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R. Zablotska,
Doctor of Economic Science, Professor, Professor of the Department of World Economy and International Economic Relations, Educational and Scientific Institute of International Relations of Taras Shevchenko National University of Kyiv
ORCID ID: https://orcid.org/0000-0001-7174-8946
H. Tamrazian,
PhD student, Educational and Scientific Institute of International Relations, Taras Shevchenko National University of Kyiv
ORCID ID: https://orcid.org/0009-0007-3505-6070

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NEW TECHNOLOGICAL INDUSTRIES AS AN ENVIRONMENT FOR THE FORMATION OF MODERN IMPERATIVES OF INTERNATIONAL TRADE SHADOWIZATION

Р. О. Заблоцька,
д. е. н., професор, професор кафедри світового господарства і міжнародних економічних відносин, Навчально-науковий інститут міжнародних відносин Київського національного університету імені Тараса Шевченка
Г. Г. Тамразян,
аспірант освітньо-наукової програми доктора філософії 292 "Міжнародні економічні відносини", Навчально-науковий інститут міжнародних відносин Київського національного університету імені Тараса Шевченка

НОВІ ТЕХНОЛОГІЧНІ ГАЛУЗІ ЯК СЕРЕДОВИЩЕ ФОРМУВАННЯ СУЧАСНИХ ІМПЕРАТИВІВ ТІНІЗАЦІЇ МІЖНАРОДНОЇ ТОРГІВЛІ

The aim of the work is to determine the structural characteristics of new technological industries as an institutional environment for the formation of modern imperatives of shadowing international trade and to substantiate the conceptual thesis about the digital-technological imperative of shadowing. The study proceeds from the fact that the structural transformation of the global economy, associated with the growing role of intangible assets, platform business models and high-tech sectors, changes the logic of the emergence of shadow practices in international trade. Shadowing is increasingly formed not on the periphery of the formal sector, but in its technological core, which requires a rethinking of its determinants and mechanisms. The work shows that in the global value chains of high-tech sectors, a specific configuration of structural conditions emerges, including high mobility of intangible assets, functional fragmentation of production, dominance of intra-firm transactions, regulatory asymmetries across jurisdictions, algorithmic pricing, cross-border data circulation, and geopolitical fragmentation of technological ecosystems. It is the combination of these characteristics that shapes the environment in which shadowing practices acquire a systemic character and become embedded in corporate business models. It is shown that the movement of value into the intangible sphere, and the growth of the role of intellectual property and digital platforms, complicate the application of traditional regulatory control instruments and create new channels for the hidden transfer of profits between jurisdictions.

It is substantiated that digitalization, platformization, and intensification of geo-economic competition form a digital-technological imperative of shadowing, in which shadow behavior is transformed from a reaction to institutional constraints into a structural property of global high-tech business. It is proven that modern forms of shadowing are determined not so much by institutional defects as by the industry characteristics of new technological sectors and the configuration of global production networks. It is concluded that the analysis of shadowing in international trade requires a transition from traditional factor models to a configurational approach that accounts for the interactions among structural, technological, institutional, and geopolitical conditions shaping hidden practices in the global economy.

Метою роботи є визначення структурних характеристик нових технологічних галузей як інституційного середовища формування сучасних імперативів тінізації міжнародної торгівлі та обґрунтування концептуальної тези про цифрово-технологічний імператив тінізації. Дослідження виходить із того, що структурна трансформація глобальної економіки, пов'язана зі зростанням ролі нематеріальних активів, платформних бізнес-моделей і високотехнологічних секторів, змінює логіку виникнення тіньових практик у міжнародній торгівлі. Тінізація дедалі частіше формується не на периферії формального сектору, а в його технологічному ядрі, що потребує переосмислення її детермінант і механізмів.

У роботі доведено, що у глобальних ланцюгах створення вартості високотехнологічних секторів формується специфічна конфігурація структурних умов, яка включає високу мобільність нематеріальних активів, функціональну фрагментацію виробництва, домінування внутрішньофірмових трансакцій, регуляторні асиметрії між юрисдикціями, алгоритмічне ціноутворення, транскордонний обіг даних і геополітичну фрагментацію технологічних екосистем. Саме поєднання цих характеристик формує середовище, у якому тінізаційні практики набувають системного характеру і стають вбудованими елементами корпоративних бізнес-моделей. Показано, що переміщення вартості у нематеріальну сферу, зростання ролі інтелектуальної власності та цифрових платформ ускладнюють застосування традиційних інструментів регуляторного контролю і створюють нові канали прихованого трансферу прибутків між юрисдикціями.

