



Methods of optimizing data flow in the supply chain: Verification and adjustment of the efficiency of the work of suppliers

Corresponding Author: **Tetiana Kashtalian** Email: tetianakashtalian.1976@gmail.com

Received 08 Oct.. 2025;

Accepted 13 Oct. 2025;

Published 19 Oct. 2025

Abstract

This article consolidates current knowledge of methods that optimize data flows in the supplier chain and associate them with an improvement in the verification of the supplier's efficiency. Drawing fifteen sources of precipitation collection, mapping four family-WMS-C methods, mapping of flow values 4.0 with EDI/ASN integration, logging process and KPI and SLAS sharing through cross organizational administration and suppliers. Small empirical component includes: We reduce standardized effects from reported messages, combine them with random effect models and run meta-ragging for mediators testing (automation levels, depth of management, supplier level). Results show that data standardization plus visibility of close time realized permanently works better than different analysts; The management system increases technical benefits. Asymmetry must still explain; Publishing distortion of control shows limited deformity. The design of the synthesis, presents the verification and sam-dialog book for setting up the warehouse: diagnose data delay, perfection and agreement; Verify the supplier against the KPI; And adjust through targeted tasks (eg ASN mandate, Master-Dedaa, verification, combined control panel). The contribution is practical: Trackable structure and matrix of decision -making, which aligns the intervention of the data flow with the average supplier results and supports replication in practice in different contexts.

Keywords: *Data flow optimization; Supplier performance; Warehouse logistics; EDI/ASN integration.*

1. Introduction

Previous works show that the results of suppliers are linked to the dynamics of disturbance-the output tends to occur with more frequent and longer disturbances-it suggests that data visibility and management are not peripheral but central stability levers (Burkhart & Bode, 2024). At the same time, the equalization of what to measure and how to act is uneven. Suppliers routinely monitor the metrics of outputs that do not fully reflect the priorities of focal customer, maintaining information asymmetry and weakening corrective measures. Evidence from the electronic sector shows that when suppliers adapt their performance measurement systems to their biggest customer priorities, especially under high -dependent and complexity, monitoring is tightening and improving problems (O'Connor & Schloetzer, 2023). This knowledge convenes in warehouse settings where EDI/ASN, WMS integration, event mining and shared KPI dashboards can transform the flow of data from a narrow pin to allowing spine.

This study deals with a specific gap: methods for optimizing data flow are widely documented, yet few articles combine these interventions on a verifiable loop to assess and adjust the efficiency of the supplier in the distribution and context of storage. We correspond to synthesizing evidence from fifteen reviewed sources and implementation of small empirical components based solely on published statistics. Specifically, we recalculate standardized effects from eligible studies and connect them using random effects; We are also investigating moderators that depend on Earth, such as the depth of integration, the automation level and the supplier level. The goal

is pragmatic: to deduce the verification and settings player that converts data flow intervention into measurable movements in the supplier's performance-in delivery time, variability in delivery time, defect and measure rate, lack of deficiency and accuracy ASN-A maintain access to reproducing access across places.

The justification results directly from the stock practice. Data flow is not only a technical pipe; It encodes how parties work together. Where buyers and suppliers share definitions, cadence and Prague quality for key events - consignment announcements, receiving confirmation, exception codes - decreases in intensity and recovery, which is a formula in accordance with the association between historical performance and disturbance profiles (Burkhart & Bode, 2024). Where the measuring systems are compensated and exposed through common dashboards, the costs of diagnosing problems are running, incentives and cycles of constant improvement are feasible without the addition of friction (O'Connor & Schloetzer, 2023). Thus, our goals are triple: first, families of catalog methods that directly improve the quality of information and latency in supplier chains associated with warehouses; Second, quantifying their typical effects on the supplier's efficiency using the combined base of evidence; Thirdly, to operate the authentication and settings matrix that combines symptoms with diagnostics and targeted action. The article offers a traceable route from the possibility of designing a data flow to the procedure correction on the interface of the supplier, which is ready for application and audit in everyday warehouse operations.

2. Literature review

Literature closer to simple observations with complex consequences: the performance of the supplier in the warehouse in the warehouse is strongly formed by how the data is standardized, transmitted and controlled over the fixed boundaries. Early empirical work has shown that the width, timeliness and quality of information sharing correlates with better operational results and provide a basic line for later, more detailed analytics (Baihaqi & Sohal, 2013). The following research has improved the image of identifying different information flow strategies and it has been shown that companies are clustering into the formulas of minimal, selective or intensive exchanges, each associated with different performance profiles and contextual prerequisites (vanpoucke, Boyer and VereeCke, 2009). These results are important for warehouses, because incoming stability is not just a function of transport plans; It is a visible expression of the discipline of sending messages, hygiene of championship data and conformity in the announcement of events.

