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ARTIFICIAL INTELLIGENCE IN THE CONTEMPORARY CHINESE HUMAN RESOURCE MANAGEMENT VIA IFLYTEK COMPANY EXAMPLE

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ABSTRACT

The rise of Industry 4.0 has accelerated the development of artificial intelligence (AI)-based solutions, making them a key driver of global economic transformation. As technologies mature and application areas expand, more companies have been integrating AI and automation into human resource management (HRM) for recruitment, training, performance evaluation, and employee relations. AI-based intelligent algorithms and automated processes enhance efficiency and address the shortcomings of traditional HRM, but also pose managerial, cultural adaptability, and legal challenges. Strict data protection regulations, particularly China's Personal Information Protection Law (PIPL), increase legal compliance pressures. In this paper the authors reveal the opportunities and challenges of AI applications in HRM through a case study of iFlytek, whose leading position and practical experience can offer valuable insights for applying AI-based solutions and supporting sustainable development for the Chinese enterprises in a competitive global environment.

Keywords: AI, Chinese HRM, cultural adaptability, legal compliance, PIPL

1. Introduction

Artificial Intelligence (AI) has gradually become one of the core tools in HRM, which can help enterprises conduct faster and more accurate data analysis to support of the decision-making process. The generated data can also be used for long-term data storage and analysis to provide data support for corporate strategic planning. When using generative AI, enterprises have to ensure security and compliance of data to cope with the increasingly stringent regulatory environment (Shanghai Overseas Service, 2024). Digital tools can also track employees' training progress, evaluate their learning outcomes, and provide data support for personalized career development planning. This digital transformation makes the company's HRM more systematic, precise, and improves the efficiency of human resource allocation (Kalvokolanu & Prasad, 2023; Zavyalova et al., 2022).

As the problem of population aging becomes more serious worldwide, many countries face the challenge of labor shortage, especially in high-demand service industries such as medical care and elderly care. Widespread application of automation and robotics technologies not only helps companies reduce their dependence on manpower in repetitive and basic work, but also significantly improves the quality of services in these areas. The development of AI technology has opened up new ways for HRM, companies can train, motivate and deploy employees more effectively, thereby realizing the added value of human capital. This symbiotic relationship will also drive companies to pay more attention to employee's experiences and gradually shift HRM from transactional work to strategic talent management (Deloitte, 2016; Gebayew et al., 2018, Tencent News, 2023).

The globalization trend of HRM has made multicultural management, cross-border legal compliance and language barriers the core issues that multinational companies have to face. Deploying AI recruitment tools, many multinational companies have to ensure that these tools comply with local data privacy protection laws, such as Europe's General Data Protection Regulation (GDPR). At the same time, the trend of globalization has also brought innovation opportunities to companies. Companies can use diverse talent resources, implement inclusive talent management strategies, and further enhance their competitiveness (Roopalatha & Sucharita (2024). In addition, the introduction of AI tools allows HR professionals to devote more energy to strategic, creative and decision-making tasks including talent development, employee training and organizational culture building. In this paper, the authors analysing the introduction of AI tools how to make transition from traditional HRM to intelligent, data-driven HRM supporting business strategies. Furthermore, this research work also proposed some potential strategic options for the decision-makers improving their employees' digital literacy and data analysis capabilities to adapt to the needs of AI-driven intelligent HRM.

2. Methodology

In this review paper, the authors had studied the available relevant theoretical literatures as reference base, gathering, structuring data and draw conclusions. The implementation methodology based on secondary or “desk” research analysing international organisations documents and special databases, scientific publications, studies, online literature sources. The literature search and analysis was carried out in a combined, “snowball method” (Jalali-Wohlin, 2012). It means that further additional relevant literatures were involved based on some pre-selected literature (per author or scientific journal) and their references, as well as additional ideas arising from the authors own existing information. Nevertheless, the diversity of the selected sources supports a multifaceted perspective, a notable portion of the documents comes from secondary media content and corporate publications. These sources provide valuable practical insights but can mean limitations in terms of independence and verifiability. To mitigate potential bias, sources were cross-checked by the authors where possible and evaluated for relevance and credibility for example, by applying qualitative techniques organizing and interpreting data based on recurring themes or patterns to enhance transparency and reproducibility. To analyse the secondary literature on AI in Chinese HRM, thematic coding was applied following Braun and Clarke's (2006) framework. Key documents—such as government action plans, iFlytek corporate reports, and academic studies—were open-coded for concepts like “algorithmic transparency,” “PIPL compliance,” and “human–technology integration.” Through iterative content analysis, these codes were grouped into broader themes linking national policy contexts with iFlytek's practical applications in recruitment, training, and performance evaluation, enabling a focused comparison of macro-level drivers and micro-level practices.

The conclusions and suggestions made by this research work in this article reflect the private professional view of the authors.

3. Landscape of AI-based Solutions Adoption in Chinese HRM

The Chinese government encourages enterprises to innovate and use AI technology to improve HRM processes improving efficiency of data processing and analysis. For example, the "Action Plan for the Implementation of the Innovation and Development of the Human Resources Service Industry (2023-2025)" states that it is necessary for the enterprises to adopt technologies such as big data, cloud computing, and AI to accelerate of business intelligence and management digitization. This policy provides policy support and development space for enterprises to apply AI technology in HR management (Roberts et al. 2021). The below Table 1 briefly summarizes the main political initiatives and Actions Plans.

Table 1. Main initiatives to promote the AI applications in HRM

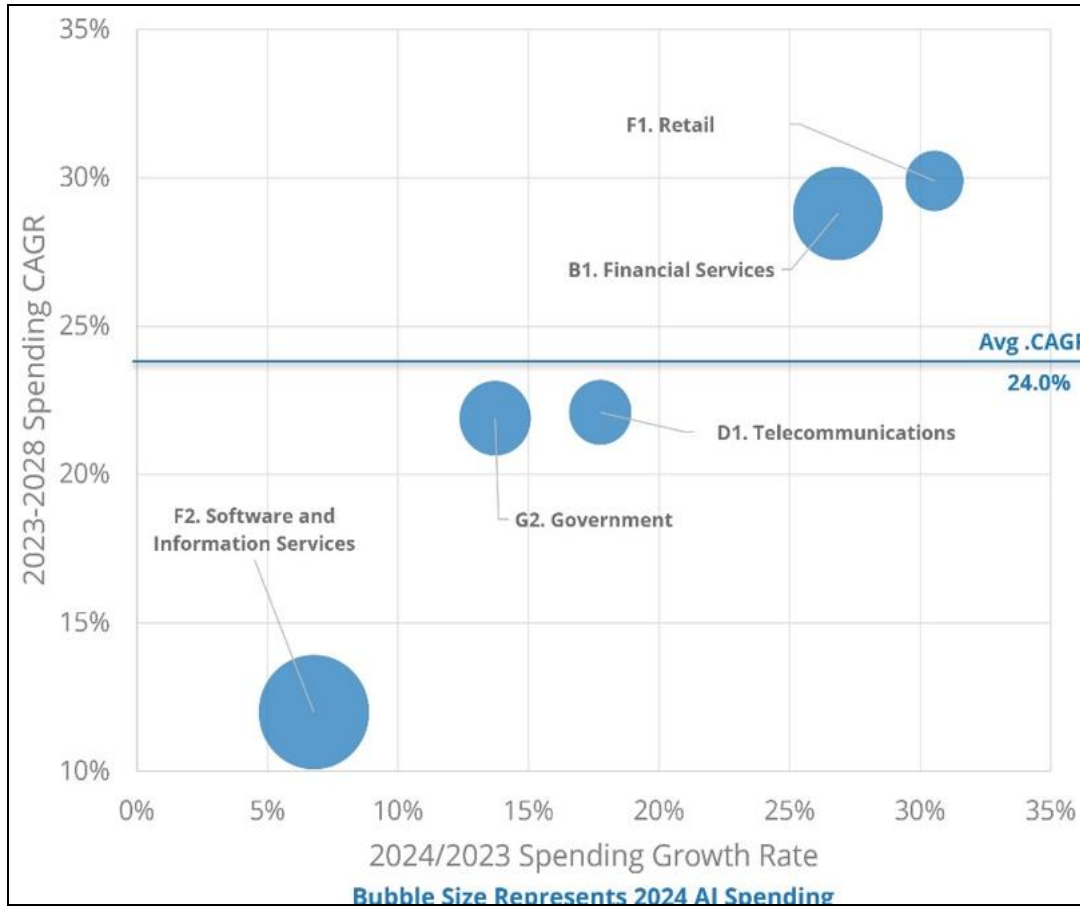
| Policy/Plan | Release Date | Key Content | Impact |
|---|--------------|--|--|
| Next-Generation AI Development Plan | 2017 | Establish an open and collaborative AI technology innovation system and promote AI applications across | Provided policy support for the application of AI in HRM |
| Action Plan for Innovation and Development in HR Service Industry (2023-2025) | 2022 | Enhance the level of AI in HRM | Promoted further application and development of AI in HRM |
| Survey on the Level of Attention to Digital Intelligence Applications in HR Systems | 2023 | Gained attention across various modules with recruitment and employee service platforms | Reflected companies growing focus on demand for the digital transformation of HRM. |

Source: Own edition based on Roberst et al. (2021)

In recent years, the Chinese government has continuously issued a series of policies, clearly pointing out the strategic position of AI in enhancing the country's core competitiveness. AI is regarded as one of the important engines of future economic development, and its application has gradually expanded to multiple key industries, such as finance, medical care, education and manufacturing, providing a strong impetus for innovation and upgrading in various fields of the economy and society. With policy support, related strategies such as new infrastructure and digital economy have further provided support for the development of AI and the rapid growth of the market. According to the forecast of International Data Corporation (IDC), China's spending on AI is increasing year by year, and is expected to reach US\$13.03 billion in 2022, showing strong market demand and investment intention. IDC further predicts that by 2026, the market size is expected to increase to US\$26.69 billion, showing the huge potential and development space of the market. The annual compound growth rate (CAGR) of China's artificial intelligence market is expected to reach 19.6% between 2022 and 2026, indicating that this field will maintain a rapid and stable growth momentum in the next few years (IDC, 2024).

You can see in the below Figure 1., that AI and Generative AI (GenAI) investments in the region are projected to reach \$110 billion by 2028, growing at a compound annual growth rate (CAGR) of 24.0% from 2023 to 2028. This indicates the region’s crucial influence in shaping the future of global scale AI-based innovative solutions.

