sustainability

Review

Technology Transfer, Sustainability, and Development, Worldwide and in Romania

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Abstract: Technology transfer (TT) is a mechanism designed to accurately make knowledge, innovations, and advancements available to the general population. TT is conducted through scientific papers, educational and governmental initiatives, and the commercialization of technology. The TT process per se is complex, involving many stakeholders and factors that can impact implementation. Feasibility studies are needed to assess the types of technology that can be transferred, the economic options to be chosen, and to stimulate the receptive part, making understandable the whole transfer flow. Furthermore, TT involves a dynamic mechanism that has advanced with the development of technology, with different linear, non-linear, and alternative models being proposed and scientifically validated, and with the possibility of addressing different perceptions of the factors involved. The international TT level, as well as the level of innovation in the economic context, differs from nation to nation. The need for this paper is based on the lack of a comprehensive detailed presentation of the TT infrastructural concept, approached in a novel and in-depth way by assessing international TT, technology flow, technology distribution and expansion, collaborative networks, TT centers and TT models, regional operational programs etc., all of which are related to national/international legislation and sustainable development. The deficit of representation and implementation of this concept in Romania was also covered, the assessment providing the current status and suggesting the need to develop and optimize the implementation of TT in this country.

Keywords: technology transfer; sustainability; development; innovation; productivity; knowledge

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1. Introduction

Technology transfer (TT) is in essence an activity that is centered around knowledge exchange. Similarly, to other extensive concepts with wide-ranging applications across different fields of activity, based on the owner's requirements and expected results, TT presents various models. Numerous areas of activity are impacted with effects on the economic, administrative, academic, social, and technological sectors, using numerous TT instruments. The triple helix of governments-universities-industries facilitates the development of innovation directly proportional to the increase in stakeholder qualification, each element of the axis being interchangeable [1]. These instruments are used by National Institute of Health (NIH) researchers to accomplish the purposes and fulfill the responsibilities of the institution. In the short period of activity in this field, the NIH Technology Transfer Office (TTO) can boast successful results in promoting TT. Data from the fiscal year 2005 proves the successful activity of the NIH TTO, which can be quantified in 307 licenses, 388 invention disclosures, and USD 98.2 million in royalty earnings through licenses. According to the royalty policy of the NIH TTO, USD 8.9 million of the total revenue was distributed to 916 inventors as compensation for their involvement and research results. The rest of the sum was allotted to different centers, in order to support TT activity and ensure further scientific studies. The most notable of the products authorized by the Food and Drug Administration (FDA), where NIH inventions brought a contribution or were licensed to product manufacturers, is the NIH TTO. Nowadays, the display of NIH technologies in clinical trials suggests that the future FDA list of endorsed products will surpass the list from this decade. However, for the contribution of NIH researchers and the implementation of the commercial technological operation to the results of the scientific research, a large number of patients would not have access to these products, be they past or future [2].

Numerous new/modern technologies (e.g., nanotechnology [3–6]) provide increasing hopes in the alleviation of human suffering (both at the population and individual level) as well as in the improvement of environmental living conditions (in the frame of increased pollution, climate change, increased food needs, etc.) by implementing new innovative environmental protection measures, respectively, of some advanced depollution techniques [5,7–9].

Patents codify specialized capabilities, and patent claims can accelerate the TT. Moreover, patents provide a demarcation of advanced technologies along with the promise of exclusivity, which companies are comfortable sharing while negotiating a licensing agreement. This might or might not be in the long-term interest of patent holders to transfer their innovations on varied terms, depending on business strategies. According to published literature, only viewing a patent is not sufficient for sustainable TT, or transfer that may result in implementation. These types of transfers should therefore involve the transfer of technical expertise, core competences, and other supplementary information in addition to the information that is disclosed in the patent and is accessible to the general public. As a result, business transactions involving the transfer of various sorts of information assets are expected to take place if patents genuinely encourage innovation by third parties [10,11].

The TT studies' findings show how patents help organizations perform research and development (R&D) transfer technologies and improve market performance. Ultimately, they highlight the importance of patents in transferring technology to start-ups, spin-offs, and existing businesses. For an optimized TT, a public-private collaboration can be formed by fusing private commercial channels with informal university assistance [12]. A useful way to enter markets with greater barriers to entry is through capturing specialized markets to increase revenue and brand exposure. The strategic relevance of patent protection depends on top executives and inventors being involved in the process of creating a patent portfolio. To broaden the extent of patent protection and establish a broad control posture, it is important to consider patenting further down the value chain and protecting applications of technology near the consumer market [13].

TT between different entities has been the basis for the development, distribution, and marketing of many patented engineering applications (i.e., technical textiles, road vehicles, additive manufacturing, measurement technology, agriculture), as it is detailed below.

The Swedish start-up, Oxeon, was founded on a novel weaving technique utilizing composite materials. The technology's intellectual property rights aided in luring private investment. The entrepreneurship center at Chalmers University of Technology provided Oxeon with additional business assistance. The commercialization of cutting-edge textiles in the industrial and aerospace sectors, as well as the licensing of the weaving technology, were both made possible by the union of private ownership with state innovation funding. Furthermore, it provides an example of TT in the field of technical textiles engineering research, implementing a private-public partnership and university spin-off model [14].

Blubrake was established to market a novel e-bike anti-lock braking system, as a consequence of cooperation between a research team at the Politecnico di Milano and e-Novia, a deep-tech enterprise developer. Patents were employed to enhance the company's market penetration and recognition in a sector of the economy dominated by large, well-established worldwide firms. To safeguard the firm's own distinctive selling point in the e-bike market, initial patent applications for customized technical features and designs were filed. It represents a successfully implemented TT model in the field of road vehicles, combining a start-up accelerator and a university spin-off concept [15].

The Technical University of Vienna was able to collaborate successfully with its industrial partner, Ivoclar, to design a long-term TT strategy that included a thoughtful distribution of usage rights. Two university start-ups were a result of this. Despite pursuing early-stage investment, Cubicure, one of these two start-ups, was able to establish strategic alliances and profit from a robust patent portfolio. Based on partnerships between industry and academia and university spin-offs, this approach to additive manufacturing (AM) proposes a TT model of AM machines and high-performance polymers for industrial applications. Based on partnerships between industry, academia, and university spin-offs, this approach to AM proposes a TT model of AM machines and high-performance polymers for industrial applications [16].

After gaining access to the Technical University of Munich's intellectual property and obtaining commercial experience, the group of researchers raised the initial capital for the development of fos4X. A continuously expanding and well-managed patent portfolio allowed the new company to obtain funding and establish itself as a leading supplier of measurement systems for wind power installations in a market dominated by large, worldwide players. It is thus a model of a TT university spin-off successfully implemented in the engineering field of measurement technology, with the main product being fiber optic sensors and measurement solutions for wind turbines [17].

Providing access to these beneficial technologies both to developed, as well as developing countries, and for all populations, is a significant challenge in the context of applied ethics. So far, TT was not an important matter for applied ethics. Nevertheless, there are signals that the situation is changing. Fundamentals regarding TT, which are relevant for states, corporations, and individuals, are stipulated in the Universal Declaration on Bioethics and Human Rights (UDBHR) of The United Nations Educational, Scientific and Cultural Organization (UNESCO). Important new strategies concerning TT, with impact on global health policy approaches, may be promoted by combining bioethics and human rights in the context of the UDBHR.

In recent decades, several policies that encourage TT from developed countries and multinational corporations were applied by developing countries with the purpose of obtaining advantages from novel health technologies for all nations. These strategies include encouraging science education, providing funds for innovative technology, tax deductions for essential equipment acquisition, and intellectual monopoly privileges (also known as intellectual property rights (IPRs). Several developing countries had unsuccessful attempts to establish an ethics code to control TT under United Nations patronage, in late 1970 [18].

TT patterns are based on continuous research aimed at consistently reducing the differences between field implementations and artificial laboratory conditions. They are directly linked to the concept of analog patterns and determined sampling, as previous research is used as an analog to support assumptions concerning fields or organisms, which have not yet been the object of research. The approval procedure that directs the development of novel drugs in the United States is a defining aspect of how the TT concept is implemented in practice (Figure 1).

The TT framework is present in education and academia as well. Higher education research centers bring together researchers with study interests in topics such as teaching and learning science, languages, mathematics, and other subjects. Various studies are performed in a controlled laboratory setting, with the purpose of looking into the main cognitive processes, which contribute to the development of novel mathematical concepts, or which guide the process of learning a second language by double immersion. The results of the research are further used to improve materials utilized in the professional development of educators, as well as in assembling the educational curriculum subsequently applied in classroom activity [19].

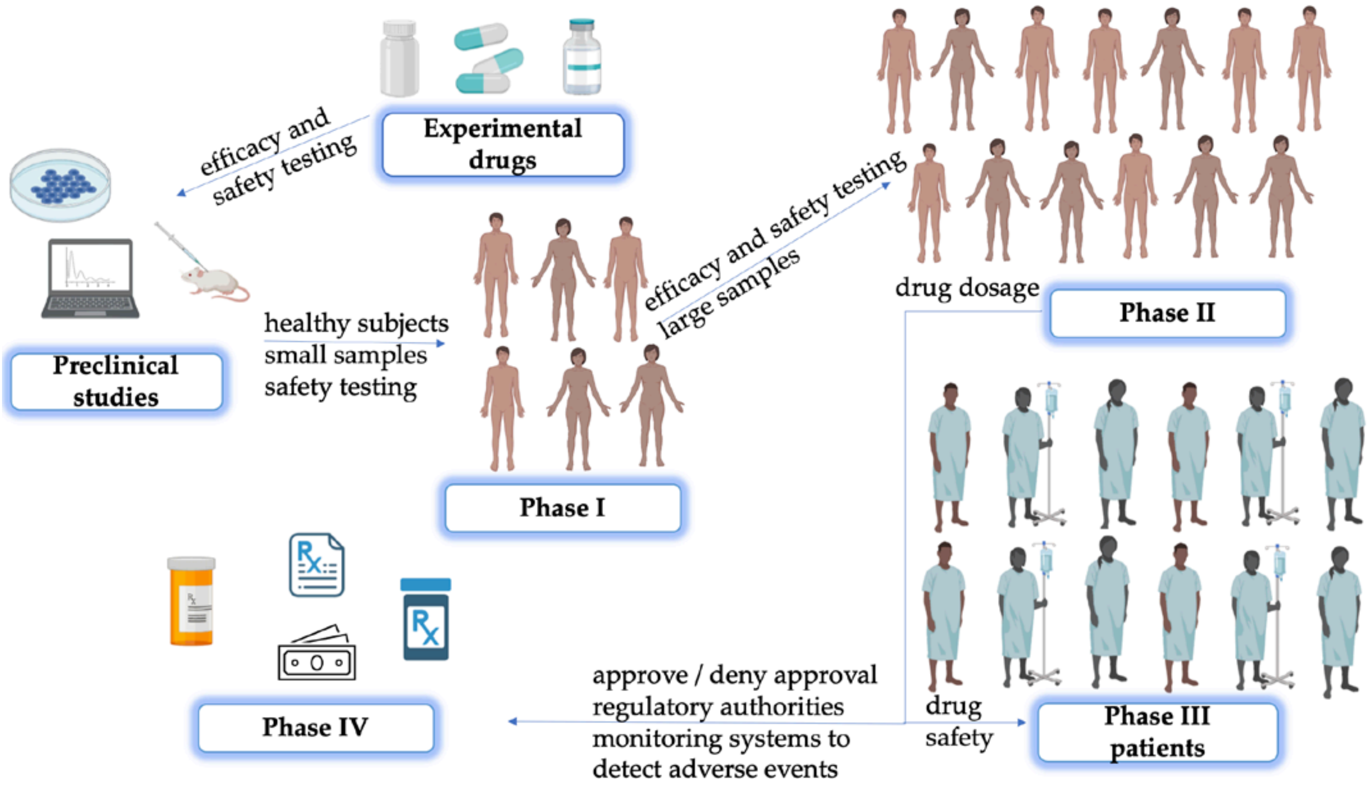

Figure 1. Pre-market approval methodology for a new medicine.

Regarding the levels of development, Romania is situated at the second level, since, historically, attention has been focused on resources instead of innovation:

- Reduced competitiveness is the most pressing challenge for Romania, as it currently has a major negative impact on the Research, Development, and Innovation (RDI) system. The economy is largely composed of sectors which employ medium and low technology and maintain a poor innovation culture and a scarce demand for knowledge [20].
- Regarding the research and development (RD) intensity score, Romania is on the last position in the European Union (EU), due to reduced innovation activity. Corporate RD is also considered to be subpar. Illustrating the decreased innovation activity level, the country was ranked by the World Economic Forum Report on Global competitiveness 2013–2014 as mainly oriented towards efficiency (together with Latvia and Bulgaria), in comparison to the economies of more advanced EU member states, which are in transition towards/at the innovation focus stage [20,21].
- The "stop–start" pattern of development—which has detrimental consequences for economic sectors requiring constant capacity building over a long period of time—is determined by continuous political inconsistency, the absence of cooperation between ministries with RD portfolios, and the absence of an applicable innovation policy.
- In Romania, 38.3% of research activities are performed within the private business sector (the EU average being 61.5%), while the rest of all RD activity belongs exclusively to the state. The segmentation of public RD represents another negative structural feature, as despite the numerous researchers, the research is largely not conducive to clear and applicable results [21].
- The tight budget for the RDI system, combined with reduced career options, determined a massive exodus of researchers, which has been ongoing from 1990 until now.

