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Development of Technology Transfer Models for Research and Technology Organisations — Transferring Key Enabling Technologies to Small and Medium-sized Enterprises

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AFFIDAVIT

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Abstract

Europe and the whole world face many challenges that require both immediate and medium-term measures. The European Commission has identified these problems and has proposed to focus on initiatives that reinforce innovation in particular, within the Common Strategic Framework for EU Research and innovation funding. A number of so-called Key Enabling Technologies (KETs) have been identified, which are of utmost importance for attaining the objectives for enhancing innovation in Europe. The diffusion of Key Enabling Technologies from research and technology organizations to small and medium-sized enterprises carries great hopes for the European industry. However, while the European research system is a global leader in developing Key Enabling Technologies, it struggles to translate this knowledge into marketable products and services. Recommended Key Enabling Technologies (KETs) include advanced manufacturing systems, photonics, industrial biotechnology, micro- and nanoelectronics, nanotechnology and advanced materials.

Research organizations are struggling to transfer the technologies and services they have developed to small and medium-sized enterprises. Most of the small and medium-sized enterprises do not know about the possibilities of cooperation with research organizations and they often do not have the financial resources to invest in the development of their operations or they have not recognized the importance of continuously innovating their operation. The huge potential of the interaction between the two parties is far from being exploited.

In order to contribute to the resolution of this innovation gap, the aim of this thesis is to develop business models for the transfer of Key Enabling Technologies from research organizations to small and medium-sized enterprises. This work is conducted with the main focus laying on the perspective of research organizations, but the perspective of other participants is also taken into account.

Based on a literature research, an examination of existing models and expert interviews, four main models with recommendations for subvariants are delivered. The implementation of the models was not the content of this work, but results and findings of this work can be used as a basis for the implementation.

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Abbreviations and symbols

BSO	—	Business support organization
ERDF	—	European Regional Development Fund
GMA	—	General morphological analysis
HPC	—	High Performance Center
IBF	—	Inspiring Business Forum
IP	—	Intellectual property
IPR	—	Intellectual property rights
KET	—	Key enabling technology
LSE	—	Large scale organization
RTO	—	Research and technology organization
SKAP	—	Smart KET Access Point
SME	—	Small and medium-sized organization
TRL	—	Technology readiness level
TT	—	Technology transfer
TTO	—	Technology transfer office

1. Introduction

Fostering the access of European companies to KETs developed by the research and innovation system is key for addressing our biggest challenges and establishing the continent's position at the forefront of advanced and sustainable economies. However, there is a gap between the globally leading performance of European KET development and the performance of translating these technologies into tangible results for the industry.

Research organizations are struggling to reach out to small and medium-sized enterprises with the technologies and services that they develop. A large proportion of small and medium-sized enterprises are not aware of the available possibilities to cooperate with research organizations. They also very often lack the financial resources to invest in developing their operation, and some even fail to recognize the importance of innovation. The enormous potential that lays within the interaction of these two parties is by far not exploited.

The aim of this thesis is to contribute to the remedying of this undesirable situation by developing innovative models for the transfer of technologies from research organizations to small and medium-sized organizations. The models should give a starting point for the implementation of the concepts that they describe.

This thesis is carried out as part of the European Union's KETGATE project, which tackles this issue by providing a platform that can help in bringing research and industry closer to each other. I have found the possibility to conduct my master's thesis as port of KETGATE very pleasing because of the promise of having the chance to work on a real problem. Conducting this work can be an important part of my professional education and it can provide me with highly valuable entrepreneurial knowledge.

In the first part of the work, a literature research is conducted to give an overview of the subject area and to identify the most important properties of the technology transfer process. In addition, an examination of practical examples of technology transfer models collected from research institutes is presented. To verify the found theoretical data and to supplement it with empirical data, semi-structured expert interviews are conducted with technology transfer specialists from five research institutes coming from different parts of Europe.

General morphological analysis is used to develop the technology transfer business models based on the generated theoretical and empirical knowledge and the models are documented.

Before beginning with the literature research, a short overview of the KETGATE project is presented in chapter 2.

2. KETGATE

The work presented in this thesis is done as part of the project "KETGATE". KETGATE is part of the European transnational Interreg program "Interreg CENTRAL EUROPE", which is funded by the European Union's European Regional Development Fund (ERDF). The objective of KETGATE is to develop sustainable linkages between the actors of the innovation systems in order to improve regional innovation capacity in Central Europe.

2.1. Key Enabling Technologies (KETs)

The KETGATE project aims at enhancing the competitiveness of the Central European SME sector, which is the backbone of the European economy by representing 99% of all businesses, through improving their access to Key Enabling Technologies (KET). KETs are knowledge- and capital-intensive technologies with rapid and integrated innovation cycles that require high R&D intensity, high capital expenditure and highly skilled employment. By exploiting KETs, countries or regions can get to the forefront of advanced and sustainable economies, and thus the European industry can provide a solution to its biggest challenges, which are global competition and the efficient use of energy and resources. The European Commission identified and defined 6 key enabling technologies with the highest potential to reverse the decline of manufacturing, stimulate economic growth and the development of new products and create new job opportunities, which are the following:

1. **Advanced Manufacturing Technology:** Circumscribes the use of technology to improve innovative products or processes. These technologies can be divided into two groups: process technology used to create any of the other five key enabling technologies, and process technology based on robotics, computer-integrated manufacturing or automation technology. The first group typically relates to production infrastructure, machinery, and processes used to produce particular components of materials. The latter group on the other hand includes measuring, testing and control equipment for machinery, tools and automated or IT-based manufacturing technology.

2. **Photonics:** A multidisciplinary physical science dealing with the generation, detection and manipulation of light. Important technologies belonging to this group include photovoltaic systems, which are used to convert sunlight to electricity, LED- or laser technologies.
3. **Advanced Materials:** The two main benefits that this field can bring are the substitution of existing materials with new, reduced cost alternatives and new materials enabling value added to products. The effects of new findings in these field effect a very wide range of fields and with a very high potential impact. Positive impact may include better recyclability, reduced carbon footprint, lower energy demand and lower demand for raw materials.
4. **Industrial biotechnology:** This group is also known as white biotechnology and covers the industrial utilization of biotechnology in the chemical, material or fuel industry. Industrial biotechnology uses microorganisms or their components like enzymes to generate chemical building blocks with specific capabilities which would not be achievable with classical petrochemical processes or to decrease the energy use or byproduct generation of the manufacturing of products. The most mature applications in this field are mostly found in the food and detergent industry, but one of the most important general expectation regarding industrial biotechnology is to replace non-renewable materials used in several industries with renewable ones.
5. **Nanotechnology:** Technologies related to this field are dealing with the manipulation of structures, devices and shapes at the nanometer scale. New developments in this field carry high hopes for radical breakthroughs in important industries such as healthcare, environment, energy and manufacturing.
6. **Micro- and nanoelectronics:** This field deals with miniaturized electronic subsystems and semiconductors and their merging into larger systems. Practical examples are nanoscale transistors or microscale transistors of a chip.

