CHAPTER 3: IMPLEMENTATION AND MODELS OF TECHNOLOGY TRANSFER

Technology can be easily understood as that knowledge, skill or equipment which is utilized in the manufacturing of a good or rendering of a service. Clearly having discussed the meaning and importance of technology transfer, an insight into how this transfer takes place, deserves mention. The process involves movement of data, design models, equipment, software or materials from one to another. This transfer can take place between organisations, businesses, industries and even countries. Greater the exploitation of the technology, greater the societal good served. It thus reaches out to maximum number of people where it is made available to its potential users who may further exploit the technology or develop it.

It is important to build a robust innovative ecosystem for an effective technology transfer. Whether it is between universities or research organizations, industries or amongst nations, it is imperative that the institution for technology transfer works as an interconnected network and stands tall as regards enabling factors such as capital, human resources, sophistication of business and market in order to create such an environment where knowledge and resource sharing with one another becomes far easy. In such a scenario, all parties collaboratively work to achieve the desired innovation aiding in regional and global development[189].

IMPLEMENTATION: As important is the idea behind technology transfer, so is its implementation. There are different factors which affect the transfer process as has been discussed previously; similarly, the different factors affect the implementation process as well. This is clearly understandable given the fact that there are not just different forms of technology transfer, but also different levels to the entire process. The WHO guidelines on Technology Transfer[190] pertaining to technology transfer in the pharmaceutical sector have mentioned that, "*transfer of technology requires a documented, planned approach using trained and knowledgeable personnel working within a quality system, with documentation of data covering all aspects of*

[189] *See,* Intellectual Property and Technology Transfer, https://www.wipo.int/technology-transfer/en/index.html

[190] Annexure 7, *WHO guidelines on transfer of technology in pharmaceutical manufacturing,* World Health Organisation, WHO Technical Report Series No.961, 2011, https://extranet.who.int/pqweb/sites/default/files/documents/TRS_961_Annex7_2011.pdf

development, production and quality control. Usually there is a sending unit (SU), a receiving unit and the unit managing the process, which may or may not be a separate entity."

For the transfer of technology to be successful, it is important that the "planned project" encompasses quality risk management[191]. An analysis of the technical gap between donor country and the receiver country should be done beforehand. The capabilities of both the parties to the transfer would not be identical, but it must be established that the receiving party has infrastructure and capacity enough to mould the technology and reproduce the transfer product or process as a matter of routine against a defined set of specifications as set by the donor unit.

Not to mention that as part of the implementation process, the regulatory requirements should be worked out in the recipient country before the final product is ready to be launched in the market. The process of technology transfer may lead to different implications. These may include assessment of intellectual property rights, royalties, conflict on the issues of loyalty and confidentiality and such other which should be specifically addressed by both the parties during the planning of the transfer leading to a seamless execution.

To effectuate a transfer process, a technology transfer office/team (TTO) may be formed which is entrusted with the primary responsibility of ensuring that the transfer takes place as planned as per the terms agreed upon by both the parties to the transfer. Technology transfer personnel amidst responsibilities of proper implementation also manage invention portfolios, check for legal protection on the process or product, monitor patent prosecution and may also be helpful in negotiating licensing agreement terms. Sometimes, patent prosecution may be a substantial part of the transfer of technology for which the National Patent Office may be involved. Technology transfer personnel are responsible for assuring that the transfer fulfils its purpose and functions.

The function of technology transfer is to:

a) Co-ordinate: Technology transfer connects technology developers and end users. A co-ordination between internal and external resources once transfer is made, has to be established.

[191] *Supra* Note 190, 69.

b) Nurture: A technology once developed has to be nurtured. For the same, commercialisation is important. The journey from developing a technology in a laboratory to taking it outside of it for commercialisation and business, can be achieved by means of a transfer.
c) Establishing a link: Assimilating resources and developing technology with an aim for it to reach to the world, requires connecting developers with entrepreneurs and other outside group organisations, which may be instrumental in working on the technology further and developing new products.

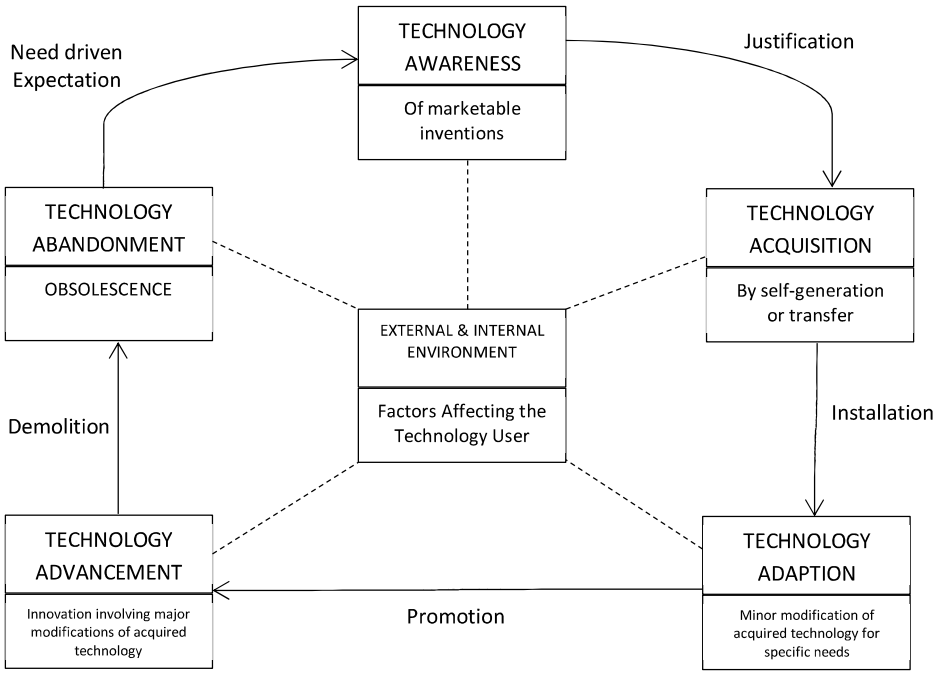
If a technology is protected by means of patent, then licensing rights play a major role in its further commercialisation as shall be discussed in the forthcoming chapters. However, before a technology enters the market, it needs to be developed through technology readiness levels (TRLs). TRLs 1-3 are more focused on research behind a technology while TRL 4 and upwards focus on the further development of the technology, bringing it out from the lab, testing it in the real world and how its efficacy is proven in the actual environment.

Moving from bottom end to the top end of the scale in the TRLs can be time consuming as it requires proper development of the technology and testing before they can be turned into proper finished products.