Romania finds itself lacking a researcher network, as 15,000 Romanian researchers are presently conducting their activity abroad.

- Regarding research excellence, Romanian universities are typically presented in the main international rankings as higher education institutions with poor scientific activity, mediocre research results, and a human resource structure which is less globalized in comparison to other EU countries [20,21].
- The RDI limitations in the business field are also alarming: few patent applications/requests in relation to the Patent Cooperation Treaty, the reduced presence of researchers in companies, and a reduced degree of corporate RD, which continues to decline over time.
- Regarding scientific and technological capacity, Romania presents prospective in new technologies of production, automotive, nanotechnology, information and computer technology, and security.
- The most important scientific fields are physics, astronomy and strategic enabling technologies, mathematics and statistics, engineering, information technologies and computers, as presented in the Romanian scientific specialization index, academic publications and citations [21].

The present paper aims to provide a comprehensive overview of TT at the global level, centralizing and assessing the current state of knowledge in the field through a methodologically distinct and up-to-date approach to the published scientific data on the concept of TT, between various stakeholders of the process, on the continuous evolution and progress over time based on highly relevant scientific models provided by the literature, with implications also on the novelty and impact of the sustainable development context.

The contribution to research in the field is provided by presenting in a new and more detailed way numerous conceptual and practical aspects of TT implementation, by linking the most relevant and current data from scientific manuscripts with the analysis of data from national and international legislation, thus giving a new approach to TT. Moreover, addition to the knowledge base includes highlighting the concept of TT infrastructure in Romania, where representation in the scientific literature is not highly extensive and up-to-date, and creating a scientific framework that comprehensively presents the current situation, suggesting the need to develop this field in correlation with sustainable development goals. An analysis of the feasibility of TT implementation was also performed, taking into account various impact factors (data on operational programs, collaborative networks, technological infrastructure, national legislation, triple helix interaction, and TT center development).

This paper can serve as a guide for researchers and academics interested in the concept of TT and sustainable development, as it addresses the gap in the level of detailed presentation of general TT infrastructure, as well as TT implementation in Romania (which is the last country in Europe regarding TT and making this paper even more necessary).

2. Methodological Approaches

The present manuscript centralizes, selects, and evaluates valuable scientific literature resources on the conceptualization, theorization, distribution, expansion, legal regulations, and the practical application of TT.

The methodological approach includes rigorous literature searches and filtering on international TT, networks, innovation development, and technological expansion, all based on a sustainable development context, outlining the current state of knowledge in the field, analysing certain aspects of TT less evaluated in the literature and in certain geographical areas, and enhancing future capacities for successful TT implementation among different stakeholders.

Achieving the proposed goal requires the use of multidisciplinary and scientifically validated databases, as well as specific search algorithms correlated with Boolean operators (Figure 2). Scientific article papers, books, and official websites of the various entities involved, written exclusively in English, and that complied with the search algorithms, were selected. Figure 2 depicts the methodological flow of literature selection and appraisal highlighted by the PRISMA diagram, according to the model established by Page et al. [22].

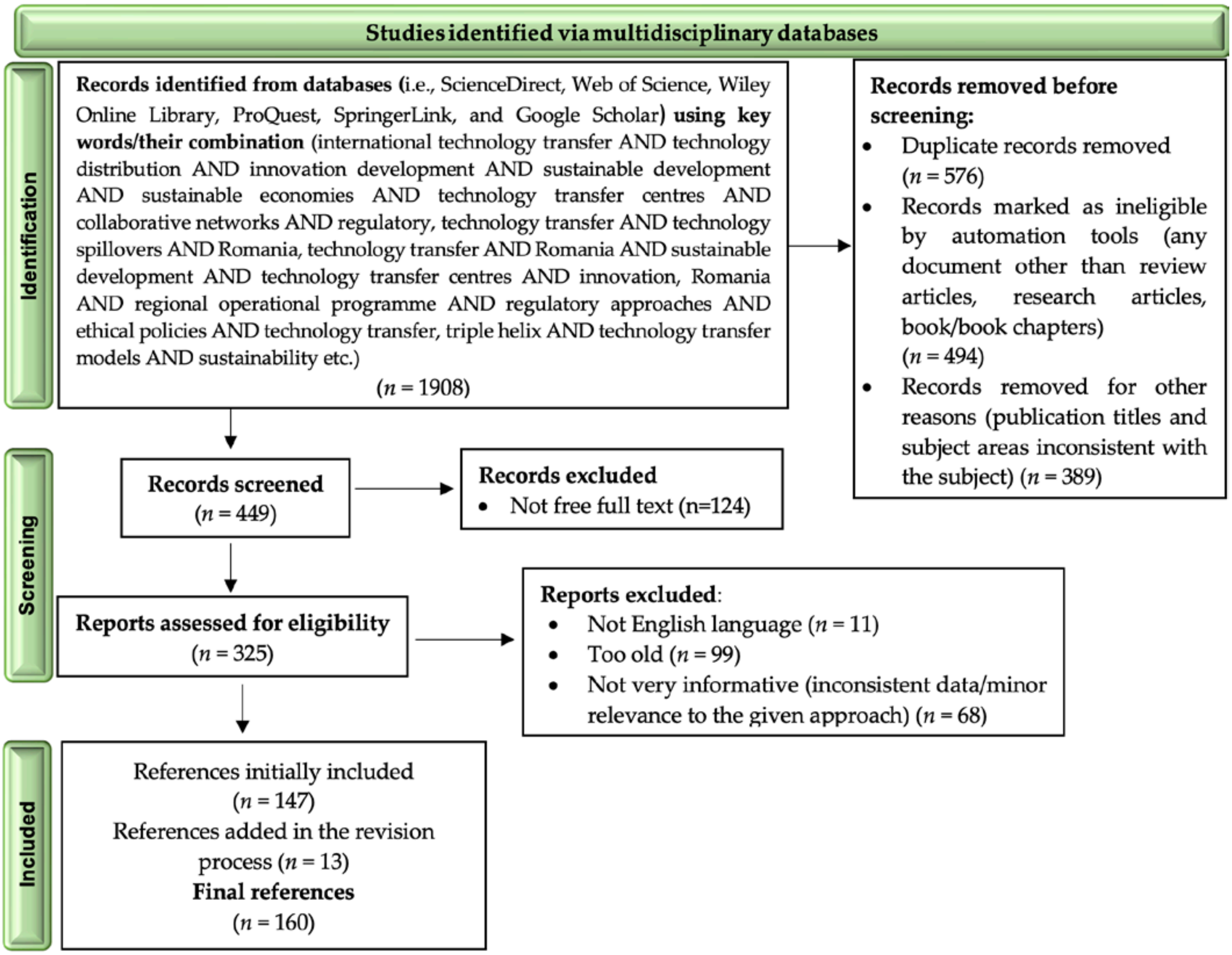

Figure 2. Literature selection depicted in a PRISMA 2020 flow diagram.

3. Global Technology Transfer

3.1. International TT

Multi-channel international technology spillover has emerged as a significant method of enhancing a nation's capacity for technological innovation in the context of an open economic system [23]. Innovation throughput has an impact on how innovation performance is embodied, which is known as innovation quality [24].

The impact of technology on enhancing productivity and improving living standards has been acknowledged for some time now. Productivity can be enhanced through technological progress and innovation, inserting new goods (capital and intermediate inputs), upgrading existing goods, and decreasing production costs. In other terms, technological progress includes changes in organization structure, management procedures, and production processes that enhance productivity. Organizations and institutions which possess the resources to perform innovation and engage in R&D are situated in a reduced number of developed countries, pertaining to the Organization for Economic Co-operation and Development (OECD). Consequently, the greatest number of patents are detained by companies in these countries. In countries where companies have not yet achieved the technological development of more advanced economies, the technology transmission may be an important catalyst for increased productivity, both by imitation and further adjustment and innovation [25].

The mechanism by which a company in one country obtains and uses products manufactured in another is known as international TT, or diffusion, and operates on a technology flow basis (Figure 3) [26].

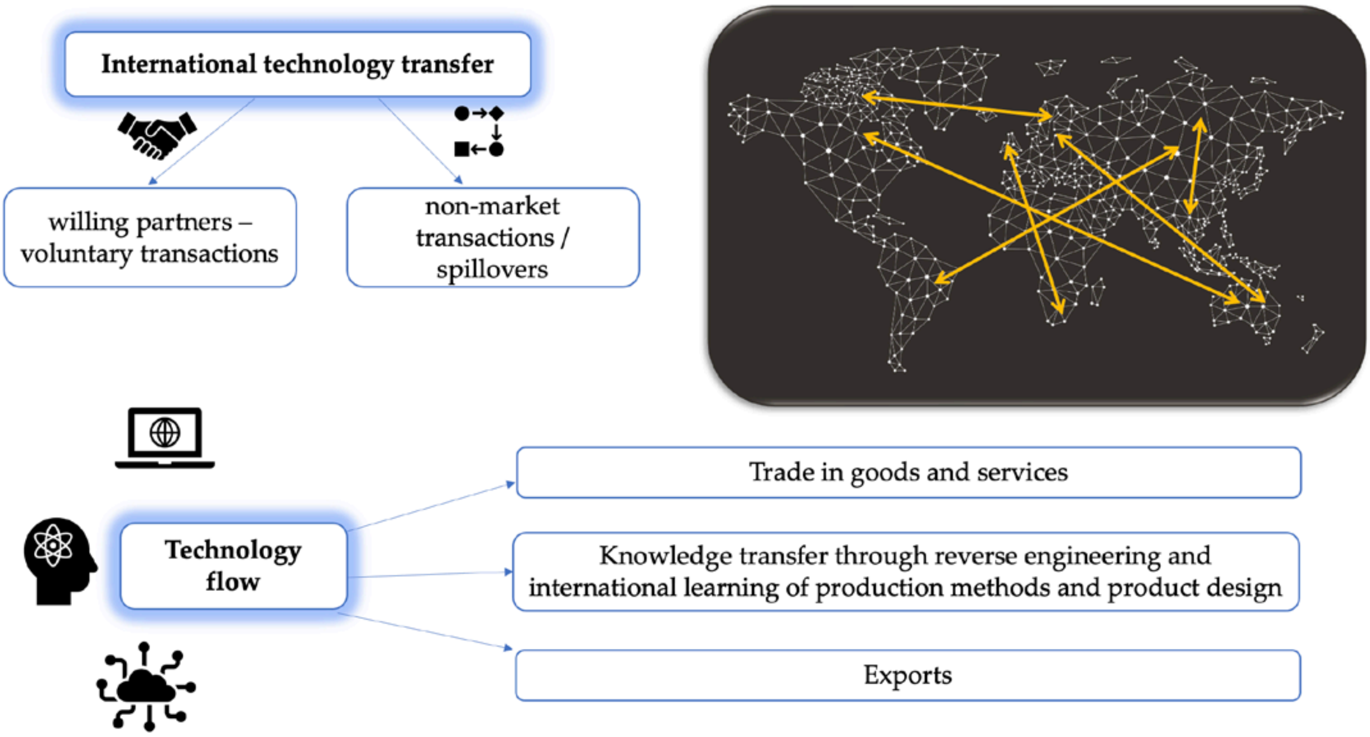

Figure 3. Operating flow of international technology transfer.

3.2. Technology Distribution

It is assumed that the customers' level of expertise can be favorable to the manufacturer when it highlights directions for upgrading the product or enhancing the manufacturing process. Another channel for technology diffusion is Foreign Direct Investment (FDI), especially internal FDI, where multinational corporations provide advanced technology for their subdivisions, technology that is likely to be distributed to companies from the host country. Licensing represents another method for technology distribution, which refers to trading the rights for the production and distribution of a product, as well as the know-how or efficient use practices of these rights [27]. The concept of joint venture typically implies incorporating both licensing, as well as FDI properties, and thus engaging in TT. The exchange of qualified and professionally competent workers between countries can also be seen as a channel for international technology distribution. The technology distribution channels may be interdependent as companies decide which path to use in dealing with foreign partners, depending on the expected yield for the technological resources utilized in the process [28].

TT can be described as the process of technology transition between institutions. The transfer is considered a success when the organization that is on the receiving end (the transferee) can utilize and integrate the transferred technology in its products and processes. The transfer process may also imply sharing technical information, physical resources, and know-how [29–31].