There is significant research going on in all of these fields in the European Union, however the results coming from these efforts are not being sufficiently translated into economic or societal gains. To overcome this gap – or better said "GATE" – the KETGATE project

proposes the execution of the following specific objectives presented in the next subchapter. (Commission of the European Communities, 2009, pp. 1-3)

2.2. Distinguishing characteristics of KETs

This section aims to elaborate the particularities of Key Enabling Technologies in comparison to traditional technologies.

Common features of KETs are a high need for research and development activities, skills and capital expenditure, a multi-disciplinary approach covering many technology areas, a long time horizon between the results of basic and applied research, high multiplier effects and a high degree of spillover to other emerging technologies and a high degree of potential for product and process innovations. They are expected to bring significant economic improvements and provide an increasing variety of applications in an increasing number of application areas and industries. Most often, the extent of their impact depends on the development of other complementary technologies and innovations.

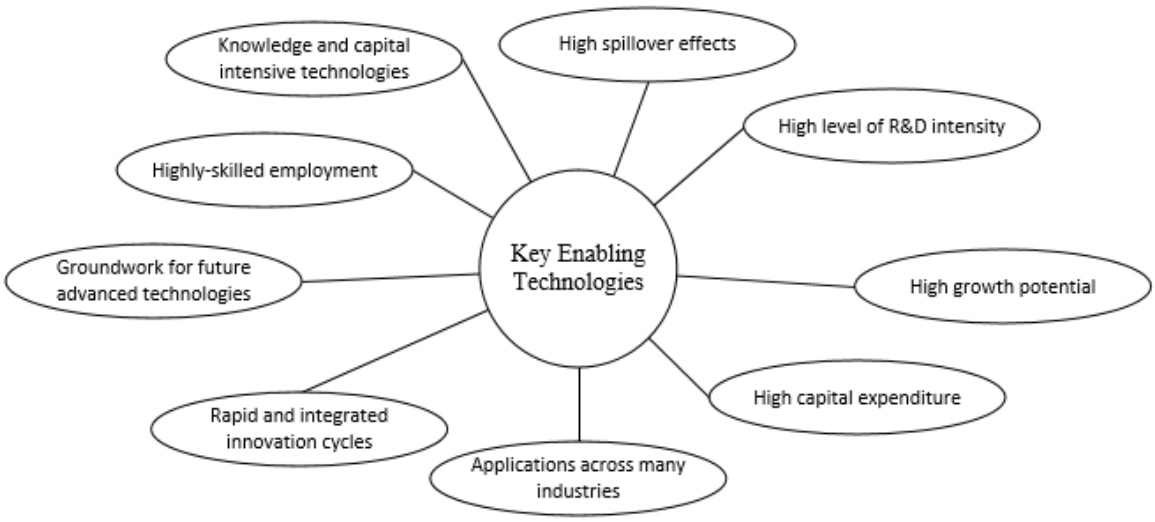

Figure 1: Characteristics of KETs.

Source: Own representation based on Commission of the European Communities, 2009

In addition, KETs are limited to areas of science and technology that provide new technological principles on which to build more complex product and process innovations and lay the groundwork for further technological development in individual industries.

Finally, KETs are expected to provide significant economic potential for entering new markets as well as to contribute to the key societal challenges of our world today.

2.3. Objectives

KETGATE has the following three specific objectives:

1. **Develop a new service portfolio for RTOs with KET infrastructures for SMEs:** KETGATE aims to provide new and improved methods and tools for RTOs to upgrade their capability to effectively serve SMEs. The focus is on providing transnational and collaborative services among RTOs to achieve the best possible service portfolio for SMEs. The new services are pilot tested and new business models also complement them.
2. **Make Central Europe a model region:** All tools, concepts and processes developed in the KETGATE project are transferable to other regions or industries which makes them accessible for reuse in future new projects and also allows the already established connections to be integrated into new projects, thus ensuring them mid- to long term support.
3. **Set up a network of regional Smart KET Access Points (SKAPs):** KETGATE launches a network of SKAPs for the tailored and effective support of SMEs. SKAPs are set up at RTOs and BSOs across Central Europe, with the aim of assessing the needs of SMEs and connecting them with competent RTO service partners in Central Europe. A pilot network of 8 SKAPs is set up for one year, which are to be followed by 12 additional RTOs and BSOs after the validation phase. A list of the 8 organizations facilitating the SKAPs for the pilot network are listed in the appendix. At least 90 SMEs should be supported by the network during the project.[1]

The aim of this thesis is to contribute to the project by delivering models to facilitate the more effective transfer of technologies from RTOs to SMEs. This means, that the work conducted here is a contribution to the first point in the objectives list above.

[1] Source: KETGATE internal documentation

2.4. Smart KET Access Points

Describing the working mode of SKAPs is a very good first example of how a detailed technology transfer model works. The purpose of SKAPs is to overcome the barriers standing in the way of spreading KETs from both the receivers (SMEs') and the senders (RTOs') side, which are the following:

- lack of access to KET technology services for SMEs in their native language
- financing of RTO infrastructure being limited to servicing domestic SMEs
- SMEs are not able to identify relevant RTOs
- RTOs' offers are too expensive
- intellectual property (IP) issues
- insufficient access of SMEs to RTOs offering KET technology services
- disparities between regions in Central Europe
- and insufficient access of SMEs to testing and piloting infrastructure.

A network of SKAPs was created to overcome these issues in 8 participating countries in Central Europe, which are the following: Germany, Austria, Italy, Slovenia, Croatia, Hungary, Czechia and Poland.

