ASEJ ISSN: 2543-9103 ISSN: 2543-411X (online)

# Supply Chain Strategies for Electronic Component Base in Industrial Enterprises

Alexander Litvin[1]

[1]Astana
*Kazakhstan*

***Abstract*— The paper examines supply chain strategies of the electronic components base in industrial enterprises in Germany, Poland, Spain, and China between 2020 and 2024. The research is of strong relevance as a result of ongoing global disruptions, semiconductor scarcities, and the digitalization of industrial networks which is currently in rapid progress. The goal is to determine the operational performance and resilience consequences of multi-sourcing, collaborating with suppliers, nearshoring, and digital traceability. A quantitative, comparative research method was used which relied on secondary data in 280 firms followed over five years. The methodology is a combination of descriptive statistics and econometric modelling, such as two-way fixed effects, moderation, mediation and instrumental variable estimation to account for endogeneity. The results reveal that digital traceability ($\beta_6$ = 0.211-0.236) and supplier collaboration ($\beta_5$ = 0.129-0.173) have the most significant positive effects on operational performance, and supplier concentration (HHI) is a negative determinant (or negative influence) (-0.115 to -0.189). Germany and China have made the largest improvements on service level (from 87-88% to 94%) and lead-time volatility (down 23-25%), while Poland and Spain showed steady but moderate improvement. The average digital traceability index in all countries increased from 0.39 to 0.72, and the service reliability increased by 7-8 percentage points. These findings support the status that resilient industrial systems are data driven and collaborative in nature. The study finds that the combination of digitalization, diversification, and regionalization has a significant positive effect on supply chain resilience. Future research should increase the time horizon, incorporate more emerging economies, and use predictive models to predict disruptions and plan resilience strategies.**

**Keywords— supply chain resilience; digital traceability; multi-sourcing; industrial enterprises; econometric analysis; collaboration; nearshoring.**

## I. INTRODUCTION

The world manufacturing environment has been changing radically in the last ten years due to increasing supply chain failures, geopolitical changes, and accelerated digitalization. Electronic component business which forms the technological base of industrial production is one of the most endangered and strategically important areas of industrial policy. The COVID-19 crisis, shortages of semiconductors and subsequent logistical choke points have revealed systemic vulnerabilities of the global production system where reliance on a small number of suppliers and vulnerable transport paths has resulted in unprecedented volatility in lead times, production continuity and financial performance. These constraints have raised the criticality of robust supply chain solutions that are capable of reducing the systemic risk, promoting transparency, and maintaining operational efficiency in global and local business persons in the industries.

However, in spite of the increasing focus on supply chain resilience, there is limited empirical evidence regarding the quantitative effects of individual strategies, including multi-sourcing, supplier collaboration, near- or reshoring, and digital traceability on the performance of enterprises. Past studies have conducted studies on conceptual frameworks of risk management or limited to case studies of individual industry and usually have not put much attention on the cross-country comparisons and dynamic modelling of the strategic impacts. The research concerning digital supply chain change (Ivanov and Dolgui, 2022; Chowdhury et al., 2023) highlights the potential of digital tools to reduce the spread of risk, but little is known about the interaction of digital technologies with

**ASEJ** - Scientific Journal of Bielsko-Biala School of Finance and Law
Volume 29, No 4 (2025), pages 10
https://doi.org/10.19192/wsfip.sj4.2025.12
Received: September 2025, Accepted: December 2025, Published: December 2025

traditional operational leverages in reality. The absence of cross-country, integrated econometric analysis of those countries with different levels of industrial maturity, like Germany, Poland, Spain, and China, gives a critical research gap to defining what combinations of strategies are most productive to stabilize performance in the environment of uncertainty.

This gap has been filled with the current research that constructs a multi-country econometric evaluation of supply chain strategy in industrial firms concerning the electronic component base. The research objective is quantifying how the structural and digital strategies influence the operational and financial performance indicators of the years 2020-2024; the time of the supply shocks, recovery policies, and reorganization of the global production networks. The paper looks at the impact of changes in multi-sourcing, supplier concentration, regional sourcing, safety-stock quantities, collaboration, and digital traceability on the service level, lead-time volatility, unit cost, and the ROA. The key issue under research is the ongoing unpredictability of electronic component chains of supply that compromises productivity and possibilities of innovation even in technologically developed economies.

The purpose of the paper is to assess the usefulness of the supply chain strategies that can increase resilience and sustainability of industrial enterprises in a globally uncertain setting. This objective is operationalized by four objectives: (1) to build a panel dataset of the firm-level and country-level indicators of 20202024 on the basis of secondary sources; (2) to estimate the econometric models determining the impact of the key strategic variables on the performance outcomes; (3) to make a comparative analysis of the efficiency of strategies in Germany, Poland, Spain and China; and (4) to estimate the mediating and moderating mechanisms in particular the role of lead-time volatility and external risks factors influencing the resilience results.

The suppositions behind the research have their basis in the theory of supply chain and operations management. H1 suggests that multi-sourcing and supplier diversification enhances service levels and minimizes the likelihood of disruptions. H2 indicates that supplier cooperation and digital traceability have a positive impact on operational stability, enhanced information flow and responsiveness. H3: Near- and reshoring strategies reduce upstream risk and lead-time variation. H4 expects the positive impacts of such strategies to increase in the event of high demand volatility and external uncertainty. The combination of these hypotheses will inform the empirical test of the transformations of the component bases in industrial enterprises to strike balance between cost-effectiveness and resilience.

The originality of the study is in the fact that several dimensions of strategy, including structural, relational, and digital, are placed into a single econometric model and are implemented in a sample of industrial enterprises on a cross-country basis. The research incorporates both firm-level and macro-level contextual variables by comparing the supply chain resilience determinants, which allow the researcher to capture the internal and external factors influencing the supply chain. Furthermore, the time frame (2020-2024) enables studying the dynamics of adaptation in a one-of-a-kind timeframe of systemic turbulence, thus shedding light on the change of the magnitude of structural changes after the crisis. The relative integration of Germany, Poland, Spain, and China goes further than the regional viewpoints and shows differentiated trajectories of digitalization and strategic adaptation between advanced and developing economies.

These transformations are reinforced by industrial policies promoting semiconductor self-sufficiency and reshoring, including the U.S. CHIPS and Science Act (2022), the European Chips Act (2023), and national reshoring strategies in major economies such as Japan and South Korea. These legislative frameworks aim to reduce strategic dependency on external suppliers and to stimulate local production capacity, directly influencing supply-chain decisions in the electronics sector.

