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ANALYTICS IN CONSOLIDATED CARGO TRANSPORTATION

Sergiy Grytsenko, Anastasiia Honcharuk. «Analytics in consolidated cargo transportation». *The article discusses the role of analytics in the sphere of less-than-container load (LCL) transportation as a key tool for optimizing logistics processes and improving operational efficiency. It examines the specific features and challenges of LCL shipments, including cost distribution, consolidation strategies, and shipment tracking. The article analyzes how data-driven approaches can enhance decision-making in logistics management, particularly in the context of fragmented supply chains and increasing customer demands. It outlines the main objectives of transportation analytics, assesses the impact of digital technologies and data platforms, and presents methodologies for evaluating performance indicators. Key areas of logistics analytics are highlighted, including route optimization, cargo consolidation efficiency, and predictive analysis in shipment scheduling. The necessary tools for implementing analytical solutions in LCL transportation are also presented, with emphasis on business intelligence systems, real-time tracking technologies, and forecasting models.*

Keywords*:* LCL transportation; logistics analytics; cargo consolidation; route optimization; freight efficiency; supply chain visibility; shipment tracking; predictive analytics; transportation costs; digital logistics; delivery scheduling; data-driven decision making

Сергій Гриценко, Анастасія Гончарук. «Аналітика у сфері збірних контейнерних перевезень». *У статті розглядається роль аналітики у сфері збірних контейнерних перевезень (LCL) як ключового інструменту оптимізації логістичних процесів та підвищення операційної ефективності. Висвітлюються особливості та виклики, притаманні LCL-перевезенням, зокрема розподіл витрат, стратегії консолідації вантажів і відстеження доставок. Проаналізовано, як підходи на основі даних сприяють покращенню прийняття управлінських рішень у сфері логістики,*

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особливо в умовах фрагментованих ланцюгів постачання та зростаючих вимог клієнтів. Окреслено основні завдання транспортної аналітики, оцінено вплив цифрових технологій і платформ обробки даних, а також представлено методики аналізу ключових показників ефективності. Виокремлено основні напрямки логістичної аналітики, включаючи оптимізацію маршрутів, ефективність консолідації вантажів та прогнозування графіків доставок. Також представлено необхідні інструменти для впровадження аналітичних рішень у сфері LCL-перевезень із акцентом на системи бізнес-аналітики, технології відстеження в реальному часі та прогностичні моделі.

Ключові слова: Збірні перевезення (LCL); логістична аналітика; консолідація вантажів; оптимізація маршрутів; ефективність перевезень; прозорість ланцюга постачання; відстеження вантажів; прогнозна аналітика; вартість транспортування; цифрова логістика; планування доставки; прийняття рішень на основі даних.

Introduction. In the context of economic globalization and the expansion of international trade, the efficiency of logistics processes is increasingly recognized as a key factor in the competitiveness of enterprises. The transportation of goods that do not fill a container completely (hereinafter referred to as LCL) occupies a special place in modern supply chains, contributing to the optimization of costs for small and medium-sized consignments. However, this segment of logistics is characterized by increased complexity, requiring the consolidation of cargo from multiple shippers, complex cost allocation methods, and coordination of the actions of multiple stakeholders involved in the process. The fragmentation of supply chains, combined with increasing customer demands for faster service, transparency, and delivery accuracy, creates significant challenges for logistics operators. The importance of the topic under study is underscored by the fact that traditional methods of managing LCL shipments have become insufficient to ensure the necessary level of efficiency, creating an urgent need to implement innovative tools based on data analysis.

A review of the literature shows that researchers are genuinely interested in optimizing logistics systems. Classic works on supply chain management laid the foundations for modeling transport flows and optimizing routes. In recent decades, the focus of research has shifted toward digital technologies. Works devoted to the Internet of Things (IoT), artificial intelligence (AI), and big data reveal their potential for real-time cargo monitoring, demand forecasting, and decision-making automation. Areas such as predictive analytics for delivery planning, consolidation optimization using machine learning algorithms, and the use of business intelligence (BI) systems to visualize key performance indicators (KPIs) are being actively explored in the context of general freight transportation.

