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STRUCTURAL TRANSFORMATION OF UKRAINE'S IT INDUSTRY, 2019-2026: FROM OUTSOURCING TOWARD PRODUCTS, AI AND DEFENSE TECH – A LONGITUDINAL MULTI-SOURCE ANALYSIS

Abstract. This study examines the structural transformation of Ukraine's information-technology industry from 2019 to the first half of 2026, with particular attention to business models, labor demand and export-market structure under wartime conditions. The analysis combines a newly constructed panel of 800 firm-period observations from sixteen DOU Top-50 rankings, a business-model classification of the largest firms, six DOU-based vacancy snapshots, and National Bank of Ukraine computer-services export statistics. Methods include longitudinal phase decomposition, employment-weighted business-model shares, Herfindahl–Hirschman concentration indices, a vacancy Structural Change Index, and pooled firm-level regressions of half-year log employment growth with lagged size and time effects. Top-50 employment rose from 58,448 in January 2019 to 99,501 in January 2022 before declining to 79,252 by July 2026. The Outsourcing share fell from 76.5% to 62.3%, while the Product share increased from 16.9% to 30.6%; these patterns remain stronger in the source-audited high-confidence sample. By contrast, the product-firm growth coefficient is positive but not statistically significant at the 5% level in the baseline regression. Between September 2024 and July 2026, the emerging-technology vacancy basket increased from 223 to 1,146 positions and its share rose from 20.7% to 59.0%, producing a Structural Change Index of approximately 0.405. Export evidence further indicates reduced single-market dominance after the 2022 concentration peak. The results suggest a process of intra-sectoral diversification, functional upgrading and capability reallocation rather than a simple one-for-one replacement of outsourcing by product companies.

Keywords: Ukraine, IT industry, structural transformation, outsourcing, product companies, artificial intelligence, Defense Tech, labor demand, computer-services exports.

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СТРУКТУРНА ТРАНСФОРМАЦІЯ ІТ-ГАЛУЗІ УКРАЇНИ У 2019-2026 РОКАХ: ВІД АУТСОРСИНГУ ДО ПРОДУКТІВ, АІ ТА DEFENSE TECH – ЛОНГІТЮДНИЙ БАГАТОДЖЕРЕЛЬНИЙ АНАЛІЗ

Анотація. У дослідженні розглянуто структурну трансформацію ІТ-галузі України у 2019 – першій половині 2026 року з особливою увагою до бізнес-моделей, попиту на працю та структури експортних ринків в умовах війни. Аналіз поєднує новосформовану панель із 800 спостережень «компанія–період» на основі шістнадцяти рейтингів DOU Top-50, класифікацію бізнес-моделей найбільших компаній, шість зрізів вакансій на основі даних DOU та статистику НБУ щодо експорту комп'ютерних послуг. Застосовано лонгитюдну фазову декомпозицію, зважені за зайнятістю частки бізнес-моделей, індекси концентрації Herfindahl–Hirschman, Structural Change Index для структури вакансій та об'єднані панельні регресії піврічного логарифмічного зростання зайнятості з контролем попереднього розміру компанії та часових ефектів. Чисельність персоналу Top-50 зросла з 58 448 осіб у січні 2019 року до 99 501 у січні 2022 року, а до липня 2026 року знизилася до 79 252. Частка Service/Outsourcing скоротилася з 76,5% до 62,3%, тоді як частка Product зросла з 16,9% до 30,6%; у вибірці з високою надійністю класифікації, перевіреною за джерелами, ці зміни є ще виразнішими. Водночас коефіцієнт зростання продуктових компаній є додатним, але у базовій регресії не досягає статистичної значущості на 5%-му рівні. У період із вересня 2024 року до липня 2026 року кошик вакансій emerging technologies збільшився з 223 до 1 146 позицій, а його частка – з 20,7% до 59,0%, що відповідає Structural Change Index близько 0,405. Дані щодо експорту також свідчать про зниження домінування одного ринку після



піку концентрації 2022 року. Результати вказують на процес внутрішньогалузевої диверсифікації, *functional upgrading* та перерозподілу спроможностей, а не на просту односпрямовану заміну аутсорсингу продуктивними компаніями.

Ключові слова: Україна, IT-галузь, структурна трансформація, аутсорсинг, продуктові компанії, штучний інтелект, Defence Tech, попит на працю, експорт комп'ютерних послуг.

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Statement of the problem. Ukraine entered the 2020s with one of the most internationally oriented information-technology sectors in Eastern Europe. Its competitive model was built primarily on software engineering services, outsourcing and outstaffing for foreign clients, supported by a large technical workforce, relatively strong engineering education and a cost-quality proposition attractive to North American and European customers. This model generated rapid pre-war expansion: within the DOU Top-50, employment increased from 58,448 specialists in January 2019 to 99,501 in January 2022. Computer-services exports expanded in parallel and became an important source of foreign-exchange earnings. The full-scale Russian invasion in February 2022 therefore struck an industry that was already globally integrated, export-dependent and organizationally distributed. Earlier Ukrainian research had already identified the importance of investment policy, regulatory quality and state support for the IT-services market and high-technology ICT entrepreneurship. Industry-wide evidence published during the war likewise documents resilience alongside changes in employment, exports and market structure [18, 23, 24, 25, 31, 35].

The war changed the conditions under which this model operated. Client risk perceptions increased, part of the workforce relocated abroad, mobilization reduced labor availability, infrastructure was repeatedly attacked and the broader Ukrainian economy shifted toward wartime production. Yet the ICT sector also displayed substantial operational resilience. Ukraine's pre-existing digital capabilities, cloud adoption and digital-government infrastructure helped organizations preserve continuity, while the economy simultaneously generated new technological demand associated with defense, autonomy, artificial intelligence, embedded systems and hardware. Research on Ukraine has documented the role of digital resilience in maintaining public and private functions during the invasion, while OECD assessments emphasize the ICT sector's contribution to resilience and recovery. Ukrainian studies conducted during the war similarly emphasize simultaneous pressure on exports, client confidence, human capital and regulation, together with firms' adaptation through relocation, market diversification and changes in business models. The international investment environment also deteriorated after the post-pandemic technology boom, with global investment weakening under overlapping geopolitical and macroeconomic shocks, while Ukrainian startup

financing remained constrained relative to the scale of the ecosystem [29, 32, 36, 39, 50, 51].

These developments raise a question that cannot be answered by aggregate export or employment figures alone: has the Ukrainian IT industry merely contracted and partially recovered, or has its internal structure changed? A cyclical interpretation would imply that the post-2022 decline mostly reflects a temporary demand shock to an otherwise stable outsourcing model. A structural interpretation, by contrast, would imply persistent reallocation across business models, skills, technologies and external markets. Such a distinction matters for national competitiveness. An outsourcing-led industry creates export revenues and engineering employment, but greater product ownership, R&D intensity, technological specialization and market diversification can alter value capture, strategic autonomy and resilience.

The international literature provides several relevant but incomplete perspectives. Business-model research emphasizes that firms differ in how they create, deliver and capture value and that diversification across business models can be a strategic response to technological and demand change. Research on software-export economies, especially India, shows that an initially service-oriented software industry can upgrade toward higher-skill R&D and product-related activities, although such development may remain uneven and externally dependent. Labor-market research, meanwhile, documents rapidly increasing global demand for AI-related skills, while recent defense-innovation studies show that commercial and dual-use technologies increasingly shape military capability. Ukraine represents an unusually important setting in which all of these mechanisms interact under extreme geopolitical stress [2, 4, 10, 41, 44, 45, 47, 53].

Despite this relevance, the empirical literature lacks a longitudinal, multi-dimensional study of the Ukrainian IT industry that jointly examines firm business models, employment composition, vacancy structure and export-market concentration over the pre-war, shock and adaptation periods. Existing industry reports are typically cross-sectional or focus on one dimension, such as total headcount, exports or labor demand. Academic work on wartime digital resilience primarily addresses public-sector continuity or digital infrastructure rather than the internal economic restructuring of the IT sector. Ukrainian scholarship has progressively examined IT-services investment policy, wartime sector challenges, digital-economy

formation, artificial intelligence and product internationalization. However, these studies are predominantly strategic, descriptive or thematic and do not combine a long-run firm panel with formal business-model concentration measures, vacancy-structure indices and export-destination concentration. This article addresses that gap by constructing a sixteen-snapshot firm panel covering January 2019 to July 2026 and combining it with vacancy and export data [27, 34].

