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ЗМІСТ / CONTENTS

Ю. Новіков

Розроблення моделей стратегічного управління в умовах технологічних інновацій.....8

Yu. Novikov

Development of strategic management models under conditions of technological innovation.....8

Х. Белааз, Р. Хамруш, Р. Маджраб

Дослідження модернізації морських портів Алжиру

як чинника сприяння експортно-імпортним операціям16

K. Belaaze, R. Hamrouche, R. Majrab

A survey study on seaport modernising in Algeria

as a driver for facilitating export and import operations.....16

Ю. Чен

Механізми подолання міжвідомчих бар'єрів у процесі цифровізації

етнонаціональної політики: від «інформаційних силосів» до інтегрованого управління27

Yu. Chen

Mechanisms for overcoming departmental barriers in the digitalisation

of ethno-national policy: From “information silos” to integrated governance27

Д. Посашкова

Культурні детермінанти національних моделей менеджменту:

доцільність впровадження іноземних практик в українському IT-секторі43

D. Posashkova

Cultural determinants of national management models:

The feasibility of implementing foreign practices in the Ukrainian IT sector43

С. Домашенко

Міжнародний досвід застосування ШІ в законодавчому процесі як приклад для України58

S. Domashenko

International experience in the use of AI in the legislative process as an example for Ukraine58

A. Pavlenchuk, N. Tsizdyn

Statistical analysis methods in the management of enterprises' foreign economic activity69

А. Павленчик, Н. Ціздин

Методи статистичного аналізу в управлінні зовнішньоекономічною діяльністю підприємств69

Development of strategic management models under conditions of technological innovation

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Abstract. Technological innovation creates a coordination problem for enterprises because technological maturity, intellectual property protection, regulatory compliance, commercial feasibility, and scaling readiness evolve at different rates. Fragmented assessment can cause premature scaling, under-protection of knowledge, or continued investment in projects without a viable commercialisation route. The study aimed to develop a conceptual strategic decision model based on an integrated three-dimensional classification of innovation projects. A structured review of peer-reviewed research published in 2021-2026, content analysis of Ukrainian and international legal sources, conceptual modelling, comparative mapping, and descriptive analysis of Ukraine's Global Innovation Index (GII) profile for 2020-2025 were applied. The study operationalised three dimensions: scientific and technological fit (N), legal and standards readiness (L), and business readiness (B). These dimensions were measured through observable managerial indicators and a documented 0-4 evidence rubric, with normalised low, medium, and high bands. It developed a closed process model comprising signal detection, classification, strategic choice, implementation, and learning, with explicit inputs, outputs, gate conditions, and feedback. A conceptual Strategic Suitability Index was introduced to rank innovation projects by N, L, B, and integrated risk R without replacing net present value (NPV), internal rate of return (IRR), or mandatory compliance gates. Six illustrative N-L-B configurations were formulated to connect project profiles with investment, intellectual property, partnership, and scaling decisions. Legal mapping showed how innovation support rules affect B and R, while patent and international trade rules affect L, commercialisation options, and enforcement risk. The national index data were retained only as contextual evidence and were not treated as validation of the project-level model. The framework can support preliminary portfolio screening, identify evidence gaps, and coordinate research and development (R&D), legal, and commercial functions under uncertainty

Keywords: dynamic capabilities; intellectual property governance; commercialisation readiness; portfolio prioritisation; ecosystem orchestration; regulatory compliance

● INTRODUCTION

Technological innovation projects rarely progress synchronously across their technical, legal, and commercial trajectories. A prototype may be technically promising but unprotectable, non-compliant with target-market standards, unsupported by complementary assets, or unable to secure financing. Conversely, a legally protected technology may have insufficient customer value or scaling capacity. When these trajectories are assessed by separate organisational functions, the firm may optimise one dimension while

increasing total project risk. The managerial problem is therefore not merely how to select a novel technology, but how to coordinate evidence, rights, standards, capital, market access, and learning at successive decision gates.

The researchers O. Bradul & Y. Novikov (2025) addressed this fragmentation by proposing a three-dimensional classification that combines scientific and technological criteria, legal criteria, and entrepreneurial criteria. Their framework creates a common vocabulary for

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interdisciplinary assessment, but it remains primarily classificatory: it does not specify a reproducible scoring procedure, transition rules between stages, or the way in which a project profile should trigger portfolio, protection, and scaling decisions. P.C. Verhoef *et al.* (2021) conceptualised digital transformation as a multidisciplinary change involving strategy, business models, organisational structures, and performance metrics. Empirically, A. Abdurrahman *et al.* (2024) found that dynamic capabilities support digital transformation and innovation performance in banking. Together, these studies demonstrate that technological adoption must be embedded in organisational choice; however, neither provides a project-level mechanism that jointly assesses technological fit, legal readiness, and commercialisation readiness.

The scientists H. Hou & Y. Shi (2021) distinguished ecosystem-as-structure from ecosystem-as-coevolution, showing that strategic coordination depends on how interdependent actors and boundaries are understood. B. Kindermann *et al.* (2022) further integrated sensing, seizing, and reconfiguring routines into ecosystem orchestration. These contributions explain how firms mobilise complements, but they leave open how legal regimes, standards, and project-specific business evidence should be incorporated before an ecosystem commitment is made. P. Hurmelinna-Laukkanen & J. Yang (2022) distinguished appropriability, the potential to protect value, from appropriation, the realised capture of value. R.A.R. Pires & J.J. Ferreira (2025) likewise showed that research on innovation strategy and intellectual property remains fragmented despite clear links among protection mechanisms, collaboration, learning, and value capture. This literature substantiates a separate legal dimension, yet it does not integrate that dimension with technology maturity and commercialisation gates in a unified project assessment.

In accordance with N. Goruppec *et al.* (2022), real-options logic can reduce irreversibility by staging commitments under uncertainty. This approach supports conditional investment, but an option gate still requires evidence about what is being protected, which standards apply, whether a viable commercialisation route exists, and which risks remain non-compensatory. A ranking mechanism must therefore be combined with minimum gates rather than used as a substitute for legal or technical requirements. Across these streams, the unresolved issue is the absence of a transparent algorithm that converts an integrated N-L-B project profile into coordinated strategic decisions and subsequently updates that profile through learning. This gap motivated the present study. The purpose of the study was to develop a conceptual model for strategic decision-making under conditions of technological innovation by operationalising the N, L, and B dimensions, formalising a process cycle and a preliminary portfolio index, and defining the link between assessment results and managerial actions.

● MATERIALS AND METHODS

This study was conceptual, qualitative, and analytical, with an illustrative descriptive component. The unit of analysis was an innovation project considered at a portfolio or stage-gate decision point. The design does not test causal hypotheses and does not constitute empirical validation of

the Strategic Suitability Index (SSI); it develops a transparent procedure that can be tested in subsequent firm-level research. The evidence base comprised four groups of materials: 20 peer-reviewed articles published in 2021–2026, including the integrated N-L-B classification developed by O. Bradul & Y. Novikov (2025); the measurement principles of the Oslo Manual (OECD & Eurostat, 2018); official statistical and legal sources relevant to innovation, intellectual property (IP), standards, and international commercialisation; and two foundational multi-criteria decision analysis (MCDA) books used only to specify future procedures for weight elicitation and sensitivity analysis.

The literature component was a structured narrative review updated through July 2026. Bibliographic searches and reference chaining used combinations of the terms “technological innovation”, “strategic management”, “digital transformation”, “dynamic capabilities”, “innovation ecosystem”, “appropriability”, “intellectual property strategy”, “real options”, and “commercialisation”. Publication metadata were checked against publisher pages and DOI records. Eligible records were peer-reviewed articles or reviews in management, business, economics, or innovation studies, published from 2021 onward, with an explicit method and a direct connection to project, portfolio, ecosystem, protection, or scaling decisions. Non-peer-reviewed commentary, conference abstracts, and records without verifiable bibliographic data were excluded. Legal content analysis covered Law of Ukraine No. 3687-XII (1993), the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) (World Trade Organization, 1994), Law of Ukraine No. 40-IV (2002) and Strategy for the Development of Innovation Activity up to 2030 (Order of Cabinet of Ministers of Ukraine No. 526-r, 2019). Each provision was coded by its direct relation to legal readiness (L), business readiness (B), or integrated risk (R), and then translated into an evidence requirement or a non-compensatory decision gate.

The conceptual model was constructed in six steps: First, the N, L, and B constructs and their subcriteria were derived from the integrated classification, while the boundary between an innovation and an innovation activity was aligned with the Oslo Manual. Second, every subcriterion was mapped to at least one observable proxy and to the managerial record that could substantiate it. Third, proxy and a common evidence scale were defined. Fourth, normalised proxy scores were aggregated within N, L, B, and R. Fifth, score patterns were linked to explicit portfolio, protection, partnership, certification, and scaling rules. Sixth, implementation outcomes were returned to the model as feedback for rescoring and revision of weights or thresholds. Proxy indicators were selected according to five principles: construct relevance, observability in ordinary managerial records, comparability across projects, unambiguous directionality, and limited duplication. Acceptable evidence included test protocols, technology-readiness reviews, patent and ownership records, standards and certification maps, customer-validation data, unit-economics calculations, financing documents, and signed partner or channel commitments. A proxy is therefore an observable indicator of a construct, not a substitute for the construct itself.

Each applicable proxy was scored on a documented five-point evidence rubric: 0 means that no reliable

evidence exists; 1 indicates a preliminary assertion or single unverified observation; 2 indicates partial documentation; 3 indicates repeated or internally verified evidence appropriate to the current decision stage; and 4 indicates external validation, certification, contractual confirmation, or equivalent robust evidence. The normalised proxy score is $z = s/4$. A dimension score was the weighted mean of its applicable normalised proxies, with within-dimension weights summing to one. N measures strategic technological fit and does not reward radical novelty by itself; technical differentiation must be compatible with maturity and the decision horizon. For interpretation, dimension scores below 0.40 were classified as low, scores from 0.40 to 0.69 as medium, and scores from 0.70 to 1.00 as high. These ex-ante bands distinguish early, intermediate, and decision-ready evidence; they are not empirically estimated cut-offs and must be calibrated by sector. Sensitivity analysis around the 0.40 and 0.70 boundaries is required when a classification changes after a small score variation. R is assessed on the same 0–4 rubric for technological, regulatory, market, and ecosystem risks, but a higher R score denotes greater adverse exposure.

The link between indicators and strategic decisions combines a compensatory ranking rule with non-compensatory gates. SSI can rank otherwise eligible projects, but a high aggregate score cannot offset a mandatory standard, unclear ownership, a failed critical test, or the absence of an executable route to market. Illustrative equal weights were used only for the configurations in this article. In an empirical application, weights should be elicited from decision-makers and checked for robustness; the Analytic Hierarchy Process (AHP) described by T.L. Saaty (1980) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) developed by C.-L. Hwang & K. Yoon (1981)

were retained as candidate procedures. Descriptive statistics were calculated for Ukraine's Global Innovation Index (GII) rankings in 2020–2025 using the country profile published by the World Intellectual Property Organization (2025). The calculation included the arithmetic mean, sample standard deviation, annual input-output rank gap, and the change between 2020 and 2025. National rankings were excluded from N, L, B, R, and SSI because economy-level indicators are not project-level measurements; they were retained only as contextual benchmarking and not as model validation or a basis for causal inference. The main limitations followed from the conceptual design. The proxy set has not undergone reliability, convergent-validity, or predictive-validity testing; thresholds and weights are normative; the six configurations are not frequency estimates; and the GII analysis is vulnerable to ecological inference and year-to-year comparability problems. The legal mapping is specific to the selected Ukrainian and international sources and does not constitute legal advice for a particular jurisdiction.

● RESULTS

The analysis produced five interrelated authorial outputs: an operational evidence system for N, L, B, and R; a five-stage process model; a conceptual SSI; six strategic N-L-B configurations; and a legal-to-model mapping. The GII analysis is presented separately as contextual benchmarking and is not treated as a test of these outputs. The classification criteria were converted into observable evidence and decision uses. Table 1 distinguishes the three positive readiness dimensions from the auxiliary adverse-risk component. The operationalisation makes explicit both the evidence owner and the managerial action that a score can inform.

Table 1. Operationalisation of the N-L-B dimensions and auxiliary risk component

Component	Construct content	Observable proxy indicators	Decision uses
N – scientific and technological fit	Technological differentiation, strategic relevance, domain fit, and maturity for the current decision horizon	Technology readiness level (TRL) and test evidence; performance against a benchmark; prototype reliability; unresolved technical assumptions; research and development (R&D) resource intensity	Experiment, continue, partner, redesign, defer, or stop; determine technical milestones and tranche size
L – legal and standards readiness	Ownership and protectability; protection regime; standards and certification; target jurisdictions	Chain-of-title evidence; patent or secrecy rationale; freedom-to-operate review; certification map; filing and enforcement plan	Protect, license, retain as know-how, redesign, select jurisdictions, or block scaling until a mandatory requirement is met
B – business readiness	Value proposition, commercialisation route, financing, complementary assets, scaling, and export readiness	Customer validation; total addressable, serviceable available, and serviceable obtainable market (TAM/SAM/SOM) assumptions; unit economics; committed financing; channel and partner readiness; export logistics	Select business and financing model; build or access complements; choose pilot, license, alliance, export, or scale route
R – auxiliary integrated risk	Technological, regulatory, market, ecosystem, cybersecurity, supply-chain, and environmental exposure	Critical unresolved failures; probability-severity register; certification uncertainty; financing runway; partner concentration; data and supply risks	Apply the SSI penalty; tighten gates; reduce tranche size; add contingencies; postpone or terminate the project

Source: developed by the author, the measurement logic is aligned with OECD & Eurostat (2018) and the N-L-B construct content is based on O. Bradul & Y. Novikov (2025)

The process model was developed as a closed cycle. At the signal stage, technology, market, legal, standards, and ecosystem changes enter the model together with the existing project dossier; the output is a documented trigger and an evidence request. The model proceeds to classification only after the minimum evidence owner and

decision horizon have been defined. At the classification stage, proxies are scored, normalised, and aggregated into N, L, B, and R, producing an evidence-backed profile, a confidence note, and a list of missing data. The transition to strategic choice requires that all mandatory technical, ownership, standards, and compliance questions be

classified as met, unmet, or explicitly unresolved; an undocumented issue cannot be treated as a positive score.

At the choice stage, eligible projects are compared through SSI and non-compensatory gates. The output is a decision to experiment, protect, partner, license, scale, defer, redesign, or stop, together with resource, intellectual-property, certification, and commercialisation commitments.

Implementation converts that decision into milestones, contracts, tests, and key performance indicators (KPIs). Learning is triggered at a milestone, a material deviation, or a new external signal; realised outcomes then update the evidence scores, risk register, weights, and next gate. Figure 1 visualises this five-stage sequence, its transition logic, and the feedback path from learning to classification.

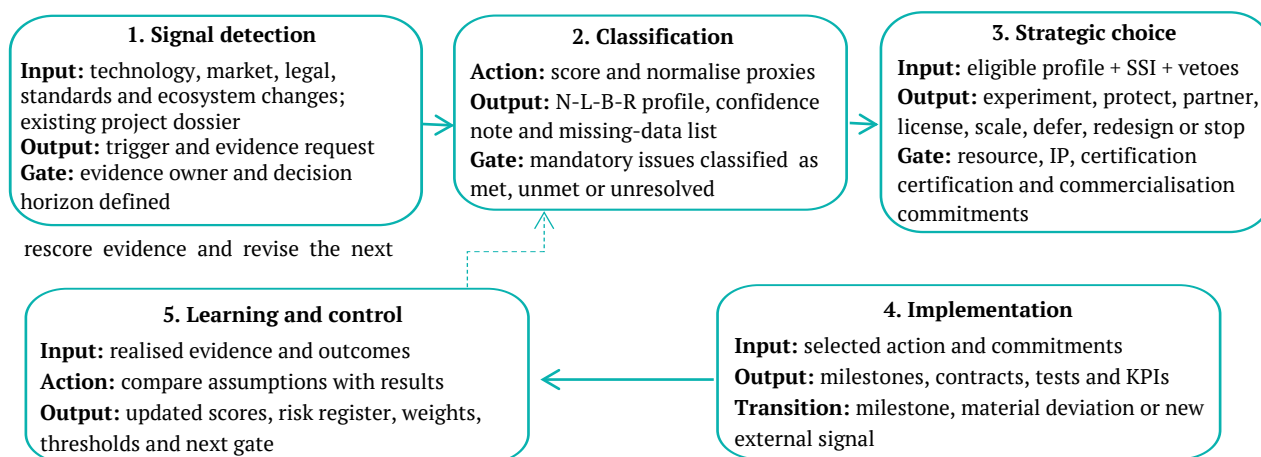


Figure 1. Five-stage process model for project-level strategic decisions under technological uncertainty

Source: developed by the author

The feedback loop is substantive rather than ceremonial: if implementation evidence changes a project's dimension band or exposes a failed gate, the project returns to classification or choice instead of continuing automatically. This mechanism converts the N-L-B framework from a descriptive taxonomy into a revisable decision architecture. SSI was formulated as a preliminary portfolio-ranking instrument for projects that have passed mandatory gates. All four inputs are dimensionless normalised scores ranging from 0 to 1. N represents scientific and technological fit; L represents legal and standards readiness; B represents business readiness; and R represents integrated adverse risk:

$$SSI = wN \cdot N + wL \cdot L + wB \cdot B - wR \cdot R, \quad (1)$$

where $wN + wL + wB + wR = 1$ and $w_i \geq 0$. The non-negative weights express the decision-maker's priorities and sum to one. SSI is a relative ranking score, not a probability of

success and not a replacement for net present value (NPV), internal rate of return (IRR), due diligence, or legal review. It may be negative when the weighted risk penalty exceeds positive readiness. Equal weights are acceptable only for illustration; empirical use requires elicitation, consistency checks, and sensitivity analysis. The decision logic also contains vetoes. A project cannot proceed to regulated-market scaling when a mandatory standard is unmet, when ownership is unclear, or when a critical technical test has failed, regardless of SSI. Low L combined with high N triggers staged investment and protection work; low B triggers customer discovery, licensing, partnership, or deferral; and a rising R score reduces tranche size or activates a stop rule. Six illustrative configurations were derived by combining the low, medium, and high bands. Table 2 summarises these decision archetypes and shows how similar aggregate SSI values may require different actions because their underlying N-L-B profiles differ; they are not empirically observed clusters.

Table 2. Illustrative strategic configurations based on the N-L-B profile

Configuration	N-L-B profile	Dominant logic	Typical portfolio, protection, and scaling decisions
Option-based radical project	High N; low/medium L; medium B	Staged learning under uncertainty	Fund critical experiments in tranches; complete IP landscape and standards map; prohibit full scaling until mandatory L gaps close
Protected scale-up	High N; high L; high B	Accelerated value capture	Secure priority jurisdictions; expand production, marketing, and service complements; execute the export or licensing plan
Regulated breakthrough through alliance	High N; high L; medium B	Risk sharing and access to complements	Use joint certification, licensing, or a strategic alliance; share financing and market-access costs with a qualified partner
Ecosystem digital project	Medium/high N; medium L; high B	Platform and complement orchestration	Pilot ecosystem rules; allocate data and IP rights contractually; test partner incentives and interoperability before expansion

Table 2, Continued

Configuration	N-L-B profile	Dominant logic	Typical portfolio, protection, and scaling decisions
Incremental process improvement	Low/medium N; high L; medium/high B	Exploitation and operational efficiency	Prioritise process KPIs and standards; replicate in phases; protect know-how and document implementation learning
Local commercialisation with weak formal IP	Medium N; low L; medium B	Speed plus organisational protection	Use secrecy, access controls, and contracts; differentiate through service; strengthen L before licensing or international expansion

Source: developed by the author

The six configurations show that a strategic decision depends not only on an aggregate readiness level or SSI value, but also on the internal N-L-B profile. Projects with similar aggregate scores may therefore require different actions: high N combined with low L calls for staged investment and protection work, whereas high L and B with only medium N supports controlled replication or process improvement. The weakest evidenced dimension identifies the immediate managerial priority and may activate a gate even when the aggregate score is comparatively favourable.

Because implementation feedback can change any dimension, the configurations should be treated as revisable decision archetypes rather than fixed development pathways. Table 3 presents the national data as contextual, not validating, evidence. Ukraine's overall GII rank changed from 45 in 2020 to 66 in 2025, while the 2025 input and output ranks were 80 and 54, respectively. The persistent input-output gap illustrates that resource conditions and realised outputs should not be collapsed into one construct, but it does not establish any causal relationship among N, L, B, R, or SSI.

Table 3. Contextual GII rankings for Ukraine, 2020-2025

Year	Overall GII rank	Innovation inputs rank	Innovation outputs rank	Inputs – outputs gap
2020	45	71	37	34
2021	49	76	37	39
2022	57	75	48	27
2023	55	78	42	36
2024	60	78	54	24
2025	66	80	54	26

Note: the mean overall rank for 2020-2025 is 55.3 and the sample standard deviation is 7.55; the 2025 rank is 21 positions lower than in 2020. Rank changes are descriptive because data availability and changes in the GII model affect year-to-year comparability

Source: author's calculations based on World Intellectual Property Organization (2025)

Accordingly, GII values are excluded from project scoring. They can inform the external signal and risk register, but they cannot demonstrate that a particular project should shift from N to L or B, and they cannot verify the reliability or predictive validity of SSI. The legal content analysis produced an explicit mapping to

L, B, and R. Table 4 presents the resulting mapping and shows that legal sources do more than define a general environment: they create evidence requirements, shape available commercialisation instruments, and expose costs or constraints that must enter project gates and the risk register.

Table 4. Mapping of selected legal sources to L, B, R, and strategic decision rules

Source	Model link	Operational result of the comparison	Decision rule in the model
Law of Ukraine "On Innovation Activity"	B; R	Project status, state-regulation instruments, and support conditions affect feasible financing and institutional exposure	Do not increase B for expected public support until eligibility and documentation are confirmed; record uncertainty as R
Law "On Protection of Rights to Inventions and Utility Models"	L; B; R	Patentability, registration, exclusive rights, assignment, and licensing connect protectability with commercialisation options and cost	Verify ownership and protection route before scale; include filing, enforcement, and design-around exposure in R
Innovation Activity Strategy up to 2030	B; R	Policy priorities shape the external support environment but do not guarantee project-level funding or market success	Use policy fit as contextual evidence only; no automatic SSI uplift without an executable instrument or commitment
TRIPS Agreement	L; R	Minimum international standards and enforcement rules create a legal floor, while protection and enforcement costs remain jurisdiction-specific	Map target jurisdictions before export or licensing; treat enforcement gaps and costs as risk rather than assuming uniform protection

Source: developed by the author based on Law of Ukraine No. 3687-XII (1993), World Trade Organization (1994), Law of Ukraine No. 40-IV (2002) and Order of Cabinet of Ministers of Ukraine No. 526-r (2019)

The mapping confirms that L is not a binary patent variable. It includes ownership, protectability, standards, certification, jurisdiction, transferability, and enforcement exposure. It also demonstrates cross-effects: public-support eligibility influences B and R; assignment or licensing affects B; and filing, certification, and enforcement costs

affect R. At low L, the managerial priority shifts from scaling to clarifying ownership, freedom to operate, the protection route, and certification requirements; external financing, licensing, and market entry should be staged or deferred. At medium L, a bounded pilot or partnership may proceed only with contractual allocation of IP and data

rights, certification milestones, and contingencies. At high L, validated ownership, standards compliance, and jurisdictional protection expand the feasible set of licensing, alliance, export, and scaling options, although continuation still depends on N, B, and R. Legal and regulatory readiness thus functions both as a value-enabling resource and as a non-compensatory gate that determines not only whether a project proceeds, but also the appropriate governance and commercialisation mode.

● DISCUSSION

The principal result is a project-level decision architecture that translates the N-L-B classification into an evidence-based cycle and combines SSI ranking with mandatory gates. Its scientific significance lies in separating compensatory portfolio comparison from non-compensatory feasibility conditions: readiness dimensions may trade off in SSI only among projects that satisfy critical technical, ownership, standards, and route-to-market requirements. This distinction explains why projects with similar aggregate scores may legitimately require different strategic actions. The results remain a conceptual integration rather than evidence of predictive validity. A. Hanelt *et al.* (2021) framed digital transformation as organisational change embedded in structures and context, while J. Konopik *et al.* (2022) showed that different organisational capabilities are needed at different stages of transformation. S. Kraus *et al.* (2022), based on a review of 217 articles, likewise positioned digital transformation as a synergistic business and management research domain. These findings support the shift from a static classification to a process model. The present framework extends that logic by making the evidence profile and gate conditions explicit at project level, but it does not estimate how strongly any capability affects outcomes.

D. Ellström *et al.* (2022) identified sensing, seizing, and reconfiguring routines that enable digital transformation. N.A. Al-Moaid & S.G. Almarhdi (2024) additionally found that change management mediates the relationship between dynamic capabilities and successful digital transformation projects. These studies support the signal, choice, implementation, and learning stages developed here. The distinction is that the N-L-B model records the state of project evidence, whereas dynamic capabilities and change management describe organisational abilities that influence how well the cycle is executed. J. Merín-Rodríguez *et al.* (2025) linked the expertise, external connectivity, and empowering leadership of chief executive officers (CEOs) to digital transformation and new-product performance in innovative small and medium-sized enterprises (SMEs). T. Yunita *et al.* (2023) found that technological capacity supports organisational ambidexterity through dynamic capabilities and also reported greater security risk in highly dynamic settings. These findings are consistent with including managerial evidence in implementation and a separate adverse-risk component R. The current framework, however, does not model CEO-level microfoundations or estimate sector-specific risk effects.

Using a configurational method, X. Xing *et al.* (2024) identified multiple pathways to inbound and outbound open innovation in a digital-platform ecosystem. J. Rabelo Neto *et al.* (2024) emphasised collaboration, governance,

human and social capital, and culture in the evolution of innovation ecosystems. Both studies support the premise that strategic outcomes arise from combinations rather than isolated indicators. Nevertheless, the six N-L-B profiles in this study are illustrative decision archetypes; unlike fuzzy-set qualitative comparative analysis (fsQCA) configurations, they have not been demonstrated to be necessary or sufficient for success. S. Marchese *et al.* (2026), drawing on eight EdTech cases, showed that digital technologies can enhance collaboration, information sharing, and the dynamic capabilities required for ecosystem orchestration. This supports the partnership and ecosystem indicators within B and the feedback function of the process model. The present study differs by requiring legal and standards readiness to be assessed before scaling, rather than treating protection and compliance as downstream implementation details.

The managerial value of SSI lies in disciplined sequencing rather than in creating another stand-alone composite score. Traditional additive ranking permits a strong score in one dimension to offset a critical weakness in another and can therefore obscure the reason for a portfolio decision. In the proposed model, non-compensatory gates are evaluated before SSI: unclear ownership, an unmet mandatory standard, a failed critical test, or the absence of an executable route to market cannot be offset by high N, L, or B. SSI then ranks only eligible projects and supports the allocation of experiment tranches, protection budgets, partnership effort, and managerial attention. The N-L-B profile and gate log retain the decision rationale and specify what evidence is required before a deferred or blocked project can be reconsidered. The legal-business coupling is also consistent with recent intellectual-property research. C. Ayerbe *et al.* (2023) demonstrated that patent-backed loans may alter borrowers' innovation strategies and can encourage short-term patent monetisation. C.T. Lohrey & K.W. Willoughby (2025) concluded that SMEs can improve innovation and business performance by treating intellectual-property management as a basic business function. Together, these findings support L as an equal strategic dimension and justify linking L with B and R. They also caution that a strong patent position is not automatically beneficial: financing terms, enforcement costs, and incentive shifts must be evaluated alongside formal rights.

● CONCLUSIONS

The study operationalised the N, L, and B dimensions through observable managerial indicators and a documented 0-4 evidence rubric, and it separated integrated risk R from the three positive readiness dimensions. The low, medium, and high bands provide a transparent preliminary interpretation while making clear that sectoral calibration remains necessary. The study developed the closed process model “signal-classification-choice-implementation-learning”. The model specifies inputs, outputs, transition conditions, non-compensatory gates, and a feedback function that updates evidence, scores, and decision assumptions after each implementation milestone. A conceptual SSI was introduced for preliminary comparison of eligible innovation projects without replacing financial appraisal or mandatory technical and legal requirements.

Six illustrative strategic configurations were formulated to connect N-L-B profiles with investment, intellectual-property, partnership, certification, and scaling choices. The legal mapping substantiated the inclusion of L as an equal component and showed how selected rules also influence B and R. The developed framework enables R&D, legal, and commercial functions to identify evidence gaps and coordinate stage-gate decisions. The 2020-2025 GII data were used only as contextual benchmarking and not as validation of the project-level model. Further research should combine Delphi or AHP-based weight elicitation with pilot application to real project portfolios, empirically calibrate proxies and thresholds, test inter-rater reliability

and predictive validity, and estimate the associations of N, L, B, R, and SSI with commercialisation, export, and survival outcomes across sectors, firm sizes, jurisdictions, and longitudinal samples.

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Розроблення моделей стратегічного управління в умовах технологічних інновацій

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Анотація. Технологічні інновації створюють для підприємств проблему координації, оскільки технологічна зрілість, захист інтелектуальної власності, відповідність регуляторним вимогам, комерційна доцільність і готовність до масштабування розвиваються різними темпами. Фрагментарне оцінювання може призводити до передчасного масштабування, недостатнього захисту знань або продовження інвестування у проекти, що не мають життєздатного шляху до комерціалізації. Метою дослідження було розробити концептуальну модель прийняття стратегічних рішень на основі інтегрованої тривимірної класифікації інноваційних проектів. Застосовано структурований огляд рецензованих наукових публікацій за 2021-2026 рр., контент-аналіз українських і міжнародних правових джерел, концептуальне моделювання, порівняльне зіставлення та описовий аналіз профілю України за Глобальним інноваційним індексом (Global Innovation Index, GII) за 2020-2025 рр. У дослідженні операционалізовано три виміри: науково-технологічну відповідність (N), правову та стандартизаційну готовність (L) і бізнес-готовність (B). Ці виміри оцінювались за допомогою спостережуваних управлінських індикаторів і документованої шкали доказовості від 0 до 4 із нормалізованими низьким, середнім і високим рівнями. Розроблено замкнену процесну модель, що охоплює виявлення сигналів, класифікацію, стратегічний вибір, реалізацію та навчання, з чітко визначеними вхідними й вихідними параметрами, умовами проходження контрольних етапів і зворотним зв'язком. Запропоновано концептуальний Індекс стратегічної придатності для ранжування інноваційних проектів за N, L, B та інтегрованим ризиком R, який не замінює чисту приведену вартість (NPV), внутрішню норму дохідності (IRR) або обов'язкові контрольні умови відповідності вимогам. Сформульовано шість ілюстративних конфігурацій N-L-B, що пов'язують профілі проектів із рішеннями щодо інвестування, інтелектуальної власності, партнерства та масштабування. Правове зіставлення показало, як норми підтримки інновацій впливають на B і R, тоді як патентні норми та правила міжнародної торгівлі впливають на L, можливості комерціалізації та ризик правозастосування. Дані національного індексу використано лише як контекстуальні свідчення та не розглядали як валідацію моделі проектного рівня. Запропонована концептуальна модель може використовуватися для попереднього скринінгу портфеля проектів, виявлення прогалин у доказовій базі та координації функцій досліджень і розробок (R&D), правового та комерційного супроводу в умовах невизначеності

Ключові слова: динамічні спроможності; управління інтелектуальною власністю; готовність до комерціалізації; пріоритизація портфеля; оркестрація екосистеми; регуляторна відповідність

A survey study on seaport modernising in Algeria as a driver for facilitating export and import operations

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Abstract. The modernisation of seaports has emerged as a strategic imperative in the contemporary global economic landscape, driven by the accelerating pace of globalisation and the sustained expansion of international trade volumes. As maritime transport remains the backbone of global commerce, the efficiency and responsiveness of port infrastructure directly influence a nation's trade competitiveness. In light of these developments, this study aimed to investigate the role of seaport modernisation in Algeria as a key driver for facilitating export and import operations. To achieve this objective, a quantitative research methodology was employed, utilising a structured questionnaire administered to a sample of 80 employees at the Skikda Port Enterprise in Algeria. The research specifically examined the contribution of port modernisation to the facilitation of foreign trade operations by focusing on three distinct yet interrelated dimensions: the adoption and integration of information and communication technology, the development and upgrading of physical infrastructure, and the simplification of governance structures and procedural workflows. The study analysed how each of these dimensions individually and collectively influences the efficiency and effectiveness of export and import activities. Respondents expressed generally favourable views across all measured domains, including information and communication technology ($M = 3.8350$, $SD = 0.52171$), governance and procedural simplification ($M = 3.7000$, $SD = 0.60713$), and infrastructure development ($M = 3.5925$, $SD = 0.64234$). The overall mean score for the facilitation of export and import operations was 3.8270. Furthermore, the questionnaire demonstrated sound psychometric properties, with Cronbach's alpha coefficients ranging from 0.769 to 0.879, indicating acceptable to high internal consistency. These improvements have been accompanied by notable reductions in processing times and operational costs. From a practical perspective, this study offers valuable empirical evidence to port authorities, logistics managers, and policymakers regarding the tangible and measurable benefits associated with strategic investments in port modernisation.

Keywords: port modernisation; digital transformation; trade facilitation; port infrastructure; governance

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● INTRODUCTION

With the accelerating pace of globalisation and the exponential growth in global trade volumes, seaports find themselves at a critical juncture. No longer merely passive transit points, they are now pivotal nodes in complex supply chains where even minor inefficiencies can cascade into significant delays, financial losses, and reduced national competitiveness. Consequently, the imperative to modernise infrastructure and implement advanced management systems has shifted from a strategic advantage to an operational necessity, making it essential to examine how effectively ports are responding to these mounting pressures.