However, the degree of research on this issue in the LCL transportation segment remains insufficient. Most existing works either consider logistics analytics in general or focus on full container load (hereinafter FCL) transportation, where operational models are more standardized. Issues related to consolidated cargo, in particular dynamic pricing, container filling optimization taking into account the heterogeneity of goods, and last-mile coordination, require more in-depth analysis.

There is a gap between general theoretical models and their practical application to the unique challenges of LCL logistics. This article aims to provide a comprehensive analysis of the role and potential of analytics in groupage freight management, systematize existing approaches, and offer a holistic view of the methodology for implementing analytical solutions to improve operational efficiency in this sector.

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Research objectives and tasks. The purpose of the study is to conduct a comprehensive analysis of the role and tools of analytics as a key factor in improving operational efficiency and optimizing logistics processes in the transportation of small consignments (LCL).

To achieve this goal, the following tasks have been set:

1. Analyze the characteristics and main challenges of organizing LCL transportation, in particular the issues of consolidation, cost allocation, and tracking in fragmented supply chains.

2. Identify the main objectives and areas of application of transport analytics to solve identified problems and strengthen the competitive advantages of logistics operators.

3. Systematize key applications of analytical methods, such as route optimization, improving cargo consolidation efficiency, and predictive analysis in delivery planning.

4. Outline the necessary technologies and tools for implementing analytical solutions, including business intelligence (BI) systems, real-time monitoring technologies, and forecasting models.

5. Propose approaches for assessing the effectiveness and impact of analytics implementation on key performance indicators (KPIs) in LCL transportation.

Main material and results. Less than container load (LCL) shipping is a key element of modern global logistics, offering significant benefits for businesses, especially small and medium-sized enterprises. The main advantage is cost efficiency. Instead of renting an entire container (FCL), the cost of which is fixed regardless of how full it is, the shipper only pays for the volume or weight of their cargo. This significantly lowers the barrier to entry into international markets. The second important advantage is flexibility in inventory management. Companies can ship smaller batches of goods more frequently, allowing them to maintain optimal inventory levels, avoid tying up working capital in large batches of goods, and respond more quickly to changes in demand. However, flexibility and cost savings come with significant operational challenges that make LCL logistics much more complex than FCL.

The central problem is the complexity of consolidation. It is a real logistical puzzle, where dozens of shipments from different shippers, with different properties and destinations, need to be coordinated in a single container. Any delay on the part of one customer can disrupt shipments for everyone else.

The second problem is the opaque distribution of costs. The total costs of freight, terminal charges, and customs clearance are distributed among all participants, and the methodology for this distribution is not always clear to the customer.

The third critical issue is the lack of comprehensive tracking. Cargo goes through many stages (consolidation warehouse, port, transshipment, deconsolidation warehouse), and each stage is often handled by different contractors. This creates "bottlenecks" in the supply chain, where it becomes almost impossible to obtain accurate information

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about the status and location of cargo in real time.

Table 1 lists the main challenges facing logisticians and their assessment according to key parameters. The priority coefficient is calculated as the arithmetic mean of three indicators (Frequency + Speed + Complexity) / 3, which allows you to identify the most important issues that require priority attention and the implementation of analytical solutions.

Table 1. LCL transportation challenges with priority coefficient calculation

Challenge / Problem	Frequency (1-10)	Speed (1-10)[1]	Complexity (1-10)[2]	Priority
Delays during cargo consolidation	9	8	7	8.0
Lack of complete transparency	9	9	9	9.0
Opaque and complex distribution of common costs	8	7	8	7.7
Customs delays due to problems with one of the cargoes	7	9	6	7.3
Difficult communication between chain participants	9	6	7	7.3
Errors in accompanying documentation	8	6	7	7.0
Risk of damage or loss of part of the cargo during transshipment	6	8	6	6.7

Source: author's own work

The analysis of problems presented in Table 1 reveals several interrelated groups of issues that hinder the efficiency of LCL transportation. The most critical problem is information chaos, which combines a lack of end-to-end tracking, communication difficulties, and documentation errors. This creates an atmosphere of complete uncertainty for both the logistics provider and the customer.

