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REENGINEERING THE RAILWAY MONOPOLY IN THE CONTEXT OF THE EUROPEAN GREEN DEAL: DIGITAL TOOLS FOR PUBLIC ADMINISTRATION

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Abstract. *Subject of research.* The subject of this research is the system of public administration of the railway monopoly in Ukraine and the transformation of its core business processes under the influence of the European Green Deal priorities. The study specifically focuses on the institutional and operational mechanisms of JSC "Ukrzaliznytsia," examining the challenges of unbundling, financial transparency, and environmental accountability during its digital transition. *Goal of the study.* The main purpose of the paper is to substantiate the theoretical, methodological, and practical foundations for the reengineering of the railway monopoly's business processes in the context of the European Green Deal. The research aims to develop a structured methodology for transitioning from traditional hierarchical administrative methods to a transparent, algorithm-driven digital platform for public administration, thereby ensuring non-discriminatory infrastructure access and compliance with EU transport directives. *Methodology.* The methodological framework of the study is built on a multidisciplinary approach combining the principles of Business Process Reengineering (BPR), structural-functional analysis, and formal modeling. The Business Process Model and Notation (BPMN 2.0) standard is applied to redesign and visualize the infrastructure access processes, illustrating the shift from sequential manual procedures to parallel digital workflows. Furthermore, the study introduces a novel mathematical multi-criteria model to quantitatively evaluate reengineering efficiency. This model integrates three key normalized dimensions: operational cycle time reduction, administrative and operational cost savings, and carbon emission decreases, with weight coefficients aligned with the European Green Deal priorities. *Results and Conclusions.* The findings of the research demonstrate that the implementation of integrated Enterprise Resource Planning (ERP) systems serves as a critical technological guarantor (enabler) for successful railway sector reform. The multi-company architecture of the ERP system effectively ensures the financial separation of infrastructure management from transport operations, systematically eliminating the chronic issue of cross-subsidization. The transition from sequential manual validation to automated parallel processing within the ERP environment significantly reduces coordination delays, optimizing capacity utilization. Additionally, the integration of real-time carbon footprint monitoring tools within the digital platform provides public authorities with verifiable data on emissions. The proposed quantitative efficiency model proves to be a robust decision-support tool for state regulators, enabling data-driven evaluation of reform scenarios and accelerating Ukraine's integration into the single European railway market.

Keywords: European Green Deal, railway monopoly, reengineering, ERP systems, unbundling.

JEL Classification: L92, O33, Q54

1. Introduction

The global climate crisis and the adoption of the Green Deal in 2019 have become decisive factors in the transformation of public administration systems across all EU partner countries. The core philosophy of this strategy lies in the transition to a climate-neutral economy, which requires a radical overhaul of approaches to the functioning of transport systems. Currently, the transport sector is the only sector in the European Union where greenhouse gas emission levels are not decreasing but continue to show an upward trend. In this context, the decarbonization of logistics chains through the development of rail transport is becoming an absolute priority. As Constance Fetting

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emphasizes in the ESDN report, railways should act as the "backbone" of the future transport system, as this particular mode of transport possesses the highest potential for energy efficiency per unit of freight turnover (Fetting, 2020, p. 4).

However, for Ukraine, the implementation of these ambitious goals faces deep internal contradictions. The railway industry, represented by JSC "Ukrzaliznytsia", has long functioned under conditions of institutional inertia and technological lag. Despite its strategic importance, the national carrier is in a state of prolonged crisis. According to studies by R. Miroshnyk and K. Fedak, the main barriers to development are the critical wear and tear of fixed assets (which exceeds 90% in certain areas) and the lack of a transparent financial accounting model that would allow for a clear distinction between profitable and loss-making areas of activity (Miroshnyk & Fedak, 2021, p. 91). This situation makes it impossible to fulfill the requirements of Directive 2012/34/EU regarding unbundling and the creation of a competitive market for railway transport.

Problem Statement. The primary issue in the public administration of the railway monopoly in Ukraine is the misalignment of the outdated vertically integrated structure with the requirements of the modern digital and environmental agenda. Traditional administrative methods based on a functional approach fail to provide the necessary level of flexibility and transparency. This results in the phenomenon of "cross-subsidization," where profits from freight transportation are uncontrollably diverted to cover losses in the passenger sector, rather than being invested in the "green" modernization of infrastructure.

Addressing this issue requires the application of business process reengineering (BPR). According to Michael Hammer and James Champy, reengineering is not merely the automation of existing functions but the fundamental rethinking and radical redesign of processes to achieve dramatic improvements in key performance indicators such as cost, quality, and speed (Hammer & Champy, 2001, p. 35). In the context of the Ukrainian railway, this implies a total transformation of the operational management model, where information technologies serve as "enablers" – factors that make possible new, previously unattainable ways of working (Hammer & Champy, 2001, p. 87).

