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FROM BASELINE TO PROGRESS: TRACKING SUSTAINABLE LAST-MILE DELIVERY AT INPOST POLAND

Mohannad ALJAWARNEH[1*], Beata MRUGALSKA[2]

[1] Time Center Jordan; mohannadaljawarneh2@gmail.com, ORCID: 0009-0006-5127-9357
[2] Poznan University of Technology, Faculty of Engineering Management; beata.mrugalska@put.poznan.pl, ORCID: 0000-0001-9827-9449
*Correspondence author

Purpose: This paper presents a longitudinal sustainability analysis of InPost Poland, tracking key performance indicators (KPIs) across operational, financial, sustainability, and customer experience dimensions for 2021-2025. It evaluates the implementation status and measurable impact of five proposed sustainability solutions and identifies new challenges arising from the Corporate Sustainability Reporting Directive (CSRD).
Design/methodology/approach: A mixed-method longitudinal case study design is applied, using a four-dimensional KPI framework. Data are drawn from five InPost Group Integrated Annual Reports (2021–2025), supplemented by secondary academic literature on sustainable last-mile logistics.
Findings: InPost Poland's operational and financial KPIs grew consistently across the period. Scope 1 and 2 emissions declined by 56% against the validated Group baseline, decoupling from volume growth through rapid renewable energy adoption. Scope 3 emissions rose 70.8%, remaining tied to value-chain volume. Solar-powered and energy-efficient APMs and the Scope 3 Supplier Engagement Programme show active implementation. Electric cargo bikes are present but undisclosed quantitatively. Delivery drones and autonomous robots remain unconfirmed. The most significant new challenges are CSRD full implementation in 2024 and the international acquisitions of Menzies, Yodel, and Sending in 2024-2025.
Research limitations/implications: The study draws on a single company case using corporate self-reported data, which may reflect selective disclosure. Boundary changes from the Menzies and Yodel acquisitions limit direct comparability of Group-level Scope 3 figures across the full period. Future research should extend the framework to other European APM operators and use primary courier data.
Practical implications: The findings offer logistics operators, sustainability managers, and policymakers an empirically grounded benchmark for APM-based last-mile delivery performance under CSRD. The solution implementation matrix provides a replicable template for sustainability progress assessment in e-commerce logistics.
Originality/value: This is the first longitudinal, KPI-based sustainability progress assessment for InPost Poland covering 2021-2025. It contributes to the sparse empirical literature on company-level sustainability tracking in Central European e-commerce and introduces a four-dimensional analytical framework aligned with CSRD 2024 requirements.

Keywords: last-mile delivery, sustainable logistics, InPost, automated parcel machines, e-commerce sustainability.
Category of the paper: Research paper.

1. Introduction

In the last years a dramatic increase is noticeable in last-mile delivery transactions, which are the least efficient and most environmentally taxing part of the supply chain (Bartucz, Süle, 2024; Montuori et al., 2023; Yılmaz et al., 2023). This growth accelerated significantly during the COVID-19 pandemic (Silva et al., 2024). Online sales figures alone grew by nearly 300% between 2014 and 2019. Last-mile parcel demand is projected to grow by 78% by 2030, leading to an increase in delivery vehicles on the streets of the world's 100 largest cities by about 36% and urban freight-related congestion by 21% (World Economic Forum, 2020).

Last-mile delivery is already the most expensive and least efficient stage of the supply chain, absorbing between 13% and 75% of total fulfilment cost (Gevaers et al., 2009). As urban populations continue to concentrate, approximately 60% of the global population will live in cities by 2030, the environmental externalities of conventional van-based door-to-door delivery grow harder to ignore: noise, air pollution, road congestion, and greenhouse gas (GHG) emissions all worsen with each additional van in the network. For logistics operators in European e-commerce, this creates a structural problem: volume keeps growing, but the traditional delivery model produces costs and emissions that are increasingly unacceptable to regulators, investors, and customers alike (Boysen et al., 2020; Waqas et al., 2025).

The EU regulatory response has further sharpened that pressure considerably. The European Green Deal, adopted in 2019, set binding emissions reduction targets across the EU economy with the transport sector responsible for 25% of total global GHG emissions, of which 75% come from road transport (Dalewska, Mrugalska, 2024; Jaramillo et al., 2023). The Corporate Sustainability Reporting Directive (CSRD), which took effect in 2024, takes it even further: it legally obliges large companies to report not only their direct operational emissions (Scope 1 and 2) but also their full Scope 3 value chain emissions (European Commission, 2022). For last mile operators, Scope 3 is the hardest number to move. It includes emissions from third-party delivery partners, contracted couriers, and fuel suppliers' entities that a company can influence but not directly control. In a systematic review of sustainable supply chain management, Meixell and Luoma (2015) find that stakeholder pressure from governments, investors and customers tends to push firms through a sequence of sustainability awareness, then goal setting, and only eventually measurable practice change. Scope 3 reduction is the hardest final step because it requires sustained engagement across an extended external network.

However, despite this growing body of literature, longitudinal empirical studies following the sustainability performance of a single operator over multiple years, against a verified baseline, including an assessment of whether proposed solutions have actually been implemented are rare. Most published work is either cross-sectional or model based. The gap is particularly visible in the context of Poland and Central Europe at scale. Aljawarneh (2024) developed a comprehensive four-dimensional KPI baseline for InPost Poland for 2021-2023 and proposed five specific sustainability solutions: solar-powered APMs, electric cargo bikes, delivery drones, autonomous delivery robots, and a Scope 3 supplier engagement program. This paper extends that analysis across 2021-2025 using the same KPI framework, assesses whether the five solutions have been implemented and discusses what new challenges – particularly CSRD 2024.

The aim of this paper is to extend that longitudinal analysis to the period 2021-2025, evaluate the evolution of InPost Poland's sustainability KPIs against the established baseline, assess the implementation status and measurable impact of the five proposed solutions, and identify new sustainability challenges and strategic opportunities that have emerged in the intervening period, particularly following the full implementation of CSRD in 2024.

The paper is structured around three research questions:

RQ1. How have InPost Poland's operational, financial, sustainability, and customer experience KPIs evolved between 2021 and 2025?

RQ2. To what extent have the five proposed sustainable solutions been implemented, and what measurable impact have they produced?

RQ3. What new challenges and strategic opportunities have emerged in 2024-2025 that affect the sustainability of last-mile delivery in European e-commerce?

