



**Publisher**

## THE COMPARATIVE ANALYSIS OF TECHNOLOGY TRANSFER MODELS\*

Sergejs Hilkevics<sup>1</sup>, Aleksejs Hilkevics<sup>2</sup>

<sup>1,2</sup> *Ventspils University College, Inzenieru 101a, Ventspils, LV 3601, Latvia*

*E-mails: [sergejs.hilkevics@venta.lv](mailto:sergejs.hilkevics@venta.lv); [aleksej.hilkevich@gmail.com](mailto:aleksej.hilkevich@gmail.com)*

*Received 14 November 2016; accepted 17 February 2017*

**Abstract.** The evolution of technology transfer models is considered in this article with the aim to compare different historical technology transfer models and to analyze main driven factors of technology transfer models evolution. From business administration point of view, technology transfer is process, which involves inhomogeneous participants from academia, government and business. The necessity to balance interests of many different participants with different goals, value systems and resources makes the administration of technology transfer as a very complicated task. In different times this task was solved by different ways and we consider the process of technology transfer models evolution from 1945-1950s until present time trying to identify main reasons, which forced the transformation of technology transfer models. We start consideration from identifying the main reason of varieties in terminology, which is important to create the basic frame for further consideration, after that we consider main classes of technology transfer models – linear, parallel sequential non-linear and back feed nonlinear – and make some forecasting about technology transfer models evolution in future.

**Keywords:** technology transfer, technology transfer models

**Reference** to this paper should be made as follows: S. Hilkevics, A. Hilkevics. 2017. The comparative analysis of technology transfer models, *Entrepreneurship and Sustainability Issues* 4(4): 540-558. [http://doi.org/10.9770/jesi.2017.4.4\(11\)](http://doi.org/10.9770/jesi.2017.4.4(11))

**JEL Classifications:** M - Business Administration and Business Economics, Marketing, Accounting, Personnel Economics

### 1. Introduction

In this article we consider the evolution of the technology transfer models. Technology transfer is complicated process, which involves participants from academia, government and business with different goals, value systems and resources. (European Commission: Improving knowledge transfer between research institutions and industry across Europe). Technology transfer (TT) is important for innovative business development and by this way for country technological and economic development. During last 30 years three generations of TT models have changed - linear models, non-linear parallel-sequential models, non-linear back feed models. The growth of TT

---

\* *The paper was supported by the project «The Development of Innovation and Entrepreneurship in Latvia in Compliance with the Smart Specialization Strategy» within the National Research Program 5.2. «Economic Transformation, Smart Growth, Governance and Legal Framework for the State and Society for Sustainable Development - a New Approach to the Creation of a Sustainable Learning Community (EKOSOC-LV)»*

models complexity corresponds to the growth of complexity of business, academic and cultural environment. The critical success factor for TT efficiency is the time interval between university scientists makes a discovery until business adapt and use the appropriate technology suggesting on the market new goods and services. (O'Shea, Allen et al. 2004) We will start the consideration of the evolution of technology transfer models from technology transfer definitions.

## 2. Technology transfer definitions

Using search engines it is possible to find in Internet more than hundred definitions of technology transfer. Let us consider several of them:

1. Technology transfer is the process of sharing of skills, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities among governments and other institutions to ensure that scientific and technological developments are accessible to a wider range of users. [http://en.wikipedia.org/wiki/Technology\\_transfer](http://en.wikipedia.org/wiki/Technology_transfer)
2. The sharing of technological information through education and training. The use of a concept or product from one technology to solve a problem in an unrelated one. [http://en.wiktionary.org/wiki/technology\\_transfer](http://en.wiktionary.org/wiki/technology_transfer)
3. The communication or transmission of a technology from one country to another. This may be accomplished in a variety of ways, ranging from deliberate licensing to reverse engineering. <http://www-personal.umich.edu/~alandear/glossary/t.html>
4. The ability to take a concept from outside the organization (typically from a government or university research programs) and create a product from it. <<http://ccs.mit.edu/21c/iokey.html>>
5. Exchange or sharing of knowledge, skills, processes, or technologies across different organizations. <http://www.nsf.gov/statistics/seind06/c4/c4g.htm>
6. Technology transfer is the process of transferring scientific findings from research laboratories to the commercial sector. <http://www.insme.org/page.asp>
7. The transfer of technology or know-how between organizations through licensing or marketing agreements, co-development arrangements, training or the exchange of personnel. <http://www.et.teiath.gr/tempus/glossary.asp>
8. This term is used to characterize "the transfer of knowledge generated and developed in one place to another, where is it is used to achieve some practical end. <http://www.rmauduit.com/glossary-t.html>
9. The transfer of intellectual property between the ERC and the private sector. [http://www.erc-assoc.org/manual/bp\\_ch6\\_attach6\\_4.html](http://www.erc-assoc.org/manual/bp_ch6_attach6_4.html)
10. The process by which energy-efficient or low emission intensive technologies developed by industrialized nations are made available to less industrialized nations. <<http://www.climatephilanthropists.org/basics>>
11. The transfer of discoveries made by basic research institutions? Such as universities and government laboratories? To the commercial sector for development into useful products and services. <http://biotech-u.com/courses/mod/glossary/view.php>
12. Technology transfer is the international communication (sharing) of knowledge, expertise, facilities, equipment, and other resources for application to military and nonmilitary systems. [http://www.onr.navy.mil/sci\\_tech/3t/transition/tech\\_tran/orta/glossary](http://www.onr.navy.mil/sci_tech/3t/transition/tech_tran/orta/glossary)
13. The diffusion of practical knowledge from one enterprise, institution or country to another. Technology may be transferred by giving it away (e.g. through technical journals or conferences); by theft (e.g. industrial espionage); or by commercial transactions (e.g. patents for industrial processes). [http://www.itcdonline.com/introduction/glossary2\\_q-z.html](http://www.itcdonline.com/introduction/glossary2_q-z.html)

14. The movement of modern or scientific methods of production or distribution from one enterprise, institution, or country to another, as through foreign investment, international trade, licensing of patent rights, technical assistance, or training. <http://www.giagroup.com/terms-of-trade-t.cfm>
15. Technology transfer occurs as a result of an offset agreement that may take the form of research and development conducted abroad; technical assistance provided to the subsidiary or joint venture of overseas investment; or other activities under direct commercial arrangement between a manufacturer and a foreign entity. <http://www.tricolom.com/glossary.htm>

The list of technology transfer definitions can be continued and the first question in technology transfer understanding is the question “What we are speaking about having so overwhelming amount of different TT definitions?” The explanation of the large amount of definitions can be found in the proceedings of RAND conference “Technology transfer of federally funded R&D”, December 12, 2002. (Wang et al. 2003). One of the declared tasks of RAND organized forum was to clarify the technology transfer terminology and after discussions it was recognized, that such clarification hardly is possible because of the following reason: three main participants gave three different definitions of technology transfer.

The definition of the National Technology Transfer Center (NTTC) was: “The process of utilizing technology, expertise, know-how or facilities for a purpose not originally intended by the developing organization. Technology transfers can result in commercialization or product/process improvement”.