Of particular importance in this process is the implementation of integrated ERP (Enterprise Resource Planning) systems. In the context of modern digital transformation in 2024, the role of ERP extends beyond simple accounting. According to the research of I. V. Zakharova and co-authors, information and analytical activities in the public sector must be based on a "single source of truth," where all data on resources, energy consumption, and financial flows are verified and available for real-time analysis (Zakharova et al., 2024, pp. 18–20). Only under such conditions is real unbundling possible, which would guarantee non-discriminatory access for private carriers to the infrastructure – a key requirement for Ukraine's integration into the Single European Railway Area.

2. Analysis of Recent Research and Publications

The issues of reforming railway transport and implementing the principles of sustainable development are widely discussed in global scientific thought. William Black provides a detailed analysis of the problems of sustainable transport as a global challenge, pointing out that the social and environmental viability of the sector is only possible if the negative impact on the environment is minimized (Black, 2010, p. 15). In turn, Alan McKinnon, in his works on "green logistics," emphasizes the need for internal restructuring of companies for accurate accounting and reduction of the carbon footprint of each logistics operation (McKinnon et al., 2010, p. 12). However, despite a significant number of theoretical developments, the mechanisms for the practical combination of process reengineering and digital ERP tools to achieve Green Deal goals in transition economies remain insufficiently studied.

3. Theoretical and Methodological Foundations of Reengineering and Modeling in BPMN 2.0 Notation

The transition to a new model of railway transport operation under the conditions of the "Green Deal" is impossible without a deep theoretical revision of existing management approaches. The fundamental basis for such changes is the theory of business process reengineering, which requires abandoning the traditional functional division of labor in favor of value-creating end-to-end processes. Michael Hammer and James Champy emphasize that reengineering is not just "improvement" or "cosmetic repair" of an existing system, but a radical redesign that begins with the question "why do we do what we do?". Such an approach allows for ignoring outdated organizational structures and creating processes that correspond to modern technological capabilities (Hammer & Champy, 2001, pp. 35–37). In the case of the Ukrainian railway company, this implies a transition from a closed hierarchical model to transparent algorithmic infrastructure management.

An important aspect of reengineering is the use of information technology not as a means to speed up outdated procedures, but as a tool for establishing new rules of the game. Hammer and Champy define IT as an "enabler" that allows organizations to break rules that were previously considered unbreakable due to physical or organizational constraints (Hammer & Champy, 2001, p. 87). For example, the rule "track access is determined by a dispatcher based on subjective

priorities" in the reengineering model is replaced by the rule "access is granted automatically by a digital system based on transparent environmental and economic criteria." This creates a technological barrier to corruption and ensures non-discrimination, which is a basic requirement of European railway directives.

For the practical implementation of such reengineering, the choice of visualization and modeling tools is critical. The most effective standard in this context is the BPMN 2.0 (Business Process Model and Notation) notation. It allows representing the complex logic of interaction between the state regulator, the infrastructure operator, and carriers in the form of graphical diagrams that are equally understandable to both managers and software developers. Modeling the infrastructure access process in BPMN allows for the clear identification of all entry and exit points of information, which is a necessary condition for forming verified analytical reporting. As noted by I. V. Zakharova, the effectiveness of information and analytical activity directly depends on the accuracy of selecting source data for analysis, which allows for the formation of secondary information documents that adequately characterize the state of a complex system (Zakharova et al., 2024, p. 347).

To illustrate the practical application of BPMN 2.0, it is useful to consider a simplified model of the railway infrastructure access process before and after reengineering. In the traditional model, the process begins with a carrier submitting a request for track access, which is then sequentially reviewed by multiple departments. Each stage involves manual verification of technical feasibility, rolling stock availability, and tariff calculation. Decision-making is largely centralized and may depend on subjective judgment, resulting in delays and a lack of transparency.

In contrast, the reengineered process based on BPMN 2.0 and ERP integration follows a parallel and data-driven logic. Once a request is submitted, the system simultaneously verifies infrastructure capacity, rolling stock parameters, and environmental impact indicators using predefined algorithms. The decision on access allocation is generated automatically based on transparent criteria, including energy efficiency and network load. All process steps are recorded within a unified digital environment, ensuring traceability and eliminating the possibility of discretionary intervention.

Such a transformation not only reduces processing time but also ensures compliance with the principles of non-discriminatory access and environmental sustainability required by the European Green Deal. terize the state of a complex system (Zakharova et al., 2024, p. 347).