Figure 1. Asia/Pacific Top Largest Spending on AI Industry



Source: IDC, 2024

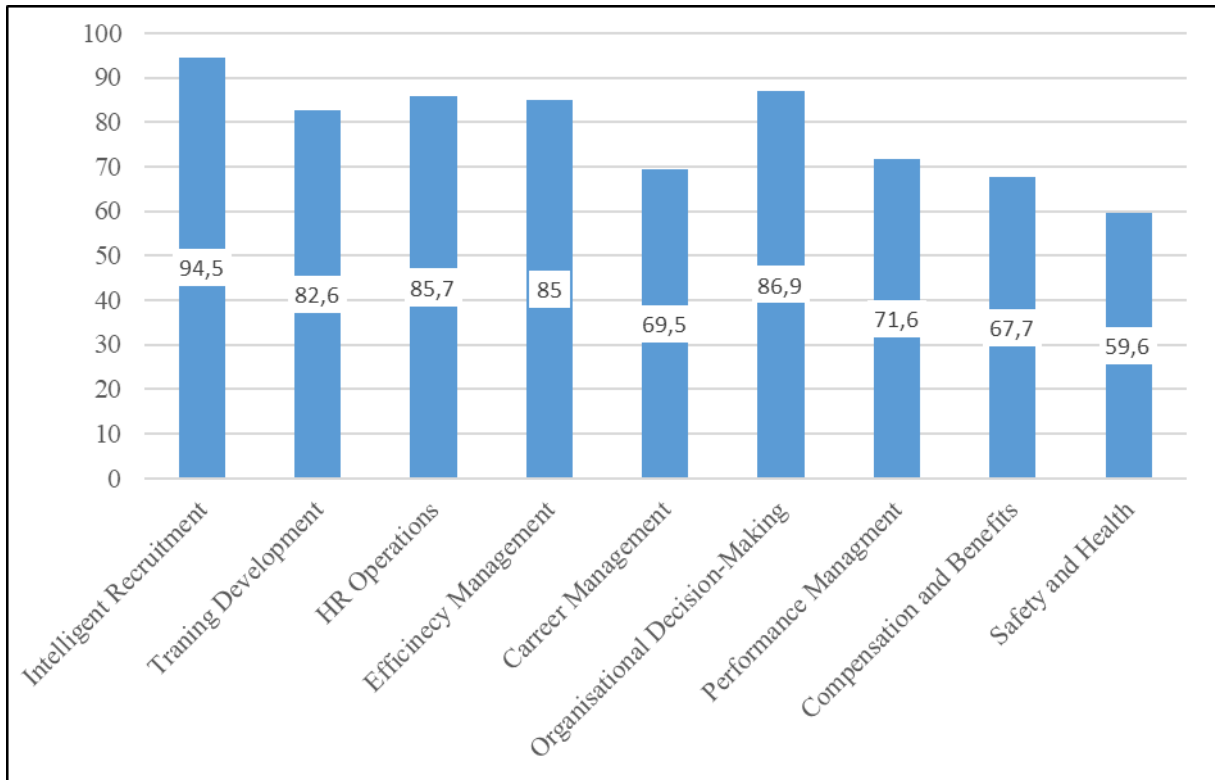
China's artificial intelligence market is expected to further enhance its position and influence in the world, laying a solid foundation for the realization of national digital transformation and innovation-driven high-quality development.

Main applications fields of AI in HRM

Through automated resume screening, intelligent preliminary interview arrangements, and evaluation and analysis in video interviews, AI helps companies significantly reduce the tedious manual operations in the traditional recruitment process, allowing HR teams to focus more on key decision-making links. Specifically, technologies such as AI-generated content (AIGC), natural language processing (NLP), and machine vision provide companies with powerful tools to quickly and efficiently screen out candidates that meet job requirements. With these technologies, AI can automatically analyze factors such as the content of a candidate's resume, work experience, and professional skills, and preliminarily screen out a list of qualified candidates, greatly shortening the initial screening time for HR (ADP, 2024; Inspur, 2022). In addition, AI technology can also analyze the candidate's tone, body language, and expression through video interviews, and even understand the candidate's soft skills such as expression ability and communication skills through voice analysis, thereby providing HR with a more comprehensive and objective evaluation. Furthermore, AI can also

predict the candidate's potential performance in the company in the future by analyzing the candidate's behavioral data and career development data. This data-driven analytical capability not only improves the accuracy of recruitment, but also makes the company more scientific and rigorous in the selection process. The below Figure 2 reveals penetration rate of AI into the different HRM fields in China.

Figure 2. Application Ratio of AI-based Solutions in the Different HRM Fields in China 2022 (in %)



Source: Own edition based on ADP, 2024; Inspur, 2022

AI also has more advanced methods in talent development, performance management and employee retention. The AI system provides key performance indicators for the HRM team by analyzing data such as employee performance, turnover rate and satisfaction. At the same time, the automated evaluation system can also reduce human bias and improve the fairness of performance evaluation. For example, the AI system can automatically collect employee behavior data at work and generate detailed reports to help HRM managing employees more scientifically. In employee retention, AI can monitor employee satisfaction, health status and turnover tendency in real time through questionnaires, employee feedback analysis, thus helping companies adopt targeted talent retention strategies and helping HR teams develop more effective retention plans reducing employee turnover (Wukong, 2024).

3.1. Impacts of accelerated digital transformation

In the process of accelerating digital transformation, the digital application of various modules of the human resources system has gradually become the focus of enterprises. According to the survey results, the attention of most modules exceeds 60%, among which the intelligent recruitment and employee service platform modules are particularly prominent, reaching a high level of attention. Specifically, the intelligent recruitment module has received 90.68% attention, while the employee service platform has also received 90.06% attention. This shows that in the process of digital transformation, enterprises are increasingly paying attention to the digital application of intelligent recruitment, employee services to

improve the efficiency and service quality of HRM. The digital application of other human resources modules is also developing in a balanced manner. The attention of modules such as performance management, core personnel management, and training management is all above 80%, reflecting that enterprises are committed to the comprehensive development of various modules in the process of promoting the digitalization of human resources to avoid falling behind in future competition. For example, the attention of performance management reached 86.34%, while the attention of training management was 82.61%, showing the key position of these functions in promoting employee growth and performance improvement. It is worth noting that although the attention paid to the labor outsourcing module is slightly lower, at 59.63%, it is still close to 60%, indicating that enterprises' demand for the digitalization of this module is also gradually increasing. Overall, this trend shows that enterprises are no longer focusing only on a single module of human resources digital transformation, but on the overall balanced development of the human resources system. In a highly competitive market environment, companies seek differentiated advantages in HRM. Large companies further enhance the flexibility and accuracy of HRM through self-developed AI systems, while small and medium-sized enterprises (SME's) achieve digitalization of HRM at a relatively low cost through outsourcing or cooperation with professional service providers. At the same time, service providers are also constantly providing customized AI solutions to meet the needs of companies of different sizes (ADP, 2024; Inspur, 2022).

According to the "2024 China Human Resources Service Industry Research Report", with the gradual improvement of relevant laws and regulations, the in-depth application of digital technology and the increasing standardization of the market, the flexible employment industry will develop in a healthier and more orderly direction, and gradually achieve scale and branding to enhance the competitiveness of each company in specific fields by building long-term partnerships (Baidu, 2024a). In this context, the popularity of remote work and flexible employment has led to an increasing demand for distributed employee management in companies. Many companies have introduced advanced digital management systems to support the work arrangements and performance evaluation of distributed teams, making HRM more convenient and efficient. This approach not only breaks the geographical limitations of traditional offices, but also enables companies to flexibly adjust human resource allocation in a broader talent market, thereby gaining an advantage in the global talent competition.

3.2. Challenges and Opportunities

Data Privacy and Security

AI systems usually need to process and analyze a large amount of data involving employee personal information, including sensitive information such as identity information, professional background, and performance records. Compliance management of data not only helps to reduce the legal risks of enterprises, but also enhances employees' trust in AI systems and promotes their effective application within the organization. In addition, enterprises often need to implement multi-level security protection measures, such as data encryption, access control, and regular system security audits, so as to reduce the risk of data leakage and abuse. At deployment of AI systems, data privacy and security have become a priority that cannot be ignored, which is of great significance to the long-term digital development of enterprises (Ministry of Justice PRC, 2024).

Technology Investment and Costs

The introduction of AI technology usually requires enterprises to invest a lot of money in hardware equipment, data storage, algorithm development in the application of generative AI and large models, the update of hardware facilities, the need for data processing, and the

requirements for technical support will bring significant cost pressure. For SME's, especially emerging "specialized and new" enterprises, this high investment may become a major obstacle to the promotion and development of AI applications. However, as AI technology becomes more popular, costs are gradually decreasing, more and more SME's can effectively control expenses by choosing cloud computing services and technology outsourcing models to improve their own technology application level (IDC, 2024; Wang, 2024).

In order to better adapt to the development and application of generative AI and large models, SME's should adopt a series of comprehensive strategies: first, invest in employee training to ensure that the existing team has AI-related skills; second, establish partnerships with professional technology partners to obtain necessary technical support and expertise. In addition, actively seeking appropriate financial support, such as government subsidies, industrial funds can provide additional resources for the application and development of AI technology. It is also key to develop a wise business plan, through a detailed cost-benefit analysis, to ensure that AI projects can achieve substantial results within a reasonable budget. Although the introduction of AI technology may face challenges in initial capital investment for SME's, through flexible cost management strategies and effective use of external resources, AI-driven HR intelligent applications offer great potential for this sector.

Synergies between outstanding talents and AI

With the widespread application of AI technology in HR management, the skill requirements of HR professionals have changed significantly. They not only need to have traditional HRM knowledge, but also need to master the skills of data analysis, technology application and AI tool operation in order to make better decisions and perform tasks in a data-driven environment. While promoting the application of AI technology, enterprises also need to strengthen the training of HR personnel's data literacy and technical capabilities. By organizing systematic training courses, encouraging participation in technical seminars or working with AI experts, enterprises can help HR teams adapt to this transformation, enabling them to effectively use AI tools in their daily work, thereby more efficiently supporting the company's talent management strategy to maintain their competitive advantage in the AI-driven market (CPPCC National Committee, 2024), Baidu, 2024b).

3.3. Cultural and Regulatory Dynamics in Chinese HR Automation

Cultural adaptability

In the Chinese company culture, "benevolence" as the core concept of Confucianism emphasizes harmonious interpersonal relationships, family ethics, and social responsibility. This spirit can be transformed into care for employees and emphasis on teamwork in modern corporate management, thus forming a unique organizational culture. In the context of the gradual penetration of automation technology and digital tools into corporate management, the integration of corporate culture with "benevolence" as the core and these technical tools provides companies with a management model that is both efficient and humane (CSTC, 2024). Employees are the most valuable resources of an enterprise. By caring about the physical and mental health of employees, companies can create a good working environment and development opportunities for them. This not only helps to stimulate employees' creativity and enthusiasm for work, but also improves the cohesion and stability of the company. According to Maslow's hierarchy of needs theory, after their material needs are met, employees will pursue a sense of identity and belonging at the spiritual level. The corporate culture with "benevolence" as the core can just meet the needs of employees in this regard, so that they feel respected and cared for at work. Companies can use data analysis tools to regularly understand employees' health status, work pressure and psychological needs, and then provide targeted support.