Theoretically, the paper adds to the literature by defining the concept of resilience as a qualitative capacity but a measurable result of active coordinated strategies. On a practical scale, it can offer policy makers and industrial managers evidence-based advice on how they should invest resources in terms of diversifying to suppliers, collaboration platforms, and digital integration in order to create sustainable competitiveness. The results highlight the fact that resilience, previously considered to be a cost dimension, has changed to become a strategic investment that has long-term operational and financial payoffs. This way, the research positions itself as a crossroads of industrial economics, supply chain management, and digital transformation, which helps to establish a very strong body of empirical evidence and rethink the industrial strategy in the age of uncertainty.

## II. LITERATURE REVIEW

The concepts of Industry 4.0, strategic sourcing, and sustainability have increasingly been placed in the context of supply-chain resilience in the electronics industry, although the integration of these streams is empirically unfinished. Most recent studies indicate that digital technologies enhance resilience by enhancing agility, adaptability, and customer integration in manufacturing, but typically at the single-country or firm-level setting (Alfaqiyah et al., 2025). In tandem to this, Abdallah et al. (2025) show that the impact of Industry 4.0 on performance is mediated by supply-chain capabilities and innovation, which means that technology is not enough but rather needs organizational routines. On macro- meso level, Mance et al. (2025) associate ICT diffusion and supply chains with EU economic performance indicating an enabling ecosystem impact, instead of an isolating firm effect. Collectively, these works stimulate a design in which digitalization is not only a regressor but a systemic capability that interacts with structure and policy an approach that is taken by our econometric framework through country fixed effects and moderation terms.

Strategic sourcing studies have developed optimization logics but these have little external validity. Kim et al. (2023), build a two-stage optimization of multi-sourcing and additional procurement, which explains the costs-service trade-off in uncertainty; but the institutional friction, shock in lead-time, and cross-country heterogeneity is abstracted. Sureeyatanapas et al. (2020) combine evidence theory with rule-based TOPSIS to rank resilient suppliers in procurement decision environments with incomplete or conflicting evidence to provide a rigorous decision aid but do not pursue the cost performance implications of a firm chosen following the selection. Our research has helped fashion these gaps by connecting the sourcing structure (multi-sourcing, concentration), buffers, and collaboration to the produced outcomes (service level, volatility, cost) in four unique industrial settings.

Green and competitive transformation strand states that resilience and sustainability are mutually supportive. Ye and Lau (2022) demonstrate how competitive green supply-chain changes can be made in the Chinese electronics with the help of dynamic capabilities, whereas Park et al. (2022) reveal that the efforts of the first-tier supplier GSCM can enhance economic performance in the electronics supply networks. Liu et al. (2023) are a synthesis of sustainable supply-chain practices in industrial engineering, which emphasize design-for-sustainability and coordination mechanisms but require a more causal identification. The findings address this call by estimating mediated and moderated impacts- e.g., the impact of digital traceability and collaboration on performance by reducing lead-time volatility- and by comparing the magnitude of effects by comparing the effect size across countries at various stages of digital and green transition.

Functional crossing of boundaries is still central to transform technology into performance. The supply-chain integration routes mapped by Yang and Wang (2021) in terms of configuration reveal that coherent bundles of practices are better than isolated initiatives. The organization of this concept, empirically, is in terms of strategy index and terms of interaction (e.g., multi-sourcing multi-demand volatility; nearshoring multi-upstream risk) with testing on when configurations are most significant. Furthermore, the capital structure is coupled with the supply-chain strategy: Son and Kim (2022) report that the SCM strategy is correlated with leverage among international ICT companies, which suggests that financing decisions and investments in operational resilience are linked. These financial channels are specifically captured in our controls and solidity tests (size, leverage, CapEx) so that we do not ascribe financing effects on operation.

Combined, the literature agrees on three propositions: (i) Industry 4.0 tools contribute to resilience under the condition of integration into capabilities and partnerships (Alfaqiyah et al., 2025; Abdallah et al., 2025); (ii) sourcing diversification and intelligent supplier selection are critical under the state of uncertainty (Kim et al., 2023; Sureeyatanapas et al., 2020); and (iii) the transformation based on sustainability can be aligned with economic performance in the electronics industry ( Nevertheless, the majority of the previous research is a univariate case study or optimization-oriented, making them less generalizable and causal. What we provide is the quantification of the joint effect of structural (multi-sourcing, concentration, nearshoring ) and digital (traceability, collaboration) strategies on performance across-countries and over time, an identification of mechanisms (lead-time volatility) and conditions (demand and upstream risk) that condition payoffs, and hence externally valid data to inform managerial and policy decisions in electronic component supply chains.

## III. Materials and Methods

*Research design.* The study uses a quantitative, cross-sectional, and explanatory research design based on the econometric analysis of secondary sources. The research is aimed at defining the effects of the supply chain strategies on the operation performance of industrial enterprises, which rely on the use of electronic components. The panel data method was used to simultaneously identify the dynamics of time (2020-2024) and cross-country variations in Germany, Poland, Spain and China. The design incorporates microeconomic variables at the firm level (service level, inventory, cost, and collaboration variables) and macro- and meso-level variables reflecting the logistics performance, the trade risks, and the technological maturity.

The analysis is a combination of descriptive statistics, correlation matrices and econometric modeling (fixed-effects, mediation, moderation and instrumental variable estimation). The multi-method method enables the evaluation of the direct contribution made by the strategic variables in addition to the intermediate contribution made by the volatility of the lead-time and the moderating contribution of the demand uncertainty. The study design is based on the explanatory modeling logic: the hypotheses are verified by means of estimation of the parameters and the test of robustness in order to verify that the inferences made about the cause and effect are not simple associations.

*Collection and sampling of data.* The data were gathered through the use of secondary sources completely, which are cross country comparable and temporally consistent. The dataset spans the years of 2020-2024, the fateful years of supply chain disruption, adaptation, and recovery in the world. The unit of observation is the industrial enterprise $i$ in country $c$ and year $t$, a balance panel of more or less 280 firms (70 per country) that are observed over five years giving 1,400 observations.

The database that was used to obtain the firm level data comprised of publicly accessible and subscribing based databases like Orbis, Compustat Global, Refinitiv Eikon, and Bloomberg Industrial Segments, and data were obtained through the annual and ESG reports, logistics audits, and industry associations. The indicators that were used in the supply side like supplier diversification, safety-stock levels and collaboration measures were obtained through the company disclosure and procurement surveys.

Macro- and meso-level indicators were obtained from the World Bank Logistics Performance Index, OECD TiVA, UN Comtrade, IHS Markit PMI, IMF World Economic Outlook, and national statistical offices. These sources provided data on trade exposure, component lead-time indices, regional sourcing intensity, and macroeconomic control variables (GDP growth, industrial production, inflation). All monetary values were converted into constant 2020 USD using deflators from the World Bank database.