This concept of TT has also been introduced in the context of the exchange or relocation of personnel, or the exchange of particular competences and technical skills [32]. Shifting technology from advanced to emerging countries, from laboratory to industry, or from one field to another, are also forms of TT. From a more restrictive perspective, when technology is defined strictly as information, TT is regarded as information implementation into practical application [33,34].

Some economists evaluated TT, based on the characteristics of generic knowledge. Specific attention has been given to variables associated with product design [35].

3.3. Conceptual Boundaries of TT

Attempts have been made to provide a more extensive definition, which describes TT as a transmission of information, abilities, management, capital, and values, from the generation site to the implementation and adjustment site. In this context, an analysis of the differences between TT and technology diffusion would be beneficial [36].

TT has been defined by sociologists in respect to novelty distribution. This approach generated confusion for many researchers and practitioners who considered the two terms—technology diffusion and TT—interchangeable. Technology diffusion is generally referred to, in literature, as a type of predominantly passive distribution, among a particular technological population, of technological information regarding a particular innovation which is deemed useful to that population [37,38].

The standpoint quality and performance characteristics can be implemented in any research organization, given the decision model's fundamental structure. Expert panels with vast knowledge of TT across different industries have confirmed each perspective and the accompanying success factor [39].

Alternatively, TT is regarded as an active process of acquiring or distributing information, experience, and associated products. Additionally, TT is characterized by a goal oriented and purposeful approach [40]. In contrast to diffusion, TT also implies a level of agreement, and is thus more restrictive in contrast to diffusion [41,42].

Novel technologies and globalization have determined a change of focus from capital and tangible assets to information and intangible assets. Recently, established competitive advantages given by a global economy have deviated TT focus from capital and physical assets to assets based on information and human resources. The transition of TT focus towards perception, knowledge, and innovation, implies that the parties involved in the process are determined and capable to identify the possibilities to implement and trade these commodities, by promoting them within society. To encourage and stimulate the process, a selection of policy directions, especially entrepreneurial policy, are to be examined, as well as intellectual property right (IPRs), the novel domains of academic and economic activities, cluster policies, and attempts at local and regional levels [43].

It is generally accepted that, in a globalized world, local and regional capacities have a strong impact on economic policy. Private sector players may pursue very specific activities and qualifications, which can be found in a specific geographical or administrative area [44].

These activities and skills can exist in connection to scientific organizations or academic institutions, which adapted their culture and mission to an entrepreneurial approach. The presence of entrepreneurship in academia, the social network status and size, as well as experience in the industrial field improve over time, and have a strong impact on the information transfer and TT [45].

3.4. Networks and Innovation Development

Overall, initiating technological partnership between countries is regarded as either mutually advantageous, or unfavorable. The global systems of innovation develop as an outcome of the segregation and differentiation of the innovation processes across the world, but also of international technological partnerships [46].

As a result, the technological partnership flow and progression are expected to satisfy the various standards of a complex global network. According to an evaluation of the international networks of innovation development, a system of classification comprising of four criteria was suggested. Thus, the focal points of this system's criteria are generating social networks, which stimulate information flows, developing partnerships, and combined efforts, which are essential for entering global markets. The networks can be created through a governmental initiative, can be supported by civic or philanthropic structures, can have distinct identity, or may be established around a technological sector [47]. The networks should have independent organization systems, funding, and goals achievement. The distribution of these features is projected to generate a debate involving sociologists and policy makers about TT in a global economy, with the goal of improving the understanding of the emergence, development, mechanics, and the results of international networks [48].

Independent companies that collaborate in the form of joint ventures in order to generate new products, or information and know-how, contribute to a worldwide technological and innovation partnership. From a macro level perspective, global technological partnerships generate information exchange between countries [49].

The technology exchanges between a group of states trigger consequences for other states, such as a more competitive market for the experienced workforce or even information breaches [50].

Studies have been made regarding the configuration and development of global technological partnership networks. These have led to the development of a global scheme of technological partnerships—the global technological partnership network—focusing on the factors that generate technological partnerships between countries. Using patent focused data of international co-inventions, evaluations of the pattern and evolution of the global technological network, as well as the network exchanges, the positions of countries and the economic fundamentals impact on the emergence of technological networks were performed [47]. By amplifying the gravity model of global technological partnership through network actions, studies revealed the powerful influence of a country's place in the network, on the extensiveness of its partnership with other states. According to research, network indices are useful when determining the position of a country in an international RD network. Furthermore, besides the standard descriptive variables, the innovation networks provide further information showing the presence and consistency of RD connections between states [51].

3.5. Technological Expansion and Sustainable Economies

Strategies encouraging entrepreneurial ventures, as well as new directions for business developments, tend to stimulate the establishment of new companies and the creation of novel economic activities. This leads to the conclusion that an entrepreneurial mindset is imposed by the situation. Policy issuing entities, higher education establishments and university governing bodies, as well as mature business, find themselves in a situation where they are required to have an entrepreneurial approach to successfully market their ideas. The pressing need of this change all around the world, eventually led to the emergence of the entrepreneurial society. University entrepreneurship was developed as the response of higher education institutions to this paradigm shift. Researchers have thus analyzed the evolution and impact of universities in society [52].

The pathway of economies, especially in Western countries, was shifted from physical capital, towards know-how and business creation. The factors that determine this economic change also determine the position and scope of universities over time. Entrepreneurial universities model functions by creating information-based startups, initiating TT, and accumulating human resources. Considering the current trend, intensified entrepreneurship and collaborative efforts are the key to success. Considerable impact on the economy is attributed to businesses that have approaches/policies of technological development, while providing occasions to adjust the acquired technologies to new processes or products. The central characteristic of technological convergence in the case of developing countries is the accumulation of technological capacities. In this process the state's contribution is minimal and with reduced impact [44].

Figure 4 illustrates the basic pattern of technological expansion of transnational corporations [53,54] and the classification system of European countries according to international TT and innovative economies [55].

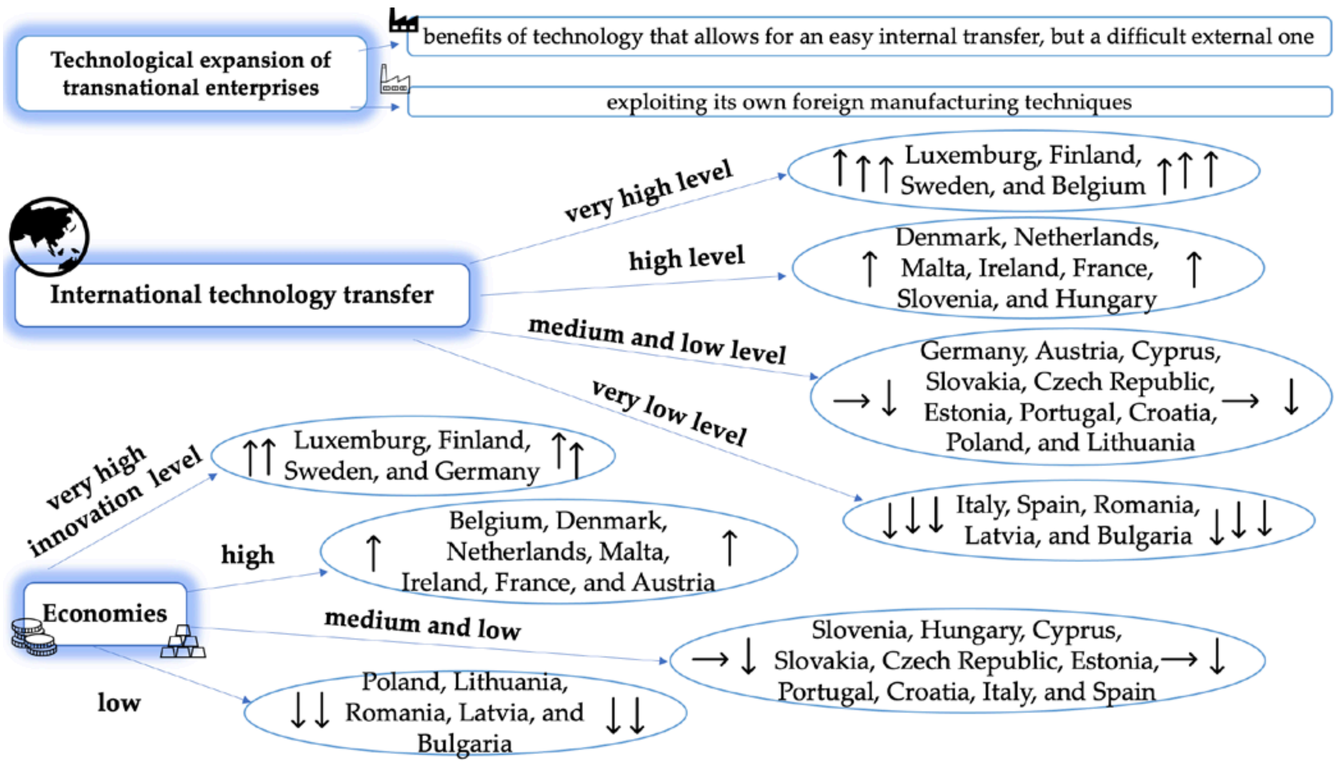

Figure 4. Technological expansion and economic classification of European countries. →, medium; ↑, high; ↓, low.

Two rankings of the examined countries in 2008, one for international TT (ITT) and one for innovation (INN), have been created based on the simulated assessments of the parameters ITT2008 and INN2008. Furthermore, 3 ITT2008 indicators with a significant relationship to the variable are "Foreign direct investment, net", "Product and/or process innovative enterprises, engaged in any type of innovation cooperation with a partner in the USA", and "Product and/or process innovative enterprises, engaged in any type of innovation cooperation with a partner in China or India". The five indicators, "Innovative enterprises", "Employment in knowledge-intensive activities", "Business enterprise R&D spending", "Total intramural R&D expenditure", and "Patent applications to the EPO", all show a substantial correlation with the latent variable INN2008. The ranking of European countries according to the ITT2008 and INN2008 indicators places Romania 24th and 26th, respectively, in the European Union. By comparison, Luxembourg ranked 1st in both categories, while other countries ranked differently according to the indicators (i.e., Sweden 3rd place-ITT2008 and 2nd place-INN2008, Finland 2nd place-ITT2008 and 4th place-INN2008, and Bulgaria 26th place-ITT2008 and 24th place-INN2008) [54,55].

The recalculation of the indicators in 2014 changed the rankings for different countries (i.e., Luxembourg ranked 5-ITT2014 and 3-INN2014, Finland ranked 7-ITT2014 and 5-INN2014, and Bulgaria ranked 23-ITT2014 and 25-INN2014), but Romania remained in the same positions in both categories. These changes suggest a continuing dynamic in terms of the TT and innovation process [55].

One approach to increasing TT is to enhance the circulation of soft technologies pertaining to international businesses, with favorable effects on competitive benefits concerning non-embodied technologies use. To initiate/generate the successful use and incorporation of the acquired technologies, it is necessary to enhance the absorption capabilities of foreign divisions. The enterprises have to direct administrative policies from the transfer of present technologies to information transfer and qualification enhancement, with the purpose of increasing research capacities and securing further development opportunities [54].

The goal of obtaining durable and overall growth for economies is often obstructed by disproportionate access to technology [56]. The homogenous distribution of essential technologies, such as medical diagnostic technologies, electricity based technologies, high-yield crops, and Internet from developed to developing countries, would generate an essential degree of progress all over the world [57].

Internet technological advancements have made the competitive environment more complex, which has led to the emergence of a brand-new, still-expanding digital ecosystem. As a result, with the development of distinctive and significant novel technologies, a company's product and service offerings are expanding and improving due to a technological emphasis [58].

The complexity of the Sustainable Development Goals demands implies on one level the trans-national distribution of technologies, and on another level the progress, adjustment, and enforcement of new technologies, as well as distribution among countries, geographical regions, and throughout socioeconomic categories. Foreign direct investment, TT reproduction and assimilation, and domestic RD, are the main options for developing countries to technological evolution and to bridge the gap between developing and developed states [26].

As developing countries have reduced capabilities and resources for domestic RD, alternative mechanisms are considered more important. In order to benefit from novel or enhanced technologies, developing countries should focus on the learning and progress opportunities from already acquired technology, and from the associated information coming from international channels. There are cases where this approach was implemented with great success. From a quality of life perspective, international technological transfer is an essential element for reaching the junction of developed and developing worlds [59].

3.6. Global Regulatory Approaches

Although the majority of EU states are on track to reaching the 2020 EU goals for renewable energy, having widely applied renewable energy technologies, there remain other EU countries which are lagging behind in this area [60]. This can potentially be explained through the difficulties in applying TT, especially since the patents regarding renewable energy are typically private property [61].