The key solution to this problem is the implementation of a unified digital platform that would integrate data from all participants in the supply chain. Using real-time analytics and IoT sensors on cargo, such a system can provide objective data on the location and condition of cargo, becoming a single source of reliable information for all parties and minimizing the risks associated with human error.

Analytics is not just an add-on, but the main driver of such a digital platform. It transforms raw data into a decision-making tool. Here's how analytics solves the problem of information chaos and what tools are used to do so.

Analytics in a unified digital platform works on three key levels to eliminate uncertainty. They are described in Table 2.

The next issue is operational inefficiency, the main cause of which is delays at the consolidation stage. This common problem disrupts schedules and has a cascading effect on the entire supply chain. To solve it, it is necessary to move from reactive to proactive management using predictive analytics and optimization models. Historical data analysis allows machine learning models to predict likely delays and build the necessary time buffers into the schedule. At the same time, special algorithms can calculate the most optimal container loading and cargo grouping schemes in real time, taking into account their parameters and urgency.

Traditionally, logistics has been predominantly reactive. A problem arises—a supplier is late, cargo is delayed at customs, the port is overloaded—and the logistician reacts, hastily searching for a solution. This approach is stressful, inefficient, and often leads to chain delays and increased costs [10].

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Proactive, data-driven management is changing this situation. It uses technology to anticipate problems and make adjustments before they affect the supply chain. This is where predictive analytics and optimization models are crucial. Predictive analytics acts as an early warning system. It analyzes vast amounts of historical and real-time data to predict future outcomes and identify potential risks.

Table 2. Key levels for eliminating uncertainty

Problem	Analytical tool	How it works	Example of a system/platform
TRACKING			
Lack of reliable and comprehensive tracking	Analysis of IoT sensor data	Collection and analysis of telemetry data (location, temperature, impacts) to detect anomalies in real time.	Samsara [1], FourKites [2]
Inaccurate and static estimated time of arrival (ETA) predictions	Modeling of estimated time of arrival (ML)	Algorithms analyze dozens of variables (weather, traffic jams, history) to calculate dynamic and accurate arrival times.	Project44 [3], Descartes MacroPoint™ [4]
COMMUNICATION			
Fragmented data and inefficient communication	Business Intelligence (BI) platforms	Integration of data from all sources into a single information panel, providing a "single source of reliable information" for all parties.	Flexport [6], Microsoft Power BI [5]
Information overload, risk of missing important events	Exception handling	The system automatically tracks deviations from the plan and sends notifications only when real problems arise.	SAP Transportation Management [7]
DOCUMENTATION			
Manual document processing and high risk of human error	Optical character recognition based on artificial intelligence (OCR)	Automatic reading, extraction, and verification of data from documents (bills of lading, invoices) to identify discrepancies.	Shipamax [8], BlueX Trade [9]

Source: author's development based on [1-9]

Key data sources include:

– Historical supplier performance metrics (delivery timeliness).

– Real-time port and terminal congestion levels.

– Weather forecasts for delivery routes.

– Traffic flows and road conditions.

– Seasonal demand fluctuations.

By processing this information, the system can generate valuable insights. For example, instead of simply waiting for a shipment from a supplier, the model can flag it as having an 85% probability of being delayed by two days, based on the supplier's past performance during the holiday season and current port congestion. This warning allows the logistics manager to act proactively. Once predictive analytics identifies a potential problem, optimization models kick in to recommend the best course of action. These are complex algorithms that can instantly evaluate millions of possible scenarios to find the most effective solution (Figure 1).

In the previous example, with a predicted two-day delay, the optimization model could:

– Reroute the consolidation plan: automatically assess whether other shipments can be rerouted in the same container or whether it is better to delay the container.

