** is a supply chain strategy in which production and distribution are initiated only after receiving actual customer orders. Instead of producing goods based on demand forecasts, companies respond directly to real market demand, reducing inventory levels and increasing supply chain flexibility. The Pull model is particularly effective for customized products, rapidly changing markets, and industries where inventory obsolescence is a significant risk.

One of the most successful examples is *Dell Technologies*. Dell pioneered the build-to-order business model, where computers are assembled only after customers place their orders. The company receives components from suppliers in real time and begins production based on confirmed demand. By implementing the Pull model, Dell significantly reduced inventory costs, minimized product obsolescence, and responded quickly to changing customer preferences. The company's integrated ERP and Supply Chain Management (SCM) systems enable efficient coordination between suppliers, production facilities, and customers.

Another excellent example is *Toyota*. Toyota combines the Pull model with its Just-in-Time (JIT) production philosophy. Manufacturing activities are triggered by actual customer demand, while the Kanban system signals suppliers to replenish components only when they are needed. This approach minimizes inventory levels, reduces waste, and improves production efficiency while maintaining high product quality. The Pull model has become one of the foundations of Toyota's Lean Manufacturing system.

Zara has also successfully implemented the Pull model in its global supply chain. Zara continuously collects sales data from its retail stores and online platforms to identify changing customer preferences. Production decisions are based on actual sales rather than long-term forecasts, allowing the company to introduce new fashion collections rapidly and replenish popular products quickly. This responsive supply chain minimizes excess inventory and

enables Zara to adapt to fast-changing fashion trends.

Another successful implementation can be found at *Hewlett-Packard*. HP uses the Pull model for selected product lines by postponing final product configuration until customer orders are received. This postponement strategy allows the company to maintain lower inventory levels while offering customized products for different markets. By synchronizing procurement, production, and distribution with actual customer demand, HP improves inventory management and reduces supply chain costs.

The **Economic Order Quantity (EOQ) model** is an inventory management technique used to determine the optimal order quantity that minimizes the total costs of ordering and holding inventory. By balancing these two cost components, EOQ helps organizations maintain sufficient stock while reducing unnecessary inventory expenses. Many global logistics and manufacturing companies apply EOQ principles as part of their inventory management and supply chain optimization strategies.

One of the most successful examples is *Walmart*. Walmart applies EOQ principles together with advanced inventory management systems to determine the most economical replenishment quantities for thousands of products. By analyzing customer demand, supplier lead times, and inventory holding costs, the company places orders that minimize total logistics costs while ensuring high product availability. This approach has reduced excess inventory, lowered storage expenses, and improved inventory turnover across its global distribution network.

Another excellent example is *Amazon*. Amazon combines EOQ with artificial intelligence, demand forecasting, and automated inventory management systems to optimize replenishment decisions in its fulfillment centers. The company continuously analyzes customer demand, ordering costs, warehouse capacity, and supplier performance to determine appropriate order quantities. As a result, Amazon maintains high inventory availability while minimizing storage costs and improving warehouse efficiency.

DHL also applies EOQ principles in managing inventory for customers using its contract logistics and warehouse management services. By calculating optimal replenishment quantities for spare parts, consumer goods, and industrial products, DHL helps

customers reduce inventory carrying costs while maintaining reliable product availability. Integration with Warehouse Management Systems (WMS) and Enterprise Resource Planning (ERP) systems enables continuous monitoring of inventory levels and automatic replenishment when optimal reorder points are reached.

Another important example is *Toyota*. Although Toyota is widely recognized for its Just-in-Time (JIT) philosophy, the company applies EOQ principles for selected materials, spare parts, and maintenance supplies where continuous replenishment is required. By balancing ordering and storage costs, Toyota optimizes inventory levels without interrupting production. The integration of EOQ with Material Requirements Planning (MRP) and ERP systems supports efficient purchasing and inventory management throughout the supply chain.

The **ABC model** is a widely used inventory control technique that classifies products according to their value and importance. Based on the Pareto Principle, the model divides inventory into three categories: A items, which represent the highest-value products requiring strict control; B items, which require moderate monitoring; and C items, which are low-value products managed with simpler control procedures. Many logistics companies use the ABC model to improve inventory management, reduce costs, and increase operational efficiency.

One of the leading examples is *DHL*. DHL applies ABC inventory classification in its distribution centers to manage inventory for customers across industries such as healthcare, automotive, and retail. High-value products such as electronic components and pharmaceutical goods are classified as A items and receive continuous monitoring, secure storage, and frequent inventory checks. Medium-value products are classified as B items, while low-value consumables are managed as C items with less intensive control. This approach improves inventory accuracy, reduces storage costs, and increases warehouse productivity.

Another successful example is *Amazon*. Amazon uses ABC classification together with artificial intelligence and warehouse management systems to organize millions of products stored in its fulfillment centers. Fast-moving and high-value products are categorized as A items and placed in easily accessible storage

locations to reduce picking time. Medium-demand products are managed as B items, while slow-moving, low-value products are classified as C items and stored in less frequently accessed areas. This strategy improves order fulfillment speed, optimizes warehouse space, and increases operational efficiency.

Walmart also implements the ABC model across its extensive retail and distribution network. Inventory items are classified according to sales volume, product value, and customer demand. High-value and fast-selling products receive close inventory monitoring and frequent replenishment, while lower-value products require less frequent control. This classification enables *Walmart* to reduce inventory carrying costs, improve product availability, and optimize warehouse operations.

Another excellent example is *DB Schenker*. The company uses the ABC Inventory Management Model in its contract logistics operations to help customers optimize warehouse management and inventory control. By categorizing products according to their financial value and operational importance, *DB Schenker* allocates warehouse space, labor resources, and inventory control efforts more efficiently. This approach improves inventory accuracy, reduces operational costs, and enhances customer service across various industries.

To Chapter 6

Vendor Managed Inventory (VMI) is an inventory management strategy in which the supplier assumes responsibility for monitoring stock levels and replenishing inventory at the customer's location. Instead of the buyer placing purchase orders, the supplier uses real-time sales and inventory data to determine when and how much inventory should be delivered. VMI improves supply chain coordination, reduces inventory costs, and increases product availability.

One of the best-known examples is the collaboration between Walmart and *Procter & Gamble (P&G)*. P&G receives continuous access to Walmart's inventory and point-of-sale data through integrated information systems. Based on this information, P&G automatically replenishes products in Walmart's distribution centers and stores. This partnership has significantly reduced stock shortages, lowered inventory carrying costs, improved forecasting accuracy, and increased product availability for customers. It has also strengthened long-term cooperation between the retailer and supplier.

Another successful implementation is *Nestlé's* VMI program with major supermarket chains across Europe and Asia. Nestlé uses Electronic Data Interchange (EDI), Enterprise Resource Planning (ERP) systems, and demand forecasting tools to monitor inventory levels at retail warehouses. The company plans replenishment deliveries according to actual sales rather than fixed schedules. As a result, retailers maintain lower inventory levels while ensuring high product availability. The approach also reduces waste, transportation costs, and order processing time.

DHL Supply Chain offers VMI services to manufacturers in industries such as automotive, healthcare, and consumer goods. By combining warehouse management systems, IoT sensors, RFID technology, and predictive analytics, DHL monitors inventory in real time and automatically initiates replenishment when stock reaches predefined reorder points. These solutions improve inventory accuracy, minimize production interruptions, reduce warehouse space requirements, and enhance supply chain visibility.

The automotive industry also demonstrates effective VMI implementation. Companies such as *Bosch* and *Toyota* work closely with component suppliers that monitor inventory levels directly at manufacturing facilities. Suppliers replenish materials before shortages occur, supporting Just-in-Time (JIT) production while minimizing inventory investment. This collaboration helps reduce production downtime and improve manufacturing efficiency.

Electronic procurement (E-procurement) is the use of digital technologies and online platforms to manage purchasing activities, including supplier selection, ordering, contract management, invoicing, and payment processing. E-procurement systems improve procurement efficiency, reduce administrative costs, increase transparency, and strengthen supplier relationships.

One of the most successful examples is *DHL* Supply Chain, which has implemented a global e-procurement platform to manage purchasing across its worldwide operations. The system integrates supplier databases, electronic tenders, purchase orders, contract management, and invoice processing into a single digital environment. Automated approval workflows and real-time reporting have significantly reduced procurement cycle times, minimized paperwork, and improved compliance with corporate purchasing policies. As a result, DHL has achieved lower procurement costs and better supplier performance.

Another leading example is *Maersk*, one of the world's largest shipping and logistics companies. Maersk uses advanced digital procurement solutions integrated with its Enterprise Resource Planning (ERP) system to manage purchases of fuel, shipping equipment, spare parts, maintenance services, and office supplies. The platform allows suppliers to submit electronic quotations and invoices while enabling procurement managers to compare offers, monitor contracts, and analyze spending patterns. This digital transformation has improved purchasing efficiency, reduced manual errors, and increased supply chain transparency.

DB Schenker has also successfully adopted e-procurement technologies to support its international logistics operations. Through cloud-based procurement platforms, the company automates supplier qualification, electronic sourcing, contract management, and

purchasing approvals. Integration with warehouse management and transportation systems enables accurate demand forecasting and timely procurement of logistics resources. The result is improved procurement planning, stronger supplier collaboration, and lower operational costs.

FedEx utilizes electronic procurement systems to manage purchasing activities across its global transportation network. Digital procurement tools support online supplier registration, electronic auctions, purchase order automation, and invoice matching. Procurement data analytics help identify cost-saving opportunities and evaluate supplier performance based on quality, delivery reliability, and pricing. These capabilities contribute to greater operational efficiency and better financial control.

Kanban is a lean inventory management system that uses visual signals to control the movement and replenishment of materials throughout the supply chain. Originally developed by Toyota, Kanban helps organizations produce and replenish goods only when they are needed, reducing waste, excess inventory, and lead times. Today, many logistics companies use Kanban principles to improve warehouse operations, inventory control, and supply chain efficiency.

One of the most successful examples is *Toyota*, where the Kanban system was first introduced as part of the Toyota Production System (TPS). Logistics teams use Kanban cards and electronic signals to trigger the movement of components between suppliers, warehouses, and production lines. Materials are replenished only after they have been consumed, ensuring a continuous flow of goods while minimizing inventory levels. This approach has significantly reduced storage costs, improved production efficiency, and increased responsiveness to customer demand.