The study has three contributions. First, it provides a longitudinal decomposition of the largest Ukrainian IT firms by business model and shows whether Outsourcing dominance has weakened over time. Second, it links firm-level restructuring to changes in labor demand, including AI/ML, data engineering, embedded systems, hardware and Defense Tech. Third, it adds the external-market dimension by examining both computer-services export scale and destination concentration. The central argument is that Ukraine's IT sector is better characterized by diversification and capability reallocation than by a simple binary transition from outsourcing to products.

The empirical results support this interpretation. The service share of Top-50 employment declines materially between 2019 and 2026, while product representation rises; the result survives high-confidence and conservative classification checks. Labor-demand composition shifts even more sharply after 2024 toward AI, data engineering, embedded, hardware and Defense Tech. Export-market concentration also falls after the 2022 peak, although the current data suggest some partial reconcentration in 2026. At the firm level, however, product companies do not display a statistically significant growth advantage at the conventional 5% level in the baseline specification. This distinction is important: the evidence for sectoral reallocation is stronger than the evidence for a simple product-firm performance premium.

Analysis of recent research and publications.

2.1. Business models, digital transformation and diversification

The business-model literature provides the first conceptual pillar for analyzing structural change within the IT industry. Teece defines a business model as the architecture through which a firm creates, delivers and captures value, while Zott et al. emphasizes a system-level perspective that focuses on configurations of activities rather than isolated products. This distinction is particularly relevant to software firms because two companies using similar technologies may monetize them through fundamentally different arrangements: client-specific engineering services, proprietary software products, captive R&D for a parent organization, or hybrid combinations of products and services. Digital transformation can intensify these differences by enabling platform models, scalable digital products and data-driven services [47, 52, 53].

Recent research increasingly treats the coexistence of multiple business models as a form of business-model diversification. Sohl et al. show that diversification can generate performance gains when business models address related demand, whereas Sohl

et al. demonstrate that the diversification-performance relationship is non-linear and sensitive to shock conditions. Berntsen et al. further argue that digital transformation has made business-model diversification a growing strategic phenomenon. These findings imply that a wartime shift in Ukraine need not take the form of a clean substitution of services by products. A more plausible process is hybridization: service firms add productized capabilities, product firms scale internal engineering, and new captive or defense-oriented R&D units enter the employment structure [5, 43, 44].

2.2. Software-export models and technological upgrading

The second literature stream concerns the development trajectory of software-export economies. Early research on India showed how international outsourcing could create a strong export industry based on engineering labor and foreign demand. However, D'Costa cautioned that rapid export growth can coexist with uneven development and persistent dependence on external markets. The key theoretical issue is therefore upgrading: whether firms remain providers of relatively standardized client services or accumulate capabilities that support more knowledge-intensive and proprietary activities [6, 10].

Parthasarathy and Aoyama provide a particularly relevant mechanism. Studying Bangalore, they document a movement from lower-skill software services toward R&D services and embedded systems, supported by local entrepreneurship and accumulated technical capabilities. This suggests that structural upgrading may occur within a services-dominated ecosystem before it results in a visible shift toward standalone product companies. Ojala and Tyrväinen likewise show that software firms' product and implementation models affect internationalization choices. For Ukraine, these studies imply that outsourcing and upgrading are not mutually exclusive. The empirical question is whether the employment distribution and labor-demand profile show a movement toward activities with greater R&D, product, AI and embedded intensity [40, 41].

Ukraine-specific research complements these international upgrading studies. Kutsyk et al. identify investment conditions and state regulation as central determinants of IT-services development, extend this logic to the activation and organizational-economic support of high-technology ICT startups. More recent work explicitly links digital transformation to sectoral structural shifts and competitiveness and documents a wartime movement from traditional service delivery toward proprietary products, R&D and more diversified market strategies. These studies provide a domestic analytical foundation for the present article, which moves from strategic interpretation to a longitudinal measurement of the reallocation itself [23, 24, 25, 26, 30, 31, 32, 34].

2.2.1. Global value chains, technological capabilities and functional upgrading

A global-value-chain perspective adds an important distinction between participation in international markets and upgrading within them.

Gereffi et al. show that value-chain governance depends on transaction complexity, codifiability and supplier capabilities. In software services, relatively codifiable tasks can be supplied at scale to global buyers without the supplier necessarily controlling the customer interface, intellectual property or downstream commercialization. The resulting model can be highly export competitive while leaving value capture concentrated in lead firms or clients. This perspective is relevant to Ukraine because the pre-war outsourcing model combined strong technical capabilities with substantial dependence on external demand and buyer relationships [15].

The upgrading literature therefore shifts attention from the volume of exports to the functions performed by local firms. Humphrey and Schmitz distinguish forms of upgrading that include improvements in processes and products as well as movement into higher-value functions. Applied to IT, functional upgrading may involve progression from staff augmentation and project execution toward architecture, R&D, product management, intellectual-property ownership, platform operation and direct customer monetization. Such upgrading does not require the disappearance of service exports. Rather, service firms can move into more knowledge-intensive positions within global value chains while product firms internalize more of the downstream value-capture functions. This distinction helps explain why employment-based diversification can be economically meaningful even before a complete shift in sectoral revenues becomes visible [17].

Dynamic-capability theory provides a complementary firm-level mechanism. Teece et al. argue that competitive advantage in rapidly changing environments depend on the capacity to integrate, build and reconfigure internal and external competences. Wartime Ukraine represents an extreme environment in which firms have had to reconfigure locations, teams, technologies, financing and customer portfolios while responding to new domestic demand. From this perspective, the rise of AI, embedded systems and Defense Tech can be interpreted not merely as the entry of new sectors but as a redeployment of accumulated software-engineering capabilities into new technological and market domains. The empirical implication is that structural transformation should be observable simultaneously in business models, skill demand and market exposure [48].

2.2.2. Product-service hybridity in the software industry

A strict product-versus-service dichotomy is also problematic in the software industry. Product companies frequently add consulting, implementation, integration and support services, while service companies increasingly productize internal tools, accelerators, platforms and intellectual property. Suarez et al. show empirically that services can become an important component of product-software firms' business models, and Cusumano et al. demonstrate that the strategic role of services changes as industries and product markets evolve. These findings reinforce the need to distinguish business-model portfolios from

simple legal or marketing labels. DOU's decision to introduce a dedicated product-company ranking likewise reflects the growing analytical relevance of product-oriented firms within Ukraine's largest technology employers [9, 11, 46].

This hybridity is particularly relevant to the Ukrainian evidence. A firm that remains classified as Outsourcing may nevertheless undertake high-value R&D or build reusable technology assets, while a Product firm may depend heavily on service-like implementation revenue. Consequently, the article treats the four-category classification as an employment-structure indicator rather than a direct measure of revenue composition. The Hybrid and Captive/R&D/Internal categories are retained precisely because the structural transformation may occur through coexistence and recombination of value-creation logics. This approach is also consistent with recent reviews of business-model diversification, which emphasize portfolios of business models and organizational ambidexterity rather than one-way replacement. Ukrainian management research also shows that AI and data-driven tools increasingly enter strategic decision-making and business-model design, including the selection of promising businesses and the formation of economically viable models [5, 20, 21, 22].

2.3. Digital resilience and wartime adaptation in Ukraine

A third stream examines resilience under crisis. Ukraine's wartime experience has generated a distinctive literature on digital resilience. Mamedieva and Moynihan show how pre-war digital-government capacities were repurposed to maintain state and social functions during the invasion. Aviv and Ferri emphasize the resilience role of telecommunications, cloud migration and the wider digital ecosystem. OECD similarly argues that digital technologies and the ICT sector have helped Ukrainian firms and institutions cope with wartime disruption and can support recovery [3, 36, 39].

This literature establishes that digital capabilities can preserve continuity under extreme shocks, but it does not directly answer whether the industrial composition of the ICT sector changes as resilience is built. Organizational continuity may be achieved by preserving existing business models, or by reconfiguring them. The distinction between resilience as restoration and resilience as transformation is therefore central to the present study. A persistent decline in service-model dominance, combined with growth in products, internal R&D and new technology domains, would indicate reconfiguration rather than simple recovery.

A related Ukrainian literature treats digital sovereignty as an industrial-development issue rather than cybersecurity alone. Kutsyk et al. argue that reducing dependence on Russian software can simultaneously lower security and vendor-lock-in risks and create domestic demand for Ukrainian software products. Their argument is consistent with evidence on the strategic importance of secure digital infrastructure during wartime and with policy

discussions of digital modernization as part of Ukraine's recovery. The present study does not measure software substitution directly, but it treats the growth of product-oriented and technology-intensive activities as one possible channel through which digital sovereignty and industrial upgrading can reinforce each other [3, 8, 28].