– Suggest alternative routes: suggest a different shipping line or a combination of land and air transport to meet the deadline.

– Adjust resource allocation: reschedule truck loading and warehouse slots to avoid downtime.,

Figure 1 – Comparison of reactive and proactive approaches to management [11]

Previously, logistics operated on a "firefighting" basis. Today, thanks to analytics, it is transforming into an early warning system. This has been made possible by integrating data from previously isolated sources: corporate ERP systems, IoT sensors on containers (which track not only geolocation but also temperature and shocks), API services for real-time traffic monitoring, and even weather forecasts. The analytics platform combines this information to create a single dynamic picture of the entire supply chain.

The first tool is predictive analytics. It uses machine learning (ML) models to analyze historical data and identify hidden patterns. For example, logistics giant DHL uses its Resilience360 platform to analyze more than 50 million data sources to identify political, natural, and infrastructure risks before they affect cargo. This means that the system can predict with high accuracy that there is a 75% probability of a particular container being delayed at the port of Singapore due to seasonal congestion, allowing the logistics provider to take proactive measures [12].

The second tool is optimization algorithms. When the predictive model signals a risk, the optimization system answers the question: "What to do next?" It instantly calculates thousands of possible courses of action and suggests the best one. This may not be just a change of route, but a comprehensive recommendation: to redirect part of the cargo to another flight, change the loading order at the consolidation warehouse, and automatically notify the customer of the change in arrival time.

By combining these two tools, the logistician no longer simply reacts to delays. They are provided with a predicted problem and a menu of optimal solutions based on data. This transforms their role from crisis manager to strategic planner, ensuring not only the efficiency of the supply chain, but also its resilience to disruptions.

The transition from reactive to proactive management is not just a trend, but a necessity for modern logistics companies. Global supply chains have become extremely complex and vulnerable. According to McKinsey, companies could lose up to 45% of their annual profits over a decade due to sudden disruptions [13]. The traditional model, in which a logistician manually tracks shipments and resolves issues over the phone, is no longer capable of coping with such challenges. This is where transport

analytics becomes a key factor in ensuring resilience and efficiency.

The third group of challenges is related to financial and external risks. Opaque cost allocation undermines customer trust, and customs delays are an uncontrollable external factor that can halt an entire container due to a problem with a single shipment. The solution lies in process automation and proactive data management. Implementing a system that automatically allocates costs based on clear parameters makes pricing transparent [14]. At the same time, analytical tools can automatically check the accuracy of customs documents before shipment, flagging potential risks and allowing errors to be corrected in advance to minimize the likelihood of delays at the border.

These risks, although different in nature, share a common root cause: a lack of data transparency and an inability to anticipate problems. Analytics addresses this root cause by turning uncertainty into manageable processes.

A). In-depth analysis of financial risks and analytical solutions

Problem: Opaque cost allocation is not just a matter of customer trust. It is a direct path to financial and operational losses. When customers do not understand what they are paying for, lengthy disputes arise, payments are delayed, and the logistics company spends hours manually compiling and justifying each invoice. Moreover, it prevents the customer from calculating a key indicator—the cost of delivery—which complicates their own pricing and financial planning.

The solution that can be proposed using analytics is shown in Table 3.

Table 3. How analytics reduces financial risks in logistics

Analytical application	Main tool/method	Function and operating principle	Practical example and advantages
Dynamic pricing and accurate cost estimation	Dynamic pricing models	Analyzes market conditions in real time: route demand, container capacity, competitor rates, and seasonal data to determine the optimal price that maximizes profit while remaining competitive.	The customer enters shipment details on the online portal and receives an instant accurate price quote. This speeds up the sales process and increases the conversion rate.
Complete cost calculation including delivery costs	Integration with customs tariff and tax databases	Automatically calculates not only the cost of transportation, but also all associated costs: insurance, import/export duties (based on HS code and destination), VAT, and last-mile delivery costs.	The customer receives a full report detailing all components of the final product cost before shipment. This is a high value-added service that helps build trust.
Automated invoice auditing	Invoice reconciliation systems	Automatically compares each item on the contractor's invoice with the original quote and tracking system data to identify discrepancies.	The system instantly flags incorrect cargo weight or unreasonable fuel surcharges from the carrier. This allows the company to dispute invoices and achieve significant cost savings.