In 2024, global maritime trade volumes reached 12,720 million tons, representing a growth rate of 2.2 percent. Meanwhile, global containerised trade volumes experienced robust growth over the same period, with an increase exceeding 6 percent, in accordance with UNCTAD (2024). P. Nguyen & T. Pham (2026) emphasised that digital transformation in the context of port modernisation must be understood as a comprehensive change process that integrates infrastructure, platforms, people, and policies, rather than merely the acquisition of technology. The authors draw on the Smart Port 4.0 model, which emphasises the integration of physical, digital, and organisational elements to build intelligent and adaptive port systems (Clemente *et al.*, 2023). They also relied on the Resource-Based View (RBV) theory, which explains how digital capabilities, as rare and difficult-to-imitate resources, can generate sustainable competitive advantage. The authors also called for enhanced regional cooperation within ASEAN for knowledge sharing and common platforms, as well as for the development of performance assessment frameworks that include digital maturity metrics alongside traditional productivity indicators.

A. Burmambet (2025) noted that Romanian ports stand at a critical crossroads in their evolution from fourth-generation infrastructure to data-driven smart ports. This transformation is not merely a technical necessity but an imperative for economic resilience, environmental responsibility, and geopolitical significance in the Black Sea region. The digital transformation of Romanian seaports from the fourth generation to smart ports has a significant impact on the global logistics ecosystem, particularly in terms of efficiency, sustainability, and resilience in the face of crises. According to O. Melnyk *et al.* (2025), the existence of a dedicated port system within the framework of digital transformation is essential. The authors drew on a wide range of literature relating to energy efficiency and green transformation in ports, the assessment of smart port maturity and performance indicators, challenges of digital transformation in developing countries including Ukraine (Muradian *et al.*, 2023), and applications of artificial intelligence and blockchain in port management (Zhou *et al.*, 2022; Haidine *et al.*, 2024). The integrated autonomous port network is not merely a technical solution but a new management philosophy that alters the traditional approach to port management in an unstable environment.

The studies of B. Belmoukari *et al.* (2023) and G. D'Amico *et al.* (2021) indicated that maritime transport and logistics benefit significantly from big data technologies and digitalisation, specifically technologies for identifying vehicles, individuals, and goods. The authors also noted that

efficiency is strongly affected by operational costs, security, and service availability, and that leading global smart ports share characteristics such as digitalisation, process automation, and the use of smart technologies. According to J. Chen *et al.* (2026), port operational efficiency is primarily linked to economic indicators and the use of alternative energy systems. The authors draw on three main strands of literature. The first concerns traditional port efficiency and focuses on economic indicators such as tariffs, labour, and productivity. The second addresses green port efficiency and incorporates undesirable environmental outputs, including NO_x and SO_x emissions (Lim *et al.*, 2019). The third examines sustainable port technologies, including alternative fuels and energy carriers such as hydrogen, ammonia, and LNG, as well as shore power, electric equipment, and IoT-based systems for monitoring and optimising fuel consumption (Nguyen & Pham, 2026). The majority of studies on port modernisation and digital transformation have focused on ports in Southeast Asia, Eastern Indonesia, Romania, Ukraine, and global maritime hubs (Pratama, 2025). There is a conspicuous absence of empirical research examining port modernisation processes in North African ports, particularly in Algeria, despite the country's strategic Mediterranean location and its ongoing national port modernisation programme launched in 2025.

Existing studies have predominantly employed quantitative methodologies, such as the Digital Transformation Index or technical design assessments, with limited attention to perceptual and experiential data from port employees and commercial operators who directly interact with modernisation initiatives. While several authors have acknowledged the importance of digital tools and automated gates, few studies have explicitly investigated the direct relationship between port modernisation and the facilitation of export and import operations. Most research on port modernisation and digital transformation has focused on Southeast Asia, Eastern Indonesia, Romania, Ukraine, and global maritime hubs, with little empirical work on North African ports, particularly Algeria, despite its strategic Mediterranean location and 2025 national modernisation programme. Existing studies are largely quantitative, paying limited attention to the experiences of port employees and commercial operators. Moreover, few studies explicitly examine how port modernisation affects export and import operations. The aim of present study was to investigate the role of seaport modernisation in Algeria as a driver for facilitating export and import operations, through a survey-based study conducted at the Skikda Port Authority, focusing on the perceptions of commercial department employees regarding the impact of modernisation initiatives on operational efficiency, customs procedures, and trade facilitation. Based on the theoretical framework and the empirical context of Skikda Port Enterprise, the following research hypotheses were formulated:

H₁: The adoption and integration of Information and Communication Technology (ICT) – particularly through interconnected systems such as SARPORT, the Port Community System (PCS), SIEL, and ALCES-positively contributes to enhancing export and import activities by improving cargo tracking, reducing processing times, and accelerating customs and administrative procedures.

H₂: The modernisation of physical infrastructure-including the expansion and deepening of berths, the acquisition of advanced handling equipment, and the intelligent reorganisation of storage areas-positively influences the volume of export and import operations by increasing reception capacity, reducing vessel turnaround time, and improving cargo flow efficiency.

H₃: The implementation of governance reforms and the simplification of port procedures-through digital coordination platforms, standardised operational protocols, and enhanced transparency mechanisms-positively stimulate export and import activities by reducing administrative bottlenecks, improving real-time data exchange, and increasing stakeholder trust.

● MATERIALS AND METHODS

The questionnaire was distributed to employees of the Skikda Port Authority. The sample included staff members from the institution's commercial department, employees of the commercial department were purposively selected as the primary respondents because they are directly responsible for the daytoday execution of export and import operations. A total of 85 questionnaires were distributed in person among employees representing the study population, and 80 completed questionnaires were returned fully completed, with no missing responses on key variables and deemed valid for analysis. The study was conducted during May 2025, a period coinciding with the launch of the port

modernisation programme in Algeria. The study was conducted in accordance with the ethical principles of the ICC/ESOMAR international code on market, opinion and social research and data analytics (2025).

The questionnaire was constructed around the central theme of seaport modernisation as a driver of trade facilitation, using Skikda Port Enterprise as a case study. The final instrument contained 25 items measured on a five-point Likert scale (1 = Strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree). To categorise respondent perceptions, the equal-interval method was adopted. The scale range (5 – 1 = 4) was divided by three to produce three equal categories, each with a width of 1.33. It consisted of two parts. The first part covered the respondents' personal and professional characteristics, including gender, age, work experience, educational level, and job position. The second part focused on port modernisation and the promotion of the foreign trade sector. This part was divided into two main variables (Fig. 1). The first variable is port modernisation, which consists of fifteen statements distributed across three distinct dimensions. The first dimension concerns information and communication technology and comprises five statements. The second dimension addresses port infrastructure development and also consists of five statements. The third dimension focuses on governance and port operations management and includes five statements as well. The second variable is facilitating export and import operations, which comprises ten statements.

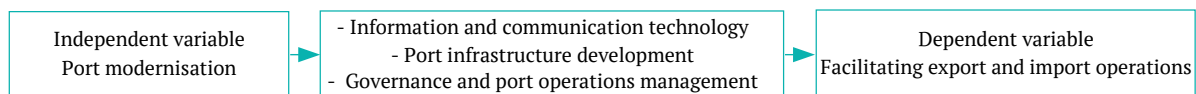


Figure 1. Variables of the study

Source: prepared by the authors

To ensure the reliability and validity of the questionnaire, Cronbach's alpha coefficients and Pearson correlation coefficients were calculated. Cronbach's alpha was used to assess the internal consistency of the items within each dimension, with higher values indicating greater reliability. Pearson correlation coefficients were used to assess internal construct validity by examining the relationships between each item and the total score of its respective dimension, as well as the correlations among the questionnaire dimensions. Statistical analysis was performed using SPSS. Descriptive statistics included the arithmetic mean to determine the average response score for each item and dimension and the standard deviation to assess the variability of responses around the mean.

● RESULTS

Results of the assessment of port modernisation and its impact on export and import operations

All Pearson correlation coefficients for the statements ranged between 0.647 and 0.833. These values are positive

and statistically significant at the significance level ($\alpha = 0.001$). Therefore, the statements are considered valid. Cronbach's alpha coefficient reflects the reliability of the instrument used in the study, namely the questionnaire. The closer Cronbach's alpha coefficient is to 1, the greater the reliability of the instrument. As shown in Table 1, the overall Cronbach's alpha value is above 0.90, reaching 0.908, which is close to 1 and considered high. Furthermore, the Cronbach's alpha values for the various dimensions ranged between 0.769 and 0.879, which are also high values, indicating the reliability and validity of the study instrument. Table 2 presents the analysis of the first dimension of the independent variable, namely information and communication technology, by showing the responses of the sample members to the statements related to ICT at Skikda Port. The overall arithmetic mean for the statements reached 3.8350 with a standard deviation of 0.52171, indicating a high level of agreement among respondents.

Table 1. Cronbach's alpha coefficient

Axis	Cronbach's alpha coefficient
First Axis – Independent Variable: Port Modernisation	0.769
First: Information and Communication Technology	0.781
Second: Port Infrastructure Development	0.809
Third: Governance and Simplification of Administrative Procedures	0.879

Table 1, Continued

Axis	Cronbach's alpha coefficient
Second Axis – Dependent Variable: Facilitating Export and Import Operations	0.838
All Items	0.908

Source: prepared by the authors based on on SPSS outputs

Table 2. Means and standard deviations of information and communication technology

No.	Statements	Arithmetic mean	Standard deviation	Agree level
01	Integrated information systems are used for managing port operations at Skikda Port	4.0000	0.59534	High
02	Port management relies on electronic programs to track and monitor the flow of goods and containers	4.0125	0.58448	High
03	Modern electronic gates are available to accelerate customs and administrative procedures	3.6750	0.85351	High
04	Economic operators can use digital platforms to declare and submit documents remotely	3.7250	0.82638	High
05	The use of smart technology has led to a reduction in operational costs at the port	3.7625	0.71589	High
Total		3.8350	0.52171	High

Source: prepared by the authors based on on SPSS outputs

Statement (2) recorded the highest arithmetic mean ($M = 4.0125$, $SD = 0.59534$), ranking first and reflecting strong agreement among respondents that electronic tracking is essential for improving port performance. Statement (1) ranked second ($M = 4.0000$, $SD = 0.58448$), indicating clear awareness of the importance of integrating modern systems into port management. Statement (5) ranked third ($M = 3.7625$, $SD = 0.71589$), showing a considerable level of satisfaction regarding technology's contribution to reducing financial burdens. Statement (4) ranked fourth ($M = 3.7250$, $SD = 0.82638$), reflecting a positive assessment of the use of digital platforms in facilitating procedures. Statement (3) ranked last ($M = 3.6750$, $SD = 0.85351$), suggesting

moderate to high agreement, which may indicate limited or varying user experience with these gateway. The high ratings for technology-related statements at Skikda Port are significant for improving port efficiency, real-time tracking reduces cargo dwell time, prevents loss, enables better planning, and accelerates cargo release. This is a direct, measurable contribution to port efficiency, and lower operational costs per container or per shipment directly improve the port's cost efficiency, making it more competitive and attractive to economic operators. Table 3 presents the analysis of the second dimension of the independent variable, namely port infrastructure development, by showing the means and standard deviations for the related statements.

Table 3. Means and standard deviations of port infrastructure development

No.	Statements	Arithmetic mean	Standard deviation	Agree level
06	The port's berths have been developed and equipped with advanced facilities to accommodate modern ships	3.6875	0.82052	High
07	Advanced handling and unloading equipment that complies with international standards is available	3.6125	0.86410	High
08	Storage areas have been expanded and organised in intelligent ways that ensure rapid access to goods	3.6750	0.93829	High
09	The port is equipped with smart devices for monitoring temperature, humidity, and secure shipping	3.4875	0.96776	High
10	The port's current infrastructure capacity is proportionate to the growing volume of maritime trade	3.5000	0.79556	High
Total		3.5925	0.64234	High

Source: prepared by the authors based on on SPSS outputs

The results indicate that statement (6) ranked first, with an arithmetic mean of 3.6875 and a standard deviation of 0.82052. This reflects strong agreement among sample members that the berths are effectively equipped to receive heavy goods. The results indicate that statement (7) ranked third, with an arithmetic mean of 3.6125 and a standard deviation of 0.86410. This suggests a considerable level of satisfaction regarding the efforts made to improve storage and handling speed. The results indicate that statement (8) ranked second, with an arithmetic mean of 3.6750 and a standard deviation of 0.93829. This indicates a considerable level of agreement concerning the modernisation of

equipment in line with international standards. The results indicate that statement (9) ranked fourth, with an arithmetic mean of 3.4875 and a standard deviation of 0.96776. This shows moderate agreement regarding the port's capacity to keep pace with increasing demand. The results indicate that statement (10) ranked fifth and last, with an arithmetic mean of 3.5000 and a standard deviation of 0.79556. This suggests moderate to high agreement, with the possibility of variation in experiences or deficiencies in certain safety or regulatory aspects. Table 4 presents the analysis of the third dimension of the independent variable, namely governance and simplification of port procedures.

Table 4. Means and standard deviations of governance and simplification of port procedures

No.	Statements	Arithmetic mean	Standard deviation	Agree level
11	The port relies on digital management that ensures rapid coordination among economic actors	3.6750	0.92470	High
12	Port management follows a clear policy for quality control and occupational safety	3.7875	0.75797	High
13	Operations are carried out according to standardised protocols to avoid delays and human errors	3.8000	0.78595	High
14	Real-time data exchange is enabled among various authorities (customs, police, handling operators)	3.5625	0.77694	High
15	Modern governance contributes to enhancing transparency and combating bureaucracy within the port	3.6750	0.77582	High
Total		3.7000	0.60713	High

Source: prepared by the authors based on on SPSS outputs

The results indicate that statement (13) ranked first, with an arithmetic mean of 3.8000 and a standard deviation of 0.78595. This suggests a strong level of agreement among sample members that working according to clear protocols has contributed to reducing errors and improving professional discipline. The results indicate that statement (12) ranked second, with an arithmetic mean of 3.7875 and a standard deviation of 0.75797. This denotes considerable satisfaction regarding the administration's commitment to applying quality standards and enforcing safety conditions. The results indicate that statement (11) ranked third, with an arithmetic mean of 3.6750 and a standard deviation of 0.92470. This justifies a positive perception regarding the effectiveness of digital management in facilitating coordination among stakeholders involved in port activity. The results indicate that statement (15) ranked fourth, with an arithmetic mean of 3.6750 and a standard deviation of 0.77582. This reflects a good level of agreement concerning the role of technology in improving the administrative climate. The results indicate that statement (14) ranked fifth, with an arithmetic mean of 3.5625 and a standard deviation of 0.77694. This denotes moderate agreement regarding the effectiveness of information exchange between departments.

Effective institutional cooperation breaks down traditional administrative barriers among the various

authorities operating within a port. When joint coordination mechanisms are established, such as unified electronic data exchange platforms and single-window systems, these authorities are enabled to function as an integrated system rather than operating in isolation from one another. This coordination reduces the duplication of procedures, eliminates inconsistencies in requirements, and limits delays caused by unclear responsibilities, thereby improving risk management without disrupting the flow of goods. Furthermore, coordinated and electronic customs procedures contribute to reducing cargo dwell time and inspection processes. The integration between port authority systems and customs enables the advance planning of loading and unloading operations, as well as the more efficient allocation of resources. Moreover, effective coordination reduces waiting time between unloading, inspection, and final release, thereby accelerating the movement of goods from the maritime gateway to warehouses or land transport modes. This acceleration lowers logistical costs, improves supply chain reliability, and enhances the port's reputation as a preferred destination for economic actors. Table 5 presents the analysis of the dependent variable, namely facilitating export and import operations, by showing the responses of the sample members to the statements related to the promotion of the foreign trade sector.

Table 5. Means and standard deviations of facilitating export and import operations

No.	Statements	Arithmetic mean	Standard deviation	Agree level
16	The development of seaports has contributed to reducing export lead times to foreign markets	3.8875	0.65591	High
17	Improving port services is considered an important factor in enhancing the competitiveness of Algerian products in the international market	3.8500	0.81287	High
18	The availability of modern port infrastructure has contributed to attracting foreign investors for export and import	3.8500	0.76473	High
19	The effectiveness of customs operations at ports has affected the quality of foreign trade	3.8000	0.66371	High
20	Digitisation in ports has facilitated the tracking of goods at the international level	3.9125	0.67868	High
21	The presence of modern equipment in ports enhances the smooth flow of exports and imports	3.9000	0.72216	High
22	The availability of real-time trade information helps in making quick decisions regarding export and import	3.8500	0.67698	High
23	The level of coordination among port stakeholders enhances the efficiency of the international supply chain	3.7875	0.72880	High
24	Fast port procedures facilitate the needs of foreign operators efficiently and flexibly	3.8125	0.74789	High

Table 5, Continued

No.	Statements	Arithmetic mean	Standard deviation	Agree level
25	Improved performance of Algerian ports encourages the entry of new products into foreign markets	3.8625	0.72468	High
Total		3.8270	0.43042	High

Source: prepared by the authors based on on SPSS outputs

The results indicate that statement (20) ranked first, with an arithmetic mean of 3.9125 and a standard deviation of 0.67868. This denotes strong agreement regarding the importance of digitisation in facilitating the control and monitoring of the global flow of goods. The results indicate that statement (21) ranked second, with an arithmetic mean of 3.9000 and a standard deviation of 0.72216. This suggests a high degree of satisfaction concerning the direct temporal impact of port modernisation. The results indicate that statement (16) ranked third, with an arithmetic mean of 3.8875 and a standard deviation of 0.65591. This shows a considerable level of satisfaction regarding the contribution of technology to reducing financial burdens. The results indicate that statement (25) ranked fourth, with an arithmetic mean of 3.8625 and a standard deviation of 0.72468. This indicates that improved port performance is considered a contributing factor to the diversification of Algerian exports. The results indicate that statement (18) ranked fifth, with an arithmetic mean of 3.8500 and a standard deviation of 0.76473. This reflects a high degree of agreement among sample members and confirms the importance of digitisation in facilitating the tracking of goods movement and improving port operational efficiency.

The results indicate that statement (19) ranked sixth, with an arithmetic mean of 3.8000 and a standard deviation of 0.66371. This reflects considerable agreement among sample members and indicates that the overall performance development of ports is considered a stimulating factor for increasing the diversity and expansion of Algerian products in international markets. The results indicate that statement (17) ranked seventh, with an arithmetic mean of 3.8500 and a standard deviation of 0.81287. This indicates that the availability of real-time data enables effective and rapid decision-making. The results indicate that statement (24) ranked eighth, with an arithmetic mean of 3.8125 and a standard deviation of 0.74789. This denotes a good awareness of the importance of accelerating procedures in improving the experience of port users. The results indicate that statement (22) ranked ninth, with an arithmetic mean of 3.8500 and a standard deviation of 0.66371. This reflects an awareness of the role of customs in either improving or hindering the commercial process. The results indicate that statement (23) ranked tenth, with an arithmetic mean of 3.7875 and a standard deviation of 0.72880. This points to the impact of institutional cooperation in strengthening the global supply chain.

This institutional integration creates an integrated working environment that enhances port efficiency and development. Through information sharing and joint coordination, vessel waiting times can be reduced, the flow of goods through ports can be improved, and customs and administrative procedures can be standardised. This integration encourages ports to adopt international standards, invest in digital and physical infrastructure, and transform themselves into multimodal logistics hubs. Furthermore,

institutional cooperation drives ports to develop their competitive capabilities by offering value-added services such as smart warehousing, redistribution, and pre-clearance customs services. Consequently, logistical and administrative barriers are lowered, and the volume of trade exchange between countries is stimulated to increase.

Assessment of the research hypotheses

The first hypothesis. The adoption of information and communication technology (ICT) contributes to enhancing export and import activities at Skikda Port Enterprise through the implementation of integrated information systems for port operations management. The port relies on four interconnected systems and provides electronic tracking and monitoring programs for the flow of goods and containers. These systems improve cargo tracking and reduce processing time. Furthermore, the availability of modern electronic gates designed to accelerate customs and administrative procedures contributes to improving the fluidity of the services provided. Based on the extent to which the sample agreed with the statements in the “Information and Communication Technology” section, it became evident that digitisation and information systems play a significant role in improving the effectiveness of port operations at Skikda Port Enterprise. The sample expressed considerable agreement with the statement: “Integrated information systems are used to manage port operations”, indicating that respondents recognise the pivotal role digitisation plays in organising work and reducing administrative inefficiencies. This positive assessment also suggests that digital transformation has contributed to enhancing coordination among various stakeholders, facilitating real-time tracking of containers and goods, accelerating procedures, and reducing document processing time-all of which positively affect the port’s overall performance. A number of digital systems and modern software have been adopted, including: The SARPORT system for managing port operations; The Port Community System (PCS) to facilitate interaction among various operators; The Economic and Logistics Information System (SIEL); The Algerian Customs Digitisation System – Algerian Customs System (G-Serport, n.d.)

Furthermore, the statement “Management relies on electronic programs to track and monitor the flow of goods and containers” received a high level of agreement. This reflects a collective awareness among respondents regarding the importance of such systems in enhancing control over the movement of goods within the port. These programs enable precise tracking of container locations at every stage of processing, thereby reducing loss and delays. They also contribute to expediting customs and logistical procedures while providing real-time data that supports fast and effective decision-making. This underscores the success of digital transformation in improving transparency and reducing the time required for the export-import cycle. Modernisation has helped reduce processing time through: integrating

digital systems into document processing; improving the internal organisation of loading and unloading operations; minimising time lost due to administrative delays.

Approximately 75 percent of the study respondents agreed with the statement: “The availability of modern electronic gates accelerates customs and administrative procedures”, which points to improved service fluidity. This reflects a clear recognition of the impact of digitisation in reducing the time and costs associated with port transactions, thereby contributing to smoother cargo flow and faster commercial operations. Such improvements support the port’s effectiveness in serving foreign trade. Technical upgrades and new equipment have increased the speed of handling operations and reduced waiting times, thereby strengthening the efficiency of the supply chain. Moreover, the adoption of “digital platforms and smart technologies” in ports represents a qualitative advancement in operations management. It has enabled economic operators to complete declarations remotely, accelerating procedures while reducing operational costs. This demonstrates a direct effect of port modernisation on improving logistical performance and supporting foreign trade.

According to G-Serport (n.d.), the presence of actual digital platforms used by employees of the port enterprise was confirmed, demonstrating that digital transformation is not merely a procedural formality but rather a practical application that contributes to enhancing performance efficiency and achieving flexibility in service delivery. Digital transformation improves interaction between Skikda Port and importers, freight forwarders, transport companies, and customs authorities. When customs procedures are digitised, unified digital windows are established, and electronic cargo tracking systems are implemented, transactions become faster and more transparent. This reduces the need for paper-based intermediation, thereby building trust and encouraging economic stakeholders to engage with the port on a more frequent basis. The adoption of digital transformation may render Algerian ports more attractive to global shipping lines that prioritise speed and transparency. Consequently, these ports would become the preferred choice for international companies, particularly given Algeria’s ambition to position its ports as alternative maritime logistics hubs.

The second hypothesis. The modernisation of infrastructure contributes to increasing the volume of export and import operations at Skikda Port Enterprise. This is achieved through the expansion of berths and the enhancement of reception capacities. The port enterprise has witnessed a series of expansion and modernisation projects, along with the provision of modern equipment for loading and unloading operations, which has improved the port’s carrying capacity and accelerated the turnover of goods. These upgrades have also helped reduce the turnaround time of ships and cargo, thereby encouraging economic operators to expand their export and import activities through the port. Based on the extent to which the sample agreed with the statements in the “Infrastructure Modernisation” section, plainly, the structural development of facilities and equipment has played a decisive role in improving the performance of Skikda Port. The sample expressed considerable agreement with the statement: “The port’s berths have been developed and equipped with advanced facilities to

accommodate modern ships”. This reflects respondents’ recognition of the importance of these works in increasing the port’s carrying capacity and improving the quality of services provided to vessels. In other words, the berths have been renewed in terms of structure and depth to accommodate large and modern ships. Technical upgrades and new equipment have increased the speed of handling operations and reduced waiting times, thereby strengthening the efficiency of the supply chain. The statement “There are advanced handling and unloading facilities that comply with international standards” also received a high level of agreement, indicating that the port is equipped with advanced facilities such as cranes and intelligent mooring systems. These enable the efficient and safe reception of modern vessels and accelerate loading and unloading operations. These works were part of a broader port modernisation project.

Regarding the statement “Storage areas have been expanded and organised in intelligent ways that ensure rapid access to goods”, this indicates that warehouse spaces and storage yards have been increased, and modern systems such as electronic coding and classification have been adopted. These facilitate the rapid location of goods and accelerate loading and delivery operations without delay or disorder. A relative improvement has been recorded in terms of reducing the time required for unloading and loading goods, and performance has become more competitive compared to the past. Furthermore, the presence of modern equipment on the berths and in cargo handling areas—such as new cranes and modern loading equipment—confirms that infrastructure modernisation is a tangible operational reality rather than a mere administrative declaration. It has clearly contributed to improving the productivity of operational processes and enhancing the port’s readiness to accommodate growing trade volumes. Accordingly, the survey results showed that the development and equipping of berths with modern handling equipment, together with the expansion of carrying capacity, have contributed to reducing vessel turnaround time and improving cargo flow. This substantiates the relationship between infrastructure modernisation and the stimulation of foreign trade. The modernisation of physical infrastructure—such as expanding and deepening berths and equipping them with modern handling equipment—enables the reception of larger vessels with reduced waiting times. This enhances port reliability and encourages economic actors to choose it over competing ports, while also reducing excess shipping costs.

The third hypothesis. Governance and the simplification of port procedures contribute to stimulating export and import operations at Skikda Port Enterprise. This is achieved through the administration’s adoption of a digital system that enables rapid coordination among various economic actors, the application of standardised protocols that ensure smooth operational execution and reduce errors and delays, the implementation of a strict policy for quality control and occupational safety, and real-time data exchange between authorities. Governance thus helps enhance transparency and reduce bureaucracy, thereby activating the flow of goods. Based on the extent to which the sample agreed with the statements in the “Governance and Simplification of Port Procedures” section, it was unmistakable that the majority of respondents believe that

improving management methods and work organisation within the port enterprise plays a significant role in enhancing its performance.

The statement “The port relies on digital management that ensures rapid coordination among economic actors” received a considerable level of agreement. This indicates that respondents are aware of the importance of coordination among various authorities-customs, police, and handling operators-in accelerating transactions and reducing administrative complexities. Digitisation has helped integrate systems and facilitate interaction among different stakeholders through the Port Community System (PCS), thereby supporting the principle of participatory governance based on real-time data and information sharing among actors (G-Serport, n.d.). Responses also showed a positive assessment of the statement “Modern governance contributes to enhancing transparency and combating bureaucracy within the port”. This suggests that the adoption of governance principles such as transparency, effectiveness, and accountability has positively affected the relationship between management and economic operators while reducing administrative obstacles. However, some reservations were expressed by operators, particularly regarding transparency and operational efficiency, indicating that the modernisation process has not yet fully translated into service quality.

Clearly, the adaptation process is still in its early stages. the absence of a smart inspection system represents a weakness in the technical governance framework, which hinders the smooth flow of exports and imports and delays operations despite efforts made in digitisation. Notwithstanding these challenges, the adoption of digital governance principles and the application of modern management tools have helped, to a certain extent, reduce administrative lead times, clarify responsibilities, and improve information tracking of files. This constitutes a step toward strengthening the port’s position within the foreign trade system. The survey results showed that the port enterprise relies on a digital administrative organisation and employs mechanisms to simplify procedures and accelerate services, which has led to a reduction in administrative obstacles and the enhancement of transparency.

● DISCUSSION

Skikda to manage port operations with a high degree of efficiency. The management of the facility relies on advanced electronic programs to monitor and track the flow of goods and containers in real time. According to A. Tei & C. Ferrari (2026), the use of advanced technologies such as artificial intelligence can enhance the capacity to improve systems and serve as an effective tool for monitoring and intervention when necessary, thereby producing a tangible impact on the port sector. Modern electronic gates are also available, which serve to accelerate the completion of customs and administrative procedures for importers and exporters. Economic operators are now able to use specialised digital platforms to declare goods and submit documents remotely. These technologies have enhanced transparency and reduced customs clearance times, eliminating the need for physical travel to the port. The adoption of smart technology has further contributed to a notable reduction in operational costs. This aligns with F. Russo & G. Musolino (2022)

conclusion, namely that the availability of emerging information and communication technologies in transport enables ports to reduce costs.

Expenditures on manual labor, paper-based processes, and human errors have decreased as a result of automation and digitalisation. In addition, fuel consumption and truck waiting times have been lowered through electronic system integration. And this is what O. Belcore & A. Polimeni (205) addressed, through an examination of the use of technology in port terminals, by applying it across all the stages that characterise a port call and the calculation of ship turnaround time. These gains have rendered the port more competitive and have attracted increased trade flows through it. Thus, digital systems emerge as a fundamental pillar for achieving a more efficient and sustainable port economy at Skikda port. The port’s berths have been developed and equipped with advanced facilities to accommodate modern ships. Advanced handling and unloading equipment that complies with international standards is available. Storage areas have been expanded and organised in intelligent ways that ensure rapid access to goods. The port is equipped with smart devices for monitoring temperature, humidity, and secure shipping. The port’s current infrastructure capacity is proportionate to the growing volume of maritime trade. Taken together, these features indicate that the port has undergone a comprehensive infrastructural upgrade, aligning its physical and technological assets with both international benchmarks and the demands of expanding trade flows. The integration of smart monitoring systems alongside expanded, intelligently organised storage zones further enhances operational efficiency and cargo security. Consequently, the port appears well-positioned to sustain its responsiveness to increasing maritime traffic without immediate capacity constraints. H. Akyıldız *et al.* (2026) contended that the development of seaports enhances competitiveness in the global maritime sector by promoting efficient, sustainable, and strategically managed port operations.

The port relies on digital management that ensures rapid coordination among economic actors. Port management follows a clear policy for quality control and occupational safety. Operations are carried out according to standardised protocols to avoid delays and human errors. Real-time data exchange is enabled among various authorities (customs, police, handling operators). Modern governance contributes to enhancing transparency and combating bureaucracy within the port. D. Sumarno *et al.* (2026) contended that the relationship between governance arrangements can be understood as part of a port development system, specifically through the application of a collaborative governance framework. Furthermore, governance can facilitate the development of logistics and transport services more broadly, particularly in developing countries and in Africa. This has the potential to bring about a paradigmatic shift toward participatory and inclusive governance of institutions (Daudet, 2025). Development projects should not be limited to technology or infrastructure alone, but must also encompass individuals by way of institutional relationships and mechanisms for workforce participation in port development. The sustainability of ports should form part of port performance evaluation, as the management of Environmental, Social, and Governance (ESG) criteria in ports can enhance sustainable development (Makkawan *et al.*, 2025).

The development of seaports has contributed to reducing export lead times to foreign markets, as improving port services is considered an important factor in enhancing the competitiveness of Algerian products internationally. The availability of modern port infrastructure has attracted foreign investors for both export and import activities, This is what M. Karthik & O. Dubey (2024) addressed, namely that the development of competitiveness depends on infrastructure. The author found that the added value within India's logistics system plays a dominant role in enhancing and diversifying the export structure of a developing country such as India, while the effectiveness of customs operations has directly influenced the quality of foreign trade. Digitisation in ports has facilitated the tracking of goods at the international level, and the presence of modern equipment enhances the smooth flow of exports and imports. Furthermore, the availability of real-time trade information supports rapid decision-making regarding cross-border transactions. The level of coordination among port stakeholders improves the efficiency of the international supply chain, and fast, flexible port procedures effectively accommodate the needs of foreign operators. Ultimately, the improved performance of Algerian ports encourages the entry of new products into foreign markets. The studies of B. Sun & R. Kauzen (2023) and A. Sahoo *et al.* (2025) have demonstrated a direct relationship between seaport infrastructure and the economy, as improving seaport infrastructure can maximise its potential for international trade and economic growth.

In light of the findings obtained from the study, it is recommended to establish partnerships with advanced foreign institutions in order to benefit from their expertise in port management and modernisation. Skikda Port Enterprise should demonstrate a stronger commitment to education and continuous training by developing periodic training and capacity-building programs for employees in the fields of logistics and information technology, the port infrastructure must be improved to align with the requirements of modern vessels and the prevailing volume of commercial activity. Digitisation should be generalised across various port activities in order to accelerate administrative procedures and enhance transparency in port operations, fees related to port services should be reduced in a manner consistent with their quality and efficiency, thereby enabling the port to compete effectively with foreign ports and attract international vessels. And efforts should be made to develop ports so that they can accommodate the growing commercial traffic between Algeria and other countries. This can be achieved through the construction of specialised ports equipped with all necessary facilities, machinery, and storage areas to serve shipping, unloading, and warehousing operations.

● CONCLUSIONS

The modernisation of seaports in Algeria contributes to stimulating the foreign trade sector by improving the competitiveness of Algerian products in the international market and facilitating export and import operations. It also leads to a reduction in both the costs and the duration of commercial procedures, while enhancing the attractiveness of Algerian ports in drawing foreign economic partners. Based on the extent to which the sample agreed with

the statements in the "Promotion of the Foreign Trade Sector" section, it became evident that port modernisation at Skikda Port Enterprise has effectively contributed to improving the quality of external commercial performance. The results showed considerable agreement with the statement "The development of seaports has contributed to reducing export lead times to foreign markets", (mean = 3.8875, standard deviation = 0.65591). reflecting a clear awareness of the role of upgrades in accelerating operations and facilitating access to international markets. This means that improving and equipping ports with modern facilities and technologies has helped speed up cargo shipping procedures and complete formalities, thereby reducing the time goods take to reach foreign markets.

The port is considered relatively advanced compared to some other national ports, yet it still requires additional developments to meet international standards. The survey results also indicated that improving port services represents an important factor in enhancing the competitiveness of Algerian products in the international market, particularly with the introduction of advanced handling equipment and the presence of effective digital platforms. This contributes to cost reduction, faster processing, and increased satisfaction among foreign operators. In other words, it directly helps accelerate operations and reduce both the costs and time required to export products, making them more attractive and their prices more competitive in global markets. The more efficient and reliable port services become, the greater the ability of Algerian products to compete effectively against those of other countries, thereby strengthening their presence in international markets. However, there are currently no active partnerships with foreign ports, which represents one of the weaknesses that could be addressed in the future.