TECHNOLOGY LIFE CYCLE

The typical rise (growth) and fall (decline) of technology from its inception to the end is known as technology life cycle. It also affects the product which is connected to the technology. Technology management requires the study of technology life cycle so that all of its stages- awareness, acquisition, adaptation, advancement and abandonment can

be in turn managed well[192]. Technology life cycle can be depicted via the following illustration:



1. Awareness: It marks the first phase of a technology life cycle where by means of a formal mechanism a company becomes aware of a new emerging technology which may be relevant to the needs of the company or may be helpful in accomplishing the vision and mission of the company.
2. Acquisition: The acquisition phase involves acquiring a particular technology. Before acquiring a particular technology, a company's technology group along with its R&D group will conduct a feasibility study that judges the technology's technical feasibility as well as economic feasibility after acquisition.
3. Adaptation: This phase of the technology is very important as nearly every entity goes through the adaptation process after acquiring technology. The adaptation phase helps adapt the acquired technology to suit one's own needs.

[192] *See generally,* S Sudha Rani et.al, *Technology Transfer: Models and Mechanisms,* 9(6) INTERNATIONAL JOURNAL OF MECHANICAL ENGINEERING AND TECHNOLOGY 971-982 (June 2018).

The process of adaptation has to be well planned and thought of before acquisition of a technology.

4. Advancement: Every technology goes through the advancement phase in order to sustain as per the prevalent needs and requirements of the time. As a company grows and proceeds in exploiting the technology, with time it becomes utmost essential that the technology improves for sustaining the business of the company as well as its growth. This improvisation can be fuelled because of constructive feedback from the company or the users of technology or be driven by new innovation and products in the market.
5. Abandonment: This marks the last phase of the technology life cycle. Some suggest that this phase is crucial as it involves a pertinent question-whether the technology has become obsolete to the extent that it cannot be improved further to match the pace of other existing technologies in the market. If a technology becomes obsolete, it is abandoned and discarded. One must adapt to the new changes and new technologies in order to survive. To come to a decision on abandonment of a technology, a company's R&D team, product and marketing team can be consulted who may provide relevant information and analysis.

GENERAL CONSTITUENTS OF TECHNOLOGY TRANSFER

The advancements in technology aid the growth of global economy as well as strengthen local innovation. Such advancements have made possible the access of technology to nations and people who would otherwise have not been able to reap its benefits. The ultimate beneficiary of the advantages of prosperity in the field of technology is the public. It is imperative that in such a scenario, all must be done to ensure that there are no roadblocks in the process of technology transfer by focusing on each and every aspect of the process. Some of the general constituents of technology transfer are discussed below:

a) Research- Without proper research, no technology can flourish. Behind a successful and working technology is good research. The technology is backed by research which has tested the working of the technology to give as output, reproducible result.
b) Paperwork- Proper documentation and paper work is required where the technology is protected by means of intellectual property rights and the same

cannot be transferred without working out the licensing terms and conditions in the agreement. In the absence of proper paperwork, issues may arise at a later stage (after the transfer).

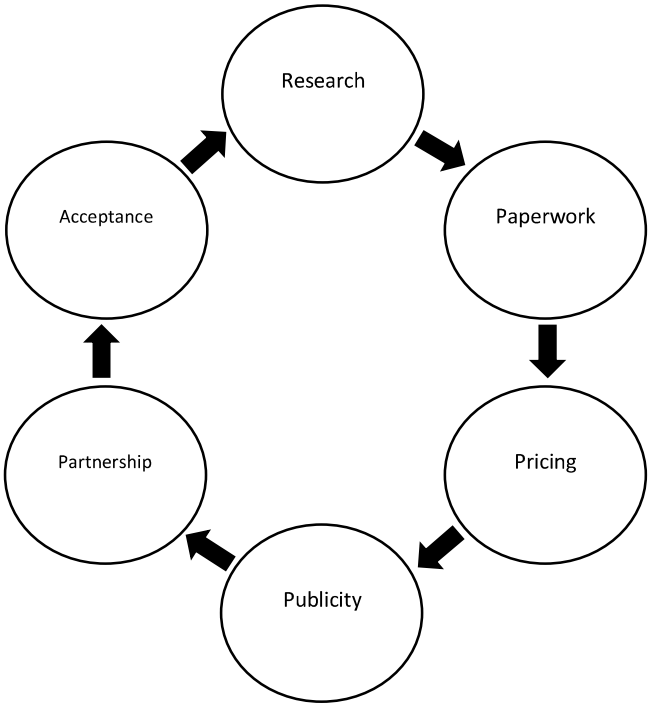
c) Pricing- One of the most important constituents of technology transfer is the aspect of pricing. Deciding royalties and pricing for the technology can be a difficult task and has to be managed efficiently. One major issue that is associated with pricing is determination of models of pricing. If the technology is too highly priced, then it can discourage purchase of the technology from a valid and interested buyer leading to less commercialisation. On the contrary, if the technology is not adequately priced, it can lead to a huge revenue loss which the inventor would in no circumstance want to suffer.

d) Publicity: Publicity of the technology intended to be commercialised by transfer helps identify the interested buyers of the technology. As much as the technology is publicised, by approach or otherwise, it is easier to place the interested party which may value the technology for what its worth.

e) Partnership: Partnership may be viewed as collaboration with industry. University-Industry partnership grew as a major transformation to technology transfer. Partnership or collaboration is important to technology transfer to ensure that the technology is effectively transferred ad adopted. Collaborations help take the university research out in the operational environment as a finished product.

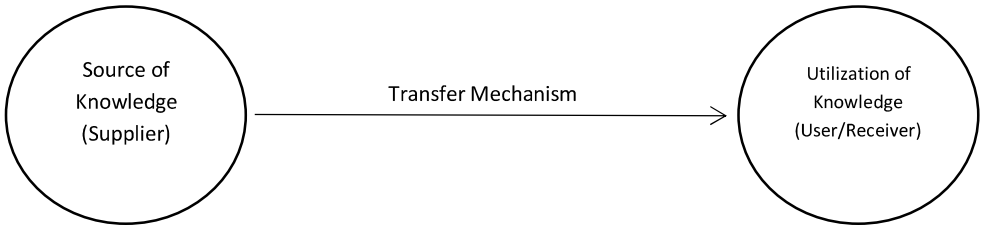
f) Acceptance: People's acceptance of the relevant technology is another inseparable part of the entire process. There is not much use researching and developing a technology which is not accepted by the people or one which cannot be made use of. If the technology is protected by means of patent, then the chances of people's acceptance increase as "utility" or "industrial application" is a mandatory requirement before the grant of patent rights. If the technology is not protected, then research will have to analyse the demand and utility of the technology to be able to gather people's acceptance.