2.4. AI skills and the changing structure of labor demand

The fourth literature stream concerns the labor-market effects of AI and digital technologies. Alekseeva et al. document a rapid increase in employer demand for AI skills and show that AI-intensive firms tend to be more R&D-oriented. OECD evidence also shows that AI vacancies have grown across multiple sectors and increasingly combine specialized technical skills with complementary managerial, communication and problem-solving capabilities. These studies justify using vacancy composition as an indicator of technological change because new technologies become visible in firms' demand for specific capabilities before they necessarily dominate output or employment [2, 16, 45].

For Ukraine, the relevant question is not simply whether AI vacancies increase. A structural shift would also be reflected in the relative decline of some traditional software categories and the simultaneous growth of data engineering, embedded systems and hardware. This is particularly important because AI adoption increasingly depends on complementary infrastructure, data pipelines, edge computing and specialized hardware. The present study therefore analyses an emerging-technology basket rather than treating AI as an isolated category. Ukraine-specific evidence is now substantial: AI House and Roosh map the domestic AI talent and company ecosystem; Renda et al. identify AI applications and competitiveness potential across Ukraine's priority sectors; and Kutsyk together with Tulika and Kovtun connect AI adoption to productivity, strategic decision-making and new business models [1, 20, 21, 22, 42].

2.5. Defense Tech, dual-use innovation and commercial technology

The fifth literature stream concerns Defense Tech and dual-use innovation. NATO's review of critical dual-use technologies highlights a reversal of the traditional defense-innovation model: militaries increasingly adopt technologies first developed in commercial markets rather than relying solely on state-led defense R&D. Ukraine represents an accelerated version of this process. Bondar documents the country's shift toward commercially driven defense innovation and faster procurement of private-sector technologies. KSE Institute et al. estimate that the Ukrainian defense-technology market reached at least USD 6.8 billion in 2025, with especially rapid growth in UAVs, ground robotics, electronic warfare and AI/software. The same report documents the breadth of the resulting private technology ecosystem across these domains [4, 7, 19].

This literature suggests that wartime Defense Tech should not be treated as an exogenous sector completely separate from IT. It draws directly on

software engineering, AI/ML, computer vision, C++, embedded systems, electronics, communications and data engineering. Therefore, a rise in Defense Tech vacancies can reconfigure the broader IT labor market, changing the relative demand for software-only versus hardware-software capabilities. DOU labor-market analytics corroborate this mechanism by showing strong demand for Hardware, Embedded, C++ and AI-related roles in defense companies. This interpretation also aligns with Tulika, which treats DefenseTech, GovTech, AI and cybersecurity as interconnected channels through which the IT industry contributes to the structural modernization of Ukraine's wider economy, and with Kutsyk and Tulika, which links AI development to DefenseTech and the changing skill structure of the IT sector [12, 49].

2.6. Research gap and hypotheses

Taken together, prior research explains why business models may diversify, how software-export industries can upgrade, how digital capabilities support resilience, why AI changes labor demand and how commercial technologies can reshape defense innovation. The Ukrainian research trajectory is also increasingly coherent: investment regulation and startup activation were examined before and during the early digitalization phase, sectoral structural shifts were conceptualized in relation to competitiveness, and later studies examined wartime IT resilience, product internationalization, digital sovereignty, AI and the role of IT in the digital economy. What remains missing is an integrated longitudinal test of these mechanisms within the Ukrainian IT industry across the pre-war, invasion and adaptation periods. No identified study combines firm-level business-model composition, technical headcount, vacancy structure and export concentration over 2019–2026.

The theoretical framework links these literatures through a common mechanism of capability reallocation under external shock. The full-scale invasion simultaneously reduced conventional foreign demand, increased uncertainty around Ukrainian delivery locations, created extraordinary domestic demand for dual-use technology and accelerated adoption of AI and autonomous systems. Firms with accumulated engineering capabilities could respond through several pathways: deepening service specialization, developing products, entering captive or defense-oriented R&D, or combining several models. At the market level, similar reallocation could appear as a changing skill mix and a broader set of export destinations. The hypotheses therefore test different observable layers of one structural process rather than five unrelated phenomena.

The study therefore evaluates five hypotheses.

1. **H1** proposes that Product firms exhibit stronger employment dynamics than Outsourcing firms, particularly after 2022.

2. **H2** proposes that IT labor demand shifts toward AI/Data Engineering and away from part of the traditional software-development stack.

3. **H3** proposes that Defense Tech and hardware-adjacent demand become a distinct structural component of the IT labor market.

4. **H4** proposes that the employment structure of the largest IT companies become less concentrated in the Outsourcing model and more diversified across Product, Captive/R&D/Internal and Hybrid models.

5. **H5** proposes that the external-market structure of exports of computer-services changes materially after 2022, with reduced dependence on the single dominant destination.

Setting the research purpose and objectives. The purpose of this study is to identify and empirically assess the structural transformation of Ukraine's information technology industry during 2019–2026, with particular emphasis on changes in business models, employment structure, technological demand, and the geographical configuration of computer-services exports. The study seeks to determine whether the post-2022 evolution of the Ukrainian IT sector should be interpreted primarily as a cyclical contraction of the previously dominant outsourcing-oriented model or as a broader process of structural diversification, capability reallocation, and technological upgrading under wartime conditions. The central research question is therefore formulated as follows: to what extent has the structure of Ukraine's IT industry changed between the pre-war expansion period and the wartime adaptation period, and which dimensions of this transformation are empirically observable at the levels of firms, labor demand, technological specialization, and international markets?

To achieve this purpose, the study pursues the following specific objectives:

- To identify the principal phases of the Ukrainian IT industry's development during 2019–2026 by analyzing the dynamics of total employment and technical employment among the largest IT companies and distinguishing the periods of pre-war expansion, the 2022 shock, post-shock adaptation, and subsequent stabilization.

- To examine changes in the business-model structure of the industry by classifying the largest IT companies into Service/Outsourcing, Product, Captive/R&D/Internal IT, and Hybrid categories and measuring changes in their employment shares and business-model concentration.

- To test whether Product firms demonstrate stronger employment dynamics than Outsourcing firms, controlling for initial firm size and common time effects, and to assess the robustness of the estimated Product–Service growth differential across alternative samples and specifications.

- To assess changes in the technological structure of labor demand by analyzing the dynamics of vacancies in traditional and emerging IT categories, with particular attention to AI/ML, Data Engineering, Embedded, Hardware, and Defense Tech, and by quantifying the redistribution of vacancy demand through a Structural Change Index.

- To determine whether Defense Tech and hardware-adjacent capabilities have emerged as a distinct structural component of Ukraine's IT labor market, reflecting a growing convergence between software engineering, artificial intelligence, embedded

торів зовнішнього середовища, and defense-oriented technological development.

- To evaluate the transformation of Ukraine's external IT-market structure by analyzing the dynamics of computer-services exports, changes in the geographical distribution of export destinations, and the concentration of exports across major partner countries.

- To integrate the firm-level, labor-market, technological, and export dimensions into a unified interpretation of structural transformation, thereby distinguishing between simple post-shock recovery and a deeper reconfiguration of the mechanisms through which the Ukrainian IT industry creates value, deploys technological capabilities, and competes internationally.

Accordingly, the study treats structural transformation as a multidimensional process rather than as a binary transition from outsourcing to product development. The empirical analysis is designed to establish whether the observed post-2022 changes represent a persistent redistribution of employment, capabilities, labor demand, and market exposure, and to evaluate the implications of these changes for the resilience and international competitiveness of Ukraine's IT industry.

Research Methodology.

4.1. Research design

The study applies a longitudinal mixed-method empirical design to identify structural changes in Ukraine's information-technology industry between 2019 and the first half of 2026. The analytical framework distinguishes between changes in industry scale and changes in industry composition. The former are captured through employment and export dynamics, whereas the latter are operationalized through business-model shares, the composition of labor demand, the share of technical specialists, and the geographical concentration of computer-services exports. The empirical strategy combines descriptive longitudinal analysis, concentration indices, a structural-change index for vacancy categories, and firm-level panel regressions. This design is appropriate because the research question concerns not only whether the Ukrainian IT sector expanded or contracted, but whether the mechanisms of value creation, labor demand and external-market dependence changed after the full-scale invasion. Recent Ukrainian ICT-startup research has likewise moved beyond descriptive statistics toward regression, variance and covariance analysis of resource and performance relationships; the present design extends this econometric orientation to a firm-period panel and combines it with structural-composition measures [33].