For example, automation systems can help companies better arrange employees' workloads, avoid excessive overtime, and provide employees with real-time care and encouragement through intelligent feedback mechanisms. Such technical means not only improve management efficiency, but also allow employees to feel the care from the company, thereby enhancing a sense of belonging and loyalty. The corporate culture based on "benevolence" can also promote team collaboration through digital means. With the help of collaboration platforms and communication tools, companies can create a more open and equal communication environment where employees can support and help each other at work strengthening the relationship between employees, making the entire team more cohesive and efficient. Companies need to improve employees' understanding and adaptation through a variety of training and communication methods to help them smoothly with positive attitude accepting the automation change. (Wang Gu Technology, 2024).

Regulatory Factors

Data privacy and information protection have become increasingly important in corporate HRM, especially in the context of the continuous deepening of artificial intelligence and digital management technology. According to information released by the Ministry of Justice, China is accelerating the improvement of data security legal system to meet the challenges of network data security. This includes comprehensive optimization of the legal framework for data privacy and information protection to ensure the compliance of enterprises in the process of data collection, processing and storage (Ministry of Justice, PCR (2024, Xinhua, 2021).

In terms of specific measures, the country has strengthened the security review of network data, encrypted data transmission, strict access control and other means to build a solid security line for network data. Such measures not only reduce the risk of data leakage, but also further protect the privacy of users, so that enterprises have laws and regulations to follow when using big data and artificial intelligence technologies for HRM. From the perspective of practical application, the protection of data privacy is not only the compliance with laws and regulations, but also the maintenance of employee trust in the company's anonymised processing of their personal data, preventing improper use of this sensitive information, which is the key to harmony and stability within the enterprise. Operating an efficient compliance management system, internal audits and external reviews have become key means to ensure that corporate behavior complies with regulations and standards identifying potential hidden risks in daily operations and ensuring internal processes maintaining with increasingly complex regulatory requirements and corporate internal policies (Visure Solutions, 2024). External audits provide companies with an objective third-party perspective that can identify issues that may be missed by internal audits. External audits are usually performed by independent third-party audit agencies providing fair feedback on the company's compliance management through authoritative compliance assessments. External audits not only help enhance the credibility of companies in the market, but also enable companies to gain an advantage in competition to meet industry standards and international norms. These tools can help companies automate compliance monitoring, including compliance tracking, risk assessment, and report generation, thereby significantly reducing the time and error risks of manual reviews and help companies adjust compliance strategies in a rapidly changing regulatory environment.

In the process of promoting HRM automation, enterprises need to comprehensively consider three factors: cultural adaptability, regulatory compliance, and data privacy and security protection (Yingsheng, 2024). Cultural adaptability is particularly important in China's management environment.

Integrating the care and team spirit in corporate culture into the automation process not only helps to improve employees' sense of identity, but also ensures that the automation system is in line with corporate values, promoting employees' active acceptance of new technologies.

4. Application of AI in the HRM at the iFlytek Company

Since its inception, iFlytek has been committed to deepening its roots in the field of artificial intelligence, and is committed to working hand in hand with the domestic software and hardware industry chain to jointly build an independent and controllable technology platform. On this basis, iFlytek continues to maintain and enhance its international leading position in core technologies, contributing Chinese wisdom and solutions to the development of global AI technology (iFlytek, 2024a).

Relying on the strong scientific research strength of iFlytek's National Key Laboratory of Cognitive Intelligence, iFlytek grandly launched the iFlytek Spark Large Model on May 6, 2023. On October 24 of the same year, iFlytek and Huawei joined forces to jointly release the first domestically produced computing power platform in China that can support the training of large models with more than 100 billion parameters, "Feixing No. 1", in Hefei. The advent of this platform undoubtedly provides strong support for the independent research and development and application of AI technology in China. In January 2024, iFlytek once again reported good news, successfully releasing the first large model in China based on domestic computing power training - iFlytek Spark V3.5. This version of the large model has achieved significant performance improvements, further consolidating iFlytek's leading position in the field of artificial intelligence. Against the backdrop of increasingly fierce competition between China and the United States in science and technology, iFlytek, with its deep accumulation in the field of general large models, is gradually showing its potential to surpass its competitors in industry models and key field applications. In the field of education, the multimodal correction and learning path planning functions of iFlytek Spark's large model provide strong support for teaching students in accordance with their aptitude and reducing burdens and increasing efficiency. According to statistics, students who use the Spark large model to study can reduce the amount of learning and practice on the same knowledge points by more than 50%.

In the medical field, iFlytek's "Smart Medical Assistant" AI auxiliary diagnosis system has been widely used in more than 500 districts and counties across the country, and has conducted more than 700 million auxiliary diagnosis and treatments, bringing more convenient, efficient medical services to the majority of patients. In the industrial field, iFlytek has also demonstrated strong technical strength. The multilingual technology for China's exported automobiles is basically provided by iFlytek. Among them, Volkswagen has jointly released a large-scale car model product with iFlytek after connecting to the iFlytek Spark large model. This cooperation not only enhances the international competitiveness of Chinese automobile brands, but also injects new vitality into the development of the global automobile industry. As of now, iFlytek has cumulatively supported more than 120 million smart terminals to go overseas, providing more intelligent and convenient services to global users. In addition, in terms of enabling software development, iFlytek's iFlytek Spark code capabilities have been successfully applied in more than 100 well-known companies such as Huawei and JD.com.. iFlytek's AI open platform has currently gathered more than 6.47 million developer teams to jointly promote the innovation and development of artificial intelligence technology.

Looking ahead, iFLYTEK will continue to adhere to the independent and controllable technology innovation route and seize the strategic opportunities of general AI. In addition, iFLYTEK will also explore the use of cutting-edge technologies such as quantum computing to break through the bottleneck of large-scale model computing power, and make early arrangements for possible revolutionary breakthroughs in the future (iFlyteck, 2024b).

4.1. Difficulties of AI Application at iFlytek

Although iFlytek's AI system has achieved certain results in the HR field, it faces challenges in data compliance, especially in the strict compliance with the provisions of the Personal Information Protection Law (PIPL) during data collection and use (Ministry of Justice PRC, 2024).

PIPL requires companies to be legal, legitimate and necessary when collecting and using data. iFlytek improves its AI algorithm to ensure that it only collects necessary candidate data in recruitment and explains the purpose and scope of data collection to the data subject (Article 6 of PIPL). According to PIPL, companies have to inform users and obtain their consent when using personal information for automated decision-making. iFlytek informs candidates in advance during the recruitment process to ensure that candidates understand the AI screening process and obtains candidates' consent before data collection (Articles 13 and 14 of PIPL). When applicants have questions, the company provides a complaint mechanism to protect users' right to know and right to object. When using AI for recruitment screening, PIPL requires companies to ensure the transparency and fairness of automated decision-making, especially for decisions that may affect personal rights and interests (PIPL Article 24). iFlytek provides explanatory and transparent functions for AI screening, allowing candidates to understand the reasons for their screening, reducing negative impact of algorithms on recruitment decisions.

Restrictions on cross-border data transmission

iFlytek needs to ensure that the data transmission of AI systems meets cross-border compliance requirements, especially when data involves cross-border, PIPL has stricter compliance requirements for data outbound (PIPL Article 38). In this context, iFlytek has formulated a comprehensive data storage and transmission management policy to ensure the security of data transmission. In traditional Chinese corporate culture, the interaction between employees and HRM departments is usually full of "human touch", that is, emphasizing the trust and understanding brought by interpersonal relationships and direct communication. However, as iFlytek introduces AI systems in HRM, some employees are worried that algorithmic decision-making may weaken this human factor, leading to deviations in performance evaluation. In the financial industry, the transparency and explainability of AI systems are considered very important to ensure compliance with regulatory requirements (China Business News, 2024). In response to these concerns, iFlytek has integrated transparency and explainability features into its AI system, allowing employees to understand the basis for the system's decisions and to intervene manually when necessary. iFlytek's AI HR system provides detailed explanations of decisions, allowing HR personnel and employees to view specific criteria for screening and evaluation understanding the factors that AI refers to during the evaluation process. This transparency helps to enhance employees' trust in AI systems (iFLYTEK, 2024c). Through these measures, iFlytek has successfully implemented AI systems in HRM while maintaining technological innovation, respecting and integrating interpersonal relationship characteristics of Chinese corporate culture.

4.2. New approaches on AI Intergation in the Chinese HRM

AI-based intelligent HR platforms have gradually replaced traditional manual processing methods, helping companies to liberate the human resources department from tedious transactional work, allowing HR to focus on more strategic tasks (AI and Human Resources, 2023; Red Sea Cloud, 2023). By building a comprehensive HRM platform, companies can achieve real-time monitoring, analysis and processing of employee data, making management more transparent and efficient. These platforms not only include employee information management, recruitment process management and performance appraisal, but also help HR departments gain in-depth insights into employee behavior, work performance and career development paths through data analysis and visualization tools. References point out that this AI-based digital management enables HR to better predict talent and allocate resources, and improves the scientificity and accuracy of decision-making (Chen & Liu, 2022; AI and Human Resources, 2023).

Intelligent Recriutment and Matching

Through natural language processing (NLP) technology and machine learning algorithms, AI can quickly screen a large number of resumes, analyze job seekers' career experience and skill levels, and combine multi-source data such as social media profiles and cover letters to accurately match candidates for positions. Traditional recruitment methods are often time-consuming and labor-intensive, and it may take days or even weeks to screen suitable candidates, while AI recruitment systems can complete this step in minutes, greatly improving recruitment efficiency. AI's intelligent screening function reduces human bias and ensures the fairness and transparency of the recruitment process, which helps to attract and retain high-quality talents (Artificial Intelligence, 2024). AI-driven training management systems can develop personalized training plans based on employees' specific needs and career development directions. AI customizes exclusive learning paths for each employee by analyzing employees' learning preferences, skill levels and behavioral data. Some studies have pointed out that personalized training can not only help employees quickly improve their skills, but also enhance employees' sense of belonging and loyalty to the company, which helps reduce employee turnover (Maimai, 2024).

Real-time Performance Feedback

Traditional performance management is usually carried out on a quarterly or annual basis, with problems such as delayed feedback and poor results. The AI-driven HRM platform makes performance management more dynamic and flexible. By collecting and analyzing employees' work data in real time, managers can provide timely and targeted performance feedback to help employees adjust their work strategies more quickly. This instant feedback mechanism improves employee engagement and enhances their sense of responsibility and accomplishment in their work. This real-time and dynamic performance feedback model effectively improves employee work efficiency and performance (AI and Human Resources, 2023).

Data Security and Privacy Protection

With increasing popularity of AI technology in HRM, there will be a requirement for enterprises to process a large amount of employee data, involving highly sensitive personal information, so data privacy issues have become the core of concern for all enterprises. For example, research points out that once big data in public sector HRM is leaked, it will cause great harm to national, organizational and personal security. As required by the PIPL, enterprises must standardize data processing processes to comply with national data protection standards and enhance employees' trust in data privacy.