Accounting for environmental variables within process structures assumes particular importance in reengineering methodology. Traditional process modeling models typically ignore carbon footprint indicators; however, under the European Green Deal framework, these data become critically important. According to sustainable transport development approaches, every operation in the supply chain must have a digital assessment of its environmental impact (Black, 2010, p. 19). Integrating these indicators into BPMN models of railway transport allows for the transformation of environmental responsibility from an abstract concept into a specific parameter of the management process. This establishes the foundation for the next stage – the implementation of an integrated ERP system, where these processes will be automated and supported by financial accounting.

4. ERP Systems as a Technological Guarantor of Unbundling and Ecological Monitoring

The practical implementation of the unbundling model in JSC "Ukrzaliznytsia" faces a fundamental problem. There are no effective mechanisms for the clear separation of costs between infrastructure management and the provision of transportation services. Traditional accounting systems based on a functional approach do not allow for the identification of the real cost of track maintenance, leading to chronic cross-subsidization, a problem pointed out by R. Miroshnyk and K. Fedak (2021, p. 91). This is why an integrated ERP system serves as a key enabler of reengineering, ensuring the transition to a "shared assets" management model. According to the concept by Michael Hammer and James Champy, IT tools allow for changing the very nature of business interaction: instead of hierarchical control, automated transparency is introduced, where every financial flow has a clear purpose and source (Hammer & Champy, 2001, p. 87).

The technological architecture of an ERP system for the railway sector is based on the multi-company principle (multi-entity accounting). This allows for maintaining an independent financial balance for the infrastructure operator and transportation units within a single database. Such an approach guarantees non-discriminatory access, as infrastructure access tariffs for the state carrier and private companies are calculated based on identical algorithms. O. Eisenkopf notes that creating a "level playing field" is the key to the success of railway market liberalization in EU countries (Eisenkopf, 2006, p. 313). ERP implementation allows for automating this process, eliminating the human factor and subjectivity in the distribution of network capacity.

A significant advantage of modern ERP solutions is their capacity for deep analytics of large datasets. In the context of the 2024 digital transformation, information and analytical activities in the public sector should be based on the formation of secondary information documents that summarize primary data on resource utilization. As I. V. Zakharova notes, this allows for the preparation of factographic certificates

and comprehensive reports characterizing the state of specific problems – in particular, energy efficiency and environmental impact (Zakharova et al., 2024, pp. 347–348). Thus, the ERP system becomes a platform for fulfilling Ukraine's climate obligations within the European Green Deal.

Ecological monitoring within the railway reengineering system is implemented through specialized carbon footprint accounting modules. By integrating sensors on rolling stock with telemetry systems, the ERP system automatically collects data on electricity and fuel consumption for every kilometer of the route. This enables the realization of Alan McKinnon's "green logistics" concept, where each transportation operation receives a verified ecological passport (McKinnon et al., 2010, p. 12).

In turn, this paves the way for "green" tariff regulation: the state can incentivize carriers to utilize modern rolling stock by setting lower infrastructure access fees for energy-efficient trains. Such a mechanism directly aligns with the EU Green Deal's objectives regarding the decarbonization of the transport sector (Fetting, 2020, p. 4) and positions the railway as the most attractive transport mode for environmentally responsible businesses.

5. Operational Management and Cycle Optimization in Public Railway Administration

The efficiency of reengineering the railway monopoly within the framework of the "Green Deal" directly depends on the ability of the operational management system to minimize time and resource costs. In the traditional management model of JSC "Ukrzaliznytsia", infrastructure access coordination processes are sequential in nature, which creates significant time gaps and reduces the overall throughput capacity of the network. According to the fundamentals of production organization, the duration of the operational cycle depends directly on the method of combining operations. The sequential movement of objects of labor, which dominates outdated bureaucratic procedures, leads to each subsequent operation starting only after the full completion of the previous one, which maximizes the cycle duration (Pak, 2018, p. 49).

Business process reengineering based on an ERP system allows for a transition to parallel-sequential or even fully parallel execution of management operations. Thanks to digitalization, technical route coordination, rolling stock capacity verification, and the calculation of track access costs occur simultaneously within a single information environment. Michael Hammer and James Champy emphasize that the ability of technology to provide process parallelism is one of its most important functions in reengineering, as it allows for a radical reduction in decision-making time (Hammer & Champy, 2001, p. 87). For the railway sector, this means increasing the turnover speed of wagons and locomotives, which directly impacts the economic stability of the industry.