The definition of the Federal Laboratory Consortium (FLC) was: “The process by which existing knowledge, facilities, or capabilities developed under federal R&D funding are utilized to fulfill public and private needs”.

The definition of the Association of University Technology Managers (AUTM) was: “The formal transfer of new discoveries and innovations resulting from scientific research conducted at universities and nonprofit research institutions to the commercial sector for public benefit”.

Although these three definitions have similarities, it is evidently that due to many reasons technology transfer means different things to different participating organizations. For governmental institutions, the most important thing in TT is to ensure transparent use of public money, for business most important in TT is profit, for academia most important in TT is scientific publications, reports on conferences, quotation indexes. Due to different systems of values of different TT process participants, they consider as most important for them different sides of the same process and following to their own opinions give different definitions of TT process.

The general conclusion of the RAND conference was that it is necessary to treat the technology transfer process very broadly, allowing individual and organizational differences even in definitions. Similarly, the metrics for technology transfer success and best practice are left open for interpretation and discussion. Considering technology transfer models it is necessary to take into account that TT processes should be considered from at least three different points of view (government, business, academia) and not always success metrics and opinions about what is good and what is bad coincide. This situation is not usual from the business administration point of view, where normally more strict definitions and methods are used, but technology transfer is generally accepted to be beneficial for society, even if specific definitions may not necessarily be agreed upon. (Sazali et al. 2009). Technology transfer peculiarities remain to keep focus of scientists, practitioners and other stakeholders (Tvaronavičienė, Černevičiūtė 2015; Ignatavičius et al. 2015; Fuschi, Tvaronavičienė 2016; Zemlickiene et al. 2017).

### **3. Linear models of Technology Transfer**

It is difficult to draw the starting line for linear technology transfer model consideration - apparently the first commonly accepted linear model of technology transfer was so called Appropriability Model, which was developed in 1945-1950s. Based on Keynes type ideas of demand driven economy, Appropriability Model considered that “technology transfer occurs when technology has found users”. (Hee Jun Choi. 2009) It was supposed in this model that the only one active agent in technology transfer chain is the private company as user of technology, but universities and government are relatively passive participants of process.

The next step in the technology transfer model development was done in Dissemination Model, which was developed in 1960 – 1970s. It was observed that in those cases, when university researches participated in potential technology users search, process was more successful. In addition to technology user as the only active agent in Appropriability Model of technology transfer, the expert, as mediator between researcher and non-expert technology user, start to play important role in Dissemination Model.

The next significant TT model was the Knowledge Utilization Model, which was developed in 1980s. This model was based on more detailed consideration of technology transfer process that it was done in previous models and on the concentration on critical success factors of technology transfer. There were two main critical success factors, which were identified in the Knowledge Utilization model – communication barriers on interpersonal level and organizational barriers on structural units level. Since 1980s it was considered that the success of technology transfer depends mostly on ability of management to break these barriers.

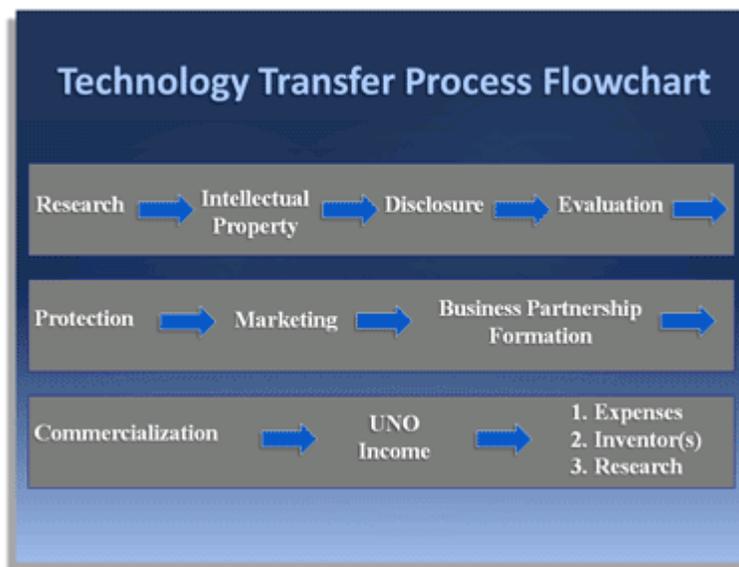
From the beginning of 1990s so called Communication Model of technology transfer became popular. It was the time when computer technologies made revolutionary changes in information transfer and processing and focus of attention in technology transfer was shifted towards information and communication processes. At this time the first attempts to combine linear models with simplest non-linear models were done. There is deep analogy between the main idea of structural programming - to organize all data flows into system of parallel and sequential flows - and new approach to technology transfer processes management in first non-linear TT models with attempt to organize activities in parallel and sequential flows also. The set of parallel and sequential processes from one side was simple enough to be good controlled, but from another side allowed to perform several tasks simultaneously, which was impossible in linear models.

It is important to underline, that from organizational point of view the development of linear technology transfer models was very closely related with the Bayh-Dole Act, developed and adopted in the USA in 1980. Bayh-Dole was originally designed to facilitate commercialization by making it easier for universities to approve legal rights to innovations developed by faculty using Federal funding. This Act appeared as the result of the understanding of the significant role of technology transfer in scientific and technical progress and the need to accelerate scientific and technological progress by new technologies development. Presently it is clear that since Bayh-Dole Act the number of research related patents has noticeably increased. Bay-Dole Act established rules that regulated relationships between universities, industry and government. The Bayh-Dole Act has led to rapid growth of activity in science and technology implementation for the new goods and services production and to the emergence of the new models of technology transfer. Bayh-Dole Act was implicitly based on an assumption of "linear model" of innovation, so the first models of technology transfer were linear models. According to linear model universities perform basic research with little concern for application and private firms invest in applied research and commercialization. The traditional linear model of university technology transfer consists of the following consequent steps:

1. University Scientist makes a discovery.
2. Scientist discloses invention to Technology Transfer Office.

3. TTO evaluates invention, decides whether to patent.
4. TTO makes the patent applications.
5. TTO markets technology to firms/entrepreneurs.
6. TTO negotiate licensing agreements/royalties/equity stake etc.
7. Technology license.
8. Existing firms adapt and use technology.
9. Spinoffs & Startup companies are created.