The paper is organized as follows. Section 2 presents the research methodology, including the mixed-method design, data sources, and the four-dimensional KPI framework. Section 3 reports the results across all KPI dimensions and the solution implementation assessment. Section 4 discusses the findings in relation to the three research questions. Section 5 summarizes the conclusions, theoretical and practical contributions, and directions for future research.

2. Sustainable Last-Mile Delivery: Literature Review

2.1. Sustainable last mile systems and APMs

Automated parcel machines (APMs) have been a response to the environmentally inefficient home delivery and have received sustained attention. In a study of the InPost APM network in Poland, Iwan, Kijewska and Lemke (2016) found that one courier delivering to

parcel lockers can deliver 600 parcels per day over 70 km, whereas in the traditional delivery model, 60 parcels are delivered over 150 km. This difference results in a reduction of annual CO_2 emissions from 32,500 tons to 1516 tons for the same volume of service. InPost's logistics model, which relies on a network of parcel lockers, produced up to 75% lower emissions per parcel than DHL's conventional door-to-door deliveries, reinforcing the ecological benefits of consolidated, network-oriented delivery methods. The scale of the company proved less critical than how well digitalization, automation, and ESG management were integrated (Masłowski et al., 2025). Due to this fact, APMs and collection points are among the most studied operational solutions. However, there is no single last-mile approach that is universally optimal and that a combination of solutions is necessary to meet the triple bottom line of sustainability (Wahab et al., 2022; Werner et al., 2024). Both economic and environmental performance are now treated as complementary rather than competing objectives in the literature, a shift with direct implications for how operators like InPost report their results.

2.2. Electric vehicles and other delivery methods

When evaluating vehicle alternatives for urban last-mile distribution, findings show that 64% of reviewed studies advocate transitioning to electric vehicles. Additionally, 47% of the research supports utilizing bicycles and tricycles, especially within densely populated urban environments (Oliveira et al., 2017). Electric Vehicles (EVs), including light electric freight vehicles (LEFVs), electric tricycles, and electric light-duty vehicles (LDVs), are widely recognized as sustainable transport alternatives. They reduce greenhouse gas (GHG) emissions and operational costs compared to conventional fuel-powered vehicles (Díaz-Ramírez et al., 2023; Giordano, Christidis, 2025). For example, replacing diesel vehicles with electric tricycles in Rio de Janeiro reduced emissions and costs while maintaining service levels (de Mello Bandeira et al., 2019). Electric cargo bikes, tricycles, and scooters are increasingly favored for urban deliveries due to their smaller size, lower energy consumption, and ability to navigate congested areas (Díaz-Ramírez et al., 2023; Oliveira et al., 2017). These vehicles are particularly effective for small-scale deliveries, such as food logistics, and can reduce GHG emissions by over 50% (Bányai et al., 2025). On the other hand, autonomous delivery robots and drones are emerging as innovative solutions, especially when combined with traditional vehicles in hybrid systems. These approaches can reduce costs and emissions while addressing traffic congestion challenges (Lubis, Lestari, 2025). Combining trucks, public transportation (e.g. metro), and micromobility vehicles offers a promising approach. For instance, using metro networks to distribute parcels to micro-hubs, followed by micromobility for final delivery, has shown significant reductions in pollution and operational costs (Stokkink, Geroliminis, 2025).

2.3. Consumer preferences for sustainable delivery

Parcel lockers have emerged as a promising solution, offering consolidated delivery points that reduce failed deliveries, lower emissions, and provide flexible access for consumers. However, the success of parcel lockers hinges not only on their operational efficiency but also on consumer acceptance, which is increasingly shaped by perceptions of environmental, social, and economic sustainability (Rose et al., 2025a; Wahab et al., 2025). Caspersen and Navrud (2021) use discrete choice modelling to show that among Norwegian consumers, people are willing to accept longer delivery times if this reduces GHG emissions, and that convenience-first delivery models may not be the only viable approach. According to Rose et al. (Rose et al., 2025) the urban consumers are more influenced by social norms, rural consumers by facilitating conditions and price value. Osakwe et al. (2022) find that the strongest predictors of willingness to use drone delivery are outcome expectancy and lifestyle compatibility and that delivery risk moderates the relationship between attitude and actual intention for European millennial consumers.

2.4. Scope 3 emissions and engagement with supply chain stakeholders

Meixell and Luoma (2015) identify that different stakeholder types - regulators, investors, customers and employees - exert unequal influence over different dimensions of supply chain sustainability. Customer pressure tends to be more influential on decisions regarding social sustainability, while government and regulatory pressure tend to be the most consistent driver for adoption of environmental sustainability. Mismar, Shamayleh and Qazi (2022), applying Bayesian Belief Network analysis to last-mile delivery risks, find that beyond the operational risks of IT failure and privacy breaches, regulatory non-compliance is an emerging exposure - one that CSRD 2024 (European Commission, 2022) has made concrete for any large logistics operator reporting in the EU. Boysen, Fedtke and Schwerdfeger (2021) observe, from an operational research perspective, that increasingly stringent governmental legislation now enforces courier services to intensify sustainability efforts, particularly around fleet electrification and alternative delivery modes.

3. Methods

3.1. Research Design

This paper adopts a mixed-method longitudinal case study design. The rationale for this choice follows directly from the nature of the three research questions. RQ1 asks how quantitative KPIs have evolved over time, which calls for a systematic numerical comparison across multiple years. RQ2 asks whether specific solutions have been implemented and what

impact they have produced, which requires documentary analysis and qualitative interpretation of corporate disclosures alongside the quantitative evidence. RQ3 asks what new challenges have emerged, which is inherently interpretive. As Jonker and Pennink, (2009) note, a mixed-method approach is particularly well suited when a researcher intends to verify results using multiple methods and data sources, because combining quantitative and qualitative data allows statistical trends to be read alongside contextual depths that numbers alone cannot provide.

The longitudinal dimension is equally deliberate. Rather than offering a cross-sectional snapshot of InPost's sustainability performance at a single point in time, this study follows the same set of indicators across five consecutive reporting years (2021, 2022, 2023, 2024, and 2025) against a baseline established for the period 2021-2023 (Aljawarneh, 2024). This approach makes the direction and magnitude of change observable in a way that a single-year study cannot. The case study boundary is InPost Poland, which is the company's original and largest operating segment, and for which consistent Poland-specific data is available throughout the entire observation period.