Considering these aspects, the EU has been supportive of the transfer of renewable technology between the member countries and other states outside of the EU. The EU is about to accomplish the 2020 goals concerning renewable energy, by following the Joint Opportunities for Unconventional or Long-term Energy Supply (JOULE) scheme [62].

Offshore islands and mountainous regions are both renewable energy targets included in the scheme. The JOULE scheme was elaborated as a collective action, offering opportunities to many EU states to take into consideration technologies for renewable energy, by transferring such technologies from national and regional networks to isolated areas. Thus, the JOULE program generated an effective TT between EU countries. The total reported innovations regarding renewable energy allow us to quantify the extent and success of TT within the EU [63].

Innovations concerning the reduction of climate change effects can also serve as an acceptable indicator for the extent of renewable energy TT. Since the 1990s, there has been a constant growth in the number of innovations reported in relation to climate change reduction [64].

It is important to note that conflicting opinions on the use of bioenergy and biomass resources represent a problem which challenges the transfer of bioenergy between the EU states. Several of those states maintain that several issues have not been addressed by the EU with full clarity and transparency. For example, several countries claim that the EU was ambiguous on the topics of land use, land use change, and forestry (sometimes referred to as the LULUCF pact) agreement, which had a particularly strong impact on bioenergy and biomass TT [65]. This agreement addresses forestry exploitation in developed countries which had agreed to cut down on the emissions of greenhouse gas, as per the Kyoto convention [66].

Some EU countries, including Finland, Sweden, and Austria, are characterized by industries based on timber exploitation. Thus, in the context that these countries strive to protect their timber-based industries, the Environment Council of Ministers failed to reach an agreement on the regulations and policies concerning forestry in developed countries. The TT of renewable energy sources, such as biomass technology and solar technology, is obstructed by issues related to IPRs [67].

Considering that there is no agreement between EU countries concerning renewable energy TT, the obstacles generated by IPRs cannot currently be settled. EU countries which possess innovative technologies concerning bioenergy are reserved in distributing their know-how, or supporting the costs of know-how distribution. In parallel, other developed countries within the EU are reluctant in accepting higher expenses, which would be generated by the distribution of these technologies. In contrast to the approach of more developed EU states, countries with less financial contributions for research and progress in the field of renewable energy sources claim that the expenses concerning IPRs should be distributed between all EU states [68].

Regulations encouraging the TT mechanism and practices appeared only recently in Europe. In Germany, for instance, the correspondent of the Bayh-Dole Act appeared only in 2002, with a delay of 20 years [69].

Consequently, the legal framework favored partnerships between universities and industry (university-industry collaboration UIC), determining the creation of TTOs, which in turn led to a higher rate of patent registrations and to enhancements of the industrial and administrative processes involved in TT [70,71].

It is worth mentioning that universities have accumulated expertise in TT processes by repeatedly engaging in collaborations and partnerships with the industry. Nevertheless, without adequate management, the processes tend to remain informal, as researchers lack the administrative competences required to successfully perform TT [72].

4. Technological Transfer in Romania

4.1. Regional Operational Programme

In Romania, Smart Specialization emerged within the timeframe of 2014–2020, primarily through the creation and application of Priority Axis 1 (PA 1), as a part of a Regional Operational Program (ROP), which was established with the goal of encouraging TT. In Romania, the PA1 ROP program is centered on investment opportunities in new fields of research and innovative business ventures. To plan and apply PA1, the managing authority of ROP developed and launched a process of business study and innovation at a regional scale, to meet the ideal preconditions for a high-quality set of projects. Smart Specialization approaches and instruments emerged as a result of the evaluation and creation process, carried out at regional and national scale, with significant and sustained help from the European Commission, especially from the Joint Research Center (JRC), which offered assistance during the entire policy cycle, in accordance with the scientific data presented by Romania.

Therefore, zone-specific innovation ecosystems (emerging models) received assistance in accelerating their development and expanding their activity, while operating in connection to a centrally administered national innovation network [73].

A novel management pattern was created and evaluated, in order to improve connections and enhance collaboration between regional and national systems and to provide optimal resolutions for associated challenges, with the goal of obtaining commercial and social benefits. Therefore, in each area, in addition to the Regional Development Council (political structure) and the Regional Development Agency (administrative agency) a Regional Innovation Consortium was established, encompassing universities, representatives from the civil society, researchers, innovative small and medium-sized enterprises, and members of the local public authorities. The role of this consortium would be to guide and advise on the development of innovation-centered projects and the Research and Innovation Smart Specialization Strategy (RIS3) [73,74]. Regarding the European Innovation Scoreboard in Romania, the recorded innovation coefficients were lower when compared to those of other EU member states. The proposed solutions to encourage TT and enhance the score imply the establishment of public-private collaborations, spin-off/derivative businesses oriented towards research outcomes, research capitalization, profile cluster growth, and offering fiscal benefits to business in the field of innovation, research, and TT [75].

Research has shown that, in Romania, RDI projects are attributed a low share of the gross domestic product budget, in comparison with the EU and international averages. The German model of capitalization on research outcomes, specifically through the Steinbeis approach, proposes sustainable TT possibilities that can be implemented in European countries, and also within Romanian research institutions [76].

4.2. Collaborative Networks in TT Framework

Concerning the evolution of TT in Romania, studies have revealed a low and insufficient level of collaboration between the main players engaged in TT, such as research institutions, universities, and the businesses sector. The legal framework concerning research is minimal and vague, and does not encourage the creation of combined spin-off/derivative/by-product type companies, which would in turn generate TT [77].

At the national scale, university research has led to a large number of registered patents, in the context which, along with ISI indexed articles, patents are considered performance indicators. However, according to a study performed on the necessity of TT between companies in the Northeastern Romania, these patents lack practical implementation, and thus remain unutilized. This situation diverges from the governmental strategies regarding research and innovation. In regard to transfer pricing, the total worth of new contracts made with companies within a year—collaboration and research contracts—the value obtained in one year from these contracts and license granting, spin-off or share sales profits are considered the major transfer pricing markers. The impact of TT is best illustrated by these indicators, therefore the university research outcomes are expected to be closely supervised, while also publicized [78].

Figure 5 shows the development of Romania's innovation and TT infrastructure through the establishment of specialized centers and facilities for support and knowledge in science and technology [79].

The limited investments and poor marketing activity, which characterize Romanian public research institutions, negatively impact the infrastructure of national TT, as concluded in the National Strategy for Research and Innovation 2014–2020. This situation has developed as a result of the lack of specialists which should ideally be involved in the technology and information transfer between public and private organizations. Although the TT framework should be adequately situated, to ensure public visibility, addressability, and commercial attractiveness, public research institutions cannot meet this goal due to the lack TT of professionals. Therefore, the chances to transfer and implement commercially or socially influential research from the academic to the socio-economic environment are fairly reduced. In 2009, the Innovation and Technology Transfer Network was established for supporting and maximizing the TT at national scale. The approach of the National Innovation and Technology Transfer Network (known in Romania as ReNITT) implies on one hand assisting the beneficiaries of TT, such as small and medium-sized enterprises, and on the other hand, supporting innovation generating agents, such as universities and research [80].

As RDI organizations are predominantly represented by laboratories, the evaluation of institutions involved in the TT process, based on the type of the institution, has produced homogenous results. Universities, however, include several types of research entities, the main being research centers, and the less prevalent entities comprising of TT centers, innovation centers, and science parks. Innovation centers are the only institutions mentioned by respondents from public research entities associated with TT programs.

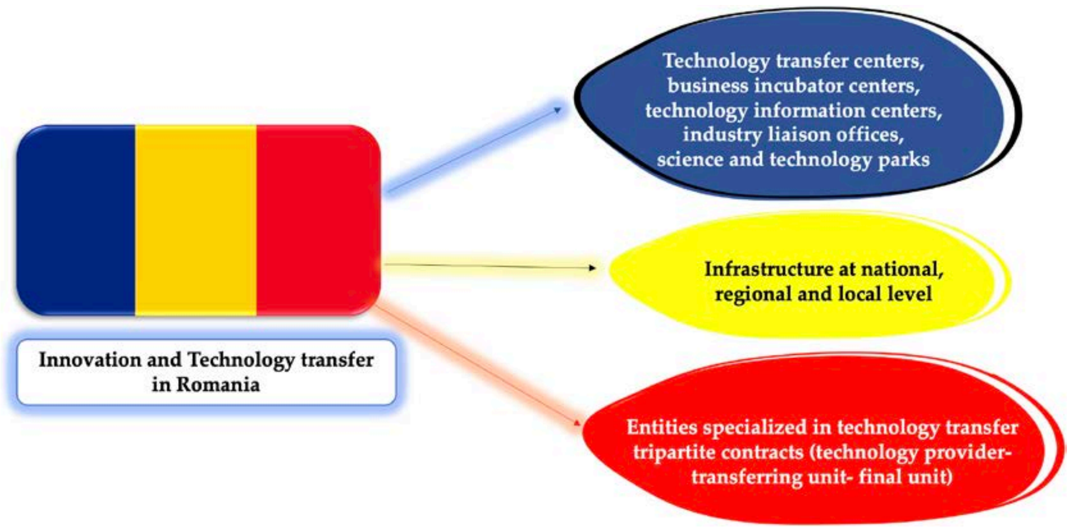

Figure 5. Development of technology transfer infrastructure in Romania.

4.3. Technology Transfer Centers

In private research facilities, the context is drastically different; the TT center and technology brokers being the most significant players in the TT processes [21]. An estimated 30% of survey respondents in businesses and governmental institutions reported the lack of organizational structures active in TT programs within their organization. Comparatively, start-up incubators appear to be among the organizational units most implied in TT procedures, both for private businesses and private research facilities. According to data collected on organizational units engaged in TT, the following parallel is drawn between RDI in the public sector and in the private sector: public RDI institutions predominantly use research departments, laboratories, and departments as the primary organizational units associated with TT; while in the private sector, RDI entities, such as businesses and research organizations which engage in RDI, typically use other types of organizational units to perform TT (expertise centers, start-up incubators). Depending on the role of a company within the TT process, different organizational bodies can be involved [21,81]. The research centers and sections, the laboratories, but also the TT centers, are the most significant organizational units engaged in TT, as revealed by the survey respondents from organizations engaged in TT activities. This is an expected result, given that the respondents are generally associated with research institutes and publicly funded universities. The respondents also mentioned start-up incubators, specialized brokerage, and science parks as other organizational institutions engaged in TT to varying degrees. According to the answers provided by representatives from technology-absorbing organizations, the entities which benefit from the technology do not have departments specialized in TT, laboratories, or research centers. The involvement of innovation hubs, start-up incubators, and technology support units in TT activities was assessed as reduced and insufficient [81].

The Center for Project Management and Technology Transfer (CPMTT) was founded as a cross-disciplinary entity of TT. It was also designed to provide resources for the management and implementation of research, alongside specialized consulting. Its goals include improving institutional achievements, optimizing the financing scheme for better project access to both national and international funds, and promoting TT between the academic environment and socio-economic entities. In the context of project management, below are the synthetic collective outcomes obtained by CPMTT from carrying out more than 13 high-impact projects (Figure 6) [41].

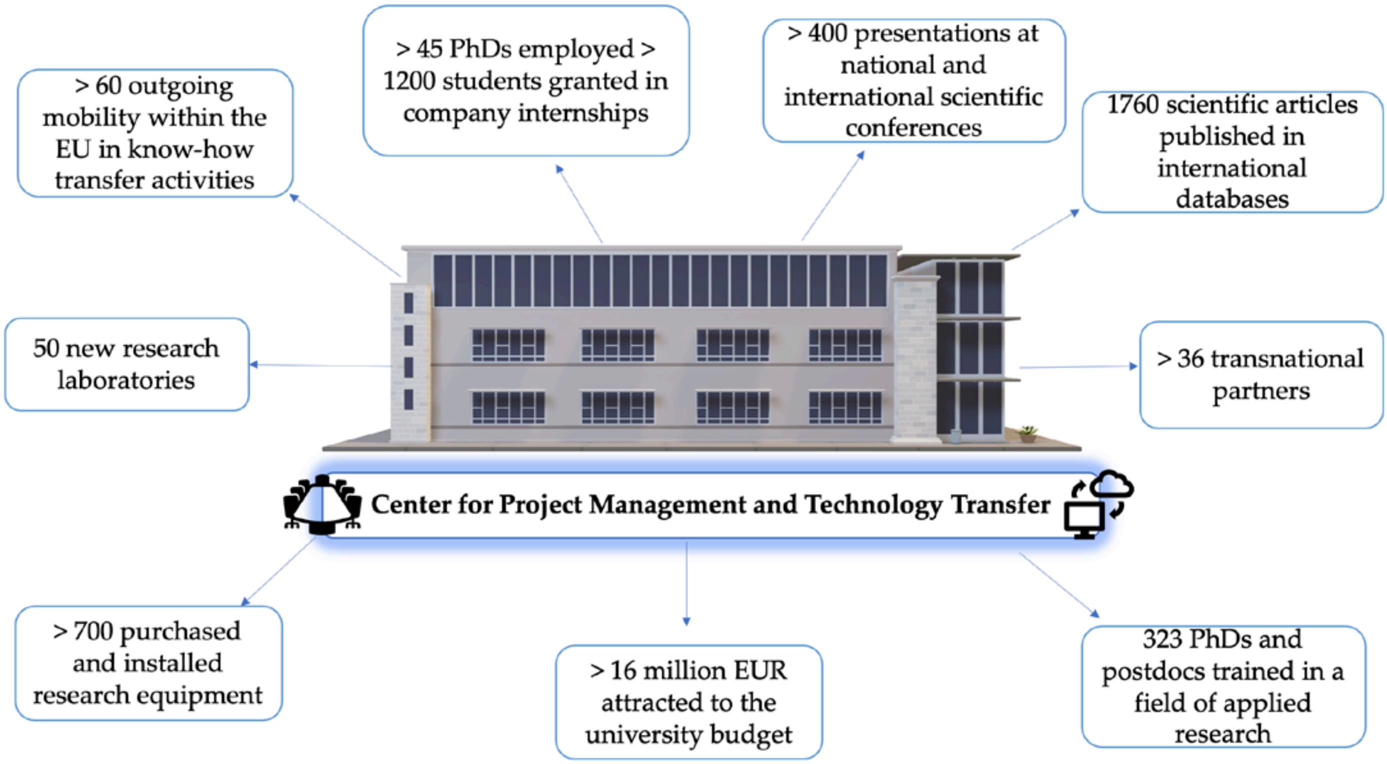

Figure 6. Results through multidisciplinary programs in the context of project management.