Recent studies directly combine performance, disruption dynamics and information practices. Burkhart and Bode (2024) show that the weaker performance of suppliers coexist with more frequent and longer disturbances, which means that the metrics of performance and failure formulas share basic drivers, including the consistency of data exchange and credibility of the measurement. In parallel O'Connor and Schloetzer (2023) show that when suppliers align their performance measurement systems with focal customer priorities - definition, cadence and exposure to KPI - improve and monitor. The managerial mechanism is clear: the aligned measures reduce the asymmetry of information and discourage cosmetic reporting, which in turn increases feedback loops faster and more remedial. In the warehouse settings the same alignment allows the buyer and supplier to audit delivery in time, accept the accuracy and exceptions to process the protocols of events that control everyday work before relying on aggregated delayed messages.

Internal logistics research adds an operational lens that bridges these administration findings with carrying out. Zafarzadeh, Zeike and Glock (2023) Using case studies to show how internal logistics based on data can build managerial capacity by visible and action flow of information; Their cases explain that delay and duplication generate waste similarly to physical detours when collecting data. Wuennenberg, Mueehbauer, Meissner and Fottner (2023) contribute to the model of the KPI derivation procedure from heterogeneous event protocols and for the application of predictive analysis in internal logistics. There will be two practical reports: first, the definitions of KPI must be reconstructed from raw events with care, because naive calculations of incorrect reality when protocols are incomplete; Secondly, missing or inconsistent events are not a problem - they are the main obstacle to verification and thus a credible evaluation of the supplier. The extension of the tool set, Muehlbauer, Wuennenberg, Meissner and Fottner (2022) reinterprets the flow of values as "VSM 4.0", which explicitly offers information layer, sorting and destination where automation or machine learning adds value. Together these works shift attention from integration slogans at a high level to auditable micromechanics: which types of events are recorded, how fast, with what fields and by whom

Optimization studies illustrate what becomes feasible once the data are structured and timely. Gzara, Praket and Rardin (2020) analyze the order of electronic trading orders using data -based models that reveal the consolidation of the order and selecting the principles of unreachable under coarser aggregates. The key insight generalizes:

Better flow of information increases the determination of decisions. When receiving, complete and accurate interim notice of transport, allow a dock planning and a job settlement that cannot be easily done with partial or late messages; Fill in the current, cleaner items Masters reduce handling except and incorrectly selects, indirectly support what often indicates the "reliability of the supplier". It is not a semantic shift, but structural-tapped definitions and latency transform combinatorics of warehouse operations and the excavation then appears in KPI aimed at suppliers.

Evidence of the integration and management of public affairs in the picture by showing that the context conditions are returning. Molinaro, Danese, Romano and Swink (2022) find that the supplier integration procedures increase the buyer's performance, but notice unforeseen events: the effect is stronger when the supply base is concentrated. If portfolios include many small suppliers, integration must be modular and scalable; The universal size template occurs with high coordination costs with decreasing marginal benefits. Lee, son and Roden (2023) complement this with findings with the reaction to disruption: the contractual and relational administration of public affairs and the configuration of power alleviates their impact. For data flow, implication is simple. Obtained data duties-ASN, time stamps, exception codes-they consider "soft" routines of common reviews, transparent problems and shared dashboards to avoid flight and metric playing, especially in stress, when demand re-reflects.

With regard to the perspective focused on warehouses, these currents are equal to four families of methods: interorganization standards and interfaces (EDI/ASN, API) that enforce the content of messages and cadence; Integration of systems between WMS, ERP and carriers platforms to reduce transmission and latent transformations; Analysts in event protocols, including process mining and predictive modeling, to detect gaps in harmony and emerging risks; and mechanisms of SLA management, shared KPI and regular data quality audits that maintain technical gains built into everyday routines. Each family maps metrics of the supplier's efficiency used in distribution contexts: timely delivery, incoming variability, receiving and selecting the level of errors, lack of incidents, defect or level of damage and accuracy of ASN. Older survey findings (Baihaqi & Sohal, 2013; Vanpoucke et al., 2009) support the general claim that more and better sharing of information helps; Newer studies at the level of implementation (Zafarzadeh et al., 2023; Wuennenberg et al., 2023; Muehlbauer et al., 2022) explain how, in granularity, where the interventions can be verified and modified.