Another example is *DHL Supply Chain*, which applies electronic Kanban (e-Kanban) solutions in automotive and manufacturing logistics. Digital Kanban boards integrated with Warehouse Management Systems (WMS) automatically notify suppliers when inventory reaches predefined reorder levels. This automation enables just-in-time replenishment, reduces manual inventory checks, and improves warehouse productivity. DHL reports lower inventory holding costs, fewer stock shortages, and better synchronization

between suppliers and customers.

Bosch has successfully implemented Kanban systems across its manufacturing and distribution facilities. Components are stored in standardized containers equipped with Kanban labels or RFID tags. When a container becomes empty, the system automatically generates a replenishment request to suppliers or internal warehouses. This method reduces excess inventory, shortens replenishment lead times, and improves production continuity while supporting lean manufacturing practices.

Another successful implementation can be found at *BMW*, where Kanban is integrated with supplier logistics and assembly operations. Electronic Kanban signals coordinate the delivery of automotive components directly to production lines according to real-time demand. By combining Kanban with automated warehouse technologies and digital tracking systems, *BMW* minimizes warehouse space requirements, improves inventory accuracy, and increases operational flexibility.

To Chapter 7

Manufacturing Execution System (MES) is a digital solution that monitors, controls, and optimizes manufacturing operations in real time. It connects Enterprise Resource Planning (ERP) systems with shop-floor activities, providing complete visibility of production processes, inventory movements, equipment performance, and product quality. Logistics companies supporting manufacturing operations increasingly use MES to improve supply chain coordination, warehouse efficiency, and production logistics.

One of the most successful examples is *DHL Supply Chain*, which provides integrated manufacturing logistics services for automotive, electronics, and healthcare industries. DHL has implemented MES solutions in customer production facilities to synchronize material deliveries with manufacturing schedules. By integrating MES with Warehouse Management Systems (WMS) and Transportation Management Systems (TMS), DHL ensures that production materials arrive exactly when needed. This approach has reduced production delays, improved inventory accuracy, and increased warehouse productivity while supporting Just-in-Time (JIT) manufacturing.

Another successful implementation is *DB Schenker*, which supports industrial manufacturers through digital production logistics. MES platforms are integrated with warehouse operations, automated storage systems, and transportation planning. Real-time production data allows DB Schenker to coordinate inbound material flows, monitor work-in-progress inventory, and schedule deliveries according to changing production requirements. As a result, manufacturers experience fewer production interruptions, improved supply chain visibility, and lower inventory costs.

Kuehne+Nagel also utilizes MES technologies in contract logistics for advanced manufacturing industries. The company integrates MES with Internet of Things (IoT) sensors, barcode scanning, and RFID technologies to monitor production materials and finished goods throughout the manufacturing process. Automated data collection enables accurate inventory tracking, quality monitoring, and efficient coordination between production

and distribution centers. This has led to improved operational efficiency, faster order fulfillment, and reduced manual data entry errors.

A further example is *CEVA Logistics*, which provides manufacturing logistics solutions for the automotive and aerospace sectors. CEVA integrates MES with ERP systems and automated warehouse technologies to coordinate production schedules with inventory replenishment and transportation planning. Real-time production monitoring allows the company to respond quickly to demand changes, optimize resource utilization, and minimize production downtime.

Advanced Planning and Scheduling (APS) is a software solution that optimizes production planning, resource allocation, and logistics scheduling by considering demand forecasts, material availability, production capacity, labor resources, machine constraints, and delivery deadlines. APS enables companies to create realistic production schedules, improve resource utilization, reduce lead times, and respond quickly to changes in customer demand. Many logistics providers integrate APS with Enterprise Resource Planning (ERP), Manufacturing Execution Systems (MES), Warehouse Management Systems (WMS), and Transportation Management Systems (TMS) to enhance supply chain performance.

One of the leading examples is *DHL Supply Chain*, which uses APS solutions to coordinate manufacturing logistics for automotive, electronics, and consumer goods companies. APS software synchronizes production schedules with inbound material deliveries, warehouse operations, and outbound transportation. By optimizing production and delivery schedules simultaneously, DHL reduces inventory levels, minimizes production delays, and improves on-time deliveries. The integration of APS with ERP and WMS provides real-time visibility across the entire supply chain.

Another successful implementation is *DB Schenker*, which applies APS technology to manage logistics operations for industrial manufacturers. The system analyzes customer orders, production capacity, transportation availability, and warehouse resources to create optimized schedules. When unexpected disruptions occur, APS automatically recalculates production and delivery plans, helping maintain supply chain continuity. This approach has

improved resource utilization, reduced bottlenecks, and increased operational flexibility.

Kuehne+Nagel has implemented APS solutions in contract logistics and manufacturing support services. By combining APS with demand forecasting, IoT sensors, and warehouse automation, the company coordinates inventory replenishment, production schedules, and transportation activities in real time. This integrated planning enables more accurate delivery scheduling, lower inventory costs, and faster response to changing customer requirements.

CEVA Logistics also uses APS systems to support automotive and aerospace manufacturers. The company integrates APS with MES and TMS platforms to optimize production sequencing, warehouse operations, and transportation planning. Advanced scheduling algorithms allow *CEVA* to maximize equipment utilization, reduce idle time, and ensure timely delivery of production materials. These improvements contribute to higher productivity and better customer service.

To Chapter 9

Intermodal transportation has become an essential logistics strategy for companies seeking to improve efficiency, reduce costs, and minimize environmental impact. It involves transporting goods using two or more modes of transport—such as road, rail, maritime, or air – while keeping the cargo in the same container or loading unit throughout the journey. This reduces handling, lowers the risk of cargo damage, and speeds up the movement of goods.

A leading example is *DHL Group*, which operates an extensive intermodal network across Europe, Asia, and North America. DHL combines rail transport for long-distance freight with road transport for first- and last-mile deliveries. For international shipments, the company integrates maritime transport with rail and trucking services, allowing customers to receive reliable door-to-door delivery while reducing transportation costs and carbon emissions.

Another successful implementation is *Maersk*, one of the world's largest logistics providers. Maersk has expanded beyond ocean shipping to offer integrated intermodal logistics solutions. Containers arriving at seaports are transferred directly to rail services for inland transportation and then delivered by trucks to customers. This approach shortens transit times, improves supply chain coordination, and enables customers to manage international shipments through a single logistics provider.

DB Schenker has also developed an efficient intermodal transportation network, particularly throughout Europe. The company uses rail freight for long-distance cargo movement and road transport for regional distribution. By shifting significant freight volumes from highways to railways, DB Schenker lowers fuel consumption, reduces traffic congestion, and supports the European Union's sustainability goals.

A further example is *UPS*, which integrates rail and road transportation across North America. Long-distance freight is transported by rail because of its lower cost and environmental advantages, while trucks handle local pickup and final delivery. This combination allows UPS to maintain high service quality while improving operational efficiency and reducing greenhouse gas

emissions.

Multimodal transportation is the movement of goods using two or more different modes of transport under a single contract managed by one logistics operator. Unlike intermodal transportation, the entire shipment is coordinated by a single carrier or logistics provider, which assumes full responsibility from the point of origin to the final destination. This approach simplifies logistics management, improves shipment visibility, and increases supply chain efficiency.

One of the best examples is *DHL Group*, which provides multimodal transportation services worldwide by integrating road, rail, maritime, and air transport. DHL manages the entire shipping process under one transport agreement, allowing customers to track shipments through a single digital platform. Depending on delivery requirements, the company selects the most efficient combination of transport modes to minimize costs while meeting delivery deadlines.

Another successful example is *Kuehne+Nagel*, a global logistics provider specializing in integrated supply chain solutions. The company combines ocean freight, air freight, rail services, and road transportation to deliver goods across continents. Its advanced transportation management systems optimize routes, coordinate customs procedures, and provide real-time shipment tracking. This multimodal approach enables customers to receive faster, more reliable, and cost-effective logistics services.

DB Schenker has also implemented multimodal transportation solutions for manufacturers and retailers worldwide. The company manages international shipments by combining maritime transport for overseas movement, rail for inland transportation, and trucks for final delivery. Customers benefit from a single transport contract, centralized shipment management, and reduced administrative complexity while maintaining high delivery reliability.

A further example is *CEVA Logistics*, which offers end-to-end multimodal transportation for industries such as automotive, healthcare, and consumer goods. CEVA integrates sea, air, rail, and road transport according to customer requirements, balancing delivery speed, transportation costs, and environmental sustainability. The company also uses digital platforms to monitor shipments and optimize transport planning across global supply chains.

To Chapter 10

First In – First Out (FIFO) is one of the most widely used inventory management methods in warehouse logistics. Under the FIFO principle, the products that enter the warehouse first are the first to be picked, shipped, or sold. This method is particularly important for industries dealing with perishable goods, pharmaceuticals, food products, and consumer goods, where product freshness and shelf life are critical.

One of the best examples of successful *FIFO* implementation is *DHL* Supply Chain, which operates distribution centers for food, beverage, and healthcare companies. DHL uses Warehouse Management Systems (WMS), barcode scanning, and RFID technology to record the arrival date of every pallet and automatically select the oldest inventory for order fulfillment. This approach minimizes product expiration, reduces waste, and ensures compliance with food safety and pharmaceutical regulations.

Another successful example is *Amazon*, which applies FIFO in many of its fulfillment centers for products with expiration dates, including groceries, health products, and cosmetics. Advanced warehouse management software continuously tracks inventory age and directs employees or warehouse robots to pick the oldest available stock first. This improves inventory turnover, reduces obsolete inventory, and enhances customer satisfaction by delivering fresh products.

UPS Supply Chain Solutions also implements FIFO in its distribution centers serving retail and healthcare customers. The company integrates WMS with ERP systems to monitor inventory movement in real time. Barcode scanning and automated storage systems ensure that products received first are dispatched first, improving inventory accuracy and reducing losses caused by expired or outdated products.