4.2. DOU Top-50 company panel

The core firm-level dataset is constructed from sixteen semiannual editions of the DOU Top-50 ranking, covering January 2019 through July 2026. The resulting panel contains 800 firm-period observations. For each ranking, the dataset records company rank, total headcount in Ukraine and, where reported, the number of technical specialists. Company identities

were harmonized across rebrandings, acquisitions and successor structures in order to avoid artificial entry and exit caused purely by naming changes.

4.3. Business-model classification

Each analytical company identity is assigned to one of four business-model categories: Outsourcing, Product, Captive/R&D/Internal IT, or Hybrid. The classification hierarchy prioritizes the current DOU “Main business” label, followed by DOU product-company evidence, official corporate information and documented historical continuity. A dedicated source audit was performed for high-impact firms, and observations are marked as High or Medium confidence. The main business-model analysis is therefore accompanied by two robustness views: a high-confidence subset and a conservative binary interpretation in which only pure Product firms are treated as non-service. This treatment is designed to reduce the risk that the central diversification result is an artefact of ambiguous hybrid or captive classifications [11].

4.4. Employment dynamics and panel specification

For companies observed in two consecutive DOU snapshots, firm-level employment growth is measured as the logarithmic change in headcount shown in Equation (1).

$$g_{it} = \ln\left(\frac{HC_{it}}{HC_{i,t-1}}\right)$$

Here, HC_{it} denotes the headcount of company i in snapshot t , while $HC_{i,t-1}$ denotes its headcount in the immediately preceding semiannual snapshot. The logarithmic transformation makes growth rates comparable across firms of different sizes. The baseline panel model used to test H1 is specified in Equation (2).

$$g_{it} = \alpha + \beta P_{it} + \gamma h_{i,t-1} + \delta_t + \varepsilon_{it}$$

In Equation (2), P_{it} is an indicator equal to one for Product firms and zero for Outsourcing firms; $h_{i,t-1} \equiv \ln(HC_{i,t-1})$ is the logarithm of lagged firm size; δ_t represents common snapshot fixed effects; and ε_{it} is the idiosyncratic error term. Standard errors are clustered by analytical company identity. The coefficient β is interpreted as the conditional half-year employment-growth differential between Product and Outsourcing firms. Robustness checks include a post-2022 subsample, a high-confidence classification sample, firms observed in at least eight snapshots, 1% winsorisation of growth, exclusion of EPAM, SoftServe and GlobalLogic, and phase-specific estimates for the pre-war expansion, the 2022 shock, the 2023–2024 adaptation period and the 2025–2026 stabilization period.

4.5. Business-model concentration

The employment weight of each business-model category is calculated as the share of Top-50 headcount attributable to category k in period t , as formalised in Equation (3).

$$s_{kt}^{BM} = \frac{\sum_{i \in k} H_{C_{it}}}{\sum_{i=1}^{N_t} H_{C_{it}}}$$

In Equation (3), the numerator sums headcount HC_{it} across all firms i assigned to business-model category k , while the denominator is total Top-50 headcount in snapshot t ; N_t is the number of firms observed in that snapshot. Concentration across the four analytical business-model categories is then measured by the Herfindahl–Hirschman Index in Equation (4).

$$HHI_t^{BM} = \sum_{k=1}^4 (s_{kt}^{BM})^2$$

The analysis uses four categories: Outsourcing, Product, Captive/R&D/Internal IT, and Hybrid. A lower HHI indicates that employment is distributed more evenly across business models. To make the diversification result directly interpretable, the aggregate non-service share is also calculated according to Equation (5).

$$s_t^{NS} = 1 - s_{Service,t}^{BM}$$

Equation (5) defines the non-service share as one minus the Outsourcing share. For interpretation, this is identical to the combined Product, Captive/R&D/Internal IT and Hybrid shares. Together, Equations (3)–(5) directly operationalize H4 concerning declining dependence on the outsourcing-dominated model.

4.6. Vacancy-structure analysis

Labor-demand transformation is assessed using six DOU-based vacancy snapshots for March 2021, April 2022, June 2023, September 2024, June 2025 and July 2026. The categories include AI/ML, Data Science, Data Engineering, C++, Embedded, Hardware, DevOps, QA, Front-end, Back-end, PM/BA and Defense Tech. Back-end and PM/BA are author-constructed composite indicators and are therefore excluded from the formal Structural Change Index. Hardware and Defense Tech are treated as missing before DOU separated these categories; missing observations are not interpreted as zero demand. For each directly observed category c , its share in the selected vacancy universe is defined by Equation (6).

$$s_{ct}^V = \frac{V_{ct}}{\sum_{c=1}^C V_{ct}}$$

In Equation (6), V_{ct} is the number of vacancies in category c at snapshot t , and C denotes the set of directly comparable categories included in the calculation. From September 2024 onward, an emerging-technology basket is defined as AI/ML, Data Engineering (DE), Embedded (Emb), Hardware (HW) and Defense Tech (DefTech). Let E_t denote the sum of vacancies in these five emerging categories. Their combined share is calculated using Equation (7).

$$s_t^{Emerging} = \frac{E_t}{\sum_{c=1}^C V_{ct}}$$

The Structural Change Index compares the complete distribution of category shares with the September 2024 baseline. It is calculated using Equation (8) [12].

$$SCI_t = \frac{1}{2} \sum_{c=1}^C |s_{ct}^V - s_{c,sep2024}^V|$$

The SCI ranges from zero to one. A value of zero indicates an unchanged category distribution, whereas larger values indicate greater reallocation of vacancy demand. The coefficient one-half prevents double-counting of increases and decreases across category shares; consequently, the index can be interpreted as the proportion of the selected vacancy distribution that would have to be reallocated to reproduce the September 2024 structure.

4.7. Export scale and geographical structure

The external-market block separates export scale from destination concentration and uses the current NBU publication as the formal source for geographical structure. Export-scale dynamics are described using the complete monthly computer-services series supplied for 2019–H1 2026. The two series are treated as separate evidence vintages and are not silently merged because the NBU periodically revises historical external-sector statistics [37, 38].

For each destination country j , the share of Ukrainian computer-services exports received by that country in period t is calculated using Equation (9).

$$q_{jt} = \frac{X_{jt}}{\sum_{j=1}^J X_{jt}}$$

In Equation (9), X_{jt} denotes computer-services exports to partner country j , and J denotes the set of destination markets represented in the NBU geographical table. Overall destination concentration is then measured by the export Herfindahl–Hirschman Index in Equation (10).

$$\text{HHI}_t^X = \sum_{j=1}^J q_{jt}^2$$

A lower export HHI indicates a more geographically balanced destination structure. The United States share, the full-country HHI and the distribution among the largest partner countries are used jointly to distinguish declining single-market dominance from a simple increase in the number of small destinations. Because the NBU table includes an aggregated “Other countries” residual, the resulting HHI is interpreted as a close but slightly upward-biased approximation of the fully disaggregated country-level concentration measure.

4.8. Limitations

Several limitations constrain causal interpretation. First, the DOU Top-50 represents the largest companies rather than the full population of Ukrainian IT firms, creating selection and membership effects. Second, business-model categories are analytical constructs and historical classifications cannot always be observed directly for every period. Third, the vacancy dataset contains six snapshots rather than a continuous monthly time series, precluding formal breakpoint or high-frequency time-series inference. Fourth, country-level export data are rounded and include an aggregated “Other countries” residual,

which slightly affects concentration measures. Accordingly, the econometric estimates are interpreted as conditional associations, while the strongest claims of the study concern structural reallocation rather than causal treatment effects.

4.9. Robustness strategy and inferential boundaries

The empirical strategy explicitly separates robustness analysis from hypothesis confirmation. For H1, the sign and statistical significance of the Product coefficient are evaluated across alternative samples and treatments rather than relying on a single preferred regression. The main robustness specifications restrict the sample to source-audited High-confidence classifications, retain only firms observed in at least eight snapshots, winsorise the top and bottom 1% of firm-level growth observations, exclude the three largest service companies, and estimate separate post-2022 and phase-specific models. This approach addresses three potential sources of fragility: classification error, influential outliers and disproportionate weight of very large firms. A hypothesis is regarded as statistically confirmed only when the coefficient is substantively consistent and reaches conventional significance in the principal specification; marginal results are reported as suggestive evidence.

For H4, robustness is evaluated through alternative definitions of diversification. The broad specification uses all four analytical business-model categories. The source-audited specification restricts the calculation to High-confidence observations. A conservative binary specification treats only pure Product firms as non-service, effectively assigning Hybrid and Captive/R&D/Internal firms to the service-adjacent side of the comparison. If the direction of change remains the same under all three definitions, the diversification result is unlikely to be driven by ambiguous boundary cases. This is important because the article’s central structural claim concerns changing employment composition, not the precision of any single company’s label.