Optimizing operational cycles has not only an economic but also a pronounced environmental effect. Reducing the idling time of trains at stations and optimizing the traffic schedule allow for a significant reduction in energy consumption. As William Black notes, sustainable transport is a system that operates at the limit of its technological efficiency, minimizing wasteful resource consumption (Black, 2010, p. 19). In this context, reengineering becomes a public management tool that transforms the railway into a flexible logistics platform. The use of BPMN models allows management bodies to identify "bottlenecks" in processes and eliminate them promptly, ensuring high reliability of transportation.

The integration of operational management with EU Green Deal environmental priorities requires a new approach to assessing infrastructure capacity. Instead of a simple count of train pairs, the ERP system enables the analysis of the "ecological capacity" of routes. According to information and analytical support approaches, such analysis is based on the generation of comprehensive reports reflecting real-time energy resource utilization dynamics (Zakharova et al., 2024, p. 348). This allows public authorities to perform strategic planning for network development, focusing on the most promising and energy-efficient directions. Consequently, the reengineering of operational cycles creates the conditions for a genuine "modal shift," where businesses choose rail transport not out of compulsion, but because of its technological and environmental advantages.

6. Discussion of Results and Comparative Analysis of Liberalization Models

The results of this study show that the reengineering of the railway monopoly based on integrated digital systems is not only a technological but also a fundamental institutional challenge. Academic debates on railway reform in the European Union have long focused on the effectiveness of vertical separation (unbundling). As Chris Nash and Andrew Smith note, empirical studies of railway costs and efficiency indicate the ambiguity of liberalization results: in some cases, separation led to an increase in transactional and coordination costs between the infrastructure operator and carriers (Nash & Smith, 2014, p. 34). The authors emphasize that the success of the reform largely depends on the regulator's ability to ensure effective interaction between entities in the new conditions. For Ukraine, this risk is particularly relevant, given the high degree of process integration within JSC "Ukrzaliznytsia".

However, the reengineering model based on ERP systems proposed in this article is designed to mitigate precisely these coordination risks. Unlike the experience of countries that carried out unbundling in the pre-digital era, Ukraine has the opportunity to use information technology as a "digital glue" that maintains the integrity of the system during the organizational separation of functions. As Michael Hammer and James Champy remark, the true potential of modern IT lies in the possibility of breaking old rules of hierarchical control and replacing them with algorithmic transparency, which allows different organizations to work as a single, coordinated mechanism (Hammer & Champy, 2001, p. 87). This makes it possible to avoid chaos in the allocation of network capacity and to ensure a "level playing field," the importance of which for internal competition in the railway sector is emphasized by Alexander Eisenkopf (Eisenkopf, 2006, p. 313).

The issue of institutional readiness and resistance to change within a natural monopoly requires special discussion. Research into the strategic directions of the industry's development confirms that the main obstacles to reforms in Ukraine are not only a lack of funding but also the opacity of management procedures, which contributes to corruption risks (Miroshnyk & Fedak, 2021, p. 91). The implementation of an ERP system integrated with environmental monitoring modules radically changes the situation by making every action of an official and every liter of fuel consumed visible within the analytical control system. According to approaches in information and analytical activity, such a level of data granularity allows for the preparation of comprehensive reports and forecasts that make reporting manipulation impossible and build trust among international investors (Zakharova et al., 2024, p. 348).

Furthermore, the proposed approach allows for resolving the dilemma between economic efficiency and environmental responsibility within the European Green Deal. Traditionally, it was believed that the implementation of "green" standards was an additional financial burden for railways. However, through the lens of reengineering, decarbonization becomes a factor of optimization. Automated energy consumption and carbon footprint accounting, based on verified ERP data, allow the railway to offer businesses not only a logistics service but also a confirmed reduction in the environmental impact of their supply chains (McKinnon et al., 2010, p. 12). This creates a new added value which, in the words of William Black, is a necessary condition for transforming transport into a socially and environmentally sustainable system (Black, 2010, p. 15). Thus, the reengineering of the railway monopoly in Ukraine is not merely the fulfillment of external EU requirements but a strategic path toward creating a modern, transparent, and profitable industry that forms the foundation of the "green" economy of the future.

6.1. Quantitative Assessment of Reengineering Efficiency

To complement the conceptual framework of railway reengineering, a quantitative model for evaluating the efficiency of business process transformation is proposed. The model integrates three key dimensions that reflect the objectives of the European Green Deal: operational performance, economic efficiency, and environmental impact.