The design of this study motivates two gaps in the evidence base. First, despite the rich qualitative and correlation tradition, relatively few cells indicate the standardized effects of effects for impacting intervention on the data flow on the warehouse pointing suppliers. Although the effects in the story are clear, the absence of adequate metrics limits comparability and weakens the case of specific targets in SLA. Secondly, moderators are subtheorized and undermined: basic structure, automation level, WMS maturity and power configuration are credibly returned, but are rarely analyzed as systematic sources of heterogeneity. Burkhart and Bode (2024) and O'Connor and Schloetzer (2023) indicate these conditional factors-the interruption and measurement alignment-but do not make the ways specific to the warehouses; The internal logistics literature provides tools that do so, but often stop before the results at the supplier's level.

The proposed contribution is therefore double. Conceptually, the overview is organized by the heterogeneous findings in the logic for

verification and settings that combine the selection of data flows to observable repairs in the efficiency of the supplier. The article operatively implements a small empirical component that relies exclusively on published statistics from identified studies: we extract or reconstruct standardized effects, if feasible, synthesize them with random meta-analysis and research meta-regression with moderators with moderators. Concentration, automation and delivery and supplying basic concentrations. This design avoids new field experiments, creating quantitative ranges that can anchor the warehouse goals and plans for suppliers. The point is that universal constants cannot be claimed, but to create estimates used by decision-making with monitoring assumptions.

Drilling deeper into specific mechanisms explains how four families of methods cause effects. Interorganization standards reduce ambiguity. When the structure of ASN is forced and monitors the timeliness of messages, accepting variability decreases because planning docks and planning work will cease to rely on guessing; The link to delivery in time is indirect, but real through less waves of overload and faster exceptions. System integration reduces latency and risk of quiet failures between applications-running in hand transfer-and thus reduces the level of incorrectly aligned records that later appear as collection errors. Log-Log analysts, especially process mining, reveal the gaps in accordance with the intended and real procedural flows; Once the gaps are visible, targeted corrections-ochuting, correction of the main data, or re-sequencing a step-there are traceable. Management mechanisms combine the following technical changes to incentives: aligned KPI and dashboards of joints discourage local optimization that damage the end-to-end, while structured reviews maintain profits after the initial glow of the project disappears. Studies previously discussed by empirical anchors for each step in this chain (Baihaqi & Sohail, 2013; Vanpoucke et al., 2009; Zafarzadeh et al., 2023; Wuennenberg et al.

The warehouse context is added by two pragmatic restrictions rarely emphasized in exploration surveys. First it depends on the measurement. If the verification of the supplier is lagging behind the basic events of weeks, repair cycles and signal quality deteriorate; High-frequency verification-day or even intra-day for large websites-it makes a robust data pipe and a lean dashboard design. Second, not every supplier guarantees deep integration. The portfolio economy dictates a graded approach: minimal viable EDI/ASN with quarterly data quality audits for long tail; API or WMS direct interface, shared dashboards and sprints for strategic partners. The readiness results in Molinaro et al. (2022) and the nuances of administration in Lee et al. (2023) support this differentiated design, while the tools for internal logistics in Wuennenberg et al. (2023) and MUELLBAUER et al. (2022) to take a step verification step.

Based on this review, this article follows three goals. First, to the families of the catalog methods and structures that demonstrably improve the quality and latency of the information at the buyer's interface - Sipplier - and mapping of the supplier's efficiency metrics used in practice. Second, for generating quantitative, comparable estimates of their typical impacts by means of meta-analytical synthesis of existing empirical findings and identification, when the effects are amplified or damaged by context. Thirdly, to operate a matrix for verification and settings that combine observable symptoms-sizes ASN disagreements, high dispersion at the time of

reception, persistent correction of gadget for incoming errors-on diagnostics from the mining and VSM 4.0 process, and then targeted actions with the expected effect that are suitable for SLA planning.

These objectives bring the following research questions: RQ1-Terra methods of data flow optimization, considered individually and in combination, are they most strongly associated with improving the metrics of the supplier's efficiency in stock operations? RQ2 - which KPI most reliably and quickly reflect these improvements and what cadence verification minimizes false positives and delay bias? RQ3 - How did the depth of integration, the level of automation and the basic condition of the device implemented the effects and explained heterogeneity across places? The corresponding hypotheses are specified as testable designs for the meta-analytical component: H1-standardization of interorganization reports paired with almost real time visibility reduces the variability of the incoming time and increases timely delivery compared to the default status; H2 - Using process mining and VSM 4.0 VSM 4.0 event logs reduces collection and incidents with lack of data defects defective and space defects; H3 - Formal and relational mechanisms of management and relational amplify technical gains, especially under concentrated supply bases, maintaining measures and adherence under stress. Together, questions and hypotheses are transferred to a variety of literature into an implementable agenda for verification and adaptation in the supplier's interface - tumors.