It is recommended that enterprises implement active measures, such as implementing multi-level data encryption strategies and identity authentication systems in HR systems, to fundamentally reduce the risk of data leakage. At the same time, regular security reviews are conducted to ensure the effective implementation of data protection policies.

Improved Employee Acceptance

According to Chen & Liu, (2022), individual acceptance is significantly affected by perceived complexity and risk perception of technology. Employees' resistance to AI mainly comes from concerns about being "replaced by machines" and fear of technological complexity. These psychological barriers may affect employees' trust in AI technology and further slow down its promotion. Companies should help employees understand the working principles and practical advantages of AI systems through internal communication and training mechanisms. Through case sharing, interactive training modules and simulated operations, employees can gradually become familiar with AI systems in actual experience and reduce their discomfort with technology. Besides that, organize successful case sharing sessions on AI technology applications to further eliminate misunderstandings about technological complexity by demonstrating how AI optimizes HR management processes and improves employee experience. Companies can conduct transparent advocacy for AI technology, explain the principles of AI in data processing and its actual impact on employee privacy and work, so as to enhance employees' trust and sense of security in AI technology.

System Stability and Scalability

Companies can set up automatic alarm mechanisms to immediately notify the technical team to repair when the system detects abnormal behavior (such as data processing delays or algorithm output deviations). In addition, real-time monitoring can provide dynamic analysis of key performance indicators (KPIs), providing a basis for companies to adjust system operating parameters in a timely manner (Baidu, 2024a; Baidu 2024b). At the same time, it is crucial to establish an employee feedback mechanism. Surveys show that system optimization strategies that include user feedback loops can significantly improve system acceptance and user experience. The feedback mechanism not only helps identify potential problems, but also promotes the matching of technology with actual business needs, and improves the applicability and stability of AI systems in enterprises. In order to meet the diverse needs of different enterprises, AI systems should have a high degree of flexible configuration and customization capabilities. Enterprises can choose suitable modules and services according to their own industry characteristics and business scenarios to ensure that the AI system can be deeply integrated with the existing HRM processes of the enterprise. This flexible configuration method can not only maximize the use of the functions of the AI system, but also significantly reduce unnecessary resource waste.

Scalability is also reflected in the system's ability to support new functions and new scenarios. For example, when enterprises transform from traditional office mode to remote or hybrid office mode, AI systems need to support functions such as remote attendance, virtual interviews and online training. This expansion capability enables enterprises to quickly adapt to changes in the external environment and maintain the efficient operation of HRM. The scalability of AI systems also depends on seamless integration with the existing information systems of enterprises. Through data sharing and business collaboration with management systems such as ERP, CRM, and financial software, AI systems can help enterprises build unified information flows and operation flows. For example, AI systems can directly obtain employee entry records and salary information from the ERP system to automatically complete performance evaluation and annual assessment.

This system integration not only reduces the workload of repeated entry, but also improves the accuracy and consistency of data. To ensure that the AI system can be continuously optimized and upgraded, enterprises need to establish a cross-departmental communication mechanism to promote in-depth understanding of system performance and business needs between the interested stakeholders.

Continuous Optimisation and Feedback Mechanism

Real-time monitoring and regular inspection of the model's prediction results, companies can promptly identify potential problems and make necessary parameter adjustments to adapt to changes in the business environment and employee needs. This dynamic adjustment not only improves the flexibility of the system, but also ensures the applicability of the AI system in different HR scenarios. Based on the latest data and employee feedback, companies should regularly update and iterate AI models, use machine learning technology to achieve self-learning and optimization, and thus improve the system's prediction and decision-making capabilities in complex human resource management. The update and iteration of the model can enhance the adaptability of the system and make it more efficient in responding to future business challenges. Finally, in order to ensure that the AI system complies with regulatory requirements and corporate values, companies need to regularly audit and evaluate AI models to confirm whether the system has achieved the expected results, and also provide data support for future optimization (Baidu, 2024a; Baidu, 2024).

The feedback mechanism of AI technology in HRM can effectively improve the adaptability of the system and employee satisfaction. Companies collect employee feedback on the AI system through online surveys, suggestion boxes understand employees' acceptance and satisfaction with AI decisions, thus discover the actual effect of the system and room for improvement. Through natural language processing (NLP) technology, companies can conduct sentiment analysis and keyword extraction on employee feedback, deeply analyze employees' emotional tendencies and concerns, providing data support for formulating more targeted improvement measures. Companies integrate these analysis results into easy-to-understand reports and visual charts, and present them to management and HRM departments help them making more evidence-based decision. Finally, based on employee feedback and the evaluation results of AI system performance, companies can continue to optimize AI algorithms and decision-making processes, continuously improve the application effect of AI in HRM and better meet corporate development and employee needs (Liu &Li, 2023).

4.3. Expected Benefits of AI Adoption for Chinese HRM Practices

The application of AI in China's HRM has brought significant changes, especially in the five major areas of recruitment, training, performance management, cost control and employee services. First of all, in terms of improving recruitment efficiency, AI accelerates the resume screening and candidate sorting process through NPL and machine learning technology, allowing HRM to screen candidates who meet job requirements in a short time, thereby effectively improving recruitment efficiency. . At the same time, the AI system can evaluate candidates' basic abilities, such as language expression and communication skills, in the initial screening stage, providing the HR team with a more accurate list of candidates and helping to reduce the number of screenings by the HRM department in subsequent interviews pressure.

In terms of optimizing employee training and development, AI can analyze employees' learning history and skill needs and help companies customize personalized training plans. This personalized training method can not only effectively improve employees' learning effects, but also help companies better explore their employees' potential.

Through the intelligent feedback function of the AI system, employees can obtain real-time progress reports and learning suggestions during the training process, helping them make adjustments based on their own learning effects and improving the overall training efficiency and effectiveness.

In terms of improving performance management, AI accurately evaluates employees' work performance through real-time data collection and analysis. By automatically collecting data such as employees' working hours and task completion status, the AI system can provide managers with detailed performance evaluation basis to ensure the fairness and transparency of management. In addition, AI can avoid the interference of human factors on performance evaluation and make the performance management process more scientific and fair. This not only enhances employees' trust, but also helps improve employees' enthusiasm and job satisfaction.

Cost saving is another highlight of AI in HRM. The automated processing function of AI technology has significantly reduced repetitive tasks in HRM, such as entry procedures, employee resignation management, salary calculation, reducing the workload and labor costs of the HRM department. By reducing errors and omissions in manual operations, AI also effectively reduces the company's operating costs and improves overall management efficiency. Through technologies such as intelligent assistants, AI can assist HRM departments in providing more personalized services to employees, including salary inquiries, vacation applications, job consultations, focusing on strategic talent management tasks.

Summary and conclusions

Introduction of AI technology has played crucial role in many areas of HRM in China. By improving recruitment efficiency, optimizing employee training, improving performance management, saving costs and providing personalized services, AI is helping companies build more intelligent and efficient HRM systems, providing solid support for the common development of employees and companies. The application of these technologies not only helps companies reduce operating costs, but also plays a positive role in improving employee satisfaction and work experience. Cultural adaptability, regulatory compliance and technology implementation costs are the three challenges in the process of Chinese companies advancing AI-based technologies. On the one hand, China's unique corporate culture emphasizes human touch and employee interaction, which conflicts with the calm and logical characteristics of automated systems. Strict regulations such as the Personal Information Protection Law (PIPL) require companies to adhere to high standards of compliance in data collection, processing and storage. In addition, SME's are also facing tremendous pressure in terms of technology investment and cost control.

The authors revealed current status, potential and limitations of the application of AI and automation technology in HR management through case analysis of iFlytek, a leading Chinese AI firm, illustrating both the potential and challenges of AI in HRM. Its Spark Large Model supports NLP, adaptive learning, and intelligent recruitment tools. Unlike many firms, iFlytek actively integrates algorithmic transparency, allowing candidates and employees to understand AI-driven decisions. This mitigates cultural resistance and aligns with PIPL requirements for informed consent and fairness in automated decision-making. However, iFlytek's reliance on proprietary algorithms and corporate-controlled datasets raises questions of bias and replicability. Its compliance strategies—such as localized data storage and consent-based screening—offer a model for other firms, but require continuous oversight. The company's integration of AI into recruitment, training, and performance review demonstrates that technology can complement rather than replace human judgment when supported by governance mechanisms.

Application of AI in HRM has brought unprecedented opportunities for change to Chinese companies but it has also put forward higher requirements for the company's technical capabilities, management concepts and compliance awareness. In the future, with the further development of technology and the gradual improvement of the regulatory environment, Chinese companies need to continue to work hard in strengthen the in-depth integration of technology and culture, combining traditional corporate values with the advantages of AI technology. Exploring innovation capabilities of AI systems can reduce dependence on external technology and enhance technological competitiveness. Through cooperation with governments, academic institutions and industry partners, jointly build a standardized, transparent and efficient HR technology ecosystem. These measures will not only help realize the intelligent HRM in enterprises, but will also promote Chinese enterprises to occupy a more favorable position in global competition.

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ESETTANULMÁNY: EGY MAGYARORSZÁGI GYÁR KÖZÜTI FUVARFELADATAINAK MULTIMODÁLIS SZÁLLÍTÁSI ALTERNATÍVÁJA

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ABSZTRAKT

A tanulmány célja egy konkrét fuvarfeladat esettanulmányán keresztül bemutatni, hogy miként alkalmazható a vasúti és közúti szállítás kombinációja a szállítási költségek csökkentése és a környezeti terhelés mérséklése érdekében. A szerzők több ajánlat összehasonlítása alapján kialakítottak egy optimális fuvarstratégiát, amelyben figyelembe vették a szolgáltatási színvonalat, a fenntarthatósági szempontokat, valamint a költséghatékonyságot. A tanulmány következtetései rámutatnak arra, hogy a multimodális szállítás – megfelelő feltételrendszer mellett – versenyképes alternatívát nyújthat a kizárólag közúti megoldásokkal szemben, különösen nagy távolságok esetén. A bemutatott módszertan alkalmas lehet hasonló logisztikai döntéshozatali helyzetek támogatására.

Kulcsszavak: ellátási lánc; multimodalitás; vasút–közút; fuvarstratégia; szállítási költségek

ABSTRACT

This study aims to demonstrate, through a case study of a specific transport task, how the combination of rail and road freight can contribute to reducing transport costs and minimizing environmental impact. Based on the comparison of multiple freight offers, an optimal transport strategy was developed, considering service quality, sustainability and cost-efficiency. The findings highlight that multimodal transport, under appropriate conditions, can offer a competitive alternative to road-only solutions, particularly for long-distance shipments. The proposed methodology may support decision-making processes in similar logistics contexts.

Keywords: supply chain; multimodality; rail–road; transport strategy; freight cost

1. Bevezetés

A közlekedési és szállítmányozási ágazat a globális ellátási láncok egyik legkritikusabb eleme, amely a gazdasági hatékonyság mellett egyre nagyobb figyelmet kap a fenntarthatóság és környezeti terhelés szempontjából is. A közúti árufuvarozás továbbra is domináns szerepet játszik Európa-szerte, ugyanakkor ezzel párhuzamosan növekszik az igény a környezetbarátabb és hatékonyabb alternatívák iránt.