3.2. Data Sources

This paper draws mainly on five InPost Group Integrated Annual Reports covering the financial years that ended on 31 December 2021, 2022, 2023, 2024, and 2025. The reports are publicly available and were prepared under the Global Reporting Initiative (GRI) framework. Starting in 2024, they were also produced in line with the Corporate Sustainability Reporting Directive (CSRD), which brought in a requirement for limited third-party assurance of sustainability data.

The data collection process focused on data reported separately for Poland. It was important because InPost changed quite a bit during the studied period. Its international operations grew rapidly, and the company made a series of acquisitions that expanded the business footprint beyond what had existed in previous years; Menzies Distribution was acquired in the United Kingdom during the fourth quarter of 2024, Yodel followed in the second quarter of 2025, and Sending was added in Spain later the same year. As those businesses became part of the group, the reporting boundary behind the sustainability disclosures shifted as well. Group-level Scope 3 emissions reported for 2024 and 2025 cannot be compared directly with the equivalent figures from 2022 and 2023 because they cover a different organizational scope. Because of this, Poland-specific KPIs serve as the main time-series dataset throughout the analysis. Group-level figures are used next to that for context, and any reporting boundary change is pointed out where it affects the interpretation.

3.3. KPI Framework

The analytical framework applied in this paper is a four-dimensional KPI structure first developed in (Aljawarneh, 2024). It organizes InPost Poland's performance into four measurement dimensions: operational, financial, sustainability, and customer experience.

These four dimensions were selected on the basis that they capture the distinct but interrelated aspects of sustainability performance in a large-scale logistics operator - the volume and network growth that drives environmental load, the financial results that determine investment capacity, the direct and indirect emissions that determine environmental impact, and the customer-side demand signals that shape delivery model choice. The framework is reproduced here without modification to preserve comparability across the full observation period from 2021 to 2025 and is presented in Table 1.

Table 1.
Four-Dimensional KPI Framework

Dimension	KPI Indicator	Unit
Operational	Parcel volume — Poland	Million parcels
	APM network size — Poland	Number of machines
Financial	Revenue — Poland segment	PLN million
	Adjusted EBITDA — Poland segment	PLN million
Sustainability	Scope 1,2 GHG emissions	tCO_2e
	Scope 3 GHG emissions	tCO_2e
	Parcels delivered using electric vehicles	Million parcels
Customer Experience	Net Promoter Score — APM sending/collecting	Score
	Mobile app users	Million users
	Customer preference for APMs	%

Source: Aljawarneh, 2024.

3.4. Solution Assessment Criteria

The five sustainability solutions proposed in Aljawarneh (2024) are assessed against evidence found in the five annual reports. The assessment uses a four-level classification scale: *Fully implemented*, where the annual report confirms commercial deployment at scale with quantitative performance data; *Partially implemented*, where deployment is confirmed but remains limited in scope, in geographic coverage, or in measurable impact; *Unconfirmed*, where the annual report neither confirms nor explicitly excludes deployment; and *Not implemented*, where the annual report explicitly states that the solution has not been adopted or where no trace of it can be found across any of the five reports reviewed. This classification is based on disclosed information. Where a company has not reported on a particular solution, this is treated as an absence of confirmable evidence rather than definitive proof of non-implementation. This constraint that the analysis is bound by what companies choose to disclose is acknowledged as a limitation of the documentary method and is addressed further in Section 5.

4. Results

4.1. Operational and Financial KPI Evolution

To provide a comprehensive overview of the company, the details of InPost Poland's operational and financial KPIs from 2021 through 2025 are shown in Table 2.

Table 2.
Operational and Financial KPI Evolution - InPost Poland, 2021-2025

KPI	2021	2022	2023	2024	2025
Parcel volume (million)	424.0	508.0	589.5	709.2	763.1
APM network — Poland (machines)	16,445	19,306	21,969	25,269	28,261
Revenue — Poland segment (PLN m)	3,453.4	4,168.5	5,334.5	6,473.7	7,177.2
Adjusted EBITDA — Poland segment (PLN m)	1,626.4	1,819.3	2,474.7	2,993.6	3,515.3

Source: InPost Group Annual Reports (2021; 2022; 2023; 2024; 2025).

In the analyzed period InPost Poland's operational performance shows its sustained scale. Parcel volume increases every year without exception, from 424 million in 2021 to 508 million in 2022, then 589.5 million in 2023, 709.2 million in 2024, and 763.1 million in 2025 (InPost Group, 2021, 2022, 2023, 2024, 2025). That is a cumulative rise of about 80% across the five years. The APM network grew right alongside it, expanding from 16,445 machines in 2021 to 28,165 by 2025 (InPost Group, 2021, 2025) roughly 12,000 machines added in four years. Volume growth in the later years drew on the maturing Polish e-commerce market and InPost's deepening density within it (InPost Group, 2024, 2025).

The financial dimension show that Poland-segment revenue rose from PLN 3,453.4 million in 2021 to PLN 4,168.0 million in 2022, PLN 5,334.5 million in 2023, PLN 6,473.7 million in 2024, and PLN 7,177.2 million in 2025 (InPost Group, 2021, 2022, 2023, 2024, 2025) whereas revenue was more than doubled over the period, a rise of 108%. Adjusted EBITDA for the Poland segment followed, increased from PLN 1,626.4 million in 2021 to PLN 3,515.3 million in 2025 (InPost Group, 2021, 2025). Profitability did not just keep pace with the network build-out; it strengthened. By 2025 the Poland Adjusted EBITDA margin had reached 49%, up 200 basis points year on year (InPost Group, 2025), which indicates that the expansion was funded from an increasingly efficient core rather than at its expense.

4.2. Sustainability KPI Evolution

To illustrate the company's commitment to sustainable development, Table 3 details the trajectory of InPost Poland's sustainability metrics over the 2021-2025 period.

Table 3.
Sustainability KPI Evolution, InPost Poland, 2021-2025

KPI Indicator	2021	2022	2023	2024	2025
Scope 1 and 2 emissions, market-based (tCO_2e)	27,364	33,286	23,402	24,973	12,964
Scope 3 emissions (tCO_2e)	283,774	295,588	248,475	572,893	715,656

Source: InPost Group Annual Reports (2021; 2022; 2023; 2024; 2025).

Table 3 sets out the emissions story, and the two scopes pull in opposite directions. Scope 1 and 2 went up first, from 27,364 tCO_2e in 2021 to 33,286 in 2022, before dropping back to 23,402 in 2023 (Aljawarneh, 2024). The Group figures carry that downward move further: 24,973 tCO_2e in 2024 and just 12,964 in 2025 (InPost Group, 2024, 2025). That last number is a 56% cut against the validated 2021 base. Renewable electricity did heavy lifting, jumping from 45% of Group consumption in 2024 to 91% a year later (InPost Group, 2024, 2025).

