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A TYPOLOGY OF CONTEMPORARY MODELS FOR DUAL-USE TECHNOLOGY TRANSFER

ТИПОЛОГІЯ СУЧАСНИХ МОДЕЛЕЙ ПЕРЕДАЧІ ТЕХНОЛОГІЙ ПОДВІЙНОГО ПРИЗНАЧЕННЯ

This paper provides an integrative analysis of key mechanisms for dual-use technology transfer, developing a contemporary typology based on real-world examples. It examines the comparative advantages and risks of direct commercial sales, licensing agreements, foreign direct investment, and international R&D partnerships. The study highlights how each mechanism enables broader dissemination of technology but also poses potential perils such as intellectual property compromise, arms proliferation, and unauthorized knowledge transfer. Dual-use technologies range across sectors like information technology, biotechnology, aerospace, and nanotechnology, with nuclear technology being a prime example. The transfer landscape involves diverse actors from governments to corporations to research institutions. Given national security implications, robust governance frameworks are needed to ensure responsible cross-border transfer.

Key words: *dual-use technology, technology transfer, export controls, trade policy, national security.*

У статті подано аналіз ключових механізмів передачі технологій подвійного призначення (ТПП), а також розроблено типологію сучасних моделей трансферу. Детально проаналізовано такі механізми як прямі комерційні продажі технологій компаніями-розробниками за кордон, ліцензування технологій іноземним компаніям, прямі іноземні інвестиції у створення за кордоном виробничих потужностей, а також міжнародні науково-технічні партнерства. Показано, що кожен механізм сприяє поширенню технологій, але також несе потенційні загрози. Зокрема це ризики порушення прав інтелектуальної власності при недостатньому захисті, ризики неконтрольованого поширення озброєнь через продаж технологій країнам з низьким рівнем експортного контролю, а також ризики несанкціонованої передачі чутливих технологічних знань через промислове шпигунство або кіберзлочинність. Проаналізовано роль різних суб'єктів, залучених до передачі технологій подвійного використання, включаючи уряди, приватні корпорації та науково-дослідні установи. З огляду на національну безпеку, запропоновано відповідні механізми контролю та моніторингу для забезпечення відповідального транскордонного трансферу таких технологій. Розглянуто приклади прямих комерційних продажів деяких ТПП, зокрема літаків Boeing P-8 компанією США до Індії та турбін Siemens до Ірану. Продемонстровано потенційні переваги та загрози цих угод. Проаналізовано ліцензійні угоди Honeywell, Rolls-Royce та GE щодо ТПП, що дозволило висвітлити економічні можливості та ризики для національної безпеки. Проаналізовано приклади прямих іноземних інвестицій у ТПП, зокрема Qualcomm в Ізраїлі, Huawei у Швеції та Samsung у США. Досліджено механізми регулювання іноземних інвестицій. Висвітлено особливості міжнародних науково-дослідних партнерств ЄС, США-Японія та США-Південна Корея як моделі передачі ТПП. Доведено, що передача ТПП використання є складним, багатогранним процесом, який вимагає глибокого розуміння різних механізмів передачі, їхніх потенційних переваг і пов'язаних з ними ризиків. Ефективне управління цими аспектами має вирішальне значення для забезпечення максимальної вигоди від передачі технологій, одночасно потенційні ризики зменшуються.

Ключові слова: *технології подвійного призначення, трансфер технологій, експортний контроль, торгова політика, національна безпека.*

Formulation of the problem. In an increasingly interconnected world where technological innovation drives both civilian life and national defence, the concept of "dual-use technology" has emerged as a critical topic in the intersection of global security, trade policy, and economic growth. Dual-use technologies, which can be deployed for both benign and military applications, present a delicate balance between promoting technological diffusion for economic growth and ensuring national security by preventing the misuse of these advancements. Given the significance of dual-use technologies, it is pivotal to understand the mechanisms for their transfer, their implications, and the principles governing these processes.

Analysis of recent research and publications. There has been significant research exploring the various mechanisms through which dual-use technologies can be transferred. One of the early and influential works is Molas-Gallart's typological framework that categorized mechanisms into four main types – straight transactions, collaborative arrangements, mixed embedded modes, and technology acquisition [12]. This classification schematic formed a basis for subsequent studies to build upon.