Working mode

The SKAP network works as follows: at every partner organization a SKAP is installed at their premises. At each SKAP a SKAP Business Advisor is present. The main tasks of a SKAP Business Advisor are presenting the service package of KETGATE to companies, presenting KET success stories to companies and they need to assess the needs of companies who request services. The SKEP Business Advisors are always physically present at the SKAP Points and they are always the first point of contact for SMEs during the whole process. They are in charge of creating so called "need assessments" of companies asking for support from the SKAP and have to report the results of the process in a structured manner. Business advisors also have the responsibility of tracking and monitoring the service process and reporting about it towards SMEs. Because SKAP advisors have to deal with

both parties during the process, they must have an understanding of the business needs of SMEs as well as the RTO potentials. Once a company contacts a SKAP and the Business Advisor creates an assessment of their needs, the assessment is forwarded to the KET Facilitator Board. The Facilitator Board assesses the report and matches it with the suitable RTO(s) and assigns the client to a KET Facilitator. KET Facilitators are physically present at all of the RTOs and are in charge of deepening the need assessment coming from the companies, further contacting the company in cooperation with the Business Advisor and being the interface with the selected RTO(s). KET Facilitators also have a technical profile with competences in KET technologies as well as the adequate skills to deal with both companies and researchers. Additionally, the Facilitator and the Business Advisor make further contacts with the client if it is needed, and the Facilitator deals with the arrangement of a multilateral agreement as well as with the provision of a commercial proposal to the client.

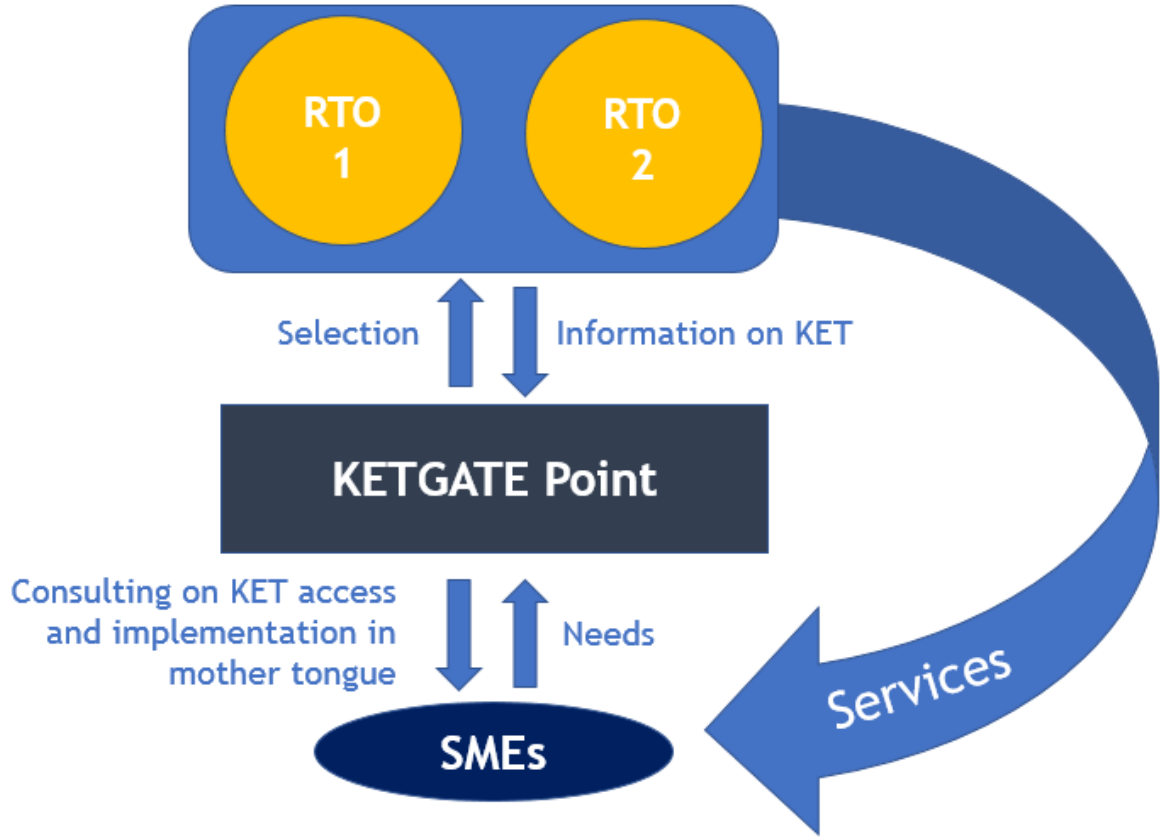

Figure 2: Working mode of SKAPs

Source: Internal KETGATE documentation

Services for RTOs

SKAPs offer a potential range of services that are also beneficial for RTOs. First, the SKAP network helps RTOs promote their services. This is done by though several measures, of which the first is mapping the RTOs so they can be easily found by SMEs around Europe. The map is available online and shows the KET providers' competences, services, location, contact information, etc. SKAPs offer RTOs the promotion of their services in visual and structured profiles. The information on the KETs is designed to highlight the benefits of the technology for the SMEs and the important topics for the SMEs such as application of the technology, added value, success stories, services and testimonials. Additionally, a KETGATE Technology Evaluation is provided by the SKAPs to build trust between the SMEs, RTOs and SKAPs. Every technology will be evaluated based on criteria developed by the KETGATE Advisory board of highly experienced experts in the technology field. This Technology Score indicates the status and assists in tracking the progress of the technology in the key areas of commercial and technical viability, economic and industry value, transparency and interaction. The new developments of RTOs are also constantly monitored and promoted within the network. The next benefit for RTOs is strengthening and facilitating SME-RTO cooperation. This is done through two channels of which the first is an Online Matching Tool. The Online Matching Tool is not open to the public and it will be used by the KET Facilitator Board to find the perfect match for SMEs. A simple search tool in the website allows SMEs to search for potential partners, however, the matching is always made by a KET Facilitator. The benefits of this solution are that SMEs are not left alone with the search because the KET Facilitator gives them personalized consulting on their specific topic in their own language. Another way of facilitating cooperation is through Matching Events. Matching events are organized by the SKAPs with actual research topics. The event can be offered as a platform for interdisciplinary exchange of knowledge and initiation of common projects. The presentation of the research results and the discussions helps the participations to develop new cooperation and to use available innovation potential. The event series is an important tool for the transfer of ideas, research results and inventions. These same channels are also useful for strengthening the cooperation between RTOs to offer better services to SMEs. A value chain analysis and/or analysis of competences of RTOs is also important to find the most suitable RTO-RTO co-operations from which SMEs

can profit the most. Simple procedures are also introduced for establishing contracts, where more than one RTO is offering the service to an SME. Special focus is given to intellectual property right issues to avoid conflicts between RTOs. It was identified as a challenge for RTOs that their staff needs training and coaching on how to move inventions out of the lab into the marketplace. For this reason, SKAPs are offering training to RTO staff in three modules: discovering the best market for an invention, developing and validating value proposition and business mode and developing a case study for partners and investors. SKAPs will provide information to the RTOs on the different funding schemes (public and private) to develop further their inventions and bring them to the market.[2]

Evaluation

The SKAP concept is a well thought out and detailed example of a technology transfer model. SKAPs provide a one-stop-shop type of service to SMEs, which makes the process less complicated for companies and requires less of their very precious time. The concept also tries to provide a solution for the uneven spread of available KET providers across Europe. Training activities are always welcome from SMEs side, which the concept also provides for them as well as for RTOs.

