DUAL-USE MATERIAL SCIENCE TECHNOLOGIES TRANSFER IN UKRAINE: PREMISES AND PRESENT CATCH-22

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ABSTRACT

The object of effort is to assess the underpin premises of transfer of dual use materials science technologies appeared in Ukraine after the Independence and those developed until nowadays. It is also to shed a light on this issue and evaluate historical, technical, political, and mental barriers between technology supplier/recipient and future prospects and successful steps to be made to overcome those.

The work **puts a problem** to scrutinize today's and future materials science dual use technology transfer control regulations and all premises associated and leaving an imprint on the realities existing in Ukraine. First of all, it is important to study technology transfer issues and a vital role of those premises appeared in Ukraine otherwise one may chase a ghost while trying to understand how to put it correct in a right legal and political way to successfully resolve this matter since in this case none turnkey solutions ever exist. For example, central to a control regime debate is to discuss an evolution, or lack of the existing transparent legislation covering dual-use technologies, and a discussion on its orientation and scope. Does this really work and sound in practice, and if "yes" then to what extent? Second, at a time of fundamental change in nature and order of international relations, the wisdom of ad hoc control regimes must not escape scrutiny. Although experts are very much aware of these problems, future of control regulations remains still blurred and uncertain, so what are their potential implications for international state's security?

The research revealed that a reassessment of the problems surrounding dual use materials science technologies and today's control regulations should be made – both in terms of their potential improvement and/or possible new universal multilateral agreements and transparency among states involved in technology transfer. This further argues a need for new international mechanisms to ensure the transfer of dual-use materials science technologies, while not powering proliferation opportunities for weapon systems.

The results of this endeavor make a ground floor for further debates in terms of politics and export control in the field of transfer of intangible technologies.

1. Introduction

By definition a dual-use technology is a technology having its potential commercial (civil) and military and/or defense applications, has been always a controversial subject in Ukraine and rest of the world. Since 1990 a lot of defense technologies in Ukraine has been unclassified and legalized for its further civil and commercial applications and/or transfer of those thanks to the conversion program announced by the government, however the actual transfer of these technologies is still dimmed and stymied and needs further loop of evolution. Undoubtedly that a certain impact and influence on international security is caused by transfer of rather sensitive dual-use materials science technologies and this proves the rationale of the present thesis. Today, a relationship between a supplier and a recipient of dual use technologies is based on rigorous control regulations which, in many instances, provide a certain background and to some extend provoke conflicting political situations. Basically, control regulations were established to effectively constrain a development of nuclear and chemical weapons, means of its delivery, military reconnaissance satellites, and other weapon systems. The argument could also be made, however, that economic considerations have also stimulated these control regulations. If to put the polemics aside, the problems caused by these regulations are that there is an urgent need to rethink and reconsider the ways of implementation of dual use technologies into a common life, added to which is the fact that control regulations have also hindered, both directly and indirectly, the development of certain civil materials science programs.

1. 1. The object of research

In view of the need to evaluate and clarify historical, political, technical, mental and other implications for the impact of transfer of dual use materials science technologies, this effort is to rate and clarify some of ramifications which are often discussed in the context of non-proliferation debate of military technologies and national security.

1. 2. Materials and Methodology

The intricate nature of dual-use technologies and their potential for enhancing Ukrainian and other economies make 'em fundamental to both R&D and political debates. It should be mentioned that there has never been a clearly defined line between defense and civil research and this border is still strongly blurred. Found in an increasing number of industrial sectors ranging from nuclear and materials science, electronics, etc., intangible technologies must have an increased attention from developers, policy, and law makers. The blurring of civilian and defense industrial bases and the increase in issues with uncertain dual-use features make distinguishing between civilian and military products and platforms more difficult and complicate the issues of export control and technology transfer.

Mechanisms for actual *viz*. commercial transfer of production technologies of advanced materials of dual-use virtually does not exist and there are strong political, economic, security and legal reasons for this. Nevertheless, despite the above the transfer of intangible technologies and conditions associated with it have continued to ignite a huge interest in the last decade. The process of technology transfer as a whole is neither simple nor systematic and far from being that perfect, especially when it comes to dual-use technologies and at present reduced to a short relationship between supplier/recipient only.