Autio advanced the field with a comprehensive classification of technology transfer mechanisms, distinguishing between the phase of transfer (e.g. sourcing, transactions), interface type (e.g. licensing, collaborative R&D), and component dependence (e.g. equipment, knowledge) [2]. Their quantitative indicators provided a means to measure different mechanisms' prevalence and impact. Around the same time, Carpenter highlighted challenges in fully capturing dual-use transfer's economic effects due to the various forms it can take and the limitations of available data [3].

More recently, sector-specific case studies have offered additional nuanced perspectives. For instance, Mendoza analyzed strategies employed by unmanned aerial vehicle firms to navigate cross-border transfer barriers [10]. Their findings demonstrated heterogeneity even within an industry and the need for adaptive, context-sensitive approaches.

Scholars also extensively debate policy and governance challenges surrounding dual-use technologies. Kanetake dissected normative tensions inherent in export control laws requiring value judgments on priorities [8]. Meanwhile, Alavi spotlighted dilemmas European Union regulators face in simultaneously safeguarding security while bolstering economies [1].

Historical works shed light on inter-country dynamics as well. Mularkey provided an in-depth examination of technology sourcing between U.S. and Japanese corporations in the late 20th century [13]. More recently, Wolf (2012) issued a damning appraisal of ineffectiveness plaguing American export controls and presented reforms needed to fix longstanding shortcomings [22].

Collectively, this body of literature underlines dual-use transfer as an intricate phenomenon demanding a nuanced understanding of myriad context-dependent mechanisms and careful balancing of stakeholders' competing needs. Overall, the field would benefit from further developing a holistic yet granularly differentiated analytical framework.

Formulation of the purpose of the article. This paper establishes a typology of contemporary key mechanisms for dual-use technology transfer, highlighting their comparative advantages and risks. It provides an integrative analysis of these mechanisms' dynamics and implications, aiming to propose guiding principles for responsible cross-border transfer that balances economic development and international security imperatives.

Presentation of the main material. The term "dual-use technology" denotes the kind of technology that, while developed for legitimate civilian or commercial purposes, can also be adopted and utilized for military objectives or which may contribute to the proliferation of weaponry, including weapons of mass destruction [12]. These technologies range across a wide spectrum of sectors, including information technology, telecommunications, robotics, artificial intelligence, aerospace, and nanotechnology. An apparent manifestation of this dual nature is nuclear technology, which while principally intended for generating power, can be repurposed for creating weapons.

The transfer of dual-use technologies is a multifaceted process that involves numerous actors and factors, including governments, multinational corporations, international research collaborations, and even individual actors, known as 'insider threats [9]. Given the extensive range of potential participants and the diversity of dual-use technologies themselves, the mechanisms for technology transfer also vary widely, each possessing distinct advantages, disadvantages, and implications.

In the present era of globalization, the mechanisms for the transfer of dual-use technologies have evolved beyond traditional state-controlled channels. The surge of multinational corporations, the proliferation of digital technologies, and the trend towards the globalization of supply chains have all contributed to reshaping the landscape of technology transfer. This transformation necessitates a thorough understanding of the contemporary typology of mechanisms for dual-use technology transfer, as they will shape both the prospects of economic development and the dynamics of international security.

Despite their potential for economic growth, dual-use technologies also entail risks, including threats to national security, potential destabilization of regional balances of power, and challenges in compliance with international non-proliferation agreements. Hence, a nuanced understanding of the benefits and drawbacks of these technology transfer mechanisms is critical for informed policy-making.

The below table summarises the advantages and disadvantages associated with the four primary mechanisms of transferring dual-use technologies.

Table 1

Advantages and disadvantages of dual-use technologies' transfer mechanisms

Mechanism	Advantages	Disadvantages
Direct Commercial Sales	Immediate revenue generation, strengthening of international relations, broad technology dissemination	Potential security risks, technology diversion, stringent regulatory controls
Licensing	Increased profit, broader technology dissemination, access to licensee's production facilities and networks	Risk of intellectual property theft, technology misuse, potential reverse engineering
Foreign Direct Investment (FDI)	Boosts local economy, improves diplomatic relations, provides direct market access	Political and economic challenges, potential misuse of technology, and foreign control concerns
International R&D Collaboration	Enhances technological advancements, promotes global cooperation, shares costs and risks of R&D	Requires significant trust, potential compromise of proprietary technology, potential misappropriation of shared information

Source: built by author

Direct commercial sales constitute the primary and straightforward mechanism for the transfer of dual-use technologies. This method involves companies that develop dual-use technologies selling their products directly to clients in other countries. These sales transactions can occur both between allies and potential adversaries, thus requiring a careful evaluation of national security implications. The concept of direct commercial sales is rooted in the global trade system's foundational principles: the open exchange of goods and services across international borders to promote economic development and prosperity.