The aforementioned findings highlight the acute need for the TTO to increase specific resources, including financial, material, human, and academic, which will contribute and support future RDI and TT efforts (as reported by the TTO project management operations previously mentioned) [82].

According to Schumpeter, as a revitalization stimulant for evolutionary economics, a specific TTO (as CPMTT) may be introduced to expand the economic area through quality-focused and change-oriented mechanisms based on innovation, defined by the economist as the novel associations of available means [83].

The focal point of "The Theory of Economic Development" by Schumpeter, is the industrial sector, with the entrepreneur as the primary agent in the act of generating innovation and invention, which would exclusively develop from business. To support the progress of open innovation through a business and entrepreneurship-oriented approach, both directly and in long-term partnerships with a university, CPMTT's advanced training and specialization measures were developed using several funding projects and engaging committed specialists with a good acumen for business and entrepreneurial approaches. Cavallini et al. acknowledged that, in the context of continuing education, unique synergies can be established if instruction is provided by an entrepreneurial institution [84].

5. Technology Transfer Models

Specialized literature in the field of TT and innovation has shown us that TT researchers have made an attempt to create a new TT model that differs from the standard models that were previously in place, with an emphasis on TT processes. Regarding their applicability to modern high-tech activities, the novel models created by researchers aim to address the drawbacks of the traditional TT models. The importance of communication between the technology creator and the final beneficiary and across multiple entities involved in TT, along with the stages of TT, factors affecting TT and knowledge transfer, and TT mechanisms in international joint ventures (IJV) were emphasized in several models created after the 1990s [85–87].

5.1. Gibson and Slimor's Model

This model operates with three degrees of involvement to represent TT from the viewpoint of technology researchers and users. The business and communication concepts serve as the framework for this approach. According to this paradigm, there are three different levels of technology adoption (TT): Level 1 (Technological Progress), Level 2 (Technology Acceptance/Approval), and Level 3 (Technology Application/Implementation). This model incorporates the processes related to the conventional models and describes the various levels of TT participation [85]. The most crucial level of technological development is when information is transferred passively using items like study reports, computer tapes and journal publications. This level pertains to the appropriability paradigm, which highlights the value of high-caliber research and trade pressure to obtain TT. A higher degree of technology acceptance means greater TT contribution. The technology developer oversees ensuring that the technology is accessible to the personnel that can comprehend it and perhaps use it [85,88]. This degree of participation corresponds to the dissemination model, which focuses on distributing new ideas to specific consumers. In TT, the level of technology application is of increased complexity. Apart from other applications, such as internal business procedures, technology application also refers to trading its use in the market. At this level, which corresponds to the expertise applying model, the focus is on the crucial connection between technology developers and consumers as well as the administrative barriers and promoters of TT [85].

5.2. Sung and Gibson's Model

The goals of this model, which are to overcome shortcomings in the conventional TT models, are comparable to those of Gibson and Slimor's (1991) model. Figure 7 shows the model described by Sung and Gibson, presenting the four levels in the development of an optimal technology transfer, starting from the creation of the research-based concept to the commercialization stage [87].

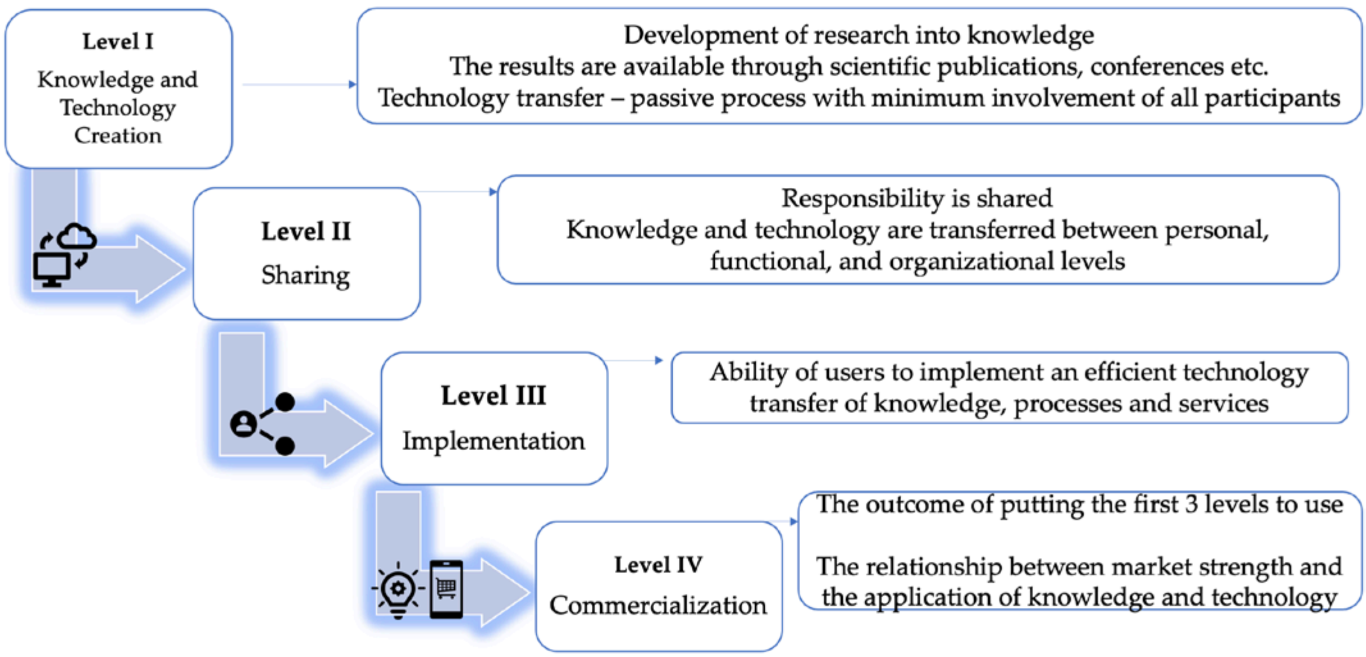

Figure 7. Sung and Gibson's Model.

5.3. Rebentisch and Ferretti's Model

Based on a study using the knowledge gained from the analysis of two IJVs, a comprehensive model of TT activity was suggested by Rebentisch and Ferretti (1995). Additional research and integration are needed in two specific TT areas: firstly, the impact of the interactions between the institutional framework and the technology features, and secondly, the balance point of the company's fundamental strengths and its capacity to take on innovative technology. The approach covers two key issues: the work volume involved in transferring a wide range of technologies, as well as the effects of current company techniques and skills on the TT activity. According to this paradigm, TT is defined as the transfer of the know-how resources between institutions [86]. Figure 8 shows the TT mechanism throughout this model.

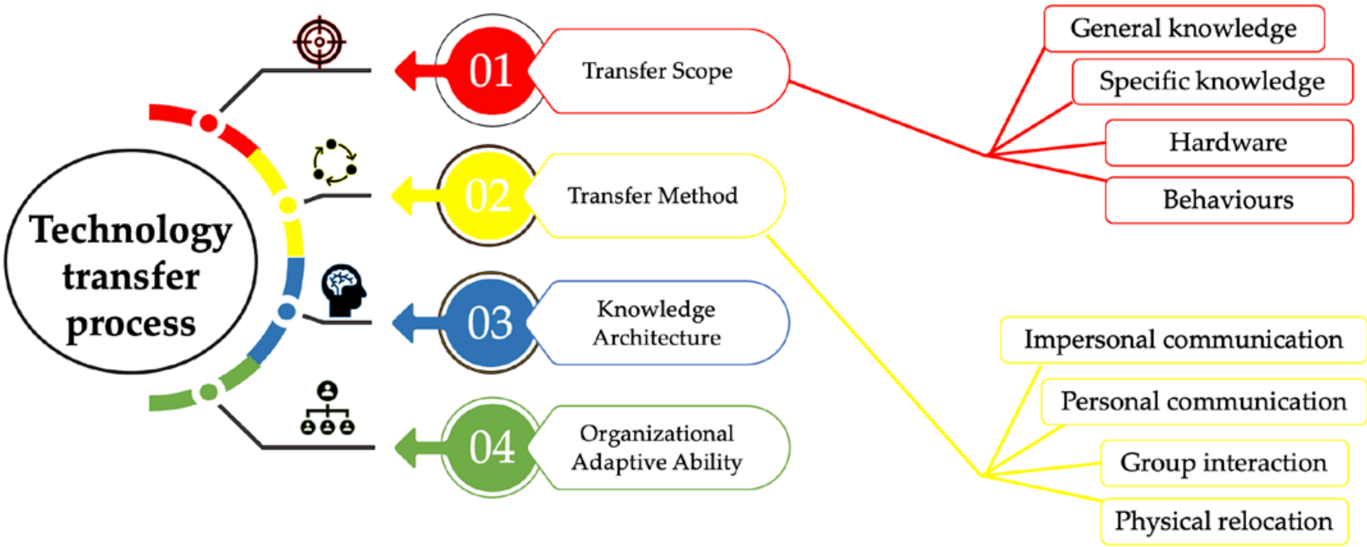

Figure 8. Rebentisch and Ferretti's model.

A description of the configuration and objects into which information has been incorporated in the organization is referred to as knowledge architecture. This novel term also outlines how the institution accumulates data and addresses that processes used to manipulate and utilize the data. Experience-based knowledge, technology instruments, institutional power structures, and processes, represent four key components of knowledge architecture that have a significant impact on the TT process. These factors are correlated with the intricacy of technology, its conformity with the institution, the extent of the associated expenses, the magnitude of transformation needed in deploying it, and the likelihood of experiencing technological resistance. The capacity of an institution to use its assets to adapt to an innovative technology, or even to itself, has been defined as the organizational adaptive ability [86,88]. Flexibility in human resource recruitment, as well as in production, are the basis of an organization's adaptive capacity. Despite being built on the basis of two IJVs, this model largely provides theoretical perspectives into the incorporated technology (specific information) or hardware TT processes. It lacks the foundation of evidence-based research or statistical assumption testing. This model has an intrinsic linear bias since it is based exclusively on the viewpoint of the transferring entity. In this context, the association and circumstantial aspects of JVs were not taken into account [86].

The National Aeronautics and Space Administration (NASA) defines TT as the activity of transmitting the existing technology of a company/institution to other external objectives and processes. Figure 9 displays the categories that can be used to classify TT forms [89].