Ezen kihívásokra válaszul a szállítási módok optimalizálása, valamint a különböző közlekedési módok – elsősorban a közút és vasút – kombinációja versenyképes lehetőségeket kínálhat a logisztikai döntéshozók számára. A multimodális szállítás lehetőséget teremt arra, hogy a fenntarthatósági célokkal összehangolt, gazdaságos megoldások szülessenek.

2. Kutatási módszertan

A tanulmány kvalitatív esettanulmány-módszertant alkalmaz, amelynek keretében egy konkrét nemzetközi szállítási feladat részletes vizsgálatára került sor. A vizsgálat célja egy fenntartható és költséghatékony fuvarstratégia kidolgozása volt, a közúti és vasúti szállítás kombinációjának lehetséges alkalmazásával. A kutatás első szakaszában piaci szereplőktől származó konkrét fuvarozási ajánlatok kerültek összegyűjtésre és összehasonlító elemzés alá. A vizsgálat során két áruszállítási megoldás – közúti és intermodális – műszaki, pénzügyi és szolgáltatási paramétereit értékeltük, beleértve a szállítási időt, költséget, fuvarozási kapacitást, fenntarthatósági szempontokat és a rugalmasságot. Az ajánlatok összehasonlítása során a vállalat több, egymással részben összefüggő kritériumot határozott meg. A döntési keret kialakításakor a költség, az idő, a szolgáltatási színvonal, a fenntarthatósági mutatók és a működési kockázatok kaptak kiemelt szerepet. Az egyes szempontok fontosságát a vállalat beszerzési és logisztikai vezetőivel folytatott interjúk alapján súlyoztuk, majd az ajánlatok pontozása ezek figyelembevételével történt. A súlyozás és az értékelés alapja az alábbi rendszer volt:

Szállítási költség (40%) – az export- és körfuvarok díjainak összehasonlítása, valamint az érzékenység vizsgálata az üzemanyag-, energia- és útdíjváltozásokra.

Tranzitidő és pontosság (20%) – a szállítmányok célállomásra érkezésének várható ideje, a rakodási határidők betartásának valószínűsége, valamint a sürgős fuvarok kezelhetősége.

Fenntarthatósági mutatók (15%) – az egyes módok fajlagos CO₂-kibocsátása (g CO₂/tonnakilométer) és az éves megtakarítás becsült értéke.

Szolgáltatási rugalmasság (15%) – többletkapacitás biztosításának lehetősége, váratlan többletrakomány kezelése, valamint az ad-hoc megrendelések elfogadása.

Kockázati tényezők (10%) – a szállítási módokhoz kapcsolódó bizonytalanságok (pl. vasúti csatlakozás kimaradása, közúti torlódások, kapacitáshiány) és ezek vállalatra gyakorolt hatása.

A döntési szempontok rendszerezése során leíró táblázatos összehasonlítás, valamint kvalitatív értékelés alapján történt az alternatívák rangsorolása. A módszertan lehetővé tette a különböző ajánlatok előnyeinek és kompromisszumainak feltárását, és hozzájárult egy olyan fuvarstratégia kialakításához, amely az adott vállalati és piaci környezetben optimális megoldást képviselhet.

3. Elméleti háttér

A közlekedés és azon belül az áruszállítás az Európai Unió közös szakpolitikáinak egyike. Már a Római Szerződés is megfogalmazta a fontosságát, azóta pedig az „Útiterv az egységes európai közlekedési térség megvalósításához – Úton egy versenyképes és erőforrás-hatékony közlekedési rendszer felé” című, 2011. évi fehér könyv már a közlekedés által okozott üvegházhatású gázok kibocsátásának csökkentését szorgalmazta (Európai Bizottság, 2011).

Az itt kitűzött célok nem bizonyultak eléggé ambiciózusnak, így többek között ez is hozzájárult ahhoz, hogy 2019-ben a Bizottság „Az európai zöld megállapodás” közleményében a közlekedési ágazat számára 2050-re 90%-os szén-dioxid-kibocsátás-csökkentést irányoz elő (Európai Bizottság, 2019).

Az európai szárazföldi áruszállítás terén a közúti fuvarozás a mai napig dominál. A kontinentális szállítványok közel 75% tisztán közúton valósul meg (Európai Számvevőszék, 2023). Ez az arányszám hazánk tekintetében is hasonló méreteket öltött az elmúlt években, nemzetközi és belföldi áruszállítást tekintve a szállítási módok közül a közút 70 % körüli értékekkel a legfrekvenciáltabb (KSH, 2024). A Számvevőszék a különjelentésében, az Európai Környezetvédelmi Ügynökség adataira támaszkodva, a közúti teherfuvarozás szén-dioxid-kibocsátását 137 g CO₂ / tonnakilométerben határozza meg, ezzel szemben a belvízi 33, a vasúti teherszállítás kibocsátását pedig 24 g CO₂ / tonnakilométerben. Az üvegházhatású gázok kibocsátásának mérséklésére kézenfekvő megoldást jelenthet az intermodális áru fuvarozás, aminek a lényege, hogy az árut egy rakodási egységként, különböző szállítási módok – közút, vasút, vízi vagy légi út – kombinációjával szállítják. A multimodális szállítás ezzel szemben a különböző fuvarozási módok egymás utáni igénybevételét jelenti, akár átrakásokkal is. A vizsgált esetben a pótkocsis szállítás közúti és vasúti kombinációja valójában az intermodális kategóriába sorolható, ugyanakkor a vállalati kommunikációban és a tenderanyagaikban gyakran a „multimodális” kifejezés szerepel, ezért a tanulmányban a két fogalmat részben szinonimaként használtuk. A Számvevőszék jelentésben kiemelték, hogy bár a környezetterhelés tekintetében jelentős kibocsátás-csökkentést lehet így elérni, mégis szabályozási és infrastrukturális akadályok miatt az intermodális áru fuvarozás mindmáig nem élvez egyenlő versenyfeltételeket az Unióban, sőt nem is létezik az intermodalitásra vonatkozó uniós stratégia (Európai Számvevőszék, 2023).

Az esettanulmány célja, hogy egy példán keresztül vizsgáljuk, hogy milyen lehetőségei vannak egy magyarországi autógyártó cégnek, ha egy rendszeres németországi közúti fuvarviszonylat esetében alternatív szállítási módokat keres, ezek milyen előnyökkel és hátrányokkal járhatnak. A reláció jelentőségét az is indokolta, hogy Magyarország külkereskedelmi termékforgalma Németország irányába a legmagasabb (KSH, 2024).

Nem kerül nevesítésre a vizsgált vállalat, sem a vizsgálatba bevont partnerek az információk érzékenysége és részben üzleti titoktartási kötelezettségek miatt, viszont a tanulmány egy megvalósult eset tapasztalatait tartalmazza.

Munkánk aktualitását a károsanyag-kibocsátás csökkentésére tett, nemcsak uniós, hanem cégszinten, a vállalatok víziójában is megjelenő vállalások, valamint az autógyártást jelenleg terhelő kihívások okozta költségcsökkentési törekvések adják.

4. A feladat leírása

A szóban forgó cég egy több éves múlttal rendelkező autógyártó tier 1-es gyártó vállalat a tatabányai ipari parkban. Az elsődlegesen fémmegmunkálással foglalkozó vállalat vevői az autógyártó OEM-jei, export fuvarfeladatainak közel kétharmadát saját költségen és felelősségi körében végzi. Az áruszállítási szolgáltatás beszerzése a helyi szervezet feladata, ezt meghatározott időközönként fuvar tender kiírásával oldják meg. Sarokszámokat tekintve éves szinten nagyságrendileg 1.000 darab szállítási feladatra adnak megbízást, amelynek hozzávetőlegesen az ötöde körfuvar, tehát az export fuvarhoz import visszáru szállítása is tartozik. A desztináció, amit vizsgálunk és ahova a fent említett mennyiségű fuvar indul, az a németországi Ruhr-vidék déli része. A cég a szállítványokat jelenleg kizárólag közúton fuvaroztatja a telephelyétől a célállomásig, a távolság Tatabányától 1.050 km. Egy rakomány átlagosan 8 tonna.

A rakodások a hét napjain, hétfőtől péntekig egyenletesen vannak elosztva, az időkapu rendszerben 08:00 órától 18:00 óráig kerülnek ütemezésre. A tranzitidő az export szállítás esetén maximum 2 nap, tehát egy „A” napon történő rakodás esetén legkésőbb „C” napon meg kell érkeznie az árunak a címzetthez. A jelenlegi szerződések alapján a leírt relációra az export fuvardíj 1.450 euró, a körfuvar ára 2.850 euró. Sürgős szállítások esetén a cég „A” napról „B” napra való kiérkezésre 2 sofőrös megbízást ad, ennél is sürgősebb esetekben a 3,2 tonna össztömegű furgonos fuvarozási módot választja. Ilyenkor a nem tervezett felmerülő plusz költség a vállalatot terheli.

Az ajánlatkérés a fenti információk alapján lett kiküldve. Fontos volt, hogy a jelenlegi partnerek mellett, akikkel a több éves partneri viszony tapasztalatai alapján a cég meg volt elégedve, legyen olyan szolgáltató is a tenderre meghívva, aki rendelkezik intermodális vagy multimodális szállítási tapasztalattal, telephelye Tatabánya tágabb vonzáskörzetében legyen (<50km) és rendelkezzen saját gépjárműparkkal. Az ajánlatadásra kéthetes határidő, a tárgyalásokra és a kiválasztásra további 3 hét lett meghatározva.

5. Ajánlatok ismertetése, összehasonlítás

Az ajánlatok beérkezése után következtek a tárgyalások, ahol az árak mellett az ajánlat feltételei is egyeztetésre kerültek. Az árazást tekintve a multimodális ajánlat (azaz a közúti és vasúti szállítmány kombinációja) az export szállítmány esetében 1.356 euró lett, a körfuvar esetében pedig 2.700 euró. Tranzitidő 2 napban került megállapításra, A napon történő rakodás esetén C napon lerakodásra kerül az áru a címzettnél. Az ajánlat feltételként előírta, hogy a tranzitidő betartása csak akkor lehetséges, ha az áru a rakodás napján 14:00 óráig elhagyja a vállalat telephelyét, ezzel biztosítva, hogy az áru közúton időben eléri az intermodális logisztikai központot, ahol a nyerges pótkocsi vasúti szerelvényre száll. Abban az esetben, ha a megbízó cég hibájából nem érkezik meg a szállítmány időben az intermodális központba, a vasúti szállítás költségei kiterhelésre kerülnek felé, mivel a vasúti szerelvényen a rakhelyet a fuvarozó partnernek előre le kell foglalnia.