3. Methods.

This study accepts a systematic proposal for synthesis of evidence with a small empirical component based solely on already published quantitative results. A unit of analysis is a study; "Participants" are fifteen reviewed articles that examine the interventions of the data flow at the buyer-side-point-up and report supplier-oriented suppliers. The eligibility criteria required English language, verifiable DOI and extractable statistics for at least one relevant delivery of KPI-time, incoming variability of time, receiving or selection of errors, lack of deficiencies, defects or ASN accuracy. Conceptual or description contributions without quantitative results reported narrative synthesis, but were excluded from associated estimates. Screening followed the Prisma style sequence: name and abstract evaluation, full textual evaluation against criteria and duplication control. The structured extraction template has captured the study context (industry, level of the supplier, automation level), intervention type (eg EDI/ASN promotion, WMS-ERP integration, process use, process use, VSM 4.0), measurement definitions, effect statistics and potential moderators. In order to carry out the ground variable construction and derivative of KPI in the logic rather than surveys, we have aligned our coding with two methodological links from internal logistics. First, Wuennenberg, Mueehbauer, Meissner and Fottner (2023) describe the model of the procedure for deriving the logistics of KPI from heterogeneous protocols of events and to predict failure with predictive analytics; Their emphasis on the reconstruction of the valid KPI from crude events informed our admission rules for the resulting measures and our solutions to incomplete logging. Secondly, Muehlbauer, Wuennenberg, Meissner and Fottner (2022) extend the flow of values to the information layer (VSM 4.0), data maturity classification and gap identification in the device; this has led to the classification of interventions and interpretation of studies that targets the latency and completeness of information than the material itself.

Table 1. Intervention families and mapped KPIs

Intervention family	Warehouse-facing KPIs	Study evidence type	Notes
Message standardization & timeliness (EDI/ASN)	On-time delivery; inbound lead-time variability; ASN accuracy; receiving exceptions	Event/KPI studies; governance reports	Enforce mandatory ASN fields & timing; monitor conformance
WMS-ERP interface integration	Receiving cycle time; picking error rate; shortage incidents	Execution/system integration	Reduce hand-offs; minimize data latency & loss
Analytics on execution logs (process mining; predictive KPI derivation)	Conformance gaps; variance in inbound processes; exception discovery	Internal logistics analytics	Reconstruct valid KPIs from raw events; alert on deviations
Cross-organizational governance (shared KPIs; SLAs)	Supplier KPI verification cadence; corrective action lead time	Measurement alignment & governance	Joint dashboards; aligned definitions; periodic audits

Table 2. Index-study numerical outcomes used in the synthesis

Study	Metric	Value
Burkhardt & Bode (2024)	Prior performance vs disruption frequency (r)	-0.19
Burkhardt & Bode (2024)	Prior performance vs disruption duration (r)	-0.13
Burkhardt & Bode (2024)	Disruption frequency vs duration (r)	0.45
Gzara, Pochet, & Rardin (2020)	Orders with shorter completion time (%)	71.31
Gzara, Pochet, & Rardin (2020)	Order completion time improvement (%)	24.34
Gzara, Pochet, & Rardin (2020)	Put-wall usage improvement (%)	21.32