The results have demonstrated that modernisation projects at Skikda Port Enterprise, particularly in terms of digitisation and infrastructure improvement, have positively impacted the effectiveness of export and import operations while reducing time and costs. This, in turn, enhances the competitiveness of Algerian products in the international market. Future research could extend the present survey study by adopting a longitudinal approach to examine how the ongoing modernisation of Algerian seaports dynamically influences export and import facilitation over time. Comparative studies across multiple Algerian ports would help identify which modernisation dimensions (e.g., digital governance, infrastructure upgrading, or customs automation) yield the most significant reductions in lead times and transaction costs.

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● CONFLICT OF INTEREST

None.

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Дослідження модернізації морських портів Алжиру як чинника сприяння експортно-імпортним операціям

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Анотація. Модернізація морських портів стала стратегічною необхідністю в сучасній глобальній економіці, що зумовлено прискоренням процесів глобалізації та сталим зростанням обсягів міжнародної торгівлі. Оскільки морський транспорт залишається основою світової торгівлі, ефективність і здатність портової інфраструктури оперативно реагувати на зміни безпосередньо впливають на торговельну конкурентоспроможність країни. З огляду на ці тенденції метою дослідження було визначити роль модернізації морських портів Алжиру як ключового чинника сприяння експортно-імпортним операціям. Для досягнення поставленої мети застосовано кількісну методологію дослідження з використанням структурованої анкети, яку було запропоновано вибірці з 80 працівників портового підприємства Скікди в Алжирі. У дослідженні проаналізовано внесок модернізації портів у спрощення зовнішньоторговельних операцій за трьома окремими, але взаємопов'язаними напрямками: упровадження та інтеграція інформаційно-комунікаційних технологій, розвиток і модернізація фізичної інфраструктури, а також спрощення структур управління та процедурних процесів. Проаналізовано, як кожен із цих напрямів окремо та в сукупності впливає на ефективність і результативність експортних та імпортних операцій. Респонденти загалом позитивно оцінили всі досліджувані напрями, зокрема інформаційно-комунікаційні технології ($M = 3,8350$; $SD = 0,52171$), управління та спрощення процедур ($M = 3,7000$; $SD = 0,60713$), а також розвиток інфраструктури ($M = 3,5925$; $SD = 0,64234$). Загальне середнє значення показника сприяння експортно-імпортним операціям становило 3,8270. Крім того, анкета продемонструвала належні психометричні характеристики: коефіцієнти альфа Кронбаха варіювалися від 0,769 до 0,879, що свідчить про прийнятну та високу внутрішню узгодженість. Зазначені вдосконалення супроводжувалися помітним скороченням тривалості оброблення операцій та операційних витрат. З практичного погляду дослідження надає портовим адміністраціям, менеджерам у сфері логістики та представникам органів державної політики емпіричні докази відчутних і вимірюваних переваг, пов'язаних зі стратегічними інвестиціями в модернізацію портів

Ключові слова: модернізація портів; цифрова трансформація; спрощення процедур торгівлі; портова інфраструктура; управління

Mechanisms for overcoming departmental barriers in the digitalisation of ethno-national policy: From “information silos” to integrated governance

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Abstract. The purpose of the study was to identify management models that can ensure consistent data exchange in the context of digital transformation of the public sector. The methodology was based on an interdisciplinary combination of tools of public administration, digital governance, analysis of information systems, and ethno-political studies, which allowed tracing the features of the functioning of state registers, mechanisms of interdepartmental interaction, and data management practices during 2015-2025 through comparative analytical and institutional approaches. The results of the study showed that “information silos” in ethno-national policy are formed through the differentiation of competencies between statistical, migration, educational, and security institutions. Comparison of national models showed that the Ukrainian digital governance system ensured the development of service platforms (dozens of registries were integrated through the Diia system, the number of users exceeded 21 million, and the Trembita platform processes millions of transactions every month), but has not formed a complete analytical consolidation between state registers. It was established that the centralised control model of China provides a high speed of analytical processing of information (more than 90% of large cities have implemented elements of smart city governance), but is accompanied by risks of excessive digital control and strengthening of supervisory functions of the state. Estonia's experience has shown that the combination of interoperability, cryptographic protection, and transparent audit of data access creates a more balanced system of interagency coordination: more than 1,000 organisations and more than 3,000 services interact through the X-Road platform, and 87.59% of the population uses electronic public services. The study confirmed that the regulation of personal data protection simultaneously performs the function of legal protection and becomes a factor of institutional isolation between state structures. The study found that overcoming information fragmentation in the field of ethno-national monitoring requires a transition from a model of data accumulation by individual departments to a management system based on standardised exchange protocols, unified metadata, and access audit mechanisms. The practical significance of the results lies in the possibility of their use by public authorities, digital governance structures, analytical centres, and developers of state information systems for the development of safe models of interdepartmental data exchange in the field of ethno-national policy and public administration

Keywords: personal data protection; interoperability; once-only principle; predictive management; federal data management

INTRODUCTION

The expansion of digital infrastructures in the public administration system is accompanied by an increase in data sets and an aggravation of contradictions between the subjects of power responsible for the accumulation,

processing, and use of information resources. This is clearly manifested in ethno-national politics. The need to harmonise demographic, migration, language, social, and security registers complicates management processes, since

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such systems operate within different administrative models and are regulated by different regulatory regimes. The introduction of digital public administration platforms has not eliminated the disunity of information flows. On the contrary, the autonomy of departmental databases, the asymmetry of technological updates, and the incompatibility of classification approaches in some cases contributed to its strengthening. Under these circumstances, interagency data exchange in the field of ethnic and national monitoring remains isolated even with high rates of service digitalisation. An additional factor is the combination of cybersecurity requirements, personal data protection, and analytical integration, which creates a contradiction between system interoperability and privacy modes. The development of algorithmic tools for state analytics has also updated the risks of reproducing administrative inequalities of historical origin when working with sensitive ethno-national data. The problem of “information silos” has acquired an institutional scale. Its content covers the managerial, legal, analytical, and political dimensions of the functioning of the digital state.

In the systematic review of N. Mendoza Castaneda (2026), coordination violations in the field of public policy were interpreted as a consequence of systemic institutional fragmentation and the existence of “information silos”. The study showed a high level of spread of such phenomena. More than 80% of the analysed studies recorded gaps between information structures of public administration, while stable interdepartmental interaction was traced in less than a third of collaborative practices. The established link between coordination failures and the management fragmentation architecture formed the basis for further analysis of the issues of “data silos” in the public sector. D.V. Thanh (2024) examined changes in research approaches to the investigation of ethnic diversity in the digital age. The researcher proved that digitalisation of ethno-national policy transforms not only the administrative tools, but also the methodological foundations of working with information about indigenous peoples and ethnic minorities. The author’s argument was based on the need to use a variety of research approaches that can combine technological means with the requirements of cultural sensitivity and ethics. K. Oldbury (2022) described digital mobility platforms as a factor in changing urban governance models. The analysis showed that the integration of platform services led to a revision of the boundaries between physical and digital infrastructure, as a result of which traditional regulatory mechanisms lost some of their effectiveness. Another pattern has also been identified: platform piloting processes hide the real scale of power and technological dependencies between public and private actors.

The legal basis of ethno-national policy through the prism of international standards for the protection of the rights of national minorities and indigenous peoples was investigated by A.V. Panov (2023). The materials of the Balkan states helped to identify the trend of expanding models of autonomous communities as a tool for maintaining the stability of the multicultural environment. The results obtained showed that the effectiveness of ethno-national policy is determined not only by the quality of legal norms, but also by the state’s ability to ensure the

integration of socio-cultural groups into the public administration space. N. Odinka *et al.* (2022) proposed the interpretation of regulatory requirements as an element of strategic management of infrastructure projects. It was established that the combination of information systems with strategic planning mechanisms reduces the likelihood of conflicts between project participants and contributes to strengthening institutional trust. The conclusion formulated by the authors expanded the understanding of data governance, taking it beyond technical optimisation. The study by O.S. Sunday & O.O. Awoyomi (2026) analysed interagency data integration based on materials from federal social assistance programmes in the United States. None of the existing integration models – centralised, federated, or predictive analytics – provided simultaneous scalability, transparency, and an appropriate level of privacy. The solution proposed by the authors involved the use of a hybrid model that combines centralised control with federal analytics when working with sensitive information.

J. Guan (2025) developed a multi-level medical data management concept that clearly distinguishes between data management and data management. Technical compatibility of information systems does not guarantee effective information exchange. Consistency of legal norms, ethical principles, and the distribution of roles among stakeholders is crucial. The results of the study showed the dependence of the stability of data exchange systems on institutional design and its integrity, and not just on the level of technological renewal. The geopolitical dimension of data management in relations between the EU and China was the subject of analysis by C. Nalbantoğlu (2022). The researcher showed that differences in approaches to access and control over data form political conflicts along with technical contradictions in the field of cyberspace. The involvement of civil society institutions in digital policy development has helped to reduce confrontational risks and create more balanced cyber governance models. M. Matteby (2025) explored the digital transformation of inter-municipal cooperation as a process of institutional entrepreneurship. An increase in the risk of forming unstable or “stillborn” institutions in the conditions of concentration of managerial functions in a narrow circle of actors is established. The effectiveness of digital transformation was associated with the gradual involvement of a wider range of participants in the development of common norms and practices of interaction. Despite the number of studies on digital governance, interagency integration, and data management, the specifics of “information silos” in the field of ethno-national policy as a complex combination of institutional, regulatory, semantic, and cybersecurity barriers remained insufficiently conceptualised. The purpose of the study was to identify the structural features of “information silos” in the system of ethnic and national monitoring to overcome interdepartmental fragmentation in the context of digital governance.

● MATERIALS AND METHODS

The research was carried out within the framework of an interdisciplinary approach that combines the tools of public administration, digital governance, data governance, ethno-political studies, and information systems analysis. The choice of chronological boundaries of 2015-2025 was

conditioned by the fact that this period covered the active phase of digital transformation of the public sector, the development of interoperability, the spread of AI analytics in public administration, and the institutionalisation of integrated databases in the EU, North America, and Asia. For individual cases, retrospective data were used to explain the genesis of digital systems, in particular regarding, the 2001 Ukrainian population census (Smutchak *et al.*, 2025), the EU migration crisis of 2015-2016 (European Migration Network, 2020), cyber attacks on Estonia in 2007 (Ansari, 2025), and the evolution of federal data management in the United States (U.S. Department of Education, 2026).

The methodological basis of the study was a systematic approach used to analyse public administration as a set of interrelated information, regulatory, and institutional contours. System analysis was used to treat digital registries, interoperability mechanisms, API architectures, interagency analytical platforms, and predictive management algorithms as elements of holistic data-based management architecture, rather than as isolated technological solutions. Through this approach, the interdependence between the structure of state information systems and the effectiveness of ethnic and national monitoring was investigated. The method of functional and structural analysis was used to assess interdepartmental barriers to digitalisation of ethno-national policy. It was used in the development of a comparative classification of organisational, regulatory, technical, analytical, cybersecurity, semantic, and political institutional barriers. The materials for the analysis were selected by the European Commission (n.d.), General Data Protection Regulation (2016), Organisation for Economic Co-operation and Development (2019). The criteria for the analysis were: the level of interagency coordination, the degree of regulatory compatibility of data access modes, metadata governance standards, the level of integration of API solutions, the scale of data duplication, the presence of unified dashboards, and the ability to anticipatory governance. The analysis was carried out by comparing the manifestations of each type of barrier, its institutional consequences, and impact on the monitoring of ethno-social processes.

A comparative analysis of national digital governance and data management models was used to compare data governance architectures and integration models of government information systems. The main comparative analysis was carried out on the example of three countries that represent different types of digital governance: Estonia (interoperability-oriented governance with decentralised registries and standardised data exchange via X-Road), China (centralised control model with integration of AI analytics, predictive governance and social monitoring systems), and Ukraine (a transition state with a fragmented registry architecture and accelerated digital transformation after 2022). In addition, individual examples from the United States, Canada, France, and Finland were used for analytical context, illustrating the features of federal data management, federal management architecture, and inter-state interoperability. The comparative method was used to compare models of digital ethno-national governance in Ukraine, China, and Estonia. The comparison criteria were: data architecture, integration model, the degree of implementation of the once-only principle, the level of

application of artificial intelligence (AI) and predictive management, digital maturity of the public sector, the data access control model, the level of personal information protection, crisis resistance, structural problems of the system, and the potential of ethno-national monitoring. The comparative model drew on material from the Delegation of the European Union to Ukraine (2021), the Ministry of Digital Transformation of Ukraine (2024) and the European Commission (2024). They were also at the heart of the analysis by S. Marak (2025) and China Academy of Information and Communications Technology – CAICT (2026). The comparison was carried out on the principle of cross-case analysis with the identification of structural differences between centralised, fragmentary, and interoperability-oriented models.

The policy analysis method was used to analyse the regulatory framework for digital governance and personal data protection. Within this stage, the European Interoperability Framework (European Commission, n.d.), General Data Protection Regulation (2016), EU Artificial Intelligence Act (2021). The crisis management analysis method was used to assess the effectiveness of interdepartmental integration during periods of migration, humanitarian, and security crises. For this purpose, materials were used by the European Migration Network (2020), Organisation for Economic Co-operation and Development (2023), International Organization for Migration (2025), Ontario Community Health Profiles Partnership (n.d.), Statistics Canada (2024; 2025). The problems of multiple registration of individuals, delays in interagency information exchange, difficulties of real-time monitoring, and the effectiveness of integrated analytical platforms in crisis conditions were analysed. Source processing methods included content analysis, topic grouping, critical matching, secondary data analysis, and comparative synthesis.

● RESULTS

Theoretical and institutional foundations for overcoming interdepartmental barriers in digitalisation of ethno-national policy

The concept of “information silos” in the theory of public administration and information systems comes from organisational science and corporate management, where it referred to isolated divisions that accumulate data without their horizontal integration. In the public sector, the term has acquired analytical meaning in the context of digital transformation of governance and data-based governance. In the theoretical dimension, “information silos” is considered as a consequence of the institutional differentiation of the state, where each administrative unit functions as a relatively autonomous decision-making system and, accordingly, forms its own information infrastructure (Jeel-Ojuade, 2024). From the standpoint of the theory of organisational cybernetics, such autonomy creates the effect of “information entropy” – an increase in the uncertainty of management decisions due to the lack of an integral information field (Parizek, 2013).

For ethno-national policy, the problem of information fragmentation is important. Analysis of ethnic processes requires a combination of data of different nature. Demographic trends, migration movements, characteristics of the linguistic environment, socio-economic indicators,

and security parameters form a single field of factors, the interaction of which determines the dynamics of ethno-social changes. In the absence of integrated access mechanisms, public administration relies on disparate information arrays, which limits the possibility of holistic interpretation of processes in a multiethnic environment. The reason lies in the distribution of competencies between different sectors of the state apparatus. Population and migration changes are the responsibility of demographic services, information on language practices and access to education is concentrated in educational institutions, indicators of integration of socially vulnerable categories of the population are accumulated by social authorities, while security structures monitor radicalisation and interethnic tension. Functional specialisation ensures the division of powers. In a digital environment, such an organisation is accompanied by the development of isolated information contours, which is why issues of interoperability and interagency use of data become central, rather than the mere accumulation of data (Organisation for Economic Co-operation and Development, 2019).

The assessment of ethnic mobility, linguistic transformation or the level of integration of minorities is beyond the scope of a separate registry. This is where the consequences of information disunity manifest themselves. Data on internal migration, when taken in isolation from educational and social contexts, are insufficient to determine the nature of the adaptation of displaced ethnic groups or to track changes in the linguistic environment at a local level. Such restrictions arise when analysing the birth rate or employment, if the corresponding indicators do not correlate with the ethno-demographic characteristics of the population. Long-term forecasting under such conditions loses the necessary level of reliability. Simultaneously, the problem is not limited to a lack of information. Differences in classifiers, accounting methods, and the frequency of updating information give rise to statistical discrepancies between state registers. The same accounting object may receive different identification parameters depending on the departmental system. Incompatibility of personal data recording standards exacerbates these difficulties. For example, the use of different first and last name recording formats makes it impossible to automatically compare information between migration, educational, and social databases (Van Rossem & Pelizza, 2025).

The impact of information fragmentation is not limited to the analytical dimension. The consequences are also reflected in the speed of development of management decisions. This dependence is clearly manifested during crisis processes related to mass migration, humanitarian movements of the population, or the aggravation of the ethno-political situation. In the absence of an integrated information environment, state institutions lose the ability to quickly form an analytical picture of events. The migration crisis of 2015-2016 in the EU countries demonstrated the consequences of a lack of interoperability of databases and insufficient digital processing of information, which made it difficult to verify information and contributed to multiple registration of the same persons (European Migration Network, 2020). Similar difficulties were found during the COVID-19 pandemic. According to the Organisation for Economic Co-operation and Development (2023), 50%

of ministries in the Czech Republic recorded problems with collecting information to support urgent management decisions. The determining factors were the technical incompatibility of data and the lack of sustainable practices of interdepartmental information exchange. The non-integration of migration, social and medical registers form a time gap between the emergence of a crisis phenomenon and the state's response. This makes it more difficult to assess the scale of ethno-demographic changes and narrows the possibilities for preventing social tensions.

After that, the European management discourse focused on "whole-of-government data governance" and integrated digital platforms. For example, Finland has a system Suomi.fi Data Exchange Layer (Digital and Population Data Services Agency, 2022), integrated with Estonian infrastructure within the X-Road Trust Federation. Organisation for Economic Co-operation and Development (n.d.) considers this case as the first example of an interstate federation of digital ecosystems, where government agencies of both countries exchange data on population, business, and tax processes in real time. For ethno-national governance, this model takes place in the context of cross-border population mobility, labour migration, and multicultural regions. In Canada, the problem of fragmentation of government data is primarily related to the federal governance structure. Provinces have autonomy in the areas of social policy, healthcare, and education, which makes it difficult to build a single information space. That is why the Canadian model focuses not on centralising databases, but on creating compatibility standards and coordination mechanisms between government levels (Marcovitch & Moffatt, 2024). This approach is defined in the literature as a "federal management architecture", where there is not control over data, but standards for their exchange (Dudoit *et al.*, 2026).

In the United States, the problem of "information silos" is conventionally viewed through the prism of federal data management. After the adoption of the Foundations for Evidence-Based Policymaking Act and Federal Data Strategy (U.S. Department of Education, 2026) US government agencies have begun to move to an integrated data management model focused on interagency analytics. It is ethnic and migration data that remains one of the most complex segments due to different methods of collecting information between the Census Bureau, the Department of Homeland Security, the Department of Education, and social services. For example, the Census Bureau uses 1,500 detailed racial categories, while Department of Homeland Security uses only aggregated groups in immigration forms, which makes it impossible to directly compare data (Congressional Asian Pacific American Caucus, 2023). Another example is that social services and health systems have barriers to systematically collecting information about a patient's race, in particular non-standardised categories and limitations of information systems, making it difficult to analyse racial disparities (Institute of Medicine, 2009). International experience shows that overcoming "information silos" in the field of ethno-national policy requires a transition from the departmental logic of data accumulation to the "governance-based data management" model. Its characteristics include standardised interoperability, unified access protocols, digital

identification, data usage audit, and the creation of unified analytical environments (Dudoit *et al.*, 2026). In the absence of such mechanisms, digitalisation does not eliminate the fragmentation of public administration, but only

translates it into a new technological form. The specific types of interagency barriers that arise as a result and their impact on the effectiveness of public administration are shown in Table 1.

Table 1. Types of interdepartmental barriers to digitalisation of ethno-national policy and their impact on the effectiveness of public administration

Barrier type	Manifestations in the public administration system	Institutional implications for ethno-national policy	Impact on the quality of monitoring of ethno-social processes
Organisational	Autonomous functioning of ministries and agencies; lack of a single coordination hub; duplication of functions between statistical, migration, educational, and social structures; different information update cycles	Development of parallel systems for managing ethno-political processes; low speed of interdepartmental coordination; lack of a unified crisis response model	Fragmentary tracking of changes in the language, migration and social structure of the population; delay in identifying regional hotbeds of social tension
Regulatory and legal	Different legal modes of access to personal data; lack of uniform data governance standards; restrictions on interdepartmental transfer of sensitive data; contradictions between the legislation on digitalisation and privacy protection	Slowdown of the integration of registries; administrative isolation of individual databases; development of “closed” information contours	Incomplete access to data on ethnic, linguistic, and migration groups; limitations on building integrated models of social integration
Technical	Incompatibility of data formats; different metadata standards; lack of API architecture; use of outdated local systems; lack of interoperability layer	High costs for manual integration of information; dependence on departmental IT solutions; low scalability of digital platforms	Statistical discrepancies between registries; duplication of records; inability to generate real-time monitoring systems
Analytical	Lack of unified dashboards and predictive analytics systems; isolation of statistical and social databases; weak use of AI and Big Data analytics	Predominance of reactive rather than predictive management; limited capacity of the state for predictive governance	Inability to predict interethnic risks, migration changes, and territorial concentration of social vulnerability
Cybersecurity	Different standards of cybersecurity governance between departments; low level of synchronisation of security systems; risks of unauthorised access to sensitive data	Distrust between authorities on information exchange; slowdown of digital integration	Restriction of access to real-time data; reduction of analytics completeness due to access segmentation
Semantic	Different criteria for classifying ethnic, linguistic and migration categories; different methods of statistical accounting	Incompatibility of indicators between state institutions; difficulties of international comparative analysis	Distortion of the assessment of the size and social status of individual ethnic groups
Political and institutional	Competition of government bodies for control over data; use of information resources as an element of bureaucratic influence	Slowdown of interoperability reforms; development of an “information monopoly” of individual departments	Incomplete integration of state analytics; fragmentation of policymaking

Note: IT – information technology

Source: compared by the author based on General Data Protection Regulation (2016), European Commission (n.d.), Organisation for Economic Co-operation and Development (2019), A.Z. Spyropoulos & V. Tsiantos (2025), A.N. Kasiwi *et al.* (2025), W. Van Rossem & A. Pelizza (2025)

The analysis of barriers has shown the multidimensional fragmentation of state registers in the field of ethno-national policy. The sources of the problem go beyond the technological characteristics of the digital infrastructure. The division of departmental powers is combined with differences in regulatory regulation of access to information, and the lack of general requirements for interoperability increases the isolation of information contours. Even in countries with developed digital services, the accumulation of large amounts of information does not ensure the development of a single analytical space. The data exists in parallel. For ethnic and national monitoring, this situation is important, since the analysis of migration mobility, language changes, and the level of social integration requires the simultaneous use of demographic, educational, social, and security registers. The origins of these restrictions are related to the history of the development of state information systems. Their creation took place in different periods and under the influence of departmental priorities. The

result was heterogeneity of the architecture, information classification principles, and information exchange procedures. After a large-scale digital modernisation of migration, demographic and social services in the EU countries during the 2010s, the problem took on a new scale: individual information resources began to duplicate identical arrays of information without automated matching mechanisms (Szymańska, 2018). In this context, the European Interoperability Framework considers interoperability as a set of several interrelated levels – legal, organisational, management semantics, and technical interaction (European Commission, n.d.). The subject of standardisation covers not only the structure of information, but also the rules of access, use procedures, and distribution of responsibility between participants in information exchange.

A certain complexity is created by combining the integration of registers with the requirements for protecting personal information. Ethno-national data is classified as sensitive data because it contains information about ethnic

origin, linguistic identity, religious affiliation, or migration status. The General Data Protection Regulation (2016) refers ethnic and racial characteristics to special categories of personal data for which a separate legal processing regime and enhanced protection mechanisms are established. The practice of EU states demonstrates the mixed consequences of this approach. In France and Germany, restrictions on the collection of ethnic information limit the possibilities of statistical analysis of migrant integration and research on structural discrimination. The French tradition of republican universalism has long held back the official accumulation of ethno-racial statistics, which has become the subject of scientific discussion on assessing social inequality (Léonard, 2023). Canadian practice shows a different model. Statistics Canada (2025) uses advanced collection of demographic diversity data, combining it with anonymisation procedures and controlled access mode through the Research Data Centres network. There is an institutional contradiction. The desire for integrated digital monitoring is accompanied by restrictions on interagency information exchange due to the high requirements of privacy protection. Under such conditions, cybersecurity and legal protection mechanisms perform not only a security function, but also the function of delineating information spaces. This issue became one of the central issues during the implementation of European Health Data Space in 2022-2024, when EU member states expressed reservations about the cross-border use of sensitive personal information even in the presence of standardised digital protection tools (de Frutos Lucas & Haugo, 2024). Similar challenges are typical for the ethno-political sphere.

The search for a balance between secure information exchange and registry integration has led to the development of new models of digital interaction. An example is the Estonian X-Road platform. Its architecture does not provide for centralised accumulation of information. Interaction between autonomous registries is provided through digital authentication, cryptographic protection, and a system for registering information requests. A digital trace is generated for each operation. A citizen gets the opportunity to control access to their own personal data by state bodies. It is on this basis that the once-only principle is implemented, which excludes repeated requesting of information already available in state registers. The API architecture also performs a similar function. Its use provides automated interaction between different systems without the need for complete unification of the internal structure of platforms. Such a mechanism has become relevant in countries where digital infrastructure has been formed during various technological stages. Finland applies Suomi.fi Data Exchange Layer for integrating municipal and central public services without creating a single super register (Digital and Population Data Services Agency, 2022). The advantage of the model is the ability to gradually connect new information resources without large-scale restructuring of the digital architecture of the state.

Technological compatibility alone does not eliminate management constraints. The availability of state analytics tools is becoming crucial. Without them, even large information arrays remain a collection of isolated resources that are not suitable for forecasting and strategic planning. That is why integrated analytical platforms

focused on combining data from different registries within a single solution support environment have become widespread in Organisation for Economic Co-operation and Development (2023) countries. The Canadian experience demonstrates the practical effectiveness of this approach. Statistics Canada (2024), together with the Canadian Centre for Justice and Community Safety, uses integrated demographics, migration and social information to identify regional vulnerabilities and assess inequalities in access to public services among Indigenous communities and migrant populations. For the sphere of ethno-national policy, the importance of such mechanisms is determined by the interaction of demography, socio-economic development, and security. In the absence of cross-sectoral interaction, state information resources do not form a holistic analytical environment necessary for developing sound management decisions.

Cross-sectoral interaction algorithms change the architecture of relationships between central and regional government structures. Traditional bureaucratic systems operated through vertical channels. Regional administrations sent data up. Based on the information received, the centre made a decision. Digitalisation breaks the old hierarchy and current coordination is determined by horizontal connections. Local authorities, educational institutions, social services and security structures have direct access to analytical platforms. The transformation in the United States is evidenced by the Federal Data Strategy and the work of shared governance frameworks for social risk analysis (Seo & Kwon, 2023). Individual states have launched integrated databases that combine migration, social, and educational indicators to assess inequality and segregation. The concept of "evidence-based governance" has received a technological foundation in the form of interdepartmental think tanks and unified dashboards. The main task of the tools is to visualise information to speed up the management response (Balabukha, 2026). The experience of the city of Sonnam in South Korea serves as an indicator of effectiveness. There, the authorities combined tax, administrative, and mobile data, which made it possible to quickly identify the locations of potential crises (Jung, 2020). The Canadian project Ontario COVID-19 Heterogeneity compared medical statistics with the results of the population census (Ontario Community Health Profiles Partnership, n.d.). The unified dashboards application provides automatic updating of indicators in real time. The new approach minimises time delays between the appearance of a problem and the actions of officials (Kulkarni *et al.*, 2025). The described technologies are of strategic importance for border areas, internal migration zones, or areas with high social polarisation.

Scaling artificial intelligence in public administration raises risks of institutionalising algorithmic bias. The problem is acute in areas with high socio-ethnic sensitivity. Programmes of the predictive systems class analyse old statistics. As a result, mathematical models copy and consolidate historical forms of discrimination. Migration service databases, social assistance registers, and police archives contain errors, as different groups of the population had unequal access to services or were subjected to excessive control. Artificial intelligence perceives mathematical correlations as real causal relationships. Therefore, there is

a dangerous phenomenon – statistical induction of risk for individual ethnic communities. An example was the Correctional Offense Management Profiling for Alternative Sanctions system in US legal proceedings. The algorithm produced false predictions of relapses due to the defendant's race, leading to large-scale academic criticism of risk scoring models (Klarmann, 2025). A similar situation has developed in the UK due to the predictive policing system from Metropolitan Police Service. Mathematical risk assessment tools automatically increased the number of patrols in minority neighbourhoods. This is how the vicious circle, or “feedback loop”, works – the programme requires increased attention to the area based on previously collected reports, which it itself provoked (dos Santos, 2025). During 2022–2024, the topic of racial bias in algorithms was analysed by the British Parliament during the development of the Public Authority Algorithmic and Automated Decision-Making Systems Bill of the UK (2024).

In the plane of ethno-national policy, this mechanism causes ambiguous consequences. Analysing migration mobility, receiving social benefits, or accessing education through forecasting systems without considering contextual variables (economic inequality, regional deprivation, or military movements) poses a danger. Under such conditions, there is a risk of reducing complex social processes to group statistical features. This approach lays the foundations for digital discrimination, because management decisions begin to rely on probabilistic models of group behaviour instead of analysing individual characteristics of a person. Regulatory counteraction to such threats is unfolding simultaneously at the level of the EU and individual countries. The main tool is the EU Artificial Intelligence Act (2021). The document introduces a risk-based classification of AI systems. The regulation explicitly classifies programmes that can influence access to social rights or assess citizens' risks as high-risk AI systems. Developers of such software should ensure data transparency, algorithm explainability, human oversight, and regular audit. The assessment of new approaches indicates a profound transformation of the concept of intelligent public administration.

Early GovTech models (2010–2018) aimed mainly at optimising the speed of array processing and automating services (Charalabidis *et al.*, 2019). The current stage (2021–2025) develops around a clear triad: analytical efficiency, ethical regulation, and algorithmic accountability (Wang *et al.*, 2026). Cross-sectoral interaction algorithms create a new architecture for public administration. Within the updated system, information is transformed into a tool for predictive coordination, leaving the function of ordinary administrative accounting in the past. However, the success of innovation is determined not only by the technological parameters of Big Data or AI analytics. Interoperability standards, the level of interagency coordination, the accuracy of primary data, and the effectiveness of mechanisms to prevent digital discrimination play a crucial role. In the absence of such conditions, predictive management may not reduce social risks, but institutionalise them digitally.

Comparative analysis of models of integrated digital management of ethno-national policy

The fragmentation of state registers in Ukraine has arisen as a result of the long-term institutional autonomy of

government bodies. Digital systems were developed for the specific functional needs of individual departments, and not as elements of a single public administration architecture. In the plane of ethno-national policy, this problem becomes of maximum complexity. Monitoring of ethno-social processes requires a simultaneous combination of demographic, migration, educational, social, and territorial information arrays. But the Ukrainian model of digital administration has long been based on the departmental principle, in which each institution functioned exclusively within its own information contour. The contemporary system of collecting and analysing ethno-demographic information in Ukraine has a high level of institutional disunity. There is no proper integration between the State Statistics Service, the State Migration Service, the Ministry of Education and Science, the Ministry of Social Policy, the Ministry of Digital Transformation, and local self-government bodies. Each structure operates with isolated registers that reflect only a separate fragment of the general ethno-social situation. The State Statistics Service accumulates demographic indicators. The State Migration Service controls migration processes and document flow. The Ministry of Education and Science records language and educational indicators. The Ministry of Social Policy is responsible for data on social support and internally displaced persons. The organisational isolation of departmental databases blocks the possibility of comprehensive risk forecasting. Simultaneously, there were no stable mechanisms for automated data exchange and unified interoperability standards between these systems for a long time (Sarioglu & Korzhunova, 2026).

An additional factor complicating the situation was the long absence of an up-to-date population census. The national census in Ukraine was last conducted in 2001. The result was a lack of relevance of ethno-demographic data at the level of state statistics. The State Statistics Service documents have repeatedly noted that population calculations are based mainly on administrative registers and demographic models, and not on the results of comprehensive census accounting (Smutchak *et al.*, 2025). Under these conditions, the assessment of ethnic population structure, language changes, and the extent of internal mobility, the intensity of which increased after 2014 and sharply increased after the full-scale invasion of 2022, is carried out based on disparate information sources (Valenti & Yasukawa, 2024). The problem goes beyond the statistical deficit. The lack of an up-to-date census narrows the possibilities for forming evidence-based ethno-national policies and limits the quality of management decisions. Without the integration of demographic accounting, it is difficult to determine territorial changes in the ethnic composition of the population, the scale of language transformations, and the concentration of internally displaced persons in the regional context. The greatest uncertainty is typical for border and de-occupied territories, where the war caused changes in the ethnic and social structure of the population.

The problem of integrating state registers acquired a new meaning after 2022. Mass internal displacement of the population has significantly increased the burden on the state accounting system. According to the International Organization for Migration (2025), as of 2024, there

were more than 3.7 million internally displaced persons in Ukraine. Their registration is carried out by several institutions simultaneously: the Ministry of Social Policy, local administrations, educational and medical institutions. Consistency between the respective databases remains limited. This creates differences in determining the number of internally displaced persons, assessing the level of integration and access to public services. A similar situation can be traced in the educational sphere. The movement of a large number of children and young people has affected the language and educational characteristics of the regions, but the state monitoring system does not provide an automated combination of information about the place of residence, internally displaced persons status, educational trajectory, and social support (Valenti & Yasukawa, 2024). Military conditions have accelerated the digital transformation of the public sector. After 2022, the development of digital governance in Ukraine was more focused on interdepartmental interaction and integration of register resources instead of supporting disjointed information contours (Vasylieva *et al.*, 2025). The central place in this process is occupied by the Ministry of Digital Transformation and the Diia ecosystem. At the initial stage of operation, the platform mainly provided access to digital services. Further development expanded its functions. Diia has gradually become a tool for integrating state registers and standardising information exchange. According to the Ministry of Digital Transformation of Ukraine (2024), as of 2024, dozens of state registers and digital services were connected to the ecosystem, and the number of users exceeded 21 million. The changes also affected the model of public administration. The digital platform began to serve as a single interface for accessing distributed government data, which set the stage for the development of an integrated data governance system.