The concept fails to provide a solution for the problematics of international collaborations between RTOs. It still requires a lot of extra effort from their side to get involved in collaborative research with other organizations from abroad. There is also no guarantee, that the outcomes of the project are going to be sustainable in the long term.

[2] Source: KETGATE internal documentation

3. Technology transfer

The aim of this chapter is to give an overview of technology transfer and how it works at RTOs by first defining what technology transfer is and what steps the process involves, then showing what channels are currently used by RTOs to transfer their technologies to SMEs, and finally giving some examples of innovative technology transfer models of RTOs.

3.1. Definition

YEAR	AUTHOR	DEFINITION
1983	*McCardel*	Technology transfer is "the process of communicating research results to potential users"
1990	*Souder,Nashar, and Padmanabhan,*	The transferring technology process is actually an integration process involving provider and receiver. Technology transfer is not a unidirectional process, but a dialogue between varieties of actors at the sender/receiver site(s) at any point in time.
1993	*Padmanabhan and Souder*	"Technology transfer is the managed process of successfully conveying a technology from some point of origin to its routine application among users"
1995	*Spann,Adams and Souder*	"Technology transfer has been generally defined as the managed process of conveying a technology from one party to its adoption by another".
2000	*Robert Krull*	Technology transfer is a process by which existing technology is transferred or transformed to fulfill the user's needs. Technology transfer is the process by which research and other new technologies are transferred into useful processes, products, and programs. Another way of saying the same thing is: technology transfer is the process by which a better way of doing something is put into use as quickly as possible
2004	*Hill*	Technology transfer as a process through which resources are transferred in the development of products and services between the organizations.
2010	*Chen et al.*	Technology transfer is the process of sharing of skills, knowledge, technologies, methods, and 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 who can then further develop and exploit the technology into new products, processes, application, materials or services.

Table 1: Overview of definitions of technology transfer.

Source: Mamat and Roslan, 2012

This chapter aims to give an overview about what is the meaning behind the term “technology transfer”. As a starting point, a collection of definitions from experts is presented in Table 1.

According to Chen (2011), researchers have developed methods to assess the efficiency of the whole process of transferring knowledge from the service provider to the recipient. Teece (1976) was cost-oriented and assumed that the impact of technology transfer could be judged on the basis of the cost involved. In terms of efficiency, Staikarn (1981) believed that successful technology transfer constructions include the practical use of technology, the full absorption of the knowledge provided, the extension of technology to the areas concerned, and the change in the need or demand for technology. objective. Mansfield (1982) suggested that the success of technology should consist of three aspects; the practical use of technology, the achievement of economic efficiency and the competence of product development. Leonard-Barton & Sinha (1993) used the satisfaction of technology recipients to assess the efficiency of the technology transfer in the electrical industry, factor analysis reached three constructs; impact on efficiency, smoothness of the transfer process, and achievement of goals. Davenport & Prusak (1998) suggested that the effectiveness of technology transfer should be assessed by the speed of technology transfer and the depth of technology transfer.

According to Bhatia (1998), technology transfer is a communication process. All means that can facilitate communication between people can also facilitate technology transfer. Technology transfer should not be a one-sided process, but rather an iterative method that starts with the understanding of the business units' markets, opportunities, and needs.

Rouach (2003) states, that the goals of an effective technology transfer can be described as follows: to develop a technology according to the strategic requirements of the customer that also meets the quality and cost expectations, is installed in a timely manner and is widely and regularly used.

The transfer of technology is usually iterative and involves several transfer steps and it is considered successful only if the result changes positively. Teaching a new skill or method may not actually qualify as a TT until it leads to a positive change (Nishimoto, 1995). Therefore, the goal is to rather execute successful TT instead of simply sharing information between two parties.

The effectiveness of the technology transfer process according to Stock and Tatikonda (2000), is defined as the degree to which the use of the transferred technology meets the intended functional goals of the receiving entity within the cost and time goals.

Pursell (2000) suggests that the adequacy of a technology influences its transferability. Suitable technologies are:

- inexpensive,
- easy to maintain,
- adequate to one's creativity needs,
- and their usage is relatively easily learnable.

Ultimately, suitable technologies are those, that meet the needs and desires of the receiving party.

It can be seen, that there are several definitions for technology transfer, and there is no consensus about where the process actually starts and ends.

Based on the above presented definitions, it could be defined, that technology transfer is the process of transferring technologies, knowledge, skills, and solutions between research organizations and the industry.

In other words, technology transfer is the process of transferring knowledge from the creator to the customer through the interplay of various skills, technologies, methods and knowledge that power the technology to develop and use new processes, applications or products.

YEAR	AUTHOR	PROCESS
1976	*Behram, Wallander, Thunmen, Stock and Tatikonda.*	Identified → namely→ pre-negotiation stage→ negotiation stage→ technology transfer start-up→ long-term development stage
1987	*Enos and Park*	planning→ negotiation between suppliers of → technology and recipients→ plant and equipment design→ procurement and construction→ installation and start-up→ production and improvement→ subsequent annovation
1987	*Noling and Gilreath*	discovery→evaluation→adaptation→implementation
1992	*Risdon*	Technology innovation → technology confirmation → targeting technology consumers→ technology marketing→ technology application→ technology evaluation
2002	*Kelly and Wiseall*	strategy→ commission→ research→ evaluation → application
2004	*Hill*	identify→ assessment → strategy development → protection→ implementation
2005	*Goktepe*	identification of needs→ choice of technology→ assessment of conditions of transfer→ evaluation→ adjustment to local conditions→ agreement→ replication→ implementation

Table 2: Overview of technology transfer process models.
Source: Mamat and Roslan, 2012

3.2. Parties

As a first step of the research, the three main parties of technology transfer are going to be presented: small and medium-sized enterprises, research organizations and intermediary organizations.