The study does not interpret pooled panel coefficients as causal treatment effects. Business-model choice is endogenous, Top-50 membership is selected, and unobserved factors such as client composition, geography, ownership and financing affect growth. Snapshot fixed effects absorb common time shocks but cannot eliminate firm-specific time-varying confounding. The regression is therefore used as a disciplined conditional comparison that tests whether the aggregate rise of Product firms is also visible as a systematic within-sample growth differential. The descriptive concentration and reallocation measures carry the main evidential weight for structural transformation.

Table 1

Long-run structural indicators of the DOU Top-50			
Indicator	Jan-2019	Jan-2022	Jul-2026
Total Top-50 headcount	58,448	99,501	79,252
Technical specialists	45,407	79,417	57,927
Technical share	77.7%	79.8%	73.1%
Outsourcing share	76.5%	75.0%	62.3%
Product share	16.9%	21.5%	30.6%
Non-service share	23.5%	25.0%	37.7%
Business-model HHI	0.617	0.609	0.485

Source: authors' calculations based on DOU Top-50 rankings

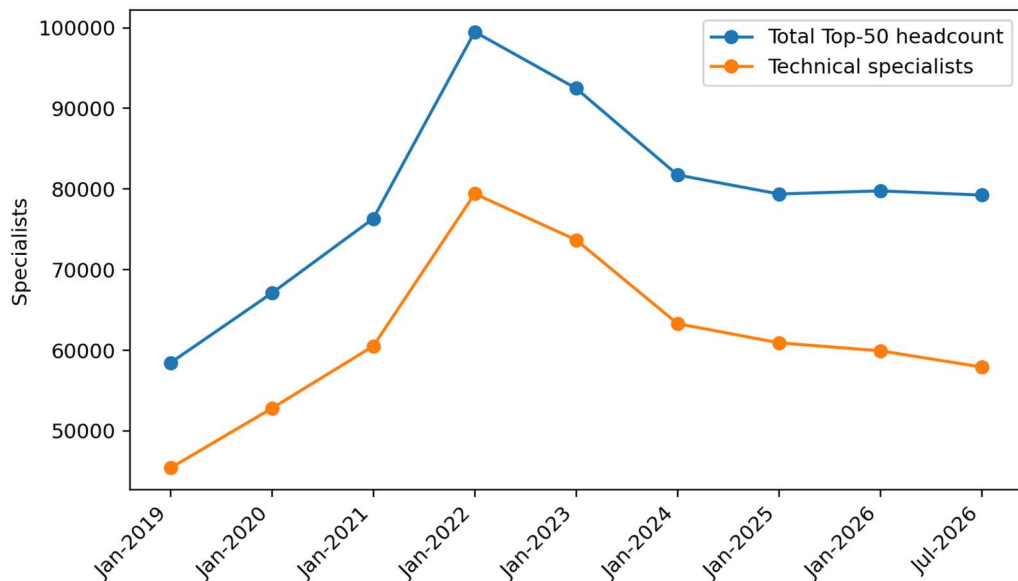


Figure 1. DOU Top-50 employment trajectory, 2019–2026

Source: authors' calculations based on DOU Top-50 rankings

Presentation of the main research material.

5.1. Long-run employment trajectory

The DOU Top-50 series reveals four distinct phases. Total employment increased from 58,448 specialists in January 2019 to 99,501 in January 2022, an expansion of 70.2%. The full-scale invasion interrupted this trajectory. By July 2026, Top-50 headcount had declined to 79,252, which is 20.4% below the January 2022 peak but still 35.6% above the January 2019 level. Technical employment followed a similar but more pronounced post-peak contraction: the number of technical specialists fell from 79,417 in January 2022 to 57,927 in July 2026, while their share in Top-50 employment decreased to 73.1%. The combined evidence therefore indicates that the industry did not simply return to its pre-war scale; rather, the post-2022 adjustment altered both the level and composition of employment, a pattern also visible in the Summer 2026 DOU snapshot [14].

5.2. Reallocation across business models

The business-model decomposition provides the clearest evidence of structural transformation. Under

the broad four-category coding, the Outsourcing share of Top-50 employment declined from 76.5% in January 2019 to 62.3% in July 2026. Over the same period, the Product share increased from 16.9% to 30.6%. The result is not driven solely by ambiguous classifications. Within the source-audited high-confidence subset, the Service share fell from 88.6% to 64.3%, whereas the Product share rose from 9.2% to 28.1%. The high-confidence business-model HHI declined from approximately 0.794 to 0.497, indicating a substantially more balanced distribution across business models. Moreover, the post-peak contraction was concentrated in the service segment: between January 2022 and July 2026, Outsourcing headcount declined much more strongly than total Top-50 employment, while the aggregate non-service segment increased. These patterns support H4 and indicate diversification rather than a uniform industry-wide contraction.

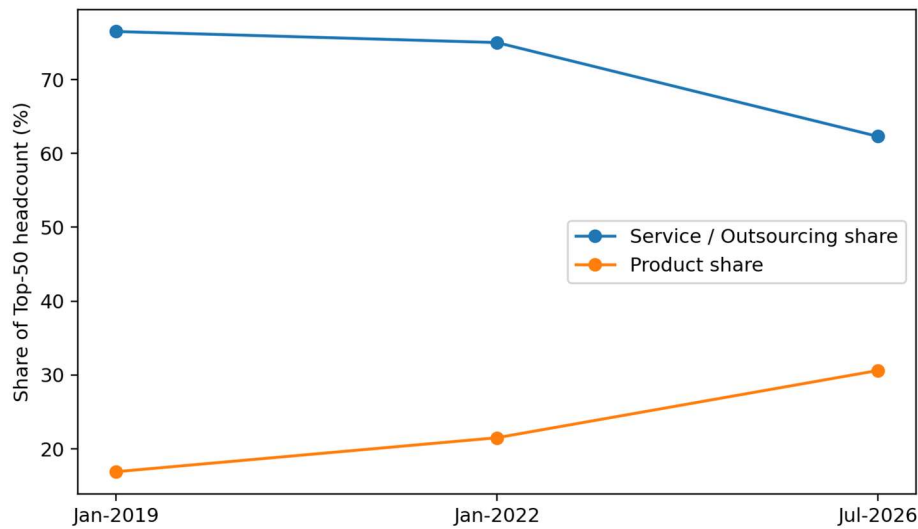


Figure 2. Service and Product shares of DOU Top-50 headcount

Source: authors' calculations based on business-model coding of DOU Top-50 firms

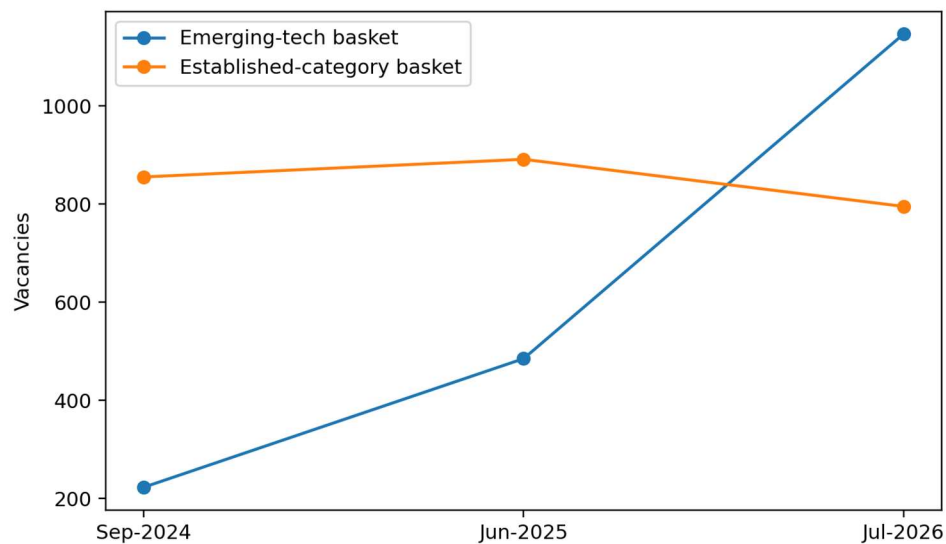


Figure 3. Emerging-technology and established vacancy baskets, 2024–2026

Source: authors' calculations from the six DOU-based vacancy snapshots

5.3. Firm-level test of the product-growth hypothesis

The firm-level regressions provide more cautious evidence. In the baseline Product-versus-Service specification, the product coefficient is 0.0219, corresponding to an approximate 2.2% higher conditional half-year growth rate, but the estimate is not statistically significant at the 5% level ($p = 0.110$). The coefficient remains positive in the high-confidence sample (approximately 3.3%, $p=0.106$), after 1% winsorisation (approximately 2.4%, $p=0.060$), and after excluding EPAM, SoftServe and GlobalLogic (approximately 2.2%, $p=0.112$). The 2025–2026 phase produces the largest phase-specific estimate, approximately 4.1%, with $p=0.054$. Thus, the evidence is directionally consistent with stronger recent growth among product firms, but H1 cannot be considered statistically confirmed. This non-result is important because it shows that structural diversification at the

aggregate level is stronger and more robust than a simple firm-level claim that product companies systematically grow faster.