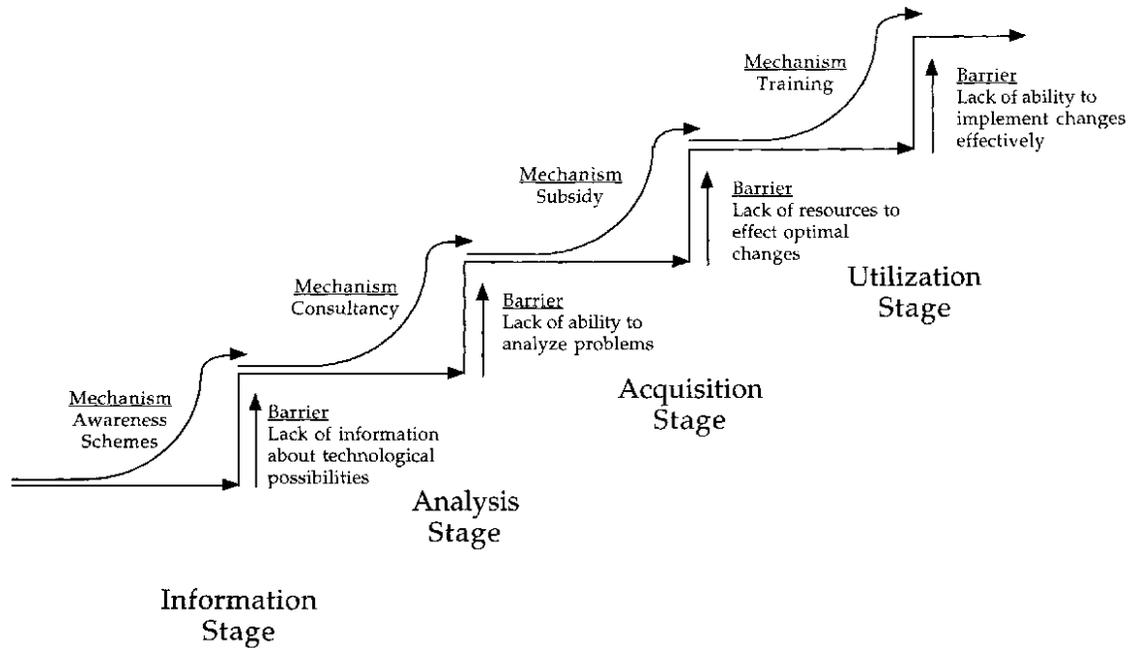
The flowchart of technology transfer process looks as follows:



**Fig. 1.** Technology transfer flowchart in linear model. Presented in “Technology Transfer Process”

Source: [http://www.uno.edu/otmc/technology\\_transfer\\_process.aspx](http://www.uno.edu/otmc/technology_transfer_process.aspx)

First technology transfer models were linear and the main difference between them was the amount of steps from the scientific discovery at university to adaptation and use of new technology in industry. The common idea that lies under all such models independently from the amount of steps is the idea of barriers overcoming.

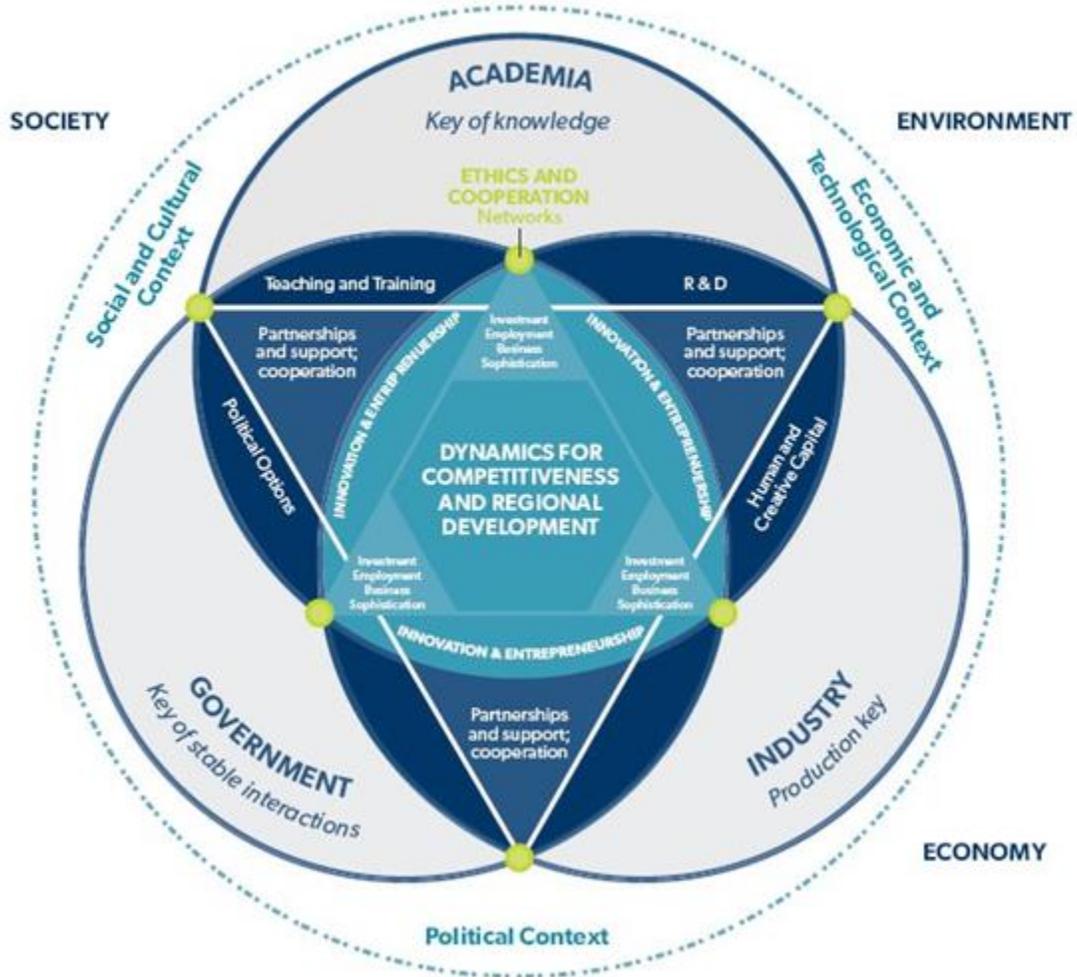


**Fig. 2.** Barriers overcoming. Presented in “Diffusion of Information Technology”

Source: <http://collections.infocollections.org/ukedu/en/d/Jwb42de/7.2.html>

The main reason of barriers is the inhomogeneous structure of technology transfer process participants - government, academia and industry have different point of views about the significance of different TT process parts as it was mentioned above.

**Farinha and Ferreira’s Triple Helix Triangulation model**



**Fig.3.** Technology transfer participants. Presented in “The Organization of Power”

Source: [http://www.channelingreality.com/Corporations/organization\\_of\\_power.htm](http://www.channelingreality.com/Corporations/organization_of_power.htm)

Depending on the character of interaction between participants of technology transfer process, many different linear models were created for technology transfer description.



Fig. 4. Typical linear six step technology transfer model.