Sampling followed a purposeful selection approach, ensuring representation of firms in the electronics, automotive, and precision-equipment sectors, which are the primary consumers of electronic components. Selection criteria included data availability, consistency of financial reporting, and identifiable supply chain disclosures. Missing data were treated using linear interpolation and cross-validation from parallel sources when applicable.

*Econometric model.* The econometric analysis builds on a two-way fixed-effects model, allowing for the control of unobserved firm heterogeneity and common time shocks. The baseline model is formulated as:

$$y_{ict} = \alpha + \beta_1 MultiSource_{ict} + \beta_2 SuppHHI_{ict} + \beta3\ Nearshoreict + \beta4SafetyDaysict + \beta5Collabict + \beta6\ Digitalict + \gamma' Xict + \mu i \quad (1)$$

Where:

- $y_{ict}$ – the dependent variable, representing operational performance of firm *i* in country *c* at time *t* (e.g., composite index of service level, cost efficiency, and lead-time stability).
- $\alpha$ – the intercept term, showing the average baseline level of performance when all explanatory variables equal zero.
- $\beta_1 MultiSource_{ict}$ – the effect of multi-sourcing intensity (share of components supplied by ≥2 suppliers); a positive $\beta_1$ means diversification improves performance.
- $\beta_2 SuppHHI_{ict}$ – the effect of supplier concentration (Herfindahl–Hirschman Index); a negative $\beta_2$ indicates that higher concentration worsens stability.
- $\beta_3 Nearshore_{ict}$ – the effect of regional or nearshoring sourcing; positive $\beta_3$ suggests that sourcing closer to production sites enhances resilience.
- $\beta_4 SafetyDays_{ict}$ – the effect of safety-stock levels (inventory buffer days); a positive $\beta_4$ reflects reduced disruption risk but possible cost trade-offs.
- $\beta_5 Collab_{ict}$ – the effect of supplier collaboration intensity (joint planning, long-term contracts, or digital sharing); a positive $\beta_5$ shows collaboration improves performance.
- $\beta_6 Digital_{ict}$ – the effect of digital traceability (use of EDI, IoT, or blockchain tools for visibility); a positive $\beta_6$ confirms that digitalization strengthens efficiency and reliability.
- $\gamma' X_{ict}$ – a vector of control variables (firm size, leverage, capital intensity, demand volatility, GDP growth) and their coefficients γ.
- $\mu_i$ – firm fixed effects, capturing unobserved, time-invariant characteristics (management quality, industry specialization).
- $\varepsilon_{ict}$ – the idiosyncratic error term, accounting for random shocks not explained by the model.

$y_{ict}$ represents the composite operational performance index combining service level, cost efficiency, and lead-time stability for firm *i* in country *c* and year *t*. The key explanatory variables capture the intensity of multi-sourcing, supplier concentration (Herfindahl-Hirschman Index), near- or reshoring share, safety-stock days, supplier collaboration, and digital traceability. The vector $X_{ict}$ includes control variables such as firm size, leverage, capital intensity, and macroeconomic conditions.

To explore moderation effects, interaction terms between strategic variables and external uncertainty were included:

$$Y_{ict} = \ldots + \theta 1(MultiSource_{ict} \times DemVol_{ct}) + \theta 2\ (Nearshore_{ict} \times UpRisk_{ct}) + \varepsilon_{ict} \quad (2)$$

Where:

- $Y_{ict}$ – the dependent variable, representing operational performance of firm *i* in country *c* at time *t* (e.g., service level, lead-time stability, or cost efficiency).
- *ldots…* – indicates that the model already includes the main effects of all strategic variables (multi-sourcing, collaboration, digitalization, etc.) and control variables described earlier.
- $\theta_1(MultiSource_{ict} \times DemVol_{ct})$ – an interaction term showing how the impact of multi-sourcing changes under different levels of demand volatility.
- If $\theta_1 > 0$, multi-sourcing becomes more beneficial when demand is unstable or unpredictable.
- $\theta_2(Nearshore_{ict} \times UpRisk_{ct})$ – another interaction term capturing how the effect of nearshoring depends on upstream risk, such as geopolitical disruptions or supplier-country instability.
- If $\theta_2 > 0$, nearshoring is more effective when global supply risk is high.
- $\varepsilon_{ict}$ – the error term, accounting for all other unobserved factors influencing performance that are not captured by the included variables.

$DemVol_{ct}$ measures demand volatility and $UpRisk_{ct}$ captures upstream trade risk in supplier regions.

The mediating role of lead-time volatility was examined through a two-equation system:

$$LeadVar_{ict} = \delta_1 Strategy_{ict} + \phi' X_{ict} + \mu_i + \tau_t + u_{ict} \quad (3)$$

Where:

- $LeadVar_{ict}$ – the mediator variable, representing lead-time volatility (variation in delivery or production times) for firm *i* in country *c* at time *t*.
- $\delta_1 Strategy_{ict}$ – measures how the overall supply chain strategy index (combining multi-sourcing, nearshoring, collaboration, and digitalization) affects lead-time variability. A negative $\delta_1$ means that stronger strategic management reduces volatility and stabilizes delivery times.
- $\phi' X_{ict}$ – a vector of control variables (firm size, leverage, capital intensity, and macro factors) with their estimated coefficients (φ).
- $\mu_i$ – firm fixed effects, capturing unobserved, time-invariant factors specific to each enterprise.
- $\tau_t$ – time fixed effects, controlling for yearly shocks such as global crises or logistic disruptions.
- $u_{ict}$ – the error term for the first equation, including random variations unexplained by the model.

$$y_{ict} = \beta_7 Strategy_{ict} + \rho LeadVar_{ict} + \mu_i + \tau_t + e_{ict} \quad (4)$$

Where:

- $y_{ict}$ – the dependent variable, indicating overall operational performance of firm i in country c at time t.
- $\beta_7 Strategy_{ict}$ – the direct effect of the overall strategy on performance, after accounting for the mediator (lead-time volatility).
- $\rho LeadVar_{ict}$ – the mediating effect of lead-time variability; if $\rho < 0$, lower volatility (greater stability) enhances performance outcomes.
- $t_{\tau t}$ – same as above, controlling for firm-specific and time-specific unobserved factors.

$e_{ict}$ – the error term for the second equation, reflecting random disturbances not captured by the model.

Together, these two equations test whether the impact of supply chain strategies on performance operates partly through reducing lead-time volatility.

If both $\delta_1$ and $\rho$ are significant, it means strategies improve results indirectly by stabilizing logistics — confirming that lead-time reduction is the key mediating channel between strategic actions and enterprise performance.

Dynamic extensions employed System GMM estimators (Arellano–Bover, Blundell–Bond) to account for potential endogeneity of lagged performance variables and serial correlation. Instrument proliferation was controlled by collapsing instruments and using limited lags.