5.4. Labor-demand shock and emerging-technology shift

The vacancy data show both a severe aggregate shock and a subsequent change in composition. Traditional categories such as Front-end, QA and Back-end fell sharply between 2021 and 2023 and recovered only partially. The recovery after 2023 was highly uneven. From September 2024 to July 2026, AI/ML vacancies increased from 37 to 192, Embedded from 48 to 174, Hardware from 52 to 298 and Defense Tech from 11 to 389, whereas Front-end declined from 270 to 126. Across the ten directly observed non-composite categories used for consistent comparison, the emerging-technology basket increased from 223 to 1,146 vacancies, while the established-category basket decreased from 855 to 795. Consequently, the

emerging share rose from approximately 20.7% to 59.0%, and the Structural Change Index reached approximately 0.405. These results support H2 and H3 as descriptive structural hypotheses: labor demand increasingly reflects AI, data engineering, embedded systems, hardware and defense-related capabilities rather than a simple restoration of the pre-war software-demand mix.

5.5. Export scale, resilience and destination rebalancing

The export evidence shows a different but complementary dimension of transformation. In the consolidated monthly series, computer-services exports increased from approximately USD 4.45 billion in 2019 to a peak of USD 7.35 billion in 2022. They then declined to approximately USD 6.73 billion in 2023 and USD 6.45 billion in 2024 before returning to growth in 2025, when the annual total reached approximately USD 6.66 billion. H1 2026 exports amounted to USD 3.343 billion, about 4.1% above H1 2025; contemporary industry analysis similarly reported renewed year-on-year export growth in early 2026. The current NBU destination series simultaneously indicates a decline in geographical concentration after the 2022 peak: the export-destination HHI fell materially by 2025, while the US share decreased. The consolidated Top-10 table further shows that the US share declined from 41.2% in 2021 to 36.9% in H1 2026, while Malta, Cyprus, Estonia and

the United Arab Emirates gained weight. However, the combined Top-10 share increased slightly, from 78.0% to 80.4%. The evidence therefore supports a more precise interpretation of H5 as partner-market rebalancing and reduced single-market dominance, rather than a simple dispersion of exports across an ever larger number of small destinations [13].

5.6. Integrated interpretation

Taken together, the results point to a multidimensional structural transformation. The largest Ukrainian IT firms remain below their pre-invasion employment peak, but the contraction is disproportionately concentrated in the traditional service model. Product and other non-service business models occupy a larger share of employment; labor demand has shifted rapidly toward AI, data engineering, embedded systems, hardware and Defense Tech; and export dependence on the single largest destination has moderated. At the same time, the firm-level regressions do not justify the stronger claim that product status alone statistically determines superior employment growth. The transformation is therefore best understood as sectoral reallocation and diversification under wartime constraints, rather than as a completed one-for-one transition from outsourcing to product companies.

Table 2

Robustness of the Product-versus-Service employment-growth coefficient

Specification	Coef.	Clustered SE	p-value	Approx. differential	N
Baseline	0.0219	0.0137	0.1101	2.2%	646
Post-2022	0.0241	0.0196	0.2193	2.4%	388
High-confidence only	0.0329	0.0204	0.1065	3.3%	367
≥8 snapshots	0.0155	0.0157	0.3245	1.6%	577
Winsorised 1%	0.0236	0.0125	0.0603	2.4%	646
2025–2026 phase	0.0401		0.0544	4.1%	125

Source: authors' calculations

Notes: dependent variable is half-year log headcount growth. Standard errors are clustered by analytical company identity. The 2025–2026 phase estimate is a phase-specific diagnostic

Table 3

Structural shift in selected DOU vacancy categories

Indicator	Sep-2024	Jun-2025	Jul-2026
Emerging-tech basket	223	485	1146
Established-category basket	855	891	795
Emerging share	20.7%	35.2%	59.0%
Emerging / established ratio	0.261	0.544	1.442
Structural Change Index	0.000	0.146	0.405
Defense Tech vacancies	11	60	389

Source: authors' calculations

Table 4

Computer-services export scale and destination concentration

Indicator	2019	2022	2025
Computer-services exports, USD mn	4,173	7,349	6,655
USA share	38.4%	40.5%	35.9%
Destination HHI	0.170	0.189	0.158
Annual phase	Pre-war baseline	War-year reference	Diversification

Source: authors' calculations

Notes: export scale and destination concentration are based on different evidence vintages where historical NBU series have been revised; they are therefore interpreted separately

5.6.1. Cross-domain consistency of structural indicators

The three independent empirical blocks point in the same direction despite measuring different economic objects. The business-model data shows declining concentration in Outsourcing employment; the vacancy data shows a sharp redistribution of demand toward AI, data engineering, embedded systems, hardware and Defense Tech; and the export data show reduced dominance of the single largest destination after 2022. This convergence strengthens the structural interpretation because no single data source is sufficient on its own. The Top-50 panel could reflect changing ranking membership, vacancy counts could reflect temporary recruitment campaigns, and export shares could move because of country-specific demand. Their simultaneous reorientation is harder to reconcile with a purely cyclical recovery narrative.

The timing also differs across dimensions, which is economically plausible. Employment restructuring is gradual because large organizations adjust headcount slowly. Vacancy composition changes faster because recruitment reflects marginal demand for new capabilities. Export-market shares adjust through client acquisition and the relative growth of destination markets. The structural transformation therefore appears as a sequence rather than a single break: a 2022 employment and demand shock, adaptation during 2023–2024, and a clearer diversification of business models and technology demand in 2025–2026.

5.7. Hypothesis synthesis

The combined evidence differentiates clearly between the five hypotheses. H4 receives the strongest support: business-model concentration declines and the service share falls materially under the broad coding, the source-audited high-confidence subset and the conservative pure-product interpretation. H2 and H3 are also supported descriptively because the labor-demand distribution changes sharply toward AI/data engineering and hardware-adjacent Defense Tech capabilities. H5 is supported as a rebalancing hypothesis: dependence on the dominant US destination decreases after the 2022 concentration peak, although the largest partner markets remain collectively important. H1 is the only hypothesis not confirmed at conventional significance levels. The positive product coefficient is robust in sign across most specifications, but its statistical precision is insufficient to establish a general product-firm growth premium.

This hierarchy of evidence matters for the interpretation of structural transformation. The observed change is therefore not reducible to one dominant mechanism. The Top-50 data show a redistribution of employment across business models; the vacancy data show a redistribution of technological capabilities; and the export data show a redistribution of partner-market exposure. These processes move in the same direction of greater diversification but operate at different levels of analysis. In particular, the absence of a conventionally significant H1 effect suggests that aggregate restructuring can arise through entry, exit, differential scaling and changes in the composition of

the largest firms even when within-firm growth differences between product and service companies are statistically modest.

Discussion.

6.1. Structural transformation rather than simple cyclical recovery

The central empirical finding is that Ukraine's IT sector has not returned to its pre-war configuration even where aggregate indicators show stabilization. Total Top-50 employment remains substantially above 2019 but below the January 2022 peak, while the internal distribution of employment has shifted away from the previously dominant service model. This distinction matters because a purely cyclical interpretation would predict recovery toward the earlier outsourcing-heavy structure once demand conditions improved. Instead, the data show a persistent increase in product and other non-service employment shares. The result is consistent with business-model theory, which treats major shocks and technological change as triggers for reconfiguration of value-creation architectures rather than only temporary changes in output. This finding gives quantitative longitudinal support to earlier Ukrainian studies that described the sector as increasingly adaptive, diversified and innovation-oriented under wartime pressure [43, 47].

The Ukrainian case also extends the software-upgrading literature. Studies of India described a movement from standard software services toward R&D services, embedded systems and more knowledge-intensive activities without implying that the service model disappeared. Ukraine shows a comparable but faster and more discontinuous process. The business-model evidence suggests diversification rather than a clean service-to-product substitution, while the labor-demand evidence points toward R&D-intensive capabilities such as AI, data engineering, embedded systems and hardware. The combination is consistent with an upgrading trajectory in which capabilities change before the industry's dominant revenue logic is fully replaced. It also complements the domestic argument that international competitiveness should be strengthened through investment, high-tech startups and functional upgrading rather than by treating outsourcing and product development as mutually exclusive policy alternatives [26, 33, 41].