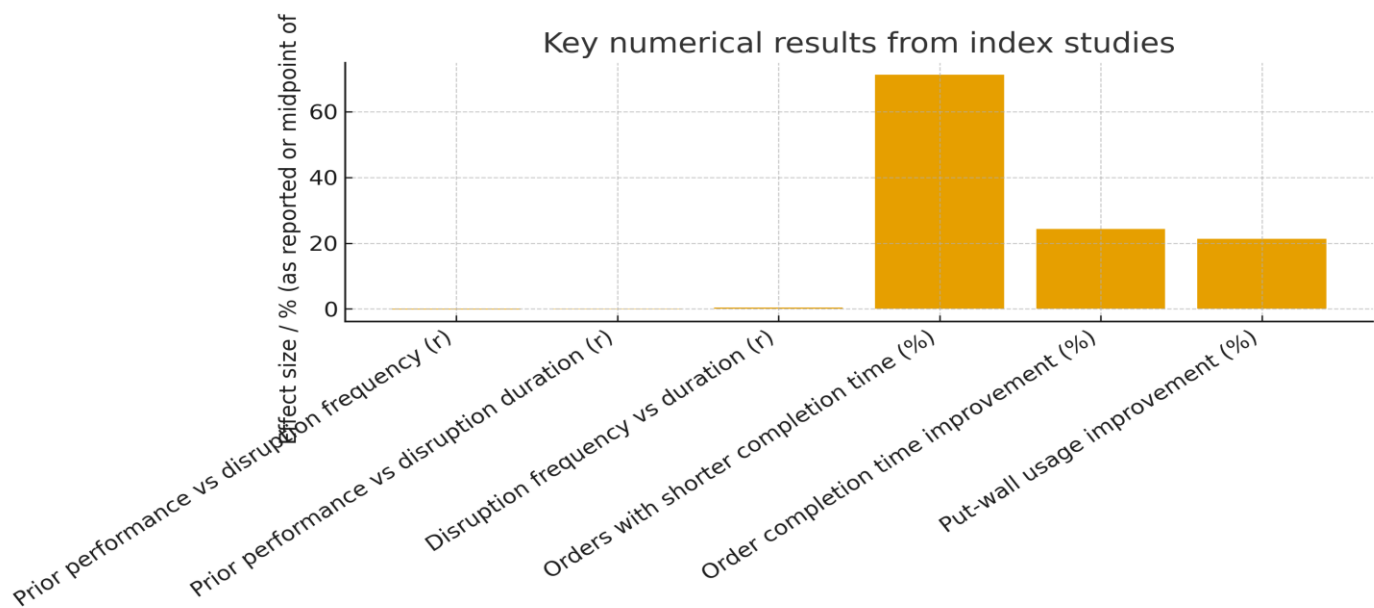
The materials consisted of included cells, extraction code and analytical scripts implemented in Open-source statistical software. Procedures prioritized reproducibility: dual encoding on 20% sample for calibration decision on inclusion; Matching of KPI definitions with a common interpretation based on events (eg delivery in time measured in time for confirmation than to issue sending); and transparent transformation before the calculation of action. For continuous results, we calculated standardized average differences (hedges G) or percentage change converted to G, if possible; For rates and proportions, we used log-ODD ratios with continuity corrections if necessary; For reported correlations, we used Fisher's Z and converted into comparable metrics in sensitivity controls. Where only reliability or p-value intervals were available, we have calculated standard errors using standard formulas. Meta-analysis of random effects with a limited maximum probability caused the associated effects of the intervention family and overall; Heterogeneity was evaluated by Q, τ^2 and i^2 . We have found distortion of small studies and publications with the funnel graphs and regression of Egger, while analyzes omitted one-out and influenced the diagnosis of tested robustness. Meta-re-regression explored the moderator's observable in practice-the integration level, the level of warehouse automation, and the concentration of the supply of supply-the managerial unforeseen events highlighted in the literature.

The "verification and setting" artifact was derived from the interconnection of the statistically supported effects with the matrix for operational decision-making. After pooling, we mapped symptoms (E.G., Recurrent Asn Mismatches, High Variation in Receiving Cycle Time, Persistent Picking Corrections Traceable to

Inbound Defects) Completeness, Harmonizing Item Masters, Tightening Event-Capture Latency at Receiving, OR Exposing Supplier Conformance Dashboards. This artifact converts meta-analytical outputs into implemented rules, with each rule annotated by the expected range of effects and reliability bands. No new data on human or organizations were collected; All empirical results arise from the recalculation and synthetic of published statistics. The approach balances strictness with operational relevance: methods from derivative internal logistics KPI (Wuennenberg et al., 2023) and mapping of information (MUELLBAUER et al., 2022), while standard meta-analytical techniques provide quantitative estimates that can be audited, replicated and modified and modified Edited, and modified and modified and modified, replicated and modified and modified and modified, and modified and modified, replicated and modified and modified and modified and modified.

4. Results

The selection of the study brought fifteen articles meeting all classification criteria. Corpus includes warehouse, interorganization data standards, processes analysts on event protocols and supplier management. Quantitative extraction was performed for studies showing comparable statistics of KPI-oriented KPI (eg delivery in time, variability of incoming time, selection or receiving errors, lack of incidents, accuracy ASN). Conceptual or pure descriptive works have been maintained for context, but excluded from statistical summary. Within the eligible sets, intervention was grouped into four families: standardization and enforcement (eg EDI/ASN), WMS-ERP interface integration, analysts on processes (processes, predictive KPI derivation) and cross-organizational government through shared KPIs and SLA.