Обґрунтовано, що цифровізація, платформізація та загострення геоекономічної конкуренції формують цифрово-технологічний імператив тінізації, за якого тіньова поведінка трансформується з реакції на інституційні обмеження у структурну властивість глобального високотехнологічного бізнесу. Доведено, що сучасні форми тінізації визначаються не стільки інституційними дефектами, скільки галузевими характеристиками нових технологічних секторів і конфігурацією глобальних виробничих мереж. Зроблено висновок, що аналіз тінізації міжнародної торгівлі потребує переходу від традиційних факторних моделей до конфігураційного підходу, який враховує взаємодію структурних, технологічних, інституційних і геополітичних умов формування прихованих практик у глобальній економіці.

Key words: international trade shadowization, fragmentation, transnationalization, global value chains, intangible assets, digital economy, transfer pricing, platform economy, technological competition, regulatory arbitrage, artificial intelligence, transnational corporations.

Ключові слова: тінізація міжнародної торгівлі, фрагментація, транснаціоналізація, глобальні ланцюги створення вартості, нематеріальні активи, цифрова економіка, трансфертне ціноутворення, платформна економіка, технологічна конкуренція, регуляторний арбітраж, штучний інтелект, транснаціональні корпорації.

INTRODUCTION

The structural transformation of the global economy, associated with the growing role of intangible assets, digital platforms, and high-tech sectors in value creation, is changing not only the sectoral configuration of the world economy but also the logic of the emergence of shadow economic practices in international trade. Shadowization is increasingly formed not on the periphery of the formal sector, but in its technological core — in the semiconductor industry, pharmaceuticals,

digital services, and the artificial intelligence sector. This requires rethinking not the general mechanisms of shadowization, but the specific conditions that transform high-tech industries into an environment with a qualitatively different configuration of incentives for shadow behaviour. The factor tradition of shadow economy analysis [1—5] convincingly explains the classical forms of shadowization [6—8] through excessive regulatory burden, the quality of institutions, and tax morality. The practical-regulatory direction fixes the scale of hidden value transfer and offers mechanisms to counteract the erosion of the tax base. However, these approaches do not sufficiently take into account the specifics of technological sectors, where shadowing is caused not so much by institutional defects as by the structural characteristics of the industries themselves — the dematerialization of production, the mobility of intangible assets, algorithmic pricing, and the geopolitical fragmentation of technological ecosystems [9—14].

The scale of the structural dematerialization of production is confirmed by empirical data. According to Ocean Tomo, the share of intangible assets in the market capitalization of S&P 500 companies increased from 17% in 1975 to 90% in 2020 [15]. According to WIPO, cross-border payments for the use of intellectual property exceeded 1 trillion US dollars in 2022—2023, doubling compared to 2010 [16]. Global investment in intangible assets reached 6.9 trillion US dollars in 2023, and since 2008, their growth rate has been three times that of investment in tangible assets [17]. These indicators reflect the scale of dematerialization, which creates an institutional space for new forms of shadowing: the higher the level of value concentration in intangible assets, the greater the space for hidden profit shifting between jurisdictions [18-21]. J. Garcia-Bernardo and P. Jansky [22] showed on a global sample that the technology and pharmaceutical sectors are the main generators of profit shifting, and the volumes of shifted profits grow in proportion to the share of intangible assets in the capital structure. The OECD series of reports "Tax Challenges Arising from Digitalisation" [23] recognizes the need to revise the rules governing the distribution of tax rights between jurisdictions when digital companies generate significant value without a physical presence in those jurisdictions. However, the question of how industry characteristics of new technological sectors shape the specific conditions for shadowing remains insufficiently explored. The identification of these characteristics is the subject of this study.

THE LITERATURE REVIEW

The research context of this work is formed by three groups of sources. The first is research on structural dematerialization: J. Haskell and S. Westlake [21] argue that intangible assets are characterized by scalability, spillover effects, sunk costs, and synergies, with direct implications for shadowing analysis. The second group is formed by research on the scale of hidden value transfer: empirical estimates of profit shifting [22], OECD reports on the tax challenges of digitalization [23], and Global Financial Integrity data [14] on discrepancies in trade statistics of developing countries. The third group is research on geopolitical transformations of technological chains: K. Lee et al. [24] analyse chokepoint strategies and their impact on the configuration of production networks, and the UNCTAD report [25] documents the growth of cross-border data flows and asymmetries in their regulation.