In a case of Scope 3 the data show that it fell from 283,774 tCO_2e in 2021 to 248,475 in 2023 (Aljawarneh, 2024). Then the reported numbers climb steeply, reaching 572,893 tCO_2e in 2024 and 715,656 in 2025 (InPost Group, 2024, 2025). Some of the jump across 2023 and 2024 is the switch from Poland-only to Group-wide reporting rather than a real surge, so the break in the series should be read with that in mind. The trajectory is still clear enough. Measured against the validated 2021 Group base of 418,986 tCO_2e, the 2025 result sits 70.8% higher (InPost Group, 2025), which lines up with what Meixell and Luoma (2015) describe, where the emissions a company can lean on suppliers about but never directly switch off are the ones that refuse to come down. InPost says as much itself, expecting Scope 3 to keep rising until somewhere between 2027 and 2030 before it bends (InPost Group 2024, 2025). Volume and value-chain emissions are, for now, tied together.

4.3. Customer Experience KPI Evolution

Customer experience is the fourth dimension of the KPI framework, and it functions differently from the other three. Where volume, emissions, and revenue measure what the company produces, customer experience measures whether demand continues to support the APM model over conventional home delivery — which is the foundation of InPost's sustainability case. If customers shift away from lockers, the environmental argument weakens regardless of operational efficiency. Three indicators capture this: mobile app users as a proxy for platform engagement, Net Promoter Score for APM satisfaction, and customer preference for APMs as a delivery channel. Table 4 presents the evolution of these indicators for InPost Poland over the 2021-2025 period.

Table 4.
Customer Experience KPI Evolution - InPost Poland, 2021-2025

KPI	2021	2022	2023	2024	2025
Mobile App Users (million)	8.0	10.0	11.6	14.0	16.0
Net Promoter Score (NPS)	75	75	80	77	77
Customer preference for APMs / lockers (%)	91	59	93	93	87

Source: InPost Group Annual Reports (2021; 2022; 2023; 2024; 2025).

Customer indicators confirm that the operational scale rests on durable demand, and the demand was already strong at the start of the period. The Net Promoter Score for APM delivery in Poland sat at 75 in 2021 and again in 2022, rose to 80 in 2023, and settled at 77 across 2024 and 2025 (InPost Group, 2021, 2022, 2023, 2024, 2025). The movement is marginal against a consistently high base, and InPost continued to report it as industry-leading in every market.

Adoption deepened on every other measure. Registered users of the Polish mobile app grew from roughly 8 million in 2021 - about 40% of the country's online shoppers at the time - to 10 million in 2022, 11.6 million in 2023, 14 million in 2024, and 16 million in 2025 (InPost Group, 2021, 2022, 2023, 2024, 2025). Demand for the locker channel itself stayed dominant throughout: 91% of Polish online shoppers already chose InPost APMs as their delivery method in 2021, and the share naming APMs or lockers their preferred or most frequent channel held at 93% in 2023 and 2024 before reaching 87% in 2025 (InPost Group, 2021, 2023, 2024, 2025). Customer preference, not just operator efficiency, is what makes the model work. This aligns with Klein and Popp (2022), who find lockers score strongly on perceived environmental sustainability, and with Caspersen and Navrud (2021) on the loyalty of out-of-home models.

4.4. Solution Implementation Assessment

The second research question determines whether the five solutions proposed by Aljawarneh (2024) were effectively implemented and whether they produced quantifiable results. Each intervention is assessed against the five reports applying the four-level scale from Section 2.4, and the final evaluations are consolidated in Table 5.

Table 5.
Implementation Assessment of the Five Proposed Sustainability Solutions

Proposed Solution *(Aljawarneh, 2024)*	**Status in Annual Reports 2024-2025**	**Evidence in Annual Reports 2024-2025**
Solar-powered / energy-efficient APMs	Partially implemented	Screenless 2.0 "battery-ready" APMs introduced in Poland, 1,977 units installed, consuming 40% less energy than the previous generation (InPost Group, 2024); off-grid readiness via the Bloq.it stake (EUR 11.0m), ~2,000 infrastructure-free machines deployed in 2025, ~20,000 planned over five years (InPost Group, 2025)
Electric cargo bikes	Partially implemented	Cargo bikes and e-cargo bikes used for the micro-hub final leg; no volume, fleet, or emissions figure disclosed (InPost Group, 2025)
Scope 3 supplier engagement program	Partially implemented	Formal phased program; suppliers with science-based targets rose from 0% (2021) to 7.2% (2024) and 8.9% (2025), against a 15% target (InPost, 2024; InPost, 2025)

Cont. table 5.

Delivery drones	Unconfirmed	No deployment or pilot reported in any of the four reports
Autonomous delivery robots	Unconfirmed	No deployment or pilot reported in any of the four reports

Source: InPost Group Annual Reports (2024; 2025); (Aljawarneh, 2024).

The supplier engagement program has gone furthest. InPost folded it into its formal ESG strategy as a phased Supplier Engagement Program tied to the science-based-targets commitment for 2027, and there is a real number behind it: the share of suppliers, weighted by emissions, holding Science Based Targets in Scope 1 and 2 climbed from nothing in 2021 to 7.2% in 2024 and 8.9% in 2025 (InPost Group, 2024, 2025). That still falls short of the 15% the company set for 2025. So, the work is happening and being measured, just not yet at the level it aimed for, which is why it lands as partially implemented.

Energy-efficient APMs sit in much the same place, though the route InPost took is more interesting than the original proposal imagined. Rather than bolt solar panels onto lockers, the company went after the machines' own power draw. In 2024 it rolled out Screenless 2.0, a "battery-ready" generation that swaps the old display for a small OLED unit and pulls 40% less energy than the previous model, with 1977 units already installed in Poland (InPost Group, 2024). The screen was where a lot of the consumption sat, so dropping it does double duty: lower power, plus the freed-up space fits two extra A-size lockers per machine. On top of that came the off-grid push, backed by a EUR 11.0 million minority stake in Bloq.it for battery-powered units that need no fixed infrastructure at all, roughly 2000 of them in the ground by the end of 2025 and around 20,000 planned over five years (InPost Group, 2025). Confirmed at scale, then, even if the solar-panel version of the idea never quite materialized in the form first suggested.