One of the elements of interagency interaction was the Trembita system, created with the support of the EU and Estonia based on the X-Road architecture (Delegation of the European Union to Ukraine, 2021). Its purpose is to ensure the electronic exchange of information between state resources. Millions of transactions pass through Trembita every month. For the field of ethno-national monitoring, such an infrastructure opens up the possibility of combining social, migration, and demographic information arrays within a common analytical environment. Despite the progress made, the level of integration of state registers remains heterogeneous. Some authorities use API solutions and automated data exchange, while other institutions continue to operate through local or semi-closed systems (Sarioglu & Korzhunova, 2026). Additional restrictions create uneven digital capacity of communities, especially in frontline regions and territories with damaged infrastructure. The lack of a single ethno-national monitoring centre remains a problem. The existing system mainly records demographic and social changes after their occurrence. The possibilities of predictive governance, which aims to identify early risks of social segmentation, linguistic polarisation, and territorial inequality, remain limited. Development prospects are associated with the creation of an integrated analytical platform. Its architecture can combine data from the State Statistics Service, the State Migration Service, educational registers, social protection systems,

and geographic information services. The combination of such resources forms the prerequisites for the transition from fixing the consequences to forecasting ethno-social processes and supporting strategic management.

The Chinese model of digital ethno-political governance has evolved as a component of the state's data-driven governance strategy, where digital technologies are used not only to modernise administrative procedures, but also to implement social monitoring and maintain political stability (Yun, 2025). In the field of ethno-national policy, this approach was accompanied by a transition from conventional administrative practices to a multi-level digital infrastructure that integrates demographic registers, public security systems, behavioural data analysis tools, and mechanisms for predicting social risks. The role in this architecture is played by the interaction of platforms of the Ministry of Public Security of China, the social governance system, local administrative networks, and digital services related to internal mobility of the population. European approaches to interoperability are based on the coordination of autonomous institutions through decentralised data exchange mechanisms. The Chinese model has a different logic for organising information flows. It is based on the vertical integration of state information resources. Data on population, migration processes, employment, education and security risks are concentrated in centralised public administration platforms, which provides an operational assessment of the situation in regions of ethnic sensitivity. This practice was most developed in the Xinjiang Uygur Autonomous Region, where digital management systems were combined with preventive security monitoring tools (Orazzo & Cappelletti, 2025). Scientific papers record the use of the Integrated Joint Operations Platform, a system that integrates information from video surveillance cameras, biometric registers, mobile applications, and administrative databases to assess the "risky behaviour" of the population (Lee *et al.*, 2025). The platform's operation is based on an automated comparison of information from various sources, including data on the movement of persons, religious activity, and the structure of social contacts.

The concept of "digital intelligence governance" in China is focused on the development of a management system in which AI analytics is used to identify latent patterns of social behaviour and improve the effectiveness of government regulation (Zhang & Zhang, 2025). The practical implementation of this model involves combining information from social security systems, population mobility platforms, educational resources, and public security structures within common analytical environments. In the largest cities of the country, there are digital urban management centres organised on the principle of unified governance platforms. Their purpose is to integrate data on traffic flows, social services, migration processes, and public safety in real time. A component of the Chinese model was the large-scale implementation of smart city governance elements using AI and Big Data. By 2019, the corresponding programme covered more than 500 cities in China (Guo & Zhou, 2025).

The development of digitalisation of ethno-political governance is characterised by a clear regional differentiation. The eastern coastal provinces of Guangdong, Zhejiang, and Jiangsu show the highest rates of digital integration.

This distribution is associated with the concentration of financial resources, technological infrastructure, and high-tech businesses. Mobile services for ethnic minorities, digital public service platforms, and AI monitoring tools for interethnic relations have become widespread in cities in the eastern part of the country. The western territories show a different level of development of digital governance. Here, digitalisation mainly focuses on administrative accounting and is not accompanied by the development of integrated analytical systems. Asymmetry is also evident between certain areas of state activity. The highest level of digital transformation is typical for the areas of administrative and social services, where algorithmisation of processes does not cause significant difficulties: population registration, migration registration, employment, and the provision of benefits. The integration of digital technologies into the practices of interethnic mediation, cultural interaction, and preservation of ethno-cultural heritage is slower. The explanation is the high level of contextuality of the corresponding processes, which limits the possibility of their formalisation in the form of algorithmic models (Yihan & Zhenlin, 2024).

Despite advances in digitalisation of governance, the Chinese model operates with a number of structural limitations. A big problem is the phenomenon of “data islands”. This phenomenon prevents state bodies from creating a coordinated information space. The problem arose due to the historical practice of departments to develop autonomous information systems. Individual ministries have launched their own digital platforms, ignoring common architectural standards and compatibility. As a result, state arrays broke up into fragments, which blocked the interdepartmental exchange of information. Organisational difficulties are compounded by uneven access of citizens to digital services. At the end of 2025, the Internet reached 80.1% of Chinese residents, and the total number of users was 1,125 billion people (China Internet Network Information Center, 2026). However, access to digital resources and the possibilities of their practical use remain unequal. Rural areas lag behind in terms of digital participation. Even after increasing internet coverage to 69.5%, farmers do not use services and receive fewer socio-economic benefits from technology. These facts confirm the existence of a qualitative digital gap along with a quantitative one (Ran *et al.*, 2026). Scaling of digital services turns them into the main channel of interaction between the population and the state. In such circumstances, the low digital literacy of older people, residents of remote regions, and parts of ethnic minorities hinders their right to administrative services. An additional challenge is the dependence of digitalisation on the old institutional development trajectory. A significant part of projects simply transfers existing bureaucratic procedures online without changing their organisational logic. The government changes the form of management processes, but leaves the old content. The creation of new platforms in itself does not modernise the mechanisms of interdepartmental coordination and interaction between the state and the population (China Academy of Information and Communications Technology, 2026).

Estonia has formed a different model of digital governance, which has become one of the most integrated in world practice. The country refused to collect state data within a

single centralised storage facility. Instead, the developers have ensured continuous interoperability of autonomous information systems. Departments have maintained their institutional independence. Coordination is guaranteed by a standardised information exchange infrastructure, based on which government agencies interact in real time without duplicating information. The basic element of the architecture was the X-Road platform. It organises secure data exchange between state registers, municipal systems, and individual private services. X-Road works as a data exchange layer, not as a centralised storage of information. Each institution independently administers its own databases, and access to information is provided by standardised APIs and cryptographically secure interaction channels. The architecture helped to avoid the emergence of new “information silos” and maintained a high level of information security. As of 2024, more than 1,000 organisations and more than 3,000 electronic services interact through X-Road (Marak, 2025). The annual volume of transactions between state information systems is hundreds of millions of transactions, and the vast majority of administrative procedures are carried out by officials without using paper documents. The conceptual basis of the Estonian digital model is the once-only principle, which is also supported by the EU’s digital governance policy (Boyli, 2022). It requires a citizen or organisation to provide the necessary data to the state system only once. Further use of information is provided by integrated mechanisms of interdepartmental exchange. As a result, the authorities reduced administrative duplication and eliminated statistical discrepancies between registers.

The practical work of this model is demonstrated by the use of registry data in social policy and demographic forecasting. Social Services and Benefits Data Register (Health and Welfare Information Systems Centre, n.d.) coordinates the activities of local authorities and central state institutions in the provision of social services in real time. To do this, the programme collects information about income, family status, place of residence, and social needs of citizens. Integration with other state registers eliminates the re-collection of information and speeds up obtaining state support. The Regulation of the Republic of Estonia No. 20 “On the Establishment and Statutes of the Register of Children and Teachers in Pre-School Education” (2025) has a similar principle. It accumulates data on educational trajectories, language training, and regional indicators of education development. Thus, analysts quickly respond to demographic changes and migration processes. The Estonian model does not use the rigid ethnic profiling of the population typical of individual centralised systems. But integrated registers allow for a multi-factor analysis of language integration, territorial mobility of the population, access to education and social services.

A security element is the distributed data storage architecture. Unlike centralised systems, where compromising a single node poses a threat to the entire infrastructure, the Estonian model minimises systemic risks through a decentralised registry organisation. After a large-scale cyberattack in 2007, Estonia strengthened its cyber defence system, and digital security became one of the basic priorities of public policy (Ansari, 2025). In 2024, Estonia retained its status as one of the most

digitalised states in the EU. According to Eurostat (2026), about 87.59% of the country's citizens have used websites or mobile applications of public authorities in the previous 12 months, which exceeded the EU average of 70.01%. However, even the Estonian model has certain limitations. Deep integration of registries requires constant updating of interoperability standards, continuous investment in cyber defence, and high digital competence of the state apparatus. The existing dependence on data-based management creates risks of over-technologisation of policymaking, when complex social processes begin to be

evaluated solely through quantitative indicators. Comparative analysis of digital ethno-national governance models has shown that the effectiveness of state policy in the field of monitoring ethno-social processes directly depends not only on the level of digitalisation, but primarily on the nature of interdepartmental integration and data governance architecture. Ukraine, China, and Estonia represent three different models of digital management organisation: fragmentary and decentralised, centralised and control, and interoperability-oriented, the comparison of which is shown in Table 2.

Table 2. Comparative model of digital ethno-national governance

Criteria	Ukraine	China	Estonia
Data architecture	Distributed ledgers + interagency integration via Trembita	Centralised government platforms with vertical integration	Decentralised registries + X-Road
Integration model	API-integration (service-oriented)	Unified state data governance	Event-based interoperability
Once-only principle	Partially implemented – fragmentary in e-services Diia) – number of services: 100+	Limited (data is duplicated between control systems)	Fully implemented; once-only scoring >90%
AI/predictive management	Limited use (primarily Diia service solutions)	Large-scale application (state risk analytics, smart policing)	Moderate (data-driven policymaking, without mass surveillance AI)
Digital maturity level (DESI / GovTech proxy)	Below the EU average	High in the public sector, but without open indexes	Top 3 EU by eGovernment
Data access control	Regulatory-European (General Data Protection Regulation alignment)	State-centred	Cryptographic-log control (audit trail)
Level of personal data protection	General Data Protection Regulation-aligned (EU approximation 2023)	Security-first governance	General Data Protection Regulation-native model
Crisis resilience	High (due to flexible digital infrastructure during the war)	Very high (centralised data management)	High (institutional stability of the system)
Main structural problems	Data silos, registry fragmentation	Excessive centralisation and opacity	Dependence on cyber resilience
Potential of ethno-national monitoring	Medium (limited data integration)	Very high (but risk of politicisation)	High (balance of analytics and rights)

Source: compiled by the author based on Delegation of the European Union to Ukraine (2021), Ministry of Digital Transformation of Ukraine (2024), European Commission (2024), K. Ansari (2025), H. Yun (2025), S. Marak (2025), T. Vasylieva *et al.* (2025), A. Orazzo & A. Cappelletti (2025), V. Sarioglo & N. Korzhunova (2026)

A comparative analysis of the three models showed that the level of interagency integration does not have a linear correlation with democracy or efficiency, but describes a nonlinear trajectory depending on the data governance architecture. Chinese digital architecture has a maximum level of integration, close to the concept of a single state data lake, so that the authorities instantly make analytical decisions. However, the developers provided a similar effect through the vertical concentration of information. Within this configuration, the state's security infrastructure completely absorbs ethno-national monitoring, which creates a threat of algorithmic discrimination. Ukraine occupies an intermediate position. Digital tools have formed a convenient service level, but analytical interaction between registries is still limited. The main problem is the lack of stable data linkage communication between the State Statistics Service, the Ministry of Education and Science, the State Migration Service, and social registers. As a result, the state system functions as a set of interrelated but isolated information contours. The Estonian model demonstrates a structural balance. The X-Road platform creates an event-based exchange system instead of accumulating a single database. This approach guarantees a high level of interoperability, while maintaining the institutional autonomy of departmental registers. Additionally, there is a transparent

auditability mechanism, in which the system records each fact of access to data and opens a report to a citizen. The described tool maintains a unique balance between the effectiveness of public administration and the legal protection of personal information.

Ethnic monitoring requires, first and foremost, the ability to integrate existing data into analytical models without breaching legal safeguards, rather than the accumulation of vast amounts of information. China provides maximum analytical power, but creates high risks of building surveillance governance. Ukraine demonstrates high adaptability, but the country lacks analytical consolidation of departmental bases. Estonia has found the optimal combination of interoperability, legal protection, and analytical functionality. The level of integration of departments directly determines the accuracy of monitoring ethnic processes. Fragmented systems, similar to the Ukrainian one, force various institutions to collect unrelated data sets. This blocks the prediction of social dynamics and provokes the appearance of statistical discrepancies. Centralised models, on the other hand, allow government agencies to create comprehensive digital population profiles and conduct real-time analysis. However, excessive concentration of information can turn ethno-national monitoring into a tool of total digital control. Models of the

interoperability-oriented type occupy an intermediate position, because developers ensure data integration without eliminating the institutional autonomy of registers.

Administrative efficiency and democratic guarantees have different ratios depending on the chosen political course. The Chinese model guarantees the highest speed of decision-making, but has zero transparency of algorithms and completely rejects public control. The Ukrainian system, despite its weak integration, retains a fragmented structure of data access. Organisational disunity partially hinders the excessive concentration of Information power, although simultaneously reduces the quality of analytics. Estonian architecture has achieved the most balanced balance between efficiency and protection of citizens' rights. Success was ensured by cryptographic protection, transparent logging of registry requests, and system interoperability. Transition-type states should abandon blind copying of other people's digital solutions and focus on forming universal principles of integrated governance. Comparative analysis confirms that an effective digital ethno-national policy should be based on several basic principles. These include standardised interoperability between registries, unified metadata standards, real-time interagency analytics, and transparent rules for accessing information. It is also mandatory to combine AI analytics with legal guarantees to protect privacy and create independent institutions to audit algorithms against digital discrimination against ethnic groups.

The interoperability-oriented model, adapted to the conditions of military and post-war management, is more suitable for Ukrainian society. Total centralisation of data on the Chinese model completely contradicts the European vector of the country's development and creates a threat of excessive concentration of digital power in one hand. But the Estonian experience has proved the possibility of successfully combining a decentralised structure of state registers with a high level of coordination of departments. This approach is of strategic importance for monitoring the internal movement of citizens, tracking regional language transformations and social integration of people during the post-war reconstruction. Digital management is subject to a universal trend – the shift from the mere accumulation of data to intelligent management based on integrated analytics. As part of this process, overcoming “information silos” is not a technical, but a systemic institutional task. It is the quality of interaction between state institutions that will determine the ability of the authorities to effectively respond to ethnic and social challenges, while maintaining a balance between security, digital efficiency, and democratic standards.

● DISCUSSION

The results of the study showed that the problem of “information silos” in the digital management of ethno-national policy is not limited to the technical incompatibility of information systems, but arises as a complex combination of institutional, regulatory, semantic, and analytical barriers. The results obtained partially correlate with the approach of M. Romano & J. Albrecht (2026), who considered silo structures as a source of communication gaps between emergency management professionals and the IT sector. The analysis confirmed that interdepartmental

fragmentation in the field of ethno-national monitoring also arose due to different managerial logic of state structures. However, if the authors focused mainly on the professional and communication dimension of the problem, the results of the study showed a more complex configuration. Structural isolation occurs simultaneously at the level of regulatory regimes for access to data, semantic incompatibility of classifiers, and political competition between institutions for control over information resources. The identified list of seven types of interagency barriers expanded the interpretation of silo fragmentation in comparison with the model of researchers, since the problem was interpreted not as a communication gap between professional groups, but as a systemic deformation of the data governance architecture. Simultaneously, the provision on the need for cross-sectoral coordination, regular training of personnel and the development of a common operational environment is consistent with the conclusion of the study on the critical role of unified dashboards and integrated analytical platforms in overcoming the fragmentation of state registers.

Conclusions of M.V. Kurniawati *et al.* (2025) on interagency data exchange in government structures also correlate with the results obtained. The analysis proved that technical integration without changing the management model does not provide a full-fledged overcoming of “information silos”. That is why the thesis of researchers on the transformation of interdepartmental data exchange from a technical procedure into a strategic tool of evidence-based policymaking coincides with the established need to move from data accumulation to “governance-based data management”. The study showed that even in the presence of developed framework structures, registry integration remains limited due to contradictions between interoperability and privacy protection. This contradiction was not a central element of the authors' research, but in the new analysis it determined the main reason for the institutional isolation of data in the field of ethno-national policy. The results showed that high standards of personal data protection, in particular within the framework of the General Data Protection Regulation-oriented governance, objectively complicate the interagency exchange of sensitive data, namely in relation to ethnic, linguistic, and migration information. Thus, the conducted research supplemented the framework approach with an institutional and legal dimension, which directly affected the possibility of integrating state analytical systems.

Approach of O. Nepomnyashchyy *et al.* (2022), based on a cluster analysis of the digitalisation of Central and Eastern European countries, generally confirmed the conclusions about the unevenness of digital transformation in the region. The study also recorded the intermediate state of Ukraine between service digitalisation and incomplete analytical integration of registers. The results allowed detailing the structural reasons for this position. If researchers interpreted the low level of efficiency of public administration mainly due to the general level of digitalisation, then the analysis revealed the key role of the data governance architecture. It was demonstrated that even the active development of the Diia and Trembita platforms did not provide full synchronisation between the State Statistics Service, the State Migration Service,

the Ministry of Education and Science, and social registers. As a result, the digitalisation of administrative services was not automatically transformed into an integrated system of ethnic and national monitoring. Thus, the results expanded the authors' cluster approach, since the effectiveness of digital transformation is not related to the number of technological solutions, but to the level of interagency interoperability and the ability of the state to form a single analytical environment.

The paper by M. Di Giulio & G. Vecchi (2021) considered digital technologies as mechanisms of organisational integration, the implementation of which was accompanied by conflicts and negative feedback. The study confirmed this pattern in the context of digital ethno-national governance. It was found that technological modernisation without transforming institutional logic does not eliminate structural fragmentation, but only transfers it to the digital environment. This conclusion correlates with the thesis on the need to coordinate ICT solutions with the management system. The analysis detailed the mechanisms of this discrepancy. In particular, in the case of Ukraine, digital platforms created a service level of interaction with the state, but interdepartmental analytics remained limited due to different metadata standards, different data access modes, and the lack of complete data linkage between state systems. Thus, the results of the study confirmed that digitalisation does not have a linear effect of improving management efficiency, but depends on the degree of adaptation of the organisational structure of the state to the new coordination model. The findings of T.C. Nguyen (2025), dedicated to the X-Road Platform, almost coincide with the conclusions of a study conducted on the Estonian interoperability-oriented model. In both studies, X-Road was interpreted not as a centralised data warehouse, but as an infrastructure for standardised exchange between autonomous registries. The analysis confirmed that it is this architecture that provides a balanced combination of efficiency and privacy protection. The results detailed the importance of audit accountability and cryptographic logging of data access as tools for maintaining institutional trust. If the author focused on the socio-technical nature of X-Road and its role in strengthening the legitimacy of digital governance, the current study showed that it was the event-based interoperability mechanism that helped to avoid the establishment of new "information silos". In addition, it was shown that the Estonian model turned out to be the most relevant for transition states, since it combines a decentralised registry structure with a high level of analytical coordination without concentrating information power in one centre.

Approach of H.Y. Quek *et al.* (2023), devoted to the problem of fragmentation in digital twin ecosystems, found a conceptual affinity with the results of the study. The researchers emphasised the role of semantic integration and bidirectional data flows, while in the analysis, the semantic barrier was identified as one of the factors of fragmentation of state registers. It was found that different criteria for classifying ethnic, linguistic and migration categories actually made it impossible to automatically compare data even within the same country. That is why the conclusion by the authors regarding the need for an active role of the state in the development of digital

integration standards correlates with the result of the study, where interoperability was interpreted as a combination of technical, organisational and semantic levels of interaction. However, the study went further, since the problem of semantic incompatibility is associated not only with technological blockages, but also with political and regulatory regimes for accounting for ethnic data. F.C. Okolo *et al.* (2022) identified the main problems of data integration as "data silos", inconsistency of standards, and complexity of interagency management. The study actually confirmed the situation, but showed that in the field of ethno-national policy, the consequences of fragmentation were deeper. If researchers analysed transport and infrastructure systems where data integration mainly affected the effectiveness of coordination, then in the current study the isolation of registers directly affect the ability of the state to predict ethnic and social dynamics and respond to interethnic risks. It was proved that the lack of synchronisation between demographic, social, migration, and educational bases makes it impossible to form complex models of social integration. The findings of F.C. Okolo *et al.* correspond to the conclusion about the need for standardised data exchange protocols, but the current study showed that this is not enough for ethnic and national monitoring without creating mechanisms for analytical coordination and algorithmic audit.

The results of A. Kirilenko (2025), devoted to the reform of public administration of Ukraine in the context of war, correlate with the conclusions on the transformation of the Ukrainian digital model after 2022. The study found that the war was a catalyst for the accelerated integration of state registers and the development of digital coordination through Diia and Trembita. The study showed that even in the context of large-scale digitalisation, the problem of "data silos" was not completely overcome. This is evident in the field of accounting for internally displaced persons, where various government agencies use incompletely synchronised data sets. Thus, the results of A. Kirilenko on the need for long-term reform strategies are consistent with the conclusion that service digitalisation cannot replace data governance system integration.

The opinion of P.K. Pemmasani & M.A. Nasaruddin (2022) on the need for an integrated approach to data management was also confirmed by the results of the study. The researchers considered centralised data management models and AI-based threat detection as security and accountability tools. However, the study showed that in the field of ethno-national policy, excessive centralisation creates risks of surveillance governance and algorithmic discrimination. It was on the example of the Chinese model that it was shown that maximum analytical power can be combined with a high level of digital control and concentration of information power. Thus, the results partially coincide with the conclusions of researchers regarding the role of interagency coordination and AI analytics, but the study revealed the need for additional mechanisms of human oversight, explainability and algorithmic audit, which showed that the effectiveness of digital governance is determined not by the amount of data collected, but by the ability to integrate analytical efficiency with democratic guarantees and legal protection of sensitive information.

● CONCLUSIONS

The conducted research confirmed that the concept of “information silos” in the field of ethno-national policy acquires specific features that differ from its classical interpretation in organisational science. Unlike corporate management, in public administration, data fragmentation is compounded not only by departmental autonomy, but also by the distribution of competencies between statistical, migration, educational, and security structures. The paper systematised seven types of interagency barriers – organisational, regulatory, technical, analytical, cybersecurity, semantic, and political institutional – which explains why even a high level of digitalisation does not guarantee data integration. It was proved that in the field of ethno-national monitoring, the consequence of such barriers is not just a statistical discrepancy, but the impossibility of building a comprehensive model of ethno-social dynamics due to the lack of synchronisation of demographic, language, migration, and social registers. It was established that the correlation between the integration of registers and the protection of personal data creates an institutional contradiction: the General Data Protection Regulation and similar regulations aimed at protecting sensitive information objectively complicate interagency exchange, turning into an additional factor of isolation. The result was a conclusion about the inefficiency of both complete data centralisation and purely technical solutions without changing the management logic.

Based on a comparative analysis of three models – fragmentary and decentralised (Ukraine), centralised and control (China), and interoperability-oriented (Estonia) – it was revealed that the Ukrainian system was in an intermediate position: the service level of digitalisation through Diia and Trembita was formed (the Diia system integrated dozens of registers, the number of users exceeded 21 million, and millions of transactions are made through

Trembita every month), but the analytical consolidation of data between the State Statistics Service, the State Migration Service, the Ministry of Education and Science, and social registers remained incomplete. The Chinese model demonstrated maximum analytical power (more than 90% of large cities have implemented smart city governance elements), but with high risks of turning ethno-national monitoring into a digital control tool. Simultaneously, the Estonian X-Road architecture provided the most balanced combination of interoperability, cryptographic protection and transparent access logging: more than 1,000 organisations and more than 3,000 services interact through X-Road, and 87.59% of the population uses electronic public services, which exceeds the European average of 70.01%. The result was the determination that overcoming “information silos” requires a transition from the departmental logic of data accumulation to the “governance-based data management” model, where standardised exchange protocols, unified metadata, and audit mechanisms are integrated rather than the databases themselves. In addition, it was found that cross-sectoral interaction algorithms reproduce structural inequalities embedded in historical administrative data without proper supervision, which forms the prerequisites for digital discrimination of ethnic groups. Prospects for further research consist in the development of a methodology for assessing algorithmic bias in state monitoring systems for ethnic processes.

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Механізми подолання міжвідомчих бар'єрів у процесі цифровізації етнонаціональної політики: від «інформаційних силосів» до інтегрованого управління

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Анотація. Метою дослідження було виявлення моделей управління, здатних забезпечити узгоджений обмін даними в контексті цифрової трансформації державного сектору. Методологія базувалася на міждисциплінарному поєднанні інструментів державного управління, цифрового врядування, аналізу інформаційних систем та етнополітичних досліджень, що дозволило простежити особливості функціонування державних реєстрів, механізми міжвідомчої взаємодії та практики управління даними у 2015-2025 рр. за допомогою порівняльно-аналітичного та інституційного підходів. Результати дослідження показали, що «інформаційні силоси» в етнонаціональній політиці формуються через розмежування компетенцій між статистичними, міграційними, освітніми та безпековими установами. Порівняння національних моделей показало, що українська система цифрового врядування забезпечила розвиток сервісних платформ (через систему «Дія» було інтегровано десятки реєстрів, кількість користувачів перевищила 21 мільйон, а платформа «Трембіта» щомісяця обробляє мільйони транзакцій), але не сформувала повної аналітичної консолідації між державними реєстрами. Було встановлено, що централізована модель управління в Китаї забезпечує високу швидкість аналітичної обробки інформації (понад 90 % великих міст впровадили елементи управління «розумним містом»), але супроводжується ризиками надмірного цифрового контролю та посилення наглядових функцій держави. Досвід Естонії показав, що поєднання взаємосумісності, криптографічного захисту та прозорого аудиту доступу до даних створює більш збалансовану систему міжвідомчої координації: понад 1 000 організацій та понад 3 000 служб взаємодіють через платформу X-Road, а 87,59 % населення користується електронними державними послугами. Дослідження підтвердило, що регулювання захисту персональних даних одночасно виконує функцію правового захисту та стає чинником інституційної ізоляції між державними структурами. У ході дослідження було встановлено, що подолання фрагментації інформації у сфері етнонаціонального моніторингу вимагає переходу від моделі накопичення даних окремими відомствами до системи управління, заснованої на стандартизованих протоколах обміну, уніфікованих метаданих та механізмах аудиту доступу. Практичне значення отриманих результатів полягає в можливості їх використання державними органами, структурами цифрового управління, аналітичними центрами та розробниками державних інформаційних систем для розробки безпечних моделей міжвідомчого обміну даними у сфері етнонаціональної політики та державного управління.

Ключові слова: захист персональних даних; взаємосумісність; принцип одноразового введення даних; прогнозне управління; федеральне управління даними

Cultural determinants of national management models: The feasibility of implementing foreign practices in the Ukrainian IT sector

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Abstract. Ukrainian management, which emerged as an independent phenomenon relatively recently, is currently transitioning from outdated practices of the Soviet era and actively adopting managerial methods from well-established foreign models, creating the need to analyse the validity of such adoptions. The purpose of this research was to evaluate the feasibility of following foreign management styles in the Ukrainian IT sector based on cultural characteristics. A mixed-methods approach, which includes comparative analysis, generalisation, and synthesis of the theoretical information and case studies of Netflix, Ubisoft, SAP, Spotify, Rakuten, and Kakao, was employed. As a result of this study, the influence of cultural characteristics on the formation of national management models in the modern context was confirmed. Long-term orientation and a focus on innovation were found to be present in each of the investigated models regardless of cultural characteristics. Calculations of Euclidean distances revealed that Ukraine shares the greatest cultural proximity with South Korea and France, while having the fewest similarities with Sweden and the USA. The Ukrainian managerial style was identified by analysing SoftServe's practices and was compared to other models. The findings indicated that the Ukrainian management approaches generally correspond to the cultural characteristics, highlighting a strong potential for their effective implementation. However, some features were adopted as a result of following foreign managerial practices without taking into account the national mentality. Consequently, recommendations for the adoption of managerial practices that correspond to cultural characteristics were formulated. The practical value of this research lies in the possibility for managers of Ukrainian IT companies and management specialists to utilise these proposals for improving the efficiency of organisational processes and identifying managerial tools that will encounter the least resistance from personnel

Keywords: adaptation of managerial approaches; managerial efficiency; Ukrainian leadership style; management methods; Hofstede's theory

● INTRODUCTION

In the context of globalisation, alongside the possibility of adopting successful foreign practices, there is an increasing risk of utilising methods that may face great resistance from employees. The war in Ukraine poses a severe threat to the state economy, and the ability of businesses to operate efficiently is not only the key to individual market success but also a crucial factor in ensuring the survival of the entire Ukrainian economy. Selecting practices that align with the national mentality can save organisations'

valuable resources, such as time and funds, which would otherwise be spent on mitigating the negative consequences of employee non-acceptance of adopted practices caused by cultural differences. In order to ensure the feasibility of adopting foreign practices, the cultural features of Ukraine and the selected companies should be analysed and compared.

V. Harkava *et al.* (2024) observed that the obstacles facing Ukrainian businesses include corruption, bureaucracy,

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a lack of well-developed infrastructure, tough competition in the international market, digital transformation, social responsibility, and regulatory changes. Furthermore, the war has led to the emergence of such problems as political risks, high economic instability, destructive consequences of the conflict, and large-scale emigration of skilled workers. The authors emphasise the need for Ukrainian management to be more flexible, innovative, and strategically oriented. In the context of active cross-cultural interaction, companies increasingly strive to adopt successful managerial practices from different national models. I. Perevozova *et al.* (2023) investigated the current trends of Ukrainian management and compared them with international practices, which helped to identify the gaps and problems hindering the process of management transformation in the country. The scholars noted that martial law in Ukraine forces organisations to seek new solutions, leading to the active integration of international experience. However, the feasibility of adopting foreign managerial practices solely based on their effectiveness in other countries may be questioned due to cultural differences. M. Averkyna & A. Matvieiev (2025) investigated the influence of Hofstede's cultural dimensions on change management in organisations. The authors identified the direct effect of six cultural characteristics of a nation on the formation of managerial practices and applied the findings to the development of a new quality control system in a German company. The scholars noted that Ukrainian IT companies operate in their own unique circumstances, which may cause variations in managerial practices, but they must still take into account national cultural characteristics during the formation of theoretical and practical principles of change management.

D.A. Firican (2022) investigated the influence of Hofstede's cultural dimensions on various aspects of management in organisations. The study found that, although it is advisable to change the culture in a company to foster innovation and facilitate change, certain characteristics of national culture are not malleable and management needs to adapt to them. P. Suslov (2024) conducted a comparative analysis of the American, Japanese, and European management models and noted that adopting foreign practices from these models can improve human resource management. Although the author argues that taking cultural aspects into account is also crucial, the research was not focused on identifying the feasibility of following foreign practices in light of specific cultural characteristics. Yu. Kopchak *et al.* (2021) investigated the specific features of managerial styles across a range of countries, noting that most methods in Ukrainian management are borrowed from the American and Japanese models. According to the scholars, new practices of companies in Ukraine do not always take into consideration the features of the local mentality. However, as a comprehensive empirical study of management in the IT sector by N. Mazur *et al.* (2025) demonstrated, the most effective project teams are those that ensure an alignment between their cultural characteristics and chosen methodologies.

T. Melnyk (2023) studied the current state and challenges of Ukrainian companies, identifying key instruments for national business development during wartime. The research focused on the actions of the government and

international partners that could improve the resilience of the Ukrainian business sector. The scholar notes that some companies may demonstrate significant potential under the circumstances of extreme crisis and become more competitive. To achieve this, the maximum flexibility and innovativeness of business management must be ensured. Currently, Ukraine faces a large number of obstacles to its development and overall survival. To support the various functions of the state, it is vital to ensure the maximum efficiency of domestic economic activity. Management in companies is still adapting to the new reality, striving to establish the most effective system. However, to identify practices that will be acceptable for Ukrainian employees, cultural features must be taken into account. Though numerous scholars emphasise this necessity, the alignment of Ukrainian managerial practices with the cultural characteristics has not yet been sufficiently studied, which highlights the relevance of this research. Given that the information technology sector is one of the most developed in Ukraine, the analysis in this article focuses exclusively on IT companies, thereby providing the study with the potential for broad practical application.

The aim of this research was to comprehensively examine the alignment of the Ukrainian management style with cultural characteristics that can ensure managerial effectiveness, and to formulate recommendations for eliminating or adopting new practices that are more suited to the national mentality. To achieve this, the strength of cultural influence on the formation of management models in the modern context had to be determined. As Ukrainian management is still in its formative stages, the identification of its current characteristics was also a necessary element of this study. To achieve this aim, the following objectives were established: to define the influence of cultural characteristics on the national managerial practices used in the representative IT companies of the American, French, German, Swedish, Japanese, and South Korean management models; to determine the features of the Ukrainian managerial style and their correspondence with national culture; to identify the managerial techniques that can be adopted in Ukraine from other national models on the basis of cultural proximity to the respective foreign countries, established by calculating cultural distances according to Hofstede's dimensions. This study contributes to the existing body of knowledge by providing a comprehensive evaluation of the compatibility of Ukrainian managerial style with national cultural characteristics using Hofstede's dimensions.