Ellenkező eset, tehát ha a feladó cég egy napon a megállapodott mennyiségen felül további rakományokat szeretne multimodális módon feladni, csak a szabad helyek függvényében lehetséges.

A multimodális szállítás során az áru a cég telephelyén történő rakodás után közúton, a bécsi intermodális terminálig halad, ahol vasútra kerül és a düsseldorfi intermodális terminálig utazik vonaton. Az utolsó 90 kilométert ismét közúton teszi meg a szállítmány a célállomásig.

A multimodális fuvarozási mód vasúti költségeit nem ismerjük részletesen, mivel a fuvarozó partner és a vasúti szolgáltató megállapodást kötnek egymással éves mennyiségre és árra, ami függ a fuvarozó tárgyalási pozíciójától és a szabad kapacitástól. Így a fuvardíjak összehasonlítását a teljes megajánlott ár alapján tudjuk elvégezni.

1. táblázat: Az ajánlatok összehasonlítása éves szinten és az elérhető legnagyobb nettó megtakarítás százalékban

| | Export | Körfuvar | Éves összesítés | |
|----------------------|-----------|-----------|-----------------|--------------|
| | 800 db | 200 db | 1 000 db | |
| Közúti ajánlat | 1 450 Eur | 2 850 Eur | 1 730 000 Eur | |
| Intermodális ajánlat | 1 356 Eur | 2 700 Eur | 1 624 800 Eur | -6,1% |

Forrás: ajánlatok alapján saját szerkesztés

A díjat befolyásoló összetevőket megvizsgálva, ha a pontos díjakat nem is, de az ár ezekre való érzékenységet megállapíthatjuk:

- a) Az útdíjak egységesítésére vannak uniós törekvések, mint például az euomatrixa-irányelv (1999/62/EK irányelv, 1999), de a pontos díjszabások alkalmazása továbbra is tagállami szinten történik, a vasúti móddal kombinált szállítás árazására kevésbé hat az útdíjak emelkedése.
- b) A gázolaj nettó beszerzési árának változása függ többek között a kőolaj világpiaci áráról, így a tisztán közúti fuvardíjak esetében az üzemanyagköltség nagyobb részt tesz ki.
- c) A vasúti szállítás díja a pályahasználati díjakon felül erősen függ az energiaárak alakulásától (Bucsky, 2023), ez a 2022-es energiaválság alatt jelentett versenyhátrányt a vasút számára.
- d) A tanúsított CO₂ kibocsátás értékesítése: a kereskedelmi rendszerekben, például az Európai Unió Kibocsátáskereskedelmi Rendszerében (EU ETS) realizálható értékesítési díjak elmaradnak az előzetes elvárásoktól. A vizsgált export fuvar esetében a Számvevőszék által megállapított érték alapján 0,7 t CO₂ kibocsátás-csökkentéssel számolhatunk, a körfuvar esetében a megtakarítás ennek a kétszerese.

2. táblázat: A károsanyag kibocsátás összehasonlítása közúti- és vasúttal kombinált áru fuvarozás esetén

| <i>Fuvar mód</i> | <i>Távolság (km)</i> | <i>Tömeg (t)</i> | <i>CO₂ kibocsátás átlag (g/tkm)</i> | <i>CO₂ kibocsátás fuvaronként (kg)</i> |
|------------------------------|----------------------|------------------|--|---|
| Közút (háztól házig) | 1050 | 8 | 137 | 1151 |
| Közúti előfutás | 58 | 8 | 137 | 64 |
| Vasút | 1170 | 8 | 24 | 225 |
| Közúti utófutás | 80 | 8 | 137 | 88 |
| Intermodális összesen | 1308 | 8 | átlag ~ 35,9 | 377 |

Forrás: Európai Számvevőszék (2023) alapján saját szerkesztés

Az értékelési keret gyakorlati alkalmazása érdekében a vizsgált két fuvarozási alternatívát (közúti és intermodális) pontozási rendszerben értékeltük. A kritériumokat 1–5 skálán pontoztuk (1 = gyenge, 5 = kiváló), majd a korábban meghatározott súlyozással összesítettük az eredményeket.

3. táblázat: A közúti és intermodális alternatíva pontozásos értékelése

| <i>Kritérium</i> | <i>Súly (%)</i> | <i>Közút (1–5)</i> | <i>Intermodális (1–5)</i> | <i>Súlyozott pont Közút</i> | <i>Súlyozott pont Intermodális</i> |
|----------------------------------|-----------------|--------------------|---------------------------|-----------------------------|------------------------------------|
| <i>Szállítási költség</i> | 40 | 3 | 4 | 1,2 | 1,6 |
| <i>Tranzitidő és pontosság</i> | 20 | 5 | 3 | 1,0 | 0,6 |
| <i>Fenntarthatósági mutatók</i> | 15 | 2 | 5 | 0,3 | 0,75 |
| <i>Szolgáltatási rugalmasság</i> | 15 | 5 | 3 | 0,75 | 0,45 |
| <i>Kockázati tényezők</i> | 10 | 4 | 3 | 0,4 | 0,3 |
| Összesen | 100 | | | 3,65 | 3,70 |

Forrás: saját szerkesztés az ajánlatok alapján

Az értékelés azt mutatja, hogy a közúti fuvarozás erőssége a gyorsaságban és a rugalmasságban rejlik, míg az intermodális megoldás a költségek és a fenntarthatóság tekintetében bizonyult kedvezőbbnek. A súlyozott pontszámok összességében kiegyenlített eredményt mutatnak, ugyanakkor az intermodális alternatíva kis előnyt ért el (3,70 vs. 3,65), ami indokoltá tette a vállalat részleges átállásról szóló döntését.

6. Kialakított fuvarstratégia

Az ajánlatok és tárgyalások eredményeinek összegzése után a vállalat egy lépcsőzetes átállási stratégiát határozott meg, miszerint kezdetben az összes fuvarfeladatainak egyharmadát átállítja az eddigi tisztán közutas áru fuvarozási módról multimodális, azaz közúti és vasúti kombinált áru fuvarozási módra.

A második lépcső az átállásban a tervek szerint fél év elteltével valósulna meg, a fuvarok kétharmadáig. Ezt az átállási ütemezést arra szeretnék felhasználni, hogy a multimodális szállítás által támasztott kötöttebb határidők teljesítéséhez alkalmazkodjanak készletgazdálkodásukban. A teljes átállás lehetőségét a cég egyelőre nem kötötte egy meghatározott határidőhöz. A jelenlegi tapasztalat azt mutatja, hogy a vállalat készletgazdálkodási stratégiája és a vevői megrendelésállomány ad-hoc jellegű változásai egyelőre nem teszik lehetővé a fuvarok teljes átállítását. A gyakorlatban ez azt jelenti, hogy a kiszállítás napján a terméknek 17:00-ig kell elkészülnie, hogy az utolsó rakodási ablakot (20:00 óra) elérje, a gyártási terv is ezzel a határidővel számol. Az így közúton elindított szállítmányok „A” napról „C” napra érkeznek a címzetthez. Ez sürgős esetben lerövidíthető két sofőrös megbízás alkalmazásával „A” napról „B” napra történő kikerülésre. Az évek során a vállalat termelési szervezete ezt a logisztika által adott rugalmasságot megszokta, és a napi fuvarok indulási időablakai többször kitolódtak a délutáni órákra.

A vasúttal kombinált szállítás tranzitidejét a partnerek „A” rakodási napról „C” napon történő árukézbésítéssel vállalják, tehát megegyezően a normál, egysofőrös közúti fuvarozás szállítási idejével. A határidő betartásának a feltétele, hogy a rakodás napján a szállítmánynak el kell hagynia a tatabányai telephelyet 15:00 óra előtt, hogy a közúti előfutással elérje az aznapi irányvonat indulási idejét.

Amennyiben ez a feltétel nem teljesül és a rakomány lekési a vonatra szállási időablakot, úgy a fuvardíjat a megbízónak ki kell fizetnie, mivel az irányvonaton a lefoglalt helyet a fuvarozónak fenntartják és díjvisszatérítés nem biztosított az elmulasztott szállítmányok esetében. Ezen felül a szállítmányt közúton kell eljuttatni a rendeltetési helyre, így a vasúti kötbér mellett a közúti fuvarozás költsége is felmerül.

A 2024-es év elemzése során a rakodások száma kicsivel meghaladta az 1000 darabot, ez a mennyiség megközelítőleg egyenletesen oszlott el a munkanapokon. Az időkapu elemzés szerint az export fuvarok 70 %-a elhagyta a gyár területét 15:00-ig, míg a fennmaradó 30% csak ezután tudott útnak indulni. Tizenkét hónap alatt összesen 37 olyan nap volt, amikor háromnál kevesebb és összesen 3 olyan nap, amikor egy fuvar sem tudott elindulni határidőre.

A multimodális szállítási módra való részleges átállás melletti döntésben tehát a várható költségmegtakarítás, az elérhető károsanyag-kibocsátás csökkentés, valamint az operációhoz való alkalmazkodás befolyásolta.

7. Összefoglalás

A tanulmány alapján megállapíthatjuk, hogy a szállítási módok között domináló közúti szállítás alternatívájaként alkalmazható a multimodális szállítás, közúti és vasúti módok kombinációjaként. A fuvarmódok gondos megválasztásával elérhető a károsanyag-kibocsátás csökkentés mellett egy jelentősnek mondható költségmegtakarítás is.

A vizsgált esettanulmány egy hazai nagyvállalat döntési mechanizmusát és annak mélységét illusztrálva mutatja be a modalitásváltás dilemmáját. Általános eredmény, azon tényezők azonosítása, amelyek megléte mellett dönt a további vizsgálatok elvégzéséről és az intermodalitás tesztjéről.

A multimodális szállítás elsősorban olyan relációkban nyújt versenyképes alternatívát, ahol a távolság meghaladja az 1000 kilométert, az árumennyiség stabil és előre tervezhető, valamint a feladónak elérhető közelségben van intermodális átrakó terminál. Kulcsfontosságú az olyan szállítmányozó partnerek választása, akik már tapasztalattal rendelkeznek intermodális vagy akár multimodális szállításokban. További megvalósítási feltétel a hajlandóság a gyártás intermodalitásra hangolására, amely jelen esettanulmányban a szállítási rugalmatlanság és kemény határidők elfogadását és rendszerbe integrálását jelentené. Ahhoz, hogy az eredményeket általánosítani lehessen átfogóbb vizsgálatra van szükség, több feladó-címzett, szállítmányozó és intermodális logisztikai központ bevonásával.