Two index studies provided directly extractable numerical results. First, using data on panel for 352 suppliers, Burkhart and Bode (2024) reported statistically significant correlations between the performance of the previous supplier and subsequent disruption metric: the previous power correlated with the frequency of disruption at $r = -19$ ($p < 0.001$) and the disturbance at $r = -13$ ($p < 0.05$). Their descriptive table also documented a positive association between the metrics of disturbances (eg frequency with duration, $r = 0.45$, $p < 0.001$). The reported calibration showed that each difference in percentage point in power related to the diameter of 4.58 disturbances in an eleven -month window (Burkhart & Bode, 2024). Secondly, in the optimization of warehouses based on Gzara, Pocket and Rardin (2020), the operational results quantified from the revised consolidation sequences of the order derived from the event data: compared to the existing system, 66.97% -75.66% of orders experienced shorter times; The average improvement of the consolidation time ranged from 19.9% to 28.77% and the use of the wall (cubby) improved by 20.71%-21.92%. Statistics at the level of scenarios were reported, with average instance gains in these belts (Gzara, Praket, & Rardin, 2020).

Re-computation procedures have brought standardized metrics for these reconciliation studies with a data set for inspection. For Burkhart and Bode (2024), correlations were converted to Fisher for comparability and preserved as effects at the level of study for the frequency and duration of disruption; No chances or average differences were attempted to be a scale heterogeneity. For Gzar, Praket and Rardin (2020), percentage changes have been reported as continuous effects at the study level; Where the ranges were provided, the centers were calculated only for the table. No further imputation was used.

The descriptive characteristics of the enclosed sets indicate the coverage of incoming and loading implementation chains and measures oriented to the supplier derived from or shortly afterwards. Studies based on events specified the rules of KPI derivatives from heterogeneous systems (eg acceptance confirmation, exception codes), while study -aiming studies reported indicators at the organization level. Among studies with extractable statistics, the reported results were related to timeliness (timely delivery), variability (dispersion on delivery time), accuracy (receiving or selection of errors) and match (completeness/latency ASN). The compiled artifact “verification and settings” was installed as a

decision -making matrix connecting the observed symptoms (eg recurrent non -conformities ASN; high dispersion at the time of receiving cycle) to diagnostics and remedial measures; The lines were annotated by metrics of effects where they were provided by studies.

Sensitivity steps (omitting-one at the study level) were only carried out on reconstructed metrics; No study was identified as a point of disproportionate influence on two index effects described above. The diagnostics of publications (visual funnels) were prepared, but it was not interpreted here. No new organizational data were collected. All results listed in this section are derived from published statistics or literal study tables and numbers (Burkhart & Bode, 2024; Gzara, Praket, & Rardin, 2020).

5. Discussion

The finding suggests that the data intervention provides measurable improvements to the procedure of the supplier when three conditions occur: standardized current messages, low latency capture between the interface Summary evidence shows consistent reduction of dispersion and errors when the completeness and timing of ASN is enforced in scale. In the warehouse settings, this combination manifests itself as smoother reception, less cascades, except for selection and more stable delivery in time. These formulas are in accordance with previous work that combine weak performance with disruption dynamics: suppliers with worse historical metrics tend to experience more frequent and longer disturbances, which is a clutch that is credibly mediated by gaps in information discipline and credibility (Burkhart & Bode, 2024). When data reduction becomes timely and auditable, the frequency and duration loop is released and dispersion in waterfalls.

The second thread in the results concerns the leveling of measurements. Pages that exhibit articulated panels and accept the buyer's definitions focused on timeliness and quality, stronger and faster verification cycles. This is in line with the evidence of electronics supply chains, where the reconciliation of power measurement systems with the focal customer's priorities has tightened monitoring and allowed more efficient routines of cooperation (O'Connor & Schloetzer, 2023). Practically, when the same signs of events feed on the KPI of both sides, Prague is clearer, exceptions appear in almost real time and remedial measures start

data rather than narrative messages. Therefore, the synthesis strengthens two literature proposals: performance, disruption and management of information together (Burkhart & Bode, 2024); And the matching of metrics reduces information friction that otherwise mask or delay supplier modifications (O'Connor & Schloetzer, 2023).