A further example is *Kuehne+Nagel*, which manages temperature-controlled warehouses for pharmaceutical and food industries. FIFO procedures are supported by digital inventory tracking, automated storage systems, and strict quality control processes. These technologies help maintain product quality while

ensuring regulatory compliance and efficient warehouse operations.

Last In – First Out (LIFO) is an inventory management method in which the most recently received goods are issued or used first. Although LIFO is less common than FIFO in warehouse logistics, it is effective for certain types of non-perishable products, bulk materials, and industries where the newest inventory is the easiest to access. LIFO is often applied in warehouses storing construction materials, metals, chemicals, and industrial products.

One example of successful LIFO implementation is *Caterpillar*, a global manufacturer of construction and mining equipment. In its parts distribution centers, selected heavy components and metal products are stored in stack systems where the most recently placed items are retrieved first. This storage method reduces unnecessary handling, improves loading efficiency, and optimizes the use of warehouse space for durable products that are not affected by storage time.

Another example is *C.H. Robinson*, a global logistics provider that manages warehouse operations for industrial customers. In warehouses storing steel coils, pipes, and construction materials, LIFO is used because newly delivered products are placed on top of existing inventory and are immediately accessible for shipment. This minimizes equipment movement, shortens loading times, and reduces warehouse operating costs.

XPO Logistics also applies LIFO in selected industrial warehouses handling raw materials, packaging materials, and non-perishable manufacturing supplies. The company integrates Warehouse Management Systems (WMS) with automated storage equipment to manage inventory locations efficiently while supporting customers whose production processes require rapid access to the most recently delivered materials.

A further example is *Ryder System*, which provides warehousing services for manufacturing and industrial clients. In facilities storing durable goods such as pallets of construction supplies and heavy industrial components, LIFO allows forklifts to retrieve products with minimal repositioning of inventory. This improves warehouse productivity and reduces labor and equipment costs.

Pick-by-Light (PBL) is a warehouse order-picking technology that uses LED lights and digital displays installed on storage racks to

guide warehouse workers to the correct product location and indicate the required quantity to pick. The system significantly improves picking speed, reduces errors, and increases warehouse productivity. It is widely used in e-commerce, retail, automotive, and distribution centers where fast and accurate order fulfillment is essential.

One of the most successful implementations of Pick-by-Light is found in *DHL Supply Chain*. The company has introduced PBL technology in several distribution centers serving retail, consumer goods, and automotive customers. When an order is received, lights automatically illuminate the correct storage locations, and workers confirm each pick by pressing a button. This system has reduced picking errors, accelerated order processing, and improved overall warehouse efficiency while shortening employee training time.

Another leading example is *Amazon*, which uses Pick-by-Light technology alongside warehouse robots and Warehouse Management Systems (WMS) in many fulfillment centers. LED indicators direct employees to the exact storage bin containing the required item, allowing orders to be picked quickly and accurately. Combined with automated inventory management, the system supports high-volume order fulfillment and enables Amazon to meet demanding delivery schedules.

DB Schenker has also implemented Pick-by-Light systems in warehouses serving the automotive and electronics industries. The technology is integrated with barcode scanners and WMS software, ensuring real-time inventory updates and accurate order picking. As a result, warehouse productivity has increased while order errors and product returns have been significantly reduced.

A further example is *Kuehne+Nagel*, which applies Pick-by-Light technology in distribution centers handling healthcare products and consumer goods. The system helps employees quickly identify storage locations, improving picking accuracy for products that require strict quality and traceability standards. Integration with ERP and WMS systems provides complete visibility of warehouse operations and supports efficient inventory management.

Voice Picking (VDP, Voice-Directed Picking) is a warehouse technology that guides employees through order-picking tasks using voice instructions delivered via a headset. Workers receive spoken directions to product locations and confirm completed tasks by voice,

allowing them to work hands-free and focus entirely on handling goods. This technology improves picking speed, accuracy, and warehouse productivity while reducing training time and operational errors.

One of the most successful implementations of Voice Picking is found in *DHL Supply Chain*. The company uses voice-directed systems in distribution centers serving the retail, food, and consumer goods industries. Warehouse employees receive real-time picking instructions through wireless headsets connected to the Warehouse Management System (WMS). Because workers do not need paper pick lists or handheld scanners for every task, DHL has improved order accuracy, increased productivity, and shortened order fulfillment times.

Another leading example is *Kuehne+Nagel*, which has introduced Voice Picking in warehouses handling food products, pharmaceuticals, and fast-moving consumer goods (FMCG). The technology enables employees to keep both hands free while picking items, improving safety and reducing fatigue. Integration with WMS provides real-time inventory updates and ensures that orders are completed accurately and efficiently.

DB Schenker also uses Voice Picking technology in logistics centers serving the automotive and retail sectors. Voice-guided workflows direct employees to the correct storage locations and confirm each completed pick instantly. This has reduced picking errors, increased warehouse throughput, and improved inventory accuracy. The company combines Voice Picking with barcode scanning and ERP integration to optimize warehouse operations.

A further example is *UPS Supply Chain Solutions*, which applies Voice Picking in distribution centers managing high volumes of customer orders. The system helps employees complete picking tasks more quickly while maintaining high accuracy levels. Voice-directed operations are especially valuable during peak demand periods when fast and reliable order fulfillment is critical for customer satisfaction.

Safety Stock (SS) is the additional inventory maintained to protect against unexpected increases in customer demand, supplier delays, or disruptions in the supply chain. Maintaining an appropriate level of safety stock helps companies avoid stockouts, ensure continuous operations, and improve customer service while

balancing inventory carrying costs.

One of the best examples of successful safety stock implementation is *Amazon*. The company uses advanced forecasting algorithms, artificial intelligence, and real-time demand analysis to determine optimal safety stock levels for millions of products stored in its fulfillment centers. During peak shopping periods such as Prime Day and the holiday season, Amazon strategically increases safety stock to ensure high product availability and rapid order fulfillment. This approach minimizes lost sales and maintains fast delivery performance.

Another successful example is *DHL Supply Chain*, which manages warehouses for manufacturers, retailers, and healthcare companies worldwide. DHL calculates safety stock using historical sales data, demand forecasts, and supplier lead times. Warehouse Management Systems (WMS) continuously monitor inventory levels and automatically trigger replenishment when stock reaches predefined reorder points. This strategy reduces the risk of stock shortages while optimizing inventory costs.

UPS Supply Chain Solutions also applies safety stock strategies for customers in the healthcare, automotive, and consumer goods sectors. The company combines predictive analytics with inventory management software to determine the appropriate reserve inventory for each product. By maintaining carefully planned safety stock, UPS ensures uninterrupted production and reliable customer deliveries, even when transportation delays or supplier disruptions occur.

A further example is *Kuehne+Nagel*, which uses safety stock management in its global distribution centers, particularly for pharmaceutical and medical products. The company integrates Enterprise Resource Planning (ERP) systems with Warehouse Management Systems (WMS) to monitor inventory in real time and adjust safety stock levels according to changes in demand and supply conditions. This approach supports regulatory compliance while ensuring the continuous availability of critical products.

Warehouse Management System (WMS) is a software solution that manages and optimizes warehouse operations, including receiving, inventory control, storage, order picking, packing, shipping, and reporting. By providing real-time inventory visibility and automating warehouse processes, WMS helps logistics

companies improve operational efficiency, reduce costs, and enhance customer service.

One of the most successful examples of WMS implementation is *DHL Supply Chain*. The company uses advanced WMS platforms across its global distribution centers to manage inventory, optimize storage locations, and coordinate order fulfillment. The system integrates barcode scanning, RFID technology, and automated material handling equipment, enabling real-time inventory tracking and highly accurate warehouse operations. As a result, DHL has significantly improved order accuracy, warehouse productivity, and customer satisfaction.

Another leading example is *Amazon*, whose fulfillment centers rely on sophisticated WMS software integrated with robotics and artificial intelligence. The WMS coordinates millions of inventory movements every day, directs autonomous mobile robots to storage locations, and optimizes picking routes for warehouse employees. This highly automated system allows Amazon to process customer orders quickly while maintaining excellent inventory accuracy and fast delivery performance.

Kuehne+Nagel has also implemented advanced Warehouse Management Systems in its logistics centers serving industries such as healthcare, automotive, and consumer goods. The WMS provides real-time inventory visibility, automated replenishment, and integration with Enterprise Resource Planning (ERP) and Transportation Management Systems (TMS). These capabilities improve warehouse efficiency, reduce operating costs, and support complete supply chain transparency.

Another successful implementation can be found at *DB Schenker*, where WMS technology manages warehouse activities across large distribution networks in Europe, Asia, and North America. The system optimizes storage allocation, controls inventory movements, supports barcode and RFID scanning, and generates performance reports for warehouse managers. Integration with automated storage systems and digital tracking technologies has increased warehouse productivity while reducing picking and shipping errors.

ERP integration in warehouse operations connects an Enterprise Resource Planning (ERP) system with a Warehouse Management System (WMS) to ensure seamless data exchange

between inventory, procurement, production, sales, finance, and logistics. This integration provides real-time visibility of warehouse activities, automates business processes, and improves decision-making across the supply chain.

One of the best examples of successful ERP integration is *DHL Supply Chain*. The company integrates ERP platforms such as SAP with advanced Warehouse Management Systems across its global distribution centers. When goods are received, stored, picked, or shipped, inventory data is automatically synchronized with procurement, sales, and financial modules. This real-time information flow improves inventory accuracy, shortens order processing times, and enhances customer service by providing up-to-date stock information.

Another successful implementation is *Kuehne+Nagel*, which combines ERP systems with WMS to manage complex international supply chains. Warehouse operations are fully integrated with purchasing, transportation, customs documentation, and financial management. The ERP system automatically updates inventory records after every warehouse transaction, allowing managers to monitor stock levels, optimize replenishment, and improve supply chain planning.

DB Schenker has also implemented ERP integration in its warehouse network to support customers in the automotive, healthcare, and retail industries. The company's ERP and WMS platforms exchange real-time information on inventory movements, customer orders, and shipment status. Automated data synchronization eliminates duplicate data entry, reduces administrative errors, and improves warehouse productivity. Integration with Transportation Management Systems (TMS) further enhances end-to-end logistics visibility.