Thus, this endeavor makes an attempt to analyze and scrutinize historical, technical, political, and mental barriers between technology supplier/recipient and future prospects and real steps forward. The work also undertakes an attempt to examine today's and future materials science dual use technology transfer control regulations. The study employs qualitative methodology and is under the umbrella of a descriptive research design to agree on historical, technical, political, and mental implications for a transfer of intangible technologies and state's security. Political, and legal analysis are conducted in relation to these technologies, actions and questions popped up nowadays associated with 'em. This descriptive research portrays a rather accurate profile of current situation happened around the dual use technologies in Ukraine. This design offers a profile of described relevant aspects of the problem of interest from author's individual perspective.

1. 3. Problem description

In former Soviet Union, Ukraine was a recognized leader in development of advanced materials with a high level of required performance and an employment of those under extreme conditions. Notably, that the main center of materials science in a face of Frantsevich Institute for Problems in Materials Science at that times was established in Kiev (1952). Although, most know that in those days it was more likely an exception to the rule since the rest R&D headquarters were situated preferably in Moscow. The USSR brought a significant state investments to science intensive materials science technologies and training of an appropriate scientific and engineering personnel to become of a high qualification. Scientific schools were established all over the USSR and those intensively developed this branch of science which allowed its quick possessing the leading position in the world scientific community. Needless to say, that, the main and only customers, and consumers of this kind of applied R&D results were defense, aviation, space and shipbuilding industries. After the USSR fallen apart, Ukraine could not simply *"digest"* (mostly due to financial reasons) the amount of knowledge that the scientific schools and institutions had created, since a dramatic fall of military and industrial sectors. All this finally brought to state's conversion program announced in early 1990. Many defense and dual-use technologies were unclassified, modified and afterwards used for civil applications. Nevertheless, it does not matter that the conversion program has negative impact on national security as a special governmental commission was established in that times and the commission after a careful study, decided which technology has to be unclassified or it should still remain state's secret. The procedure stayed aside from cutting-edge technologies as the technologies of tomorrow are as untouchable stock or like a forbidden fruit for any developed country as they may significantly affect state's national security. Thus, the conversion program was a rather bold plan at that times, however, all this has a profound significance and made good odds in favor of materials science schools and teams to survive and participate in various international

competitions and R&D programs. This was only the first step made towards a transfer of materials science dual use technologies, meaning the transfer not to any particular company and/or state but to the world scientific and industrial communities. In other words, it was just the first attempt of sharing the formerly classified R&D results with the rest of the world, using such newly established organizations as for an example, Science & Technology Center in Ukraine [1]. Meanwhile, a solid, transparent and proven mechanisms for actual *viz* commercial transfer of production technologies of advanced materials virtually are not exist when strong political, technical, mental, security and legal reasons are still alive and add the fuel to the flame.

Thus, what's the catch? Historically, after the Soviet Union collapsed, a strong grows of a number of participants in foreign economic activity came to light. For many of them, commercial interests were much more attractive, important and understandable than the national, economic and political security of Ukraine. Under the umbrella of disappearance of many administrative mechanisms, this brought to elevation of physical volume of sales of strategic goods and advanced technologies abroad, which may pose a threat to national security, regional and global stability, and a competitiveness of domestic economy. Another reason for a catastrophic aggravation of the situation with critical exports could be associated with the fact that in Ukraine the export control system, at that times young and not that experienced, was developed simultaneously under the influence of the Western and Soviet models. Formally, the basis of the Western and Ukrainian models is the licensing procedure for the export of critical goods, which is included in one form or another, as soon as the goods leave the state's jurisdiction. The Soviet model of export control was designed to abort all transactions that did not meet the national interests even before they were concluded, based on complex and informal internal and interdepartmental procedures for coordination with the final stage of discussion of each significant contract at the highest level, up to the Politburo of the Communist Party. Thus after 1991, the situation drastically changed. The increasing decentralization of control led to the fact that not every transaction went through the existed and well developed channels of the Soviet era. The emerging Western model was far from being that perfect at that times in Ukraine, covering the most visible and least important sphere of control, from the point of view of criticality, – the export of strategic goods outside the customs during the transactions between independent counterparties. As a result, multiple "*open windows"* popped up, rushing at those whose goal was only the earliest possible and fast enrichment, and even more those windows appeared every year because of underfunding of the Ukrainian military-industrial complex and the National Academy of Science.

Nevertheless, despite the above a transfer of dual use technologies and conditions associated with it have continued to ignite a huge interest in the last decades. The process of technology transfer as a whole is neither simple nor systematic as it may seem at first blush and far from being that perfect, and it does not happen overnight, especially when it deals with dual-use technologies and at present reduced to a short relationship between supplier/recipient only. Meaning the short-term relationships between the scientific laboratories or between scientists as a result of which in terms of the contract or not eventually a technology transfer takes place. Nevertheless, the technology transfer, if legally and not done under the table, is a rather complicated, translucent, multi-level and multi-players process which follows several factors and conditions that determine its success or failure at the end.