With the advent of sophisticated technologies that have both civilian and military applications, direct commercial sales have become an increasingly critical channel for technology transfer. In the context of dual-use technologies, direct commercial sales involve the exchange of fully formed products, parts, software, or technical data. Companies that specialize in producing such technologies often engage in these sales to expand their market reach, drive revenue, and promote their brand on a global scale.

For example, in 2014, the United States company Boeing sold 22 P-8 Poseidon maritime patrol aircraft to India for a total of $3.2 billion. The P-8 is a dual-use technology, as it can be used for both civilian and military purposes. Boeing's sale of the P-8 to India was seen as a major economic boon for the company and its suppliers, creating jobs and generating billions of dollars in revenue. It also strengthened diplomatic ties between the United States and India and helped India to modernize its military capabilities. However, some critics argued that the P-8 sale could catalyze an arms race in the region and destabilize regional power balances. There were also concerns about the technology falling into malicious hands and being used for human rights abuses or terrorism [7].

Similarly, in 2017, the German company Siemens sold a gas turbine power plant to Iran for €10 billion. While economically beneficial for Siemens, some argued it violated international sanctions against Iran's nuclear program and could aid the development of weapons of mass destruction. This underscores the need to weigh economic incentives against potential security risks [6].

Direct commercial sales can have several advantages, including revenue generation, strengthened international relations, and technology dissemination. However, they also present risks like arms race, power imbalance, sanctions violations, and misuse by malicious actors. To mitigate these risks, direct sales often require export licenses, with approval dependent on technology, end-user, and usage factors. So, balancing growth and security remains an intricate challenge in direct sales of dual-use technology.

Licensing has emerged as a widely utilized mechanism for the transfer of dual-use technologies on the global stage. Licensing agreements grant permission for one entity to access, utilize, produce or distribute another entity’s proprietary technology within delimited boundaries, enabling the broader dissemination of specialized knowledge, techniques, and products with both civilian and military applications. While licensing presents notable advantages, this form of technology transfer also carries potential risks and challenges that call for judicious governance.

Licensing contracts are undertaken between commercial firms, academic institutions, government agencies and other actors across and within national borders. The licensor possesses ownership rights over intellectual property, while the licensee receives sanctioned access to this proprietary technology or knowledge, typically in exchange for royalty payments based on usage or production volume. From the perspective of firms that develop dual-use technologies, licensing enables tapping into overseas markets and generating new revenue streams without the overhead of establishing foreign production facilities. For licensees, absorbing new technologies via licensing can catalyze the development of domestic industries and associated economic benefits.

However, licensing agreements involving dual-use technologies frequently engender controversy given the prospect of proliferation and unauthorized usage of sensitive intellectual property. For instance, in 2019, the U.S. firm Honeywell authorized the Chinese company Avicopter to employ its helicopter engine designs in manufacturing processes. While financially advantageous for both corporations, policymakers voiced concerns about the Chinese defence industry gleaning valuable technical insights from this deal that could confer military advantages [20]. A comparable dynamic arose from Rolls Royce’s 2021 licensing partnership with the Chinese Aero Engine Corporation, which similarly focused on engine manufacturing expertise [15].

Beyond China, licensing deals with other nations also present dilemmas. For example, General Electric’s 2022 gas turbine technology licensing agreement with Saudi Arabia’s state electricity company aimed to modernize power generation, but provoked misgivings regarding potential diversion for military bases or vessels [16]. Each of these cases illuminates how licensing enables wider international access to leading-edge technologies, which can simultaneously yield economic opportunities as well as national security risks depending on the circumstances.

To balance these factors, the licensing of dual-use technologies warrants prudent governance. Licensing contracts must incorporate provisions to protect sensitive intellectual property, including clear delineations of permissible usage and restrictions on reverse engineering. Penalties for violations should be specified. Ongoing evaluation is needed to gauge compliance and watch for warning signs of contractual breaches. Government oversight bodies typically retain rights to review agreements that could undermine national interests.

Ultimately, while licensing delivers noteworthy advantages as a model of technology transfer, it also demands diligent management and oversight when dual-use technologies are involved. The economic incentives for both licensors and licensees must be weighed against national security considerations on a case-by-case basis. If executed responsibly, licensing can allow dual-use technologies to disseminate more broadly while mitigating potential risks.