Source: <http://www.ec21.com/co/e/eurastech/upimg/img2.jpg>

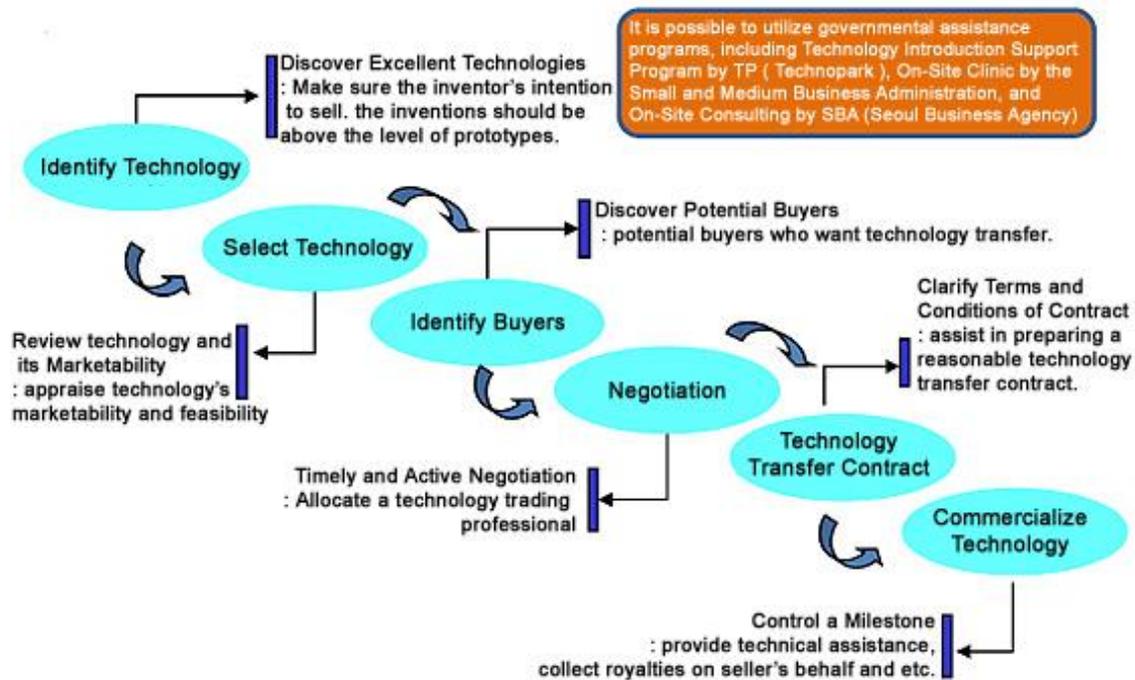
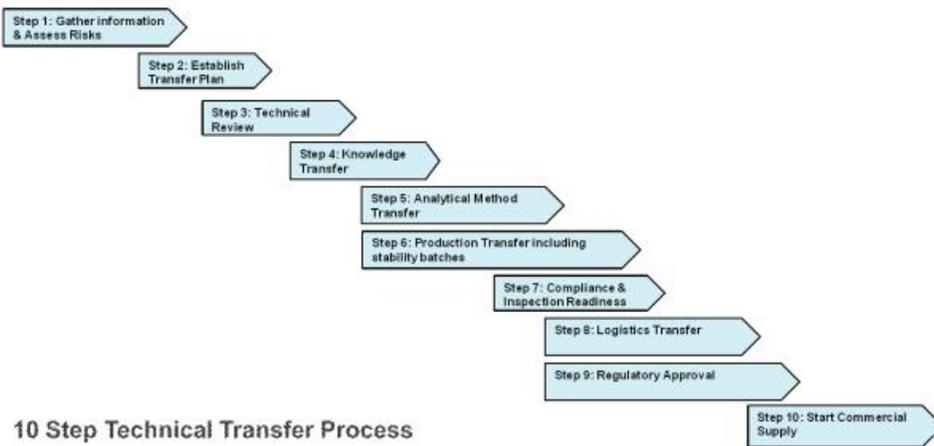


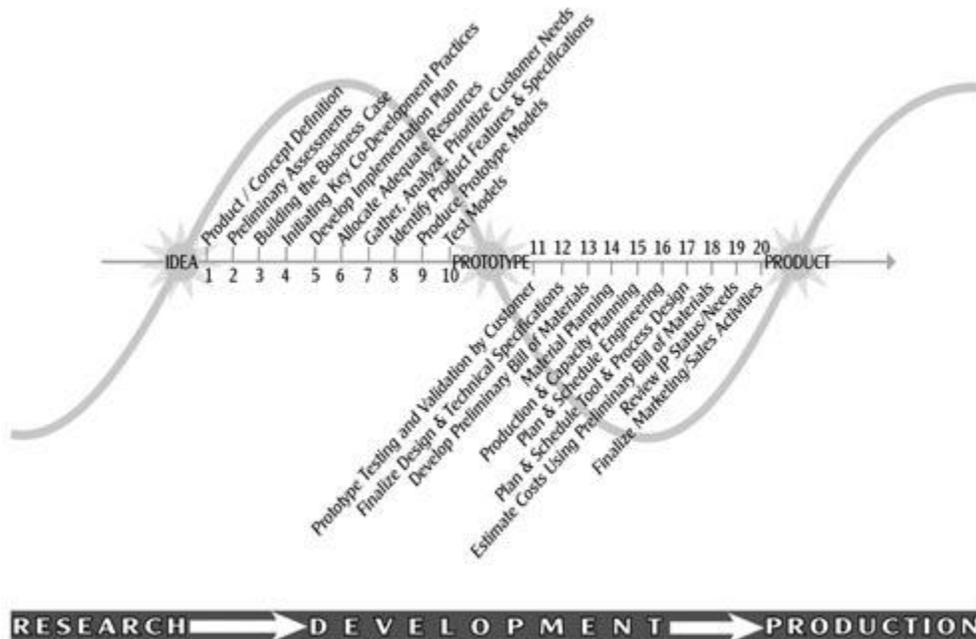
Fig. 5. Another six step linear technology transfer model.

Source: <http://www.nickdavesassociates.com/consulting-services/developing-and-implementing-supply-chain-strategies/technology-transfer>



**Fig. 6.** Ten step linear technology transfer model.

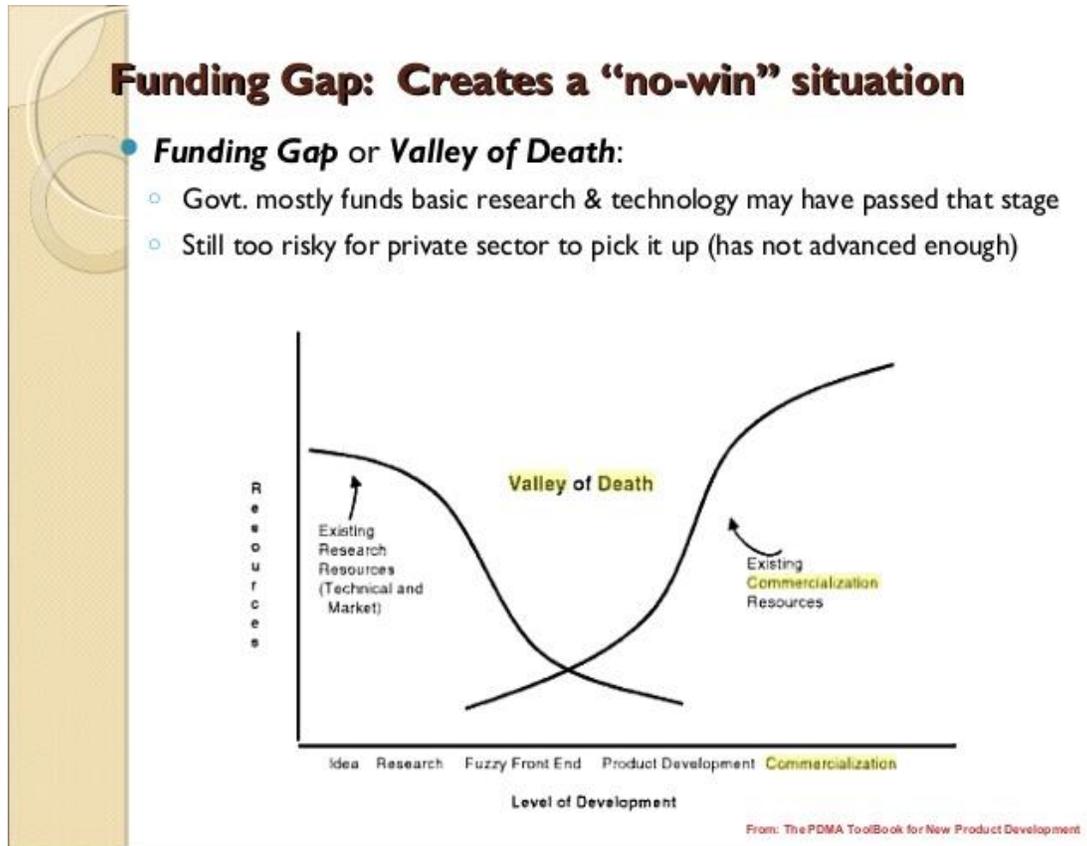
Source: <http://www.nickdavesassociates.com/consulting-services/developing-and-implementing-supply-chain-strategies/technology-transfer>