In consequence, the following questions may then be raised therein: (1) what are dual-use materials science technologies, and (2) how can they be distinguished from single-use technologies? Are operational interactions and technical similarities the only criteria to differentiate dual- from single-use technologies? Or are there other more conceptual and less technical reasons?

The term dual is used in its generic sense to denote the mathematical number "two". When used in relation to an operative verb such as use, "dual" means more than one, nature, or characteristic of a given object or method, or any other word it qualifies. More specifically, in the context of materials science technologies, dual use can be defined as being a usage which has both civil and military application, whether proven or potential. In a more general sense, dual use also embraces weapon technologies and their systems and sub-systems, in any of their different basing modes: ground or mobile, ship- and air-mounted, etc. However, while there are a great variety of weapon specific systems that could be associated with, it is the non-weapon technology that could be employed for military purposes which is the most difficult to define.

Dual-use issues in science are increasingly discussed in literature [2] and in policy-making, as well as in media and in public discourse. However, there presently exists no widely accepted definition of dual-use. While previously the term was used in relation to specific technology applications, latterly

research too has entered the debate on dual use. A clear definition is necessary to ensure adequate consideration of the ethical issues involved. This definition should be neither narrow, hence liable to rule out issues of genuine importance, nor wide, making oversight of dual-use science ungovernable. For example, if the definition of dual-use is limited to particular experiments in the life sciences [3] involving dangerous biological or chemical agents, then scientists or policymakers may fail to take into account other types of potentially dangerous R&D, such as research that could be used to play havoc with computer networks, jeopardize buildings or contaminate the food supply. If the definition of dual use is too wide in a scope, it may be applied to areas of science that are very unlikely to be used for malevolent purposes, place futile administrative burdens on scientists, and eventually boost innovation that might prove beneficial to society.

Thus, it has always been a controversial and disputable subject not only in Ukraine and the EU but all over the world as there is a very thin boundary between the applications. While having a legal access to Ukrainian dual-use technology, in practice in other countries the access has been restricted to civil application. As it was above said since 1990 a lot of defense technologies in Ukraine has been unclassified and legalized for its further civil and commercial applications and/or transfer of those thanks to the conversion program announced by the government, however the actual transfer of these technologies is still dimmed and stymied and needs further successful loop of evolution as mentioned above, it does not happen overnight and requires further and further elaboration.

Nevertheless, the development of materials science technologies continues in a quagmire of conflicting interests and technology transfer export control rationales. First, there are political-military considerations where a state's decision to develop weapon systems or related applications can be assessed not only as a function of perceived levels of threat to its security, but also as a need to respond and/or step forward to potential technological innovations; and second, the fundamental conceptual differences in appreciation among countries of the right to possess different advanced weapons systems for defensive or offensive purposes. This is not only a question limited to the dual-use issue. It has been always at the heart of all debates and all non-proliferation talks about materials science technologies employed by nuclear, chemical, and biological industries for decades. Third, there are certain economic implications, which impact is perhaps the least well-known and debated. Amid of these and other interests the transfer of dual use technologies is stuck somewhere in between severe control regulations on the one hand and the absence of a kind of universal agreement — of mutual interest signed between a potential supplier/recipient of a technology on the other. Transfer of dual-use technologies does not take place in *"a space"*. At present, it is being strongly affected by the echo of the USSR collapse and recent aggressive hybrid threat came from Russia and it is of a significant concern not only in Europe but all over the world. In conjunction with the above, a new era calls for a reassessment of national priorities related to international security which affects the way of global and regional geopolitical policies and the important to this concern is the transfer of dual-use materials science technologies. For the time being, discussions on intangible technologies, misuse of those and WMD proliferation threat lack creativity; political and diplomatic initiatives really came nowhere as well.