A separate subgroup is formed by studies of institutional mechanisms through which globalization transforms incentives for shadow behaviour. These works identify two interconnected channels: first, regulatory arbitrage and tax engineering as corporate strategies for exploiting inter-jurisdictional differences [2; 3]; second, fiscal competition between jurisdictions, which institutionally entrenches asymmetries and increases the returns from moving operations to preferential environments [9]. For this study, these results are important because they capture the transition of shadowing from individual violations to systemic corporate practices embedded in the architecture of transnational business. At the same time, the digital transformation of the institutional environment of international trade — from changing competitive strategies in the context of platformization [10] to the emergence of new channels of value creation through e-commerce [11; 12] and the formation of the digital media market as an independent segment of the global economy [13] — has been studied mainly in the context of the legal sector. The question of how these digital transformations change the configuration of shadowing conditions in high-tech industries remains open.

THE PURPOSE OF THE ARTICLE

The purpose of the article is to determine the structural characteristics of new technological industries as an institutional environment for the formation of modern imperatives of shadowing international trade and to substantiate the conceptual thesis about the digital-technological imperative of shadowing.

RESEARCH RESULTS

A key prerequisite for the shift in shadowing practices is the structural dematerialization of production. J. Haskell and S. Westlake [21] characterize this process as the emergence of "capitalism without capital", in which intangible investments acquire four specific properties: scalability, irreparability, spillover effects and synergy. Scalability means that an intangible asset can be used simultaneously in several jurisdictions without additional reproduction costs, creating opportunities to place property rights in the jurisdiction with the most favourable tax regime. Spillover effects complicate the definition of the boundaries of the value created by a specific division of the corporation. Synergy enhances these effects, as the value of intangible assets depends on their combination with other assets, thereby complicating market assessment of intra-firm transactions.

Practical manifestations of these mechanisms are illustrated by cases of technology corporations. Apple, through Irish subsidiaries (the Double Irish scheme),

accumulated a significant part of its profits by placing intellectual property rights in a jurisdiction with an effective tax rate of less than 1%. Alphabet (Google), through a Bermuda structure, channelled technology licensing revenues from the Netherlands to Bermuda. Both schemes were based on the properties of intangible assets: scalability, mobility of IP rights, and the complexity of valuing unique technological solutions.

In such an environment, shadowing takes on new forms, related not to the physical movement of goods outside customs control, but to the institutional architecture of corporate structures. The shift of value to the intangible sphere complicates the application of traditional control tools, since the object of trade is increasingly licenses, software solutions, and digital services that do not cross physical borders in tangible form. High-tech industries are characterized by a multi-level division of production operations between jurisdictions with different regulatory regimes. The most illustrative example is the semiconductor industry, where, according to K. Lee et al. [24], the production process is divided between design (mainly the USA), chip manufacturing (Taiwan, South Korea), equipment supply (Netherlands, Japan), and assembly (China, Southeast Asian countries). A similar fragmentation is observed in pharmaceuticals, digital services, and the artificial intelligence sector.

Such fragmentation creates a situation in which a significant portion of transactions occurs within transnational corporations and does not reflect market prices. J. Garcia-Bernardo and P. Janski [22] empirically confirm that profit shifting is most pronounced in sectors with a high share of intangible assets and deep functional fragmentation. According to WIPO statistics, disproportionately high volumes of patent applications are concentrated in jurisdictions that are also key points in corporate tax planning schemes (Ireland, the Netherlands, Singapore, Luxembourg), indicating a systemic connection between the placement of intangible assets and profit-shifting strategies. The dominance of intangible assets in companies' capital structures creates opportunities for erosion of the tax base, which becomes a structural element of corporate competitive strategies [9; 19]. In this context, regulatory arbitrage [2] becomes systemic and shifts from a cost-optimization tool to a mechanism of structural shadowing. As demonstrated in studies of tax engineering in offshore financial centres [3], the line between legal optimization and shadowing in such conditions becomes increasingly blurred.