Source: author's own work

B). In-depth analysis of external risks and analytical solutions

Problem: Customs delays are a classic example of the domino effect. An error in one shipper's documents leads to a thorough inspection of the entire container. The result is not just a loss of time. It is demurrage and detention (paid storage of the container at the port), which can cost thousands of dollars, disruption of the customer's production plans due to a lack of components, empty shelves in stores, and damage to reputation. Analytics

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turns this "uncontrollable" risk into a predictable one.

The solution that can be proposed using analytics is shown in Table 4.

Table 4. How analytics reduces external (customs) risks

Analytical application	Main tool/method	Function and principle of operation	Practical example and advantages
Automated classification of goods	AI-based HS code classification models	An artificial intelligence model, trained on millions of customs declarations, analyzes the text description of the goods and suggests the most accurate HS code.	The sender describes "men's leather boots," and the system provides the correct code, minimizing the risk of an error that could delay the entire container.
Monitoring changes in legislation	Integration with regulatory intelligence services	The platform tracks changes in trade legislation, sanctions, and tariffs for countries along the delivery route in real time.	The system generates notifications about new product certification requirements in the destination country, allowing documents to be prepared in advance.
Forecasting customs risks	Machine learning models for risk assessment [15]	The system analyzes a set of factors (shipper history, type of goods, country of origin, discrepancies in documents) and assigns a risk rating to each shipment.	High-risk shipments (e.g., 8/10) are automatically flagged for detailed inspection by an expert before shipment, preventing problems at customs.

Source: author's own work

Proposal. The analytical platform for LCL shipments is an integrated cloud-based SaaS (software as a service) platform that functions as a central digital operating system for managing all aspects of consolidated cargo.

Its main goal is to transform a chaotic flow of data from various sources into a single source of reliable information, ensuring transparency, predictability, and control over the entire logistics chain.

The platform consists of several interconnected modules, each of which solves specific business tasks:

– Visibility and Tracking Module: integrates data from IoT sensors on cargo, GPS trackers, and carrier information systems. Using machine learning models, it provides not only the current location but also the accurate estimated time of arrival (Predictive ETA), taking into account weather, traffic jams, and port congestion.

– Proactive Risk Management module: analyzes accompanying documents for errors, checks compliance with customs requirements, and assigns a risk rating to each shipment. This allows you to identify potential problems (such as incorrect HS codes) before shipment and prevent delays.

– Financial Control and Automation Module: automates the process of allocating costs between different shipments in a container, checks contractor invoices for discrepancies, and generates transparent invoices for customers.

– Business analytics module: visualizes all operational and financial data in the form of interactive dashboards. This allows management to track key performance indicators (KPIs) such as on-time delivery, average transportation costs, and profitability to make informed strategic decisions.

Thus, this platform is not just a tool, but a strategic asset that radically changes the approach to logistics management—from reactive problem solving to proactive, data-driven development.

Assessment of economic efficiency and return on investment using the example of FTP LLC

The implementation of a centralized analytical platform is a strategic investment aimed at improving operational efficiency and expanding the range of services. This

section presents a detailed financial justification for such a project using the example of the logistics company FTP LLC, which allows assessing its feasibility in real business conditions.

FTP LLC is a Ukrainian logistics operator founded in 2011 in Kyiv, specializing in comprehensive international trade services. The company offers a full range of services that go beyond ordinary cargo transportation. FTP LLC specialists provide advice on foreign economic activity, assist with customs clearance, take over the management of the entire logistics chain from the moment of loading the cargo to its final delivery, provide support in concluding contracts and financial transactions, and assist in import processes [16-17].