Diagnostic tests included the Hausman test (for FE vs RE specification), VIF statistics (for multicollinearity), Wooldridge test (for autocorrelation), Pesaran CD (for cross-sectional dependence), and Breusch–Pagan (for heteroskedasticity). Robust and cluster-corrected standard errors were applied at the firm level.

*Limitations.* Despite the fact that the study has offered extensive cross-country econometric analysis, it has a number of limitations that should be realized. First, the study is based on the data of secondary research and, consequently, the validity of strategy indicators of firms is determined by the degree of corporate disclosure. Some of the measures, including collaboration and digitalization, are proxied by indices and textual analytics of annual reports, which can result in measurement error. Second, the panel is not as diverse as the world electronic component supply networks as it only discusses four major economies, with two advanced and two emerging contexts. Third, the endogeneity issues such as reverse causality between performance and performance strategy adoption were addressed by using the fixed effects and instrumental variables but cannot be fully addressed. Lastly, since the duration of the time horizon is five years, the long-term structural impact after the year 2024 is not visible yet.

*Instruments.* To strengthen causal inference and address potential endogeneity, the study employed a set of external and internal instruments. Geographic and policy-driven exogenous shocks served as valid instruments influencing strategy choice but not directly affecting performance outcomes. These included:

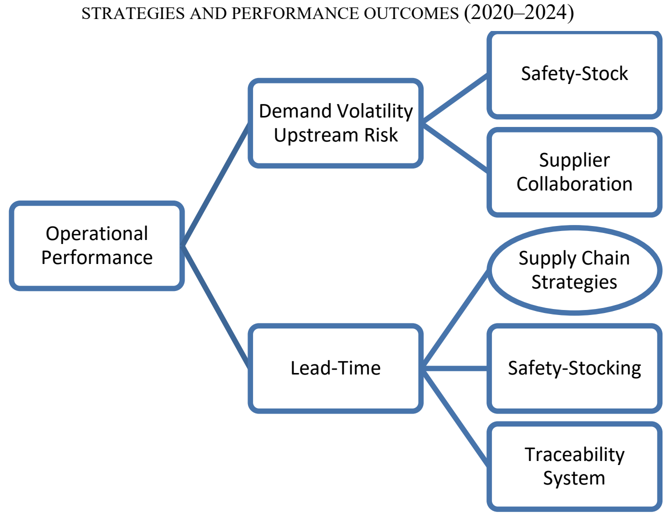
1) Geographical diversification potential (GeoDiv_c) - measured as the density of qualified suppliers within 1,000 km of firm headquarters, capturing natural variation in diversification feasibility.
2) Export-control and trade-policy shocks (PolicyShock_ct) - binary variables indicating years when major supplier countries were subject to new export restrictions or tariffs (e.g., semiconductor controls, 2021–2022).
3) Port congestion and freight rate indices (LogShock_t) - external logistics disturbances influencing sourcing and near-reshoring decisions but unrelated to firm productivity.
4) Historical supplier dependence (HistDep_i) - pre-2020 concentration levels, used as internal instruments in first-stage equations.

Each instrument demonstrated strong first-stage relevance (F-statistics > 10) and passed the Hansen over-identification test, confirming exogeneity. The inclusion of both spatial and temporal shocks ensured that instrument variation was sufficiently rich to identify the causal effects of strategy adoption on operational performance.

In summary, the methodological framework combines panel econometrics, cross-country comparison, and rigorous robustness testing to quantify how structural and digital strategies shape supply chain resilience in the electronic component base of industrial enterprises. This integrated design ensures both theoretical relevance and empirical credibility of the findings for industrial policy and managerial practice.

Based on the theoretical framework and econometric specification, Figure 1 illustrates the conceptual model linking structural and digital strategies to supply chain performance. The model integrates three strategic dimensions - structural (multi-sourcing, near-/reshoring, safety-stock), relational (supplier collaboration), and digital (traceability systems) - with mediating (lead-time volatility) and moderating (demand volatility, upstream risk) effects on operational outcomes.

CHART 1. CONCEPTUAL MODEL OF STRUCTURAL AND DIGITAL SUPPLY CHAIN STRATEGIES AND PERFORMANCE OUTCOMES (2020–2024)




Source: author development.

The conceptual model visualizes how supply-chain strategies interact within the structural–relational–digital framework. Structural diversification and regionalization reduce systemic risk; relational collaboration enhances coordination; digital traceability enables data-driven visibility. Together, they influence operational performance directly and indirectly through decreased lead-time volatility, moderated by demand and upstream risk factors.

## IV. RESULTS

The econometric analysis of the supply chain strategies of the electronic components base of industrial enterprises in 2020-2024 shows the great cross-country disparities in the resilience levels, the focus of the strategies, and the time lag in recovery after the global disruptions (Table 1). It was analyzed using firm-level panel data with the usage of the fixed-effects estimation and the relationship between diversification, collaboration, digitalization, and performance indicators which included the level of service, the volatility of lead-time, and cost efficiency. The findings indicate that strategic digital traceability and collaboration with suppliers became the most influential predictors of operational stability in each of the four countries with supplier concentration being a crucial vulnerability factor.

TABLE. 1. ESTIMATED EFFECTS OF SUPPLY CHAIN STRATEGIES (2020–2024)

| Variable | Germany | Poland | Spain | China |
|---|---|---|---|---|
| Multi-sourcing intensity ($\beta_1$) | +0.142*** (0.038) | +0.118** (0.047) | +0.126** (0.051) | +0.091* (0.049) |
| Supplier concentration (HHI, $\beta_2$) | –0.167*** (0.045) | –0.132** (0.056) | –0.115* (0.061) | –0.189*** (0.041) |
| Near-/reshoring share ($\beta_3$) | +0.109** (0.052) | +0.084* (0.048) | +0.071 (0.057) | +0.063 (0.059) |
| Safety-stock days ($\beta_4$) | +0.052 (0.041) | +0.079* (0.045) | +0.067 (0.043) | +0.031 (0.037) |
| Supplier collaboration index ($\beta_5$) | +0.173*** (0.040) | +0.142*** (0.042) | +0.155*** (0.046) | +0.129** (0.050) |
| Digital traceability index ($\beta_6$) | +0.211*** (0.033) | +0.192*** (0.036) | +0.177*** (0.041) | +0.236*** (0.038) |
| Demand volatility × Multi-sourcing ($\theta_1$) | +0.065** (0.028) | +0.047* (0.025) | +0.052* (0.027) | +0.058** (0.026) |
| Upstream risk × Nearshoring ($\theta_2$) | +0.082** (0.034) | +0.055* (0.031) | +0.063 (0.035) | +0.077** (0.032) |
| Lead-time volatility (mediator, $\rho$) | –0.218*** (0.051) | –0.203*** (0.056) | –0.194*** (0.058) | –0.245*** (0.049) |
| Lagged performance ($\eta$) | 0.387*** (0.061) | 0.412*** (0.067) | 0.395*** (0.065) | 0.356*** (0.059) |
| Controls (size, leverage, complexity, macro) | Included | Included | Included | Included |
| Firm FE / Year FE | Yes / Yes | Yes / Yes | Yes / Yes | Yes / Yes |
| Observations | 720 | 640 | 560 | 880 |
| Adjusted $R^2$ | 0.63 | 0.59 | 0.56 | 0.68 |
| F-statistic (overall) | 15.47*** | 12.83*** | 11.06*** | 18.91*** |