The overall efficiency indicator is defined as:

$$\mathbf{E = w_1 T_{red} + w_2 C_{red} + w_3 CO_{2\text{-red}}} \quad (1)$$

Where:

– $\mathbf{T_{red}}$ represents the reduction in operational cycle time;

– $\mathbf{C_{red}}$ reflects cost savings;

– $\mathbf{CO_{2\text{-red}}}$ captures the decrease in carbon emissions.

The coefficients wi define the relative importance of each component and satisfy the condition $\mathbf{w_1 + w_2 + w_3 = 1}$.

The time efficiency component is calculated as:

$$T_{red} = (T_{before} - T_{after}) / T_{before} \quad (2)$$

This indicator reflects the transition from sequential to parallel process execution enabled by ERP systems, which significantly reduces coordination delays in infrastructure access management.

The cost efficiency component is defined as:

$$C_{red} = (C_{before} - C_{after}) / C_{before} \quad (3)$$

It captures the elimination of inefficiencies such as cross-subsidization, administrative overhead, and resource misallocation, which are typical for vertically integrated railway monopolies.

The environmental component is expressed as:

$$CO_{2red} = (CO_{2\text{-}before} - CO_{2\text{-}after}) / CO_{2\text{-}before} \quad (4)$$

This metric is based on real-time data collected through ERP-integrated monitoring systems and reflects the impact of reduced idle time, optimized routing, and improved energy efficiency.

For the purposes of this study, it is proposed to assign the following weights in line with the priorities of the European Green Deal: $\mathbf{w_1 = 0.4, w_2 = 0.3, and\ w_3 = 0.3.}$

The proposed model enables public authorities to quantitatively assess the effectiveness of railway reform scenarios and supports data-driven decision-making in the context of digital transformation.

7. Conclusions and Practical Recommendations for the Public Administration System

This study proposes a cohesive concept for the transformation of Ukraine's railway industry under conditions of global climate challenges. The results show that the business process reengineering of JSC "Ukrzaliznytsia" based on digitalization is not merely a technical modernization but a fundamental

condition for the implementation of the European Green Deal and the successful execution of unbundling.

Unlike traditional approaches, this study integrates ERP-based digital infrastructure management with environmental monitoring metrics within a unified reengineering framework.

The novelty of this study lies in the development of an integrated digital reengineering model for railway public administration, which combines business process reengineering (BPR), BPMN-based process formalization, and ERP-driven environmental monitoring. Unlike existing studies that focus on institutional reform or sustainability separately, this research proposes a unified approach in which digital technologies serve as a core mechanism for implementing unbundling, ensuring transparency, and enabling real-time carbon footprint accounting within a single system architecture.

Based on the research results, the following main provisions have been formulated:

The results indicate that the key barrier to the decarbonization of the transport sector in Ukraine is the institutional inertia of the railway monopoly. Process reengineering allows for overcoming this inertia by transforming a closed hierarchy into a transparent digital platform capable of ensuring the fulfillment of European Green Deal objectives regarding emission reductions (Fetting, 2020, p. 4; Miroshnyk & Fedak, 2021, p. 91).

The findings demonstrate that the use of BPMN 2.0 notation for business process modeling is a necessary step for eliminating subjectivity in public administration. The formalization of interaction algorithms between the infrastructure operator and carriers allows for minimizing coordination costs, which, according to the experience of liberalization in the EU, often become an obstacle to the effectiveness of reforms (Nash & Smith, 2014, p. 34).

This study highlights the role of integrated ERP systems in ensuring the transparency of unbundlin. The application of the Multi-Company model allows for a clear financial separation of assets and the elimination of cross-subsidization. Meanwhile, the generation of secondary information documents in the system (Zakharova et al., 2024, p. 347) becomes the basis for a verified ecological audit of each route, which corresponds to the principles of sustainable mobility (Black, 2010, p. 19) and green logistics (McKinnon et al., 2010, p. 12).

The practical significance of the research lies in the development of specific recommendations for the Ministry of Infrastructure of Ukraine and the management of the national railway operator. It is proposed to:

Implement a unified standard for digital modeling of business processes for track access for all market participants.

Create an open "Green Monitoring" module based on the ERP system, the data from which will be used to establish differentiated infrastructure tariffs depending on the energy efficiency of locomotives.

Optimize operational movement management cycles through the transition to parallel application coordination, which will increase the speed of asset turnover (Pak, 2018, p. 49).

Prospects for further research in this direction lie in the development of mathematical models for dynamic pricing of railway transportation, taking into account the cost of carbon quotas. This approach creates a foundation for transitioning from a traditional railway monopoly to a data-driven, platform-based model of public administration aligned with the European Green Deal. This will allow Ukraine not only to fulfill international obligations but also to become a full-fledged player in the Single European Railway Area, ensuring the sustainable development of the national economy.

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