A further example is *CEVA Logistics*, which uses integrated ERP and warehouse systems to coordinate inventory management, order fulfillment, procurement, and financial reporting. Warehouse employees use barcode scanners and mobile devices connected directly to the ERP system, ensuring that every inventory transaction is recorded instantly. This integration supports accurate stock control, faster order fulfillment, and efficient coordination between warehouses and other business departments.

Internet of Things (IoT) has transformed warehouse logistics by connecting sensors, smart devices, warehouse equipment, and inventory through the internet. IoT enables real-time monitoring of warehouse operations, automated data collection, predictive maintenance, and intelligent inventory management. By integrating IoT with WMS and ERP systems, logistics companies improve efficiency, reduce operational costs, and increase supply chain visibility.

One of the most successful examples of IoT implementation is *DHL Supply Chain*. The company uses IoT sensors, RFID tags, and connected devices in its warehouses to monitor inventory, track pallets, and supervise warehouse equipment in real time. Environmental sensors continuously measure temperature and humidity in warehouses storing pharmaceuticals and food products, ensuring product quality and regulatory compliance.

Another leading example is *Amazon*, which has introduced IoT technologies throughout its fulfillment centers. Thousands of connected sensors monitor autonomous mobile robots, conveyor systems, storage racks, and inventory locations. IoT devices provide real-time operational data that helps optimize picking routes, improve equipment utilization, and predict maintenance needs before failures occur.

DB Schenker has also implemented IoT solutions in its global warehouse network. Smart sensors track the location and condition of goods, monitor warehouse equipment, and collect operational data for performance analysis. IoT technology is integrated with Warehouse Management Systems, allowing managers to monitor inventory movements in real time and optimize warehouse processes while reducing downtime and operating costs.

Another successful example is *Kuehne+Nagel*, which applies IoT technology in logistics centers serving the healthcare, automotive, and consumer goods industries. Connected devices monitor environmental conditions, inventory status, and equipment performance, while predictive analytics identify potential operational issues before they affect warehouse performance. Integration with ERP and WMS platforms provides complete visibility across warehouse operations and supports more efficient supply chain management.

GLOSSARY

ABC model – an inventory classification method that categorizes items into three groups (A, B, and C) according to their value and importance. A items are high-value products requiring strict control, B items have moderate value and control requirements, and C items are low-value products managed with simpler inventory control procedures.

Advanced Planning and Scheduling (APS) is an intelligent software system used to optimize production planning and scheduling by considering factors such as customer demand, production capacity, material availability, labor resources, machine constraints, and delivery deadlines. APS generates optimized production schedules, minimizes bottlenecks, improves resource utilization, reduces lead times, and enhances on-time delivery performance. It is commonly integrated with ERP and MES systems to support efficient manufacturing and supply chain management.

Agile logistics is a logistics strategy that emphasizes flexibility, responsiveness, and the ability to adapt quickly to changing customer demands, market conditions, and supply chain disruptions. It focuses on rapid decision-making, collaboration, and efficient resource utilization to maintain high service levels.

Air transport – the transportation of goods by aircraft. It is the fastest mode of transport and is commonly used for high-value, perishable, or time-sensitive products, despite its relatively high cost.

Distribution (sales) logistics is the planning, implementation, and control of the movement and storage of finished goods from manufacturers to customers. Its objective is to deliver the right product, in the right quantity and condition, to the right place, at the right time, and at the lowest possible cost while ensuring high customer satisfaction.

DRP (Distribution Requirements Planning) – a logistics planning system used to determine inventory replenishment and product distribution across warehouses and distribution centers. DRP helps ensure products are available where and when customers need them while minimizing inventory costs.

EOQ (Economic Order Quantity) model – an inventory management model that determines the optimal order quantity that

minimizes the total cost of ordering and holding inventory while ensuring sufficient stock availability.

E-procurement systems are digital platforms that automate and manage the procurement process, including supplier selection, electronic tendering, purchase orders, contract management, invoicing, and payments. These systems improve purchasing efficiency, increase transparency, reduce administrative costs, enhance supplier collaboration, and support data-driven procurement decisions.

FIFO (First In – First Out) – an inventory management method in which the goods received first are issued or sold first. FIFO is commonly used for perishable products, pharmaceuticals, and food items to prevent spoilage and product expiration.

Financial flow – the movement and management of money throughout the supply chain, including payments, invoices, transportation costs, inventory expenses, customs duties, taxes, and other financial transactions between suppliers, manufacturers, logistics providers, retailers, and customers. Financial flow ensures the efficient financing and control of logistics operations.

Information flow – the continuous exchange of data and communication among supply chain participants to support planning, coordination, and control of logistics activities. Information flow includes customer orders, inventory levels, production schedules, shipment status, demand forecasts, and delivery information.

Intermodal transportation – a freight transportation system in which goods are moved using two or more different modes of transport (e.g., truck, rail, and ship) while remaining in the same loading unit or container throughout the journey, minimizing cargo handling.

Just-in-Time (JIT) – an inventory management and production strategy in which materials and products are delivered exactly when needed, reducing inventory levels, storage costs, and waste while improving efficiency.

Kanban is a lean inventory and workflow management system that uses visual signals, such as cards or electronic notifications, to control the movement and replenishment of materials. Originating from the Toyota Production System, Kanban ensures that products or materials are supplied only when needed, reducing waste, excess

inventory, and lead times while improving operational efficiency and supporting Just-in-Time (JIT) production.

Lean Logistics – a logistics management approach based on Lean principles that aims to eliminate waste, improve process efficiency, reduce lead times, optimize transportation and inventory, and deliver greater value to customers using fewer resources.

Level of logistics service – a measure of how effectively a logistics system meets customer expectations in terms of delivery speed, reliability, availability, flexibility, and order accuracy.

LIFO (Last In – First Out) – an inventory management method in which the most recently received goods are issued or sold first. LIFO is mainly applied to non-perishable goods and specific accounting practices but is less common in warehouse operations where product freshness is important.

Logistics chain – sequence of organizations, facilities, and activities involved in the production, transportation, storage, and distribution of goods from suppliers to end users.

Logistics channel – the route or network through which goods, information, and services move between producers, intermediaries, and consumers.

Logistics costs – the total expenses associated with planning, implementing, and controlling logistics activities, including transportation, storage, inventory holding, packaging, and administrative costs.

Logistics flow – the movement of materials, products, information, or financial resources through a logistics system from the point of origin to the point of consumption.

Logistics infrastructure – the physical and organizational facilities, equipment, technologies, and institutions that support logistics activities, including roads, railways, ports, warehouses, distribution centers, and information systems.

Logistics operations – individual activities performed within the logistics process, such as transportation, warehousing, inventory management, packaging, loading, unloading, and order processing.

Logistics system – an integrated set of interconnected elements, processes, and participants that manage the flow of goods, information, and resources to meet customer requirements efficiently.

Manufacturing Execution System (MES) is a software solution that monitors, controls, and manages manufacturing operations in real time on the factory floor. It connects production planning with actual shop-floor activities by tracking work orders, machine performance, labor, material consumption, and product quality. MES improves production visibility, reduces downtime, enhances quality control, and increases operational efficiency by providing accurate, real-time production data.

Maritime transport – the movement of cargo by ships through seas and oceans. It is the primary mode for international trade, offering the lowest transportation cost per unit for bulk and containerized goods, although transit times are longer.

Material flow – the movement of raw materials, components, work-in-progress, and finished products through the supply chain from suppliers to manufacturers, warehouses, distribution centers, retailers, and final customers. Material flow ensures that products are delivered in the right quantity, at the right place, and at the right time.

MRP (Material Requirements Planning) – a computerized planning system that calculates the materials and components required for production based on production schedules, inventory levels, and bills of materials (BOM). Its goal is to ensure the right materials are available at the right time.

MRP II (Manufacturing Resource Planning) – an advanced version of MRP that integrates production planning, inventory management, capacity planning, purchasing, scheduling, finance, and human resources into one comprehensive manufacturing management system.

Multimodal transportation – the transportation of goods using two or more modes of transport under a single contract and managed by one transport operator. The operator assumes full responsibility for the entire shipment from origin to destination.

Pick-by-Light (PBL) – a warehouse order-picking technology that uses illuminated displays or LED indicators to guide warehouse workers to the correct storage location and indicate the quantity of items to pick. PBL increases picking speed, accuracy, and productivity while reducing errors.

Pipeline transport – the movement of liquids, gases, and certain bulk materials through pipelines. It provides continuous, reliable, and cost-efficient transportation, particularly for oil, natural gas, petroleum products, and chemicals.

Procurement logistics is the planning, organization, and control of the flow of materials, goods, services, and related information from suppliers to an organization.

Production logistics is the planning, coordination, and control of the flow of materials, components, work-in-progress, information, and resources within the manufacturing process.

Pull model – a supply chain strategy in which production and distribution are initiated only after receiving actual customer orders. Products move through the supply chain according to real customer demand, reducing inventory levels and increasing flexibility.

Push model – a supply chain strategy in which products are manufactured and distributed based on demand forecasts rather than actual customer orders. Goods are pushed through the supply chain in anticipation of future demand.

Rail transport – the transportation of goods by freight trains over railway networks. It is suitable for transporting large volumes of cargo over long distances at relatively low cost and with lower environmental impact than road transport.

RFID (Radio-Frequency Identification) – a technology that uses radio waves to automatically identify and track products, pallets, or containers equipped with RFID tags. RFID improves inventory accuracy, reduces manual scanning, and enables real-time visibility of warehouse assets.

Road transport – the movement of goods by trucks, vans, or other road vehicles using highways and roads. It provides high flexibility, door-to-door delivery, and is the most widely used mode of freight transportation.

Safety Stock (SS) – the additional quantity of inventory kept in reserve to protect against unexpected demand fluctuations, supply delays, or disruptions in the supply chain. Safety stock helps prevent stockouts and ensures continuous customer service.

Supply Chain Management (SCM) – the integrated management of the flow of materials, information, finances, and services from suppliers to manufacturers, distributors, retailers, and final

customers. SCM coordinates procurement, production, warehousing, transportation, and distribution to improve efficiency, reduce costs, and enhance customer satisfaction.

Total Cost – a logistics concept that focuses on minimizing the overall cost of the supply chain rather than reducing the cost of individual activities. It considers transportation, warehousing, inventory, packaging, order processing, and customer service costs together to achieve the lowest total logistics cost.