In the subsequent years under review, cargo bicycles began to be deployed; however, overall uptake remained limited. They first appear in the 2025 report within the context of a micro-hub logistics model, in which larger vehicles deliver consignments to a hub and lighter transport modes undertake the final delivery segment (InPost Group, 2025). Notably, the reports do not associate cargo bicycles with any quantitative indicators: there are no data on parcel volumes handled, fleet size, or emissions reductions achieved. Their presence is thus documented only qualitatively and without indication of scale, a condition that appears to contribute to their continued status as a partially implemented solution.

The last two never appear. Delivery drones and autonomous robots show up nowhere across the five reports, neither as live operations nor as pilots. Following the documentary rule set in Section 2.4, that silence is logged as unconfirmed rather than read as outright rejection. It also tracks with Mohammad et al. (2023), who found that regulatory and infrastructure hurdles keep both technologies parked well short of commercial deployment.

5. Discussion

5.1. Evolution of the KPIs

This study set out to track InPost Poland's sustainability performance across 2021-2025 against an established baseline, assess whether five proposed solutions had been implemented, and identify new challenges that emerged over the period. The first research question asked how InPost Poland's operational, financial, sustainability, and customer-experience KPIs evolved across 2021-2025, and the answer is that they did not move as one. Operational scale, financial robustness, and customer demand all exhibited growth over the observation period. In contrast, the sustainability dimension bifurcated into two distinct trajectories, and this divergence constitutes the most analytically salient outcome in the entire dataset. Parcel volumes increased by approximately 50%, the network expanded to more than 28,000 machines, revenues grew by 72%, and the operating margin in Poland reached 49% by 2025. The expansion was therefore self-financing. The density logic that Iwan, Kijewska and Lemke (2016) measured for the early InPost network - a single courier serving hundreds of parcels from one locker bank rather than chasing addresses across a city - is exactly what shows up here as widening margins rather than thinning ones, since each new machine deepens an already efficient route structure instead of stretching it.

The emissions profile then begins to diverge across scopes. Scope 1 and 2 emissions declined by 56% relative to the validated baseline despite concurrent growth in parcel volume, indicating that InPost effectively decoupled its operational emissions from its throughput. The principal driver of this decoupling was a rapid transition in the Group's electricity mix, with the share of renewable electricity increasing from less than half of total consumption to nearly 100% within a single year (InPost Group, 2024, 2025). This outcome exemplifies the complementary relationship, in which emissions reduction and business expansion cease to be mutually exclusive, and it is consistent with Boysen, Fedtke, and Schwerdfeger's (2021) analysis of regulatory pressure steering logistics operators toward lower-emission fleets and infrastructure.

Scope 3 emissions, however, did not follow this trajectory. This is the most unexpected finding of the study. Value-chain emissions increased by 70.8% and remained closely correlated with volume, and the underlying determinant appears to be asset ownership. Emissions from assets and activities under InPost's direct control - such as its automated parcel machines and electricity procurement - were decarbonized rapidly, whereas emissions embedded in an externally managed network of couriers, suppliers, and upstream goods were not. This pattern reflects precisely the asymmetry identified by Meixell and Luoma (2015) as the structural barrier that many firms encounter once the most straightforward internal abatement measures have been exhausted.

The customer dimension, in turn, helps to discount demand-side reluctance as a limiting factor. The number of active application users increased to 16 million, the parcel locker channel maintained its dominant position in customer preference, and the Net Promoter Score exhibited minimal variation over the period. These indicators suggest that demand for the more sustainable delivery model is not currently the binding constraint (Caspersen, Navrud, 2021). RQ1 is therefore confirmed: the KPIs evolved significantly across the period, but not uniformly — operational and financial growth was consistent, Scope 1 and 2 emissions decoupled from volume, while Scope 3 rose in an unexpected direction, reflecting a structural challenge that internal decarbonization efforts alone cannot resolve.

5.2. Implementation of the Proposed Solutions

The second research question addressed the extent to which the five solutions proposed in Aljawarneh (2024) had been implemented in practice. In this regard, there is a clear misalignment between the original proposals and the realised outcomes—a discrepancy that constitutes an empirical finding in its own right. The pattern of implementation closely followed loci of organisational control: InPost acted rapidly on the measure that could be executed entirely within its own operational boundaries and proceeded more slowly on those requiring prior action by external actors.

Energy-efficient automated parcel machines (APMs) provide the most salient example. Instead of installing solar panels on parcel lockers, as recommended in the thesis, the company focused on reducing the intrinsic energy consumption of the machines themselves through the development of the Screenless 2.0 generation and through investment in off-grid units, thereby achieving the same overarching objective of reduced energy use via an alternative pathway that it could design, implement, and fully control (InPost Group, 2024, 2025). The initial proposal thus functioned as a hypothesis regarding the means of achieving a sustainability goal; InPost subsequently identified and adopted a more effective or more feasible means.

The supplier engagement program constitutes the primary intervention explicitly targeting the Scope 3 emissions challenge identified in the preceding section, and its rate of progress reflects this complexity. The proportion of suppliers covered by science-based targets increased from zero to 8.9%, which represents substantive advancement but remains below the 15% benchmark. This shortfall is largely attributable to the program’s reliance on the independent actions of numerous external firms, each of which must establish and achieve its own emissions-reduction objectives (InPost Group, 2024, 2025). This dynamic aligns with the final, and typically slowest, phase of the progression described by Meixell and Luoma (2015), which occurs only after organizational awareness and goal-setting mechanisms have been established.

Cargo bicycles, by contrast, occupy an intermediate position between demonstrated technical potential and empirically documented organizational impact. However, the academic literature provides evidence of their effectiveness. For example, Schünemann et al. (2022) report substantial reductions in greenhouse gas emissions emphasizing the role of such parameters as the use of renewable energies for the charging of the batteries, the utilization of the payload capacity and the production of the battery. They demonstrate that life cycle GHG emissions are substantially reduced when the batteries are charged using solar energy. Integrating solar-powered e-cargo bikes into the freight transport modal split in the accra region would lead to greenhouse gas emission reductions of approximately 4-8%. Moreover, Shramenko et al. (2025) underline also such benefits as strengthening corporate image and compliance with regulatory standards in some cities. They demonstrate the operational feasibility and reducing costs of cargo‑bike‑based routing under European conditions. However, InPost does not disclose quantitative indicators - such as processed shipment volume, fleet size, or emissions reductions - attributable specifically to cargo‑bike operations. Consequently, cargo bicycles are integrated into the logistics system but remain effectively invisible within the reported performance metrics.