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GREEN LOGISTICS LANDSCAPE OF THE CENTRAL AND EASTERN EUROPEAN 3PL PROVIDERS

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ABSTRACT

This study focuses on the challenges and strategic potential of green logistics within the third-party logistics (3PL) sector in Central Europe, a key industry segment increasingly impacted by environmental regulations and market demand for sustainability. The paper examines how medium to large-sized 3PL companies implement green governance strategies, assessing their impact on environmental and financial performance. The analysis is based on a sample of 25 logistics providers across Hungary, Slovakia, and Austria, selected based on annual revenue (above 10 million euros) and presence of ESG reporting between 2020–2023. Methodologically, the research combines qualitative content analysis of ESG reports with quantitative evaluation of sustainability KPIs (e.g., carbon footprint, fuel efficiency, packaging waste) and revenue growth. This approach enables a focused exploration of the relationship between green practices and competitive advantage. The study contributes by offering specific insights into how regulation, strategy, and technology interact to shape green transformation in the regional logistics landscape.

Keywords: Green logistics, 3PL providers, ESG, sustainability KPIs, Central-Europe, Carbon footprint, logistics strategy

1. Introduction

Global trade and commerce depend heavily on logistics, including transportation, warehousing, inventory management and packaging. Sustainability has become a strategic request in the different industrial sectors, with the logistics sector under particular scrutiny due to its environmental impact. Environmentally friendly practices are increasingly being mandated for this sector, one of the biggest contributor to global greenhouse gas emissions (Lin et al., 2015; Yang et al., 2015; Kong et al., 2016; Li et al., 2023; Nagy & Szentesi, 2024).

As the fastest growing source of greenhouse gas emissions, transportation in logistic sector has a huge impact on the environment. A green transportation system should reduce greenhouse gas emissions, air pollution, noise and space utilization, as well as promote economic growth supporting environmental sustainability (Abreha, 2007; Badami & Haider, 2007). Logistics that minimizes the negative environmental externalities as a consequences of this sector referred “green logistics” (Dieng & Yvon, 2017). While "green logistics" is widely discussed, research often lacks focus when addressing such a complex and heterogeneous field.

This study narrows the scope to third-party logistics (3PL) providers in Central Europe, a segment where operational decisions directly influence emissions, packaging waste, and transport efficiency. Recent literature highlights the importance of integrating green governance into logistics to meet regulatory requirements and shifting consumer expectations (Zhu et al., 2008; Wu & Dunn, 2015; Larina et al., 2021; Kesidou & Demirel, 2012; McKinnon, 2010; Qi, 2019; Sarkis et al., 2020). However, evidence on how these strategies transform into measurable outcomes remains fragmented, especially in the post-COVID recovery phase where digital transformation accelerated (Li et al., 2023).

This paper addresses the following research questions: a) What are the core drivers and barriers for 3PL companies in Central Europe implementing green logistics practices? b) How do these practices affect their environmental and economic performance? c) What role does government policy play in shaping strategic alignment?

By focusing on a manageable and strategically relevant segment, the paper provides comprehensive overview that are both academically robust and practically implementable.

2. Methodology

In this review paper, the authors had combined quantitative analysis of sustainability indicators from ESG reports with secondary policy review and benchmarking. 25 medium-to-large 3PL providers in Hungary, Slovakia, and Austria were selected based on: a) Annual income more than 10 million euro between 2020 and 2023 time-period; b) Publication of ESG reports during this period; c) Operations across at least two Central European countries.

The authors thoroughly analysed environmental performance through the following indicators: a) Carbon footprint (CO₂ e/ton-km); b) Fuel consumption per delivery unit (litres/km), c) Waste management ratio (Recyclable vs. non-recyclable packaging ratio), d) Return logistics efficiency. The economic indicators based on ESG and annual reports (n=25), Policy review of the EU Green Deal and national frameworks.

You can see the 25 3PL company list from Austria, Hungary and Slovakia in the below Table. These companies are active in freight forwarding, contract logistics, and distribution services, and are known to have substantial regional or international operations—some also publish ESG/sustainability reports. The selection criteria were: a) Medium to large 3PL firms with cross-border operations; b) Active in logistics, warehousing, or freight services; c) Known public presence or participation in sustainability and ESG initiatives

These companies are frequently cited in logistics rankings (e.g., Top 100 Logistics Europe) and represent the professional landscape relevant to Central Europe's green logistics transformation.

Table 1. List of 3PL companies included in this study

| No. | Company name | Country | Services |
|-----|---|---------|--|
| 1. | Gebrüder Weiss GmbH (Gesellschaft mit beschränkter Haftung) | Austria | Freight forwarding, contract logistics |
| 2 | Quehenberger Logistics GmbH (Gesellschaft mit beschränkter Haftung) | Austria | Transport, warehousing, value-added |
| 3 | Cargo-partner GmbH Gesellschaft mit beschränkter Haftung) | Austria | Air & sea freight, logistics, IT |

| | | | |
|-----|--|----------|---|
| 4 | Lagermax Logistics Austria GmbH (Gesellschaft mit beschränkter Haftung) | Austria | Automotive, warehouse, forwarding |
| 5 | Rail Cargo Group (ÖBB) | Austria | Rail freight and intermodal logistics |
| 6 | DB Schenker Austria | Austria | Land, air, sea logistics |
| 7 | Kühne - Nagel GmbH (Gesellschaft mit beschränkter Haftung) Austria | Austria | Global forwarding, contract logistics |
| 8. | Waberer's International Ltd. | Hungary | Full truckload (FTL), freight, warehousing |
| 9. | Trans-Sped Ltd. | Hungary | Regional transport & contract logistics |
| 10. | Fiege Ltd.. | Hungary | Warehousing and distribution |
| 11. | Révész Group | Hungary | Tanker and road transport |
| 12. | Delta-Sped Ltd. | Hungary | National freight & warehouse logistics |
| 13. | DHL Supply Chain Hungary | Hungary | Distribution, contract logistics |
| 14. | Kühne Nagel Ltd. Hungary | Hungary | Integrated logistics services |
| 15. | DSV Road Ltd.. | Hungary | European road freight, supply chain |
| 16. | Nagel Hungaria Ltd. | Hungary | Food logistics |
| 17. | Dachser Slovakia. | Slovakia | Transport, warehousing |
| 18. | Gebrüder Weiss s.r.o. (Spoločnosť s ručením obmedzeným" – Ltd.) Slovakia | Slovakia | International forwarding |
| 19. | Raben Logistics s.r.o. (Spoločnosť s ručením obmedzeným" – Ltd.) Slovakia | Slovakia | Full 3PL service provider |
| 20. | Express Group s.r.o. (Spoločnosť s ručením obmedzeným" – Ltd.) | Slovakia | Pallet and express freight |
| 21. | Slovak Parcel Service s.r.o. (SPS) | Slovakia | B2B and B2C parcel delivery |
| 22. | GEBRÜDER WEISS Slovakia | Slovakia | Contract logistics |
| 23. | Hopi SK s.r.o. (Spoločnosť s ručením obmedzeným" – Ltd.) | Slovakia | Retail and food distribution |

| | | | |
|-----|---|----------|----------------------------------|
| 24. | Kühne - Nagel s.r.o. (Spoločnosť s ručením obmedzeným" – Ltd.) Slovakia | Slovakia | Freight and contract logistics |
| 25. | DB Schenker Slovakia | Slovakia | Road, rail, sea, and air freight |

Source: Own edition based on ESG Reports (2020-2023)

The conclusions and suggestions made by this research work in this article reflect the private professional view of the authors.

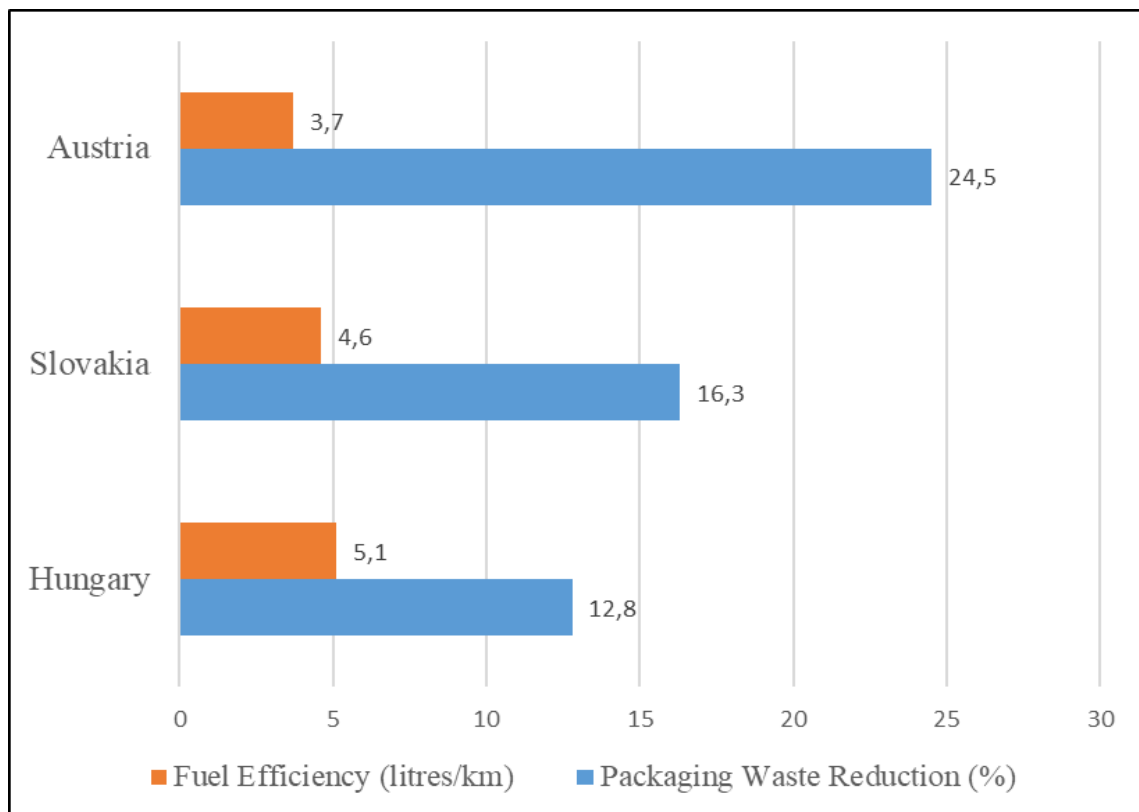
3. Insight of the Green Logistics

Environmental performance by countries

It was announced in 2019 that the European Green Deal (EGD) should be the “masterplan” to make transformation in the key areas of the EU countries economy after signing the Paris Agreement and the UN Sustainable Development Agenda (McKinnon, 2010; EC, 2019; EC, 2021; EC, 2023; Domorenok & Graziano, 2023; Hereu-Morales et al., 2023)

A comparative analysis of key environmental performance indicators revealed a notable disparity between countries. Austrian 3PL providers demonstrated significantly better results in terms of carbon efficiency, packaging waste reduction, and fuel use. This advantage is attributed to a more mature regulatory framework and access to green subsidies.