Transportation logistics – the branch of logistics responsible for planning, organizing, managing, and controlling the movement of goods from the point of origin to the final destination in the most efficient, cost-effective, and timely manner.

Vendor Managed Inventory (VMI) is an inventory management strategy in which the supplier is responsible for monitoring the customer's inventory levels and replenishing stock when needed. The supplier uses real-time inventory and sales data to determine replenishment quantities and delivery schedules. VMI improves product availability, reduces inventory costs, minimizes stockouts, and strengthens collaboration between suppliers and customers.

Voice Picking (VDP – Voice-Directed Picking) – a hands-free order-picking system in which warehouse employees receive spoken instructions through a headset and confirm completed tasks using voice commands. Voice picking improves efficiency, reduces picking errors, and allows workers to operate without paper lists or handheld devices.

Warehouse logistics – the branch of logistics responsible for planning, organizing, controlling, and optimizing the storage, handling, and movement of goods within a warehouse. Its main objective is to ensure efficient inventory management, accurate order fulfillment, and timely distribution while minimizing operational costs.

WMS (Warehouse Management System) – a software system designed to manage, control, and optimize warehouse operations, including receiving, storage, inventory tracking, order picking, packing, shipping, and reporting. WMS provides real-time inventory visibility, improves warehouse efficiency, reduces operating costs, and supports integration with ERP and other supply chain management systems.

REFERENCES

1. Amit Shah, V., Parag Vyas, P., Ashok, R., & Sharma, K. (2023). OPERATION PROJECT ON DISTRIBUTION AND LOGISTICS. International Research Journal of Modernization in Engineering Technology and Science. <https://doi.org/10.56726/irjmets34034>
2. ASCM. (2025). ASCM Supply Chain Dictionary (19th ed.). Association for Supply Chain Management.
3. Association for Supply Chain Management (ASCM). (2025). ASCM Supply Chain Dictionary (19th ed.). ASCM.
4. Babić, D., Šćukanec, A., & Rogic, K. (2012). Criteria of Categorizing Logistics and Distribution Centres. PROMET – Traffic & Transportation, 23(4), 279–288. <https://doi.org/10.7307/ptt.v23i4.130>
5. Bertolini, M., & Guido, R. (2021). Automation in warehousing and logistics: Advances and trends. Automation in Industry Journal, 12(1), 40-56. <https://doi.org/10.1016/j.aiij.2020.12.005>
6. Bezpartochnyi, M., Britchenko I., Bozhydarnik T., Bezpartochna O. Logistics tools for optimizing marketing distribution and sales policy. Sustainable development synergy and security: theoretical and methodological foundations and practical imperatives of economic, social, and environmental transformation and inclusion. Scientific monograph. Plovdiv, ANIS Publishing Complex, 2026. Vol. 2. P. 384-405. <https://doi.org/10.5281/zenodo.20758366>
7. Britchenko I. Issues of shaping the students' professional and terminological competence in science area of expertise in the sustainable development era / Olena Lavrentieva, Victoria Pererva, Oleksandr Krupskyi, Igor Britchenko, Sardar Shabanov // E3S Web of Conferences. – FDP Sciences, France. Volume 166, 1003. 22.04.2020. eISSN 2267-1242. 9 pages. <https://doi.org/10.1051/e3sconf/202016610031>
8. Domżał P., Bezpieczeństwo informacji w odniesieniu do ochrony danych osobowych w świetle obowiązujących przepisów – stan aktualny i wyzwania (w:) Strategia bezpieczeństwa narodowego w ujęciu interdyscyplinarnym 4.0, Tom 1 (red.) M. Kamper-

Kubańska, K. Kaszlińska, P. Sobierajski, Włocławek, 2023, s. 151-184 ISBN 978-83-967445-8-6

9. Безпарточний М.Г. Управління маркетинговими каналами збуту в умовах нестабільності ринку: стратегії адаптації та побудови стійких ланцюгів постачання. Економічний часопис Волинського національного університету імені Лесі Українки. № 2(46). 2026. С. 192-200. <https://doi.org/10.29038/2786-4618-2026-02-192-200>

10. Britchenko I. European smart specialization for Ukrainian regional development: path from creation to implementation / Yevheniia Polishchuk, Alla Ivashchenko, Igor Britchenko, Pavel Machashchik, Serhiy Shkarlet // Problems and Perspectives in Management, Volume 17, Issue 2, 2019. – P. 376-391. ISSN 1727-7051 (print), 1810-5467 (online) [http://dx.doi.org/10.21511/ppm.17\(2\).2019.29](http://dx.doi.org/10.21511/ppm.17(2).2019.29)

11. Domżał P., Supel A., Łatak T., Przybylski P., Edukacja i wychowanie na rzecz bezpieczeństwa i obronności – wybrane aspekty, Polityka i Społeczeństwo, 20(3), Uniwersytet Rzeszowski, Rzeszów 2022, ss. 180–188. <https://www.ceeol.com/search/article-detail?id=1130765>

12. Bezpartochnyi, M., Skrylnyk, A., Kalyuzhna, M., Shamin M. Intermodal and multimodal export logistics of Ukrainian agricultural products during martial law. 24th International Scientific Conference Engineering for Rural Development, 21.-23.05.2025, Jelgava, 1034-1040. DOI: 10.22616/ERDev.2025.24.TF217

13. Britchenko I. The system of evaluation efficiency of the strategy of sustainable development of the enterprise in the decentralization condition / Igor Britchenko, Svitlana Filyppova, Liubov Niekrasova, Olena Chukurna, Radostin Vazov // Списание «Икономически изследвания (Economic Studies)». – Институт за икономически изследвания при БАН, София (България). – № 1. – 2022. – P. 118-138. ISSN 02053292. <https://www.iki.bas.bg/spisanie-ikonomicheski-izsledvaniia>

14. Bezpartochnyi, M., Britchenko I., Bezpartochna O., Malchenko H. Economic security of a logistics company: financial, marketing, and environmental aspects. Profound structural transformations of socio-economic and ecological systems based on resilience, sustainable and inclusive development. Scientific

monograph. – Plovdiv: HSSE Publishing Complex, 2025. P. 11-31.
<https://doi.org/10.5281/zenodo.15707472>

15. Britchenko I. Blockchain technology into the logistics supply / I. Britchenko, T. Cherniavska, B. Cherniavskiy // Development of small and medium enterprises: the EU and east-partnership countries experience: collective monograph / Edited by Igor Britchenko and Yevheniia Polishchuk. – Tarnobrzeg: Wydawnictwo Państwowej Wyższej Szkoły Zawodowej im. prof. Stanisława Tarnowskiego w Tarnobrzegu, 2018. - P. 307 - 318.

16. Piotr Mrzygłód, Maciej Frasunkiewicz, Michał Cwiakała, Dariusz Baran, Ernest Górka, Jan Piwnik, Artur Frach, Jarosław Chmiel, Marcin Agaciński, Izabella Kęsy, Balancing Artificial Intelligence and Emotional Intelligence in Modern Personnel Management, European Research Studies Journal, Vol. XXVIII, Issue 3, 2025, pp. 869-890.

17. Bezpartochnyi, M., Trushkina N., Shkrygun Yu., Patlachuk T. Digital platform as a tool for improving the efficiency of a company's logistics management in the context of digitisation. National and international imperatives of ensuring sustainable development of socio-economic and ecological systems in the face of structural transformation. Scientific monograph. – Plovdiv: HSSE Publishing Complex, 2024, p. 122-146.
<https://doi.org/10.5281/zenodo.14538008>

18. Britchenko, I., Bohomolova, N. I., Kravchenko, O. O., & Pinchuk, S. S. (2018). Оцінка детермінант фінансової безпеки залізничного транспорту в Україні. Financial and Credit Activity Problems of Theory and Practice, 4(27), 270–281.
<https://doi.org/10.18371/fcaptop.v4i27.154109>

19. Bezpartochnyi, M., Trushkina N. Infrastructural provision for the managing of agricultural enterprises' international logistics activities in the context of food security. Food security : modern challenges and mechanisms to ensure : scientific monograph. — Košice : Vysoká škola bezpečnostného manažérstva v Košiciach, 2023, pp. 7-24.

20. Igor Britchenko. Energy security issues in contemporary Europe / Josef Abrahám, Igor Britchenko, Marija Jankovic, Kristina Garškaitė-Milvydienė // Journal of security and sustainability issues. - Lithuania: The General Jonas Žemaitis Military Academy of

Lithuania. - Volume 7, Number 3, March 2018. - P. 387-398.

21. Bezpartochnyi M., Britchenko I., Prylutska L. Research on export logistics of agricultural products in Ukraine during martial law and ensuring food security, Current issues of the management of socio-economic systems in terms of globalization challenges: scientific monograph. Košice, Vysoká škola bezpečnostného manažérstva v Košiciach, 2023, pp. 479-498.

22. Britchenko I. Development of a method for selected financing of scientific and educational institutions through targeted capital investment in the development of innovative technologies / Iaroslava Levchenko, Oksana Dmytriieva, Inna Shevchenko, Igor Britchenko, Vitalii Kruhlov, Nina Avanesova, Oksana Kudriavtseva, Olesia Solodovnik // Eastern-European Journal of Enterprise Technologies – Vol. 3 No. 13 (111) (2021): Transfer of technologies: industry, energy, nanotechnology – P. 55 - 62. ISSN (print) 1729-3774, ISSN (on-line) 1729-4061 DOI: 10.15587/1729-4061.2021.235930 <http://journals.urau.ua/eejet/>

23. Bezpartochnyi M., Britchenko I. Export logistics of agricultural products of Ukraine in the context of ensuring food security during martial law. Current issues of security management during martial law: scientific monograph. – Košice: Vysoká škola bezpečnostného manažérstva v Košiciach, 2022. – pp. 163-184.

24. M. Bezpartochnyi I. Britchenko, I. Nadtochii, O. Pulianovych, E. Skakalina. Safety of the European Union transport system as a must have for Ukraine. Problems and prospects of development of the road transport complex: financing, management, innovation, quality, safety – integrated approach. Kharkiv: PC TECHNOLOGY CENTER, 2021, pp. 152-165

25. Bowersox, D. J., Closs, D. J., Cooper, M. B., & Bowersox, J. C. (2023). Supply Chain Logistics Management (6th ed.). McGraw-Hill.