All of the constituents discussed above hold equal importance and no one aspect is any less than the other.



PROCESS OF TECHNOLOGY TRANSFER

The process of technology transfer is a complex one and may involve many steps. Although the aim and end of the process is simple and clear i.e. a transfer from the supplier who has the source of knowledge to the user who makes good the utilization of knowledge, it has various elements/levels to it.



The major highlights of the technology transfer process are the people involved in it, namely, the transferor (owner of the technology), the transferee (beneficiary of the transfer), the technology involved (subject matter of transfer), the mechanism of

transfer (method of transfer depending on technology and various factors) and the environment of the transfer (terms and conditions from both the parties)[193].

- **IDEA-** Every creation or invention has an idea behind it. Any technology is developed with labour, skill and monetary investment; however, the beginning of any growth is a small idea which is born in the mind of a human being. The idea, as it is, may not be liable for protection, as would be advocated by intellectual property enthusiasts, but the protection awaits so long as the idea gets a physical manifestation. In letter, protecting an idea may not seem feasible at all, but in spirit, when intellectual property protection is extended to any creation or invention, it is the idea disguised in the physical manifestation which is protected. Hence for any technology to grow and develop, the journey begins with a simple yet novel idea, which may not have occurred to anybody else.
- **RESEARCH-** For the idea to develop, grow and probably take the intended shape as was thought of in the mind of the inventor, research follows inception of idea. No idea can ever materialise if not succeeded by proper research. Research not only helps to figure ways out how to conceptualise the idea into a finished product, but also lays down the possible ways of achieving the end result, the feasibility of the methods and also exposes the bottlenecks that may be faced in the journey, if any. All of these hints, equip the inventor better so that he may plan and progress accordingly, avoiding or minimising the effects of the bottlenecks. Research is a continuous process. It may be preliminary research conducted at an initial level, or advanced research conducted during the time of development of technology or research which continues even later on for improvisations in the established technology[194].
- **DEVELOPMENT-** After the roadmap for the technology has been laid out by preliminary research, development of technology by R&D happens. The term 'development' encompasses all the steps beginning from building on the idea of the particular technology to reaching the end result, seeing the finished product and everything related to improving it even afterwards. Research and Development go hand in hand. Just as research is an ongoing process, so is

[193] Akshay Khivansara et. al, *Review Article on Technology Transfer,* 2(3) INTERNATIONAL JOURNAL OF PURE AND APPLIED BIOSCIENCE 145-153 (2014).
[194] Dorothy Leonard-Barton & William A. Kraus, *Implementing New Technology,* HARVARD BUSINESS REVIEW (November, 1985), https://hbr.org/1985/11/implementing-new-technology

development. Research done to compute properties and functions of the technology come under initial development. On the basis of innovator product characteristics, the working of the technology is tested and analysed. Quality check and identification of specifications which meet the desired criteria also form part of development process just like innovation and R&D.

- **R&D-** The higher a company or a firm spends on R&D, higher are the chances that the company innovates[195]. This concludes that a lot of technological innovation depends on economic forces. In most of the industrialised countries like France, United States, United Kingdom, Germany and Japan[196], expenditure spent on R&D accounts for almost two to three percent of GDP, very unlike what is usually spent in developing countries[197]. If a firm spends on R&D more, it better prepares itself for increasing profits and keeping up with competition from other firms. Spending on R&D is also an indication of economic prosperity of a nation. There are three factors which determine the level of R&D of a company or firm; "these are:
  - The productivity of the R&D activity
  - The degree of appropriability of research results
  - Level of R&D expenditure of other firms"

  a. <u>The productivity of R&D</u> can be measured by the number of innovations of the firm that result from the research and development activity. If this productivity is high, firms will spend more in research resulting in a shoot up in technological innovation. For R&D activity to bear productivity, there has to be a fine balance between basic research and applied research. Basic research involves research on a general principle whereas applied research is application of the basic research for specific and particular uses and situations. In addition to this, the quality of education also influences the R&D productivity. If scientists and researchers are well-educated, the rate of innovation in a country will naturally be high. An educated system supports research which leads to the development of new products.

[195] Background Note by Secretariat of Working Group on Trade and Transfer of Technology is available at WT/WGTTT/W/1 [Dated 2nd April 2002].
[196] *Id.*
[197] *See,* Press Release, Anand JC, The Economic Times, India's R&D spends amongst the lowest in the world: NITI Aayog study (Jul 21, 2022), https://economictimes.indiatimes.com/news/india/indias-rd-spends-amongst-the-lowest-in-the-world-niti-aayog-study/articleshow/93024586.cms?from=mdr

Introduction of new products and processes in the market yields profitability.

b. Appropriability of research results is usually reckoned by the extent to which firms derive profits from the results of their research. If their research leads to a product which hits off successfully at the market and yields profits on commercialisation, the R&D can be said to be productive. Benefits from innovation may depend on a number of factors like the nature of innovation or the likeliness of the innovation to get a legal protection in the form of patent. If the technology is liable to be upgraded or transformed in a short time, then the company will not profit much as it shall be in a position of losing the title of being the first innovator.

c. A higher level of R&D expenditure of other firms may influence a company's R&D activity. A company's decision to compute R&D expenditure and spend accordingly is a strategic decision. If it is known that a competitor firm spends more on R&D[198], a firm naturally gets a better incentive to innovate as whoever innovates and commercialises first, gets a bigger market share and experiences profit while others may be forced to exit the market in instances of monopoly of another.

- **PRODUCTION-** Manufacturing and production are essential steps for the transfer of technology. First the technology is developed followed by production. Production is put to implementation only after studies can validate that the technology or the technology based product is stable. The R&D department of the transferor firm should perform quality checks and performance assessment. The manufacturing department of the transferee should also ascertain if they have the capacity and production environment for utilisation of the technology as per needs or mass production of the product.
- **INVESTMENT-** Investment is desirable not only from the perspective of development of a technology but also for its outreach and commercialisation. Technology transfer and diffusion can happen efficiently when a balance between the demands of developing countries of "fluid transfers with profit-driven needs" and monetary requirements of technology holders is established.

[198] Usually big companies make public data in the form of Annual Records which contains information like annual expenditure on R&D which is desired by investors, so as to make a well-reasoned decision about investment to the firm.

Pricing usually creates a barrier to the transfer as for various reasons; most common being developing nations not being in a position to match the monetary expectations of the technology holders due to lack of resources. A plausible solution to the problem could be creation of such a global forum in which technology holders, venture capitalists, investors, entrepreneurs from developing countries can all come together and work out an effective way of transfer where monetary concern shall not remain the only barrier affecting international transfer of technology detrimentally.