Research organizations

As summarized by Rauter (2013), within the innovation system there is a wide range of organizations that can provide technologies to the economy. Walter (2003, p. 17) defines a technology provider as the party that has the know-how regarding the transfer object and acts as a solution provider, an assistant in the process, networker and often as an initiator. These can be for example universities, universities of applied sciences, competence centers, research centers, research institutes, technology transfer centers, technology parks, private

companies or research and technology organizations. Universities are the oldest form of research institutions. Their peculiarity comes from the fact that while they operate publicly and provide services to third parties, they do so not for their own profit, but rather for the general interest of the public (Zißler, 2011, p. 42). While the goal of universities is to commercialize their services, their operation does not automatically contain the implementation and application of their result. In addition, the management of universities is complex, due among other things to the large number of different stakeholders, ranging from employees to politics and economic, whose needs and expectations are to be met. The costs and prices of their own services can hardly be controlled by themselves and thus make it difficult for universities to prevail in markets with dynamic competition and to cooperate with commercial organizations. However, the role of research institutions, especially universities, has changed due to the increasing focus on the commercialization of research results achieved in recent years. However, the role of research institutions, especially universities, has changed due to the increasing focus on the commercialization of research results achieved in recent years. In addition to the original assignments of teaching and research, the focus on the economy has risen substantially. Hovewer, as stated by Schmoch (2000) Universities of Applied Sciences are also gaining importance as they cover in cooperation with industry the field of short-term, applied research and development. Universities of Applied Sciences are ideal partner for small and medium-sized enterprises when it comes to short-term problem solutions for the new and further development of products and / or processes.

Non-university research institutions are much more likely to commercialize and apply their own research results than universities, and in business-oriented collaborations, they may benefit from organizational flexibility or focus on a specific area of expertise. (Rauter, 2013, pp. 16-17)

Small and medium-sized enterprises (SMEs)

A widely used and common criterion for demarcating and classifying SMEs is the number of employees. However, when using this criterion, it should be noted that it is not consistently understood and is a subject to change over time. The division of small and medium-sized businesses based on the number of employees is quite common, but not

always unproblematic – mainly the sole use of a single quantitative measure appeared problematic in the past. However, in order to have a common understanding about the definition SMEs, the following should be taken into account: An enterprise is a unit, independent from its legal form, that undertakes economic activity. This also includes those units that perform craft or other activities as one-person or family businesses, as well as partnerships. In regard of the number of employees and their financial performance, Micro-enterprises and SMEs employ less than 250 people, have an annual turnover of up to EUR 50 million, and have a maximum annual balance of EUR 43 million. Within this category of SMEs, a small business is defined as one which employs fewer than 50 people and whose annual turnover or annual balance does not exceed EUR 10 million. A micro-enterprise is one which employs fewer than ten people and whose annual turnover or annual balance does not exceed EUR 2 million. (Rauter, 2013, pp 17-18)

Based on Fichtel (1997, p. 69 f), the macroeconomic importance of SMEs for competition is undisputed, and not only from a quantitative but also from a qualitative perspective. With the variety and specialty of the service and product range, SMEs are a cornerstone of a pluralistic, market-based system. SMEs therefore play a significant role in the overall economy of a country and, on the other hand, require special treatment due to their special characteristics, even when it comes to establishing and promoting knowledge transfer between research institutions and SMEs.

Business support organizations (BSOs)

Whereas direct knowledge transfer takes place directly between sender and recipient, indirect knowledge transfer takes place via so-called knowledge intermediaries, like business support organizations or transfer offices.

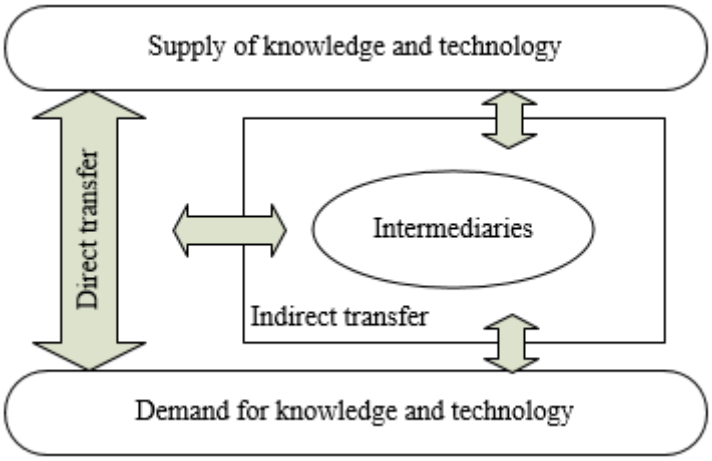

Figure 3: Intermediaries in knowledge and technology transfer.
Source: Own representation based on Rauter (2013, p. 18)

Intermediaries are therefore organizations or persons who act between knowledge producers and knowledge consumers. Intermediaries have the primary task of initiating and maintaining the transfer of knowledge, assisting with the transfer, and bringing the expectations and ideas of the two parties closer to each other. Thus, they help buyers and sellers to minimize their search and transaction costs, but in most cases do not have the competence and know-how to act as knowledge transmitters, which is why the transfer per se, in turn, happens between research institutions and companies. (Rauter, 2013 pp. 18-19)

Czarnitzki et al. (2001, pp. 40-49) identified four different types of intermediaries: institutionalized science-related, business-oriented, independent transfer intermediaries and special forms of support infrastructure such as trade fairs, technology exchanges, competence networks or technical-scientific associations. An equally important mediating role, however, also comes from institutions such as incubator and technology centers or technology and science parks, which convey in the transfer itself or provide material and immaterial support for business start-ups.

3.3. Technology transfer channels at RTOs

It is important to hereby present the main forms and channels for technology and knowledge transfer that can take place between research organizations and SMEs. This knowledge in one of the essential elements of every TT processes and is indispensable for the development of new TT models. Before doing so, the term "transfer channel" needs to be defined. A transfer channel defines the type of utilized activity, that allows the transfer between the sender and the receiver to be established, without specifying the exact subject of the transfer.

Rauter (2013, pp 112-118) listed the possible transfer channels that are most frequently used for transferring knowledge or technology to SMEs, which are the following:

4. Consulting: This form of transfer is unidirectional, since the expertise is on the side of the research institution and is passed on to the company. This allows a high degree of interaction and the transmission of personal, implicit knowledge at a relatively low degree of formalization.
5. Exploitation of patents and licensing: Patents and licenses form a highly formalized transfer channel with little personal interaction but allow a very detailed and comprehensive knowledge and technology transfer. Patents and licenses represent a limited, but highly specialized know-how area where the form of the transfer subject can be regarded as very individual and is directly transferred into the company's activities. Because of this, very high transaction costs of TT have to be considered. Patents are generally a highly relevant form of transfer, however their significance for SMEs that are not active in technologically demanding industries is considered to be medium to low.
6. Contract research: The transfer form contract research is used when an institution requests the research and elaboration of a certain task from another institution. This requires a high degree of formalization and legal protection in terms of secrecy and IPR. The content-wise and temporary extensiveness of a contract research project depends strongly on the respective task. The extent of transferred implicit knowledge can be considered moderate, and personal face-to-face contact is not

often mandatory, since the goal is to directly transfer achieved results rather than to jointly achieve them.