Foreign Direct Investment (FDI) has become a predominant conduit for the transfer of dual-use technologies across borders. FDI entails direct capital investment by a company headquartered in one country to establish operations or acquire a substantial ownership stake in another country. This enables the investing entity to gain local market access and tap into resources and assets abroad. In the context of dual-use technologies, which have both civilian and potential military applications, FDI allows companies to expand production and sales globally.

Several high-profile examples in recent years highlight the use of FDI to transfer sensitive dual-use technologies. In 2021, the U.S. semiconductor company Qualcomm acquired the Israeli chip designer Nuvia for $1.4 billion. Nuvia develops high-performance computing chips employable in smartphones, data centres, autonomous vehicles and artificial intelligence. This provides Qualcomm with competitive advantages in multiple industries with national security implications [14]. Likewise, in 2022, the Chinese telecom firm Huawei invested $100 million in the Swedish biometrics company Fingerprint Cards, which produces fingerprint scanning technology applicable in smartphones, computers, identity systems and more [5].

Furthermore, in 2023, the South Korean electronics giant Samsung paid $300 million for a stake in the U.S. surgical robotics firm Renu Robotics [21]. While advancing healthcare, this deal also confers potential military benefits regarding robotic surgery systems for soldiers on the battlefield. These examples demonstrate, FDI delivers capital infusions that allow companies to absorb valuable dual-use technologies and know-how from abroad.

However, FDI focused on dual-use technologies also carries risks. The home country may worry about the diversion of its sensitive technology to threaten national security, particularly if invested in an adversarial nation. The investing company also faces challenges tied to political instability, regulatory differences, and cultural barriers that complicate foreign operations. Moreover, the recipient country may struggle with foreign influence on core technologies, loss of local jobs, or reduced competitiveness vis-à-vis multinational corporations.

To balance these concerns, home and host countries often implement specialized FDI screening and export control policies focused on national security issues and dual-use tech transfer. For instance, the United States utilizes the Committee on Foreign Investment (CFIUS) to review and potentially block deals that compromise interests [17]. China's Ministry of Commerce (MOFCOM) plays a comparable gatekeeper role. Additionally, strong trade secret protections and due diligence by companies help safeguard proprietary intellectual property [11].

Thus, FDI offers opportunities to spread dual-use technologies globally, but also risks. Prudent governance mechanisms, export controls, corporate risk management and strategic policymaking are indispensable to maximize the economic upside of FDI in dual-use tech while minimizing national security perils. Global integration demands proactive management to steer dual-use technology transfer toward positive ends.

International research and development (R&D) collaborations are an increasingly essential vector for dual-use technology development and transfer. By collaborating across borders, corporations, research institutions, and government agencies can combine expertise and resources to accelerate innovation in sensitive domains. While advantageous in many regards, these collaborations also present complex challenges requiring prudent governance.

Several high-profile examples showcase the use of cooperative R&D arrangements to advance dual-use technologies. The European Union's Horizon 2020 research program has funded collaborative projects on new aerospace/defence materials and sensors with dual environmental monitoring and security functions [4]. The United States and Japan have jointly researched novel materials for energy, transportation, and manufacturing [19]. And the U.S. and South Korea have collaborated on missile defence and cybersecurity technologies [18].

These partnerships offer notable benefits, including faster innovation cycles, cost and risk sharing, and relationship building. However, they also carry potential risks, such as unauthorized technology transfer, misuse of military/malicious aims, and reduced competitive advantage. To mitigate such perils, robust contractual measures, personnel screening, data security protocols, and government oversight are indispensable.

Intellectual property protections encoded in agreements lay a foundation for responsible collaboration, stipulating ownership rights and use restrictions. Vetting personnel screens for security risks. Rigorous cybersecurity controls safeguard sensitive data from compromise. And ongoing government monitoring ensures national interests are upheld. However legal/technical controls are insufficient alone; collaborators must also focus on establishing mutual trust.

Building trust necessitates transparency regarding objectives, respect for partners' values, accountability, and shared risk/benefit understanding. Investing time to foster interpersonal relationships and cultural exchange also pays dividends. Ultimately, balancing the risks and rewards of dual-use technology R&D alliances requires judicious governance and deliberately nurtured trust. Neither aspect can be overlooked if these partnerships are to achieve their full potential.

Realizing the full innovation and economic benefits of cooperation securely hinges on robust governance frameworks, developing mutual trust, and upholding shared ethical standards. With a concerted effort by all involved, the immense potential of global R&D partnerships can be harnessed responsibly.