6.2. Why H4 is stronger than H1

An important contribution of the study is the contrast between the robust aggregate evidence for H4 and the statistically inconclusive firm-level evidence for H1. Product firms occupy a much larger share of Top-50 employment by 2026, yet the regressions do not establish a conventional 5% significant product growth premium across the full period. This means that the structural transformation cannot be reduced to the statement that product firms simply grow faster than service firms in every period. Entry, exit, acquisitions, differential shock exposure and the expansion of a subset of very large firms all contribute to aggregate reallocation.

This result is theoretically plausible. Business-model diversification research emphasizes that performance effects depend on demand relatedness,

sequencing and external conditions. During the immediate 2022 shock, the estimated product differential is negative and highly imprecise; it becomes positive again during adaptation and is largest in 2025–2026. The pattern suggests that business-model advantages may be state-dependent rather than structural constants. For the scientific contribution, this is preferable to overclaiming: the robust result is the decline in service-model dominance, while a firm-level product growth premium remains a hypothesis for further research. Kutsyk et al. had identified a strategic movement from service-based toward product-oriented models as one adaptation mechanism, while the present regression results qualify that proposition: aggregate reallocation is visible, but a universal product-firm growth premium is not statistically established [29, 43, 44].

6.3. AI, embedded systems and Defense Tech as a capability cluster

The vacancy results indicate that the labor-market shift is not limited to AI. AI/ML grows rapidly, but the strongest post-2024 expansion also occurs in Hardware, Embedded and Defense Tech. This matters because these categories are technologically complementary. Modern autonomous and defense systems combine software, computer vision, edge AI, embedded computing, communications and physical platforms. International research on AI labor demand shows that technological diffusion creates demand for complementary skills and organizational capabilities rather than a single isolated occupation. Ukraine's vacancy structure provides a conflict-driven example of this complementarity. The pattern is consistent with Ukrainian AI-ecosystem evidence on the expansion of AI/ML capabilities and the increasing integration of AI into business processes, as well as with management research on AI-supported strategic decisions and business-model design [1, 2, 16, 20, 21, 22, 27, 42].

The Defense Tech evidence also links private-sector digital capabilities to a new industrial domain. Bondar describes the shift toward commercial-sector defense innovation, while KSE Institute et al. document the scale of the resulting market. The rapid increase in Hardware and Embedded vacancies on DOU is therefore economically meaningful: it indicates a partial convergence of the traditional software labor market with electronics, robotics and defense manufacturing. This is a form of structural transformation because it broadens the technological base of the sector beyond export-oriented software delivery. Kutsyk and Tulika similarly identify DefenseTech as one of the areas in which AI can create new exportable, dual-use capabilities, while Tulika situates DefenseTech within a broader process of digital-economic modernization [7, 49].

6.4. Export resilience and market rebalancing

The export results show that structural change is occurring alongside continued dependence on foreign demand. Computer-services exports reached a peak in 2022, contracted in 2023–2024 and returned to modest growth in 2025 and H1 2026. At the same time, the destination structure became less dominated by the United States after the 2022 concentration peak. This

supports H5, but the mechanism is better described as rebalancing among major partner markets than as simple dispersion toward a long tail of small destinations. The Top-10 share remains high, while Malta, Cyprus, Estonia and the UAE gain relative weight. This market-rebalancing result also develops the internationalization argument of Kutsyk et al. who emphasize both the opportunities and constraints facing Ukrainian IT products in foreign markets, and the market-diversification strategies described by Kutsyk and Tulika. The market-level interpretation is also consistent with Digital Tiger 2024, which explicitly evaluates Ukrainian IT opportunities across major export markets and highlights international market development as a strategic industry issue [18, 30, 37].

This nuance is important for competitiveness policy. Reduced dependence on one market can improve resilience, yet a high overall concentration among a limited number of destinations still leaves the sector sensitive to external demand cycles. The service-export literature has long noted that software exporters can achieve rapid foreign-exchange growth while retaining dependence on external markets and clients. Ukraine's post-2022 experience suggests that business-model diversification and geographical diversification should be treated as complementary, not interchangeable, dimensions of resilience [10].

6.5. Theoretical implications

The findings support a view of structural transformation as reconfiguration across several linked layers: business models, capabilities, labor demand and markets. This differs from classical structural-change studies that focus on employment shifts between agriculture, manufacturing and services. Within a knowledge-intensive service industry, structural change can occur inside the sector through altered value-capture models and technology bundles. The falling business-model HHI and rising emerging-technology vacancy share provide two different empirical manifestations of such intra-sectoral transformation.

The Ukrainian case further suggests that extreme shocks can accelerate diversification while simultaneously reducing aggregate scale. In conventional growth narratives, upgrading is often observed during expansion. Here, part of the upgrading occurs under contraction and wartime constraints. This is consistent with resilience research that distinguishes restoration from reconfiguration: firms and ecosystems may survive not by recreating their previous structures but by reallocating capabilities toward new uses. The combination of digital resilience and wartime demand therefore creates a distinctive pathway of shock-induced technological upgrading.

6.6. Practical implications and limitations

For firms, the evidence implies that maintaining competitiveness increasingly requires capabilities beyond conventional project-based software delivery, including product management, AI/data engineering, embedded systems, hardware integration and access to multiple export markets. For policymakers, the results support measures that strengthen R&D commercialization, product financing, defense-to-civil dual-use spillovers, engineering education and

international market diversification. The data also highlights a need to preserve the service-export base: outsourcing remains the largest employment model and continues to generate substantial export revenues, so policy should encourage upgrading rather than frame services and products as mutually exclusive alternatives.

The limitations constrain the strength of causal claims. The Top-50 panel is selected and membership changes over time; business-model coding is partly historical; vacancy data consist of six snapshots; and export concentration is affected by rounding and residual aggregation. These limitations are addressed through source audits, conservative classification variants and explicit separation of descriptive and econometric claims. Future research should extend the analysis to the broader firm population, obtain continuous vacancy time series and distinguish company revenue by business model rather than relying solely on employment classification.

6.7. Implications for Ukraine's international competitiveness

The results have direct implications for the international competitiveness of Ukraine's IT industry. Before 2022, competitiveness was closely associated with the ability to supply skilled software-engineering labor to foreign clients on a scale. That advantage remains important: Outsourcing is still the largest business-model category and computer-services exports continue to generate several billion dollars annually. However, the post-2022 evidence suggests that cost-quality outsourcing alone is unlikely to define the sector's next growth phase. Product ownership embedded and AI capabilities, defense-related engineering and access to a broader portfolio of foreign markets increasingly shape the industry's ability to capture value and manage external risk.

For firms, this implies a need to move up the value chain without abandoning the service base that created Ukraine's global market position. Service companies can upgrade through deeper domain expertise, R&D services, productized intellectual property, AI-enabled delivery and co-development arrangements. Product firms, in turn, require stronger commercialization, international distribution and financing capabilities. The emergence of Defense Tech creates an additional route to upgrading because it links software talent to electronics, robotics, autonomous systems and manufacturing. These activities may create dual-use knowledge that can later diffuse into civilian sectors, but such spillovers are not automatic and depend on intellectual-property regimes, export controls, financing and post-war demand.

For public policy, the evidence favors a portfolio approach. Measures that protect the export-oriented service sector should be combined with support for R&D commercialization, scale-up finance, engineering education, military-to-civilian technology transfer and market-entry support outside the dominant US destination. The objective is not to replace outsourcing with product firms, but to increase the share of activities in which Ukrainian companies control technology, intellectual property, customer

relationships and higher-value stages of the global value chain. In this sense, structural transformation should be evaluated by the breadth of capabilities and value-capture mechanisms available to the ecosystem rather than by the disappearance of any single business model. This policy mix is consistent with earlier work on state regulation of IT-services investment and high-tech ICT startups and with the argument that digital structural shifts should be coordinated with national competitiveness objectives [23, 24, 25, 26, 31, 34].

6.8. Global-value-chain upgrading and policy sequencing

The global-value-chain perspective clarifies why policy should not evaluate upgrading solely by the share of firms formally classified as Product. In software and engineering services, movement into architecture, domain consulting, managed platforms, R&D services and reusable intellectual property can represent functional upgrading even when revenue is still booked as services. Gereffi et al. and Humphrey and Schmitz emphasize that upgrading opportunities depend on supplier capabilities and value-chain governance. Ukraine already possesses a large base of engineering capabilities; the policy challenge is to increase the functions controlled by Ukrainian firms and the share of value captured locally. This may occur through product companies, but also through higher-value service models and technology partnerships [15, 17].