**Fig. 7.** Twenty step technology transfer model.

Source: “Facilitating Technology-Based Knowledge Utilization”  
[http://ktdrr.org/ktlibrary/articles\\_pubs/ncddrwork/focus/focus26](http://ktdrr.org/ktlibrary/articles_pubs/ncddrwork/focus/focus26)

Linear models in a relatively short time identified the main problem of technology transfer process – the existence of the such stage of technology transfer process, when the idea is already not interesting for academia, but still not interesting for business. This stage was called as “Valley of Death” and efforts to improve the process concentrated on this stage analysis.



**Fig 8.** Valley of Death.

Source: “Leading Molecules from Bench to Bedside in Academic World.”  
<http://www.slideshare.net/Brainleague/101520114-leadingmoleculiestomarketanoverviewonlicensing>

Looking into details, it is possible to understand the structure of technology transfer problems during the “Valley of Death” stage.

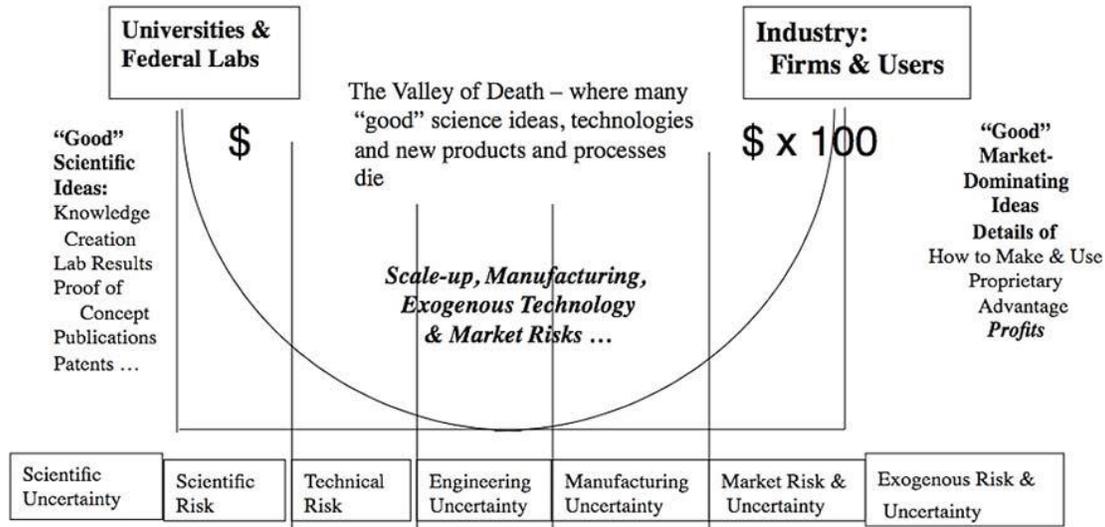


Fig. 9. Valley of Death structure.

Source: "Lessons Learned in Technology Transfer from Dr. Gregg Vanderheiden and the Trace Research & Development Center"  
[http://ktdrr.org/ktlibrary/articles\\_pubs/focus37](http://ktdrr.org/ktlibrary/articles_pubs/focus37)

It is necessary to underline, that depending on industry the structure of the Valley of Death can be different – e.g. in the biomedicine there can be two Valleys of Death.

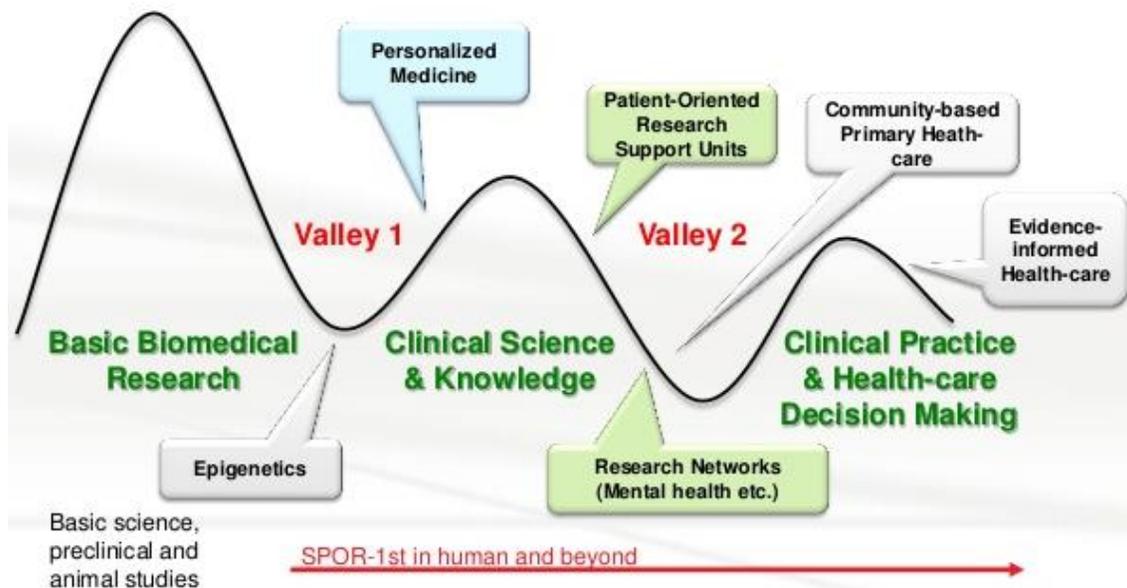


Fig. 10. Two Valleys of Death.

Source: "SPOR - Patient Engagement and Knowledge Translation"  
<http://www.slideshare.net/NeuroDevNet/cihr-jeff-latimer-ppt-presentation>

After certain period, the ways to solve the “Valley of Death” problem were found and it became clear, that new additional sources and forms of financing should be used at this stage of process. In the USA the attraction of governmental financing became a main tool for further technology transfer process development.