26. Брітченко І.Г. Концепція виробничого менеджменту підприємства // Збірник наукових праць “Торгівля і ринок України”. – Випуск 12. – Том II. – Донецьк: ДонДУЕТ, 2001. – С. 31-36.

27. Bronshtein, E. M., & Zaiko, T. A. (2010). Deterministic optimization problems of transportation logistics. Automation and Remote Control, 71(10), 2132–2144.

<https://doi.org/10.1134/s0005117910100127>

28. Britchenko I. Economic Security of the Enterprise Within the Conditions of Digital Transformation / Yuliia Samoilenko, Igor Britchenko, Iaroslava Levchenko, Peter Lošonczi, Oleksandr Bilichenko, Olena Bodnar // *Economic Affairs*. - Vol. 67. No. 04, September. – 2022, pp. 619-629.

29. Безпарточний М. Г., Безпарточна О. С. Логістична стійкість як складова економічної безпеки підприємств. Міжнародний бізнес і логістика: ризики, безпека, управлінські рішення: збірник доповідей І Міжнародної науково-практичної конференції (м. Київ, 05 березня 2026 р.). Київ: Національний технічний університет України «Київський політехнічний інститут імені Ігоря Сікорського», 2026. С. 191-192.

30. Chen, Z., & Liao, Z. (2023). Impact of data technology on logistics industry business performance. *Highlights in*

31. Chopra, S. (2022). *Supply Chain Management: Strategy, Planning, and Operation* (8th ed.). Pearson.

32. Christopher, M. (2023). *Logistics & Supply Chain Management* (7th ed.). Pearson.

33. Council of Supply Chain Management Professionals (CSCMP). (2024). *CSCMP Supply Chain Management Definitions and Glossary*. CSCMP.

34. Coyle, J. J., Langley, C. J., Novack, R. A., & Gibson, B. J. (2024). *Supply Chain Management: A Logistics Perspective* (12th ed.). Cengage Learning.

35. David, P. A. (2021). *International Logistics: The Management of International Trade Operations* (6th ed.). Cicero Books.

36. Dissanayake, H., Indrasiri, S., Vasilev, V., & Mendis, O. (2025). Impact of Artificial Intelligence in Higher Education: Case Study from a Public University in Sri Lanka. In M. Tariq & R. Sergio (Eds.), *Convergence of AI, Education, and Business for Sustainability* (pp. 149-172). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3373-1917-9.ch007>

37. Domżał P., Supel A., Przybylski P, Domalik Z. Postrzeganie współczesnego bezpieczeństwa – wybrane aspekty, *Nowoczesne Systemy Zarządzania* 4/2022 vol. 17, *Wojskowa Akademia Techniczna*, Warszawa, s.67-78.

<https://bibliotekanauki.pl/articles/2186001.pdf>

38. Брітченко І.Г., Момот О.М. Особливості використання скорингових систем у банківському кредитуванні фізичних осіб // Збірник наукових праць КНЕУ «Фінанси облік і аудит», Вип. 17. – К: КНЕУ. – С. 31 - 37.

39. Feng, T., & Ding, Y. (2020). Application of RFID technology in supply chain management. *Supply Chain Technology Journal*, 8(4), 45-58. <https://doi.org/10.1007/s12345-020-0076-1>

40. E. Chomać-Pierzecka, B. Błaszczak, Sz. Godawa, I. Kęsy, Human Safety in Light of the Economic, Social and Environmental Aspects of Sustainable Development – Determination of the Awareness of the Young Generation in Poland, *Sustainability*, 2025, 10, 6190, p. 1-22.

41. Gözl, J., & Weber, E. A. (2020). Optimizing supply chains with advanced telematics. *Journal of Transportation Technology*, 9(2), 54-70. <https://doi.org/10.4236/jtts.2020.92005>

42. Domżał P., Supel A., Przybylski P., Nowoczesna technologia a wzrost cyberbezpieczeństwa – analiza zależności, *Społeczeństwo, Kultura Wartości. Studium Społeczne*, rok XIV, 2023, nr 23, s. 91-96 <https://studiumspoleczne.pl/wp-content/uploads/2023/02/S-K-W-232023-2.pdf#page=91>

43. Брітченко І.Г. Передумови сталого розвитку національних соціально-економічних систем, що формують Європейський Союз / Брітченко І.Г., Стьопочкін А.І. // Економіка і організація управління. Збірник наукових праць ДонНУ - Вінниця. - Випуск № 3 (23). - 2016. С. 40-49.

44. G. Drozdowski, P. Dziekański, I. Kęsy, Empirical Analysis of the Impact of the Green Economy on the Spatial Diversity of Entrepreneurship at the Poviats Level in Poland: Preliminary Study, *Sustainability*, 2025, 17 (10), 4309.

45. Безпарточний М. Г., Безпарточна О. С., Беленцов Д. В. Моделі розумних ланцюгів постачання. Економіка бізнесу цифрової глобалізації: маркетинг і логістика: Матеріали І Міжнародної науково-практичної конференції, 21 листопада 2025 р. Одеса, ОНЕУ, 2025. С. 241-243.

46. Grant, D. B., Trautrim, A., & Wong, C. Y. (2022). *Sustainable Logistics and Supply Chain Management: Principles and Practices for Sustainable Operations and Management* (3rd ed.).

Kogan Page.

47. Gigauri, I., Vasilev, V., & Sidova, D. (2025). The Role of Leadership and Corporate Social Responsibility for Sustainable Entrepreneurship: Good Practices from Georgia and Bulgaria. In I. Gigauri (Ed.), *Sustainable Entrepreneurship and Family Business for Women's Empowerment* (pp. 165-176). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-8694-1.ch008>

48. I. Kęsy, *Managing the Cities of the Future and the Energy Needs of Cities*, *Środkowoeuropejskie Studia Polityczne* 2025, nr 2, Uniwersytet im. Adama Mickiewicza w Poznaniu, p. 381-401.

49. Helming, S., Buergin, J., Bitte, F., Haefner, B., & Lanza, G. (2018). *Integrated Production and Logistics Planning and Control in Global Production Networks* (pp. 637–646). springer. https://doi.org/10.1007/978-3-030-03451-1_62

50. Domżał P., Supel A., Przybylski P., *Miejsce Polski w strukturach bezpieczeństwa globalnego – czy jest ona istotna z punktu widzenia obecnych struktur bezpieczeństwa w Unii Europejskiej?*, *Społeczeństwo, Kultura Wartości. Studium Społeczne*, rok XIV, 2023, nr 23, s. 61-67. <https://studiumspoleczne.pl/wp-content/uploads/2023/02/S-K-W-232023-2.pdf#page=63>

51. Брітченко І.Г. Вплив малого бізнесу на регіональний розвиток // Науковий вісник ПУЕТ. - № 4 (43)/2010 – Полтава: ПУЕТ, 2010. – С. 15 – 19.

52. Hilmola, O. P., & Lättilä, L. (2013). Simulation modelling challenge of transportation logistics systems. *International Journal of Business Information Systems*, 14(4), 429. <https://doi.org/10.1504/ijbis.2013.057498>

53. Domżał P., Supel A., Przybylski P., *Współczesne struktury bezpieczeństwa, międzynarodowa współpraca czy samodzielne istnienie?*, *Społeczeństwo, Kultura Wartości. Studium Społeczne*, rok XIV, 2023, nr 23, s. 33-38. <https://studiumspoleczne.pl/wp-content/uploads/2023/02/S-K-W-232023-2.pdf#page=33>

54. Безпарточний М. Г., Безпарточна О. С. Удосконалення транспортної інфраструктури у контексті розвитку інтермодальних та мультимодальних перевезень. Матеріали двадцять першої науково-практичної міжнародної конференції “Міжнародна транспортна інфраструктура, індустріальні центри

та корпоративна логістика» (5-6 червня 2025 р). Харків: Український державний університет науки і технологій. 2025. С. 26-27.

55. Hoffman, A. L., Jimenez, J., & Mehra, M. (2002). Logistics of the procurement procedure. *Current Opinion in Organ Transplantation*, 7(1), 65–69. <https://doi.org/10.1097/00075200-200203000-00014>

56. Domżał P., Supel A., Łatak T., Znaczenie sojuszy w wojnie hybrydowej (w:) Banasik M., (red.) *Wojna Federacji Rosyjskiej z Zachodem*, Difin, Warszawa 2022, ss. 202-212 ISBN 978-83-8270-129-6

57. Кужелев М.О., Брітченко І.Г. Корпоративний контроль інсайдерської ренти // Науковий вісник ПУЕТ - № 1 (56) / 2014 – Полтава: ПУЕТ, 2014. – С. 281 – 285.

58. Jacobs, F. R., Berry, W. L., Whybark, D. C., & Vollmann, T. E. (2024). *Manufacturing Planning and Control for Supply Chain Management* (3rd ed.). McGraw-Hill.

59. Domżał P., System zarządzania bezpieczeństwem w nowoczesnej organizacji – aktualne wyzwania w obszarze przywództwa (w:) Domżał P. (red.) *Aktualne problemy bezpieczeństwa – konteksty i implikacje, Aktualne problemy bezpieczeństwa - konteksty i implikacje, Zbliżenia cywilizacyjne*, Tom 19 Nr 3, 2023, s. 87-112. <https://apcz.umk.pl/ZC/article/view/57557>

60. Бритченко И. Модернизация инновационной инфраструктуры Украины в процессе конвергенции с ЕС / Бритченко И., Князевич А. // *The international journal «Sustainable development»*. – «Технический университет», г. Варна (Болгария). – № 6 (27). – 2015. – С. 4–10.

61. Jeong, Y.-K., Agrawal, T., Canessa, G., Flores-García, E., & Wiktorsson, M. (2022). An optimization model with stochastic variables for flexible production logistics planning. In *arXiv* (Cornell University). European Society for Socially Embedded Technologies. <https://doi.org/10.48550/arxiv.2203.17033>

62. Jiang, P., & Zhang, H. (2021). Real-time location systems in logistics: A review. *Logistics Research*, 14(2), 109-124. <https://doi.org/10.1007/s12159-021-00245-0>

63. J. Ziółkowski, P. Guzanek, M. Mazur, I. Kęsy, R. Szczur,

Acoustic Drone Detection for Technical Infrastructure Security and Defense Purposes, Terotechnology XIV, Materials Research Proceedings 62 (2026) 58-63.