7. Joint development: Contrary to the form of contract research just described, joint research projects involve a strong interaction between the partners involved in problem solving, which means that the transfer of implicit knowledge as well as the degree of formalization are very high. The aim and use of such R&D cooperation is the creation of something new that would not be possible through the services of the individual partners. Joint development is therefore established when at least two organizations voluntarily agree to cooperate in sub-areas of their activity and as partners also contribute their own (financial, human, or other) resources to the cooperation. Cooperations can range from loose and weak forms to very intensive and strong forms. Collaborative research can be considered the strongest form in the context of knowledge transfer. They cause corresponding transaction costs and enable a high exchange of knowledge, are bidirectional and usually yield a benefit for both organizations involved. By contrast, SME relevance is considered to be rather low, as the likelihood of an R&D cooperation is proportionate to the increase of both enterprise size and R&D intensity.
8. Use of technical infrastructure (e.g. open lab, pilot factory): This transfer channel is clearly unidirectional and allows companies to expand their competences through the use of infrastructure available at research facilities. A highly formalized, orderly use of the infrastructure has to take place and personal interaction with scientists as well as the exchange of implicit knowledge is limited. However, this transfer channel can be considered as highly relevant for SMEs.
9. Internships, theses, dissertations, PhD projects: In this transfer channel, a range of different formats of work are combined in one group. The most cost-effective and least extensive student work is the conduction of a bachelor thesis. In this form, thematically delimited questions can be processed according to the qualification of the student within a limited period of several weeks or months. In terms of content, it is more difficult to write a diploma or master's thesis, which is prepared for graduation and often conducted in cooperation with a company or directly at

company. The scope and duration are correspondingly broader and longer, and the transaction costs of the knowledge transfer for the company are higher. In return, an individual solution is developed that is tailored to the company's needs and can make a direct contribution to entrepreneurial activity. Clearly distinguished from bachelor's and master's theses are commissioned or written doctoral dissertations or PhD projects funded by the company. The latter are to be distinguished on the one hand because of the high transaction costs, which are due to the personnel costs and the time duration of several years, on the other hand due to the extent of the knowledge. The question to be worked out must be specific and at the same time comprehensive as well as time-critical or future-oriented, otherwise the result may be sub-optimal for both sides. In summary, these transfer channels diverge in terms of degree of formalization, time duration and transaction costs incurred and are to be checked specifically for their suitability for the respective application.

10. Transfer of personnel: Personnel mobility is a very broad transfer channel and ranges from temporary staff exchanges to permanent transfer. In the second case, a scientist would switch from the workplace at the research institution to a company and vice versa. A controversial question is whether the employment of young academics or graduates also corresponds to this form. The other group involves the temporary employment of academic staff or students within the company with the aim of transferring the acquired know-how to the company. The benefit for both the company and the individual is considered high.
11. Training: This transfer channel covers the participation of company employees in the educational offers of the research institutions as well as the training of employees directly in the company. As the need for continuing education services is constantly increasing, this form is becoming increasingly popular. While in the first variant offers a less standardized and possibility for broader audience, the second variant can be tailored to suit the organization's specific needs regarding the know-how extension of employees. In the innovation-relevant context, these educational and training offers refer to increasing the innovation competence of the persons involved. The transfer of knowledge therefore takes place from "head to head", the integration of knowledge into the company itself is then a second step, meaning that

the implementation is not automatically guaranteed. This form of transfer can be classified as less formal, but it incorporates a high relevance for SMEs and a relatively high potential for the transfer of implicit knowledge, especially if in addition to theoretical learning, experimental learning is also incorporated.

12. Meetings, conferences, informal personal contact: This transfer form again combines various forms of interorganizational exchange, usually those which, because of their non-measurability and quantifiability, cannot be assigned to any other transfer channel. The participation of scientists and businesspeople in meetings and conferences, which take place in or outside the research facility, represents an unformulated form of the flow of knowledge, yet allows for a high exchange of implicit knowledge and personal interaction. Personal and informal contacts are not tied to an organizational form such as a conference, but are rather strongly linked to the personal contacts, networks and experience of the respective persons both from the part of the companies and on from part of the research institutions. Hardly measurable, informal contacts - which actually play a permanent role - represent a very central aspect for the successful implementation of a transfer project.
13. Publications: Publications of research institutions and companies, are a form of transfer, which in particular covers the transfer of explicit knowledge, but also allows a broad applicability of research results (basic research). There are very few or no formal requirements, the transfer of implicit knowledge is limited, and personal face-to-face contact is excluded. The knowledge recipient must acquire the knowledge on his own. The extent to which publications represent the appropriate form of transfer depends on a number of factors, such as the area of research and the scope or level of education of the individual. For knowledge transfer with SMEs this form is considered to be less suitable.

3.4. Barriers and challenges of the collaboration of SMEs and KET providers

The European Commission (2015, pp. 48-51) identified the most relevant barriers and challenges that the process of diffusion of KETs among SMEs is facing, which will be presented in this subchapter. The findings about the issues affecting both SMEs' and the KETs Technology Infrastructure's[3] side are presented assigned to the most important main topics.

SMEs' human resource capacities

SMEs need trained staff to be able to understand and apply KETs knowledge. The technology infrastructures of KETs prefer to work with technology-driven SMEs, because they have common ground for the exchange of knowledge. Innovation management capacity building is another issue for SMEs and one of the main reasons why SMEs do not use R&D results. Besides, there is a need for international experience in accessing KET infrastructure services in another EU country. This requires internal strategies and processes and the staff needs to implement transnational cooperation.

Trust building

In order to be able to organize regular meetings or site visits, regional cooperation is preferred. Transnational cooperation involves travel costs and international cooperation experience, since building trust is very person-centered (at least in the beginning). Only through continuous collaboration, after many contacts and good practices, trust is built on KETs technology infrastructure and SME. SMEs also lack advisory services for information about technology and investment services, technology infrastructures for KETs, etc.

Regular meetings with the KET technology infrastructures create confidence. In practice, this only takes place in a regional context where KET technology infrastructures and SMEs can meet on different occasions, such as workshops, conferences, etc. organized by

[3] Official naming used by the European Commission for research organizations offering services about KETs.