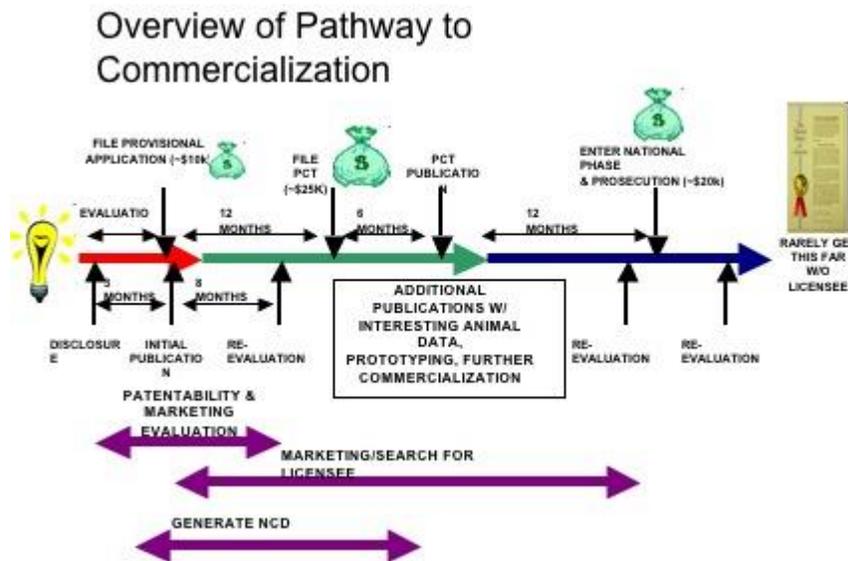


Fig. 11. Different financing sources for different technology transfer stages.

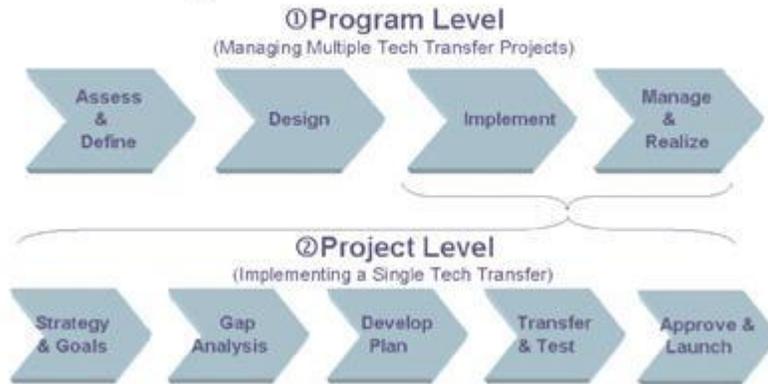
Source: “Overview of Pathway to Commercialization” <https://www.bc.edu/research/otl/faculty-and-staff/marketing.html>

After the identification of Valley of Death as the most important problem of linear models and its solution using financial sources diversification, the period of more complicated, than linear technology transfer models, started. First such more complicated models became parallel-sequential models.

#### 4. Non-linear parallel-sequential models

It is easy to understand the origin of non-linear parallel-sequential models from the Figure 12. If we deal with the single technology transfer, we can follow to linear model, but when we try to attract financing for different stages of many separate technology transfers, we should use some kind of industrial approach that is oriented on mass production. Mass production processes are cyclical. On the level of separate technology transfer model is linear, but on the level of whole program, which consists of many processes, TT model should be cyclical.

**Technology Transfers need to be managed at two levels**

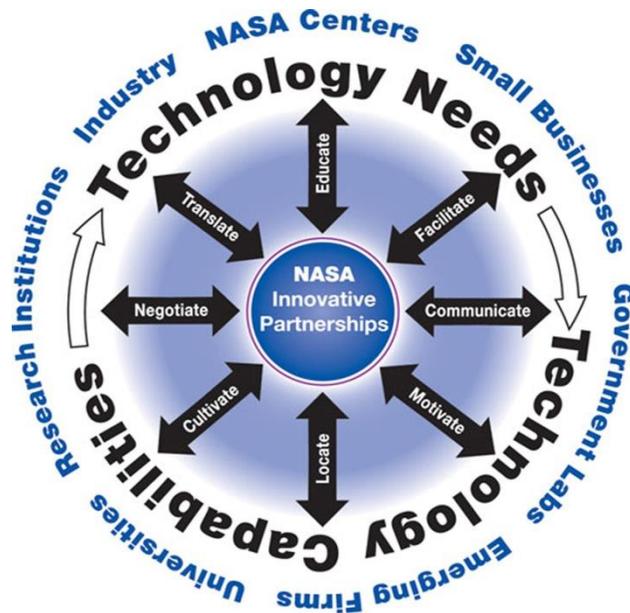


**Fig. 12.** Two level technology transfer model.

Source: “Technology Transfer by Design”.

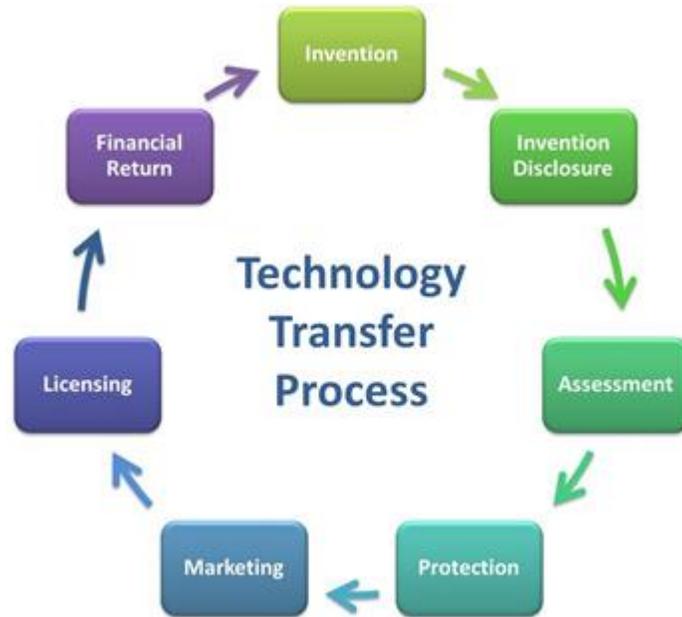
[http://www.contractpharma.com/issues/2007-06/view\\_features/technology-transfer-by-design](http://www.contractpharma.com/issues/2007-06/view_features/technology-transfer-by-design)

At the first stage of cyclical models development and implementation, many different cycles with different numbers of stages were suggested in the similar way as we saw before with linear models.