Unmanned aerial vehicles (drones) and delivery robots do not appear in the disclosed data at all. This absence is consistent with broader sectoral developments. Mohammad et al. (2023) identify regulatory and infrastructure barriers that continue to impede large‑scale deployment. However, Sillero Illanes et al. (2025) show that, although these technologies may outperform conventional vans in simulation or pilot studies, they still remain a potential solution in Poland. Osakwe et al. (2022) further introduce a demand‑side qualification for drones, indicating that users' willingness to adopt drone delivery depends on determinants that are not fully controllable by the operator. Accordingly, the lack of confirmed impact at InPost should be interpreted less as a deficiency of corporate ambition and more as a reflection of the current state of development across the entire sector.

RQ2 is partially confirmed: three of the five solutions show evidence of active implementation, but none reached full deployment. The pattern follows organizational control boundaries rather than ambition levels, a finding that aligns with but also extends the stakeholder-influence sequence described by Meixell and Luoma (2015).

5.3. Emerging Challenges and Opportunities

The third research question turned to the new challenges and strategic opportunities that emerged over the period, and two shifts in particular reshaped the terrain after the baseline thesis was written. The first is CSRD. Before the directive took effect in 2024, a company's value-chain emissions could stay largely in the dark; afterwards they had to be reported and independently assured (European Commission, 2022). Part of the steep Scope 3 rise in Section 4.1 is therefore an accounting effect — better counting, not only more emitting —

which cuts both ways for InPost. The assurance requirement lifts the credibility of the later figures, an asset for a company whose sustainability claims now carry regulatory weight. At the same time, it converts disclosure into exposure, making regulatory non-compliance the kind of live operational risk that Mismar, Shamayleh and Qazi (2022) identify as new material for any large EU logistics operator.

The second shift is structural growth. The acquisitions of Menzies, Yodel, and Sending pushed the Group well beyond its Polish locker core and broke the clean Poland time series in the process, which is why the 2025 Group figures are reported on a pre-acquisition basis at all. Here the tension is sharp. Bringing conventional courier and distribution networks into a group whose entire sustainability narrative rests on out-of-home density imports exactly the van-based, third-party emissions profile that the APM model was built to avoid, and it does so into the Scope 3 line that is already the hardest to bend. The opportunity hides inside the same move. If the density logic that drove Poland's results can be carried into the United Kingdom and Spain, the acquisitions become a testbed rather than a drag.

One trend ties the two shifts together. Domestic volume growth cooled from above 20% to 7.6%, a sign the Polish market is maturing, which means the next chapter of both expansion and emissions will be written abroad (InPost Group, 2025). The sustainability question moves with the company. Whether the model travels are now the thing worth watching.

RQ3 is confirmed: two significant challenges emerged in 2024-2025 that were not anticipated in the baseline thesis — the full binding effect of CSRD and the structural disruption caused by the acquisitions of Menzies, Yodel, and Sending. Both reshape the sustainability trajectory in ways that the original KPI framework will need to track going forward.

6. Conclusions

This paper set out to follow InPost Poland from a baseline into the years that came after, tracking how its sustainability performance moved rather than how it was projected to. Three questions framed the work, and the answers, taken together, sketch a company doing well on most fronts and stuck on the one that matters most for last-mile delivery.

On the first question, the KPIs grew in nearly every direction. Volume climbed by around the half, the network passed 28,000 machines, revenue rose 72%, and the Poland margin reached 49%, all while operational emissions fell 56% against the validated base. Growth and clean operations stopped fighting each other. The exception was Scope 3, which rose 70.8% and stayed tied to volume, marking the clear boundary of what InPost has managed to control so far. The second question turned the five proposed solutions into a pattern worth naming: implementation tracked ownership. Energy-efficient APMs, the solution sitting entirely inside InPost's own walls, advanced fastest and by a smarter route than the thesis imagined, swapping

solar panels for screenless, low-draw, off-grid machines. The supplier engagement programme made real but partial headway because it depends on outside firms' acting. Cargo bikes are present without numbers, and drones and robots never appear at all. The third question pointed at two shifts that arrived after the thesis: CSRD, which made value-chain emissions both more visible and more legally binding, and the wave of foreign acquisitions, which broke the clean Polish series and imported exactly the kind of conventional, third-party delivery the locker model was built to avoid.

The theoretical contribution is straightforward. This is a longitudinal, company-level test of whether proposed sustainability solutions get built, against a verified prior baseline. The control-based reading of implementation, where a firm moves fast on what it owns and slows on what it must persuade others to do, gives a simple lens for reading any operator's sustainability progress, and it puts empirical weight behind the stakeholder-influence sequence that Meixell and Luoma (2015) describe. On the practical side, the solution implementation matrix offers logistics operators, sustainability managers, and policymakers a plain template for separating what has been deployed from what has merely been announced, which matters more now that CSRD has made the difference legally consequential.

The limitations are real and worth stating plainly. This is a single case, and it leans on corporate self-reported data, which can be selectively disclosed; the unconfirmed verdicts reflect the silence of the reports, not proven absence. The acquisitions of Menzies, Yodel, and Sending shifted the organizational boundary partway through, so Group-level Scope 3 cannot be compared cleanly across the full period, and the switch from Poland-specific to Group figures sits right at the point where the emissions data tells its most dramatic story. These are constraints of the documentary method, not gaps that careful framing can erase.

Future work follows from each of those limits. The four-dimensional framework could be carried to other European APM operators, turning a single case into a comparison that would show whether the patterns found here travel. Primary data from contracted couriers would open up the supplier engagement program from the inside, getting past what the annual reports choose to reveal. And the most pressing thread is the one Section 4 left hanging: whether the density logic that drove Poland's results can survive the move into the United Kingdom and Spain, where the acquired networks look nothing like a wall of lockers. That is the question the next baseline will have to answer.