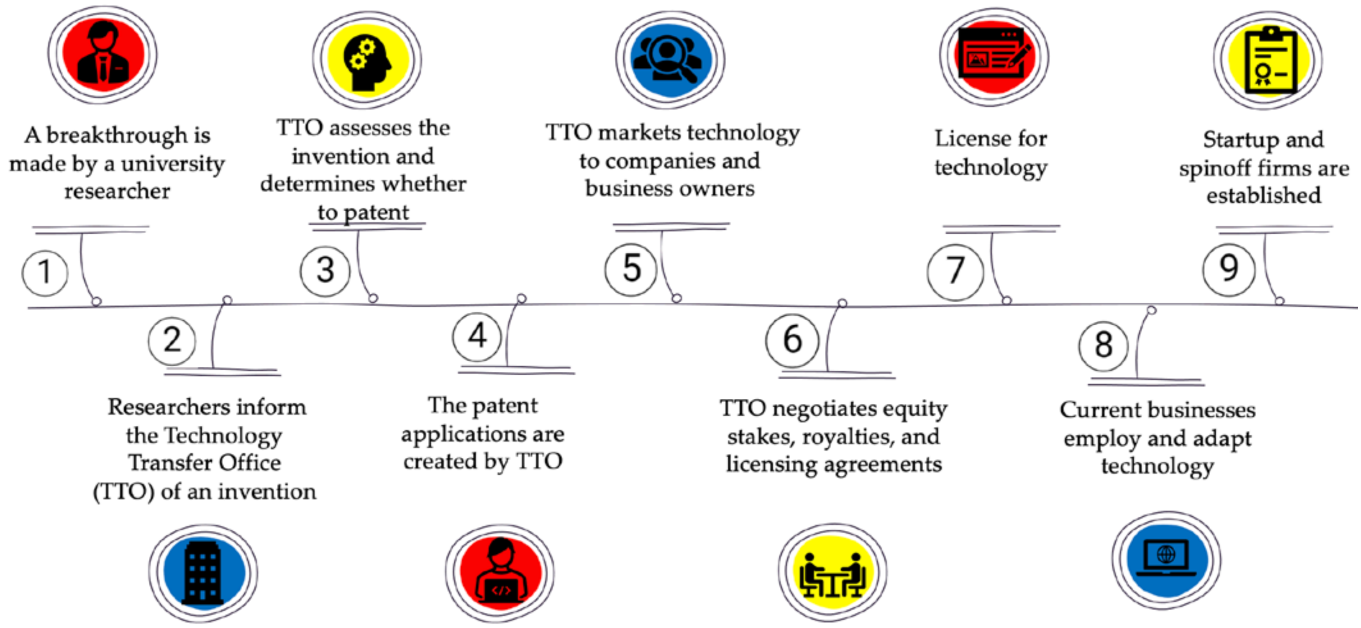

Figure 9. Types of technology transfer.

5.4. Linear Models of Technology Transfer

Establishing a point of origin for the evaluation of linear TT models can be challenging; nonetheless, the Appropriability Model, created in the 1940s and 1950s, seems to be the earliest widely recognized linear model of TT. The Appropriability Model assumed that TT materializes when the transferred technology has identified its consumers. This view is founded on the Keynesian theories of a request-driven economy [90]. The model's key elements are presented in Table 1.

Table 1. Key Factors of the model, by qualitative methodology.

Range	Model's Key Factors	Ref.
General model of technology transfer, practical case	This model considers the transmission of information, and the promotion of a product is the key to its delivery.	[91]
Between areas of a company, conceptual model	It is based on the diffusion process. The model is valid within the same institution, between its agents, and summarizes positive/negative factors that affect the TT process.	[92]
University-industry, practical case	The model provides the specific approaches that are used considering the particular characteristics of the agents, describing the role of any new actor that can facilitate the "translation" of the language used between the transmitter/sender and the receiver.	[93]
University-industry, conceptual model	The model describes the approach of the system based on the triple helix, the main actors being the university (technology creator), the TTO (intermediary agent) that supports the TT process and the industry (technology receiver).	[94]
University-industry, practical case	This model is built based on a given case and details the 7 steps that must be considered in carrying out TT.	[95]
Between international industries, quantitative	The model states that TT is conditioned by the socio-political framework, also describing the role and relevance of the learning process based on previous experiences, in order to optimize the next TT processes.	[96]
University-company, practical case	This model details 3 levels offered by university research, namely: that of technology, of science, and of use, the TT being realized at any of the levels.	[97]

Table 1. *Cont.*

Range	Model's Key Factors	Ref.
Between areas of a company, conceptual model	This is a model based on another one presented in the literature [92], being completed with the "big environment", showing that the legislative framework influences TT.	[98]
General model of TT, conceptual model	As an essential factor, this model considers the effectiveness criteria for the TT process. The importance of the public is added to the update of the 2015 model, as a determining factor in obtaining the success of a TT.	[99]
University/industry, conceptual model	This model states that besides the formal TT, there is an informal TT as well, and considers that a university also has the mission of powering the industry to generate innovation.	[100]

TT, technology transfer; TTO, technology transfer office.

According to the linear model of TT, government and universities are viewed as uninvolved actors in the process, while comparatively private enterprises acting as technology exploiters are the sole active participants. The Dissemination Paradigm, which was created between 1960 and 1970, represented the next stage in the progress of the TT model. It was noted that the TT procedure was more effective when academic researchers engaged in identifying potential technology users [88]. While the Appropriability Model of TT presents the technology user as the only active representative within the TT process, the Dissemination Model, additionally assigns an essential role to the specialist, as the intermediary between researchers and non-specialized technology users. The 1980s brought about the development of the next notable TT model, namely, the Knowledge Utilization Model [101,102].

The Knowledge Utilization Model was developed with a focus on the crucial success features of TT, and it was characterized by a more thorough analysis of the TT process, in comparison to earlier models. Interpersonal communication obstacles and organizational impediments in terms of structural units were the two key critical success determinants identified by the Knowledge Utilization Model [88]. From the 1980s onwards, it was believed that management's capacity to overcome these obstacles is predominantly responsible for the effectiveness of TT. The next popular approach was the Communication Model, established at the beginning of the 1990s. During this period, computer technology was responsible for drastically altering how information was exchanged, delivered, stored, processed. As a result, the focus in TT switched to information and communication technologies and associated processes [103]. The earliest efforts to integrate linear models with the most basic non-linear models were made around this time. Parallels can be drawn between the core principle of structural programming—systematizing all information stream into a structure of parallel and consecutive flows—and the innovative strategy to conduct TT processes in the first non-linear TT models, with an effort to coordinate operations in parallel and consecutive stream [102].

It was feasible to do several activities at the same time, which was not possible with linear models, thanks to various parallel and consecutive processes, which were relatively simple and allowed for easy and efficient management from one side. It is worth noting that the Bayh-Dole Act, which was adopted in the USA in 1980, was strongly linked to the evolution of linear TT models from an organizational perspective [104]. The Act made it easier for academic institutions to endorse legal rights to technologies generated by academics with Federal financing, with the goal of promoting commercialization. Bayh-Dole emerged once the crucial role of TT in advancing science and technology was recognized, and as soon as the need to hasten scientific progress through the creation of new technologies became more pressing. Currently, it is obvious that the number of research-based patents has significantly surged since the Bayh-Dole Act was adopted. The Act created guidelines for how academia, the government, and business should interact and administer their relationships [105].

It has accelerated the development of new models for TT and has increased science and technology application operations for the creation of new products and services. The early TT models were linear models because the Bayh-Dole Act was implicitly rooted in the paradigm that innovation follows a "linear model". The linear model entails those private businesses finance action-oriented research and marketing, while universities focus mostly on basic research with minimal consideration for the potential to practically implement the research. The stages that make up the conventional linear model of university TT [102] are presented in Figure 10a–c, through three linear models, structured on six steps.

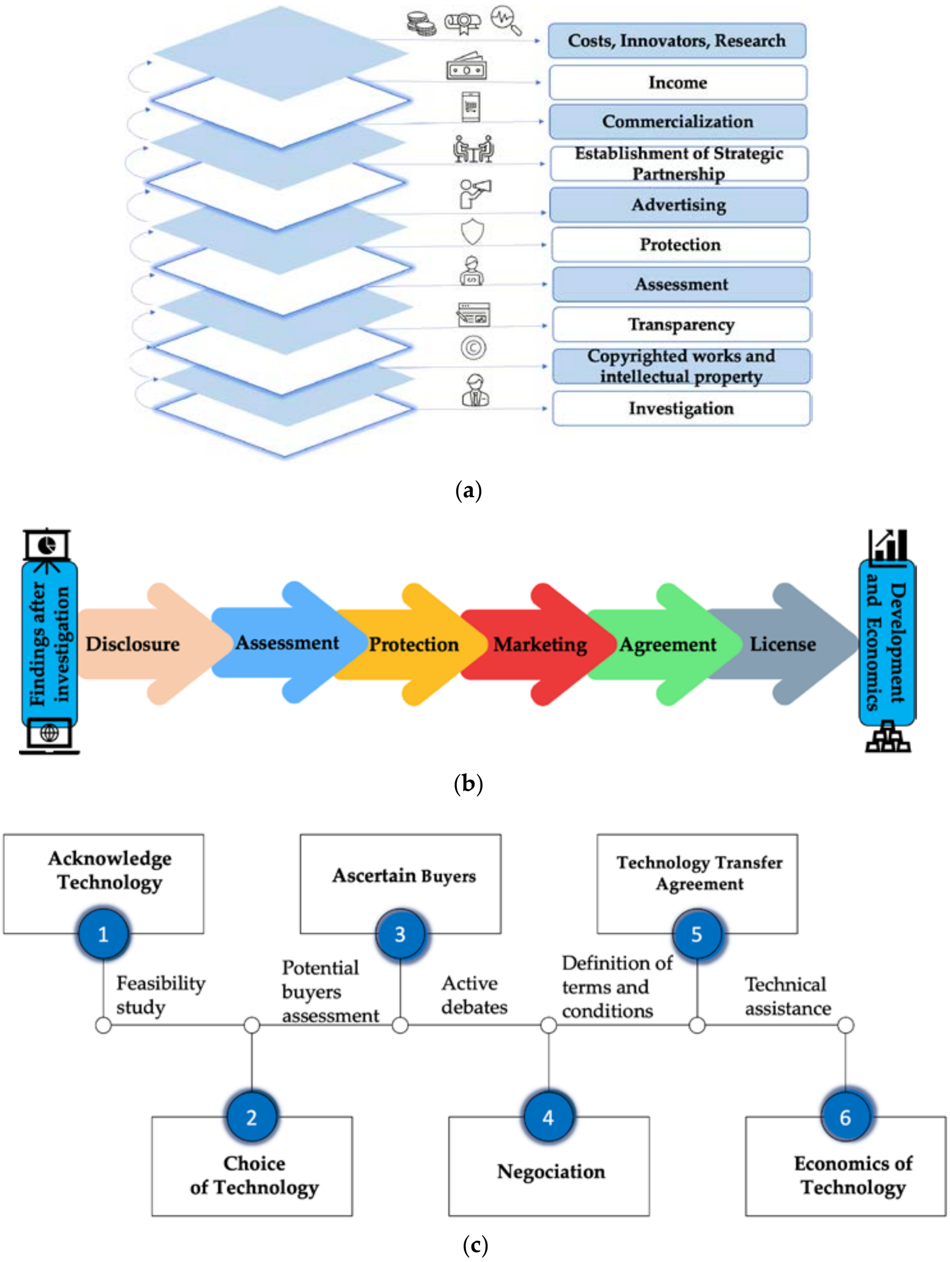

Figure 10. (**a**–**c**) Three different linear models of university technology transfer, in six steps.

5.5. Non-Linear Parallel-Sequential Models

The history of non-linear parallel-sequential models can easily be comprehended. When conducting a singular TT, a linear model can be used. However, in the attempt to obtain funding for several independent TTs at various phases, the recommendation is to apply an industrial strategy that is focused on mass production. Mass production is characterized by cyclical processes. TT models are linear at the level of individual technologies, but they should be cyclical when considering the entire program. Since the TT program comprises of several activities, cyclical processes are more suitable [88,102].

A model based on corresponding parallel-sequential patterns and other alternatives was created during the second phase of the cyclical models' evolution, through conjunction with linear models. In contrast to linear models, the key benefit of these models is the ability to carry out several tasks at once, cutting down on the process' overall time. Following subsequent evolutions, parallel-sequential models were converted in models with bask feeds (Figure 11) [102].