**Fig. 13.** NASA 8 steps cyclical model.

Source: “NASA’s Legacy of Technology Transfer and Prospects for Future Benefits” [https://spinoff.nasa.gov/hist\\_techtransfer.pdf](https://spinoff.nasa.gov/hist_techtransfer.pdf)



**Fig. 14.** Cyclical 7 steps model.

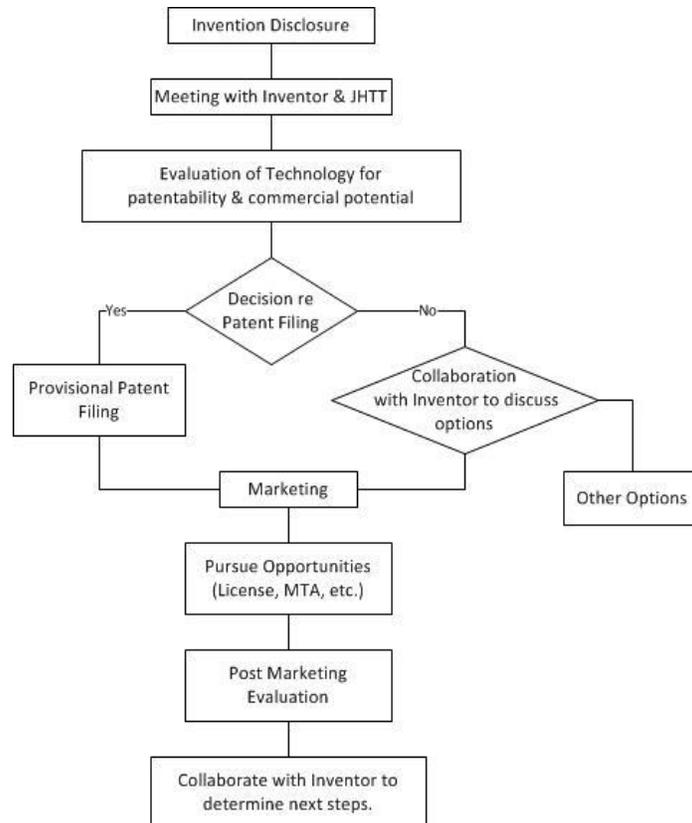
Source: "What is the Process of Technology Transfer?"  
<http://www.cdc.gov/od/science/technology/techtransfer/technology-transfer-process.htm>



**Fig. 15.** Pharmaceutical 8 steps cyclical model.

Source: "Technology Transfer in Pharmaceuticals" [www.pharmaguideline.com/2015/07/technology-transfer-in-pharmaceuticals.html](http://www.pharmaguideline.com/2015/07/technology-transfer-in-pharmaceuticals.html)

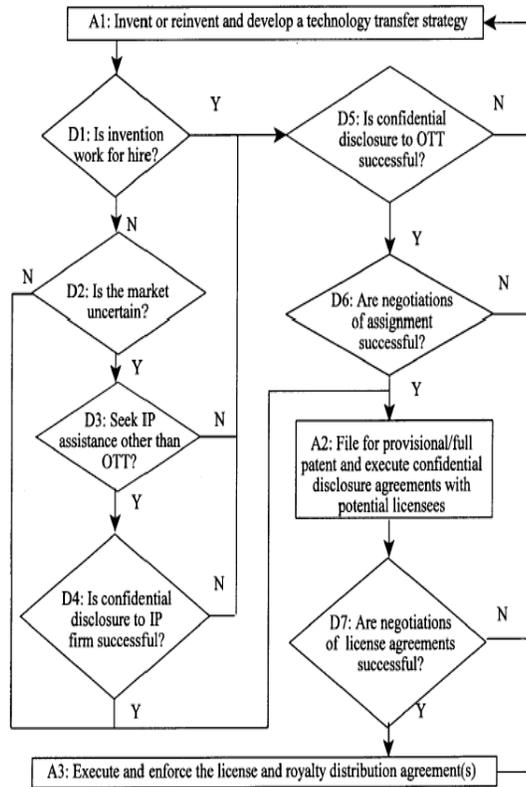
At the second stage of cyclical models development and combination with linear models the approach based on alternatives and appropriate parallel-sequential models were created. The main advantage of such models comparing with linear models is the possibility to perform certain activities simultaneously, decreasing the total time of the process. During the further development parallel-sequential models were transformed into models with bask feeds.



**Fig. 16.** Model with alternatives.

Source: "Invention Process Workflow"

<http://ventures.jhu.edu/invention-process-workflow>

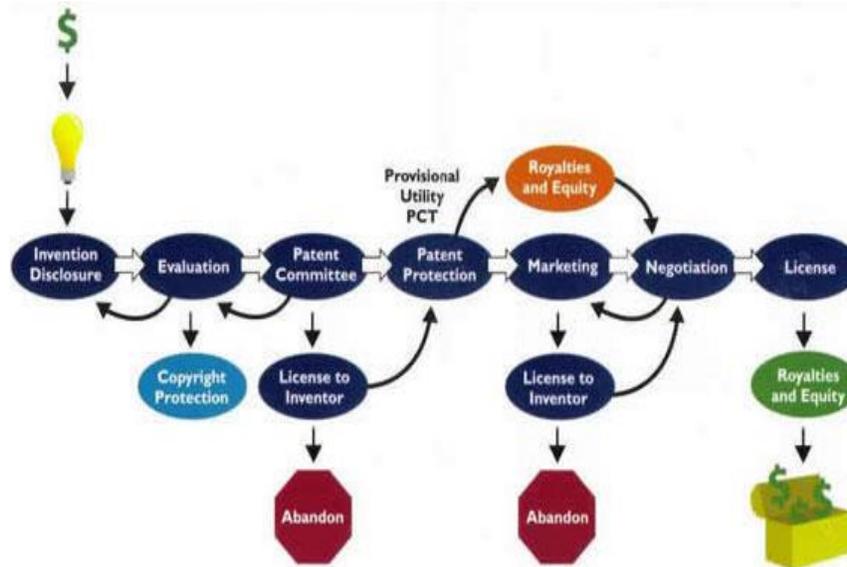


**Fig. 17.** Model with alternatives.

Source: “The Process and “Curriculum of Technology Transfer”  
<https://scholar.lib.vt.edu/ejournals/JOTS/Winter-Spring-2001/song.html>