Over the years, FTP LLC has achieved significant success. In 2014, it received recognition as the "Industry Leader of 2014" in Ukraine. An important milestone in its development was the opening of a branch in Warsaw in 2016, which expanded the company's geographical reach and allowed it to operate effectively even in the difficult conditions associated with the war in Ukraine. In 2020, the company joined the prestigious World Cargo Alliance (WCA), confirming its high standards of service and gaining access to a global network of 12,229 offices in 197 countries. These achievements underscore the reliability and leadership position of FTP LLC in the international logistics services market.

The company is engaged in the following activities [17]:

52.29 Other auxiliary transportation activities;

46.74 Wholesale trade in cast iron products, cast iron products, plumbing and heating equipment and accessories;

47.52 Retail sale of hardware, building materials, and plumbing equipment in specialized stores;

52.10 Warehousing;

52.24 Cargo handling;

70.22 Business and management consulting;

69.10 Legal activities;

49.41 Road freight transport;

50.20 Sea freight transport;

51.21 Air freight transport.

Profile of FTP LLC:

– Staff: ~160 employees in offices in Ukraine and Poland.

– Business model: Asset-light (no own transport), use of partner warehouses in key hubs (China, Poland, EU).

– Services: Comprehensive logistics, financial, banking, and brokerage services, mainly in the import segment from Asia and Europe.

– Finance: Annual net income ~ UAH 30 million (approximately US$750,000).

– IT infrastructure: A set of disparate systems (BAF, CRM, Power BI, messengers) is used, which creates the problem of "information silos" and complicates comprehensive control.

Investment goal: Implementation of a unified analytical platform for data integration, process automation, and creation of new data-driven services for customers.

Detailed analysis of investment costs for FTP LLC

Investments for FTP LLC are not directed at physical assets, but at creating a unified digital ecosystem, which is a key element of the asset-light model.

The main investment is the SaaS platform. For a company that works with multimodal transportation (sea, air, road, rail) and a large number of contractors, a cloud-based SaaS solution is optimal. It provides flexibility and scalability. The license fee of $55,000 per year includes visibility, contractor management, and financial analytics modules [18-19].

Ensuring visibility: IoT operating costs. Since FTP LLC does not own any transport, purchasing a fleet of expensive reusable sensors is not feasible. Instead, a budget of $7,000 per year covers the cost of using disposable trackers or data from partners to monitor the most valuable LCL cargo from Asia.

System integration: Integration. This is the most important one-time expense. It will

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cost $30,000 to seamlessly integrate the new platform with FTP LLC's existing systems – BAF (operational data), CRM (customer data), and financial programs. Without this, the platform will not be able to become a "single source of truth" [18-19].

Staff training: An investment of $10,000 is aimed at training 40-50 key employees in the operational, financial, and commercial departments so that they can use all the capabilities of the new system for analysis, not just for simple monitoring [18-19].

Detailed analysis of the potential benefits for FTP LLC

The advantages of the project lie not only in cost savings, but also in the creation of new sources of income, which is extremely important for a service company.

Reduced demurrage and detention costs. For FTP LLC, maritime transport from Asia is a key area where the unpredictability of port operations often leads to penalties. Estimated time of arrival (ETA) allows for advance planning of container removal. This reduces costs by at least 50%, which is equivalent to savings of $15,000 per year.

Optimization of contractor selection. FTP LLC's main expenses are payments for carrier services. The platform allows you to create a rating of contractors based on historical data analysis (timeliness, cost, reliability). Choosing partners based on data, not just price, reduces overall transportation costs by 2-3%, resulting in savings of approximately $25,000 per year [20].

Increased productivity. Operations managers at FTP LLC spend up to 40% of their time on routine tasks: tracking shipments in different systems, communicating in messengers, and preparing reports. Automating these processes frees up the equivalent of 1.8 employees' productivity, which translates into $36,000 per year.

Creating new sources of income. The analytics platform allows FTP LLC to monetize data. The company can launch new premium services:

– Pro-Visibility package: providing customers with access to real-time tracking using IoT sensors.

– Risk Management Service: analytical reports on route risks and insurance services.