An influence of the political factor on transfer of dual use material science technologies can be tracked down from the experience of Frantsevich Institute of Problems in Materials Science, National Academy of Sciences of Ukraine (IPMS NASU), which, since the Soviet Union, has been one of the European leaders in the development of advanced materials for aerospace engineering and weapons systems. A certain part of export of R&D results at different stages of readiness (from directed fundamental research to pilot lab production of individual parts) was carried out through the STCU with an appropriate state export control procedure. The most striking examples of negative impact of the political factor on promoting institute's R&D results to the world market and material science community could be the following two. The first on is that in 2012, the institute was visited by a delegation of the US Navy top level experts. A seminar was set up at the highest level (with the presence of top level officials of Ukraine). IPMS presented 12 projects devoted to advanced materials science technologies. Six months took leading US experts to evaluate all projects and to select 4. They were approved and submitted to the US government for contracting through the STCU, as the United States is one of the co-founders of this organization.

Since the total amount of these contracts was significant (over $ 30 million) and this was the first unprecedent case for Ukrainian R&D contracts, the issue was referred to the US Secretary of State. It was a period that there was some tension in political relations between the USA and Ukraine and the

issue of allocation of money was vetted by Hillary Clinton, who was at that time the Secretary of State. Later it became known that the issue was vetoed solely for political reasons as she said to her scientific advisors who prepared the package of documents.

A second good one is IPMS project with the National University of Singapore in 2015 to develop a technology for production of nanocomposites based on dichalcogenides for the advanced electronics. The results obtained in terms of this project were planned to be included in the BIG DATA database for a computer design of nanomaterials of tomorrow, which then was launched in Singapore. It was a director of the Big Date Center, who initiated and ordered this project.

At that time in Ukraine, a new government began to work, and for more than six months could not determine its attitude to the STCU and did not give a permission for this work covering its' reluctance with a debate about dual-use issues. When the political decision was made and the project was approved, the political factor came from Singapore's government. One day before signing the contract the government banned the financing of R&D projects performed abroad. This decision was motivated as the one belonging to a set of factors developed by the government to fight a corruption when using budgetary funds.

On the side, this kind of a decision (a total ban on the export of state budget funds for scientific research to be carried out abroad) was adopted in some other countries as well. Namely this one inhibits a civilized transfer of advanced materials science technology (which usually are of dual use) and encourages a development of ways of imperceptible transfers of these technologies. China, which pace of industrial development requires the most rapid introduction of modern technologies, was the first one to realize a futility of practice of imperceptible transfer and began to look for other ways.

Since the beginning of 2020, controlled export of budgetary funds was allowed in China's most important open economic zones to finance foreign R&D projects in priority areas of state's development and a development of new materials is one of the first priorities. The government delegation of Guangzhou province, where this kind of a free economic zone was already established in January 2020, visited IPMS NASU and signed a Cooperation Agreement in the field of development of advanced materials. The Agreement already contains the above discussed provision (budgetary support of R&D projects to be performed abroad). This political decision is a good step forward towards a new approach to civilized transfer of dual use materials science technologies.

A political attitude of the Ukrainian government on this initiative has yet to be worked out, nevertheless it should be mentioned that a similar one was taken for the Western countries at the interstate level through the establishment of the STCU (USA, Canada, Sweden with the accession of the European Union and Japan).

Thus, this set of factors that affect an efficient and proper functioning and optimization of the process of transfer of dual-use materials science technologies, is quite a challenge nowadays.

2. Historical and Other Premises

It is well known that any developed economy is based on a solid Science&Knowledge background. New production technologies of high-tech products are the main driving force of any state's progress, and a success of their implementation in basic industries allows increasing national welfare and taking a stable high place in the world rankings [4]. However, for the last 27 years of independence, a business in Ukraine should have become more civilized. Every year, a rather large number of students graduate from Ukrainian technical institutes and universities, but there are no longer those industrial R&D institutes and industrial enterprises that previously could employ this annual huge flow of young specialists and attract those to development of high technologies. All this leads to the enormous outflow of talented young people from a scientific community, industrial and engineering sector, as well as to the crisis in materials science itself, which results in a decrease of a level of high-tech industry based on advanced materials. Nevertheless, the highest scientific level of knowledge accumulated by Ukrainian material science experts, gives a hope and good odds to revive these enterprises by attracting both knowledge and investments. The more are specialists experienced in the field of technology transfer, and able to work with experienced and powerful investors, the easier would be to tackle the problem and enter the global Hi-Tech market. It is obvious that training of technology transfer office staff and creation of national system of advanced training of scientists in the field of technology transfer management and export control that meets international requirements, are a key task that need to be resolved in the near future if Ukraine is to move towards a market economy and wants to meet the international standards.