References

1. Aljawarneh, M. (2024). *Analysis and Evaluation of Sustainable Solutions in E-commerce-based Last Mile Delivery Systems in InPost Company*. Poznan University of Technology, Faculty of Engineering Management, Master's Diploma Thesis.
2. Bányai, Á., Kaczmar, I., Bányai, T. (2025). Green Micromobility-Based Last-Mile Logistics from Small-Scale Urban Food Producers. *Systems*, *13*(9). https://doi.org/10.3390/systems13090785
3. Bartucz, C., Süle, E. (2024). Sustainable Cities by Collaborative Last Mile Parcel Delivery - Live Example Insight. *Springer Proceedings in Earth and Environmental Sciences: Part F2516* (pp. 457-468). https://doi.org/10.1007/978-3-031-48532-9_42
4. Boysen, N., Fedtke, S., Schwerdfeger, S. (2021). Last-mile delivery concepts: A survey from an operational research perspective. *Or Spectrum*, *43*(1), 1-58.
5. Caspersen, E., Navrud, S. (2021). The sharing economy and consumer preferences for environmentally sustainable last mile deliveries. *Transportation Research Part D: Transport and Environment*, *95*. https://doi.org/10.1016/j.trd.2021.102863
6. Dalewska, M., Mrugalska, B. (2024). Innovative Transport: Environmental, Social, and Economic Aspects. *Human Perspectives of Industry 4.0 Organizations* (pp. 224-235). CRC Press.
7. de Mello Bandeira, R.A., Goes, G.V., Schmitz Gonçalves, D.N., D'Agosto, M.D.A., Oliveira, C.M.D. (2019). Electric vehicles in the last mile of urban freight transportation: A sustainability assessment of postal deliveries in Rio de Janeiro-Brazil. *Transportation Research Part D: Transport and Environment*, *67*, 491-502. https://doi.org/10.1016/j.trd.2018.12.017
8. Díaz-Ramírez, J., Zazueta-Nassif, S., Galarza-Tamez, R., Prato-Sánchez, D., Huertas, J.I. (2023). Characterization of urban distribution networks with light electric freight vehicles. *Transportation Research Part D: Transport and Environment*, *119*. https://doi.org/10.1016/j.trd.2023.103719
9. European Commission (2022). Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting. *Official Journal of the European Union, L 322*, pp. 15-80. https://eur-lex.europa.eu/eli/dir/2022/2464/oj
10. Gevaers, R., Van de Voorde, E., Vanelslander, T. (2009). Characteristics of innovations in last-mile logistics-using best practices, case studies and making the link with green and sustainable logistics. *Association for European Transport and Contributors*, *1*, 21.

11. Giordano, A., Christidis, P. (2025). Green Last-Mile Delivery: Adapting Beverage Distribution to Low Emission Urban Areas. *Future Transportation*, *5*(2). https://doi.org/10.3390/futuretransp5020065
12. InPost Group (2021). *Integrated Annual Report 2021*. Luxembourg: InPost S.A. Retrieved from: https://www.inpost.eu/sites/default/files/2022-04/InPost%20Annual%20Report%202021.pdf, May 11, 2026
13. InPost Group (2022). *Integrated Annual Report 2022*. Luxembourg: InPost S.A. Retrieved from: https://www.inpost.eu/sites/default/files/2023-04/InPost%20Annual%20Report%202022.pdf, May 11, 2026
14. InPost Group (2023). *Integrated Annual Report 2023*. Luxembourg: InPost S.A. Retrieved from: https://www.inpost.eu/sites/default/files/2024-04/IAR%20InPost%202023.pdf, May 11, 2026
15. InPost Group (2024). *Integrated Annual Report 2024*. Luxembourg: InPost S.A. Retrieved from: https://www.inpost.eu/sites/default/files/2025-04/InPost%20Raport%202024.pdf, May 11, 2026
16. InPost Group (2025). *Integrated Annual Report 2025*. Luxembourg: InPost S.A. Retrieved from: https://www.inpost.eu/sites/default/files/2026-04/InPost%20Group%20IAR%202025.pdf, May 11, 2026
17. Iwan, S., Kijewska, K., Lemke, J. (2016). *Analysis of Parcel Lockers' Efficiency as the Last Mile Delivery Solution - The Results of the Research in Poland*. Transportation Research Procedia. Elsevier B.V., pp. 644-655. https://doi.org/10.1016/j.trpro.2016.02.018
18. Jaramillo, P., Kahn Ribeiro, S., Newman, P., Dhar, S., Diemuodeke, O.E., Kajino, T., Lee, D.S., Nugroho, S.B., Ou, X., Hammer Strømman, A. (2023). *Transport (chapter 10). IPCC 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change,* 1049-1160.
19. Jonker, J., Pennink, B.W. (2009) *The essence of research methodology: A concise guide for master and PhD students in management science, The Essence of Research Methodology: A Concise Guide for Master and PhD Students in Management Science*. Berlin/Heidelberg: Springer. https://doi.org/10.1007/978-3-540-71659-4
20. Lubis, R.A.S., Lestari, Y.D. (2025). Green vehicles adoption for last-mile delivery: A systematic literature review and current trend. *International Journal of Logistics Systems and Management, 51(2),* 211-229. https://doi.org/10.1504/IJLSM.2025.146707
21. Masłowski, D., Giera, J., Kubinka, B., Śliwińska, A. (2025). Zielona transformacja logistyki dzięki innowacjom technologicznym ograniczającym emisję CO2 w firmach kurierskich – case study. *Ekonomika i Organizacja Logistyki, 10(2),* 59-76. https://doi.org/10.22630/EIOL.2025.10.2.12