This can generate up to $30,000 in new high-margin revenue per year.

Total estimated annual benefit: $15,000 + $25,000 + $36,000 + $30,000 = $106,000.

Return on investment (ROI) is a performance metric used to measure the effectiveness or profitability of an investment. It means how much net profit you get for every dollar invested. It is always expressed as a percentage.

Payback period (PP) is the amount of time it takes for an investment to generate enough cash flow to recoup its initial cost. It is expressed in units of time (e.g., months or years).

Net present value (NPV) is an important financial metric that calculates the profitability of an investment, taking into account the time value of money. Simply put, it shows managers how much all future cash flows from a project are worth today. A positive NPV indicates that the project is expected to generate more value than it costs.

All these characteristics were calculated in Table 5, as shown below.

Assumptions for calculation:

Project implementation period: Net present value was calculated for a standard 5-year period.

Discount rate: A discount rate of 12% was used. This rate reflects the minimum return that the company expects from an investment with a similar level of risk.

Cash flows: The calculation uses an initial one-time investment (-$40,000) and a net annual cash flow (benefits minus current expenses) of +$44,000 per year.

A positive NPV of $118,611 over five years strongly indicates that the investment in the analytics platform is financially sound and will create significant value for the company that will far exceed the initial costs.

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Table 5. Calculation of the financial impact of the investment plan implementation

Indicator	Formula	Year 1	Year 2	5-year forecast
Total investment amount	Sum of one-time and annual costs	$102,000	$62,000	-
Total annual benefit	Sum of direct and indirect savings	$106,000	$106,000	-
Net result for the year	Benefits - Investments	$4,000	$44,000	-
Return on investment (ROI)	(Net result / Investments) × 100%	3.9%	71%	-
Payback period	Total investments / (Benefits / 12)	-	-	11.5 months
Net present value (NPV)	∑((1+r)t/CFt)−C0*	-	-	$118,611
*Explanation of NPV formula variables	CFt : Net cash flow for time period t r: Discount rate (required rate of return) t: Time period (e.g., year 1, year 2) C0 : Initial investment cost (at time 0)			

Source: author's own work

KPI assessment

The last part of this work is devoted to the structure of analytics performance evaluation. The true indicator of the success of any technological initiative is its quantitative impact on key business indicators. The implementation of an analytics platform in LCL transportation is not an end in itself, but only a tool for achieving specific business results. At the end of this work, we propose a comprehensive structure for evaluating the effectiveness of the project, which allows us to justify its value to all stakeholders.

This methodology is based on the "before and after" principle, which requires the collection of baseline indicators prior to implementation and their regular monitoring after the platform is launched. The assessment is built around four key areas of impact.

1) Operational efficiency – this group of key performance indicators shows how much more streamlined, faster, and more efficient the company's internal processes have become. The main goal is to measure the reduction of friction in day-to-day operations. Analytics directly contributes to improved planning and automation of routine tasks, which should be reflected in metrics such as on-time delivery (OTD), reduced order processing time, increased container utilization, and accelerated inventory turnover. The platform's optimization algorithms and predictive capabilities are the main drivers of these improvements.

2) Financial indicators – these indicators directly reflect the impact of the project on the company's final financial result. Here, the final financial condition of the logistics provider is measured. By optimizing routes, minimizing costs, increasing productivity, and ensuring accuracy, analytics should reduce the average cost of processing a cubic meter. This is complemented by a significant reduction in penalty costs, such as downtime and delay penalties. In addition, automation allows the company to process more volume with the same staff, which should lead to increased revenue per employee and improved billing accuracy.

3) Service quality and customer satisfaction – this category assesses how technological changes have improved the customer experience. Successful implementation makes life easier for customers and makes their business more predictable. This can be measured using direct feedback tools such as Net Promoter Score (NPS) or Customer Satisfaction (CSAT). A key indicator of proactive service is a reduction in customer inquiries per shipment, as customers have all the information they need on the self-service portal. Ultimately, the most important indicator is customer

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retention, as high quality and transparency of service are key to long-term loyalty.