- **COLLABORATION-** Collaboration with industry is an excellent way to use and commercialise a technology[199]. Collaborative agreements are entered into by parties who wish to, by mutual co-operation, develop and commercialise the technology further. After investment of resources and human skill, parties together define objectives and framework of the collaboration and what they intend to derive out of the collaboration[200]. With the help of collaboration, the technology is publicised and reaches out to the larger public. For e.g. university-industry collaborations in the context of academic research.
- **DISTRIBUTION-** The borrowing unit (recipient country) needs to ensure a robust channel of distribution of the good to meet the demands of the people. If a technology has been borrowed because there is a growing demand of it in a developing country, then that transfer process will be futile if the country does not ascertain an efficient system of proper distribution. For the same, the borrowing unit can collaborate with companies or entities that can successfully warrant proper distribution channels so that people have access to the technology or technology driven good or service.
- **COMMERCIALISATION-** The end goal of technology transfer is commercialisation. International transfer of technology involves the transfer being made from developed nations to a developing nation where the recipient country engages into using the technology for production of commercially viable products. The receiver would end up paying so much for the technology only when it believes that it shall be able to reap benefits or make profits from

[199] David Bennett, *Technology Transfer through Collaborative Partnership Agreements: Issues and Considerations,* International Conference on Management of Technology (2001).
[200] *See Collaborative Research Agreements* in Technology Transfer Agreements, WIPO, https://www.wipo.int/technology-transfer/en/agreements.html

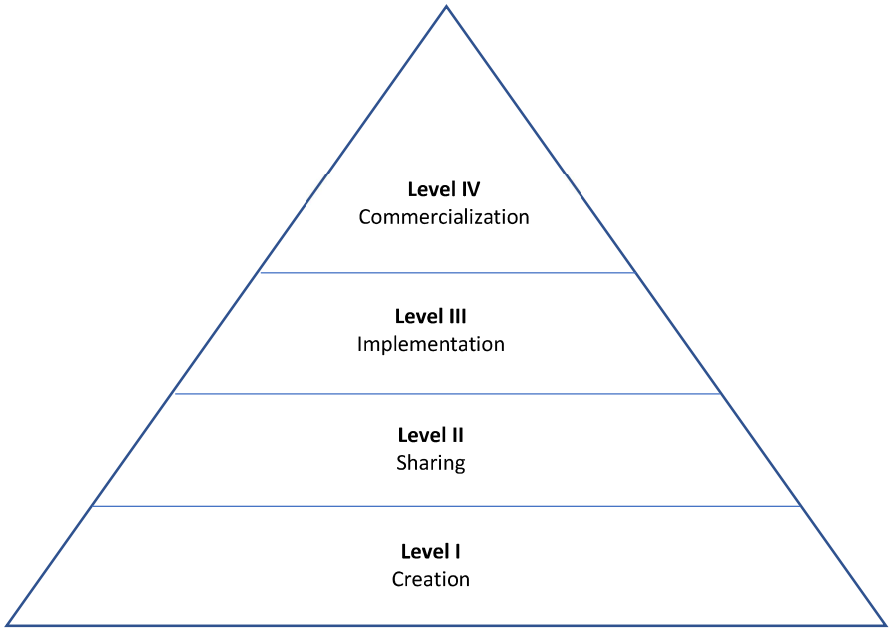
the transfer upon successful commercialisation. Commercialisation helps not only the transferee match the demand with the production supply but also benefits the transferor in the sense that the technology or the product gains publicity and has greater reach amongst people. Any transfer of technology is done with the ultimate aim of commercially exploiting the technology; as either that technology is the need of the hour or it helps in the development of related technologies and product which shall immediately supply to people's demands. Hence, it is understood that a successful technology transfer is one which ends with a proper commercialisation of the technology.

The abovementioned are some elements of technology transfer as discussed in detail. If clubbed together, broadly these can be categorised as four levels of transfer, which are:

i) Knowledge and Technology Creation (Level 1)
ii) Sharing (Level II)
iii) Implementation (Level III)
iv) Commercialisation (Level IV)

There are certain key factors that influence the process of knowledge and technology transfer[201]; communication, distance, equivocality and motivation are some of them. For knowledge and information transfer, it is important that the means of communication are effective. The medium for communication should be such as to convey accurately all task related/technology related information to the person or entity which seeks such information. Distance in the present context involves both physical distances as well as cultural and technological gaps between parties to the transfer. Knowing the distance would help parties negotiate terms of the transfer well[202]. Equivocality indicates the degree of substantial knowledge intended to be transferred while motivation demarcates the incentives behind transfer that may encourage the parties to enter into an agreement for transfer.

[201] Tae Kyung Sung & David V. Gibson, *Knowledge and Technology Transfer: Levels and Key Factors,* Proceedings of 4th International Conference on Technology Policy and Innovation (2000).
[202] *Id.*



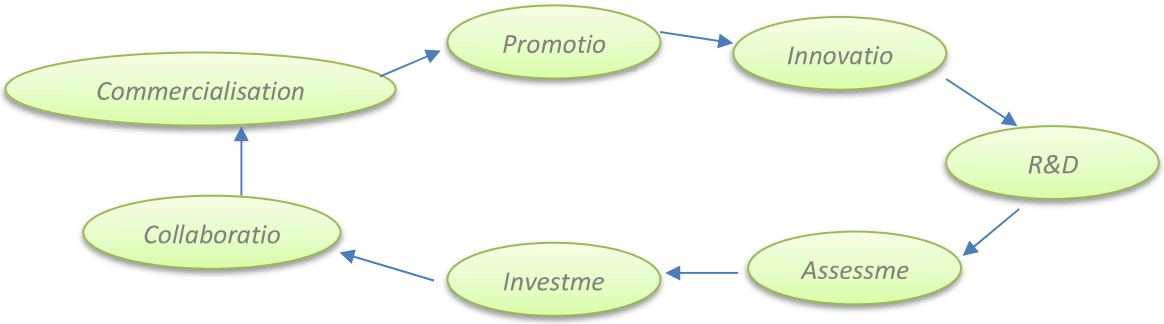
The initial level for every technology transfer process is generally creation of knowledge. At this level, researchers conduct novel research, put their research to test and finally publish their research by different means. Knowledge transfer at this stage is a mere passive process and only reflected during collaboration amongst researchers in a team which may even be stationed across national boundaries[203]. The second level of sharing depicts clear knowledge and technology transfer between developers and users. An established instance of success is when the transfer occurs across personal, functional or organisational boundaries and is accepted and clearly understood by the users so designated.