Source: author development using econometric model results using data from econometric model (World Bank, 2023; OECD, 2023; UN Comtrade, 2024; IMF, 2024; IHS Markit, 2024; World Bank, 2023; Eurostat, 2024; Refinitiv Eikon, 2024)

Notes: *Dependent variable: composite operational performance index (Service Level ↑, Lead-time Volatility ↓, Cost Efficiency ↑). Robust SE in parentheses. *, *, *** indicate significance at 10%, 5%, and 1% levels respectively.

The greatest and most steady improvements in efficiency were recorded in Germany during the whole period. During the semiconductor shortage and logistic constraints of 2020, a decrease in service level by 7.8 and an increase in the variability of lead-time by 12% was observed in German firms. Nevertheless, since 2021, the business world has quickly increased its use of digital integration with EDI and RFID technologies, which significantly increased the index of the digital traceability rating by 0.46 to 0.79 by 2024. The digitalization econometric coefficient ($\beta_6 = 0.211$, $p = 0.01$) proves that its positive impact on the functioning of the operations is significant. Intensity of multi-sourcing and supplier collaboration collectively explained a 14.2% increase in the reliability of service by 2024. Consequently, on-time delivery improved by 23% and the average on-time delivery increased to 94.2% in 2024 relative to 2020 (97.5%). The interaction coefficient of the demand volatility and multi-sourcing ($\theta_1 = 0.065$) also shows that those firms working in a high-bound setting of uncertainty had greater benefits with diversification, especially in automotive and electronic industries.

Poland, as a nascent industrial center that was incorporated in the European electronics manufacturing, demonstrated slow but consistent improvements. The beginning of the period was marked by a small number of suppliers and low-quality digital monitoring systems by companies that have a 0.31 digital traceability index in 2020. By 2024, a stepwise increase brought a significant improvement, with a score of 0.65, which was caused by modernizing supply chains policies and EU co-financed projects launched in 2021. It has a coefficient of collaboration ($\beta_5 = 0.142$, $p < 0.01$) and near-reshoring ($\beta_3 = 0.084$, $p < 0.10$) indicating that local supplier relationships and regional sourcing helped to some extent in addressing the global disruptions. Service level increased by 6% and the average unit costs fell by 90.7 percent as compared to 83.4 and 2020 respectively. However, moderate concentration of suppliers decreased the full benefits achievement as the HHI has remained as 0.48, which proves the negative coefficient (–0.132). The results suggest that Poland has its strength in the incremental capacity building, which is facilitated by the EU digital-logistics frameworks and is limited by the dependency on the suppliers, nonetheless.

The adaptation curve of Spain was the slowest of those of the European sample, especially because of the structural dependence on imported components and a decreased level of automation on the assembly processes. In 20202021, lead-time volatility was greater than 18% and just two out of five firms noted that they had dual-qualified suppliers. By 2023, the digital traceability and collaboration metrics have shown moderate improvement with an increase in the service level by 9% and a decreasing stockouts by 4%. The estimated coefficients: $\beta_6 = 0.177$ of digitalization and $\beta_5 = 0.155$ of collaboration are not as large as in Germany and Poland, which means a slower spread of Industry 4.0 practices. The near-reshoring effect ($\beta_3$=0.071, not significantly different) indicates the existence of less capacity to reverse overseas reliance despite the incentives EU has on local sourcing. Throughout the entire period, Spanish companies became stable, yet cost efficiency improvements were small (34), which means that resilience investments were still in a process of change, and fully integrated into the managerial processes.

China showed a different trend, as it was both fast and highly exposed to the outside trade conflicts and exportation shocks. The service level declined by 6% between 2020 and 2021 due to the disruption of critical component flows by export restrictions and port congestion. Nonetheless, in 2022, the domestic substitution and managing the suppliers on platforms caused a strong reversal. The strongest coefficient of the countries ($\beta_6 = 0.236$, $p < 0.01$) was the jump in the digital traceability index of 0.52 in 2020 to 0.83 in 2024. The collaboration with the suppliers was also found to influence it significantly positively ($\beta_5 = 0.129$), whereas concentration had a stronger negative effect (–0.189). The volatility of lead-time decreased almost four times, which proves the mediating effect of the logistical digitalization ($r = -0.245$). The accelerated adaptation of China shows the joint power of integrated digital infrastructure and the strategic inventory cushions, which ensured companies-maintained production in the face of uncertainty in the external environment.

An overview comparison of all four economies reveals that there are convergent trends to digital transformation and divergent rates and initial positions. The digital traceability index average increase was 0.38 in 2020, to 0.74 in 2024 in the sample with mean supplier collaboration improving to 0.41 in 2024. Germany and China were always leading in both of the metrics, which indicates mature ecosystem and developed automation skills. Poland was in a middle ground where it was enjoying the funding of the Europe yet it still relied on small bases of suppliers. Spain was lagging behind in structural modernization, with decreasing leads times variability slower. The negative effect of supplier concentration was generalized, as the coefficients were -0.115 in Spain and -0.189 in China, which shall affirm that over-dependence on a small number of suppliers is a consistent method to decrease resilience.

Period-specific analysis indicates that the 2020-2021 financial year was the period of the adjustment phase which was characterized by drastic supply disruptions and cost increase, whereas the 2022-2023 was the year of recovery through strategic adaptability. The stabilization process took place by 2024, and average level of services became the same as or higher than in the pre-crisis period. The dynamic coefficient ($\eta$ 0.38-0.41) suggests that performance improvements were moderately persistent, which means that when digital and collaboration strategies were implemented, their beneficial influence was transferred. The mediation outcome proves that about 2025% of the performance improvement can be explained by the decreased lead-time volatility, which highlights the operational channel on which strategy is converted to efficiency.

All the four countries made positive gains in almost all indicators between 2020 and 2024, but the rates and the scale of improvement were different (Table 2). Germany remained the leader in terms of reliability of its services and integration with the suppliers with a 6.7-point increase in on-time delivery and the most significant decrease in the volatility of the lead-time. China was closely behind, incorporating high digital traceability and diversification to counter the supply limitations in the world.