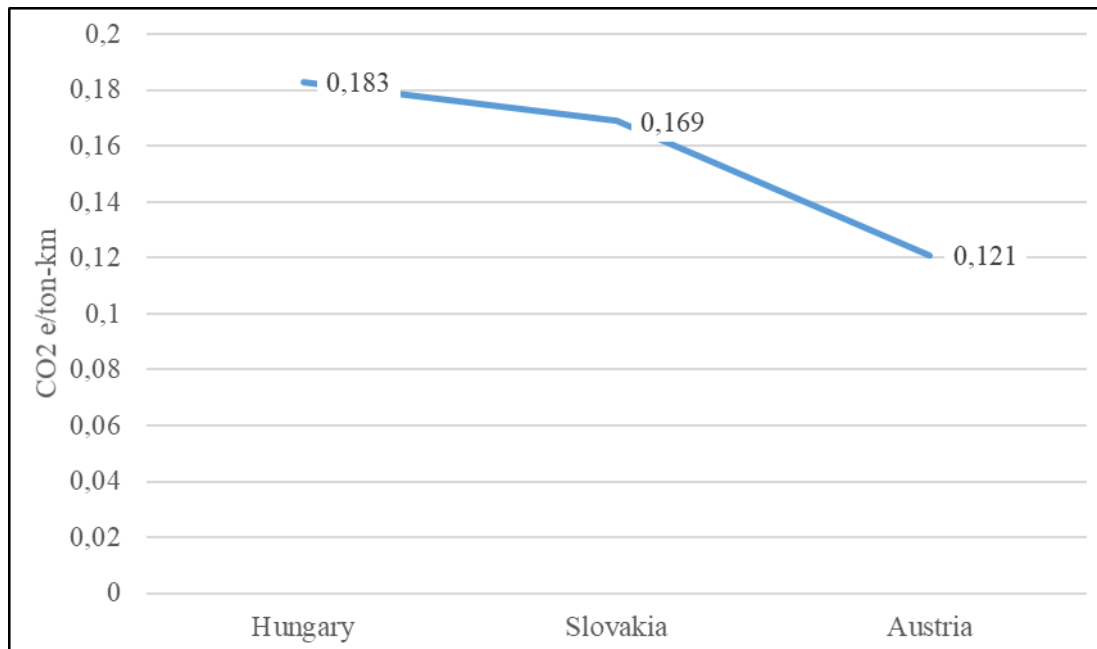
Figure 1. Average Environmental KPIs (1) by Country



Source: Own edition based on on ESG Reports (2020-2023)

These facts clearly pointed out the correlation between state-level green policy support and operational environmental performance. Austrian firms benefit from the early implementation of the EU’s Green Deal targets into national regulation, including tax incentives for electric vehicle fleets and green infrastructure.

Figure 2: Average Environmental KPI'S (2) by Country



Source: Own edition based on on ESG Reports (2020-2023)

Key Drivers and Challenges

The research identified several internal and external factors that influence the success or failure of green logistics adoption across the analyzed companies involving in this study.

Table 2. Summary of Main Motivation Factors and Barriers

| Category | Top 3 Drivers | Top 3 Barriers |
|------------------|--|--|
| External Factors | Government subsidies (84%) Pressure from multinational clients (72%) EU regulatory compliance (65%) | Policy uncertainty in Hungary/Slovakia (40%) High initial capital costs (60%) Lack of harmonised ESG standards (48%) |
| Internal Factors | Digitalisation & route optimisation (76%) Internal green strategy alignment (60%) Top-management commitment to ESG (48%) | Skills gap in sustainability (66%) Lack of ESG integration into supply chain processes (42%) Short-term profit focus over long-term sustainability (38%) |

Source: Own edition based the ESG Reports (2020-2023)

The findings suggest that regulatory pressure, digital infrastructure, and client expectations are the most influential drivers. Firms that aligned their internal sustainability goals with digital innovations (e.g., telematics, AI-based routing, emissions tracking) outperformed others in both carbon savings and logistics cost reduction.

Impact of Digital Maturity

The presence of digital fleet management systems and AI-enabled warehouse operations correlated strongly with improvements in both efficiency and sustainability. High-digital maturity firms reached: a) 7–12% reduction in average fuel costs over three years, b) 15–20% lower packaging waste, c) Faster compliance with evolving EU emission regulations

For example, one Austrian provider using a smart routing system across three countries reduced CO₂e emissions by 18% over 24 months while increasing load efficiency by 11%.

Reverse Logistics and Cost Impacts

Reverse logistics—especially in B2B deliveries—proved to be a powerful lever for improving environmental performance. Firms with structured return flows and load-consolidation strategies reported: a) Up to 11% cost savings in last-mile transport; b) Reduced use of single-use packaging materials, c) Enhanced collaboration with key clients to co-design circular systems

However, smaller logistics firms struggle to implement reverse logistics due to lack of warehouse space, IT systems, or contractual arrangements with clients.

ESG Reporting and Compliance Gaps

Only 9 of the 25 firms published complete ESG data, including Scope 1–3 emissions, biodiversity impact, and waste volumes. Most firms rely on voluntary frameworks, with inconsistent application of GRI (Global Reporting Initiative) or CSRD (Corporate Sustainability Reporting Directive) standards.

There is a pressing need for:

- Unified ESG reporting standards
- Uncentivised third-party auditing for credibility
- Sector-specific guidance on measuring logistics-related emissions

This gap in standardisation undermines benchmarking efforts and weakens the strategic feedback loop between ESG performance and stakeholder trust.

Green logistic everyday's operational practices of selected 3 PL companies

Waberer's International Ltd. (Hungary) , Kühne - Nagel GmbH (Austria) and Raben Logistics Slovakia were selected because they represent three distinct yet complementary profiles within the European 3PL sector: a regional market leader with deep Central European embeddedness, a global integrator with advanced digital solutions with strong sustainability commitments in Eastern Europe. These facts clearly highlight a complex, relevant picture of how decarbonisation strategies are translated into everyday operational practices across different scales and market positions.

Waberer's International is the largest road freight operator in Central and Eastern Europe, making it a particularly relevant case for understanding how a regionally dominant fleet-based operator integrates modernisation of assets, rail substitution and alternative fuels into daily dispatching and route optimisation (Waberer's International, 2023; Waberer's International, 2025).

On the contrary, Kühne – Nagel GmbH is one of the largest global 3PL providers, and its case illustrates how international companies deploy digital tools for emissions visibility and customer choice while embedding low-emission fuels and modal shifts into routine supply chain management (Kuehne- Nagel, 2024a; Kuehne - Nagel, 2024b).

Raben Group, operating extensively in Slovakia and across Central and Eastern Europe, provides a valuable mid-sized example of science-based target setting and piloting of sustainable fuels (such as HVO100) in daily operations, along with enhanced EcoVadis ratings that reflect supplier engagement and day-to-day execution of sustainability strategies (Raben Group, 2024a; Raben Group, 2024b).

Operationally, these companies converge on similar everyday practices: data-driven telematics and CO₂ calculators for planning and customer reporting, optimisation to reduce empty mileage, renewal of tractor and trailer fleets to improve fuel efficiency, and the trial and adoption of alternative fuels where infrastructure allows. Waberer's has centralised its ESG agenda into routine vehicle renewal and subcontractor engagement, while Kühne- Nagel focuses strongly on integrating emission-based routing into customer interfaces, effectively giving clients the option to select lower-carbon alternatives at the shipment level. Raben Logistics Slovakia demonstrates the practical implementation of HVO biofuels on regional lanes and explores electric solutions for urban distribution, complementing its broader sustainability strategy. These combined case studies highlight how three different 3PL profiles systematically integrate green logistics into daily operations, reflecting scalable models for decarbonisation in European logistics (Trans.INFO, 2023; Raben Group, 2025).

The findings demonstrate that green logistics initiatives yield both environmental and economic benefits when supported by digital innovation and policy clarity. However, uneven policy enforcement, fragmented ESG reporting, and skills shortages continue to limit the scalability of green transformation—particularly among SMEs in Hungary and Slovakia.

Summary and conclusions

This research provided insights into the opportunities and limitations of green logistics within the Central European 3PL sector. The findings clearly show that firms integrating sustainability into their core strategies can realize not only environmental improvements but also financial benefits and competitive advantages. However, such transformations require supportive institutional frameworks, sufficient capital, and internal capacity building.

From a strategic standpoint, companies that proactively align their logistics models with ESG goals are better positioned to capture emerging market opportunities, attract sustainability-conscious clients, and comply with tightening regulations. This strategic realignment also enables them to leverage technological tools—like digital route optimization and vehicle monitoring systems—to reduce emissions and optimize load efficiency. Conversely, firms that fail to adopt green logistics may struggle with rising compliance costs, reputation risks, and operational inefficiencies.

In terms of environmental impact, this study documented 3PL providers that actively adopted green logistics strategies succeeded in reducing their carbon emissions and waste output significantly. Especially Austrian firms, who benefit from strong government backing and clearer regulatory frameworks, demonstrated superior performance across all KPIs measured.

Nevertheless, many providers in Hungary and Slovakia face challenges related to inconsistent policy frameworks, a lack of standardised ESG reporting mechanisms, and a shortage of skilled professionals trained in sustainability practices. These structural gaps impede their ability to plan long-term and make the necessary capital investments.

Key Recommendations

Harmonise ESG Reporting

Governments should implement and enforce a regional ESG standard for logistics. This would enable comparability across companies and countries, improve investor confidence, and support public policy monitoring. Industry bodies could also play a role in developing shared templates and audit mechanisms.

Incentivise Technology Adoption

Policymakers should offer grants and tax credits to support the transition to green fleets (e.g., electric vehicles, hydrogen trucks), low-emission warehousing, and advanced transport analytics. Particular emphasis should be placed on funding telematics, IoT-based routing, and carbon tracking systems that offer high Return on investment (ROI), which used to be calculated by dividing the profit earned on an investment by the cost of that investment.

Develop Talent Pipelines

A major barrier to green transformation is the shortage of personnel with relevant sustainability skills. National education ministries, universities, and logistics firms should co-develop logistics-specific sustainability curricula to ensure a future-ready workforce.

Support SMEs in Green Transition

While large firms may afford green investments, SMEs struggle without targeted support. Governments should design subsidy and low-interest loan schemes tailored to mid-sized logistics providers, especially those operating internationally or cross-border.

Encourage Cross-border Partnerships

Given the transnational nature of logistics, cross-border platforms for knowledge sharing, benchmarking, and regulatory alignment should be fostered. Joint EU projects, pilot initiatives, and regional best-practice hubs can accelerate learning and standardisation.

The future competitiveness of the logistics industry in Central Europe hinges on the extent to which environmental innovation is embedded into strategy, policy, and practice. A unified and inclusive approach—spanning policy support, corporate initiative, and academic collaboration—will be crucial in achieving the dual objective of economic efficiency and environmental stewardship in the 3PL sector.

Green logistics is not merely a compliance issue, but a strategic asset. Companies that embrace this early and holistically are more likely to withstand economic volatility, meet future regulatory thresholds, and build trust with environmentally conscious stakeholders. Central Europe now stands at a crucial inflection point where leadership in green transformation will determine the long-term viability and reputation of its logistics ecosystem.

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