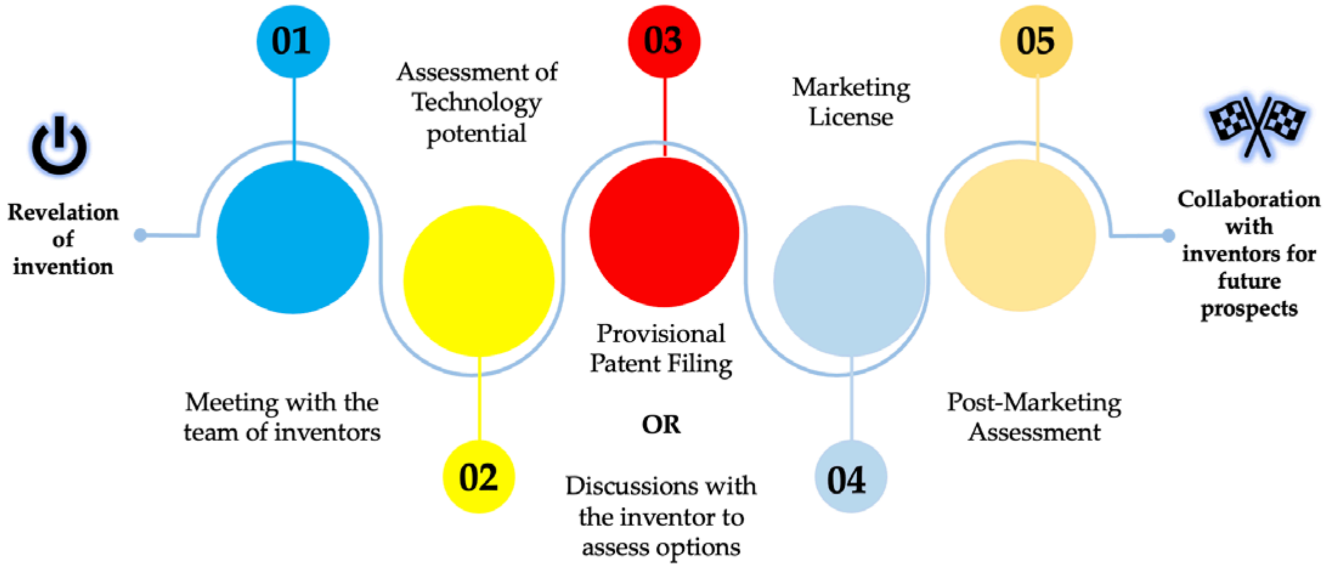

Figure 11. Non-linear model with alternatives.

6. University Technology Transfer

In recent years, academic researchers, university governing bodies, research funding entities, and government regulators, have recognized the increasing significance of university technology transfer (UTT) [106]. Researchers across a plethora of academic fields, such as public policy, innovation, geography, economics, and business administration, have developed a strong interest in UTT. It represents a subdivision of the larger area of TT and entails the transfer of university research findings from academia to industry, so that industry can finance the creation of goods and services that bring a positive contribution to society. Various fields of study can be the source of viable and applicable research results [105].

Moreover, the results are not constrained to one concept of technology and can be applied to both existing and novel businesses, regardless of their profit profile and history. In order to transform the results of early-stage research into innovative products and services, the base activity implies certifying patent requests and different intellectual property to existing enterprises, as well as creating new companies that increase investment capital [106]. To oversee and administer their UTT efforts, research universities have established TTOs. A project management methodology is used by TTOs to assist academic researchers in applying their findings to the external business sector. The following project phases are involved: identification, assessment, protection, commercializing, deal agreement, and post-agreement management. TTO activities largely focus on licensing, entrepreneurship, and patenting, however they also support other complementary activities, which prove to have a beneficial impact on society [107].

In recent years, communities have seen numerous transformations and encountered various barriers. For any politician, comprehension emerges as the most important requirement. A rising amount of literature also discusses how universities, enterprises, and governments interact. A basic paradigm, strategic framework, and methodology are provided by the triple helix theory for examining the interaction of innovation stakeholders at the network level. The underpinning paradigm is distinct from other strategies and ideas, such as the triangle concept or innovation policy systems. According to the human capital concept, education systems are crucial for fostering conditions that will lead to long-term advancement and development [108,109].

Universities are currently gaining more recognition for encouraging entrepreneurship and functioning as a bridge to further high-tech innovations. The integration of the triple helix, which has a strong connection and effective cooperation, enables countries to foresee how they might create income and establish a knowledge-based society. Achieving a balanced and strongly supportive dynamic between sustainable development and technological progress represents a major task for society [110,111]. Therefore, it is crucial to evaluate how the triple helix axis is operating globally.

Depending on their social role and impact, universities are classified as either research-focused, teaching-focused, or entrepreneurial. In the context of UTT, TT can be defined as the process of marketing university research with the goal of obtaining impact via knowledge breakthroughs, innovation, and community involvement [112–114].

The information ingrained in research is claimed to be capitalized upon within the university's research marketing process, with institutions that focus on such actions seen as "entrepreneurial" [115]. Commercialization has frequently been used as the term to collectively refer to TT mechanisms that yield financial benefits [116]. The disclosure of a researcher's discovery to the institution has a formalizing effect on the mechanism of commercialization. Basically, this means that universities can safeguard their research output as intellectual property which would then be traded to the business sector or final consumers. It is often implied that the revenue from this process is reinvested in universities to support upcoming academic research [115–117].

Models of Entrepreneurial Universities and Knowledge Capitalization

Studies on knowledge development and TT have sparked a discussion on what exactly constitutes research commercialization by academics or scientists, encouraging a reinterpretation of the concept of commercialization and challenging the idea of entrepreneurial university. The work of Gibbons et al. is used to clarify these two concepts. In this regard, it is hypothesized that the operations performed by academic institutions can be divided into three categories: Modes 1, 2, and 3, with Mode 1 corresponding to the core pursuits of the academic institution [112,118].

In regard to teaching and essential discipline-based study, Mode 1 involves the internal generation and consumption of knowledge within the academic institution. Publications are used to distribute knowledge, which in turn, improve the teaching resources [112,118].

Mode 2 implies that academic institutions serve as a research and innovation center, where UTT is employed to advance research that contributes to innovative technological results. Within the parameters of Mode 2, markets and industries have an impact on the mechanisms of knowledge production, with the purpose of generating research that can be used in the business sector and other areas where knowledge leads to financial gains. Commercialization-focused UTT initiatives are carried out in Mode 2. The fundamental justification for pursuing commercialization is the presumption that academics might be more inclined to engage in TT projects when there is a strong motivation, and that academic institutions will encourage TT operations if they prove to be economically advantageous to the institution [119,120].

There are two reasons why UTT is employed as a tool for leveraging knowledge. As financial support for research becomes more challenging to obtain, academic institutions must explore additional sources of funding so that they can reinvest into future research. In order to obtain funding from the business sector, academic institutions make use of their expertise to create technologies that are marketable [105]. This is accomplished by licensing university intellectual property, the development of spin-off businesses based on internally developed technologies, collaborative commercial research with business partners, as well as consulting services. These endeavors are sources of dependable income, which is not reliant on governmental assistance. Furthermore, from a business organization's standpoint, innovation is essential for a company's development and survival. On the other hand, technological innovation implies both high costs, and considerable risk. Businesses explore outside of their own existing resources for innovation, aiming to reduce the risk and expense associated with the process. Because of their research capacity, universities are regarded as being powerhouses for new novel ideas and discoveries, making them the main source for innovative concepts and models. As a result, there is a supply-demand dynamic between businesses and academic institutions [121,122].

Activities involving knowledge transfer are classified as Mode 3. The expertise of academic researchers can be shared via public lectures and unofficial guidance when technological property does not offer the possibility of acquisition by the university, such as in cases of IPRs. Miller et al. suggested that university researchers can still be acknowledged as agents who engage in TT, although they do not officially market their discoveries. Abreu and Grinevich contend that Mode 3 processes will influence the economic appraisal of higher education institutions, even though there are no immediate financial gains. This is because they will enhance their reputation and prestige, and will benefit society, all of which can affect the probability that other types of research will eventually be marketed. Furthermore, Mode 3 conceptualization justifies the necessity to address objectives, including "social impact", taken into account by allowing universities to fund TT initiatives with hazy profitability [123,124].

7. Ethical Policies in the EU and Romania Related to the Process of Technology Transfer

Due to a combination of factors, including past events, economics, and the results of prior decisions, the current market can be described as heterogenous. The variety of economically viable designs for a technology is constrained due to the requirement for economies of scale. Regarding the application of information technology in a learning environment, it is considered that in essence, there is an inversely proportional relationship between the instrument's (or training department's) educational contribution standard and the manufacturer's net income. If economic forces are the only standard, then educational gear and technology must be created to meet the requirements of the most wealthy and influential segment of users, which comprises of the upper- and middle-class population [125]. Considering the accessibility of certain operating systems and components, it is easy to comprehend how technology bundle packages (such as software systems and hardware parts) can develop and then be incorporated inappropriately, or applied to unsuitable situations. Additionally, it is not hard to predict the objectives of information systems sales representatives when determining and meeting the demands of emerging economies. It can even be argued that these motivations are questionable, from the perspective of a more skeptical mindset [126].

Computer literacy is referred to as a euphemism for consumer awareness by Mowshowitz [127]. Understanding who has the potential to benefit the most from encouraging computer knowledge should not require much effort. Is the introduction of computers into classrooms the result of an unrestricted and impartial choice to accept a neutral technological innovation? Could someone genuinely talk about free decision-making regarding neutral, universally accessible technology, considering the emerging economies' eagerness to participate in the modernization process? This means that, in addition to the disparities across the technologies already in use, the widespread notion that technologies are neutral is also false. Each technology is developed regarding specific technological mechanisms and is based on the principles that generated to its creation. Efforts are generally made to conceal the base values and principles that stand at the core of a technology, through a practice known as technological packaging. However, a comprehensive needs analysis should reveal these characteristics, to guarantee their suitability and applicability for the issues to be addressed by the technology in question [127,128].

In essence, ethical concerns are crucial for assessing the suitability and implications of certain technologies and their distribution as they can identify the applicability and relevance of a technology, as well as highlight the effects of applying and transferring a specific technology. However, there are also disadvantages, as this ethical approach may also make TT challenges more complex. There is an underlying concept that is tied to the information era, a concept characterized by questionable values and purposes, and which may be detrimental to the standard of living worldwide, with an emphasis on underdeveloped countries. This philosophy states that technology is the solution to any problem, that it is an unquestionable good, and that it is ethically neutral. Thus, the attribution of criticizing this commonly accepted ideology is assigned to ethics. Research published in 1987 highlights the need for a purposeful perspective to challenge this unspoken but widely held worldview [129].

Media coverage on healthcare organizations and scientific research in the field of biotechnology is largely responsible for calling the public's attention to the links between elementary and clinical research and medical breakthroughs, involving research universities and enterprises, and between biomedicine and finance. Achievements in biotechnology and research have been emphasized, even though there have been reports of research malpractice and injuries to the study population. Nowadays, journalists frequently discuss the possible negative impacts of business financial contributions on important university and research health center operations, in instances of biomedical academic research, training, and clinical care [130,131].

Even though the early conflict of interest regulations tended to be more concentrated on the individual participants, there is a heightened awareness of the importance to further address organizational issues. Organizations can undertake a variety of functions, including those of an educational facility, research institute, clinic, and business collaborator, and in these roles, there is also the potential for conflict of interest to arise. How about the higher education institution with the medication patent in the publication scenario? Conflicting interests that could potentially arise within the institution have been investigated, but not fully resolved so far [132,133]. According to the results presented in a survey of institutional review board (IRB) members, who play a major part in examining clinical tests and safeguarding human study participants, several IRB representatives admitted to not reporting a conflict with a guideline before approving it. In a different study conducted on higher education institutions, it highlighted that the majority of respondents (mid-level representatives, 69%; senior representatives, 71%; IRB representatives, 81%; and executive board representatives, 66%) indicated a set of procedures for institutional representatives, but only 38% indicated guidelines for their organizations. In the context of benefits arising from research patents and business collaborations, there is a dilemma concerning whether institutional ambitions a positive influence on the organization's culture and objectives, or alternatively, whether they negatively impact research oversight and researcher management of research. This concern has in turn led to questioning whether a research institution should be the entity engaged in evaluating a component or substance for which it possesses, or whether it should relinquish this attribution, in order to avoid conflicts [132–136].

8. Efficiency in Technology Transfer

According to Anderson et al., TT efficiency results from the contribution of one or several agents or decision makers, such as TTOs, researchers, business owners, and private enterprises, with the purpose of transforming initial inputs (data, raw materials) into final outputs (products, processes) [71].

The most frequently mentioned primary contributions in TT are represented by RD, which can come from either privately owned businesses or public sources, with scientific outcomes comprising of scientific discovery releases [137,138].

According to most scholars, the prevailing forms of output resulting from university/business sector TT are as follows: revenue resulting from licensing; revenue resulting from business sponsored research; the number of issued patents, the number of established spin-offs; and the number of business collaborations. One or more of the elements collectively referred to as " determinants of TT efficiency" may inhibit or promote the effectiveness of this discourse [71,138].

Regarding TT drivers, according to specialty literature, two main categories have been established. The first is referred to as "internal conditions", which include institution size, experience and tenure in the market, organizational culture, management structure, benefits, training practices, technology type and level, environment and behavioral policies, and accepted practices, as well as connections to external stakeholders. The second refers to "framework conditions", and this includes geographical area, background, legislative framework, and governmental guidelines. The variables that impact innovation and TT achievements are shown in Figure 12 [139].