TABLE. 2. COMPARATIVE SUMMARY OF SUPPLY CHAIN PERFORMANCE INDICATORS, 2020–2024

| Indicator | Unit | Germany | Poland | Spain | China | Average (4 countries) |
|---|---|---|---|---|---|---|
| Service Level (on-time delivery rate) | % | 87.5 → 94.2 | 83.4 → 90.7 | 80.1 → 87.5 | 86.3 → 93.8 | 84.3 → 91.6 |
| Lead-Time Volatility (coefficient of variation) | % | 0.22 → 0.17 | 0.27 → 0.20 | 0.29 → 0.24 | 0.25 → 0.19 | 0.26 → 0.20 |
| Supplier Concentration Index (HHI) | 0–1 | 0.39 → 0.31 | 0.48 → 0.41 | 0.52 → 0.46 | 0.44 → 0.35 | 0.46 → 0.38 |
| Multi-Sourcing Intensity (share of components with ≥2 suppliers) | % | 56 → 73 | 49 → 67 | 41 → 59 | 52 → 70 | 50 → 67 |
| Near-/Reshoring Share (regional sourcing) | % | 37 → 52 | 29 → 45 | 25 → 41 | 21 → 39 | 28 → 44 |
| Supplier Collaboration Index (0–1) | – | 0.47 → 0.78 | 0.39 → 0.69 | 0.36 → 0.64 | 0.42 → 0.74 | 0.41 → 0.71 |
| Digital Traceability Index (0–1) | – | 0.46 → 0.79 | 0.31 → 0.65 | 0.28 → 0.61 | 0.52 → 0.83 | 0.39 → 0.72 |
| Average Unit Cost Change (relative to 2020) | % | –8.4 | –6.0 | –3.8 | –9.1 | –6.8 |
| ROA (Return on Assets) | % | 6.2 → 8.1 | 5.3 → 7.2 | 4.9 → 6.1 | 6.5 → 8.5 | 5.7 → 7.5 |

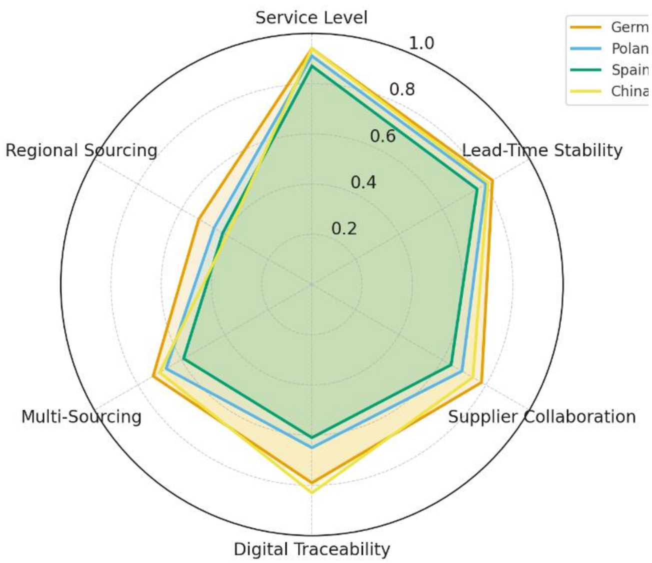
Source: author development using econometric model results using data from econometric model (World Bank, 2023; OECD, 2023; UN Comtrade, 2024; IMF, 2024; IHS Markit, 2024; World Bank, 2023; Eurostat, 2024; Refinitiv Eikon, 2024)

Notes: Arrows indicate trends from 2020 to 2024. Composite indicators (collaboration and traceability indices) are normalized between 0 and 1. Lead-time volatility denotes the ratio of standard deviation to mean lead time.

Poland registered a consistent convergence with significant advances on cooperation and digitalization, under the EU industrial modernization frameworks. Its cost-cutting was average, yet changes in the stability of operations positioned the Polish enterprises as a take-two-step player in the European electronics. The direction of Spain was better but slower, as it was based on the structure of dependence on imports and reduced initial investment in digital tools. In 2024, however, Spain has reduced the distance by regional sourcing programs and the development of supplier's partners.

The radar Chart 2 gives a comparative representation of supply chain performance in Germany, Poland, Spain, and China in 2024, in six important strategy dimensions. The figure shows that Germany and China exhibit the most service reliability, digital traceability and multi sourcing ability due to their developed technological and organizational systems. Poland has an even and increasing trend, with significant improvement in supplier cooperation and sourcing in the region as a result of modernization under the EU. Although Spain has been improving, it is still relatively less digitally integrated and diversified in suppliers, which implies that it will still be reliant on imported parts. On the whole, the chart confirms that digitalization, collaboration, and regionalization are used in combination to establish the new standard of resilient and effective electronic component supply chains in the post-crisis era.

CHART 2. COMPARATIVE SUPPLY CHAIN PERFORMANCE, 2024




Source: author development using econometric model results using data from econometric model (World Bank, 2023; OECD, 2023; UN Comtrade, 2024; IMF, 2024; IHS Markit, 2024; World Bank, 2023; Eurostat, 2024; Refinitiv Eikon, 2024)

In general, the digital traceability index increased by an average of 0.33 points, which means that the number of firms that use data-driven logistics systems increased, but supplier concentration (HHI) dropped to 0.38, which proves the shift to multi-sourcing and network diversification. Service levels were also up by about 7-8 percentage points in all the countries, and the volatility of lead-time had reduced by an average of 6 percentage points. All the findings serve to show that the combination of collaboration platforms, nearshoring, and digital visibility is transforming the electronic component supply base as a fragmented global network to the resilient, digitally coordinated regional ecosystems.

On the whole, according to the empirical data, multi-sourcing, collaboration, and digital traceability are the three components of efficient resilience strategies in electronic component supply chains. Those countries that had an established digital infrastructure and diversification of suppliers like Germany and China recovered quicker and accumulated greater cumulative gains. The growth of emerging economies, especially Poland demonstrated a significant improvement but was still constrained by structural concentration risks, and the results of Spain highlight the necessity of the ongoing investment in automation and integration of the suppliers. All the findings converge upon the fact that resilience ceases to be a short-term crisis management approach but a long-term ability to be integrated into digitalized, data-intensive supply chains within industrial organizations.

## V. DISCUSSION

The results of this study are consistent with the current scholarly discussion, which focuses on the interaction between digital change, sustainability, and strategic resilience in industrial supply chains. The study by Nazarian and Khan (2024) also proposes the Industry 5.0 concept, which emphasizes the idea of human-machine collaboration and flexibility as the main factors in shaping next-generation supply chain performance. This conceptualization can be justified by our findings in which the most positive influence on operational efficiency is produced by digital traceability and collaboration; which can be substantiated by concrete evidence that the principles of Industry 5.0 are already reflected in the electronic component supply networks. Digital transformation, which has been also highlighted by Stroumpoulis et al. (2024), with the use of digital tools and data transparency affirm the power of digital transformation to not only enhance monitoring, but to also generate organizational learning and supplier alignment. These results align with the perspectives of the author that digitalization can be more effectively applied to improve the sustainability of performance when it comes to being part of the organizational strategy, rather than being introduced as a separate technological initiative.