4) Strategic impact. Strategic supply chain planning is a comprehensive, comprehensive, and integrated planning process to achieve competitive advantages for the chain by increasing added value and improving service parameters. Supply chain optimization should be viewed from the perspective of a holistic analysis of the value chain and key performance indicators (KPIs), rather than local optimization of production cycle time, inventory levels, etc. [21, pp. 122-126]. The proposed KPIs are described in Table 6.

Table 6. Summary of Key Performance Indicators (KPIs)

Category	KPI	How analytics drives improvement
Operational efficiency	On-time delivery (OTD)	Arrival time forecasting and proactive risk management.
	Order processing time	Automation of documentation and planning.
	Container utilization rate	Load optimization algorithms for maximum space utilization.
Financial results	Cost per cubic meter	Optimization of routes, workforce, and assets; cost reduction.
	Downtime and delay costs	Accurate arrival forecasting and proactive alerts.
	Revenue per employee	Automation allows existing staff to handle a greater volume of work.
	Invoice accuracy	Automated auditing and data verification.
Service quality and customer satisfaction	Customer loyalty index (NPS) / CSAT	Increased transparency, reliability, and proactive communication.
	Number of shipping requests	Customer self-service portals with real-time tracking data.
	Customer retention rate	High-quality service builds long-term loyalty.
Strategic impact	Data-driven decision-making rate	Measures cultural shift toward analytical decision-making.

Source: author's own work

Evaluating analytics effectiveness should not be a one-time event. It should become part of a continuous cycle of "Measurement → Analysis → Optimization." This structure provides a clear roadmap not only for validating the value of the initial investment, but also for transforming the analytics platform into a dynamic tool for finding new avenues for growth. This data-driven approach to management is the foundation for creating a sustainable competitive advantage and establishing leadership in the logistics market.

Conclusions. The study confirms that the targeted use of analytics in consolidated freight transportation is a key factor in the transition from traditional, reactive methods to a proactive, data-driven business model. Analytics is not just an optimization tool, but a fundamental basis for survival and growth in this complex and competitive segment of logistics. In the course of the work, all the tasks set in the context of the research topic were completed.

First, the features and key challenges inherent in consolidated transportation were analyzed. The study showed that the main problems of the LCL segment are the complexity of physical consolidation of cargo from different shippers, the lack of transparency in the distribution of shared costs between them, and the fragmentation of tracking on multi-stage routes.

Second, the main goals and areas of application of transport analytics for solving these problems were identified. It was found that the main goal of analytics in LCL is to transition to a proactive model capable of managing the high volatility and risks characteristic of consolidated freight supply chains. This allows logistics operators to strengthen their competitive advantages through reliability and transparency.

Thirdly, the paper systematizes key areas of application of analytical methods directly for LCL operations. It shows how modeling the estimated time of arrival for multi-stage consolidated routes, optimization algorithms for maximizing container loading, and intelligent processing of different document packages from multiple senders within a single consolidation can effectively solve specific problems in this market.

Fourth, the technologies and tools required to implement analytics in consolidated transport were outlined. The study showed that the basis is a SaaS cloud platform specialized in managing multi-client LCL shipments. The key tools are machine learning models for forecasting and business analytics platforms for monitoring KPIs specific to group logistics.

Finally, approaches to evaluating the effectiveness of analytical solutions in the LCL sector were proposed. A KPI system was developed and a detailed ROI calculation model was provided. Calculations based on the example of FTP LLC showed that with an initial investment of $102,000 and an annual benefit of $106,000, the project pays for itself in 11.5 months, and the return on investment in the second year reaches 71%. This proves the high economic feasibility of investing in specialized analytical systems for managing consolidated cargo.

Thus, the introduction of analytics into consolidated freight logistics is a sensible and necessary step. It not only solves existing operational problems, but also creates a basis for innovation and transforms information into a strategic asset for gaining a decisive advantage in the competitive market of consolidated transportation.

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