If to analyze a foreign experience gained in this area, one may to observe that institutions involved in R&D results commercialization, so-called technology transfer offices (TTO), are established almost in every university or R&D institute [5]. Thus, it is natural, since the main scientific research in Europe, USA, Singapore, Japan, etc. are conducted namely by scientists in R&D institutes and universities labs, and a product for further commercialization is either a technology, and/or a material, or a specific responsible article. However, it should be highlighted that TTO mainly provides consulting, investment involvement, and conducts thematic trainings, seminars, training courses on industrial development of scientific research and trade control, especially when it comes to dual-use technologies and misuse of those. All this helps scientists to acquire the required knowledge for further successful steps and safe implementation of their inventions. Nevertheless, if those offices are not necessarily aware of trade control of strategic goods constraints that might raise the risks of misuse and proliferation.

For Ukraine, a history of advancement of scientific developments and technologies that implement those (especially dual-use products) [6] to a consumer market is almost zero. At the USSR epoch the state usually divided a financial support of science and transferring R&D results to industry. And if the financial issues, as a whole, had a consistently moderate and controllable level throughout the country, the financial support of technology transfer to industry had a significantly higher priority, nevertheless, was geographically (geopolitically) clustered in nature and concentrated mainly in the environs of Moscow and Leningrad. An exception was a development of new advanced materials for military complex, aerospace, electronics and other high-tech industries. The Academy of Sciences of Ukraine has been the recognized leader in this field however, this may not be referred to most researchers but was also of a clustered nature and singled out certain groups of scientists who carried out targeted research and development programs fixed by the government decrees with specially allocated funding. One of such programs was a development of new industry - Powder Metallurgy (PM). Scientists from Frantsevich Institute for Problems in Materials Science, National Academy of Sciences of Ukraine created this new industry – Powder Metallurgy and commissioned four plants and more than 50 workshops at the existing other plants.

After collapse of the Soviet Union, a governmental umbrella and patronage of transfer of R&D results to industry were almost curtailed for all countries of the former Soviet Union except Russia, since all specialized and innovative institutions remained on its territory and under the state's authority.

Thus, a paradoxical situation has appeared – the carriers of knowledge in development of new materials remained *"homeless"* in own country. From the one hand they possessed a great value in hands, but simply do not know how to offer it to the world market and had no experience how to resolve this serious and important issue. In case of dual-use technologies, a danger of violation of the Law on State Secret, which has not been never canceled [7], still exists.

Nowadays, the Ukrainian materials science institutes, recognizing and understanding the world level of their developments, understand that their developments (both current and those left from the Soviet times) may not be easily brought to a format perceived by the global market (experiencing technical problems – a problem of certification, etc.) and to bring those to this market without any efforts applied. Thus, the biggest problem here is that scientists simply do not know how to competently and professionally do this as it was not simply their mandate! In the era of the USSR, 1) none of them even cared and 2) nobody taught them a way it can be done, and even at present a well-developed system of education does not exist, despite being of extremely important. The educational activities on innovation, trade control and technology transfer, which are conducted by international foundations are ineffective and not that systematic. During the last decade only a few organizations [1] originating from its mission, tried to manage and bring those efforts to the Ukrainian and former CIS scientific community. To study this problem abroad for Ukrainians is a very problematic, both due to financial and language barriers. In addition, such training does not account for peculiarities of a mentality of scientists from former Soviet Union and national regulatory and control system.

As it was above highlighted, the problem of a technology transfer itself and specifically transfer of dual-use technologies is mainly associated with the fact that the dual use has always been a rather tricky subject [8]. For Ukraine, at present, all these problems should be considered accounting for the fact that this is the two-way road. On the one hand, Ukraine with its military conflict in the East, needs to modernize the existing weapon systems and influx of new dual-use technologies. On the other, having a *"golden stock"* of materials science developments, Ukraine is extremely interested in export of those to elevate a level of its economy and total welfare. Thus, due to the technical problems, first and

foremost, virtually every exported technology is not that new to the state which want to acquire it and it makes sense as it was above mentioned the developed countries do not transfer the cutting-edge technologies as not to create competitors and potential threats to state's security.

Successful overcoming of the existing problems is possible only in case of the implementation of an effective national policy for innovative development as a component of socio-economic policy. The most important issue in this area is to create an effective, transparent and healthy system of interaction and development of institutions heavily involved in state's regulation of innovative processes, stimulate the innovative activity, financial, industrial and technological, human and information support, generation and commercialization of innovative ideas in all sectors of national economy. By forming an effective innovation infrastructure in Ukraine, a synergistic effect can be achieved from interaction of various institutions, which contributes to the most effective communication between science, education, business and the state for a continuous implementation and sale of scientific developments as well as ensure the competitiveness of the domestic economy based on its involvement into the international transfer. The need for active participation of the state in this process is justified by the current market failures and gaps in formation of national demand for new technologies and innovative products in the face of low competitiveness and drastic degradation of the economy. A comparative analysis of macroeconomic elements in Ukraine emphasizes the need for government active intervention in innovation processes as a generator of incentives for innovations that cannot yet be ensured by a fragile market system and existing institutional environment due to their imperfections at the initial stage of development.