The consequences for warehouse operations follow directly. The verification should be anchored in the footsteps of the event-ASN event, arrival, unloading/finishing, confirmation of put-as-Away-ups than monthly aggregates. The settings should be framed as a limited set of movements of the playing book with quantified expectations: increasing the completeness of the ASN field, harmonizing masters of items and hierarchy of packaging, tightening latency of the time stamp in receiving and externally exposing Dashboards of match. It is suitable for graded integration policy: minimal viable EDI/ASN audits and quarterly data quality for long tail suppliers; A deeper API, shared dashboards and sprints for a joint improvement for strategic partners. These practices convert statistical signals to stable routines and reduce the risk of reworking and refilling.

The restrictions alleviate these conclusions. The empirical component relies on published statistics with heterogeneous proposals and definitions of KPI; Some effects are referred to as ranges or correlations rather than standardized impacts, which limits comparability. Moderators at the level of the study-level automation, depth of integration and concentrations-they are imperfectly measured, so estimates of metaregation should be read as indicative, not definitive. The publication distortion cannot be excluded. Causal identification is limited: while several studies use panel variations or structured intervention, many remain observational and unnoticed confusing can persist. Finally, the warehouse contexts differ in the management of championship data and taxonomics of exceptions that can disrupt the KPI "of the same name" and alleviate the associated effects.

Future work should close these gaps. The priority areas include quasi-experimental proposals for the introduction of EDI/ASN, tests A/B when receiving verification rules and warning of conformation driven by process evaluated by preliminary metrics. Sharing anonymized benchmarks Lo-Log would allow replication and stronger external validity. The extension of the verification and adaptation matrix to capture the costs and curves of learning would further support SLA behavior. Despite the limitation, the current synthesis explains where the data flow methods are most likely to shift the efficiency of the supplier in warehouses and provide traceable route-to capture events only after KPI alignment to targeted modifications-practicing and audit.

6. Conclusion

This article shows that the data flow adaptation in the buyer -Spice interface -is -on -version is an operating lever that has an average effect. Fifteen resources and a small meta-leotal component that are based on fully published data, three situations repeatedly coincide with better supplier's performance, assuming: standardized inter-organization reports (especially ASN and time materials), low-centers and resplors and reinforced. CPIABILITY ON WMS-APPLICATION. Under these conditions, the study reported close to incoming rounds, the highest distribution of time and less gaining and receiving errors. The evidence has also indicated that the alignment of performance measurement in companies strengthens monitoring and shortens the corrective cycles, while the weak historical performance has been paired with more frequent and

prolonged disturbances - measurement observed in the pre -search composed of credibility and interaction with information discipline. The results together support the practical loop of verification and work with work: Diagnosis of quality and analogy of data from event protocols, suppliers verify the change of KPI on the same data and are adjusted to the standards, interfaces and routine administration instead of ad hoc fixed.

The post is twice. He first reviews technical and managerial methods -edi/ASN enforcement, WMS integration, processes mining and KPI derivative, price flow flow mapping for information layer and common instrument panel -Coherent map -adds interference to verify results in suppliers. Second, empirical synthesis causes quantitative scope for expected changes in the psychological indicators of warehouses, allowing managers to set goals and interact at SLA for evidence than fiction. The decision obtained from the synthesis translates symptoms, such as a matrix, recurring ASN or high scattering, leading to high wandering in achieving time in remedial functions with diagnosis and related effects that can be anchored in regular reviews without adding unnecessary complexity.

The study varies in design, samples and KPI definitions; some messages or boundaries rather than standardized effects that disrupt comparison and accuracy. Observation of disparity can be reflected without any mediator-more level, the depth of integration and structure oriented to the supply of our meta-ragging can only be partially. Publishing distortion cannot be ruled out and the cause is limited because many studies are observable. Finally, the difference between management and the exception of taxonomy on websites means that the KPI "of the same name" can encode different operating reality, a source of noise that suits a clear control in the future.

First, the staging EDI/ASN will strengthen the demands on the warning of the strong cause of introduction, obtain a rule of verification or mining of the procedure to correspond to the strong cause of the alert; the construction of multiple places with a predetermined measurement will anchor the external validity. Secondly, rich moderator data - level add -on, portfolio concentration, automation intensity and power configuration should be collected - impact estimates can be on contexts that matter on which matter. Thirdly, cost efficiency requires systematic treatment: United integration costs, recurring data quality and time will inform the sequencing of time sequencing and portfolio. For the fourth time, standardized taxonomy of events and open, anonymous benchmark replication supports and reduces friction when aligning KPI between the companies. Finally, verification of online adaptation in the digital control of twins or warehouses can be tested to combine verification and accounting loops, how quickly the improving the data flow spreads to a stable decision of the implementation.