The digitalization of production and trade is creating a new type of institutional environment, characterized by high speed of cross-border transactions, algorithmic pricing, and anonymity of a significant part of market participants. The UNCTAD report [25] records that the volume of cross-border data flows in 2017 was 20 times higher than in 2007, and the regulation of these flows remains fragmented: the USA focuses on data control by the private sector, China — on state control, the EU — on the protection of individual rights. This regulatory fragmentation creates additional space for hidden value transfers between jurisdictions. The development of digital trade [11] and the spread of financial technologies [12] are fundamentally changing the channels of value transfer in international trade. In digital ecosystems, platforms act as intermediaries between producers and consumers, serving as infrastructure for financial settlements and data exchange. As shown in studies of the digital media market [13], such a concentration of functions complicates regulatory control. A series of OECD reports [23] acknowledge that the current tax architecture, based on the principle of physical presence, is not adapted to the realities of the digital economy. A case in point is Amazon. The corporation sells in dozens of countries, but a significant portion of its profits is concentrated in the jurisdictions where key intangible assets are registered, such as its technology platform, logistics algorithms, and AWS cloud infrastructure. In 2017, the European Commission ordered Amazon to repay Luxembourg € 250 million in tax breaks that it deemed illegal state aid, a decision later overturned by the General Court of the EU, highlighting the complexity of legal control over platform value-transfer models.

A similar logic is demonstrated by Meta (Facebook), which generates revenue from advertising targeted to users in specific jurisdictions, but accounts for this revenue through its Irish headquarters. These examples illustrate that the platform business model enables the transfer of value not through physical commodity flows but through the registration of rights to algorithms, data, and digital infrastructure. The development of artificial intelligence and digital data processing infrastructure is particularly important. Data processing centres, cloud services, and algorithmic systems create new channels for the transfer of value that are not subject to traditional customs control. Data becomes an independent economic resource, and its cross-border circulation is often not regulated by a unified set of international norms. The intensification of geopolitical competition is becoming an independent structural factor that significantly expands the configuration of shadowing conditions. K. Lee et al. [24] demonstrate that the US "chokepoint" strategies in the semiconductor sector have become systemic after 2022. The key elements are: restricting China's access to advanced EUV lithography systems from ASML, banning the supply of advanced equipment from Tokyo Electron and Applied Materials, and restricting the participation of American specialists in the development of the Chinese semiconductor industry. In response, China has introduced restrictions on the export of critical materials — gallium, germanium, and antimony.

This mutual escalation of restrictions directly stimulates the formation of circumvention supply schemes. After the introduction of export restrictions in 2022—2023, a significant increase in semiconductor equipment supply via transit jurisdictions, particularly Malaysia, Vietnam, and Central Asian countries, was observed. Companies use these jurisdictions to change the origin of products, create intermediate corporate structures to access restricted technologies, and develop hidden channels for the transfer of dual-use technologies. Similar processes are observed in the artificial intelligence sector, where restrictions on the supply of high-

performance GPUs (in particular, NVIDIA A100 and H100) stimulated the formation of "gray" supply channels through intermediaries. Geopolitical competition expands the traditional understanding of shadowing, adding geopolitical motives (circumventing restrictions, ensuring technological sovereignty) to economic motives (tax minimization, profit shifting).

Analysis of high-tech sectors shows that shadowing practices are formed with distinct industry-specific characteristics, due to the nature of intangible assets, the degree of fragmentation of production chains and the features of the regulatory environment. In the semiconductor industry, patents on chip architecture, licenses for electronic design automation tools and technological processes play a key role. The industry is characterized by very high functional fragmentation between design, equipment production, chip manufacturing and assembly centres, which creates opportunities for manipulation of license fees, the use of transit jurisdictions and hidden technology transfer. The sector has a critically high geopolitical sensitivity due to the use of chokepoint strategies and export control regimes, while detecting shadowing schemes requires analysing license agreements and product technical parameters.

The pharmaceutical sector is based on patents on drug molecules and formulas, clinical trial data, and other intellectual property. Global fragmentation of value chains combines research and development in developed economies with substance production and clinical trials in developing countries. Typical mechanisms of shadowing include the placement of patent rights in tax-advantaged jurisdictions and the manipulation of license and contract research costs. Identifying such practices requires specialized expertise in the valuation of intellectual property and clinical data, while regulatory gaps arise between the jurisdictions of research and patent registration.

The digital services and platforms sector is dominated by algorithms, software, and user data sets. Functional fragmentation manifests in the spatial distribution of development, server infrastructure, and the commercialization of digital products. Shadowing practices are associated with the registration of intellectual property in low-tax jurisdictions, algorithmic pricing of advertising services, and monetization of data outside the jurisdiction of its creation. The geopolitical sensitivity of the sector is growing due to the fragmentation of data regulatory regimes and the formation of a policy of "digital sovereignty". The difficulty in detecting such practices stems from the absence of material flows and the dominance of algorithmic mechanisms for value creation.