Chambers of Commerce, Enterprise Europe Network or other regional public and private actors.

Risk management

SMEs may consider the introduction of KET to be too risky - especially if the benefit is not fully clear and the market pull / demand for new technology is not too high. This can lead to an unwillingness to invest in longer-term technology projects. This fear of failure may again be in correlation to the lack of KET knowledge, the lack of technological intelligence and innovation management problems such as market trends and developments.

Technology transfer / knowledge transfer services

KETs technology providers are not investing enough time and money in promoting their knowledge to SMEs. Training may be offered, but these are not necessarily meant for SMEs. SMEs may be aware of the importance of a KET, but it can happen that they do not have any knowledge about the remaining five KETs.

KETs Technology Infrastructure competence marketing

SMEs do not know what the KETs technological infrastructures offer across Europe, and the service portfolio of the KET providers are not actively marketed to SMEs at European level. At regional level, KETs technological infrastructures try to connect with local SMEs as their public or private mandate is to serve these SMEs. The number of active relationships, even at regional level, is often rather small and limited to technology-based SMEs.

IPR

Small and medium-sized enterprises do not have the necessary knowledge about intellectual property rights for acquiring new innovative technologies, except if they are technology-driven themselves and have their own IPR experience. The KETs technology infrastructures have their own interests and their own intellectual property rights practices, which may not always useful for SMEs.

Financing

Transnational cooperation requires further investments - starting from travel budgets to international IPR management and contracting advice. The KETs technology infrastructures are also not completely familiar with international SME contracts, intellectual property rights, unless they have an international division that deals with international business. Most important of all, there is a lack of funding schemes or incentives for KETs technology infrastructures to work with SMEs in other countries. Considering that their political mandate is primarily to primary work with local SMEs, without a clear mandate from their funding bodies, or without specific budget lines for the promotion of their services across Europe, members of the KETs technology infrastructure staff will find it difficult to participate in the sale of their services to SMEs abroad, taking into account that additional budget lines required for travel, translation and other international cooperation investment needs must be bared before the investment can be returned in the form of a contract.

Lack of access to KETs Technology Infrastructure knowledge and service in many European regions

In many Member States and regions, SMEs do not have access to KETs knowledge at Technology Readiness Level (TRL) 3-8 locally, but only at another TRL level or for another KET. Only 17% of KETs technology infrastructures that responded to our online surveys provide joint services with other KETs technology infrastructures. Fear of competition, loss of customers and lack of motivation for such cooperation are possible obstacles. The joint provision of transnational services requires much more effort on the administrative and personnel side than a bilateral contract from a single SME. Without a clear mandate from the KETs technology infrastructures manager or funding body, this step cannot be taken. With the given gaps in the EU's KETs service availability, only through the joint offer of several KET technology infrastructures can provide the only solution to offer all KETs at all TRL for all interested SMEs. So far, neither the political actors nor the technology infrastructures of KETs seem to be aware of the fact that there are shortcomings in access to KET knowledge for SMEs in many European regions. The technology infrastructures of privately owned KETs are more likely to cooperate with large companies. In general, public KET technology infrastructures appear to be more open towards SMEs than private

organizations. The platform of public KET technologies would therefore be more interested in transnational cooperation with other (public) platforms to participate in projects requiring transnational cooperation solutions.

4. Examples of technology transfer models

This chapter is dedicated to practical examples of technology transfer models used at research and technology organizations. The methodology of the search can be described as follows: First, larger organizations and organizations that were participating in any EU project that somehow involved technology transfer to SMEs were selected. This was based on the assumption that these organizations either had sufficient resources or were more SME focused, which could mean that they already had innovative technology transfer models. After this, these organizations' websites and annual reports were reviewed, and searched on the internet to find out if these RTOs had such models.

Fraunhofer-Gesellschaft – High Performance Centers

The Fraunhofer-Gesellschaft is a German, Munich-based research organization specialized in applied research. Its 72 institutes and research units – all dealing with different fields of research and operating independently from each other – are operating with an annual research budget of 2,3 billion euros, of which 2 billion euros are generated through contract research. 70% of its contract research revenue is derived from contracts with the industry or publicly financed research projects. (Fraunhofer, 2018)

Fraunhofer-Gesellschaft has developed their unique concept of "High Performance Centers". The 17 High Performance Centers (HPC) found in different cities throughout Germany create topic-based collaborations between universities, non-university research organizations, institutes of the Fraunhofer-Gesellschaft and industry (especially SMEs). The focus of HPCs cover a wide range of today's hot topics in research, such as photonics, microelectronics or smart production. The aim of such HPCs is to develop and implement tailored transfer roadmaps, which involve several transfer channels, such as contract research, licensing, further-training courses or knowledge transfer. The paths of knowledge- and technology transfer within HPCs is shown in Figure 5. (Fraunhofer, 2018)