● MATERIALS AND METHODS

The study was theory-driven research combined with a case-based analysis of national management models. This approach allowed for the identification of the current developmental state of these models in the modern business environment. The research consisted of two main stages, enabling a comprehensive examination to be conducted, which can have practical application due to the consideration of real-world examples of managerial practices in currently operating companies.

At the initial stage, the theoretical foundations of factors influencing the formation of national management models were investigated by reviewing relevant

literature, facilitating a comprehensive overview of this issue. Given that cultural aspects were found to be one of the most important factors influencing the formation of managerial styles within a country, Hofstede's Cultural Dimensions Theory was examined in greater detail, as it is widely used in studies with a similar aim (Şenkaya, 2022; Averkyna & Matvieiev, 2025). The scientific literature regarding the five cultural dimensions, which are power distance, individualism, uncertainty avoidance, long-term orientation, and masculinity, and their direct impact on particular characteristics of managerial styles was reviewed. Additionally, the national management models of Japan, South Korea, France, Germany, Sweden, and the USA were examined through an analysis of Ukrainian and foreign theoretical literature. As the models' characteristics were identified in earlier studies, an analysis of managerial practices in the companies headquartered in the corresponding countries was conducted in order to confirm that, despite the homogenising trends of the modern globalised market, national culture still significantly influences managerial styles. To achieve this, the annual reports and publicly available corporate information of Rakuten (Japan), Kakao (South Korea), Ubisoft (France), SAP (Germany), Spotify (Sweden), Netflix (USA), and SoftServe (Ukraine) were analysed. Practices that directly reflect characteristics shaping a management style were gathered and structured into three tables. The initial table represents guiding values and principles of the companies together with their corporate structures. The focus of the subsequent table is human resources management, particularly training systems, evaluation methods, and staff engagement, while the final table characterises the strategic development of the companies, represented by time horizons and innovation activities.

Data regarding employee evaluation, compensation and engagement were extracted from the official, publicly available resources, such as annual reports, universal registration documents, and corporate websites. The analysis of compensation focused on the diversity of remuneration tools and declared methods used by the companies to incentivise their employees. Due to the lack of detailed public information across all investigated organisations, the flexibility granted to employees in allocating their remuneration elements (e.g., choosing salary-to-stock ratio) was examined only in cases where such data was explicitly disclosed, namely for Netflix. The assessment of employee engagement involved comparing the diversity of claimed practices utilised by the companies for staff participation in corporate management. To provide an objective baseline for comparison, quantitative engagement scores (measured on a 100-point scale) from the most recent available reporting period were extracted. However, these figures were analysed only for the companies that officially published them.

Based on the studied managerial practices and theoretical literature, a summary table of national management models' characteristics was compiled using interpretive analysis. Subsequently, the features were analysed through the lens of the cultural dimension scores of each country. As the world is changing rapidly today, it was crucial to confirm that cultural influence on the formation of managerial practices remains present. In the subsequent phase

of the study, a quantitative method was employed. The cultural distances from Ukraine to each of the investigated countries were calculated using the Euclidean distance formula, which is often used by scholars in studies regarding the influence of culture on management formation (University of Pennsylvania, 2023; Gama *et al.*, 2025). The standard Euclidean distance formula is expressed as follows (Akhimien & Adekunle, 2021):

$$CD = \sqrt{\sum_{i=1}^n (I_{iHOME} - I_{iHOST})^2}, \quad (1)$$

where CD – the Euclidean distance between the home (Ukraine) and host country based on Hofstede's dimensions; I_{iHOME} – the score of dimension i for the home country (Ukraine); I_{iHOST} – the score of dimension i for the target country; n – the number of dimensions included in the index ($n=5$).

This part of the study was dedicated to the investigation of the Ukrainian management style. As it is undergoing rapid transformations due to the highly unstable political situation, Ukrainian management characteristics were defined on the basis of the studied practices of SoftServe, a Ukrainian IT company. To evaluate the Ukrainian managerial style, which actively adopts foreign practices, its cultural congruence was investigated. The analytical framework was grounded on the concept that practices are considered more effective if they do not cause resistance among the workforce due to cultural and mental incompatibility. Pattern-matching method was applied, enabling the detection of Ukrainian managerial practices, which differ from those behavioural expectations dictated by the country's Hofstede scores. For this, similarities and differences between managerial practices of Ukraine and each of the investigated countries were identified. For the practices that coincide, numerical indicators of Hofstede's cultural dimensions, which influence the formation of these management techniques, were compared between Ukraine and the corresponding country. Instances where cultural characteristics were different, though the practices were identical, were noted as those that require more managerial attention, as they contradict national peculiarities and may be ineffective due to mental resistance among employees.

Additionally, a broader comparative evaluation was applied using the calculated Euclidean distances. Attributes of national management style that aligned with the models of countries with which Ukraine has the greatest cultural distances were identified as those that can be incompatible with the national mentality and, accordingly, be ineffective. Conversely, management models of countries with the smallest cultural distances to Ukraine were highlighted as subjects for future investigation regarding the possible adoption of culturally compatible practices. Based on this analytical framework, recommendations for Ukrainian management transformation were formulated. The analysis of managerial practices in the selected companies relied predominantly on corporate reports and official public disclosures. While these documents provide a comprehensive overview of the established procedures, they may represent the intended or idealised corporate culture, which may occasionally differ from the everyday operational reality.

● RESULTS

The role of cultural characteristics in the formation of national management models

The economy is an integral part of any country, and its development directly influences the state's significance on the international market. Economic growth makes it possible to support the sustainable development of the whole country by enabling greater investment resources into infrastructure, health, education, and other sectors. Every economy has its own specific characteristics and, besides the significant influence of geographical features of the area, there is a range of other factors that shape the economic activity of a country. D.E. Silaban (2025) points out that economic policies and the political situation in a state influence the volume of capital attracted, which directly affects the speed and trajectory of the economic and, consequently, the national development. I. Perevozova *et al.* (2023) note the influence of history, religion, and culture on the formation of economic activity. Accordingly, the general sequence of factors that shape market activity in a country can be presented as follows: cultural and historical heritage influences the formation of the political system in a state, which, in turn, shapes the legal institutions directly influencing the economic activity. Therefore, the weight of culture should not be underestimated while investigating a national economy.

As business entities are integral components of it, the national ethos is also the foundation of a management style of a particular country. Hofstede (n.d.a) investigated the influence of some cultural factors on the managerial activity and developed the theory of cultural dimensions, which can describe the characteristics of socio-economic models and, accordingly, national models of management. The scholar identified a set of cultural indicators. Among

them are the Power Distance, Individualism, Masculinity, Uncertainty Avoidance, and Long-Term Orientation indices. The Power Distance Index (PDI) corresponds to the level of inequality between the representatives of different hierarchical levels, namely managers and subordinates in a managerial context. Higher scores indicate greater responsibility of supervisors and the presence of larger barriers to free interaction between them and staff. The Individualism Index (IDV) is contrasted with the degree of collectivism. It indicates “the degree whether the interests of the group [prevail over interests] of the individual in a society” (Şenkaya, 2022). Masculinity (MAS) “is the extent to which the use of force [is] endorsed socially” (Hofstede, n.d.b). In masculine societies, competitiveness is more pronounced. Uncertainty Avoidance Index (UAI) measures the degree to which a nation tries to ensure a stable environment. As E. Şenkaya (2022) points out, the “higher the anxiety, [the] higher the UAI”. Long-Term Orientation (LTO) is opposed to short-term orientation and it shows the time horizon on which people focus. Identifying the cultural nuances within the framework of Hofstede's dimensions helps to explain the characteristics of a particular national management model. To examine the conceptual alignment between a nation's values and managerial styles, this study investigated them across a range of countries and the companies that represent them. The scores of the analysed countries according to five Hofstede indicators are presented in Table 1. Although these scores serve as relative guidelines rather than absolute metrics, they establish approximate levels of each indicator, which can reliably describe general cultural patterns across different countries. E. Şenkaya (2022), T. Malmi *et al.* (2022), D. Aziewicz (2024), and other researchers effectively utilised these rankings while investigating different aspects of enterprise activities.

Table 1. Hofstede's cultural dimension scores by country

Country	PDI	IDV	MAS	UAI	LTO
USA	40	91	62	46	26
France	68	71	43	86	63
Germany	35	67	66	65	83
Sweden	31	71	5	29	53
Japan	54	46	95	92	88
South Korea	60	18	39	85	100
Ukraine	90	40	40	90	86

Source: compiled by the author based on Hofstede (n.d.a)

Comparative analysis of national management models

In order to study national management models, representative companies from each of the selected countries were chosen: Rakuten (Japan), Kakao (South Korea), Ubisoft (France), SAP (Germany), Spotify (Sweden), Netflix (USA),

and SoftServe (Ukraine). The corporate purposes, missions, values, principles and organisational structure were investigated through annual reports and other information published by the companies. The gathered data about management in the chosen organisations is presented in Table 2.

Table 2. Strategic frameworks, guiding principles, and organisational structures of the investigated companies

Company Name	Strategic Framework	Guiding Principles	Organisational Structure
Netflix	Mission: “To entertain the world with amazing films, series and games that inspire and thrill audiences everywhere”	Values: selflessness (“you seek what's best for Netflix, not yourself or your team”), candour, creativity Culture focus: Treating staff as a sports team, prioritising high performance over family-like tenure	Fosters a culture of “extraordinary candor”, which involves sharing and receiving constructive feedback regardless of job position Employs a “context, not control” approach, which implies explaining the vision to employees rather than giving them rigid guidelines Avoids decision-making by committee; informed captains, who assume full responsibility for the results, are appointed for each working team

Table 2, Continued

Company Name	Strategic Framework	Guiding Principles	Organisational Structure
Ubisoft	Mission: “Enrich players’ lives by creating original and memorable gaming experiences” Strategic focus areas: “Product, people & culture, social impact”	Focus areas: growth mindset, discipline, innovation, creativity, team diversity	Transition towards “a more focused, agile and disciplined organisation” with an emphasis on flexibility and efficient collaboration
SAP	Purpose: “Help the world run better and improve people’s lives”	Focus areas: innovation, developing solutions, supporting customers	No clear top-down or bottom-up management style
Spotify	Mission: “To deliver creativity to the world by connecting the world to the art and creatives that shape it”	Values: one team, human judgement (thoughtful decisions), make it happen (produce results that matter)	Absence of formal centralised control; focus on community rather than structure Employs the “Spotify model”, which implies the division of employees into Squads (self-organised groups of up to 8 people with diverse expertise); Squads are grouped into Tribes, supplemented by less formal Guilds (groups of people united by similar interests)
Rakuten	Mission: “To contribute to society by creating value through innovation and entrepreneurship”	Focus areas: teamwork, professionalism, achieving goals, continuous progress (“always improve, always advance” principle)	Committees make resolutions based on proposals from subcommittees Regular progress reporting to directors Mandatory daily company-wide Asakai meeting, during which progress and agendas are discussed
Kakao	Mission: “Kakao brings the future we need closer, using technology that understands people” Goal: “[To] promote social value”	Values: integrity (prioritisation of “Kakao’s mission over personal goals”), user-centricity, a challenge for excellence, team synergy	Rigid hierarchical structure Authority is “concentrated in the CA [Corporate Alignment] Council, adding another layer to decision-making”
SoftServe	Mission: “To enable talented people to change the world”	CARE principles: curiosity, authenticity, respect, empathy Core principles: “Make [...] clients successful, develop [...] teams, and innovate daily”	Matrix structure

Source: compiled by the author based on P. Hourlias (2023), Kakao Corp. (2024), Netflix, Inc. (2024), Rakuten Group, Inc. (2024), SoftServe (2024), SAP SE (2025), Spotify (2025), Ubisoft (2025), H.-W. Oh (2026), Ubisoft (2026), Netflix, Inc. (n.d.a), Netflix, Inc. (n.d.b), Rakuten Group, Inc. (n.d.), Rakuten Today (n.d.), SoftServe (n.d.a), SoftServe (n.d.b), SoftServe (n.d.c), Spotify (n.d.b), Ubisoft (n.d.a), Ubisoft (n.d.c)

The American management model is one of the most globally distinctive. The core goal is profit maximisation. The American approach is highly market-oriented: quick innovations, an agile approach depending on the market situation, and orientation towards short-term achievements are inherent to it. Employees are perceived as resources, and their individual contribution is the measure for evaluation (Suslov, 2024). Hard skills, the ability to make decisions quickly and independently, and leadership are highly valued (Kopchak *et al.*, 2021; Frantsyz, 2024). Rigid hierarchy and discipline are considered to be traditional features of the American management style. Nowadays, however, more liberal approaches and the establishment of flatter organisational structures are practised by US companies (Kopchak *et al.*, 2021). Netflix’s managerial practices exemplify the American approach. The mission’s formulation emphasises the role of two subjects for the company: customers and products (entertainment content). Though this does not indicate a focus on income directly, products should be perceived as the instrument for the achievement of the ultimate goal, which is increasing income and shareholder value maximisation. The embedded values at

Netflix show a clear prioritisation of the company’s interests, in contrast to the Japanese management model, where people are the core of the organisation. Individual performance has absolute primacy over all other employee qualities. Netflix exemplifies modern American companies that strive to implement less rigid and hierarchical structures. This organisation advocates for a minimum number of rules, fostering a culture of straightforwardness towards colleagues regardless of position, seniority, or background. Though employees are given the power to make a wide range of decisions independently, they have to take absolute responsibility for them, which is clear evidence of the American approach. Though the German, French, and Swedish management approaches possess unique features, they are part of the European model, which encompasses the general management philosophy across Europe (Kopchak *et al.*, 2021). The German management model is focused on achieving better quality in different aspects of business operations (Shorobura, 2023). During the employee evaluation process, the level of qualification, experience, and the degree of mastering new working methods are taken into account. The German management style is

characterised by a clear distribution of responsibilities and formal reporting procedures. Professionalism is highly valued. Long-term employment is inherent to this model.

According to I.M. Shorobura (2023), the characteristics of the French management model are informal relationships, a preference for qualitative methods of analysis and logical approaches, and thorough planning, together with an authoritarian and strictly hierarchical approach. The Swedish management model is focused on achieving social welfare (Frantsyz, 2024). The decision-making process includes discussions with employees from all hierarchical levels; “group dynamics are the most important aspect of management culture” (Mäkinen & Varis, 2023). In general, the European model is characterised by formalised and scientifically grounded management, a high degree of specialisation of employees, and individual evaluation according to personal results (Frantsyz, 2024). Besides economic efficiency, a strong focus is placed on social prosperity (Suslov, 2024). Employees are often engaged in decision-making. SAP’s mission and values directly illustrate the company’s focus on social welfare. While the employees’ interests are taken into account, a strong hierarchy and formal control are present in the company, which means that there is no direct indication of a flat structure at SAP.

Ubisoft (2025) strategic focal points, in particular culture and social impact, prove its alignment with the European management style. In its 2024-25 Universal Registration Document and Annual Financial Report, the company places an emphasis on fostering discipline in the organisation, which proves the French model’s inclination towards a classical authoritarian approach and formal control while preserving flexibility. The analysis of Spotify’s managerial practices demonstrates the company’s focus on collaboration and the perception of employees as integral components of a larger whole, whether that be a group or society. The company’s core values indicate a strong preference for logical approaches. The company’s structure is flat, granting employees a high degree of autonomy in decision-making and action. The Japanese management model is significantly different from the American one. The core idea that serves as the foundation for different aspects of this model is the pursuit of harmony. The Japanese model is human-centred; all employees are perceived as integral team members rather than resources, which is why collaboration and a consensus-based approach to decision-making are among the main characteristics of this management style (Suslov, 2024). An important concept within Japanese management is the Kaizen approach, which implies continuous improvement in all business processes, including production, human resources development, and management itself. The Japanese approach is directed towards satisfying consumer needs and improving the quality of goods and services, together with decreasing costs and losses (Demianiuk, 2022).

Group responsibility, the evaluation of effectiveness as a result of collective work, and the engagement of employees to drive innovation as one team are inherent to the Japanese management model. The sense of belonging to the collective, whether it is the workforce or society, led to the emergence of such a unique feature as lifelong employment, which helps people become reliable elements

of the system in which they work or live (Frantsyz, 2024; Suslov, 2024). The most prominent characteristics of the Japanese management style can be observed in Rakuten’s approach. The mission emphasises serving society, while the concept of Kaizen is deeply embedded in the core values and principles guiding the company. In its 2024 Integrated Report, Rakuten discusses the promotion of “kaizen activities from both ‘quality improvement’ and ‘quality assurance’ perspectives”. The existing hierarchical structure, the corporate governance system, as well as the communication and reporting practices directly indicate the presence of a consensus approach to decision-making, which implies taking into consideration the proposals of lower hierarchical levels. Still, a strict chain of command is preserved, which is observable in the custom of the Asakai meeting. Although the decisions made may include suggestions from subordinates, the orders and overall strategic direction are given by top management.

The Korean management model adopted some features of the American and the Japanese models, while retaining unique characteristics. S. Petko (2023) asserts that, similarly to the Japanese approach, rigid hierarchy, authoritarian leadership, and prioritising collective interests are inherent to Korean management. The scholar notes that collectivism served as the foundation for the formation of Korean corporate management. Like American companies, Korean organisations started to recognise the need for creative approaches under the influence of globalisation, which required constant innovation. A distinctive feature of Korean management is the chaebol-type corporate structure (large financial-industrial group). The term “kkondae”, which denotes a self-righteous older person, appeared in the Korean language to describe a widespread phenomenon of older people lecturing younger people, which causes generational conflict (Lee *et al.*, 2025). As part of Korean culture, it can also be used to characterise management features in South Korea, in particular, the presence of seniority-based authoritarianism. The mission and one of the major goals of Kakao, a South Korean company, indicate its focus on delivering social value, which supports the assertion about prioritising the collective in South Korean culture and, consequently, management. The same characteristics are evidenced by the company’s core values, in particular, integrity and team synergy. Kakao has a rigid structure with multiple hierarchical levels, which is entirely consistent with the traditional Korean management model.

The Ukrainian management model does not have well-defined characteristics, and it is currently in its formative stage (Frantsyz, 2024). Although scholars previously identified some features of Ukrainian management, which inherited a range of legacy principles from the Soviet administrative system, it is currently undergoing radical transformations (Kopchak *et al.*, 2021). In addition to the digitalisation and internationalisation processes, which influence management models around the world, the reasons for these changes are the ongoing military conflict within Ukraine, political and economic instability, and regulatory changes in the country. Due to multiple risks, companies are forced to adapt constantly, which makes flexible management more valuable in the current environment (Chaikova *et al.*, 2026). Ukrainian businesses try to adopt modern and effective managerial practices used

in foreign countries. In particular, scholars note that the level of investment made in human resource development has increased notably in recent years (Harkava *et al.*, 2024). However, Y. Kopchak *et al.* (2021) argue that Ukrainian management does not take cultural specificities into account while adopting new methods. SoftServe's mission is focused on providing opportunities and, ultimately, changing the world. The analysis of its core principles indicates

the company's commitment to innovation and development while maintaining empathy in its business operations. The formulation of the "making clients successful" principle shows that SoftServe places an emphasis on people rather than on the products that enable this success (SoftServe, 2024). The analysis of the selected companies regarding corporate culture and human resource management is presented in Table 3.

Table 3. Corporate culture and human resource management of the analysed companies

Company Name	Talent Development and Acquisition	Evaluation and Compensation	Employee Engagement
Netflix	Training model: "peer-to-peer learning model where internal subject-matter experts (SMEs) lead workshops and share their expertise" Active investment in the development of new talent with diverse backgrounds	Evaluation: based on "performance – not seniority, tenure or unconditional loyalty" Compensation: employees choose their annual salary-to-stock ratio Executive officers: "performance-based restricted stock unit awards and time-based restricted stock unit awards"	Engagement through regular meetings, surveys, and shared memos Feedback and comments are highly encouraged
Ubisoft	Culture of continuous learning Training focus: soft and hard skills Training volume: employees completed an average of 6.94 hours of training (2024-2025 financial year)	Four types of promotion: "development within the same position, lateral mobility, promotion to positions of greater responsibility, and international mobility" Compensation: salary, benefits, shares Annual salary increases according to individual performance, job-related expertise, and market positioning of the role	High engagement and autonomy in the game development process Freedom to experiment with different ideas instead of following strict instructions (during one of the stages of the creation process, the development team members present the game they want to produce, which becomes the prototype for the final product) Engagement score: 62 (2025)
SAP	Training volume: employees completed an average of 28 hours of training (2024) Internal portal SAP One for access to learning materials Hiring: based on abilities instead of purely on experience or educational qualifications	Performance management approach Compensation: base salaries and target bonuses	SAP Talk conversations between employees and their supervisors, during which personal progress is reviewed and discussed Top-voted issues addressed to top management during company meetings Prioritisation of the "interests, views, and rights of [...] employees in all operations", including strategy development Engagement score: 76 (2025)
Spotify	Training focus: "T-shaped" upskilling (improving expertise in the field of main activity together with expanding knowledge in other areas of knowledge)	Evaluation: based on individual performance "Equal access to benefits regardless of seniority" Compensation: base salary, target bonuses, shares	"Culture is built on the energy of being together" Organisational structure designed to maximise employee engagement
Rakuten	Training focus: business, digital, and leadership skills; mindset development seminars	Departmental KPIs Compensation: benefits and a flexible work schedule Executive directors: performance-based compensation (including non-cash options) tied to individual and overall company metrics	Regular one-on-one meetings between managers and employees Fosters a culture of entrepreneurship among employees via R-Pitch (a programme that allows employees to develop business ideas with mentorship; the most outstanding projects are later funded and launched) Engagement score: 83 (2024)
Kakao	Training focus: core job skills, cross-functional competencies, soft skills	Evaluation: "a multi-perspective review process involving the individual, peers, and leaders" based on the Growth Stage System, which outlines the expected competency levels; assessment of individual performance, growth potential, and job-related skills Compensation: "performance-based compensation includes various forms such as salary increases, bonuses, and stock compensation"	Engagement score: 53 (2024)

Table 3, Continued

Company Name	Talent Development and Acquisition	Evaluation and Compensation	Employee Engagement
SoftServe	Diverse types of training with an emphasis on soft skills improvement Training volume: employees completed an average of 44 hours of training (2024)	Evaluation: based on “technical skills and how employees embody core values”	Active interaction “with a wide range of internal and external stakeholders to understand their concerns and priorities” The stakeholders’ expectations are taken into account in operations, strategy, decision-making, and CSR activities

Source: compiled by the author based on Yip (2018), Spotify (2021), Kakao Corp. (2024), Netflix, Inc. (2024), Rakuten Group, Inc. (2024), SoftServe (2024), SAP SE (2025), Ubisoft (2025), Netflix, Inc. (n.d.a), Netflix, Inc. (n.d.b), Netflix, Inc. (n.d.c), PlusPlus (n.d.), Spotify (n.d.a), Spotify (n.d.b), Ubisoft (n.d.b)

Rakuten, Ubisoft, SoftServe, and Kakao make more disclosures regarding the provision of soft skills, compliance, awareness, and well-being training for employees, while Netflix and SAP focus more on job-related skills. Spotify and Kakao disclose training initiatives aimed at improving cross-functional competences among their staff. SoftServe notes that considering an employee’s compliance with the company’s values is a key criterion during the evaluation process. Job-related expertise, not only individual performance, is explicitly considered during employee evaluation at Ubisoft. Kakao has established a well-defined system for staff evaluation and promotion, in which an emphasis is placed on competency levels. Peer-to-peer evaluation practices are more widespread at Spotify and Kakao, which indicates a focus on the collective rather than the

individual. Netflix has a clearly expressed culture of granting employees the freedom to make decisions individually while requiring them to assume total responsibility for the outcomes, which is reflected in the practice of choosing the structure of compensation. The employee engagement level at Kakao was 53% in 2024, which is the lowest score compared with Rakuten, SAP, and Ubisoft. The employee engagement practices and indicators at Rakuten show its commitment to valuing staff’s interests and influence, which fully corresponds to the Japanese management style. Spotify emphasises its team-centred culture, which corresponds to the Swedish management model. The final part of the analysis of the studied companies was devoted to examining strategic orientation, R&D (research and development) activities, and innovations (Table 4).

Table 4. Innovation, R&D activities, and strategic orientation of the investigated companies

Company	Innovation and R&D Activities	Strategic Orientation
Netflix	Continuous investment in technology and development	Long-term horizon
Ubisoft	Active engagement of scholars in research and development activities to achieve synergy between practical and theoretical knowledge	Long-term horizon with a focus on constant improvements
SAP	Increase in research and development investments in 2020-2024	Long-term horizon
Spotify	Investments in AI (artificial intelligence) tool development and their integration into company operations	Culture of “failing fast” to facilitate quick learning; preference for small launches over large updates to drive continuous improvement
Rakuten	“Guided by the power of innovation” since its foundation in 1997	Continuous development
Kakao	Invests in AI development and its integration into platforms and daily operations; established the Kakao AI Campus for these purposes	Maintains the “continuity management system”
SoftServe	Established a Generative AI Lab for artificial intelligence R&D activities; invests in diverse innovation initiatives	Focus on ensuring long-term resilience

Source: compiled by the author based on SoftServe (2024), Kakao Corp. (2024), Netflix, Inc. (2024), Rakuten Group, Inc. (2024), SAP SE (2025), Spotify (2025), Ubisoft (2025), SoftServe (n.d.b), Ubisoft (n.d.d)

Rakuten, as a prominent representative of the Japanese management model, emphasises its focus on continuous development. The same approach is reported by Spotify and Kakao. In general, it can be seen that well-established companies from different countries focus on long-term development regardless of cultural peculiarities, because it helps to ensure survival and competitiveness. The same reason

makes organisations around the world, including all seven companies in this study, conduct research and development activities and constantly implement innovations. Based on the analysis of the management approaches in the selected technology companies, Table 5 summarises the general features of the national management models in the USA, France, Germany, Sweden, Japan, and South Korea.

Table 5. Key characteristics of the investigated national management models based on the technology sector

	USA	France	Germany	Sweden	Japan	South Korea
Main goal	Profit maximisation, company growth	Balance between economic performance and social impact	Balance between economic performance and social impact	Balance between economic performance and social impact	Contribution to society, satisfying customer needs	Introducing innovation and promoting social value
Values	Selflessness, candour	Discipline, innovation	Social responsibility, supporting customers	Teamwork, thoughtfulness	Teamwork, continuous progress	Teamwork, challenge for excellence

Table 5, Continued

	USA	France	Germany	Sweden	Japan	South Korea
Training	Focus on job-related skills	Focus on soft skills; cross-functional and non-job-related hard skills	Focus on job-related skills	Focus on cross-functional skills	Focus on soft skills; cross-functional and non-job-related hard skills	Focus on cross-functional skills
Innovation	Focus on innovation	Focus on innovation	Focus on innovation	Focus on innovation	Focus on innovation	Focus on innovation
Evaluation criteria	Individual performance	Individual performance and job-related expertise	Individual performance	Individual performance	Individual and overall company performance	Correspondence to the expected competency levels, individual performance, and job-related skills
Staff engagement	Individual empowerment	Democratic participation through dialogue	Democratic participation through dialogue	Team empowerment	Collective participation	Not explicitly defined (engagement score: 53)
Corporate structure	Horizontal	Hybrid hierarchical	Hybrid hierarchical	Horizontal	Hierarchical	Hierarchical
Strategy	Long-term	Long-term (focus on continuous development)	Long-term	Long-term (focus on continuous development)	Long-term (focus on continuous development)	Long-term (focus on continuous development)

Source: compiled by the author

Highlighting general approaches in national management models helps to assess their correspondence to the cultural characteristics of the respective countries. The USA and Sweden have some of the lowest power distance indices, which is manifested in the prevalence of horizontal organisational structures in these countries' organisations, as seen at Netflix and Spotify. Japan, South Korea, and France have higher PDI scores, which corresponds to the presence of authoritarianism and vertical structures in these countries' management models. France, Germany, Sweden, and the USA have the highest scores regarding the individualism criterion, which is fully expressed in the managerial practices of the representative companies of the mentioned countries. Though the engagement score at Rakuten, the Japanese company, is one of the highest among the analysed companies, the character of staff involvement is fundamentally different compared to that of the USA and European countries. While collective participation is inherent to the Japanese model, American and Swedish companies, in particular Netflix and Spotify, practise granting a high degree of autonomy to employees, enabling them to make independent decisions. South Korea has one of the lowest engagement indices, which fully corresponds to the national peculiarity of low individualism (18 points). The influence of masculinity indices on managerial styles cannot be clearly traced through the aspects that have been analysed in this article. The USA has a high score, which is reflected in the main goal of company growth, namely competitiveness, while Sweden has the lowest score, and this is represented in the desire of companies in this country to have a positive social influence, which is a clear prioritisation of caring for others. The high masculinity index in Japan does not contradict the consensus approach in this country's managerial style, which is explained by low individualism, but rather reflects their culture of hard work.

Japan, South Korea, and France have the highest scores regarding uncertainty avoidance, and this national feature

is manifested in the companies' focus on continuous development. Although Spotify's focus on constant improvements does not correspond to Sweden's low score on UAI, it can be explained by its relatively high long-term orientation index. However, the direct influence of the low uncertainty avoidance scores of both Sweden and the USA can be observed in Spotify's and Netflix's cultures of minimal rule presence. Scholars note that an orientation towards short-term achievements is a distinctive feature of the American management model, a practice that perfectly corresponds to the USA's minimal score on the long-term orientation index (Suslov, 2024). However, the rapidly changing environment of the modern world forces companies to focus on long-term operations in order to stay competitive, regardless of national characteristics. Consequently, the analysis of established national management models demonstrated a close correspondence between cultural characteristics and managerial practices. This understanding can be applied to the Ukrainian managerial style in order to define managerial practices that are more inherent to the national culture and, consequently, more effective and acceptable within this country.

Assessing the integration of foreign practices in the Ukrainian IT sector

Ukrainian management, which emerged as an independent phenomenon relatively recently, is currently transitioning from old practices inherited from the Soviet era and is actively adopting methods from well-established foreign models. Comparing Ukraine with the other analysed countries through the lens of Hofstede's cultural dimensions can enable the identification of those countries that are the most similar and, accordingly, determination of national management practices from which Ukrainian managers can learn. The results of the calculation of Euclidean distances between Ukraine and the other analysed countries through the framework of Hofstede's cultural dimensions are presented in Table 6.

Table 6. Euclidean distances between Ukraine and the selected countries based on Hofstede's cultural dimensions

USA	France	Germany	Sweden	Japan	South Korea
105.46	44.71	71.16	102.36	66.07	40.07

Source: calculated by the author

As can be seen from Table 6, Ukrainian cultural characteristics are closest to the South Korean and French ones. The country has the greatest differences from Sweden and the USA, while being moderately similar to the Japanese and German cultures. This indicates that flat and highly autonomous practices, which are inherent to the American and Swedish models, contradict the national characteristics. This misalignment poses a particular challenge for Ukrainian business, especially in the IT sector, where organisations actively adopt American approaches. In order

to analyse the current cultural compatibility of the Ukrainian managerial style, it is necessary to examine its similarities with other management models and check whether the adopted practices correspond to those that are suitable for the Ukrainian mentality. Although drawing broad conclusions requires caution as the data is summarised based on the analysis of a single IT company, the general patterns of the Ukrainian management style in the technology sector can be outlined through the case study of SoftServe's managerial practices (Table 7).

Table 7. Characteristics of the Ukrainian managerial style in the technology sector (the case of SoftServe)

Main goal	"To enable talented people to change the world"
Values	Curiosity, empathy, team development
Training	Focus on soft and job-related hard skills
Innovation	Focus on innovation
Evaluation	Job-related expertise and correspondence to company values
Staff engagement	Democratic participation through dialogue
Organisational structure	Matrix structure
Strategy	Long-term

Source: compiled by the author

The mission and core values of SoftServe indicate a focus on showing empathy, supporting, and helping others, which contrasts with the American management style. Among all the analysed management styles, Ukraine has a unique training system that combines a focus on soft skills and job-related hard skills. This differs from all other management styles, in which the emphasis is placed on cross-functional or non-job-related hard skills development, or less attention is paid to soft skills. A focus on innovation is inherent to all of the studied management styles today, because it helps to ensure a company's long-term competitiveness. The evaluation process in Ukrainian management, the characteristics of which were identified based on the SoftServe analysis, demonstrates a unique feature: the consideration of an employee's correspondence to the company's values during staff evaluation. Another important criterion in this process is job-related expertise, which is similar to the French and South Korean managerial styles. Staff engagement and organisational structure in Ukrainian management, as observed at SoftServe, do not exactly match any of the analysed models. However, the matrix structure is more similar to a hybrid hierarchical structure than to purely horizontal or hierarchical ones. Consequently, Ukrainian management is close to the German and French management models in this aspect. The strategy has a long-term horizon; however, a focus on continuous development is not observed, which corresponds to the American and German managerial styles. This analysis showed that the Ukrainian management model applied at SoftServe shared the most similarities with the French and German models. There is no clear indication of following the Swedish managerial style, which is a positive sign, because this model contradicts the Ukrainian mentality. However, the match with the South Korean, French, and Japanese

management models, which are culturally closer to Ukraine, is not highly pronounced.

It is advisable to consider the possibility of expanding cross-functional skills development in Ukrainian companies. This approach in employee training is practised by French, Japanese, and South Korean management in the corresponding IT companies and broadens the possibilities for innovation development. Furthermore, it helps to ensure the long-term competitiveness of staff, which is not only crucial in today's rapidly changing world but also fully corresponds to the long-term orientation and high uncertainty avoidance of Ukrainians. Uncertainty avoidance and long-term orientation are among the highest in Ukraine, together with Japan, South Korea, and France, which place a focus on continuous development in their strategic management, unlike Ukraine. While it may not be relevant to focus on a long-term development perspective for Ukraine today due to the current highly turbulent political situation, which leads to the impossibility of implementing long-term plans due to an extremely high number of possible risks, concentration on continuous development can help to create plans that consider the maximum possible number of risks in advance, so that new strategies with high levels of stability could be implemented. Although the war can be an obstacle for some companies in Ukraine to orient towards continuous development, businesses should switch their strategic focus to this immediately after the war ends, because this approach corresponds to Ukrainian cultural characteristics and will help to ensure long-term survival, which is crucial given the presence of a hostile neighbouring country.