In the field of artificial intelligence, the main intangible assets are AI models, training data sets, and computing infrastructure. The industry is characterized by high fragmentation between model development centres, computing clusters, and commercialization platforms. Shadowing practices are manifested in the placement of AI model rights in favourable jurisdictions, the complexity of assessing the value of training datasets, and the use of informal supply channels for high-performance graphics processors. Identifying such schemes is complicated by the lack of market analogues for valuing AI assets, while a key regulatory gap is emerging between the speed of technological development and the pace of regulatory framework formation.

Summarizing the analysis, it is appropriate to formulate a conceptual thesis about the digital-technological imperative of shadowing. The configurational approach assumes that outcomes are determined not by individual factors, but by specific combinations of conditions. Applying this logic to the analysis of shadowing in technology sectors allows us to identify an expanded configuration of structural conditions. To the general conditions inherent in global value chains as such (functional fragmentation of production, intra-firm nature of trade, regulatory asymmetries between jurisdictions, multi-level corporate structures), conditions specific to technology industries are added: high mobility of intangible assets, algorithmic pricing, cross-border data circulation as an independent economic resource, and geopolitical fragmentation of technological ecosystems. It is this expanded configuration that shapes the environment in which shadow behaviour ceases to be a reaction to institutional constraints and becomes embedded in companies' business models. The use of regulatory differences across countries, the optimization of corporate ownership structures, and the identification of hidden value transfers are becoming tools for ensuring global competitiveness.

CONCLUSIONS

The aim of the article, which was to determine the structural characteristics of new technological industries as an institutional environment for the formation of modern imperatives of shadowing international trade and to substantiate the conceptual thesis about the digital-technological imperative of shadowing, was achieved by systematizing the sectoral features of high-tech business and their connection with the mechanisms of hidden value transfer in global networks. New technological industries appear as an environment in which shadowing shifts from the periphery of the formal sector to its technological core, acquiring the features of structural embeddedness in corporate models of creating and distributing added value.

It is determined that the basic prerequisite for such a transformation is the structural dematerialization of production and the concentration of value in intangible assets. Scalability, mobility of intellectual property rights, synergy of intangible resources, and the complexity of their market valuation reduce the transparency of comparative analysis of intra-firm transactions and expand the space for regulatory maneuvering between jurisdictions. As a result, shadowing practices are not accidental but systemic, as they become functionally linked to the architecture of global value chains in high-tech sectors.

It has been established that the functional fragmentation of production, the dominance of intra-firm transactions, and regulatory asymmetries between jurisdictions form the configuration of conditions under which the hidden movement of profits and the distortion of the parameters of trade and financial flows become an element of competitive strategy. High-tech industries demonstrate the sectoral specificity of such practices, but they are united by a common logic: shadowing is determined not so much by the institutional defects of individual states as by the sectoral properties of value creation in the digital

economy, including algorithmic pricing, cross-border data circulation and the advantage of intangible products that do not require the physical crossing of borders in material form.

It is argued that digitalization and platformization not only complicate the application of traditional regulatory control tools but also change the nature of shadowing, shifting it to the plane of institutional construction of market presence and allocation of rights to intangible assets. In such an environment, the boundary between legal optimization and shadowing becomes less defined due to the complexity of attribution of the place of value creation and the dependence of financial results on data access regimes, infrastructures, and technological ecosystems.

It is proven that the intensification of geo-economic competition and the fragmentation of technological ecosystems expand the configuration of shadowing conditions, adding to economic incentives, geopolitical motives related to bypassing supply channels, export control regimes, and access to critical technologies. This strengthens the structural nature of shadowing in technological sectors, as shadow practices begin to serve as a means of adaptation to external constraints, embedded in the logic of ensuring technological capability and competitive sustainability.

A conceptual thesis about the digital-technological imperative of shadowing is formulated and confirmed, according to which shadow behaviour in high-tech industries is transformed from a reaction to individual institutional constraints into a structural property of global high-tech business. This conclusion necessitates a transition from traditional factor models of shadowing to a configurational approach that accounts for the interactions among structural, technological, institutional, and geopolitical conditions in shaping hidden practices in international trade.

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