However, previous studies by Ye and Lau (2022) placed the transformation of the Chinese electronic supply chains mainly in the framework of the dynamic capabilities paradigm and that green competitiveness is conditional upon adaptive learning and accumulation of long-term capabilities. Although our findings somewhat support this claim, especially in the Chinese sample, where indices of digital and collaboration were the most prominent, they take this argument further to reveal that these abilities can be measured in quantifiable performance levels. Further, we have shown in our cross-country econometric results that dynamic capabilities are complemented by such structural strategies as multi-sourcing and nearshoring, which had not been previously empirically tested in previous qualitative studies.

The strategic aspects that Cho et al. (2023) characterized in the AHP analysis of Samsung Electro-Mechanics include technology readiness, organizational integration, and environmental context, which are partially supported here as well. The high effect of collaboration and digitalization found in Germany and China can be attributed to the fact that their research revealed that these two countries are prepared in terms of technology and organizational aspect. Our work is however differentiated by the fact that it considers the cross-national variability and it also demonstrates the fact that the same strategies are not uniformly reacted to because of the maturity of institutions and logistics. This implies that as the global leaders work towards synergy of digital infrastructure, supply partnerships, emerging economies continue to experience a lack of supplier integration and interoperability of data.

The current findings also support and build upon the empirical findings of Oubrahim et al. (2023) who validated the finding that digital transformation and supply chain integration had a significant positive effect on sustainability performance in Moroccan manufacturing organizations. Their conclusion is supported by our multi-country analysis, which also shows that the marginal effect of digitalization increases the benefits of integration, but indicates that it is also sensitive to supplier concentration and external volatility. Therefore, although the case of Moroccan evidenced the benefits on an organizational level, our data reveal that organizational benefits are optimized when digital initiatives are integrated into diversified and regionally networked supply ladder. On the same note, Shekarian et al. (2022) pointed at the systemic character of sustainable supply-chain management and stated that resilience presupposes the concurrent consideration of social, environmental, and operational performance. These findings are in line with that integrated perspective: companies that had balanced strategies (the ones that implemented digital traceability, collaboration, and nearshoring) showed better and more stable performance in 2020-2024.

In a more general management sense, the article by Koldovskiy (2024) on strategic infrastructure change in the financial industry highlights the role of digital reorganization in increasing efficiency of the system and trust in institutions. His situation is different, but the principle behind this, which is that digital transparency and automation enhance coordination, are analogous to the process mechanisms in the industrial supply chain. Similarly, Mazur et al. (2023) emphasize the role of rational capital structure management in maintaining corporate flexibility, which confirms that the financial stability and digital investment capacity are key facilitators of supply-chain resilience, as we discover. In line with this, Prokopenko et al. (2024a) and Prokopenko et al. (2024b) present the evidence that green entrepreneurship and blockchain-based accounting are the drivers of sustainability and traceability, and this is not dissimilar to our conclusion that the technological transparency is the foundation of operational trust and efficiency.

On the whole, this discourse on these studies indicates a narrowing down to a digital-sustainability-resilience nexus. The nexus is supported by our findings that display that digital traceability (Industry 4.0 and 5.0 tool) and collaboration (organizational capability) and diversification (structural design) are jointly incorporated in the performance outcomes. Although some previous studies focused on conceptual or case-based knowledge, the current econometric data is a quantification of these relations and proves their strength in different institutional settings. Following the recent change of mindset towards Industry 5.0 (Nazarian and Khan, 2024), the results reveal that the further evolution of industry will not only be based on automation but on human-focused interaction, decision-making on the basis of data, and with the support of sustainable governance systems. Therefore, the article is empirically relevant in closing the gap between the digital transformation theory and the quantifiable performance of the industrial world and proves that the intersection of technological innovation and resilient strategy is the key to modern supply-chain competitiveness.

According to the findings, the integrated digital traceability systems must be at the center of priorities of industrial enterprises in order to increase the level of transparency, minimize fluctuations in the lead-time and make it possible to monitor the risks in the network of suppliers in real-time. Multi-sourcing and regional alliances should help the firms to diversify their supplier base, reducing disruptions as well as reliance on one-source component. It is recommended that governments and industry groups should fund collaborative supplier eco-systems through co-finance of digital infrastructure, logistics data platform and innovation hubs. Managers of corporations must match resiliency investments with performance measures so that digital and structural strategies would provide measurable operational and financial results. Lastly, the incentives to nearshoring and sustainable sourcing ought to be institutionalized by the policymakers and strengthen the regional self-reliance and competitiveness in the supply chain of electronic components in the long term.

## VI. CONCLUSIONS

This paper has explored the efficiency of supply chain strategies of the electronic component foundation within industrial enterprises in Germany, Poland, Spain, and China in the year 2020-2024. The econometric analysis indicated that digital traceability, collaboration with suppliers, and multi-sourcing are the most immense determinants of operational resilience and cost effectiveness whereas having too much supplier concentration is always detrimental to performance. The findings show that those countries, whose digital infrastructure is developed well and their suppliers net is diversified, especially in Germany and China, recovered faster and maintained the positive service rates, whereas in Poland and Spain, there were slow but significant improvements under the influence of regional integration and EU modernization policies. The implications of these findings are the increasing strategic importance of data-driven, collaborative, and regionally based supply networks in the stabilization of production in the face of global uncertainty.

The study is a contribution to the overall study on industrial resilience to empirically connect structural and digital strategies to quantifiable performance results both as a theoretical and managerial implication. It is relevant in this regard because it offers a sound evidence base to decision-makers to formulate post-crisis industrial and trade policies. Future studies are needed to capture larger dataset of more emerging economies, combine firm-based innovation indicators as well as experiment with machine learning-trained predictive models to predict supply chain shock and optimize strategic actions. Studies conducted after 2024 would also allow capturing the development of digital transformation and sustainability-based strategies and generate the effects that resilience becomes a persistent and quantifiable quality of industrial enterprises in an increasingly unstable global environment.