## 5. Non-linear back feed models

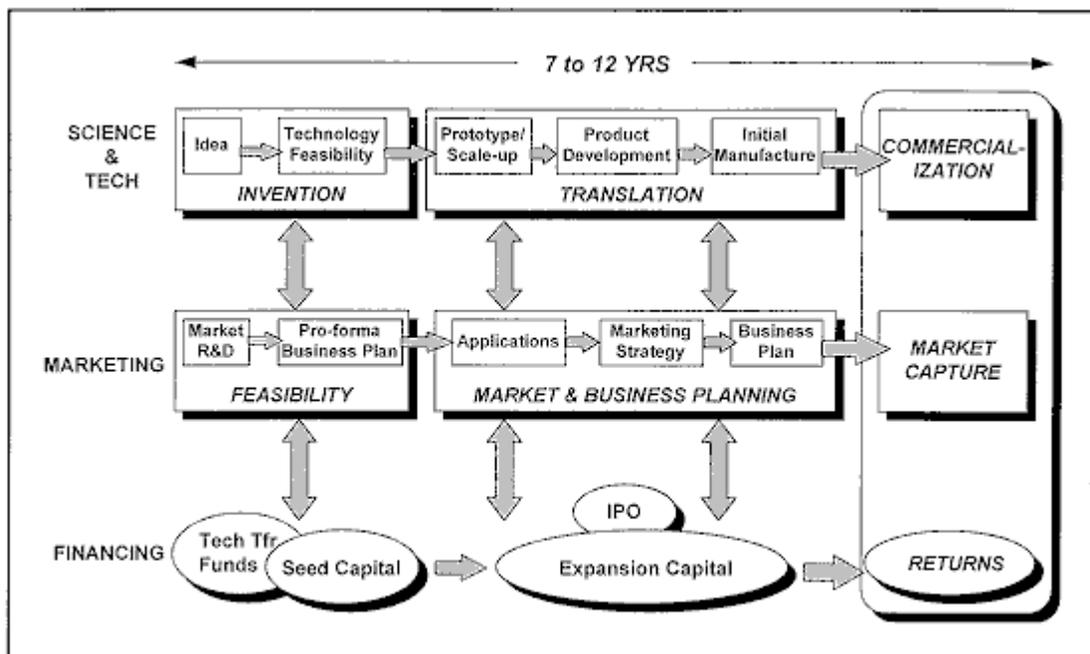
The transformation of parallel-sequential models into back feed models happened in a very natural way (Fig. 18). Let us consider, for example, the flow of the technology transfer documentation. It is normal for administrative processes when there are many returns of documents from responsible institution to previous institutions for further development. This is the simplest form of back feed and it needs to forecast possible objections from technology evaluators and to perform activities in advance to remove obstacles from technology transfer process



**Fig. 18.** Back feeds in technology transfer.

Source: “The Technology Transfer Process”  
<http://www.gdrc.org/techtran/tt-process.html>

Back feed processes can be more complicated and include not only closest stages in linear model, but far stages also. This makes technology transfer model similar to set of parallel processes with links between different branches. This is more complicated construction than non-linear parallel-sequential model and needs more flexible methods of administration.



**Fig. 19.** Complicated back feeds in technology transfer

Source: "The Technology Transfer Process"  
<http://www.gdrc.org/techtran/tt-process.html>

## Conclusions

We have considered the evolution of technology transfer models from linear to non-linear parallel-sequential and further to non-linear backfeeds models. It is necessary to underline, that there are no "bad" and "good" models - from theoretical point of view, models of all kinds can be used successfully at present time depending on industry and conditions of implementation. From the practical point of view, the critical success factor for TT efficiency is the time and here TT models are not equivalent.

Linear models are good when dominant role in TT process play universities. Universities are big and conservative structures and therefore linear TT models are relatively slow.

Non-linear parallel sequential models are good when dominant role in TT process play the stable old companies. Stable old companies are more flexible then universities and therefore parallel sequential TT models are faster then linear TT models.

Back-feed models are good when dominant role in TT process play new created companies - spinoffs and startups. New created companies are even more flexible then existing companies and therefore backfeed TT models are faster then parallel sequential TT models, but the implementation of such models is related with higher risks.

## References

- European Commission: Improving knowledge transfer between research institutions and industry across Europe. Available on the Internet: [http://ec.europa.eu/invest-in-research/pdf/download\\_en/knowledge\\_transfe\\_07.pdf](http://ec.europa.eu/invest-in-research/pdf/download_en/knowledge_transfe_07.pdf)
- Fuschi, D. L.; Tvaronavičienė, M. 2016. A network based business partnership model for SMEs management, *Entrepreneurship and Sustainability Issues* 3(3): 282-289. [http://dx.doi.org/10.9770/jesi.2016.3.3\(5\)](http://dx.doi.org/10.9770/jesi.2016.3.3(5))
- Hee Jun Choi. *Technology Transfer Issues and a New Technology Transfer Model*. Available on the Internet: <https://scholar.lib.vt.edu/ejournals/JOTS/v35/v35n1/choi.html>
- Ignatavičius, R.; Tvaronavičienė, M.; Piccinetti, L. 2015. Sustainable development through technology transfer networks: case of Lithuania, *Journal of Security and Sustainability Issues* 4(3): 261-267. [http://dx.doi.org/10.9770/jssi.2015.4.3\(6\)](http://dx.doi.org/10.9770/jssi.2015.4.3(6))
- O'Shea, R; Allen, T.J; O'Gorman, C.; Roche, F. 2004. Universities and Technology Transfer: *A Review of Academic Entrepreneurship Literature*, Irish Journal of Management 25.2 2004. 11-29. Available on the Internet: <http://search.proquest.com/openview/42d030200760d31c341c1594e4d35360/1>
- Sazali A.; Haslinda A.; Jegak U.; Raduan C. 2009. *Evolution and Development of Technology Transfer Models and the Influence of Knowledge-Based View and Organizational Learning on Technology Transfer*. 2009 Research Journal of International Studies - Issue 12 October. Available on the Internet: [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=1949174](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1949174)
- Tvaronavičienė, M.; Černevičiūtė, J. 2015. Technology transfer phenomenon and its impact on sustainable development, *Journal of Security and Sustainability Issues* 5(1): 87-97. DOI: [http://dx.doi.org/10.9770/jssi.2015.5.1\(7\)](http://dx.doi.org/10.9770/jssi.2015.5.1(7))

Wang M., Pflieger S., David M. et al. 2003 *Technology Transfer of Federally Funded R&D. Perspectives from a Forum.* (p.23) Available on the Internet: [http://www.rand.org/content/dam/rand/pubs/conf\\_proceedings/2006/CF187.pdf](http://www.rand.org/content/dam/rand/pubs/conf_proceedings/2006/CF187.pdf)

Zemlickiene, Vaida; Mačiulis, Alminas; Tvaronavičienė, Manuela. 2017. Factors impacting the commercial potential of technologies: expert approach, *Technological and Economic Development of Economy* 23(2): 410-427 <http://dx.doi.org/10.3846/20294913.2016.1271061>

### **Acknowledgements**

*The paper was supported by the project «The Development of Innovation and Entrepreneurship in Latvia in Compliance with the Smart Specialization Strategy» within the National Research Program 5.2. «Economic Transformation, Smart Growth, Governance and Legal Framework for the State and Society for Sustainable Development - a New Approach to the Creation of a Sustainable Learning Community (EKOSOC-LV)».*

**Sergejs HILKEVICS** is the Professor of Business Administration at Ventspils University College, Latvia. At Ventspils University College he accepted positions of Dean of Faculty of Economics and Business Administration, Head of Department of Research and Development, Vice-Rector in Research and Development. He is consultant of private companies, municipal and state institutions. Research interests: entrepreneurship and innovative business, financial analysis, technical and fundamental analysis, investment theory and applications.

**Aleksejs HILKEVICS** received his degree of Master of Business Administration at Daugavpils University and is post-doctorant at Ventspils University College. During his work at Technology Transfer Centre of Ventspils University College, he practically studied and compared different Technology Transfer models used by Latvian companies. Research interests: entrepreneurship and innovative business, technology transfer, business valuation.

Register for an ORCID ID:

<http://orcid.org/0000-0003-3555-1729>

---

Copyright © 2017 by author(s) and VsI Entrepreneurship and Sustainability Center

This work is licensed under the Creative Commons Attribution International License (CC BY).

<http://creativecommons.org/licenses/by/4.0/>