In Ukraine, according to the official data [9], the downward trend in innovation activity remains crucially constant, and a development of national economy is carried out by increasing the raw material and agricultural segments in Gross Domestic Product. This is a consequence of insufficient state funding of fundamental applied nature R&D, which is a solid background for the development of high-tech highly profitable technologies of top industries. Unlike the developed countries, which actually (first and foremost) provide an innovative development of their own economies, in Ukraine this process still remains only a declarative, since there is no modernization of the national economy on an innovative basis and there are no incentives and levers to revitalize this process. All this unfortunately prevents the active involvement of Ukraine in the international technology transfer [10]. Thus, Ukraine, possessing a significant innovative potential, especially in the field of advanced materials and technologies, has not yet elaborated the effective mechanisms for implementation and transfer of those at the level of real sector of its economy.

3. Result and Discussion

The question of whether there should be a better restructuring a dual-use technology transfer process would now appear to be irrelevant without a better understanding of present relationship between Ukraine and other countries on vital materials science sector of national security debate. The quest for improved relationships in respect of technology transfer and dual use must first start with an assessment of historical, mental, political, military, technical, economic and other implications of materials science technologies. Any such assessment must therefore consider the relevance that access to these technologies has for different geopolitical situations. Only by tight and trustful cooperation can the supplier/recipient relationship be established in a sound, durable and in an open manner. However, any such cooperation must be reinforced by solid and transparent agreements to ensure transparency and predictability on issues which directly affect the states' security, economy, and development.

The right of any state to develop materials science technologies is unquestionable and a conscious necessity is dictated by the generally accepted paradigm that *"a material is a heart of any article"*. In practice, problems arise when technology development approaches the very fine and sharp border between civil and military application, as most of the technologies can be used for dual purposes. This dichotomy raised a number of technical, political, military, and other concerns which crucially affect the transfer of materials science technologies, and particularly between established and emerging materials science competent of Ukraine and other countries, thus the technology transfer process is a hard way which do not have turnkey solutions and each transfer activity has to be treated as to be the first one and unique.

This argument is not just ideological. It could constitute the basis of a policy that could be implemented if certain specific initiatives are taken. To build confidence between supplier and recipient countries of intangible technologies, adhesion to bilateral agreements on materials science technologies, limitation agreements on weapons of mass destruction, and other measures would offer elevated and re-

quired transparency in development of materials science technologies of tomorrow. Of course, the roles of both supplier and recipient in unilateral, reciprocal measures would have to be carefully evaluated. Concession issues would need to be given the highest priority due to improve predictability and creation of mechanisms of crisis management and resolution. There should also be an agreement to establish a transparent dialogue between the supplier's and the recipient countries, to enable mutual political objectives to be complemented by compliance and enforcement procedures. Central to the debate is fundamental and practical questions associated with transfer of dual-use technologies and a lot of questions comes to light. For example: is it appropriate to undertake multilateral negotiations? Then if so, in what form and what type they should be? However, scrutinizing ways of creating new relationships between supplier and recipient in transfer of dual-use materials science technologies can easily be a zero-sum-game endeavor. The challenge is to initiate impartial and innovative thinking. Steps towards cooperation simply for the sake of ensuring the transfer of dual-use technologies are not the answer. Moreover, while international organizations have their role, they are not a panacea, as the comprehensive test ban treaty discussions have shown.

4. Conclusion

In conclusion, the question of whether there should be a better restructuring of dual-use technology transfer would now appear to be irrelevant without a better understanding of present relationship between Ukraine and other countries on vital materials science sector of national security debate. The quest for improved relationships in respect of technology transfer and dual use must first start with an assessment of political, military, technical, and economic implications of materials science technologies. Any such assessment must therefore consider the relevance that access to these technologies has for different geopolitical situations. Only by tight and trustful cooperation can the supplier/recipient relationship be established in a sound, durable and open manner. However, any such cooperation must be reinforced by solid and transparent agreements to ensure transparency and predictability on issues which directly affect the states' security and development.

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