The third level is marked by orderly and effective implementation of the knowledge and technology thus shared[204]. To accomplish this level, the users having borrowed the technology must stand tall on the resources required to implement the technology. The transfer will solve its purpose only when it meets the demands for which the transfer process was initiated. For this, borrowing the technology or knowledge alone is not sufficient, but a strong setup (technology ecosystem) or infrastructure is needed to work the plan. The last stage is the stage of commercialisation. None of the objectives of the first three stages can be well achieved if the technology or knowledge is not

[203] Devine, M. D. et. al, *Government Supported Industry Research Centres: Issues for Successful Technology Transfer*, 12(1) JOURNAL OF TECHNOLOGY TRANSFER 27-38 (1987).
[204] Gibson, David & Niwa, K., *Knowledge- Based Technology Transfer*, Proceedings of Portland International Conference on Management of Engineering and Technology, 1991.

commercialised. Commercialisation helps achieve market strength when the product or technology is purchased and used by the general public for whom it is meant. More the product or technology is commercialised, the more benefits it shall reap to the borrower as the same can be treated as return on investment (investment which is made during purchase of the technology). A big market share sure denotes success.

Usually for technology transfer in the pharmaceutical sector, the same process is bifurcated in three phases, the **research phase**, **development phase** and the **production phase** which follows a similar pattern



IP PROTECTION- A technology which is the subject matter of transfer may or may not be protected. However, a protected invention is always encouraged for better record and documentation and also for asserting the right owner's claim over the other. Intellectual property protection is a crucial step in the process of technology transfer. What may be the subject matter of transfer can commonly be protected as patents or trade secrets in the intellectual property rights regime. A technological invention which ought to be transferred can be an invention which is of utmost importance to a business, has commercial value attached to it and is of such nature that it makes the heart and soul of the business. Such can be protected by means of a trade secret[205].

Most commonly technological inventions are protected by means of patent as an intellectual property. This can be understood given the fact that patents protect "inventions". In its legal understanding and clarity, the Patents Act 1970[206] defines invention and extends protection to all inventions that fulfil the requisites laid down for an invention[207] under the Act. A technological invention, that fulfils the given criteria,

[205] "Section 7: Protection of undisclosed information- Article 39, TRIPS Agreement."
[206] "Section 2 (j): "invention" means a new product or process involving an inventive step and capable of industrial application."
[207] *Id.* Criteria for patentability under the Act: Novelty, Non-obviousness (inventive step) and Utility (industrial applicability).

is liable for protection. This assumes importance at the time of transfer of the technology when the licensing of rights and payment of royalties also find adequate discussion and mention in the transfer agreements.

In short, the journey of technology creation to its relocation and finally absorption is all that is traced in the process[208]. The relocation and absorption of technology are generally given the most emphasis. For effective relocation it is needed that the flow of conceptual knowledge behind the working of the technology runs parallel to the flow of technology itself[209]. The conceptual knowledge must be open to the human resources handling the technology. This eventually is essential to the absorption process.

In international transfer of technology, for any such transfer, the sale and licensing agreements are drafted at the outset addressing all related industrial property like patents and utility models, and also investors certificates[210]. The agreements also cover know-how and technical expertise including any diagrams, models, specifications, training equipment and other knowledge which might be required. It furthermore thereafter covers issues related to installation and operations of plant or other machinery. Lastly, industrial and technical co-operation agreements of any kind are also included for e.g. turn-key arrangement and other provisions for management and marketing of the technology.

TECHNOLOGY TRANSFER AGENTS AND ORGANISATIONS

As stated above, the major actors behind the technology transfer process are the people behind it[211]. The job of ensuring a smooth transfer process and a perfect implementation of the terms of the agreement to the transfer, is generally assigned to technology transfer teams or technology transfer organisations.

The agents involved in a technology transfer as has been mentioned before are universities, research centres, technology institutes, private research companies, spin-offs, start-ups and other companies with a relatively large R&D department[212]. In many universities or research centres, there now is a systematised **Transfer of Technology**

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[208] K. ASWATHAPPA, INTERNATIONAL BUSINESS 324 (2016).
[209] *Supra* Note 192, 73.
[210] *Id.*
[211] Navid Khabiri et. al, *Identifying Main Influential Elements in Technology Transfer Process: A Conceptual Model,* 40 PROCEDIA- SOCIAL AND BEHAVIOURAL SCIENCES 417-423
[212] *Supra* Note 193, 77.

Office (TTO) to look after related activities. Its major operations involve identification of research that has high potential and commercial viability. Such offices also look after how to exploit efficiently a particular technology which is borrowed or if not, then should be borrowed. In universities, these offices are generally created to manage IP assets of the universities and ensure smooth transfer from university to industry. These offices can have different nomenclature for e.g. be known as Technology Management Office, Technology Transfer Interface, Technology Licensing Office, Intellectual Property and Technology Management Office and many other. Due to the technicalities and complexities involved in a technology transfer process, the team of a Technology Transfer Office may comprise of engineers, economists, scientists and even lawyers.

In such offices and organisation generally the team comprises of people who have designated jobs to do. The overall management of the team, co-ordination and responsibility would be assumed by a Project Manager. For managing the regulatory affairs of the technology, the department or concerned authority would advise on filings, documentation and responses on regulatory inquiries. Understanding and operating technology per se would go into the hands of engineers who would also be in charge of managing construction of equipment and their installation. A research and development team would sit separately focusing on the nitty-gritties of the concerned technology. The major function of the team is to act like a link joining the developer of the technology with its ultimate user and also between a researcher and a developer/manufacturer.

In addition to these offices, there are **Technology and Innovation Support Centres**[213] (TISCs) that help budding innovators, generally in developing countries, have access to technological information and other related services so that they can manage their intellectual property better. These centres better equip the innovators with knowledge about patents, technical literature, operating online databases, using research tools and provide assistance on utilising resources optimally so as to further innovation, technology transfer and in turn its commercialisation. The World Intellectual Property Organisation (WIPO) supports TISCs in over eighty countries and provides for an exhaustive list of services that are offered by the TISCs.

[213] *See, Technology and Innovation Support Centres,* WIPO, https://www.wipo.int/tisc/en/.

Science and Technology Parks (STP) are examples of spaces that are built to promote innovation and where potentially strong research thrives. These are purpose built territorial spaces usually around universities and research laboratories designed in a manner to support research and growth in science and technology through technology transfer and open innovation[214]. They are affiliated to such laboratories and universities based on proximity.