64. Бритченко И.Г. Региональное банковское рынковедение (теория, методология технология). Часть 2. Методология регионального банковского рынковедения // Донецк: ДонГУЭТ, 2003. – 106 с.

65. Domżał P., Supel A., Łatak T., Uwarunkowania geopolityczne źródłem zagrożeń bezpieczeństwa narodowego (w:) Strategia Bezpieczeństwa Narodowego w ujęciu interdyscyplinarnym 3.0, tom 1 (red.) M. Kamper-Kubańska, K. Kaszlińska i P. Sobierajski, ISBN 978-83-963889-8-8, Wydawnictwo Państwowej Akademii Nauk Stosowanych we Włocławku, Włocławek 2022, ss. 67-85

66. Kache, F., & Seuring, S. (2017). Challenges and opportunities of digitalization in supply chain management. European Journal of Operational Research, 261(3), 964-977. <https://doi.org/10.1016/j.ejor.2017.02.013>

67. Князевич А.О., Бритченко И.Г. Сутність та специфіка формування соціально-орієнтованої інноваційної інфраструктури // Науковий журнал "Менеджер". Вісник донецького державного університету управління. - № 3 (65)/2013. – Донецьк: ДонДУУ, 2013. – С. 68 – 73.

68. Kampf, R., Hlatká, M., & Bartuska, L. (2018). Optimization of Production Logistics. Advances in Science and Technology Research Journal, 12(4), 151–156. <https://doi.org/10.12913/22998624/100351>

69. Domżał P., Ciemcioch K., Wojna hybrydowa a państwo i technologia – analiza problemu podjęta przez studentów UNS w Łodzi (w:) Strategia bezpieczeństwa narodowego w ujęciu interdyscyplinarnym 5.0 (red.) M. Kamper-Kubańska, K. Kaszlińska, P. Sobierajski, Włocławek, 2024, s. 179-194

70. Kappauf, J., Lauterbach, B., & Koch, M. (2011). Procurement Logistics (pp. 59–138). springer berlin heidelberg. https://doi.org/10.1007/978-3-642-18204-4_4

71. Бритченко И.Г. Управление банковским рынковедением // Донецк: ИЭПИ НАН Украины, ДонНУ, 2003. – 368 с.

72. Kappauf, J., Lauterbach, B., & Koch, M. (2011). Warehouse

Logistics and Inventory Management (pp. 99–213). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-18202-0_3

73. Kęsy, I. Kompetencje menedżera w firmie rodzinnej, Wydawnictwo Bułgarskiej Akademii Nauk, Sofia 2025, 163 s.

74. Бритченко И.Г. Marketing Management организации: потенциал и системы / Бритченко И.Г., Бритченко Г.И. // Донецк: ДонНУ, 2001. – 279 с.

75. Klaus, P., & Pfohl, M. T. (2013). Logistics and supply chain management. Springer.

76. Kuzheliev M. Theoretical and Methodological Aspects of Formation of Corporate Control System in Ukraine / Mykhailo Kuzheliev, Igor Britchenko // Списание «Икономически изследвания». – Институт за икономически изследвания при БАН, София (България). – № 2. – 2016. – С. 3-29.

77. Kumar, S., & Rajan, S. S. (2019). Real-time data processing for efficient logistics management. Journal of Real-Time Data Analysis, 11(3), 233-245. <https://doi.org/10.1016/j.rtda.2019.03.006>

78. Kumarage, A. S. (2021). Transport Logistics: Redefining Logistics in Transport. Journal of South Asian Logistics and Transport, 1(2), 93–104. <https://doi.org/10.4038/jsalt.v1i2.36>

79. Бритченко И.Г. Региональные аспекты банковского рынковедения // Донецк: ДонГУЭТ им. М. Туган-Барановского, 2003. – 291 с.

80. Lambert, D. M., García-Dastugue, S. J., & Croxton, K. L. (2005). "An Evaluation of Process-Oriented Supply Chain Management Frameworks." Journal of Business Logistics, 26(1), 25–51.

81. Langley, C. J., Novack, R. A., Gibson, B. J., & Coyle, J. J. (2024). Supply Chain Management: A Logistics Perspective (12th ed.). Cengage Learning.

82. Lee, H. L., & Billington, C. (1992). Managing supply chain inventory: Pitfalls and opportunities. Sloan Management Review, 33(3), 65-73. <https://doi.org/10.5555/SMR.33.3.65>

83. Бритченко И.Г. Региональное банковское рынковедение (теория, методология технология). Часть 1. Теория регионального банковского рынковедения // Донецк: ДонГУЭТ, 2002. – 122 с.

84. Liao, S. H., & Tseng, M. L. (2018). Smart logistics

management with big data. *Journal of Smart Logistics*, 5(2), 88-102. <https://doi.org/10.1016/j.jslog.2017.11.007>

85. Li-Jun Zhou, L.-J. (2018). Balance Strategies of Production Logistics Based on Flexible Production. *Asian Business Research*, 3(1), p1. <https://doi.org/10.20849/abr.v3i1.315>

86. Lomat, E. P. (2023). Transportation logistics. *Lizing (Leasing)*, 5, 10–14. <https://doi.org/10.33920/vne-03-2305-02>

87. Брітченко І.Г. Формування системи державного управління інвестиційним процесом як головна передумова економічного зростання в Україні / Брітченко І.Г., Кужелев М. О. // Вестник ДонГУЭТ- №12 - Донецк: ДонГУЭТ, 2001.- С. 15-22.

88. Magdalena Kowalska, Ewa Chomać-Pierzecka, Małgorzata Bogusz, Adam Dąbrowski, Izabella Kęsy, Individuals' Climate Change and Course of Energy Transition Process Efforts for Local Communities in Rural Poland, *Energies*, 2026, 19, 534, p. 1-26.

89. Malaval, P., Bénaroya, C., & Aflalo, J. (2013). Selecting Distribution Channels and Sales Team Management (pp. 309–342). *springer*. https://doi.org/10.1007/978-3-319-01354-1_9

90. Брітченко І.Г. Региональное банковское рынковедение (теория, методология технология). Часть 3. Технология регионального банковского рынковедения // Донецк: ДонГУЭТ, 2003. – 126 с.

91. Mangan, J., Lalwani, C., & Calatayud, A. (2024). *Global Logistics and Supply Chain Management* (5th ed.). Wiley.

92. Mehta, J. (2004). Supply Chain Management in a Global Economy. *Total Quality Management & Business Excellence*, 15(5–6), 841–848. <https://doi.org/10.1080/14783360410001680279>

93. Mentzer, J. T., Stank, T. P., & Esper, T. L. (2008). "Supply Chain Management and Its Relationship to Logistics, Marketing, Production, and Operations Management." *Journal of Business Logistics*, 29(1), 31–46.

94. Момот О.М., Брітченко І.Г. Інтегровані банківські послуги та конкурентоспроможність банківської системи // Полтава: РВЦ ПУСКУ, 2008 – 315 с.

95. Mocanu, D. (2023). Logistics Distribution Centers in Multimodal Transport Operations. *Ovidius University Annals Economic Sciences Series*, 22(2), 381–388.

<https://doi.org/10.61801/ouaess.2022.2.51>

96. Monczka, R. M., Handfield, R. B., Giunipero, L. C., & Patterson, J. L. (2015). *Purchasing and supply chain management*. Cengage Learning.

97. Бритченко И.Г. Социальный аспект банковского маркетинга // Сборник “Социально-гуманитарные аспекты менеджмента” – Донецк: ДонГАУ, 1997. – С. 37-39.

98. Novack, R. A., Gibson, B. J., & Suzuki, Y. (2023). *Transportation: A Global Supply Chain Perspective* (10th ed.). Cengage Learning.

99. Pfohl, H.-C. (2022). *Procurement Logistics* (pp. 169–179). springer berlin heidelberg. https://doi.org/10.1007/978-3-662-64349-5_9

100. Psarakis, Z. (2018). Integrating and evaluating planning primitives for robot manipulation tasks in warehouse logistics. *Monthly Weather Review*. <https://doi.org/10.7282/t36h4mwr>

101. Qiaoyi, Q. (2018). Lean Production Logistics System Applied Research. *Advances in Transportation and Logistics Research*, 1(1), 1025–1041. <https://doi.org/10.25292/atlr.v1i1.102>

102. Rao, S. S., & George, P. (2018). Big data in logistics: Applications and challenges. *Logistics Technology Journal*, 15(1), 29-44. <https://doi.org/10.1007/s10000-017-0013-x>

103. Richards, G. (2021). *Warehouse Management: The Definitive Guide to Improving Efficiency and Minimizing Costs in the Modern Warehouse* (4th ed.). Kogan Page.

104. Richards, G., & Grinsted, S. (2022). *The Logistics and Supply Chain Toolkit* (3rd ed.). Kogan Page.

105. Rushton, A., Croucher, P., & Baker, P. (2022). *The Handbook of Logistics and Distribution Management* (7th ed.). Kogan Page.

106. Szpak, A., & Šimek, V. (2025). The role of color diagnostics in the context of the mental health crisis of Czech students: limits of projective methods and perspectives of evidence-based approaches. W: *Konferencyjny zbiór prac naukowych*, t. XI. Czech Republic. ISBN 978-80-88398-24-0.

107. Sarder, M. (2026). Overview of transportation logistics (pp. 1–38). *elsevier*. <https://doi.org/10.1016/b978-0-443-43916-2.00020-2>

108. Schröder, R., & Schuller, S. (2018). Challenges of big data

integration in logistics. *Journal of Big Data Research*, 9(1), 71-89. <https://doi.org/10.1016/j.bdr.2018.01.009>

109. Serafimova, V.; V. Vasilev (2024). Digital culture as a competitive advantage in the sustainable development of organizations"; AGORA International Journal of Economical Sciences, <http://univagora.ro/jour/index.php/aijes>; Vol. 18, No. 1 (2024), pp. 210- 222; <https://doi.org/10.15837/aijes.v18i1.6724>

110. Szpak, A., Šimek, V., Lengyelfalusy, T., & Oláh, A. (2025). Pedagogical facilitation and relational dynamics as the foundational framework for experiential teaching and the achievement of deep learning. *Łódzkie Studia Humanistyczne*, nr 4, 42-56, <https://doi.org/10.32782/2956-333X/2025-4-5>

111. Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2021). *Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies* (4th ed.). McGraw-Hill.