A high power distance index, a high uncertainty avoidance index, and moderate individualism, similar to Japan's, call into question the possibility of matrix structure implementation in Ukrainian companies. Though scholars insist

that hierarchical structures hinder free communication, collaboration, idea exchange, and, consequently, appropriate development of the company, they are culturally more acceptable to Ukrainians. Even a matrix structure, as observed at SoftServe, may contradict the mentality, which is why it makes sense to consider the preservation of a strong hierarchy. High uncertainty avoidance excludes the possibility of rejecting rules in companies, and a substantially high score on power distance indicates a low potential for a non-hierarchical organisational structure in Ukrainian firms. Still, Japan's extensive experience regarding hierarchical structure management can be adopted in Ukraine, which will help to mitigate the significant number of negative consequences of avoiding a flat structure. Specifically, collective participation, such as a consensus-based approach, may be fostered in companies. Alternatively, the switch to the hybrid hierarchical structure, as in Germany and France, should be considered. As the Ukrainian management style is not well defined yet, and managerial practices in organisations may vary significantly today due to different circumstances, particularly those related to the war, the analysis of cultural distance between Ukraine and the other six countries can be used by other companies' management teams who are looking to adopt effective foreign practices. As the research showed, Ukraine has the most similarities with South Korea and France regarding cultural characteristics; thus, it is advisable to investigate and follow the management models of these countries.

● DISCUSSION

The results of this study reinforced the view that cultural characteristics are aligned with the peculiarities of national managerial styles. In particular, they confirmed the presence of links between Hofstede's cultural dimensions and the features of managerial practices in different countries, as M. Averkyna & A. Matvieiev (2025) stated. However, this study added practical evidence of these relations through the analysis of management approaches in the companies representing each of the investigated models. At the same time, it was also identified that certain characteristics, such as the focus on innovation and long-term planning, are common across all models. This phenomenon reflects convergence theory, supported by numerous scholars, which suggests that globalisation leads to the unification of managerial values and behaviours globally (Girlando *et al.*, 2026). As the mentioned characteristics were found to be the same across all the investigated managerial styles, the unifying impact of globalisation can be identified in this case. Flat structures, long-term orientation, and a focus on innovation and agility have become global trends, as these practices are universally expected to drive managerial effectiveness. However, as Y. Robul *et al.* (2025) highlight, even when a company attempts to integrate these global norms, managers frequently face significant resistance from employees due to a "value gap of management". This phenomenon leads to a discrepancy between managerial expectations and subordinate behaviours. It indicates that such resistance arises not merely from national mentality, but from a failure to adapt the internal corporate culture to these new approaches. Flat structures without deep institutional trust lead to defensive autonomy rather than collaboration; ambition without continuity and agility without

embedded responsibility become destructive to an organisation rather than beneficial. Thus, establishing moral alignment and the required organisational culture within the workforce becomes a challenge and one of the crucial tasks for managers who strive to follow global trends rather than practices dictated by national culture. For instance, as A. Trzaskowska-Dmoch *et al.* (2025) note, a tailored approach to corporate culture and leadership enabled Spotify to create an organisation that is not only structurally flat but also possesses the necessary flexibility. Their analysis demonstrated that even the highly successful Spotify model is not a universal template that can be blindly adopted, but rather the result of context-specific adaptation.

Y. Frantsyz (2024) investigated the features of foreign management models and noted that short-term employment is inherent to the American and European models. Additionally, P. Suslov (2024) emphasised the short-term strategic orientation of the American style. However, the analysis of the companies' management showed that a long-term orientation, as well as the focus on innovation implementation, are characteristics of all the investigated models, including the American and European approaches, regardless of cultural features. This proved that the desire to stay competitive in the market may change some management methods, even though they may contradict national characteristics. D.A. Firican (2022), who investigated the influence of Hofstede's cultural dimensions on change and innovation strategies and acceptance in organisations, argued that, although some managerial methods should be adapted to cultural characteristics, certain cultural features are flexible, and a company should adjust them according to business needs, particularly the need to stay innovative and competitive. Globalisation enables multinational trade agreements and technology transfers that lead to the adoption of innovations in companies across the globe, enhancing global competitiveness and the need to innovate constantly in order to survive on the international market (Alkharafi & Alsabah, 2025). As competitiveness grows, long-term orientation becomes another instrument for companies to survive. Thus, globalisation can be viewed as one of the fundamental factors that led to the unification of approaches to innovation and strategic time horizons across all investigated companies. Other reasons may include digitalisation and scientific and technical progress.

As most of the practices are formed under the influence of cultural features, Ukrainian management was analysed from the cultural perspective. Yu. Kopchak *et al.* (2021) compared managerial approaches in different countries and stated that Ukrainian management adopts new practices that do not always correspond to the national mentality. This research showed that a large number of characteristics of the current Ukrainian management style are aligned with the culture. However, some features seemed to appear as a result of following modern practices without taking into account the cultural peculiarities. In particular, shifting to a flatter organisational structure looks like an attempt to adopt successful American or European approaches, while ignoring the fact that its implementation may be ineffective because of national characteristics, particularly high power distance and uncertainty avoidance indices, unlike in the USA and most European countries.

P. Suslov (2024) compared management types in particular countries and formulated recommendations for the improvement of the Ukrainian management style. The author noted human resource development as one of the most crucial steps to be taken in order to make domestic production more effective. P. Suslov emphasised the need to consider foreign experience in this matter, while also taking into account cultural features. However, the elaboration of particular steps for improvement was not the main objective of the mentioned research. In this regard, the results of this study complement the recommendations of P. Suslov, as it was determined that the implementation of cross-functional skills development in Ukrainian companies, which fully corresponds to the national culture, will benefit human resource development and, consequently, the effectiveness of the Ukrainian managerial style.

This study's recommendation to prioritise continuous development closely aligns with the findings of M. Uygur & B. Peyravi (2025), who recommended that Ukrainian organisations focus on long-term economic stability rather than short-term achievements. They suggested that investing in infrastructure, workforce and technology development, in particular through data security, support of remote working and elaboration of robust communication channels, is essential to provide long-term resilience for business entities. A significant limitation of this study was the generalisation of the Ukrainian management model based on a single case study. Although SoftServe is a leading enterprise in the Ukrainian IT sector and provides valuable insights into modern managerial transformations in the country, it may possess unique characteristics that may not fully represent the broader Ukrainian managerial style inherent to other companies. Nevertheless, the calculated cultural distances and identified features of national management models can be used in further studies regarding the feasibility of following international practices in any other Ukrainian company or in the Ukrainian management style in general.

● CONCLUSIONS

The study confirmed a close correspondence between cultural characteristics and the formation of national management models, although companies across all investigated countries maintain a focus on long-term development and innovation regardless of the specificities of national peculiarities. The results of cultural distance calculations showed that Ukrainian culture is closest to that of South Korea and France, and differs most from those of Sweden and the USA. The Ukrainian management style shares the most similarities

with the French and German models, with certain practices aligning with the South Korean model, whereas employee evaluation and training approaches do not align with any of the other analysed styles and exhibit unique national features. The study revealed that a long-term orientation with a focus on continuous development is inherent to the Ukrainian mentality, though management usually considers solely a long-term orientation. During the research, it was found that Ukrainian management tends to implement a matrix structure in organisations, even though Ukraine's indices of power distance, uncertainty avoidance, and individualism more closely resemble those of Japan than Western nations.

Based on the findings, practical recommendations were formulated. Ukrainian managers should incorporate a focus on cross-functional skills development into their training systems, which is expected to be well-received by employees given their cultural characteristics and can provide a competitive advantage to the company. It is advisable for companies to focus on continuous development to ensure long-term survival and sustainable existence. In order to eliminate the discrepancy between the cultural characteristics and the utilised organisational structure, Ukrainian managers should consider the successful practices of preserving a hierarchical structure and evaluate its implementation, or at the very least, approach the preservation of a matrix structure more carefully. As the Ukrainian managerial style does not have well-defined characteristics and in this study it was identified on the basis of management in one company, the formulated recommendations may not be universally applicable to all other organisations. However, the calculated cultural distances and identification of national management models' characteristics with the help of concrete practices provide a basis for further analyses of management and formulation of recommendations for adopting foreign practices in any Ukrainian company. Additionally, the practices of other national management models and cultural distances to the corresponding countries should be investigated in order to identify the methods that may be successfully adopted in Ukraine.

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Культурні детермінанти національних моделей менеджменту: доцільність впровадження іноземних практик в українському IT-секторі

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Анотація. Український менеджмент, який став незалежним явищем відносно нещодавно, наразі відходить від застарілих практик радянських часів та активно впроваджує методи управління усталених зарубіжних моделей, що зумовлює потребу в аналізі обґрунтованості таких запозичень. Метою цього дослідження було визначення доцільності наслідування іноземних стилів менеджменту в українському IT-секторі на основі культурних характеристик. Було застосовано комбінований метод дослідження, що включає порівняльний аналіз, узагальнення та синтез теоретичної інформації, а також аналіз практичних кейсів Netflix, Ubisoft, SAP, Spotify, Rakuten та Kakao. У результаті дослідження було підтверджено вплив культурних характеристик на формування національних моделей менеджменту в сучасному контексті глобалізації. Визначено, що довгострокова орієнтація та фокус на інноваціях присутні в кожній із досліджуваних моделей незалежно від культурних особливостей. Обчислення евклідових відстаней виявило, що Україна має найбільшу культурну близькість із Південною Кореєю та Францією та найменше схожих рис зі Швецією та США. Український стиль менеджменту було визначено за допомогою аналізу практик компанії SoftServe та порівняно з іншими моделями. Результати засвідчили, що підходи в українському менеджменті загалом відповідають культурним характеристикам, що підкреслює значний потенціал для їхнього ефективного використання. Водночас наявні певні риси, які були запозичені в результаті наслідування іноземних управлінських практик без урахування національного менталітету. За результатами дослідження було сформульовано рекомендації щодо інтеграції управлінських практик, які відповідають культурним особливостям. Практична значущість роботи полягає в можливості використання зазначених пропозицій менеджерами українських IT-компаній та спеціалістами з управління для покращення ефективності організаційних процесів та пошуку інструментів менеджменту, які матимуть найменший опір з боку персоналу

Ключові слова: адаптація управлінських підходів; ефективність управління; український стиль керівництва; методи управління; теорія Гофстеде

International experience in the use of AI in the legislative process as an example for Ukraine

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Abstract. The purpose of the study was to provide a comprehensive theoretical analysis of international practice in implementing neural-network technologies in law-making. The research process combined comparative-legal, formal-legal, structural-functional, and systems methods to compare regulatory frameworks, institutional constraints, and the architecture of digital platforms in three states: Ukraine, the Italian Republic, and the Federative Republic of Brazil. The study identified digitalisation as an objective necessity for reducing the bureaucratic burden, particularly during the adaptation of more than 2,700 acts of European law, when the drafting of only one regulatory document required 130 specialists and more than 22 thousand hours of work. The Italian and Brazilian parliaments successfully used natural language processing and machine-learning tools to categorise citizens' comments and cluster proposals. Official parliamentary reports showed that specialised algorithms could substantially accelerate the processing of large document sets, including sorting 82 million amendments within three days and publishing draft transcripts of sittings 40 minutes after a speech. Automation streamlined routine procedures, but neural networks could not independently produce legally flawless texts due to the high risk of algorithmic errors. The analysis supported the conclusion that human oversight cannot be replaced, and final verification of generated content must remain the exclusive responsibility of a person. The practical value of the results lies in the possibility for the Office of the Verkhovna Rada of Ukraine and the Ministry of Digital Transformation of Ukraine to use the proposed recommendations when developing internal regulations

Keywords: digital platforms; public administration; machine learning; natural language processing; large language models; personal data protection; digital transformation

● INTRODUCTION

The development of digital technologies has transformed traditional institutions of public administration. Law-making, as a basis for the functioning of any state governed by law, faces increasingly complex social relations and growing volumes of information. Governments have to process large bodies of text, including aligning new draft regulatory acts with laws already in force, assessing socio-economic consequences, and considering citizens' proposals. For countries adapting national legislation to international standards, this creates a bureaucratic burden on the staff of representative bodies. Artificial intelligence (AI) systems offer new possibilities for streamlining law-making. Large language models, natural language processing algorithms,

and machine learning can accelerate expert procedures, automate the detection of legal gaps, and increase parliamentary transparency. Delegating even part of the analytical work to neural networks, however, introduces risks. These concern mainly algorithmic bias and opacity in decision-making, extending to the possibility of systemic legal errors. Research on international experience in integrating intelligent systems into the work of supreme legislative bodies is therefore relevant, particularly for building a safe and effective digital environment for the state.

The legal regulation and introduction of new technologies in public institutions remain subjects of academic debate. A.V. Sterpetti *et al.* (2025) examined the legal and

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ethical consequences of using AI in medical decision-making through clinical practice in vascular surgery. The authors concluded that, despite the accuracy of algorithmic recommendations, the final decision must always be made by a specialist in order to avoid legal disputes. G. Mercan & Z.V. Selçuk (2024) examined the opportunities and challenges associated with integrating AI into legal practice. They argued that protection of individual rights required management strategies that ensured algorithmic transparency. M. Rönnblom *et al.* (2024) analysed the discourse around “ethical” and “responsible” AI and the political consequences of shaping such policies. They concluded that an exclusive focus on ethics depoliticised the problem by concealing real power imbalances in the introduction of technologies into the governance of society. N. Khmelevska (2025) assessed the prospects and obstacles associated with the use of AI systems in juvenile justice. She reported that working with algorithms reduced the time needed for procedures, but required a clear regulatory framework for the protection of personal data and the administration of justice. O. Bessonov (2025) considered international experience in the legal regulation and use of assistive AI systems in the judiciary of different states. He identified no single global model for the digitalisation of justice: some countries delegated certain powers to algorithms for predicting case outcomes, while others introduced legislative prohibitions on such practices.

V. Boiko (2024) described the development of international regulation aimed at using international standards in the formation of national legislation on public administration. The researcher argued for a flexible regulatory environment that took account of the European Artificial Intelligence Act and supported technological development without creating a risk of human-rights violations. V. Kozma (2023) assessed the extent to which intelligent systems had entered global politics. The author reported that, under conditions of armed conflict, AI had become a tool for analysis and intelligence gathering. This created new tasks for political science and democratic control. V. Franchuk (2025) characterised the governance potential and socio-economic risks of introducing AI into public administration. The analysis concluded that reducing these threats required the state to establish a coordinating body, develop legal safeguards for transparency, and introduce educational programmes for public servants. D. Lande *et al.* (2025) examined a set of social and legal conflicts arising in regulatory fields from the characteristics of AI systems. The researchers developed a system of parliamentary oversight using prompts and primitives for automated detection of conflict-generating provisions in draft laws. N. Rotar (2026) traced the institutional integration of AI technologies into the routine work of representative bodies of government. She argued that successful parliamentary digitalisation depended on the quality and reliability of data, while the innovations themselves should remain auxiliary tools and could not provide political accountability for legislators. Z. Lupak *et al.* (2025) systematised the evolution of intelligent systems through doctrinal legal challenges arising from the digitalisation of social relations. The authors concluded that existing regulation did not provide legal certainty on liability and the status of information systems, which

pointed to a need to harmonise national rules with European safety standards.

Despite the existing research on the influence of AI on legal practice, several theoretical gaps require closer examination. Instrumental use of algorithms in a formalised legislative process remains underexplored. Most authors concentrated on judicial proceedings, ethics, or general administration and gave less attention to the praxeological dimension of parliamentary work, such as technologies for clustering parliamentary amendments, automated semantic analysis of draft laws for compliance with European standards, or neural-network processing of public-hearing materials. The study aimed to analyse international experience in implementing AI technologies in the legislative process from a theoretical perspective. The objectives were to examine the current stage, technological strategies, and regulatory challenges of implementing AI tools in the work of the parliament of Ukraine; analyse advanced practical experience; and develop recommendations for adapting effective international practices to the law-making process of Ukraine.

● MATERIALS AND METHODS

The theoretical part of the study covered the information and legal environments of three main states: Ukraine, the Italian Republic, and the Federative Republic of Brazil. Experience of the European Parliament and the parliamentary practice of Greece and Cyprus were also included as supplementary comparative material for assessing the legislative process of Ukraine. This selection of jurisdictions allowed comparison of different stages and scales of digitalisation in public administration. Ukraine was treated as a transitional model, Italy was included as an example of a European innovation ecosystem, while the experience of Brazil represented a model for managing very large document flows in the bicameral system of a federal state. The comparative-legal method was used to compare the fundamental principles for integrating automated systems into traditional law-making. The analysis covered core provisions of the national constitutions: Constitution of Italy (1948), Federal Constitution of Brazil (1988), Constitution of Ukraine (1996), and framework and specialised laws regulating law-making and the use of advanced technologies: Law of Ukraine No. 3354-IX (2023) and Law of Italian Republic No. 132 (2025). This methodological set made it possible to identify common regulatory trends in the standardisation of algorithmic decisions and to trace how different legal systems balanced the aim of streamlining legislators’ work against the need to preserve their exclusive discretionary powers.

The formal-legal approach was used for detailed examination of institutional and procedural restrictions, personal data protection rules, and strict procedural requirements for information processing in parliaments. Assessment of the legislation of Ukraine covered parliamentary rules of procedure and personal data protection provisions: Law of Ukraine No. 1861-VI (2010) and Law of Ukraine No. 2297-VI (2010). The provisions of Law of Ukraine No. 2807-IX (2023) were also examined. Procedural requirements and amendments to Chamber of Deputies of Italy (1971) were examined from official acts. Brazilian procedural rules and legislation on digital governance were analysed on the

basis of the relevant laws and resolutions: Resolution of the Rules of Procedure of the Chamber of Deputies of Brazil No. 17 (1989), Law of Brazil No. 95 (1998), and Law of Brazil No. 14.129 (2021). Separate attention was given to the requirements of Brazilian data-protection legislation, Law of Brazil No. 13.709 (2018) and Agency for Digital Italy (2019). These regulatory sources clarified the legal barriers limiting unrestricted use of commercial neural networks and the requirements for processing confidential information when preparing comparative tables or financial and economic justifications. Structural-functional analysis was used to examine the architecture of digital platforms and software systems. The analysis focused on technical descriptions, instructions, and reports on the operation of specific algorithms (Senate of the Italian Republic, 2025; Public Sector Tech Watch, 2026). These materials clarified the specific roles of large language models (LLMs), retrieval-augmented generation (RAG), optical character recognition (OCR), and blockchain architecture in daily workflows.

Systems analysis, together with an analytical and synthetic approach, was used to examine government concepts and road maps of Ukraine in the field of AI: Decree of the Cabinet of Ministers of Ukraine No. 1556-2020-r (2020) and documents of the Ministry of Digital Transformation of Ukraine (2023; 2024). Materials on interparliamentary cooperation with Greece and Cyprus, together with initiatives of the Research Service of the Verkhovna Rada of Ukraine (2024; 2025), were examined through official reports and webinars. European approaches were analysed using the European regulation, European Parliament reports, and the guidelines of the Inter-Parliamentary Union (2024; 2026). Analytical assessments of the Organisation for Economic Co-operation and Development (OECD) (2025; 2026), and the national strategies of Italy and Brazil, were examined through the relevant documents of Ministry of Science, Technology and Innovation (2024) and Agency for Digital Italy (2024). Examination of these materials was intended to combine individual technological practices and soft-law provisions into one set of recommendations for the legislature of Ukraine

● RESULTS

Theoretical-legal and praxeological foundations for implementing AI in the legislative process of Ukraine

The increasing complexity of social relations and intensifying European integration processes have created challenges for the legal system of Ukraine that require substantial revision of traditional approaches to law-making. Under Constitution of Ukraine (1996), the sole body of legislative power in the state is parliament – the Verkhovna Rada of Ukraine – whose exclusive competence includes adopting laws, determining the principles of domestic and foreign policy, and implementing the strategic course towards full EU membership. This course places a very high cognitive and administrative burden on parliamentary staff and the subjects of legislative initiative. According to official data from the relevant parliamentary committee, full EU membership requires the state to implement more than 2,700 acts of European law. If the current pace of traditional law-making is maintained, this work may extend over more than one and a half decades (Research Service of the Verkhovna Rada of Ukraine, 2024). The drafting of only one document required

for European integration, the draft law on electronic communications, illustrated the scale of the task: more than 130 specialists were involved, spent over 22 thousand person-hours, and prepared more than 30 thousand pages of supporting materials. These resource requirements make the search for new technological solutions necessary, including AI systems that can streamline structural and algorithmic analysis of large bodies of legal data. Assessment of the current introduction of intelligent systems into the work of the Verkhovna Rada of Ukraine showed that, as of 2026, the process remained mainly at the stage of active testing, conceptual development, and educational preparation of staff rather than official full-scale incorporation into procedural rules. One example was a specialised educational webinar held by the Research Service of the parliament in early 2025 on integrating AI tools into the work of members of parliament and their advisers (Research Service of the Verkhovna Rada of Ukraine, 2025). Expert input from the parliaments of Greece and Cyprus allowed legislators of Ukraine to examine practical examples of machine-learning algorithms used for automated text processing, analysis of legislative initiatives, and, more importantly, forecasting the socio-economic consequences of regulatory acts. This corresponded to the requirements of the legislation of Ukraine, which requires an impact assessment of a draft regulatory legal act on social relations, including forecasts of demographic, economic, regulatory, and corruption-related consequences. Generative models can accelerate preparation of financial and economic justifications and comparative tables, which are mandatory supporting documents when draft laws are submitted for a second reading.

The technological tools currently being tested and planned for the national legislative process combine neural-network solutions, cloud computing, and cryptographic databases. According to statements by the leadership of the Committee on Digital Transformation, the strategic vision of parliament is based on large language models (LLMs) for automated detection of conflicts between draft national laws and the EU *acquis* (Research Service of the Verkhovna Rada of Ukraine, 2024). Integration of blockchain technologies is also planned to provide transparency, immutability, and protection against unauthorised interference with draft laws during drafting, committee consideration, and final voting. Development of such systems rests on the state informatisation policy, which gives legislative priority to digital technologies for improving public administration and requires localisation of software products used by public authorities. A domestic, localised architecture is a national-security requirement, since processing the texts of laws before official publication may involve sensitive information of state importance, including state secrets and other protected information. The regulatory framework that legitimises and directs the use of AI in Ukraine has developed gradually and follows the so-called “bottom-up” approach (literally, “from the bottom upwards”).

The basic document setting the direction for this field was Decree of the Cabinet of Ministers of Ukraine No. 1556-2020-r (2020), which already in 2020 identified the need to use intelligent systems for analysing the texts of administrative decisions, streamlining public administration, and reducing excessive bureaucracy in the state apparatus. The Ministry of Digital Transformation

subsequently conceptualised development of the regulatory field in a dedicated Road Map (Ministry of Digital Transformation of Ukraine, 2023) and set out further detail in a White Paper (Ministry of Digital Transformation of Ukraine, 2024). The approach chosen by the state has two main stages. The first stage, planned for the period up to 2026, avoids mandatory regulation and relies on soft-law instruments. These include voluntary codes of conduct, methodological recommendations, a voluntary

labelling mechanism for synthetic content, and regulatory “sandboxes” for safe algorithm testing. The second stage provides for adoption of a comprehensive law as a national counterpart to Regulation (EU) 2024/1689 (2024) (AI Act), which will harmonise national legislation with EU requirements. Table 1 was prepared to systematise the phased introduction of intelligent systems into national parliamentary practice and to present the architecture of the planned changes.

Table 1. Strategic vectors for implementing AI in the legislative process of Ukraine

Implementation vector	Technological tools	Expected praxeological effect	Mandatory preventive measures
Adaptation to the EU acquis	Specialised large language models (LLMs), RAG technology	Automated semantic search, rapid detection of conflicts between national and European law	Deployment of algorithms only on closed local servers (open commercial models prohibited)
Optimisation of committee work	Natural language processing (NLP), spatial clustering algorithms	Rapid generation of comparative tables, bulk sorting of amendments to draft laws	Compliance with the “Human in Command” principle (absolute human verification of final texts)
Transparency and accountability	Blockchain architecture, OCR	Ensuring the immutability of texts during drafting, digitisation of historical archives	Mandatory machine-readable labelling of all generated synthetic content

Source: compiled by the author based on Ministry of Digital Transformation of Ukraine (2024), Research Service of the Verkhovna Rada of Ukraine (2024), Regulation (EU) 2024/1689 (2024)

The effects of intelligent algorithms in law-making need to be assessed against both their advantages and the risks identified. One positive area, where the technology already improves existing processes, is the speed of analytical processing of legal texts. Under the procedural rules, parliamentary committees must carry out a preliminary review of a draft law within thirty days and obtain conclusions on its budgetary impact and its compliance with Law of Ukraine No. 1861-VI (2010). AI gives them a tool for automating routine expert review. Its capacity to generate comparative tables and detect terminological inconsistencies reduces the routine workload of expert units of the Office of the Verkhovna Rada. Analytical systems can also make legal monitoring of legislation in force more efficient, a requirement that has been established at legislative level. At the same time, these technologies create several threats that may lower the quality of the legislative process when adequate safeguards are absent. The principal risks are algorithmic “hallucinations” and substantive model bias, which in law-making may lead to regulatory acts containing hidden legal gaps or discriminatory provisions. Under conditions of full-scale armed aggression, parliamentary infrastructure is also a continuing target for external cyberattacks and information operations.

Specialised security centres report that hostile intelligence services actively use AI to generate fake documents, deepfakes of public officials, and disinformation intended to undermine trust in public institutions (Research Service of the Verkhovna Rada of Ukraine, 2025). These challenges were emphasised separately during educational activities for parliamentarians of Ukraine, where the need for robust cybersecurity policies and control over the use of generative models in public institutions was discussed. Another concern for the legal system is the risk of violating fundamental rights when unverified algorithms are used. The legal order in the state rests on the principle that no one may be compelled to do what is not required by law. Use of AI to model the social consequences of laws or support public consultations involves processing very large volumes of

personal data. Law of Ukraine No. 2297-VI (2010) prohibits the processing of sensitive data on ethnic origin and political or religious beliefs without the person’s consent, and it guarantees every citizen protection against an automated decision that has legal consequences for that person. Delegating functions related to social scoring or profiling of citizens to neural networks during regulatory impact assessment of draft laws is therefore categorically unacceptable.

The combined theoretical and empirical material was used to formulate a set of research-based recommendations for further application of international experience with AI in the legislative process of Ukraine. The need for such implementation is beyond doubt, since only technological automation can ensure timely and high-quality implementation of thousands of acts of European law into national legislation. This process, however, must retain an anthropocentric approach. The guidelines of the Inter-Parliamentary Union (2024) state that AI should be treated only as a tool for extending human capabilities, not as a substitute for democratic deliberation or direct political decision-making. Members of parliament must remain personally responsible for their votes, and no algorithm may replace the discretionary powers of a legislator. Ukraine needs to accelerate institutional development in digital oversight. International experts reported that effective implementation of European rules requires Ukraine to establish a single independent digital regulator – the National Commission for State Regulation of Digital Spheres (OECD, 2026). The relevant law is expected to be adopted by the end of 2026, allowing oversight of algorithmic systems, digital services, and data governance to be centralised. Such a body, provided with sufficient financial and human resources, would ensure professional review of intelligent systems planned for integration into the Office of the Verkhovna Rada.

In developing its own counterpart to European AI legislation, the parliament of Ukraine should clearly classify any algorithmic systems used in law-making or electoral procedures as “high-risk” systems. Under the logic of the

European regulation, public authorities must carry out an in-depth assessment of their effect on fundamental human rights before these systems are placed in service. This assessment includes potential threats to particular social groups, methods of human oversight, and routes for contesting algorithmic errors. Any synthetic content generated for parliamentary hearings or public consultations should also carry a clear machine-readable label identifying it as artificially created. The parliament of Ukraine should therefore adapt successful European practices for narrow, specialised uses of language models. One example is the European Parliament, where an EUBERT-based model is used for automatic classification of very large bodies of legal documents with the standardised EuroVoc thesaurus (Inter-Parliamentary Union, 2026). A comparable specialised model trained only on verified legislation of Ukraine and decisions of the Constitutional Court could reduce the problem of “hallucinations” associated with general-purpose commercial models, such as ChatGPT, Gemini, and Claude. Integrating such narrow-domain solutions, while also using chatbots to improve public access to parliamentary information, could increase the transparency of the legislature and strengthen public trust in law-making during digital transformation.

International experience in the use of AI in the legislative process

The review of international experience in implementing AI technologies in law-making confirmed that digitalisation of parliamentary procedures is a necessary part of the global transformation of public administration. Reports by leading international organisations treat AI not only as an object of state regulation, but also as a tool used by governments and legislatures to improve productivity, timeliness, and accountability in public policy (OECD, 2025). The experience most relevant to Ukraine, which is adapting national legislation to European standards, is that of the Italian Republic and the Federative Republic of Brazil. Both states face excessive bureaucratic burdens on their parliaments, which has encouraged a move from traditional methods towards LLMs, ML, and NLP.

The Italian Republic is one of the recognised European leaders in parliamentary innovation. Under Constitution of Italy (1948), the legislative function is exercised jointly by both chambers of parliament, which involves a complex procedure for considering drafts, introducing amendments, and approving them. Chamber of Deputies of Italy (1971) required detailed committee examination of every draft law, assessment of its financial implications, and review of constitutionality, producing a very large body of documentation. The Senate of Italy introduced several AI-based tools to streamline these processes, and they are already used officially in daily work. The central technology is *Ge-store EMendamenti* (GEM) – an integrated amendment manager that uses natural language processing algorithms and generative AI for clustering, analysing, and determining the voting order of amendments (Senate of the Italian Republic, 2025). The *Similis* algorithm operates alongside GEM and can identify identical or similar amendments among thousands of submitted documents within seconds, avoiding duplicated committee work. *TeSeo* is another officially deployed tool: a system for classifying parliamentary

acts, based on an open machine-learning engine trained on tens of thousands of historical Senate documents. *Lincoln* software, based on NLP, is also used actively. It automatically recognises legal references in texts and creates hyperlinks, making it easier to check new acts for consistency with legislation in force.

The GENAI4LEX-B project, developed by the University of Bologna, is at the pilot-testing stage in the Chamber of Deputies of Italy. The tool combines symbolic AI (Law as Code) and generative AI to automate searches for relevant legal documents and generate summaries of amendments (Public Sector Tech Watch, 2026). It uses the EuroVoc legal ontology for thematic classification, complies with the international Akoma Ntoso (LegalDocML) standard for machine-readable legal documents, and applies the Houdini deductive-logic engine for automated checking of draft laws against current strategies and constitutional principles. The regulatory framework of Italy that permits such use evolved from general acts towards specialised legislation. Agency for Digital Italy (2019), which encourage public authorities to share source code for their solutions, and compliance with Legislative Decree No. 196 (2003) were important elements. Italian strategy for artificial intelligence 2024-2026 published by Agency for Digital Italy (2024) became a strategic reference and provided for large-scale investment in AI for public administration. Law of Italian Republic No. 132 (2025) was the fundamental act establishing official use of AI. Article 14 of this Law directly permits public authorities to use AI to improve efficiency, reduce procedural time, and improve services, but it also imposes requirements. AI may serve only an auxiliary function, and full responsibility for a decision always remains with a person. In the Senate of Italy, this approach is termed “Human in Command”, the main safeguard against algorithmic errors and neural-network “hallucinations” (Senate of the Italian Republic, 2025). Alongside the conceptual advantages, pilot testing of GENAI4LEX-B identified several fundamental challenges affecting the technological and financial sustainability of innovation. The system developers reported that training AI on specialised legal terminology required continual improvement of the models, while deployment of generative solutions required substantial investment in scalable computing infrastructure. High hardware costs and the risk of systemic failures during processing of large data sets required technical specialists to monitor computing performance continuously. Transparency and explainability of algorithmic actions for non-technical users, particularly parliamentarians and staff, formed an additional barrier. Italian practice addresses these obstacles by requiring exclusive use of reliable parliamentary sources and strict observance of the hierarchy of legal acts. The digitalisation process is also regulated closely by the guidelines of the Agency for Digital Italy (AgID). These rules require public authorities, when carrying out comparative assessments, to give absolute priority to open-source software and to implement personal data protection mechanisms from the architectural design stage, in accordance with the European regulation and Legislative Decree No. 196 (2003).

The experience of the Federative Republic of Brazil is also representative. Federal Constitution of Brazil (1988) establishes a bicameral National Congress in which

legislative initiative, consideration of vetoes, and delegated legislation require detailed examination. Procedural rules require congressional committees to examine the legal, economic, and social aspects of each act in detail, and they set strict rules for consolidating and amending legislation in force: Resolution of the Rules of Procedure of the Chamber of Deputies of Brazil No. 17 (1989) and Law of Brazil No. 95 (1998). In response to these requirements, the Chamber of Deputies of Brazil has officially used the Ulysses AI Suite platform since 2018. The system applies machine learning and natural language processing to classify very large sets of laws, speeches, and research documents, and it also helps parliamentarians draft texts and locate similar bills considered previously (OECD, 2025). One of the main Ulysses functions is automatic classification and analysis of citizens' comments during public consultations, which allows key areas of public interest to be identified and addressed more quickly. A generative AI tool for automatic transcription and summarisation of public hearings is also being tested.