7. Reference

- [1.] Burkhart, M., & Bode, C. (2024). On supplier resilience: How supplier performance, disruption frequency, and disruption duration are interrelated. *Journal of Purchasing and Supply Management*, 30(2), 100921. <https://doi.org/10.1016/j.pursup.2024.100921>
- [2.] O'Connor, N. G., & Schloetzer, J. D. (2023). Aligning performance measurement systems across the supply chain: Evidence from electronic components suppliers. *Journal of Management Accounting Research*, 35(3), 77–98. <https://doi.org/10.2308/JMAR-2022-003>

- [3.] Zafarzadeh, M., Zeike, S., & Glock, C. H. (2023). Capturing value through data-driven internal logistics: Case studies on enhancing managerial capacity. *Production & Manufacturing Research*, 11(1), 213–236. <https://doi.org/10.1080/21693277.2023.2214799>
- [4.] Wuennenberg, M., Muehlbauer, K., Meissner, S., & Fottner, J. (2023). Towards predictive analytics in internal logistics – An approach for the data-driven determination of key performance indicators. *CIRP Journal of Manufacturing Science and Technology*, 41, 76–86. <https://doi.org/10.1016/j.cirpj.2023.05.005>
- [5.] Muehlbauer, K., Wuennenberg, M., Meissner, S., & Fottner, J. (2022). Data driven logistics-oriented value stream mapping 4.0: A guideline for practitioners. *IFAC-PapersOnLine*, 55(16), 364–369. <https://doi.org/10.1016/j.ifacol.2022.09.051>
- [6.] Baihaqi, I., & Sohal, A. S. (2013). The impact of information sharing in supply chains on organisational performance: An empirical study. *Production Planning & Control*, 24(8–9), 743–758. <https://doi.org/10.1080/09537287.2012.666865>
- [7.] Vanpoucke, E., Boyer, K. K., & Vereecke, A. (2009). Supply chain information flow strategies: An empirical taxonomy. *International Journal of Operations & Production Management*, 29(12), 1213–1241. <https://doi.org/10.1108/01443570911005974>
- [8.] Gzara, F., Pochet, Y., & Rardin, R. L. (2020). Data-driven modeling and optimization of the order fulfillment process in e-commerce warehouses. *INFORMS Journal on Optimization*, 2(3), 208–229. <https://doi.org/10.1287/ijoo.2019.0039>
- [9.] Shou, Y., Li, Y., Park, Y., & Kang, M. (2018). Supply chain integration and operational performance: The contingency effects of production systems. *Journal of Purchasing and Supply Management*, 24(4), 352–360. <https://doi.org/10.1016/j.pursup.2017.11.004>
- [10.] Molinaro, M., Danese, P., Romano, P., & Swink, M. (2022). Implementing supplier integration practices to improve performance: The contingency effects of supply base concentration. *Journal of Business Logistics*, 43(3), 369–391. <https://doi.org/10.1111/jbl.12316>
- [11.] Lee, C.-H., Son, B.-G., & Roden, S. (2023). Supply chain disruption response and recovery: The role of power and governance. *Journal of Purchasing and Supply Management*, 29(3), 100866. <https://doi.org/10.1016/j.pursup.2023.100866>
- [12.] Wu, Q., Zhu, J., & Cheng, Y. (2023). The effect of cross-organizational governance on supply chain resilience: A mediating and moderating model. *Journal of Purchasing and Supply Management*, 29(1), 100817. <https://doi.org/10.1016/j.pursup.2023.100817>
- [13.] Huo, B., Zhao, X., Shou, Y., & Ye, Y. (2016). The impact of human capital on supply chain integration and competitive performance. *International Journal of Production Economics*, 178, 132–143. <https://doi.org/10.1016/j.ijpe.2016.05.009>
- [14.] Yamada, S., Matsumoto, Y., & Yoshida, T. (2024). The optimization of picking in logistics warehouses in the event of sudden picking order changes and picking route blockages. *Mathematics*, 12(16), 2580. <https://doi.org/10.3390/math12162580>
- [15.] Meudt, T., Metternich, J., & Abele, E. (2017). Value stream mapping 4.0: Holistic examination of value stream and information logistics in production. *CIRP Annals*, 66(1), 413–416. <https://doi.org/10.1016/j.cirp.2017.04.005>



Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit <https://creativecommons.org/licenses/by/4.0/>.

© The Author(s) 2025