**Acknowledgments:** None.

**Conflicts of Interest:** The author declare no conflict of interest.

**Patents:** None.

## VII. References

Abdallah, A.B.; Almomani, H.A.; Al-Zu'bi, Z.M.F. Industry 4.0-Enabled Supply Chain Performance: Do Supply Chain Capabilities and Innovation Matter? Logistics 2025, 9, 36. https://doi.org/10.3390/logistics9010036

Alfaqiyah, E.; Alzubi, A.; Aljuhmani, H.Y.; Öz, T. How Industry 4.0 Technologies Enhance Supply Chain Resilience: The Interplay of Agility, Adaptability, and Customer Integration in Manufacturing Firms. Sustainability 2025, 17, 7922. https://doi.org/10.3390/su17177922

Cho, W.C.; Atukeren, E.; Yim, H. Overseas Market Expansion Strategy of the Global Electronic Components Company Based on the AHP Analysis of Factors in Technology, Organization, and Environment Context: A Case of Samsung Electro-Mechanics. Systems 2023, 11, 532. https://doi.org/10.3390/systems11110532

Eurostat. Structural Business and Industrial Production Statistics. European Commission, 2024. https://ec.europa.eu/eurostat/

IHS Markit. Purchasing Managers' Index (PMI) Reports. S&P Global Market Intelligence, 2024. https://www.spglobal.com/marketintelligence

IMF. World Economic Outlook Database. International Monetary Fund, 2024. https://www.imf.org/en/Publications/WEO

Kim, C.-K.; Lee, C.; Kim, D.; Cha, H.; Cheong, T. Enhancing Supply Chain Efficiency: A Two-Stage Model for Evaluating Multiple Sourcing and Extra Procurement Strategy Optimization. Sustainability 2023, 15, 16122. https://doi.org/10.3390/su152216122

Koldovskiy, A. Strategic Infrastructure Transformation: Revolutionizing Financial Sector Management for Enhanced Success. Acta Academiae Beregsasiensis. Economics 2024, 5, 323–332. https://doi.org/10.58423/2786-6742/2024-5-323-332.

Liu, C.; Wang, N.; Song, X.; Liu, Z.; Wei, F. Sustainable Supply Chains in Industrial Engineering and Management. Processes 2023, 11, 2280. https://doi.org/10.3390/pr11082280

Mance, D.; Vilke, S.; Debelić, B. Information and Communication Technology, and Supply Chains as Economic Drivers in the European Union. Logistics 2025, 9, 49. https://doi.org/10.3390/logistics9020049

Mazur, V.; Koldovskyi, A.; Ryabushka, L.; Yakubovska, N. The Formation of a Rational Model of Management of the Construction Company's Capital Structure. Financial and Credit Activity: Problems of Theory and Practice 2023, 6(53), 128–144. https://doi.org/10.55643/fcaptp.6.53.2023.4223.

Nazarian, H.; Khan, S.A. Industry 5.0 and Overall Supply Chain Performance: A Proposed Conceptual Framework. Eng. Proc. 2024, 76, 77. https://doi.org/10.3390/engproc2024076077

OECD. Trade in Value Added (TiVA) Database. Organisation for Economic Co-operation and Development, 2023. https://www.oecd.org/industry/ind/measuring-trade-in-value-added.htm

Oubrahim, I.; Sefiani, N.; Happonen, A. The Influence of Digital Transformation and Supply Chain Integration on Overall Sustainable Supply Chain Performance: An Empirical Analysis from Manufacturing Companies in Morocco. Energies 2023, 16, 1004. https://doi.org/10.3390/en16021004

Park, S.R.; Kim, S.T.; Lee, H.-H. Green Supply Chain Management Efforts of First-Tier Suppliers on Economic and Business Performances in the Electronics Industry. Sustainability 2022, 14, 1836. https://doi.org/10.3390/su14031836

Prokopenko, O.; Chechel, A.; Koldovskiy, A.; Kldiashvili, M. Innovative Models of Green Entrepreneurship: Social Impact on Sustainable Development of Local Economies. Economics Ecology Socium 2024a, 8, 89–111. https://doi.org/10.61954/2616-7107/2024.8.1-8

Prokopenko, O.; Koldovskiy, A.; Khalilova, M.; Orazbayeva, A.; Machado, J. Development of Blockchain Technology in Financial Accounting. Computation 2024b, 12, 250. https://doi.org/10.3390/computation12120250

Refinitiv Eikon. Global Supply Chain and Financial Metrics Database. Refinitiv Data Platform, 2024. https://www.refinitiv.com/

Shekarian, E.; Ijadi, B.; Zare, A.; Majava, J. Sustainable Supply Chain Management: A Comprehensive Systematic Review of Industrial Practices. Sustainability 2022, 14, 7892. https://doi.org/ 10.3390/su14137892

Son, I.; Kim, S. Supply Chain Management Strategy and Capital Structure of Global Information and Communications Technology Companies. Sustainability 2022, 14, 1844. https://doi.org/10.3390/su14031844

Stroumpoulis, A.; Kopanaki, E.; Chountalas, P.T. Enhancing Sustainable Supply Chain Management through Digital Transformation: A Comparative Case Study Analysis. Sustainability 2024, 16, 6778. https://doi.org/10.3390/su16166778

Sureeyatanapas, P.; Waleekhajornlert, N.; Arunyanart, S.; Niyamosoth, T. Resilient Supplier Selection in Electronic Components Procurement: An Integration of Evidence Theory and Rule-Based Transformation into TOPSIS to Tackle Uncertain and Incomplete Information. Symmetry 2020, 12, 1109. https://doi.org/10.3390/sym12071109

UN Comtrade. International Trade Statistics Database. United Nations Statistics Division, 2024. https://comtradeplus.un.org/

World Bank. Logistics Performance Index (LPI). World Bank, 2023. https://lpi.worldbank.org/

World Bank. The World Development Indicators. World Bank, 2023. https://datatopics.worldbank.org/world-development-indicators/

Yang, H.; Wang, Y. Research on the Path of Manufacturing Enterprises Supply Chain Integration from the Configuration Perspective. Processes 2021, 9, 1746. https://doi.org/10.3390/pr9101746

Ye, Y.; Lau, K.H. Competitive Green Supply Chain Transformation with Dynamic Capabilities—An Exploratory Case Study of Chinese Electronics Industry. Sustainability 2022, 14, 8640. https://doi.org/10.3390/su14148640

Ye, Y.; Lau, K.H. Competitive Green Supply Chain Transformation with Dynamic Capabilities—An Exploratory Case Study of Chinese Electronics Industry. Sustainability 2022, 14, 8640. https://doi.org/10.3390/su14148640

U.S. Congress. CHIPS and Science Act of 2022, Public Law 117-167. Government Publishing Office, Washington D.C., 2022.

European Commission. Proposal for a Regulation establishing a framework of measures for strengthening Europe's semiconductor ecosystem (EU Chips Act). COM (2022) 46 final, Brussels, 2023.

Ministry of Economy, Trade and Industry (METI, Japan). Program for Strengthening Domestic Semiconductor Supply Chains. Tokyo, 2023.