The sequence of policy interventions therefore matters. In the short run, preserving export continuity remains essential because service companies account for the majority of Top-50 employment and foreign-exchange earnings. Measures that reduce delivery risk, retain specialized talent and support access to international clients protect the capability base from which upgrading can occur. In the medium term, scale-up finance, stronger intellectual-property commercialization, corporate R&D incentives and international sales support can help firms capture more downstream value. For Defense Tech, procurement predictability and testing infrastructure are particularly important because wartime innovation has been accelerated by close feedback between users and private developers. The relevance of startup-specific resource constraints is reinforced by Kutsyk et al., whose econometric analysis of Ukrainian high-technology ICT startups highlights human, financial, material and innovation-technological resource provision as interdependent determinants of startup potential [7, 33].

A further issue is whether wartime Defense Tech capabilities can produce durable civilian spillovers. The KSE Institute et al. report shows that Ukraine has created a substantial market in UAVs, electronic warfare, ground robotics and AI/software. These technologies overlap with civilian applications in logistics, agriculture, industrial automation, geospatial analysis and autonomous systems. Dynamic-capability theory suggests that firms can redeploy knowledge across domains when complementary assets and market access exist. Post-war competitiveness will therefore depend partly on whether the institutions built

for rapid defense innovation can support certification, export compliance, private investment and civilian commercialization rather than becoming isolated wartime structures [19, 48].

Human-capital policy is another binding constraint on this transition. International vacancy research shows that AI adoption changes not only demand for specialist machine-learning skills but also the complementary mix of data, managerial and digital capabilities required by exposed occupations. Ukraine's own vacancy evidence adds embedded, electronics and defense-related engineering to this mix. Universities and professional-training systems therefore face a portfolio problem: maintaining the broad software-engineering base that supports services while expanding deeper pathways in mathematics, data engineering, control systems, electronics, robotics and product management. Because wartime migration and mobilization have reduced the domestic labor pool, the effectiveness of upgrading will depend on retention, return migration and the ability to attract diaspora specialists into Ukrainian firms and R&D projects. The OECD similarly identifies skills and digital-capability constraints as a barrier to broader business transformation. Human-capital policy should therefore be treated as a structural-competitiveness instrument rather than only a labor-market response [16, 39, 45].

The export evidence reinforces the need for sequencing. Reduced dependence on the United States lowers exposure to a single demand center, but the Top-10 destinations still account for most exports. Market diversification should therefore combine geographic expansion with business-model upgrading. A service firm that adds clients in several countries is more resilient geographically but may remain functionally dependent on buyer-controlled value chains; a product firm with global intellectual property may capture more value but remain exposed to one market. Competitiveness policy should treat functional upgrading and market diversification as two distinct dimensions of the same resilience strategy.

6.9. Digital sovereignty, import substitution and domestic product demand

The uploaded study on Russian software adds a complementary mechanism to the structural-transformation argument. Kutsyk and Tulika frame dependence on Russian software as a combined cybersecurity, economic and technological-sovereignty problem: vendor lock-in and security exposure create costs, while substitution creates a protected demand window for domestic products. This is analytically relevant to the present findings because a rising Product share and growing demand for AI, data, embedded and cybersecurity capabilities may be reinforced by domestic substitution as well as by export demand. In other words, wartime de-risking can operate as an industrial-policy shock that changes which technologies and firms receive demand [28].

At the same time, this mechanism should not be overstated. The current dataset does not identify procurement origin or measure migration away from specific software vendors, so import substitution cannot be treated as a tested hypothesis in this article.

Instead, it is incorporated as a theoretically and policy-relevant extension: domestic demand for secure Ukrainian alternatives can strengthen product capabilities, but long-run competitiveness still requires interoperability, international certification and access to foreign markets. This distinction prevents digital sovereignty from being equated with technological autarky.

6.10. Future research agenda

The analysis opens several avenues for further research. First, revenue-level data would allow the employment classification to be complemented by direct measures of value capture. Company headcount can show where labor is allocated but cannot identify the share of sales generated by proprietary products, R&D services or staff augmentation. A panel combining revenue composition, export destinations and employment would permit a stronger test of whether productization and functional upgrading improve productivity and resilience.

Second, a continuous monthly vacancy series would permit formal time-series analysis. With sufficiently long category histories, future work could estimate structural breaks around February 2022 and subsequent policy or technology milestones, test whether Defense Tech vacancies lead broader hardware demand, and distinguish trend changes from short-term recruitment campaigns. Skill-level data would also make it possible to measure complementarity between AI, embedded, electronics and software capabilities rather than relying on category-level vacancy counts.

Third, the Top-50 should be extended to a wider firm population. The largest companies are economically important but may adjust differently from startups and small product teams. A broader sample could test whether wartime structural change is driven by incumbent transformation or by entry of new firms, especially in Defense Tech. Finally, comparative research with other software-export economies could evaluate whether Ukraine's trajectory represents a general pathway from service exports toward diversified digital capabilities or a distinctive form of shock-induced upgrading created by wartime demand.

Conclusions and prospects for further research in this area. The article investigated whether the post-2022 evolution of Ukraine's IT industry is best understood as a cyclical contraction of an outsourcing-led sector or as a broader structural transformation. Using a sixteen-snapshot DOU Top-50 panel, business-model coding, vacancy data, and computer-services export statistics, the study finds stronger support for the structural interpretation. The largest firms remain below the January 2022 employment peak, but the composition of employment has changed materially.

The business-model analysis provides the strongest evidence of this transformation. The Outsourcing share falls from 76.5% in January 2019 to 62.3% in July 2026, while the Product share rises from 16.9% to 30.6%. This result remains visible in a source-audited high-confidence sample and under a conservative classification that counts only pure Product firms as non-service. H4 is therefore supported. By contrast, H1 is not statistically confirmed: Product firms exhibit a

positive conditional growth differential in most regression specifications, but the baseline and robustness estimates do not meet the conventional 5% significance threshold, although the 2025–2026 phase provides suggestive evidence of a stronger Product growth differential.

Labor demand provides a second dimension of structural transformation. The emerging-technology basket – AI/ML, Data Engineering, Embedded, Hardware, and Defense Tech – rises from 223 vacancies in September 2024 to 1,146 in July 2026, increasing its share of the selected direct categories from approximately 20.7% to 59.0%. The associated Structural Change Index reaches approximately 0.405. These findings support H2 and H3 descriptively and indicate that the IT labor market is increasingly oriented toward AI, data, embedded, and hardware-intensive capabilities. The rise of Defense Tech is particularly significant because it connects the software ecosystem with robotics, electronics, autonomous systems, and industrial production.

The external-market evidence points in the same direction. Computer-services exports contracted after their 2022 peak but returned to modest growth in 2025 and H1 2026. At the same time, dependence on the United States as the dominant destination declined, while several European and other partner markets gained weight. H5 is therefore supported as a hypothesis of partner-market rebalancing, although export concentration among the largest destination markets remains substantial.

Taken together, the results indicate that Ukraine's IT industry is not undergoing a completed transition from outsourcing to product development. Rather, it is undergoing a process of diversification and capability reallocation. Service exports remain the largest employment and revenue base, but the ecosystem increasingly combines Service/Outsourcing, Product, internal R&D, Hybrid models, AI-intensive activities, and Defense Tech. Accordingly, the evidence supports an interpretation of structural transformation as a multidimensional reconfiguration of business models, technological capabilities, labor demand, and external-market exposure rather than as a simple substitution of one business model by another.

For policy and business strategy, the priority should therefore be capability upgrading rather than substitution. This implies preserving the globally competitive service base while simultaneously expanding product ownership, R&D commercialization, AI and engineering capabilities, dual-use innovation, and access to a broader range of international markets. Such an approach would allow Ukraine to retain the advantages accumulated through its export-oriented service model while increasing domestic value capture and the technological complexity of the sector.

Future research should test these mechanisms using company-level revenue data, a continuous vacancy time series, and a broader population of firms beyond the DOU Top-50. Relative to the authors' preceding thematic studies of the IT sector, AI, digital sovereignty, and digital-economy formation, the

incremental contribution of the present article lies in its empirical integration: it tests previously identified transformation mechanisms within a single longitudinal, multi-source framework and explicitly distinguishes robust structural findings from statistically inconclusive firm-level relationships [27, 28, 29, 30, 32, 49].

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