Technology Incubators are basically organisations that help incubate growing businesses and help them with a plethora of services such as funding, training, hiring, technology and the like. They help start-up businesses develop and grow their business. Initially, the concept of technology incubators grew in the United States to promote growth and innovation, devising economic development strategies with the aid of technology application and support. They provide a mechanism for technology transfer as universities and other research organisations are commonly the developers of technology business incubator programs[215]. Although these incubators were established with an aim to ensure technology transfer, they have recently not been able to serve the purpose well. Structural and functional reorganisation for technology incubators needs to be done to warrant transfer and commercialisation of technology.

Intellectual Property Marketplaces are internet based online platforms which provide spaces to innovators all over the world to connect with one another. The innovators can, not just connect with other innovators but also potential clients as technology seekers. An example of one such platform is WIPO GREEN[216] which is an online platform initiative by World Intellectual Property Organisation (WIPO). The platform enables collaborations between green technology developers and technology seekers in order to meet the current demands of a clean environment and sustainable development.

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[214] *See generally, Establishing Science and Technology Parks: A Reference Guidebook for Policymakers in Asia and the Pacific,* United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), 2019. https://repository.unescap.org/bitstream/handle/20.500.12870/114/ESCAP-2019-MN-Establishing-science-and-technology-parks.pdf?sequence=1

[215] Rhonda G. Phillips, *Technology business incubators: how effective as technology transfer mechanisms?* 24(3) TECHNOLOGY IN SOCIETY 299-316 (2002).

[216] *See, "WIPO GREEN- The Marketplace for Sustainable Technology,* https://www3.wipo.int/wipogreen/en/. The platform for technology exchange supports global efforts to address climate change by connecting providers and seekers of environmentally friendly technologies. Through its database, network and acceleration projects, it brings together key players to catalyse green technology innovation and diffusion."

Just as one may lead a horse to water but cannot make him drink is as applicable in the field of technology transfer as any other. One may have a novel idea of creating a path breaking technology that would in future have commercial viability also, but so long as the willingness to create, innovate and commercialise is not there, the need to utilise a better method or concept also does not get a push[217]. Whatever be the organisations or the people involved in the process, in the end, there has to be a willingness to create, diffuse and adopt.

MODELS OF TECHNOLOGY TRANSFER

Since the early 1970s, several research endeavours have focused on creating models for the transfer of technology. There have been various models proposed by researchers that are both qualitative and quantitative[218]. While qualitative models state elements that are essential in managing a technology transfer project and also attempts to elicit factors that can influence the success and effectiveness of a transfer process, the quantitative models on the other hand attempt to quantify the parameters on which success of a technology transfer project depends. They also try to measure grounds of incompatibilities between the transferor and transferee and suggest ways to minimise them. These models effectually aid in the better planning and implementation of a technology transfer project.[219] For a good technology transfer, an appropriate model or mechanism should be adopted. Some of the most popular technology transfer models are discussed below; each having its separate set of objectives.

a) **The Bar-Zakay Model:** Bar Zakay in 1971 developed a transfer of technology model based on a project management approach. He classified the entire process of technology transfer into four stages namely Search, Adaptation, Implementation and Maintenance[220]. He divided the activities and milestones separately for the transferor (or donor) and the recipient and depicted the same in a pictorial representation. The need for acquiring skills related to technological forecasting, long range planning and gathering project related intelligence for both the donor and recipient has been emphasised in the model.

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[217] Jolly & Creighton, *The technology transfer process: Concepts, framework and methodology,* 1(2) THE JOURNAL OF TECHNOLOGY TRANSFER 77-91 (1977).
[218] *Supra* Note 211, 84.
[219] *Id.*
[220] K. Ramanathan, *An Overview of Technology Transfer and Technology Transfer Models*, Chemistry (Easton)., 2011.

However there have been some criticisms to the proposed model[221]. At the outset, the model uses the term "donor" for the transferor which gives the impression that the owner of the technology has agreed to transfer the technology for selfless reasons, which is a little misleading. K.I. Jagoda[222] stated, *"The model has limited relevance today since many of the activities, terms, and ideas expressed reflected the setting of the late 1960s to early 1970s, when buyers of technology were mainly passive recipients who depended greatly on aid programs for the purchase of technology. It was also an era when government controls were instrumental in determining the rate, direction, and scope of technology flows."*

Some of the takeaways from the Bar-Zakay model are:

1. A detailed examination of the entire process of technology transfer right from "search" phase to "post-implementation" activities is needed.
2. For planning and implementing of technology transfer projects technology transfer projects, a process approach should be adopted.
3. Having milestones and decision points are important so that activities directed towards technology transfer are strengthened, mistakes can be corrected and the project contract can be terminated at any point of time[223].

b) The Behrman and Wallender Model: Behrman and Wallender (1971) have in their model suggested a seven-stage process for international transfer of technology that may be more suitable for multinational corporations. "These seven stages are:

i) Manufacturing proposal and planning to arrive at decisions regarding location and preparing a business case including good resource assessments.
ii) Deciding the product design technologies to be transferred.
iii) Specifying details of the plant to be designed to produce the product and other aspects related to construction and infrastructure development.
iv) Plant construction and production start-up.

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[221] *Supra* Note 193, 77.
[222] *See generally,* R. J. Lonseth et. al, *Efficacious Management of Technology Transfer Projects: Lessons from a Canadian Case Study,* POMS 20th Annual Conference, USA, 2009.
[223] Bar-Zakay, *A technology transfer model*, 2 TECHNOLOGICAL FORECASTING & SOCIAL CHANGE 321-337 (1971).

v) Adapting the process and product if needed and strengthening production systems to suit local conditions.
vi) Improving the product technology transferred using local skills.
vii) Providing external support to strengthen the relationship between the transferor and transferee."

This model too, suffers from certain weaknesses. One of the things pointed out is that in the course of the first three steps is that the transferor progresses in the development of the technology without much help from the transferee which in a way makes the transferee all the more dependent on the transferor for the technology and its functioning. This does not however mean that the model leaves no room for the transferee's involvement. Step five and six have sufficient scope for the transferee to work on and advance technology.

Some takeaways from the Behrman and Wallender model are:

1. It is desired that the transferee in a technology transfer is involved in the process, namely the planning and implementation of the project, right from the very beginning.
2. A project of transfer of technology is not deemed to end with the commencement of production as there remains scope for the transferee to work on and develop the technology further in an attempt to improve it.
3. So long as specific measures to ascertain integration of the borrowed technology are laid out, the transfer of technology shall be deemed to have turned out as successful[224].

c) **The Dahlman and Westphal Model:** Dahlman and Westphal (1981) after carrying out substantial research work in the Republic of Korea and analysing the situation in rapidly industrialising countries in East, during the 1980s, came up with a model that proposed a nine-stage process for technology transfer. "These are-

i) Carry out pre-investment feasibility to gather information and carry out a techno-economic analysis to establish project viability.