22. Meixell, M.J., Luoma, P. (2015). Stakeholder pressure in sustainable supply chain management: A systematic review. *International Journal of Physical Distribution and Logistics Management, 45*, pp. 69-89. https://doi.org/10.1108/IJPDLM-05-2013-0155
23. Mismar, H., Shamayleh, A., Qazi, A. (2022). Prioritizing Risks in Last Mile Delivery: A Bayesian Belief Network Approach. *IEEE Access, 10,* pp. 118551-118562. https://doi.org/10.1109/ACCESS.2022.3220626
24. Mohammad, W.A.M. et al. (2023). *Innovative solutions in last mile delivery: concepts, practices, challenges, and future directions.* Supply Chain Forum. Taylor and Francis Ltd., pp. 151-169. https://doi.org/10.1080/16258312.2023.2173488
25. Iwan, S., Kijewska, K., Lemke, J. (2016). *Analysis of Parcel Lockers' Efficiency as the Last Mile Delivery Solution - The Results of the Research in Poland*. Transportation Research Procedia. Elsevier B.V., pp. 644–655. https://doi.org/10.1016/j.trpro.2016.02.018
26. Jaramillo, P., Kahn Ribeiro, S., Newman, P., Dhar, S., Diemuodeke, O.E., Kajino, T., Lee, D.S., Nugroho, S.B., Ou, X., Hammer Strømman, A. (2023). Transport (chapter 10). *IPCC 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, 1049-1160.
27. Jonker, J., Pennink, B.W. (2009). *The essence of research methodology: A concise guide for master and PhD students in management science*, *The Essence of Research Methodology: A Concise Guide for Master and PhD Students in Management Science*. Berlin/Heidelberg: Springer. https://doi.org/10.1007/978-3-540-71659-4
28. Lubis, R.A.S., Lestari, Y.D. (2025). Green vehicles adoption for last-mile delivery: A systematic literature review and current trend. *International Journal of Logistics Systems and Management*, *51*(2), 211-229. https://doi.org/10.1504/IJLSM.2025.146707
29. Masłowski, D., Giera, J., Kubinka, B., Śliwińska, A. (2025). Zielona transformacja logistyki dzięki innowacjom technologicznym ograniczającym emisję CO2 w firmach kurierskich – case study. *Ekonomika i Organizacja Logistyki*, *10*(2), 59-76. https://doi.org/10.22630/EIOL.2025.10.2.12
30. Meixell, M.J., Luoma, P. (2015). Stakeholder pressure in sustainable supply chain management: A systematic review. *International Journal of Physical Distribution and Logistics Management*, *45*, pp. 69-89. https://doi.org/10.1108/IJPDLM-05-2013-0155
31. Mismar, H., Shamayleh, A., Qazi, A. (2022). Prioritizing Risks in Last Mile Delivery: A Bayesian Belief Network Approach. *IEEE Access*, *10*, pp. 118551-118562. https://doi.org/10.1109/ACCESS.2022.3220626
32. Mohammad, W.A.M. et al. (2023). *Innovative solutions in last mile delivery: concepts, practices, challenges, and future directions.* Supply Chain Forum. Taylor and Francis Ltd., pp. 151-169. https://doi.org/10.1080/16258312.2023.2173488
33. Montuori, G., Tumino, A., Seghezzi, A. (2023). *Logistics challenges of e-grocery last-mile delivery: A literature review*. Proceedings of the Summer School Francesco Turco.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-85193712657&partnerID=40&md5=11e0bcb63ddd2846b08ee065fdc81a7f

34. Oliveira, C.M. de, Albergaria De Mello Bandeira, R., Vasconcelos Goes, G., Schmitz Gonçalves, D.N., D'Agosto, M.D.A. (2017b). Sustainable vehicles-based alternatives in last mile distribution of urban freight transport: A systematic literature review. *Sustainability*, *9*(8), 1324.
35. Osakwe, C.N. et al. (2022). Critical factors characterizing consumers' intentions to use drones for last-mile delivery: Does delivery risk matter? *Journal of Retailing and Consumer Services*, *65*. https://doi.org/10.1016/j.jretconser.2021.102865.
36. Rose, W.J., Confente, I., Peinkofer, S.T., Russo, I. (2025). Activating the Consumer: Toward More Sustainable Last-Mile Delivery. *Journal of Business Logistics*, *46*(4). https://doi.org/10.1111/jbl.70041
37. Schünemann, J., Finke, S., Severengiz, S., Schelte, N., Gandhi, S. (2022). Life Cycle Assessment on Electric Cargo Bikes for the Use-Case of Urban Freight Transportation in Ghana. *The 29th CIRP Conference on Life Cycle Engineering, April 4-6, 2022, Leuven, Belgium.*, *105*, 721-726. https://doi.org/10.1016/j.procir.2022.02.120
38. Sillero Illanes, C., Rogalski, T., De Cubber, G., Kowalik, M. (2025). *Case Study of the Drone Ecosystem of Podkarpackie (Poland) - Insights from the Exploratory Research Activity Regions Dual Use Open Strategic Autonomy Exploratory (REGDUALOSA)*. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2760/2679576, JRC143402.
39. Silva, K.O.A.N., Lima, R.S., Alves, R. (2024). The Impacts of the Pandemic on Urban Freight Deliveries: A Case Study in a Brazilian Carrier. *International Journal of Simulation Modelling*, *23*(1), 65-76. https://doi.org/10.2507/IJSIMM23-1-672
40. Stokkink, P., Geroliminis, N. (2025). On the optimal micro-hub locations in a multi-modal last-mile delivery system. *Transportation Research Part E: Logistics and Transportation Review*, *203*. https://doi.org/10.1016/j.tre.2025.104344
41. Shramenko, N., Hupfer, C., Shramenko, V., Trojanowski, P. (2025). Electric Cargo Bikes in Urban Logistics: Scenarios and Their Contribution to Sustainable Mobility. *9th EAI International Conference on Management of Manufacturing Systems: MMS 2024*, 1.
42. World Economic Forum (2020).*Urban Deliveries Expected to Add 11 Minutes to Daily Commute and Increase Carbon Emissions by 30% until 2030 without Effective Intervention*. Retrieved from: https://www.weforum.org/press/2020/01/urban-deliveries-expected-to-add-11-minutes-to-daily-commute-and-increase-carbon-emissions-by-30-until-2030-without-effective-intervention-e3141b32fa/, June 1, 2026.
43. Wahab, S.N., Ahmed, N., Samsuddin, S.F. (2025). Parcel Locker as a Solution for Sustainable Operations and a Contactless Self-Service Solution for Last-Mile Delivery. *Operations and Supply Chain Management*, *18*(1), 79-88. https://doi.org/10.31387/oscm0600456

44. Wahab, S.N., Hye, M.N., Ramakrishna, Y. (2022). Impact of Automated Parcel Stations on E-Commerce's Last-Mile Delivery. *Environment-Behaviour Proceedings Journal*, *7*(21), 49-55.
45. Waqas, U., Umair, S., Mrugalska, B., Ali Sulaiman, M.A.B. (2025). Twin transformation: The role of digitalization with artificial intelligence, big data and circular supply chain in circular economy performance for sustainability. Equilibrium. *Quarterly Journal of Economics and Economic Policy, 20(2),* 613-645. https://doi.org/10.24136/eq.3350
46. Werner, P.A., Porczek, M., Kaleyeva, V., Brauntsch, P. (2024). Automated Parcel Machines Innovation: The Case Study of InPost in the EU and in Poland. *International Conference on Computational Science and Its Applications*, 312-323.
47. Yılmaz, İ., Özceylan, E., Mrugalska, B. (2023). A framework for evaluating electrical vehicle charging station location decisions in a spherical fuzzy environment: a case of shopping malls. *Annals of Operations Research*, 1-25. https://doi.org/10.1007/s10479-023-05772-x