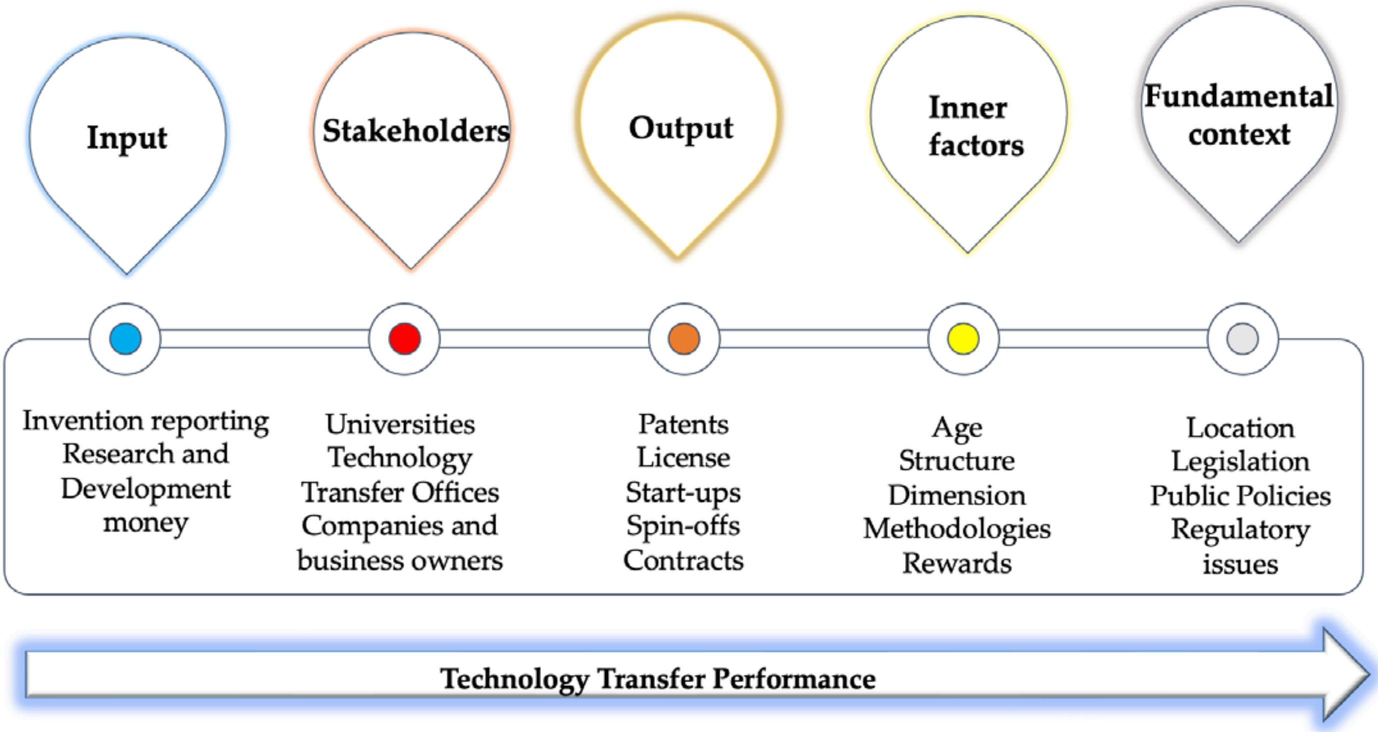

Figure 12. Technology transfer performance factors.

While organizational factors, including compensation structures in the form of monetary and non-monetary bonuses, and human resources practices and policies within the TTO, appear to constitute the most observed obstacles to successful UTT, they do not exclusively account for variations in TTO effectiveness. Organizational and environmental elements are expected to additionally be relevant factors that influence overall effectiveness [139].

According to Debackere and Veugelers, factors which are associated with "context" relate to the institutional climate, internal guidelines, the organizational culture, practices, and history. In contrast, factors assigned to the general "framework" involve components, which influence the conduct of entities and individuals in the business world and in the research sector, which are engaged in knowledge and innovation transfers. The items which are significantly influenced by policy measures, or which could actively be developed by legislators, are referred to as "policy-related framework conditions", specifically public marketing campaigns and strategies, subsequently regarded as innovation strategies [140].

The evaluation of a production limit generally serves as the foundation for performance assessment techniques. These techniques can generally be assigned to one of two categories, namely parametric and non-parametric. Depending on the operational structure, parametric limits can be probabilistic or predictable. An effectiveness evaluation technique which can highlight the relative strengths of numerous decision-making units (DMUs) using a variety of parameters, is represented by the data envelopment analysis. DMUs comprise of a set of institutions which will undergo evaluation. A DMU should share the same objective and intention in addition to general inputs and outcomes, to conform to the similarity concept. Based on the most recent input and output standards, an optimal DMU is first identified through this technique. Subsequently, the success rate from each DMU is compared and evaluated in contrast to the optimal DMU [141,142].

The focus is shifting to other initiatives in several advanced economies, including the US, the EU, and the Republic of Korea. For instance, TTOs in these states have implemented measures to enhance outcomes, including a greater emphasis on researcher evolution, incorporating management consultancy services, the development of a patent value system, a transition from fundamental to applied research, and regulatory measures for the fusion of industry, science, and education. Thus, in these nations, the ensuing elements significantly contributed to the development of TTOs: the growing importance of organizational, administrative, informational, and intellectual assets and the concept that people are the primary, essential, and endless source of economic development [143].

According to European TTOs, academic institutions must seek out top academics and scientists, offer them monetary and material resources, and create platforms which will enhance and simplify collaborative relationships between the businesses sector and the academic institution [144].

Observing the situation of TT in the USA, several studies demonstrate a link between the performance of TTOs and the rate of innovation. As the USA is a leader in merging industry, science, and education, the claims of the study are in relation to the income generated by granting licenses and starting new business ventures. Besides the fact that they accelerate the process of linking innovative research results and business commercialization, the TTO's assets and expertise also have an impact on the speed of innovation implementation and transfer [145].

The Chinese government has historically engaged in a unique practice requiring that international companies perform scientific studies, so that China can benefit from their knowledge. As a result, Chinese privately owned businesses were able to "acquire" cutting-edge technology from foreign businesses. This aspect is quite problematic in regard to management systems undergoing international transfers.

In their intriguing approach, Lindner and Wald investigated the problem of intellectual capital management and distribution. They developed a framework for managing assimilation initiatives. Without solid assimilation management programs, innovation would stagnate. The system put forth by Lindner and Wald separates the project management procedure into a variety of indicators, which can later be quantified and assessed. In essence, these are indicators which promote the development of appropriate management techniques [146].

Project management elements that can predict the outcome of RD projects and the development of new products, were established by Balachandra and Friar. They focused on the most important ones, as there is an overwhelming number of factors to consider. Several project management elements were identified, including quality and performance assurance, the function of the project manager, participant/partner oversight, and the control of operational risks [147].

9. Sustainability—A Strong Point in Technology Transfer

Another pathway is suggested by encouraging financial support and assistance for the creation and transmission of sustainable technology. There are several financial incentive methods which can be addressed and are presented in Figure 13, according to the literature [148–154].

The Clean Development Mechanism (CDM) is another frequently approached concept that supports the TT process. Although TT is not defined as a specific goal of the CDM, projects that aim to reduce emissions imply the involvement of CDM in encouraging TT [150].

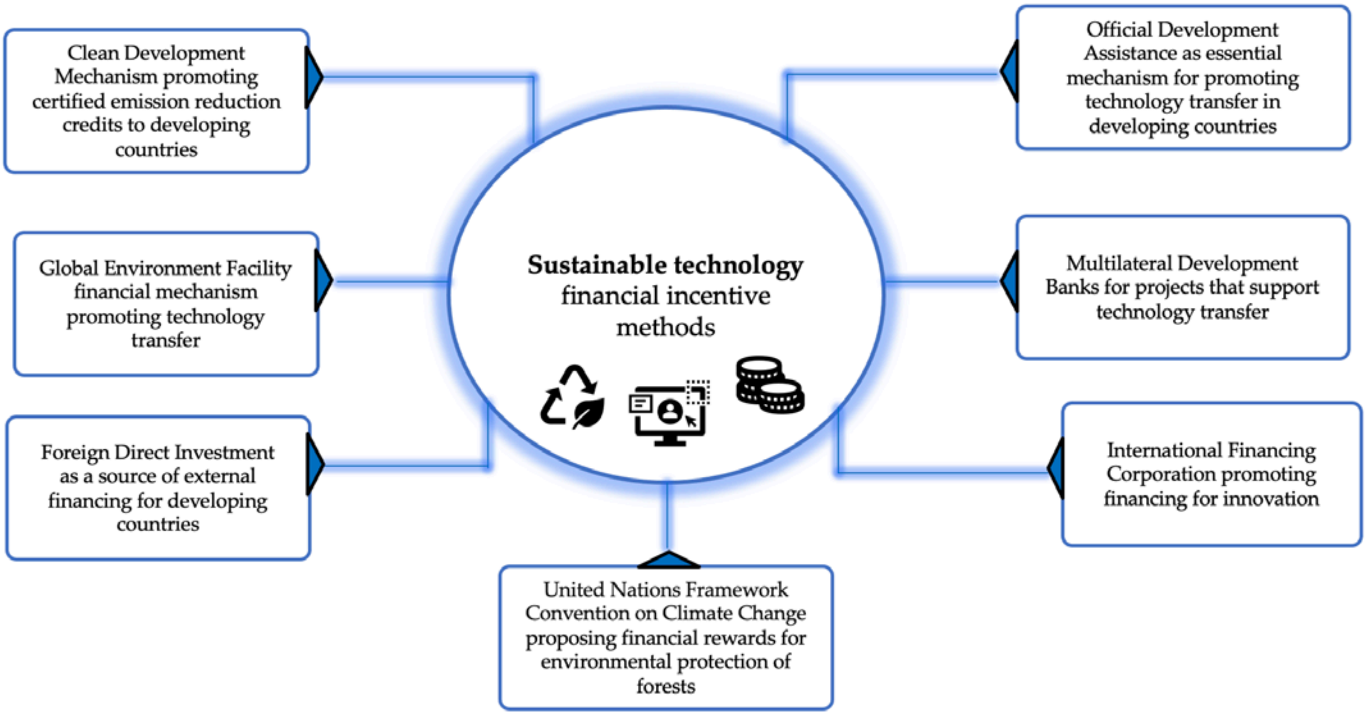

Figure 13. Sustainable technology financial incentive methods.

According to the concept of green core competence, performance is considerably influenced by green core qualifications, and the interaction between these two variables is mediated by green absorptive dynamic capabilities [155,156].

Strategies for choosing the most suitable technologies were also discussed. The Technology Needs Assessments (TNA) and the ENTTRANS Project are two of the mentioned procedures. The TNA technique identifies a nation's specific requirements and chooses the optimum technology to address those demands. On the other hand, ENTTRANS, which stands for "The Potential of Transferring and Implementing Sustainable Energy Technologies through the Clean Development Mechanism" examines the technological possibilities using characteristics that prioritize sustainability in the context of economic advancement. To improve the use, further TNA are required [157,158].

A revitalized participation to sustainable development (SD) and the encouragement of a socially, economically, and environmentally sustainable existence for our world and for today's and tomorrow's generations play a central role in the global development agenda from 2015 onwards. Additionally, it is acknowledged that the overarching goals and fundamental prerequisites for sustainable development include poverty elimination, eliminating all that is non-sustainable and promoting sustainable consumption and production practices and development, and preserving and maintaining the natural resource foundation of economic and social growth [159]. The SD action plan therefore concentrates on a wide range of interrelated fields such as food production and nutrition, sustainable agriculture, poverty elimination strategies, global warming, sanitation and water supply energy resources, healthcare and demographics, and proactive gender equality actions. The associated goals are rendered achievable in 17 UN Sustainable Development Goals and 169 variables [160].

10. Conclusions

The present manuscript reviews in a comprehensive manner the field of TT, updating the state of knowledge in the field by detailing the concept at a global level, with an emphasis on the practical applicability of the concept in Romania, a topicality that is scarcely addressed in the literature.

The theorization of the concept coupled with new possibilities of practical approach have developed simultaneously with scientific progress and increasing knowledge levels, in close correlation with the optimization of policies and regulations to enhance the relationship between governments, universities, and industries.

The highlighting of the different forms of international TT, the distribution of technology, the delineation and clear definition of the conceptual framework that highlights the new networks created, the expansion of technology, and the development of innovation and sustainable economies contribute to filling some of the research gaps in the literature. Furthermore, the detailing of TT infrastructure in Romania, together with the description of operational projects, collaborative networks, and TT centers related to sustainable development, provides a new and comprehensive approach to this topic in this geographical area.

International TT and the level of innovation and economy in European countries are very varied and continuously evolving, depending on the factors underlying TT performance. Although deficient at European level in the qualitative and quantitative implementation of TT, in Romania different programs and centers have been created recently, which will contribute in the future to increasing and optimizing the results. Furthermore, the detailed presentation of these concepts in an updated form opens dynamic research directions to identify and correctly evaluate current conceptual models, thus having the potential for their efficiency both from a technological and economic point of view, based on the improvement of the government-university-industry relationship.

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