[224] J.N. BEHRMAN & H.W. WALLENDER, TRANSFERS OF MANUFACTURING TECHNOLOGY WITHIN MULTINATIONAL ENTERPRISES (1976).

ii) Carry out a preliminary identification of technologies needed, based on the feasibility study.
iii) Carry out basic engineering studies that involve the preparation of process flow diagrams, layouts, material and energy balances and other design specifications of the plant and machinery and the core technology to be transferred.
iv) Carry out a detailed engineering study that involve the preparation of a detailed civil engineering plan for the facility, including construction and installation specifications and identification of the peripheral technology needed to make the transfer effective.
v) Carry out the selection of suppliers for equipment and subcontracting services to assemble the plant and machinery and plan for the co-ordination of the work among various parties.
vi) Prepare and execute a training and education plan, in consultation with the suppliers of technology, for the workers who would be employed in the technology transfer project.
vii) Construct the plant.
viii) Commence operations.
ix) Develop trouble-shooting skills and put in place arrangements to solve design and operational problems as they arise, especially during the early years of operation."

The model has been considered as an enhancement to the model proposed by "Behrman and Wallender" as this involves the participation of the transferee at almost all stages of the transfer process. One of the criticisms that it attracts is that because of such proactive involvement from the transferee, it assumes that the transferee has skills enough to understand, operate and work any technology which may not be the case all the time. Also, in developing countries, this seems all the more difficult to achieve. Another criticism is that the model misses focus on negotiation and post-implementation assimilation activities.

Some takeaways from the Behrman and Wallender model are:

1. The best way to study a technology transfer project is by means of a sequential process perspective.

2. No project concerning technology transfer should begin without a cautious feasibility study. This is because these projects demand heavy resource commitments.
3. The involvement of the transferee should be ensured from the beginning.
4. Developing robust engineering and project management skills is crucial for recipients, as the effective management of the process of transferring technology depends on these capabilities[225].

d) The Schlie, Radnor and Wad Model: 1987 saw the Schlie, Radnor and Wad Model that basically lay down seven elements that define the success behind a technology transfer process. It includes points that can influence the planning and implementation of the process. "These seven key elements are:

i) The transferor, which is the entity selling the technology to the recipient.
ii) The transferee, which is the entity buying the technology.
iii) The technology that is being transferred.
iv) The transfer mechanism that has been chosen to transfer the chosen technology.
v) The transferor environment which is the immediate set of conditions, in which the transferor is operating. Attributes of the transferor environment that can influence the effectiveness of the transfer process include, among others, economic status, business orientation (inward versus outward), stability, attitude and commitment to the transfer project, and operating policies.
vi) The transferee environment which is the immediate set of conditions under which the transferee is operating. Attributes of the transferee environment that can influence the absorptive capacity of the transferee include physical and organisational infrastructure, skills availability, attitude and commitment to the transfer project, technological status, business orientation (inward versus outward), economic status, and stability.
vii) The greater environment which is that surrounding both the transferor and the transferee. There may be layers of this environment that are sub-regional, regional, and global. Even if the immediate operating

[225] C.J. Dahlman & L.E. Westphal, *The meaning of technological mastery in relation to transfer of technology,* 458 THE ANNALS OF THE AMERICAN ACADEMY OF POLITICAL AND SOCIAL SCIENCE 12-26 (1981). https://www.jstor.org/stable/1044311

environments of the transferor and the transferee are favourable to the technology transfer, if the layers of the greater environment are not supportive, then cross-border and international technology transfer could be adversely affected. Factors in the greater environment such as political relationships between countries, exchange rates, investment climates, trade negotiations, balance of trade, relative technological levels, and the status of intellectual property protection regimes could have a great influence on the success of a technology transfer project."

These seven pointers are considered valid in today's business setting as well, yet keeping the concept intact, it can structurally mould itself with the changes in time. One aspect where the model lack is that no clear guidelines or markers are given to help with what a transferee should do. Some of the takeaways from this model are:

1. The numerous transformations occurring in the current global business landscape highlight the necessity for technology managers to acquire deep insights into both the transferee and transferor environments, as well as the broader context when strategizing and executing a technology transfer project.
2. Selection of the mechanism for transfer of technology should be grounded in a comprehensive understanding of the remaining six elements.

e) **The Chantramonklasri Model:** This model in 1990[226] came as a further improvement to the Dahlman and Westphal Model. "The model proposes five phases to the technology transfer process:
   i) Carrying out a pre-investment, economic and technical feasibility study.
   ii) Developing engineering specifications and design based on the feasibility study.
   iii) Commence capital goods production based on the engineering specifications and designs that have been developed.

[226] N. CHANTRAMONKLASRI, *The development of technological and managerial capability in the developing countries*, in TECHNOLOGY TRANSFER IN THE DEVELOPING COUNTRIES (M. Chatterji ed., 1990).

iv) Installation and testing of machinery, commissioning and start-up including comprehensive use of the workforce.
v) Commence commercial production.

While the phases of the model are valid and clear, the fact whether the transferee has manufacturing capacity enough to lead to mass production of capital goods is uncertain. It is concluded that while this model can work out in relatively more advanced developing nations with larger manufacturing capacities such as China and India, it may not work equally well in other smaller developing countries. The takeaways from this model are similar to the Dahlman and Westphal Model."

The abovementioned are some of the most popular qualitative models to technology transfer amidst many others. Lee *et. al*, in 1988 developed a similar model which is also known as the longitudinal model of technology transfer. The model is based on a study conducted on fast and rapidly industrialising countries. It highlights the needs of the transferee to strategize how to acquire, assimilate and eventually improve borrowed technology. It makes the transferee firm choose the appropriate methods of transfer process depending upon the kind of technology and the stage of technology life cycle it is at; keeping in mind its own production capacities. It specifies that the transferor before transferring technology will analyse the newness of the technology to be transferred, its importance to the transferor and the intellectual property rights attached to it[227].