Implementation of these innovations in Brazil rests on Law of Brazil No. 14.129 (2021), which establishes principles of debureaucratisation, system interoperability, and the use of open data in governance, and on Law of Brazil No. 13.709 (2018), which regulates the processing of personal information by public authorities. Ministry of Science, Technology and Innovation (2024), adopted in 2024, provides for infrastructure development, national Portuguese-language models, and the use of AI to improve public services. Law of Brazil No. 2338 (2023) on AI regulation is also under consideration. It establishes rights for persons affected by AI and classifies the use of algorithms in the administration of justice and political processes as "high-risk systems" requiring enhanced oversight. The draft specifies that "high-risk" systems include technologies used in the administration of justice, assessment of the reliability of evidence, and support for

decisions by public authorities that affect citizens' rights and freedoms. Developers and operators of such systems would be required to introduce governance measures, including documentation of every stage of an algorithm's life cycle, automatic logging of operations, regular testing for accuracy and reliability, and inclusive development teams to reduce cognitive and social bias. In practical terms, the Chamber of Deputies of Brazil coordinated the development of clear institutional guidelines for the use of intelligent systems in parliaments in 2024. These criteria cover the principle of complementarity, under which human oversight cannot be replaced; requirements for accuracy and reliability, including continuous calibration of algorithms to avoid reproducing bias; and full transparency towards the public. Parliamentary rules also emphasise the security of confidential data during automatic transcription and document analysis. They require any experiment with AI to begin only as a small pilot project with controlled risks and accountability protocols. Comparison of the constitutional principles of Italy and Brazil confirmed that neither legal system allows the discretionary powers of a legislator to be delegated to AI. Structural-functional analysis of the technical architecture of GEM in Italy and Ulysses in Brazil showed that the software design of both platforms follows these constitutional requirements. Both systems have a modular architecture. The first level aggregates incoming document sets, the second carries out semantic processing with NLP and the EuroVoc legal ontology, and the third produces analytical extracts without intervening in decision-making (Senate of the Italian Republic, 2025). This division follows constitutional principles of accountability and transparency while leaving members of parliament in control of the content of legal acts. Table 2 provides a detailed classification of the functions and technological basis of the intelligent platforms that have already proved viable in the parliaments of Italy and Brazil.

Table 2. Comparative characteristics of AI tools in the legislative practice of Italy and Brazil

State	Platform/project name	Core technology	Area of parliamentary application
Italy	GEM	NLP, specialised machine-learning algorithms	Structuring amendments, immediate detection of textual duplicates, optimisation of the voting order in the Senate
Italy	GENAI4LEX-B (pilot stage)	Symbolic AI (Law as Code), EuroVoc legal ontology	In-depth search for relevant legal acts, automated checking for compliance with constitutional norms
Italy	TeSeo and Linkoln	Open ML engines, parsers	Cataloguing archival documents, automatic generation of active legal hyperlinks in legislative texts
Brazil	Ulysses AI Suite	Machine learning, NLP	Categorisation and content analysis of citizens' comments during public consultations, navigation through bodies of legislation
Brazil	Automatic transcription systems	Generative AI, speech recognition	Preparation of detailed transcripts and concise summaries following public parliamentary hearings

Source: compiled by the author based on Senate of the Italian Republic (2025), OECD (2025), Public Sector Tech Watch (2026)

Assessment of AI use in the legislative processes of Italy and Brazil identified substantial improvements. In Italy, GEM and Similis allowed processes to be dematerialised and saved a very large amount of time. One example was the processing of more than 82 million algorithm-generated amendments to a constitutional law in 2015; with the new software, Senate staff sorted and classified them in only three days. Automatic transcription technology allowed the Senate to publish draft transcripts of sittings 40 minutes after a speech (Senate of the Italian Republic, 2025). In Brazil, Ulysses improved parliamentary

transparency and public engagement through rapid analysis of public requests. International experience also identified several risks accompanying digitalisation. AI requires considerable financial resources for model training and computing capacity, regardless of the state in which it is used. Generative AI is also prone to "hallucinations" and legally incorrect constructions. For this reason, both Italy and Brazil recognise that AI does not improve the process when used autonomously. Improvement occurs only when the principles of complementarity, meaning that human involvement cannot be replaced, algorithmic transparency,

data security, and continuous risk control are maintained. Experts from the OECD (2025) also noted that, without auditing, confidentiality safeguards, and explainability of decisions, excessive reliance on machine outputs could lead to systemic errors and loss of trust in public institutions.

Additional recommendations for introducing AI into the legislative process of Ukraine were formulated from the international experience examined. Such implementation is unequivocally appropriate in view of the volume of European-integration legislation that the Verkhovna Rada must process. Ukraine should also adopt the Italian “Human in Command” concept and establish in legislation that neural networks may not generate final legally binding texts without human review and authorisation. Based on the trust framework proposed by the OECD (2025), implementation in Ukraine should begin not with AI-generated laws, but with semantic-search systems, amendment clustering modelled on the Italian GEM system, and analysis of public consultations modelled on the Brazilian Ulysses platform. This requires integration of NLP technologies with existing parliamentary databases. Under the analytical methodology of the OECD, the most promising approach for a legislature is to combine NLP with RAG technologies. This approach will produce neural-network responses solely from a verified internal database of national legislation and European-law directives, fully excluding unverified external sources. OCR technologies are also suitable for large-scale digitisation of archival parliamentary materials, while “rules as code” algorithms can support automated checking of new draft laws for structural conflicts with public-administration rules in force.

Any AI tools used in the parliament of Ukraine should therefore comply with personal data protection and cybersecurity standards, operate on open machine-readable formats such as LegalDocML, and include audit mechanisms to prevent algorithmic bias and maintain a high quality of national legislation. The analysis of digitalisation outcomes in the parliamentary procedures of Ukraine, Italy, and Brazil confirmed that automated systems had become a means of streamlining work with large bodies of legal texts. The greatest practical effect in law-making came from specialised solutions based on natural language processing, machine learning, and RAG, particularly when they were embedded in the internal databases of legislative bodies. Comparison of the Italian GEM platform, the Brazilian Ulysses platform, and initiatives in Ukraine showed that compliance with cybersecurity requirements, personal data protection, and the “Human in Command” principle was necessary for preventing errors. The data obtained provide a basis for further academic discussion of the changing role of intelligent technologies in state governance.

● DISCUSSION

The results of this theoretical study on implementing AI technologies in the legislative processes of Ukraine, Italy, and Brazil provided a new conceptual view of the limits and possibilities of digital transformation of the state. The analysis indicated that large language models, NLP, and ML could increase the productivity of law-making in parliaments by turning a bureaucratised process into a more flexible, data-oriented mechanism. The study did more than record technological progress; it identified an institutional

shift. AI is moving from an auxiliary information-search tool towards an active role in analytical support for law-making, as illustrated by amendment clustering through GEM in Italy and analysis of public input through Ulysses in Brazil. At the same time, the analysis made clear that the principal barrier for Ukraine was not a lack of technology, but the absence of clear regulatory safeguards capable of preventing algorithmic bias and protecting the process from AI “hallucinations”. Parliamentary digitalisation therefore needs to begin with audit institutions and implementation of the “Human in Command” concept rather than delegation of powers to neural networks. The patterns identified in the study are consistent with international academic debate and extend the conclusions of several researchers. The conclusion that uncontrolled use of AI in legislation may lead to systemic errors and violations of basic legal principles corresponds closely to the concerns of S.G. Peschke & L. Peschke (2022). They analysed ethical and legal conflicts associated with the integration of machine learning into EU practice and argued that new initiatives, including the Data Act and AI Act, created considerable legal uncertainty regarding privacy protection where access to large data sets was easy. M. Jarota (2023) likewise stressed the need for a clear allocation of responsibility when algorithms are introduced. In examining occupational safety in the EU, he argued that European regulation remained insufficient and that AI should be treated solely as a work tool, with human control supported by sanctioning mechanisms of the relevant authorities. A. Drahmann & A. Meuwese (2022) also examined the potential of AI to improve legislative texts and process monitoring. Using the Dutch Digitaal Stelsel Omgevingswet project, they reported that parallel design of data and legislation increased the transparency of legal rules, although it also created risks at early stages.

N. Rangone (2023) also supported the proposition that AI could reduce the routine workload of parliamentary staff, as illustrated by the Italian experience. She examined the effect of AI on the life cycle of public decisions and reported that neural networks substantially expanded access to knowledge bases and helped simplify the regulatory environment, although the process required a phased experimental approach to avoid discrimination. The Brazilian part of the present study, particularly the use of Ulysses for public participation, corresponded directly to the conclusions of D.J. Wardana & D. Setiawan (2025). They analysed the integration of AI into the legislation of Indonesia and concluded that automation and NLP could make law-making more participatory, democratic, and responsive to public needs when personal data protection safeguards were maintained. The prioritisation of parliamentary technologies also corresponded to the empirical study by J. von Lucke *et al.* (2022). The authors systematised more than 210 proposals for introducing AI into parliamentary work and argued that automation of legislative procedures was the most realistic and most in-demand area for public authorities. The scepticism of the present study towards full automation of legal work was supported by N. Khatniuk *et al.* (2023), who examined the use of AI in legal services and stressed the need for strict legislative measures to ensure ethical implementation of such tools. M. Araszkievicz & M. Florczak-Wątor (2025) considered applied aspects of legal-text optimisation identified through the analysis of

Linkoln. They analysed the capacity of NLP models to detect structural defects, ambiguities, and conflicts in laws and concluded that AI was an effective means of maintaining consistency, but its use required awareness of related ethical risks. O. Shevchuk *et al.* (2023) and P. Parycek *et al.* (2024) examined the role of AI in administrative procedures and its limitations. The researchers from Ukraine argued that algorithms could be introduced into administrative proceedings only under judicial control in order to avoid violation of the rule of law. The European researchers stressed that integrating AI into governance required systematic monitoring of transparency and the quality of representative data to prevent bias.

T. Wahl (2024) described the importance of systematic digitalisation through the example of Norway, which corresponded with the evidence on strategy development in Ukraine. He analysed the StorSak project in the Norwegian Storting, where AI is used to categorise documents from metadata, supporting the global trend towards automated parliamentary document management. A. Goldmann & S. Plümer (2026), together with A. Chiappetta (2023), examined the political dimension of narratives around AI. They analysed how members of the European Parliament perceived the AI Act and reported that legislators viewed AI both as a source of innovation and as a serious threat due to algorithmic bias, prompting demands for strict regulatory intervention. P.F. Bresciani & M. Palmirani (2025) raised the question of whether national parliaments themselves fall within the scope of the AI Act. They concluded that, although the European regulation extends to parliaments, their obligations are minimal, placing responsibility for protecting democracy in the digital era on the representative bodies themselves. H. Farrell (2025) conceptualised the fundamental influence of AI on bureaucracy and governance as “AI as Governance”. He proposed that political scientists should consider AI not simply as a technology, but as a new form of governance with its own coordination mechanisms capable of substantially changing markets and democracy.

C.M. Cordeiro *et al.* (2025) and A. Batool *et al.* (2025) also examined this corporate and social influence. Through semantic analysis and a systematic review, they argued that acts such as the AI Act were moving corporate governance from formal reporting towards accountability to stakeholders at multiple levels. The threat of AI to representative democracy also forms part of this debate. The present conclusion about the risk of distorting public opinion is consistent with the work of S. Kreps & D. Kriner (2023). Their experiment showed that language models such as GPT-3 could improve legislators’ efficiency when drafting replies to constituents, but low-quality generation or concealment of AI use undermined citizens’ trust in public authorities. A. Jungherr (2023) supported this position by proposing a move away from concern about artificial general intelligence (AGI) towards monitoring the concrete effects of existing narrow AI on electoral institutions and equality in democratic society. The use of AI in the legislative process can therefore be treated as an irreversible development that requires reconsideration of the nature of law-making. The analysis of international experience and previous research indicated that successful transformation depended not on algorithmic power, but on the quality of

representative data and the capacity of the state to integrate ethical safeguards. Ukraine has an opportunity to avoid the errors of “first movers” by building parliamentary digital architecture around the “Human in Command” principle, maintaining algorithmic transparency, and preserving an anthropocentric approach in which AI remains an analytical tool and responsibility for the fate of a law remains with a person.

● CONCLUSIONS

The theoretical study included a comparative-legal analysis of the introduction of intelligent information systems. The analysis confirmed that automation of parliamentary procedures was necessary for public administration to reduce the administrative burden. For Ukraine, this process had practical importance due to the need to harmonise national legislation with EU law, which requires processing more than 2,700 acts required for European integration. Examination of the current digitalisation of the Verkhovna Rada of Ukraine showed that the country was at the stage of testing NLP and LLM tools. Regulation of this field followed a “bottom-up” approach based on the Concept for the Development of Artificial Intelligence, the government Road Map, and the White Paper, with a later transition towards implementation of the European Artificial Intelligence Act.

Analysis of the international practice of the Italian Republic and the Federative Republic of Brazil confirmed the effectiveness of specialised digital platforms in the daily work of parliaments. The Senate of Italy successfully used GEM to cluster parliamentary amendments, Similis to detect textual duplication, and Linkoln to create legal hyperlinks. The GENAI4LEX-B platform was being tested in the Chamber of Deputies of Italy, combining the EuroVoc legal ontology with AI and the LegalDocML standard. The legislative basis of the Italian model was the Law of 23 September 2025, which defined the auxiliary status of algorithms and established the “Human in Command” rule. Examination of the Chamber of Deputies of Brazil confirmed the effectiveness of the Ulysses AI Suite platform for classifying citizens’ submissions during public consultations and providing semantic navigation through bodies of legislation. Brazilian practice rested on the General Data Protection Law, the Brazilian artificial intelligence plan published by Ministry of Science, Technology and Innovation (2024), and Law of Brazil No. 2338 (2023), which classified algorithms used in law-making as high-risk systems. Comparison of the technical architecture of these platforms with the provisions of the Constitution of Italy and the Constitution of Brazil showed that constitutional rules prohibited transfer of parliamentarians’ discretionary powers to automated systems.

Theoretical synthesis of international experience indicated that neural networks accelerated processing of legal texts, cataloguing of archival documents, and preparation of comparative tables. Algorithms, however, could not independently produce legally complete legislative texts due to the risk of substantive bias. The results confirmed the need to adapt the Italian and Brazilian approaches to the legislative process of Ukraine. The legislator was advised to establish the principle of human oversight in law, under which final verification of generated texts remained the duty of a specialist. Technical integration of algorithms into the Office of the Verkhovna Rada of Ukraine should

be based on specialised language models and RAG. Such models should operate on state servers and be trained on a verified body of national legislation and decisions of the Constitutional Court of Ukraine. This would meet the requirements of the Law of Ukraine “On the Protection of Personal Data” and the Law of Ukraine “On Law-Making Activities”. The state should also introduce mandatory machine-readable labelling of synthetic content and establish an independent supervisory body for digital spheres as part of legal-act quality control. Future research should include practical modelling and testing of Ukrainian-language

neural networks during large-scale semantic processing of real national draft laws.

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Міжнародний досвід застосування ШІ в законодавчому процесі як приклад для України

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Анотація. Метою дослідження було проведення всебічного теоретичного аналізу міжнародної практики впровадження технологій нейронних мереж у законотворчість. У процесі дослідження поєднувалися порівняльно-правовий, формально-правовий, структурно-функціональний та системний методи для порівняння нормативно-правових баз, інституційних обмежень та архітектури цифрових платформ у трьох державах: Україні, Італійській Республіці та Федеративній Республіці Бразилії. У ході дослідження було встановлено, що цифровізація є об'єктивною необхідністю для зменшення бюрократичного навантаження, зокрема під час адаптації понад 2 700 актів європейського права, коли для розробки лише одного нормативно-правового документа було залучено 130 фахівців та витрачено понад 22 тисячі годин роботи. Парламенти Італії та Бразилії успішно використовували інструменти обробки природної мови та машинного навчання для класифікації коментарів громадян та групування пропозицій. Офіційні парламентські звіти показали, що спеціалізовані алгоритми можуть суттєво прискорити обробку великих масивів документів, зокрема сортування 82 мільйонів поправок протягом трьох днів та оприлюднення проектів стенограм засідань через 40 хвилин після виступу. Автоматизація спростила рутинні процедури, однак нейронні мережі не змогли самостійно створювати юридично бездоганні тексти через високий ризик алгоритмічних помилок. Аналіз підтвердив висновок про те, що людський контроль неможливо замінити, а остаточна перевірка згенерованого контенту має залишатися виключною відповідальністю людини. Практична цінність отриманих результатів полягає в тому, що Апарату Верховної Ради України та Міністерству цифрової трансформації України можна використовувати запропоновані рекомендації під час розробки внутрішніх нормативних актів

Ключові слова: цифрові платформи; державне управління; машинне навчання; обробка природної мови; великі мовні моделі; захист персональних даних; цифрова трансформація

Statistical analysis methods in the management of enterprises' foreign economic activity

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Abstract. The aim of this study was to assess the potential for applying statistical tools to support the management decision-making process in the field of foreign economic activity, using Nokia Corporation as a case study. The methodology was based on time series analysis, comparative statistical analysis, structural analysis, correlation analysis and trend forecasting. It was found that the European Union's imports in trade with countries outside the Union rose from 2,123.3 billion European Currency Units/EUR in 2021 to 2,523.0 billion European Currency Units/EUR in 2025, whilst exports increased from 2,180.9 billion European Currency Units/EUR to 2,643.8 billion European Currency Units/EUR. The largest foreign trade deficit was recorded in 2022 at 431.96 billion European Currency Units/EUR. Germany took the lead with exports of EUR 689.2 billion and a trade surplus of EUR 215.8 billion. The largest surpluses in the product structure were generated by chemical products and related goods (EUR 255.99 billion) and machinery, equipment and transport vehicles (EUR 172.7 billion), whilst the largest deficit was observed in mineral fuels, lubricants and related products (EUR 298.1 billion). In the case of Nokia Corporation, it was established that the largest volumes of net sales were generated in the Europe, Middle East and Africa and Americas regions, whose combined share exceeded 70% of total sales. Net sales peaked at EUR 24.91 billion in 2022, before falling to EUR 19.89 billion in 2025. Correlation analysis revealed a strong link between sales in the Americas region and net sales ($r = 0.870$) and net profit ($r = 0.865$). Forecasting indicated a possible decline in sales in the Europe, Middle East and Africa region to EUR 7.95 billion in 2028. The results of the study, using Nokia Corporation as a case study, confirmed the feasibility of using statistical methods to evaluate foreign economic activity and support management decisions. The practical significance of the study lies in the possibility of using its results to assess the effectiveness of foreign economic activity and to select priority markets

Keywords: dynamics; exports; imports; trade balance; international markets

● INTRODUCTION

The increasing integration of enterprises into international markets is accompanied by a rise in the volume of export and import transactions, the growing complexity of logistics processes, an increase in currency and commercial risks, and the need to respond promptly to changes in the

external environment. Under such conditions, the effectiveness of management decisions depends to the increasing integration of enterprises into international markets is accompanied by growing volumes of export and import operations, increasing complexity of logistics processes,

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higher currency and commercial risks, and the need to respond promptly to changes in the external environment. Under these conditions, the effectiveness of management decisions largely depends on the quality of analytical support and enterprises' ability to assess trends in the development of foreign economic operations in a timely manner.

The insufficient substantiation of management decisions in the field of foreign economic activity, caused by the high dynamism of the international environment, currency fluctuations, changes in logistics routes, and increasing uncertainty in foreign markets, remains a subject of academic research. In particular, V. Bokovets *et al.* (2025) examined analytical and statistical methods for assessing the risks of enterprises' foreign economic activity. The study found that the use of statistical tools, in particular correlation and regression analysis, econometric modelling and time series analysis, helps to improve the accuracy of risk assessment and enhances the information base for management decisions. The authors also justified the advisability of combining analytical and statistical methods within a single system for managing enterprises' foreign economic activities. The specific features of the methodology for analysing foreign economic activity and its information support were investigated by T. Talakh & V. Talakh (2024). As a result, it was established that effective management of foreign economic operations requires the comprehensive use of strategic analysis methods, in particular Strengths, Weaknesses, Opportunities, Threats (SWOT), Social, Technological, Economic, Political (STEP) and Strategic Position and Action Evaluation (SPACE) – the General Electric (GE)/McKinsey analysis and model, as well as a systematic assessment of performance indicators for exports, imports and foreign economic operations as a whole. The authors also emphasised the crucial role of high-quality information provision in formulating well-founded management decisions and enhancing the competitiveness of enterprises in international markets.

The increasing complexity of managing enterprises' foreign economic activities, against a backdrop of intensifying international competition, an unstable external environment and rising demands for the efficiency of export and import operations, necessitates the improvement of analytical support for management decisions. A study conducted by Z. Zhyvko *et al.* (2024) examined the main tasks and methods of analysing an enterprise's foreign economic activity. The stages of analysing foreign economic operations were systematised, and the rationale for using SWOT analysis, trade balance assessment, currency analysis, investment activity analysis and factor analysis of export revenue was substantiated. The authors also identified the main objectives of analysing foreign economic activity, proposed approaches to assessing the fulfilment of export contracts, and explored ways of improving the efficiency of export operations through cost optimisation and control of trade receivables. O.G. Melnyk *et al.* (2021) investigated approaches to assessing the effectiveness of foreign economic activity management based on target indicators. As a result, the main groups of evaluation indicators were systematised, in particular absolute, relative, structural and efficiency indicators, and a sequence of stages for evaluating the effectiveness of foreign economic activity management was proposed. The authors justified the need

to use a comprehensive system of indicators for analysing export and import operations, assessing profitability, the structure of foreign trade and the extent to which an enterprise's target objectives have been achieved.

The uncertainty of the external economic environment, currency fluctuations and the need to minimise risks when conducting international operations necessitate the use of quantitative tools to support management decisions. The use of statistical methods in the risk management process when planning enterprises' foreign economic and logistical activities was investigated by M. Ivanova *et al.* (2024). As a result, the authors demonstrated the validity of using correlation and regression analysis to assess the impact of macroeconomic factors on the exchange rate, developed a model for forecasting exchange rate fluctuations, and proposed an approach to formulating a strategy for hedging currency risks based on statistical calculations. The study also confirmed the possibility of using statistical methods to improve the effectiveness of planning foreign economic activity and to reduce the negative impact of risks on enterprises' performance. V. Kraievskiy & O. Skoryk (2024) examined an enterprise's foreign economic activity through the prism of accounting and analytical support for management. As a result, the authors systematised the accounting and analytical aspects of managing foreign economic activity, identified key criteria for assessing its effectiveness, and developed a model for decomposing foreign economic activity, encompassing organisational, information, accounting and analytical management technologies.

The complexity of establishing an objective information base for managerial decision-making in the field of foreign economic activity is exacerbated by the instability of the international environment, high competition in foreign markets and the need for the timely identification of opportunities to improve the efficiency of export and import operations. The study by O. Podra & N. Petryshyn (2023) examined the theoretical and methodological aspects of analysing enterprises' foreign economic activity. The study summarises approaches to analysing foreign economic activity, justifies a comprehensive methodology for its evaluation, and develops a system of indicators covering the dynamics of exports, as well as the efficiency and structure of foreign economic operations. Furthermore, the significance of mathematical, statistical, factor and specialised methods of analysis for assessing the effectiveness of foreign economic operations and formulating an enterprise's foreign economic strategy was determined. The application of statistical methods of economic analysis in enterprise management was investigated by O.M. Kudyrko & I.F. Lobacheva (2023). The study explores the possibilities of applying statistical methods of horizontal and vertical analysis and describes the use of extrapolation, trend models, dynamic indicators, interval forecasting and the index method for assessing the performance of enterprises. It also analyses the use of time series to identify trends in indicators and to generate forecasts as a tool to support management decisions.

In the studies examined, the main focus was on risks, analysis and management of foreign economic activity, whilst the application of statistical methods for assessing efficiency, identifying causal relationships and forecasting

indicators requires further research. The aim of this study was to assess the potential for applying statistical tools to provide information to support the management decision-making process in the field of Nokia Corporation's foreign economic activity. To achieve this aim, the following objectives were identified: to analyse the possibilities of using statistical methods to evaluate enterprises' foreign economic activities; to investigate the geographical structure and performance of foreign economic activities using Nokia Corporation as a case study and applying statistical methods; to assess the possibilities of using statistical analysis and forecasting to support management decisions in the field of foreign economic activities.

● MATERIALS AND METHODS

The study employed a retrospective empirical design and was based on an analysis of official statistical data and corporate financial statements, covering the period 2021-2025. This time period was chosen due to the availability of a complete set of statistical data on the European Union's foreign trade and Nokia Corporation's financial statements, which made it possible to conduct a comprehensive analysis of the dynamics of foreign economic activity, assess changes in its geographical structure, and investigate the relationship between regional sales and the company's financial performance.

The dynamics of the European Union's foreign trade were analysed using the statistical method of time-series analysis for 2021-2025. The study covered annual volumes of EU-27 imports and exports of goods in trade with countries outside the European Union, the trade balance, and import and export growth rates, which made it possible to assess changes in foreign economic activity over the study period. The information base of the study comprised data from International trade in goods – an overview (2025) and Intra and Extra-EU trade by Member State and by product group (2026) on annual volumes of imports and exports of goods between the EU-27 and countries outside the European Union (Extra-EU trade), as well as the trade balance for 2021-2025, expressed in European Currency Unit (ECU)/euro (EUR). The intensity of changes in foreign trade flows was assessed using relative measures of dynamics, in particular chain growth rates of imports and exports. The growth rate was determined as the ratio of the absolute change in an indicator to its value in the previous year, expressed as a percentage.

The role of individual countries in shaping the European Union's foreign trade flows was examined using the comparative statistical analysis method based on data from Intra and Extra-EU trade by Member State and by product group (2026). The analysis included the seven EU Member States with the largest volumes of foreign trade with countries outside the Union in 2025, making it possible to characterise the main participants in the European Union's foreign trade flows. The use of absolute foreign trade indicators made it possible to rank the countries by export and import volumes in 2025 and compare their foreign trade positions. In addition, the trade balance was calculated as the difference between export and import volumes, making it possible to identify countries with a foreign trade surplus or deficit.

The product aspects of the European Union's foreign trade were examined by combining time-series analysis

and comparative statistical analysis. The information base comprised data from International trade of the EU, the euro area and the Member States by SITC product group (2026) on the trade balance, as well as EU-27 export and import volumes in trade with countries outside the European Union by major product groups. The trade balance, exports and imports were analysed using individual Eurostat statistical indicators (Trade balance in million European Currency Unit/Euro (ECU/EUR), Exports in million of ECU/EUR, and Imports in million of ECU/EUR). Due to the specific characteristics of the construction of these indicators, individual figures may differ slightly from one another, which does not affect the overall trends in foreign trade. Time-series analysis was used to assess changes in the trade balance by product group in 2021-2025, making it possible to identify the product groups that generated a surplus or deficit in EU foreign trade. Comparative statistical analysis was applied to compare EU export and import volumes by major product groups in 2024-2025, making it possible to identify differences between individual product groups and assess changes in foreign economic volumes over the study period (International trade in goods, 2026). The geographical characteristics of the European Union's foreign trade were analysed using comparative statistical analysis. The information source was data from Extra-EU trade by partner (2026) on EU-27 export and import volumes in trade with its main foreign trade partners in 2024-2025. The analysis included countries with the largest volumes of foreign trade with the EU in 2025, enabling a comparison of the contribution of the main partners to the formation of foreign trade flows.

For the practical assessment of the potential for applying statistical methods to the management of foreign economic activity at the enterprise level, Nokia Corporation (n.d.) was selected. The company was selected due to its significant international presence and the availability of detailed financial reports in the public domain, containing information on the regional structure of sales and financial performance. This made it possible to examine the specific features of the enterprise's foreign economic activity based on actual statistical data. The information base of the study comprised Nokia's annual financial reports for 2021-2025 (Report for Q4..., 2022; Report for Q4..., 2023; Report for Q4..., 2024). These reports were selected as the company's official source of information because they contain standardised indicators of net sales, financial performance, and their regional distribution, ensuring data comparability over time and enabling the application of statistical analysis methods. In addition, the company's reports for subsequent years, which contain consolidated results for previous periods, were used (Report for Q4..., 2025; Report for Q4..., 2026). Their use made it possible to verify the consistency of the indicators for individual years and ensure the completeness of the study's information base. To examine Nokia's foreign economic activity, the time-series analysis method was used to assess the company's net sales by world region in 2021-2025. Sales were grouped into the Americas, Asia-Pacific (APAC), Europe, Middle East and Africa (EMEA), and Submarine Networks (the submarine telecommunications networks business), in accordance with the structure of the company's corporate reporting. The data were grouped

to assess the geographical structure of the company's foreign economic activity and determine the role of individual regions in generating its revenues. The structural statistical analysis method was applied to determine the share of each region in total net sales. The share of a region was calculated using the following formula (1):

$$S_i = \frac{NS_i}{NS_{total}} \times 100\%, \quad (1)$$

where S_i – the share of the region in total sales, %; NS_i – net sales for the relevant region, million EUR; NS_{total} – the company's total net sales, million EUR. The use of structural analysis made it possible to assess changes in the geographical structure of Nokia's foreign economic activity and to identify the regions that accounted for the largest share of the company's international revenue.

An analysis was also carried out of the trends in Nokia's key financial indicators, specifically Net sales, Operating profit, Net income and Operating margin for the period 2021-2025. Time series analysis was used to assess changes in the company's financial results over time and to identify trends in the development of its international operations. Correlation analysis was used to determine the relationship between regional sales and Nokia's financial results. The calculation was based on Pearson's linear correlation coefficient between sales volumes in the Americas, APAC and EMEA regions and the indicators net sales, operating profit, net income and operating margin. The unit of observation was the calendar year, and the sample comprised five annual observations for 2021-2025.

The trend forecasting method was applied to assess possible directions for the development of Nokia's international business activities. The forecast values for net sales in the Americas, APAC and EMEA regions for 2026-2028 were determined using a linear trend model of the form (formula (2)):

$$y = a + bt, \quad (2)$$

where y – the forecast net sales volume; t – the sequential number of the year; a – the intercept; b – the trend coefficient. The model parameters were determined using the least squares method based on annual time series for 2021-2025.

In the final stage, a method for generalising and interpreting the results of the statistical analysis was applied to formulate recommendations on the use of the obtained results in the management decision-making process. The limitations of the study include the use of aggregated statistical data from the European Union and indicators from a single company, which restricts the ability to generalise the findings to the entire population of enterprises engaged in foreign economic activity.

● RESULTS

Statistical assessment of trends in the development of the European Union's foreign trade

Foreign economic activity is one of the key factors in the development of European enterprises, as it provides access to international markets, diversifies sources of supply and expands opportunities for international cooperation. Against a backdrop of transformation in the global economy, changes in trade routes, increased geopolitical instability and growing competition in international markets, a statistical assessment of trends in foreign trade development makes it possible to identify changes in foreign trade activity and to evaluate the operating conditions for enterprises in international markets. To assess the operating conditions for enterprises in foreign markets, the dynamics of imports and exports of goods between the European Union and countries outside the EU (Extra-EU trade) for the period 2021-2025 were analysed. Based on annual data, the trade balance was analysed and the growth rates of imports and exports were calculated (Table 1).

Table 1. Dynamics of EU-27 imports and exports with countries outside the EU in 2021-2025, million ECU/EUR

Year	Imports, million ECU/EUR	Exports, million ECU/EUR	Balance, million ECU/EUR	Import growth rate, %	Export growth rate, %
2021	2,123,279.0	2,180,895.8	57,616.8	-	-
2022	3,008,539.2	2,576,575.9	-431,963.3	41.7	18.1
2023	2,523,880.0	2,565,971.6	42,091.6	-16.1	-0.4
2024	2,454,156.8	2,594,323.5	140,166.6	-2.8	1.1
2025	2,523,016.4	2,643,817.0	120,800.6	2.8	1.9

Source: compiled by the authors based on International trade in goods – an overview (2025)

Fluctuations in export, import, and trade balance volumes were observed in the foreign trade of the European Union with countries outside the EU during 2021-2025 (Table 1). In 2022, imports increased by 41.7%, while exports rose by 18.1% compared with the previous year, resulting in a negative trade balance of EUR 431.96 billion. In 2023, the trade balance became positive again, reaching EUR 42.09 billion, owing to a 16.1% reduction in imports, while exports decreased by only 0.4%. In 2024, the trade surplus increased to EUR 140.17 billion as a result of a 2.8% decrease in imports and a 1.1% increase in exports. In 2025, imports increased by 2.8% and exports by 1.9%, while the positive trade balance amounted to EUR 120.80 billion. Overall, during the study period, the volume of EU imports from countries outside the Union increased from EUR 2,123.3 billion

to EUR 2,523.0 billion, while exports increased from EUR 2,180.9 billion to EUR 2,643.8 billion. Following the substantial deficit recorded in 2022, the foreign trade of the European Union was characterised by a sustained positive trade balance in 2023-2025. The findings indicate the sensitivity of EU foreign trade to changes in international economic conditions and confirm the appropriateness of using statistical methods to identify trends and provide information support for management decisions in the field of foreign economic activity. To assess the role of individual countries in shaping the European Union's foreign trade flows, a comparative statistical analysis of the export and import volumes of EU Member States in 2025 was conducted. The results of the analysis of the foreign trade volumes of the leading European Union countries are presented in Table 2.

Table 2. Export, import and foreign trade balance of the leading EU economies in trade with countries outside the EU in 2025, EUR million

Country	Exports	Imports	Balance
Germany	689,162.1	473,364.2	215,797.9
the Netherlands	271,150.4	446,640.4	-175,490.0
Italy	313,014.6	256,767.8	56,246.8
France	280,530.9	260,262.6	20,268.3
Belgium	155,217.5	177,557.5	-22,340.0
Spain	148,642.8	196,736.6	-48,093.8
Poland	92,496.4	119,874.8	-27,378.4

Source: compiled by the authors based on Intra and Extra-EU trade by Member State and by product group (2026)

The results show that the EU's largest economies are focused on foreign trade. Germany continued to lead in terms of export and import volumes, whilst the Netherlands, Italy and France were also among the countries with the highest volumes of foreign trade. The trade balance showed that Germany, Italy and France had a surplus, whilst the Netherlands, Spain, Poland and Belgium had a deficit. The Netherlands had the largest deficit. An analysis of the commodity structure of foreign trade was the next

stage in the statistical assessment of foreign economic activity, as this characterises the specialisation of the economy and the specific features of a country's or an integration group's participation in the international division of labour. To identify the commodity groups that accounted for the largest share of the European Union's foreign trade flows in 2021-2025, the structure of the trade balance by major commodity groups with countries outside the EU was analysed (Table 3).