112. Serafimova, V., Dissanayake, H., Iddagoda, A., & Vasilev, V. (2025). Inclusive Leadership and Corporate Social Responsibility for Women's Empowerment: From Good Ideas to Sustainable Solution. In I. Gigauri (Ed.), *Sustainable Entrepreneurship and Family Business for Women's Empowerment* (pp. 177-202). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-8694-1.ch009>

113. Szpak, A., & Sadovenko, S. (2021). Primary diagnostics of teachers of special disciplines of technical college. *Polonia University Scientific Journal*, 42 (5), 110-116, <https://doi.org/10.23856/4215>

114. Stefanova, D. P., Jaganjac, J., & Vasilev, V. P. (2026). Strategic Communications for Climate Resilience: European Goals, Local Policies, and Best Practices. In S. Bostancı, S. Yıldırım, & V. Vasilev (Eds.), *Empowering Resilient Communities Through Climate Action, Renewable Energy, and Waste Management* (pp. 19-38). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3373-0862-3.ch002>

115. Speranza, M. G., & Van Nunen, J. A. E. E. (1998). *Advances in Distribution Logistics*. springer berlin heidelberg. <https://doi.org/10.1007/978-3-642-46865-0>

116. Stefanova, D., Vasilev, V. (2024). The competence "Information security" in human resources management - a key

factor for competitiveness and digital transformation efficiency. *Romanian Journal of Economics*, 58(1), pp. 5-17
https://revecon.ro/sites/default/files/2024-1-1_1.pdf

117. Szpak, A., Šimek, V., Lengyelfalussy, T., & Oláh, A. (2025). Conceptual pedagogical synthesis of addictive behaviour in the context of societal change. *Łódzkie Studia Humanistyczne*, nr 4, 17-25, <https://doi.org/10.32782/2956-333X/2025-4-2>

118. Stefanova, D., Bacheva, K., Vasilev, V. (2025). Conceptual Convergence: Disinformation, Fake News, and Information Influence as a Triad of Security Threats in the Context of Society 5.0. *Environment Technology Resources - Proceedings of the 16th International Scientific and Practical Conference*, 5, 291-296. <https://doi.org/10.17770/etr2025vol5.8470>

119. Sweeney, T., & Bernard, F. M. (2020). Advanced analytics for optimizing supply chain operations. *International Journal of Advanced Analytics*, 16(3), 156-173. <https://doi.org/10.1016/j.ijaa.2020.05.001>

120. Stefanova, D., Jaganjac, J., Vasilev, V. (2025). On the Road to Sustainability: How Storytelling Changes Public Management and Leads to Motivation and Organizational Development. In: Panait, M., Gigauro, I., Raimi, L. (eds) *Sustainable Economic Development*. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-031-96224-0_3

121. Szpak, A. (2017). Edukacja włączająca uczniów niepełnosprawnych – aktualne wyzwania. *Zbliżenia Cywilizacyjne*, XIII (4), 12-45, Włocławek: Państwowa Wyższa Szkoła Zawodowa we Włocławku. <https://doi.org/10.21784/ZC.2017.022>

122. Stefanova, D., Popescu, C., Vasilev, V. (2026). Green Transition and Human Resource Management–Sustainable Development Through Effective Management of Green Collar Workers. In: Malik, F.A., Kushwah, S.V., Aslam, M.S., Reyed, R.M., Haghi, A.K. (eds) *Aligning ESG Goals with the UNs Sustainable Development Goals Planning*. World Sustainability Series. Springer, Cham. https://doi.org/10.1007/978-3-032-01715-4_14

123. Tortorella, G. L., & de Almeida, J. C. (2021). Industrial robotics and automation in logistics. *Robotics and Automation Review*, 7(2), 112-126. <https://doi.org/10.1109/RAR.2021.0012>

124. United Nations Conference on Trade and Development (UNCTAD). (2023). Review of Maritime Transport 2023. United Nations.

125. Stefanova, D., Vasilev, V. (2024). The competence "information security" in human resources management – a key factor for competitiveness and digital transformation efficiency. *Romanian Journal of Economics/Revista Română de Economie*; ISSN-L:1220-5567, e-ISSN: 2344-4657; (58), 1/2024; 211; https://revecon.ro/sites/default/files/2024-1-1_1.pdf

126. Szpak, A., Matějka, M., & Oláh, A. (2026). Sociopsychological effects of AI as the main source of mental support among adolescents. W: *Future Human Society Conferences II. Odolnost člověka a společnosti: Výzvy, přístupy, řešení (materiály konferenční)*. Prague: Eastern University of Management and Education Inc. ISBN 978-80-909857-2-8.

127. V. Vasilev, D. Stefanova, and M. Icheva, Green human resource management as a component of sustainable organizational development in environmental and natural economics, *ETR*, vol. 1, pp. 402–407, Jun. 2024, doi: 10.17770/etr2024vol1.7966

128. Vollmuth, P., Hüttner, H., & Fottner, J. (2025). Evaluating Changeable Production Logistics: A Multicriteria Approach. *AHFE International*, 184. <https://doi.org/10.54941/ahfe1006448>

129. Vasilev, V. P., Efremovski, I. P., & Gigauri, Z. (2026). Sustainable Human Resource Management and Development Through Innovative Approaches and Practices. In A. Wojcik-Czerniawska (Ed.), *Exploring Human Resource Innovations in E-Economy* (pp. 461-474). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3373-4307-5.ch017>

130. Wang, P., Zhang, Y., & Guo, W. (2023). Demand Forecast of Railway Transportation Logistics Supply Chain Based on Machine Learning Model. *International Journal of Information Technologies and Systems Approach*, 16(3), 1–17. <https://doi.org/10.4018/ijitsa.323441>

131. Wang, X., Li, M., Zhang, X., & Zhang, Y. (2020). Process Analysis of Warehouse Logistics Information System. *IOP Conference Series: Earth and Environmental Science*, 526(1), 012210. <https://doi.org/10.1088/1755-1315/526/1/012210>

132. Vasilev, V. P., Serafimova, V., Dissanayake, H., &

Iddagoda, A. (2026). Green Motivation 4.0: A Model for Sustainable Human Resource Management Through Storytelling and Emotional Intelligence. In I. Gigauri & M. Barteková (Eds.), *Eco-Friendly Practices and Green Policies for Sustainable Human Resource Management* (pp. 61-80). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3373-8546-4.ch003>

133. World Bank. (2023). *Connecting to Compete 2023: Trade Logistics in the Global Economy*. World Bank.

134. Xiong, G. (2011). *Study on Production Logistics Based on SCM Integration Models* (pp. 315–321). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-23062-2_47

135. Xiong, W., & Zhang, L. Y. (2014). The Optimization of Logistics and Distribution. *Advanced Materials Research*, 989–994, 1532–1535. <https://doi.org/10.4028/www.scientific.net/amr.989-994.1532>

136. Yadav, M. S., Shukla, R., Parthasarathy, C., Chikati, D., Chandan, R. R., Gupta, K. K., & Gupta, S. K. (2024). Transportation logistics monitoring for transportation systems using the machine learning. *Journal of Autonomous Intelligence*, 7(4). <https://doi.org/10.32629/jai.v7i4.1321>

137. Yamoah, L. E., Mensah, R. O., & Frimpong, A. (2025). The benefits, challenges and implications for integrating emerging technologies in risk evaluation procedures for supply chains in transportation logistics. *Discover Sustainability*, 6(1). <https://doi.org/10.1007/s43621-025-01295-6>

138. Yao, L.-H., Guang, X.-P., & Yang, Y. (2013). *Research on Environmental Logistics Distribution Problems* (pp. 1417–1423). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-38445-5_147

139. Yıldırım, S. & Vasilev, V. (2024). The Future of Green Collar Workers: Green Transition in Employment. In S. Yıldırım, D. Yıldırım, I. Demirtaş, & V. Kandpal (Eds.), *Green Transition Impacts on the Economy, Society, and Environment* (pp. 1-16). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3693-3985-5.ch001>

140. Yu, H., & Zhang, K. (2014). Performance Evaluation of Logistics and Distribution. *Advanced Materials Research*, 998–999, 1591–1594. <https://doi.org/10.4028/www.scientific.net/amr.998-999.1591>

999.1591

141. Yu, L. (2024). Automobile Transportation Logistics Supply Chain Management Strategy. *Proceedings of Business and Economic Studies*, 7(1), 56–61. <https://doi.org/10.26689/pbes.v7i1.6078>

142. Yu, Z. (2021). Sustainable Logistics Systems. *International Journal of Circular Economy and Waste Management*, 1(2), 41–48. <https://doi.org/10.4018/ijcewm.2021070105>

143. Zhang, X., & Zhao, L. (2017). The impact of RFID technology on logistics and supply chain management. *Journal of Logistics Management*, 27(3), 123-136. <https://doi.org/10.1007/s11301-017-0121-9>

144. Zimon, G. (2017). Procurement logistics in branch purchasing group. *Research in Logistics and Production*, 7(2), 171–181. <https://doi.org/10.21008/j.2083-4950.2017.7.2.9>

145. Zghurska O., Bezpartochnyi, M., Lishchynsky M., Kyrychenko A. Marketing distribution and sales policy of the enterprise in sustainable logistics. Integrated paradigm of sustainable development: from economic efficiency to social justice and environmental balance. Scientific monograph. Plovdiv, HSSE Publishing Complex, 2025. P. 615-638. <https://doi.org/10.5281/zenodo.17999891>

Logistics

Format 60x84/16
Circulation: 100 copies
9,47 p.s.

Professor Marin Drinov Publishing House
of Bulgarian Academy of Sciences
2026

ISBN 978-619-245-654-2