The model proposed by Reddy and Zhao[228] (1990) is somewhat similar to the Schlie, Radnor and Wad Model[229] where it focuses on three major components of an international technology transfer. These components are home-country component, host-country component and transaction component; where the home-country is the transferor and host-country the transferee. The home country component includes examining the country's government policies (encouragement and restrictions) on technology transfer, studying the method of transfer, role of transferring firms in

[227] *Supra* Note 220, 87.
[228] Reddy N, Zhao L., *International technology transfer: A review*, 19 RESEARCH POLICY 285-307 (1990).
[229] T.M. Schlie et. al, *Indicators of International Technology Transfer*, Centre for the Interdisciplinary Study of Science and Technology, North Western University, Evanston. (1987)

foreign direct investment, the type and nature of technology transferred and transferring firm's global R&D activities. The host-country components would include host-country government policies of trade, technology transfer and foreign investment, how suitable is the technology being considered for transfer to the host-country, the technological capability of the host country to develop and upgrade the technology and the scope for assimilating the technology transferred. The transaction component includes elements which are crucial to the transfer and negotiated between the home-country and the host-country like pricing of the technology, intellectual property rights attached to it, methods of payment and other issues that may arise as bottlenecks to the effective transfer of technology, if not addressed earlier.

Keller and Chinta[230] in 1990 developed a model for technology transfer that worked on the transferor's and transferee's willingness to work around the barriers (social, political, technological, economic and legal) to effective transfer. The parties to the transfer strategize how a "win-win" situation can be arrived at.

Durrani et. al[231] (1998) proposed a model which consisted of five essential steps to the technology transfer process. These are:

- Establishing market-place requirements
- Identifying technology solutions
- Classifying the identified technology solutions
- Establishing sources from where the desired technology could be acquired
- Finalising the technology-acquisition decision

Although the model ends at technology acquisition and does not elaborate further on the absorption of technology, it nonetheless in its fourth step highlight the need for identifying various sources from where the technology can be acquired and making a reasoned choice by selecting one. This provides the transferee to choose from multiple transferors.

[230] Keller R, Chinta R., *International technology transfer: strategies for success*, 4 THE EXECUTIVE 33-43 (1990).
[231] T Durrani et. al, *Managing the technology acquisition process*, 18 TECHNOVATION 523-528 (1998).

Bozeman[232] (2000) has also proposed a model which is known as the contingent effectiveness model. While the prevalent flow of transfer of technology was from universities and government laboratories to industry, this model draws relevance to inter-firm technology transfer also. The model lays down the key elements to the transfer process which are the transferor, transferee, the transfer mechanism, the object to be transferred (content and scope of technology) and the 'demand environment' guided by the market factors along with the need for the technology. The model studies impact assessment; measures that may have an impact on the transfer like market forces, political benefits, economic development, opportunity costs and development of scientific and human capital.

While there isn't much available literature when it comes to **Quantitative Technology Transfer Models**, yet there are some models that may deserve a brief mention. One of the first quantitative models is that of Sharif and Haq[233] (1980) which had the concept of potential technological distance (PTD) assess technology transfer. The inference of the research as proposed by the model is that if PTD between the transferor and transferee is either too much or extremely less, then the effectiveness of the transfer is quite low. Hence, if a transferee has to look for a potentially effective transfer, he should look for one which has an 'optimal' PTD. However, the transferor firm may not be very eager to divulge information about PTD.

Another quantitative model was proposed by Raz et. al[234], in 1983 presented a model of technological "catch-up" that revolves around how a technology pioneer assists the technological development of a recipient through technology transfer. "The model examines three growth phases of technology transfer with regard to the technological gaps:

- Initial slow phase with high technological capability gap
- Fast growing learning phase with the technological gap decreasing
- Catch-up phase when the technological gap has reduced to almost nil

[232] B. Bozeman, *Technology transfer and public policy: a review of research and theory,* 29 RESEARCH POLICY 627-656 (2000).
[233] Sharif & Haq, *A time-level model of technology transfer*, 27(2) IEEE TRANSACTIONS OF ENGINEERING MANAGEMENT 49–58, (1980).
[234] Raz B, et. al, *A quantitative model of technology transfer and technological catch-up: The case of developed countries*, 24(1) TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE 31–44 (1983).

This would help transferors develop clear policies on technology transfer, competitiveness and other related matters."

Based on a study conducted in Korea and Japan, Klein and Lim (1997) using an econometric model studied the technological gap existing between general machinery and electronic industries. The model suggested that technology transfer can play a crucial role in the advancement of technological levels. The model by means of empirical studies also emphasises the requirement of post-implementation activities that would enable assimilation and moulding of the technology that has been transferred[235].

Quantitative models of technology transfer have used analytical approaches to study and generate information about technology transfer. Both the qualitative and quantitative models have helped understand the functioning of technology transfer better. Following are some of the valuable lessons that have been conveyed by the models:

- ✓ It is important to expend comprehensive analytical effort in establishing the need for a technology transfer project prior to the commencement of a TT project.
- ✓ A TT project should not be commenced without a careful feasibility study since such projects often require heavy resource commitments.
- ✓ A process approach must be adopted in planning and implementing TT projects and to ensure effective technology transfer there is a need to comprehensively examine the entire process from "technology search" right through to "post-implementation" activities.
- ✓ The many changes that have taken place and are taking place in the global business setting today have made it imperative for managers of technology to gain good insights into the transferee environment, transferor environment, and the greater environment when planning and implementing a TT project.
- ✓ Multiple sources of technology must be identified to enable a good choice of transferor.

[235] Nirmal Kundu et. al, *Development of Framework for an Integrated Model for Technology Transfer,* 8(35) INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY 1-14 (Dec 2015).

- ✓ The transferee must be involved right from the beginning in the planning and implementation of a TT project.
- ✓ It is important for transferees to develop sound engineering and project management skills without which the technology transfer process cannot be managed effectively.
- ✓ Partners in TT projects need to develop skills to be able to use formal, analytical approaches that can generate needed information for better technology transfer planning.
- ✓ It is important to have milestones and decision points so that activities can be strengthened, mistakes corrected, or even the project terminated at any point in time.
- ✓ The mechanisms chosen by a transferor to transfer technology will depend on the transferor and transferee setting, the technological capability of the transferee, the relative newness of the technology, its strategic importance to the transferor firm, and the level of intellectual property protection needed.
- ✓ As a transferee firm advances technologically, it needs to choose appropriate mechanisms of transfer, depending on the stage of the life cycle of the technology and its own technological capability profile.
- ✓ A technology transfer project does not end with commencement of production. Unless explicit measures are in place to ensure assimilation of the transferred technology the technology transfer cannot be said to have been successful.
- ✓ The success of a technology transfer project would be determined by the extent to which the transferor and transferee manage the barriers that impede transfer and strengthen initiatives that facilitate it.

The flow of technology across boundaries, different regions, companies, different departments within organizations or even among individuals, is a continuous process. Behind every effective technology transfer process is a proper strategy formulated on the mechanism and mode of transfer chosen depending upon the nature and kind of technology involved.