Table 3. Foreign trade balance of the EU with countries outside the EU by major product groups in 2021-2025, EUR million

Product group	2021	2022	2023	2024	2025
Total goods	57,616.8	-431,963.3	42,091.6	140,166.6	120,800.6
Food, beverages and tobacco	58,629.4	55,416.7	59,829.9	52,471.9	39,605.4
Raw materials	-35,732.6	-48,864.3	-29,148.1	-27,808.1	-28,951.5
Mineral fuels, lubricants and related products	-285,938.1	-650,364.7	-403,330.2	-338,591.3	-298,094.0
Chemicals and related products	185,308.1	188,798.6	199,525.9	238,488.3	255,992.9
Other manufactured goods	-28,285.7	-93,583.3	-12,038.0	-16,784.5	-41,748.1
Machinery, equipment and transport equipment	166,907.2	126,692.1	209,566.9	211,931.5	172,725.3
Goods and transactions not classified elsewhere	-3,271.4	-10,058.4	17,685.3	20,458.9	21,270.6

Source: compiled by the authors based on International trade in goods (2026), International trade of the EU, the euro area and the Member States by SITC product group (2026)

As shown in Table 3, the EU trade balance differed substantially across product groups in 2021-2025. The largest surplus throughout the entire study period was generated by chemicals and related products, for which the balance increased from EUR 185.31 billion in 2021 to EUR 255.99 billion in 2025. A positive balance was also maintained for machinery, equipment and transport equipment, although its magnitude varied over the study period. Food, beverages and tobacco also recorded a surplus, which gradually declined. The largest negative balance was observed for mineral fuels, lubricants and related products. Following the maximum deficit recorded in 2022, its magnitude gradually decreased; however, it remained substantial in 2025. A negative balance was also maintained for raw materials and other manufactured goods, although the scale of these

deficits was considerably smaller. The findings indicate that the main sources of the European Union's foreign trade surplus were chemicals and related products, as well as machinery, equipment and transport equipment. The largest deficit was associated with imports of mineral fuels, lubricants and related products. From 2023 onwards, the EU trade balance remained positive: the surplus increased in 2024 and declined slightly in 2025 but remained higher than in 2023. This indicates that the European Union maintained a positive trade balance following the deficit recorded in 2022. To assess the product structure of the European Union's foreign trade, a comparative statistical analysis of export and import volumes by major product groups in 2024-2025 was conducted. The results of the analysis are presented in Table 4.

Table 4. Volumes of EU exports and imports with countries outside the EU by major product groups in 2024-2025, million ECU/EUR

Product group	Exports 2024	Exports 2025	Imports 2024	Imports 2025
Total goods	2,594,396.6	2,644,414.2	2,454,143.0	2,522,606.2
Food, beverages and tobacco	209,770.9	214,665.3	157,293.6	175,024.2
Raw materials	68,530.5	69,033.6	96,338.8	97,874.0
Mineral fuels, lubricants and related products	131,498.0	116,664.3	470,068.2	414,732.8
Chemicals and related products	562,419.0	603,953.8	323,976.6	347,706.8
Other manufactured goods	558,256.0	555,176.1	575,027.5	596,806.5

Table 4, Continued

Product group	Exports 2024	Exports 2025	Imports 2024	Imports 2025
Machinery, equipment and transport equipment	1,016,924.3	1,027,603.3	804,899.6	854,415.7
Goods and transactions not classified elsewhere	46,997.9	57,317.9	26,538.8	36,046.3

Note: the Table has been compiled using the figures for “Exports in millions of ECU/EUR” and “Imports in millions of ECU/EUR”; these figures may differ from the trade balance figures given in Table 3; minor discrepancies between the total figures and the sum of the product groups are due to the rounding of the source data

Source: compiled by the authors based on International trade of the EU, the euro area and the Member States by SITC product group (2026), International trade in goods (2026)

The data in Table 4 indicate that the largest volumes of the European Union’s foreign trade were generated by machinery, equipment and transport equipment. Chemical products ranked second in terms of foreign trade volume. In 2025, compared with the previous year, the volume of its exports and imports increased. By contrast, mineral fuels, lubricants and related products saw a decline in both exports and imports. An increase in foreign trade

flows was also recorded for food, beverages and tobacco. Overall, the European Union’s foreign trade structure was dominated by machinery, equipment and transport vehicles, as well as chemical products. To assess the geographical characteristics of the European Union’s foreign trade, a comparative statistical analysis of export and import volumes with its main trading partners in 2024-2025 was carried out (Table 5).

Table 5. EU export and import volumes with key trading partners in 2024-2025, in millions of EUR

Trading partner	Exports 2024	Exports 2025	Imports 2024	Imports 2025
United States	535,628.1	554,612.2	337,996.8	356,231.3
United Kingdom	343,709.8	345,348.7	164,078.6	158,729.5
China (excluding Hong Kong)	213,504.3	199,431.9	525,726.0	559,989.7
Switzerland	193,418.4	219,424.1	134,897.6	143,166.7
Turkey	113,195.4	114,174.2	98,054.6	103,328.0
Japan	67,423.4	65,750.2	64,202.2	63,327.6
Norway	62,927.1	64,004.1	96,824.7	95,685.2
South Korea	55,860.3	54,533.2	68,608.6	69,733.1
Mexico	53,174.2	52,932.1	29,221.8	33,950.8
India	48,827.7	48,883.0	71,481.1	69,477.2
Brazil	43,808.2	42,744.4	46,089.7	44,344.3

Source: compiled by the authors based on Extra-EU trade by partner (2026)

The data in Table 5 indicate that the United States remained the European Union’s largest trading partner in terms of export volumes, while China was the main source of imports of goods into the EU. The United Kingdom and Switzerland also accounted for substantial volumes of foreign trade. A positive trade balance was observed in trade with the United States, the United Kingdom, Switzerland, Turkey and Mexico, whereas China, Norway, South Korea and India recorded imports exceeding exports. Overall, the results of the analysis indicate that EU foreign trade flows are concentrated around a limited number of key partners.

The findings can be used by enterprises when formulating their foreign economic strategy. Analysis of the geographical structure of trade makes it possible to assess the capacity of individual markets, identify countries with the highest levels of demand, and select priority directions for exports or diversification of foreign trade activities. Assessment of the product structure makes it possible to identify product groups with the highest export potential or the greatest import dependence, which can be used when planning exports and imports, developing the product portfolio, seeking alternative suppliers, and assessing the risks of supply chain disruptions. Analysis of the trade balance and the dynamics of foreign trade provides an information base for assessing the risks of entering new markets, forecasting changes in international market conditions, and making management

decisions regarding the development of enterprises’ foreign economic activity.

The statistical analysis established that the European Union’s foreign economic activity in 2021-2025 was characterised by unstable dynamics in foreign trade flows and changes in the trade balance in trade with countries outside the EU. Germany, Italy, France and the Netherlands played the largest role in shaping foreign trade, while the main external partners of the EU remained the United States, the United Kingdom, China and Switzerland. Analysis of the product structure showed that chemicals and related products, as well as machinery, equipment and transport equipment, held leading positions in exports and in generating a positive trade balance, whereas the largest deficit was associated with imports of mineral fuels and energy resources. The findings indicate that the European Union has maintained its specialisation in high-value-added products while remaining dependent on external supplies of certain types of raw materials and energy resources.

A statistical analysis of Nokia Corporation’s foreign economic activity

Nokia Corporation (n.d.) is one of the world’s leading manufacturers of telecommunications equipment, software and digital networking solutions. The company operates in approximately 130 countries worldwide and provides telecommunications infrastructure for telecoms operators,

corporate clients and government agencies. The significant scale of its international presence means that Nokia's performance is highly dependent on the state of external markets and the regional structure of its sales.

The company's foreign economic activity is carried out through the sale of products and services in the markets of Europe, North and Latin America, the Asia-Pacific region, the Middle East and Africa. In Nokia's financial

statements, the results of its international operations are reflected through net sales figures by major world regions, which makes it possible to assess the geographical structure of the company's foreign economic activity. To assess the geographical structure of Nokia's international operations, the trends in the company's net sales by major world regions for 2021-2025 were analysed. The results of the analysis are presented in Table 6.

Table 6. Nokia's net sales by region worldwide, 2021-2025, in millions of EUR

Region	2021	2022	2023	2024	2025
Americas	8,506	9,611	6,779	6,276	6,985
APAC	5,146	5,519	6,436	4,549	4,639
EMEA	8,550	8,631	7,923	8,395	8,265
Submarine Networks	-	1,150	1,120	-	-
Total	22,202	24,911	22,258	19,220	19,889

Source: compiled by the authors based on Report for Q4 and full year 2021 (2022), Report for Q4 and full year 2022 (2023), Report for Q4 and full year 2023 (2024), Report for Q4 and full year 2024 (2025), Report for Q4 and full year 2025 (2026)

The data in Table 6 indicate that, throughout 2021-2025, the largest volumes of Nokia's net sales were generated in the EMEA and Americas regions. In 2021-2022, the Americas region held the leading position, with sales reaching EUR 9.61 billion in 2022; however, in subsequent years, this figure declined to EUR 6.9 billion in 2025. The EMEA region remained the company's most stable area of operations, generating between EUR 7.92 billion and EUR 8.63 billion in net sales over the study period. At the same time, the APAC region experienced greater fluctuations in its indicators: after increasing to EUR 6.44 billion in 2023, sales declined to

EUR 4.55 billion in 2024 and remained at a similar level in 2025. Sales of the Submarine Networks segment exceeded EUR 1 billion per year in 2022-2023, indicating its significant contribution to the company's overall sales volume. Overall, the findings confirm a high degree of diversification of Nokia's foreign economic activity and the significant role of the European, American, and Asia-Pacific markets in generating the company's revenues. To assess changes in the geographical structure of Nokia's foreign economic activity, the share of each region in the company's total net sales was calculated for 2021-2025 using Formula 1 (Table 7).

Table 7. Breakdown of Nokia's net sales by region, %

Region	2021	2022	2023	2024	2025
Americas	38.3	38.6	30.5	32.7	35.1
APAC	23.2	22.2	28.9	23.7	23.3
EMEA	38.5	34.6	35.6	43.7	41.6
Submarine Networks	-	4.6	5.0	-	-
Total	100.0	100.0	100.0	100.0	100.0

Source: compiled by the authors based on Report for Q4 and full year 2021 (2022), Report for Q4 and full year 2022 (2023), Report for Q4 and full year 2023 (2024), Report for Q4 and full year 2024 (2025), Report for Q4 and full year 2025 (2026)

The data in Table 7 indicate that, throughout 2021-2025, the EMEA and Americas regions dominated the structure of Nokia's net sales. The share of the Americas region was 38.3% in 2021 and reached a maximum of 38.6% in 2022, after which it declined to 30.5% in 2023 and increased to 35.1% in 2025. The share of the EMEA region fluctuated between 34.6% and 43.7%, with the highest value recorded in 2024. The APAC region accounted for between 22.2% and 28.9% of the company's total sales, with its largest share recorded in 2023. The share of the Submarine

Networks segment in 2022-2023 was approximately 5% of total sales. Overall, the findings indicate that Nokia's foreign economic activity was predominantly oriented towards the European and American markets, while maintaining a significant presence in the Asia-Pacific region. To assess the performance of Nokia's foreign economic activity, the dynamics of the company's key financial indicators in 2021-2025 were analysed. The analysis included net sales, Operating profit, Net income, and Operating margin. The results are presented in Table 8.

Table 8. Trends in Nokia's key financial indicators for 2021-2025

Year	Net sales, million EUR	Operating profit, million EUR	Net income, million EUR	Operating margin, %
2021	22,202	2,158	1,645	9.7
2022	24,911	2,318	4,259	9.3
2023	22,258	1,688	679	7.6
2024	19,220	1,999	1,284	10.4
2025	19,889	885	660	4.4

Source: compiled by the authors based on Report for Q4 and full year 2021 (2022), Report for Q4 and full year 2022 (2023), Report for Q4 and full year 2023 (2024), Report for Q4 and full year 2024 (2025), Report for Q4 and full year 2025 (2026)

The data in Table 8 indicate that Nokia's financial results were characterised by unstable dynamics throughout 2021-2025. The highest level of net sales was recorded in 2022, at EUR 24.91 billion, after which the indicator gradually declined to EUR 19.89 billion in 2025. Operating profit increased from EUR 2.16 billion in 2021 to EUR 2.32 billion in 2022; however, in subsequent years, it declined, reaching EUR 0.89 billion in 2025. A similar trend was observed for Net

income, which, after reaching a maximum of EUR 4.26 billion in 2022, declined to EUR 0.66 billion in 2025. Operating margin fluctuated between 4.4% and 10.4%, indicating changes in the efficiency of the company's operating activities amid transformations in the market environment. To determine the nature of the relationship between the regional structure of sales and Nokia's performance, a correlation analysis was conducted (Table 9).

Table 9. Results of the correlation analysis between Nokia's regional sales and financial indicators

Indicator	Net sales	Operating profit	Net income	Operating margin
Americas	0.870	0.559	0.865	0.261
APAC	0.625	0.223	0.089	0.028
EMEA	0.321	0.557	0.732	0.481

Source: compiled by the authors based on Report for Q4 and full year 2021 (2022), Report for Q4 and full year 2022 (2023), Report for Q4 and full year 2023 (2024), Report for Q4 and full year 2024 (2025), Report for Q4 and full year 2025 (2026)

The data in Table 9 indicate varying strengths of the relationship between regional sales and Nokia's financial performance. The highest correlation coefficients were recorded between sales in the Americas region and Net sales ($r = 0.870$) and Net income ($r = 0.865$), indicating a strong positive relationship. A noTable positive relationship was also observed for the EMEA region with Net income ($r = 0.732$) and Operating profit ($r = 0.557$). Sales in the APAC region demonstrated a moderate relationship with the company's Net sales ($r = 0.625$), whereas their relationship

with the other financial indicators was weak. Among the performance indicators, the highest coefficient was observed between Operating margin and sales in the EMEA region ($r = 0.481$). The findings indicate that the strongest statistical relationship with Nokia's financial performance was observed for sales in the Americas and EMEA markets. To assess possible directions for the development of Nokia's foreign economic activity, net sales volumes by major world regions were forecast for 2026-2028. The forecast results are presented in Table 10, based on Formula 2.

Table 10. Forecast of Nokia's net sales by region for 2026-2028, in millions of EUR

Year	Americas	APAC	EMEA
2026	5,718.3	4,662.6	8,111.0
2027	5,080.6	4,464.2	8,030.4
2028	4,442.9	4,265.8	7,949.8

Source: compiled by the authors based on Report for Q4 and full year 2021 (2022), Report for Q4 and full year 2022 (2023), Report for Q4 and full year 2023 (2024), Report for Q4 and full year 2024 (2025), Report for Q4 and full year 2025 (2026)

The forecast results presented in Table 10 indicate differing prospects for the development of Nokia's regional foreign economic activity. For the Americas region, a gradual decline in net sales is forecast, from EUR 5.72 billion in 2026 to EUR 4.44 billion in 2028. A decline in sales is also expected in the APAC region, from EUR 4.66 billion in 2026 to EUR 4.27 billion in 2028. For the EMEA region, the model forecasts a slight decrease in sales from EUR 8.11 billion in 2026 to EUR 7.95 billion in 2028; however, this region will maintain the company's highest net sales volumes. Overall, the forecast results indicate that the EMEA region will retain its leading role in the geographical structure of Nokia's sales, despite the projected decline in sales volumes across all regions under study.

Thus, Nokia's foreign economic activity in 2021-2025 was characterised by a high degree of geographical diversification and an orientation towards three key regional markets – Americas, EMEA and APAC. The Americas and EMEA regions made the largest contributions to the company's revenues, with their combined share exceeding 70% of total net sales throughout the study period. Analysis of the sales structure showed a gradual increase in the importance of the EMEA region, whose share reached 43.7% in 2024, whereas the role of the Americas region declined somewhat after reaching a peak in 2022. The APAC region remained one of the company's areas of international activity, but was

characterised by greater instability in sales volumes. The forecast calculations indicate a possible decline in net sales across all regions under study in 2026-2028; at the same time, the EMEA region is expected to retain its leading position in generating the company's revenues.

Using the results of statistical analysis to support management decisions

The results of the statistical analysis confirm the feasibility of using quantitative methods to support management decisions in the field of enterprises' foreign economic activity. The application of trend analysis, structural analysis, correlation analysis and forecasting enable to obtain information on trends in the development of international operations, assess factors related to the company's performance, and formulate well-founded directions for further development in foreign markets. The results obtained can be used as an information basis for the strategic and operational management of enterprises' foreign economic activities. An analysis of the European Union's foreign trade revealed that, in 2021-2025, foreign economic activity was characterised by volatile trends in trade flows, shifts in the balance between exports and imports, and dependence on specific product groups and trading partners. Machinery, equipment, transport vehicles and chemical products made the largest contribution to positive foreign trade results,

whilst the largest deficit was associated with imports of energy resources. These results indicate the need for continuous monitoring of the commodity structure of foreign economic operations and for taking into account changes in the international economic environment when making management decisions regarding the development of enterprises' export activities. A statistical analysis of the geographical structure of the European Union's foreign trade also revealed a high concentration of trade flows centred on a limited circle of trading partners, among which the United States, the United Kingdom, China and Switzerland are of the greatest significance. This highlights the need to take into account the risks associated with dependence on individual foreign markets, as well as the importance of diversifying international economic relations. For enterprises, such information can be used when selecting priority sales markets, assessing the prospects for entering new markets and formulating a foreign economic strategy.

The practical application of statistical methods was demonstrated using the example of Nokia Corporation, whose operations are characterised by geographical diversification and a presence in the world's major markets for telecommunications equipment and digital technologies. An analysis of the structure of net sales showed that the bulk of the company's revenue is generated in the EMEA and Americas regions, which together accounted for over 70% of total sales during the period under review. The results obtained make it possible to identify the most significant areas of the company's foreign economic activity and to assess the extent to which its performance depends on individual regional markets. For the management of foreign economic activity, such information can be used when allocating resources between regions, planning marketing activities, developing partnerships and setting priorities for international expansion.

The results of the correlation analysis showed that the strongest statistical link with Nokia's financial results was observed for sales in the Americas and EMEA regions. The highest correlation coefficients were recorded between sales in the Americas region and the company's Net sales and Net income. A noticeable positive correlation was also established for the EMEA region with regard to operating profit and net profit. The results obtained indicate that changes in sales volumes in these regions were accompanied by changes in the company's key financial results. From a management perspective, this allows regional sales figures to be used as indicators for monitoring the performance of foreign economic activity and to be taken into account when making decisions regarding the expansion or adjustment of the company's international presence.

Within the statistical framework for managing foreign economic activity, forecasting is used to assess possible future changes in indicators. The forecast of Nokia's regional sales for 2026-2028 revealed a potential strengthening of the EMEA region's role in generating the company's revenue and more subdued sales growth in the Americas and APAC regions. The resulting forecasts enable the early identification of potential changes in the structure of the company's international operations and the development of alternative scenarios for the growth of its foreign economic operations. The use of forecasting models makes it possible to adjust strategic plans in a timely manner,

optimise the allocation of resources between regions and prepare for possible changes in market conditions.

Thus, the results of this study confirm that statistical methods can be used not only to describe the current state of enterprises' foreign economic activities, but also to form an information base for management decisions. Dynamic analysis enables the identification of trends in the development of international operations; structural analysis allows for the assessment of the geographical and commodity characteristics of foreign trade; correlation analysis helps to identify interrelationships between performance indicators; and forecasting makes it possible to assess the prospects for the future development of foreign economic operations. The comprehensive use of these methods enhances the soundness of management decisions, promotes a more efficient use of the enterprise's resources and ensures that foreign economic activities are adapted to changes in the international economic environment.

• DISCUSSION

The conditions governing international trade are characterised by the growing influence of global economic transformations, trade conflicts, regional integration, digitalisation and structural changes in the world economy. The concentration of foreign trade flows around the leading economies of the European Union, identified in this study, is partly consistent with the findings of K. Siddiqui (2024). The author also identified China's dominant role in shaping the trade and economic ties of the Association of Southeast Asian Nations (ASEAN) countries, which confirmed the trend towards the concentration of international trade around the largest economic centres. At the same time, the results differ in terms of the nature of the development of trade relations. Whilst this study recorded an EU trade deficit in 2022 and a surplus in 2023-2025, K. Siddiqui noted an expansion in trade between China and the ASEAN countries and a strengthening of their trade dependence on the Chinese economy. This points to differences in the structure of foreign economic relations and the mechanisms governing trade flows in various regions of the world. The findings also partially corroborate the conclusions of X. Han & E. Laing (2025) regarding the importance of quantitative analysis in supporting managerial decisions in international operations. Both studies showed that rising uncertainty necessitated the use of analytical tools for risk assessment and decision-making. At the same time, X. Han & E. Laing found that enterprises with more developed risk management systems made more active use of mechanisms to hedge against currency fluctuations. In contrast, the results of this study indicate the high sensitivity of the EU's foreign trade to changes in the international economic environment and the need to monitor trends in exports, imports and the trade balance. Thus, both studies confirm the importance of analytical support, although they focus on different aspects of international business.

The findings of this study are partly consistent with the conclusions of B. Xu (2024) regarding the significant influence of the external environment on international economic relations. Both studies identified a concentration of trade flows around leading economic partners and confirmed the role of international trade in economic development. At the same time, B. Xu concluded that there is

a high level of economic interdependence between China and Japan, whereas the results of this study point more to the unevenness of the foreign trade positions of individual EU countries and the existence of differences in their trade balances. This indicates different forms of economic integration and interrelationships in the regions under study. The findings of Y. Chen (2025) regarding the high sensitivity of international trade to external economic shocks are also partially confirmed by this study. An analysis of EU foreign trade showed that changes in the international environment were accompanied by fluctuations in exports, imports and the trade balance. At the same time, Y. Chen found that the trade war between the US and China led to a reduction in China's foreign trade activity and a redistribution of trade flows. In contrast, the results of this study point more strongly to the influence of energy factors and the commodity structure of trade on the formation of the EU's external trade deficit. Thus, both studies confirm the dependence of international trade on external factors, although the sources of such changes proved to be different. The findings of Y. Yang *et al.* (2026) show a certain similarity to the results of this study. The authors established that the development of enterprises' international activities depended on institutional conditions, access to resources, and their ability to adapt to changes in the external environment. Similarly, the findings of this study confirm the high dependence of foreign trade on external economic conditions. At the same time, Y. Yang *et al.* demonstrated the positive impact of specific support mechanisms for cross-border e-commerce on the international expansion of enterprises, whilst the results of this study indicate the presence of structural imbalances in EU foreign trade and varying performance across individual product groups and participating countries.

The results of T. Zhao *et al.* (2024) are also partially consistent with the findings obtained in this study. The authors concluded that successful international activities of enterprises depended on a combination of internal advantages and external operating conditions. A similar approach can be seen in the study by A. Pavlenchuk & N. Tsizdyn (2025), who demonstrated that the effective management of the foreign economic activities of tourism enterprises in the Lviv region is a key factor in shaping their competitiveness. This study also found that the results of foreign economic activity were determined not only by the size of individual countries' economies, but also by the structure of foreign trade flows and the characteristics of the international environment. At the same time, T. Zhao *et al.* linked success in foreign markets primarily to the level of innovation, digitalisation and productivity of enterprises, whereas the findings of this study reflect, to a greater extent, the macroeconomic patterns of foreign trade development. A comparison with the findings of M.I. Al-Karkhi (2024) reveals a commonality in identifying the uneven distribution of economic activity. The author found that individual sectors of the Scottish economy differed significantly in terms of economic growth rates and their contribution to gross value added. Similarly, this study revealed significant differences between product groups and European Union countries in terms of export volumes, imports and trade balances, indicating an uneven distribution of foreign trade activity. At the same time, whilst M.I. Al-Karkhi analysed intra-regional

differences in economic development, the results of this study characterise cross-country and commodity imbalances in the European Union's foreign trade. The findings of M. Gumenna-Derii (2025) partly coincide with the results obtained here. The author emphasised the importance of information provision and analytical tools for improving the efficiency of enterprises within the European economic area. Similarly, the results of this study confirm the value of using statistical analysis to assess foreign trade trends and support management decisions. At the same time, M. Gumenna-Derii focused primarily on digitalisation, automation and accounting processes, whereas the findings of this study demonstrate the decisive role of the commodity and geographical structure of foreign trade in shaping the European Union's foreign economic performance. The conclusions of K. Kiyota (2026) complement the findings of this study regarding the role of international trade in ensuring economic development. In line with the findings presented here, the author emphasised the high sensitivity of foreign trade processes to changes in the global environment, trade conflicts and the transformation of world markets. At the same time, whilst the results of this study revealed changes in the dynamics of the EU's exports, imports and trade balance, K. Kiyota demonstrated that a country's long-term competitive advantages are shaped not only by trade, but also by the interaction of foreign trade flows with foreign direct investment, productivity and employment. Thus, both studies confirm the importance of international trade for economic development, although they examine this impact at different levels. The issue of external challenges to international trade is further explored in the work of G. Felbermayr *et al.* (2024). Like the findings of the present study, their conclusions confirmed the dependence of the EU's foreign trade on the international economic environment and the trade policies of key partners. At the same time, whilst this study identified actual changes in exports, imports and the trade balance, G. Felbermayr *et al.* focused on the potential consequences of trade wars, protectionism and the fragmentation of the global economy. Thus, both studies highlight the vulnerability of European trade to external shocks but examine it from different temporal perspectives – through established trends and possible future scenarios. In contrast to macroeconomic studies, H. Zhaldak & V. Antonov (2025) analysed foreign economic activity at the enterprise level. However, the findings of H. Zhaldak & V. Antonov also confirm the importance of analytical support for improving the efficiency of international operations. Whilst in this study statistical analysis revealed patterns in the development of EU foreign trade, H. Zhaldak & V. Antonov demonstrated that a similar approach helped to optimise an enterprise's import activities by improving its work with suppliers and logistics processes. This demonstrates the universality of analytical tools, regardless of the level of research. The findings of L. Jiaying *et al.* (2025) broaden the understanding of the economic consequences of international integration. The present study demonstrated the impact of foreign trade processes on the economic performance of EU countries, whereas L. Jiaying *et al.* established a relationship between foreign direct investment, economic growth, and the quality of governance in China. Common to both studies is the confirmation that international economic interaction

remains one of the key factors in the development of national economies, although the specific mechanisms of this influence proved to be different. The findings of T. Casas-Klett *et al.* (2026) also reflect the impact of global changes on international economic activity. The authors showed that the activities of foreign companies in China depended to a considerable extent on the competitive environment, investment climate, and regulatory conditions.

A similar dependence can also be observed in the findings of the present study, where changes in the international environment affected the foreign trade activity of EU countries. However, while T. Casas-Klett *et al.* (2026) focused on the behaviour of enterprises, the findings of the present study reflect changes at the level of the foreign trade system. The issue of risks associated with international activities was addressed from a different perspective by S. Alamad (2025). His findings confirmed that instability in the external environment increased the need for foreign exchange risk management tools. In the present study, a similar relationship is reflected in the instability of foreign trade indicators and the need for their continuous monitoring. At the same time, while S. Alamad focused on mechanisms for mitigating foreign exchange risks, the findings of the present study make it possible to assess the consequences of external changes for EU trade flows. The importance of international trade for economic development is also confirmed by the findings of T. Kroeger *et al.* (2025). The authors showed that international trade remained one of the factors contributing to productivity and economic growth in Germany, alongside digitalisation, demographic changes, and decarbonisation. In turn, the findings of the present study demonstrate that foreign trade activity shapes the structural characteristics of the EU economy.

Y. Chen & N. Qiao (2025) reached conclusions similar in substance. The authors showed that external economic links, investment and structural features of the economy influenced Japan's economic growth. Similarly, the results of this study attest to the significant influence of foreign trade on economic processes in the EU. At the same time, whilst Y. Chen & N. Qiao explained economic development through a combination of internal and external factors, this study focuses specifically on foreign trade trends. The role of international integration in the development of economic entities is also confirmed in the study by F.M. Muneeb *et al.* (2025), whose authors demonstrated its importance for small and medium-sized enterprises in developing countries. The authors found that attracting foreign investment and early internationalisation contributed to the expansion of business opportunities. Although the present study focused not on enterprises but on the EU's foreign trade, both works confirm that effective participation in international economic processes creates the conditions for economic development and improved business performance.

A comparison of the findings of the present study with those of other scholarly works revealed common trends in the development of international trade and foreign economic activity. Most studies confirmed the dependence of foreign trade processes on changes in the international economic environment, the concentration of trade flows around leading economic centres, and the appropriateness of using analytical methods to support management decisions. At the same time, the findings obtained made it

possible to identify specific characteristics of the European Union's foreign trade, including the uneven distribution of trade flows across countries, structural imbalances, and changes in the trade balance. This confirmed the potential for the effective application of statistical methods to assess foreign economic processes and establish an information base for the management of foreign economic activity.

● CONCLUSIONS

The study identified opportunities for using statistical methods to support management decisions in the field of enterprises' foreign economic activity. An analysis of the European Union's foreign trade showed that, between 2021 and 2025, the dynamics of foreign trade flows were characterised by fluctuations in the volumes of imports, exports and the trade balance.

EU imports increased from EUR 2,123.3 billion in 2021 to EUR 2,523.0 billion in 2025, while exports increased from EUR 2,180.9 billion to EUR 2,643.8 billion. The largest foreign trade deficit was recorded in 2022, amounting to EUR 431.96 billion. In 2023-2025, EU foreign trade was characterised by a positive trade balance of EUR 42.09 billion, EUR 140.17 billion, and EUR 120.80 billion, respectively. It was established that Germany had the largest volumes of foreign economic activity among EU Member States, with exports reaching EUR 689.2 billion in 2025 and a positive trade balance of EUR 215.8 billion. Analysis of the product structure showed that chemicals and related products, as well as machinery, equipment and transport equipment, made the largest positive contributions to the trade balance, with surpluses of EUR 255.99 billion and EUR 172.7 billion, respectively, in 2025. At the same time, the largest deficit was associated with mineral fuels and energy resources, for which the negative balance reached EUR 298.1 billion. The practical application of statistical methods was demonstrated using Nokia Corporation as an example.

It was established that the largest volumes of the company's net sales were generated in the Americas and EMEA regions, whose combined share exceeded 70% of total sales. The maximum level of net sales was recorded in 2022, at EUR 24.91 billion, after which it declined to EUR 19.89 billion in 2025. Correlation analysis showed the strongest statistical relationship between sales in the Americas region and Net sales ($r=0.870$) and Net income ($r=0.865$), whereas for the EMEA region, a positive relationship was identified with Net income ($r=0.732$) and Operating profit ($r=0.557$). The forecast results for 2026-2028 indicated a possible decline in sales in the EMEA region to EUR 7.95 billion in 2028, as well as decreases in the forecast values for the Americas and APAC regions.

The findings confirmed that time-series analysis, structural analysis, correlation analysis, and forecasting can be used to assess the performance of foreign economic activity, identify relationships between indicators, and establish an information base for management decision-making. The application of these methods makes it possible to identify trends in the development of foreign economic operations in a timely manner, assess possible changes in the market environment, and substantiate directions for the further development of enterprises in international markets. Future research should focus on expanding the sample of enterprises, using regression modelling, and applying multivariate

statistical methods to assess the impact of economic factors on the performance of foreign economic activity.

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● CONFLICT OF INTEREST

None.

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Методи статистичного аналізу в управлінні зовнішньоекономічною діяльністю підприємств

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Анотація. Метою даного дослідження було оцінювання можливостей застосування статистичного інструментарію для інформаційного забезпечення процесу прийняття управлінських рішень у сфері зовнішньоекономічної діяльності на прикладі Nokia Corporation. Методологія ґрунтувалася на аналізі динамічних рядів, порівняльному статистичному аналізі, структурному аналізі, кореляційному аналізі та трендовому прогнозуванні. Встановлено, що обсяг імпорту Європейського Союзу у торгівлі з країнами поза межами Союзу зріс з 2,123,3 млрд European Currency Unit/Euro у 2021 р. до 2,523,0 млрд European Currency Unit/Euro у 2025 р., тоді як експорт збільшився з 2,180,9 млрд European Currency Unit/Euro до 2,643,8 млрд European Currency Unit/Euro. Найбільший дефіцит зовнішньої торгівлі було зафіксовано у 2022 р. на рівні 431,96 млрд European Currency Unit/Euro. Провідні позиції займала Німеччина з експортом 689,2 млрд євро та позитивним сальдо 215,8 млрд євро. Найбільший профіцит у товарній структурі формували хімічна продукція та пов'язані товари (255,99 млрд євро) і машини, обладнання та транспортні засоби (172,7 млрд євро), тоді як найбільший дефіцит спостерігався за мінеральним паливом, мастильними матеріалами та спорідненою продукцією (298,1 млрд євро). На прикладі Nokia Corporation встановлено, що найбільші обсяги чистих продажів формувалися у регіонах Europe, Middle East and Africa та Americas, сукупна частка яких перевищувала 70 % реалізації. Максимальний обсяг чистих продажів становив 24,91 млрд євро у 2022 р., а у 2025 р. скоротився до 19,89 млрд євро. Кореляційний аналіз виявив сильний зв'язок між продажами у регіоні Americas та чистими продажами ($r=0,870$) і чистим прибутком ($r=0,865$). Прогнозування показало можливе скорочення продажів у регіоні Europe, Middle East and Africa до 7,95 млрд євро у 2028 р. Результати дослідження на прикладі Nokia Corporation підтвердили можливість використання статистичних методів для оцінювання зовнішньоекономічної діяльності та підтримки управлінських рішень. Практичне значення дослідження полягає у можливості використання його результатів для оцінювання ефективності зовнішньоекономічної діяльності та вибору пріоритетних ринків

Ключові слова: динаміка; експорт; імпорт; торгівельне сальдо; міжнародні ринки

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