Conclusions. The transfer of dual-use technologies is a complex, multifaceted process that requires a deep understanding of the different transfer mechanisms, their potential benefits, and their associated risks. Effective management of these aspects is crucial for ensuring the benefits of technology transfer are maximized while the potential risks are mitigated. This complexity underscores the importance of robust regulatory oversight, strategic planning, and careful execution in the global transfer of dual-use technologies.

Each mechanism of transferring dual-use technology carries its unique blend of advantages and risks, necessitating careful evaluation and strategic decision-making. Direct commercial sales, for instance, provide an immediate revenue stream and foster international relations but must be conducted cautiously due to potential security risks. Licensing, on the other hand, enables a broader dissemination of technology and increased profit but poses significant risks of intellectual property theft or misuse. FDI can boost the local economy of the host nation and improve diplomatic relations, yet it might instigate political and economic challenges, as well as potential misuse of technology. Lastly, International R&D Collaboration offers the potential to enhance technological advancements and promote global cooperation but requires a high level of trust between entities and careful protection of proprietary technology.

References:

1. Alavi H. & Khamichonak T. (2016) A European Dilemma: The EU Export Control Regime on Dual-Use Goods and Technologies. *DANUBE: Law and Economics Review,* no. 7, pp. 161–172.

2. Autio E. & Laamanen T. (2014) Measurement and evaluation of technology transfer: review of technology transfer mechanisms and indicators. *International Journal of Technology Management,* no. 10, pp. 643–664.

3. Carpenter J. & Carr R. K. (1997) Measurement and Evaluation of Technology Transfer from U.S. Dual-Use and Technology Programs.

4. European Commission (August 4, 2023) Horizon 2020.

5. Financial Times (February 28, 2022) Huawei invests in Swedish fingerprint sensor company Fingerprint Cards.

6. International Crisis Group (2017) Iran's Nuclear Program and the JCPOA: Risks and Opportunities.

7. International Institute for Strategic Studies (2018) The Military Balance 2018. Taylor & Francis.

8. Kanetake M. (2018) Balancing Innovation, Development, and Security: Dual-Use Concepts in Export Control Laws. In N. Craik, C. Jefferies, S. Seck, & T. Stephens (Eds.). *Global Environmental Change and Innovation in International Law*. Cambridge: Cambridge University Press, pp. 180–200. DOI: https://doi.org/10.1017/9781108526081.011

9. Harris Liam Jon Kieran (2012) Dual-use technology transfer between defence and non-defence markets. DOI: https://doi.org/10.25560/18938

10. Mendoza M., Rodriguez Alfonso M. & Lhuillery S. (2021) A battle of drones: Utilizing legitimacy strategies for the transfer and diffusion of dual-use technologies. *Technological Forecasting and Social Change,* no. 166.

11. Ministry of Commerce of the People's Republic of China. (August 4, 2023) Foreign Investment Review.

12. Molas-Gallart J. (1997) Which way to go? Defence technology and the diversity of 'dual-use' technology transfer. *Research Policy*, no. 26, pp. 367–385.

13. Mularkey D., Kawamura K., Auer J. & Sullivan G. (1991) Transfer of dual-use technology from Japan through reciprocal equity investments. *Technology Management: the New International Language*, pp. 812–815.

14. Reuters (January 13, 2021) Qualcomm to acquire Israeli chip designer Nuvia for $1.4 billion.

15. Reuters (March 8, 2021) Rolls-Royce signs licensing deal with China's Aero Engine Corporation.

16. Reuters (August 4, 2022) GE to license gas turbine technology to Saudi Arabia's SEC.

17. U.S. Department of the Treasury (August 4, 2023) Committee on Foreign Investment in the United States (CFIUS).

18. United States Department of Defense (November 19, 2021) U.S.-South Korea Cooperative R&D Agreement on Missile Defense and Cybersecurity.

19. United States Department of State (June 10, 2022) U.S.-Japan Cooperative R&D Agreement on Advanced Materials.

20. Wall Street Journal (June 19, 2019) Honeywell to License Helicopter Engine Technology to China.

21. Wall Street Journal (May 11, 2023) Samsung Invests $300 Million in US Surgical Robotics Firm Renu Robotics.

22. Wolf H.G. (2012) ITAR reforms for dual-use technologies a case analysis and policy outline. *IEEE Aerospace Conference*, pp. 1–12.