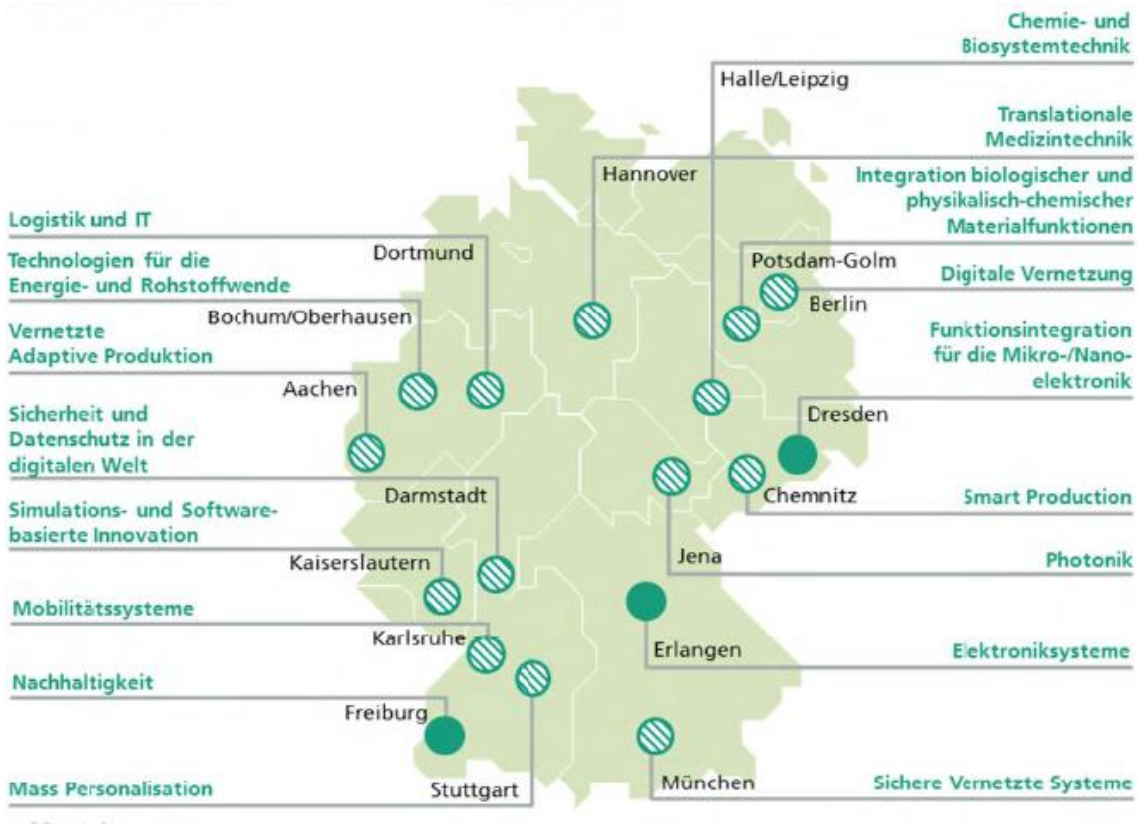

Figure 4: Fraunhofer HPCs in Germany

Source: Fraunhofer, 2018

Evaluation

Such a collaboration may provide a solution to some of the issues that a large proportion of SMEs is facing:

- A common problem during technology transfer projects with SMEs is their lack of expert knowledge, which hinders them in adapting new technologies into their day-to-day business. Being part of an HPC may relief them from this issue by having access to university and non-university specialists and researchers within the HPC.
- Cross-organizational use of infrastructure at HPCs can compensate for the lack of resources of SMEs.
- The lack of resources (i.e., time and money) for the development of their staff is a common issue for SMEs. Participating in further-training courses, consulting experts within the HPC and knowledge spillover all contribute to the development

of the staff of an SME, which could make it easier for them to conduct technology transfer projects.

- When an SME participates in such a collaboration, it can also profit from the inherent spillover effect of the process. This helps them to develop themselves as an individual entity as well.

The model is very well suited for KETs, because it organizes all the most important players who drive innovation into one place. This is very important for such knowledge- and expertise intensive technologies.

The biggest drawback of the model is that it requires substantial amounts of monetary investment. It also creates a difficulty, that all parties have to invest additional time to work in a HPC. This may prove much more difficult for SMEs than for large scale organizations (LSE).

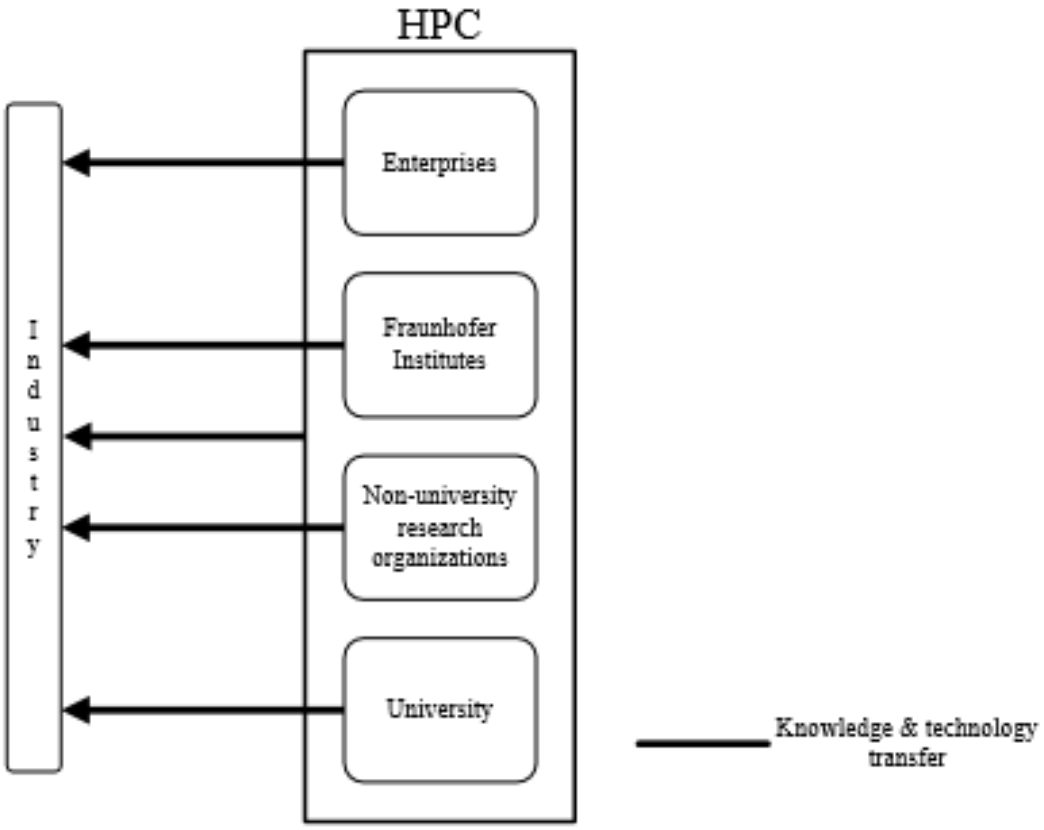

Figure 5: Concept of an HPC

Source: Own representation based on Fraunhofer, 2018

The Welding Institute – Additive Manufacturing Technology Transfer

The Welding Institute (TWI) is a research organization specialized in joining technologies based in Cambridge, United Kingdom. TWI is membership-based organization, which means that they provide their services to companies and to individuals only in exchange for a membership fee. They offer their member companies and professionals technical support, access to latest their technological innovations, as well as to their research results and database of welding and joining know-how. (The Welding Institute, 2019)

TWI launched its Additive Manufacturing Technology Transfer project to help companies exploit the possibilities that additive manufacturing can provide them. The project is intended for both companies who already have experience with additive manufacturing and companies who would like to start experiencing with it. Highlight of the project's offerings is an up to seven days free technical support service provided by TWI to the companies, which is intended to help companies profit from the technology as much as their capabilities and resources allow them to. A model of the process and the services provided by TWI within the Additive Manufacturing Technology Transfer project in shown in Figure 6. (The Welding Institute, 2019)

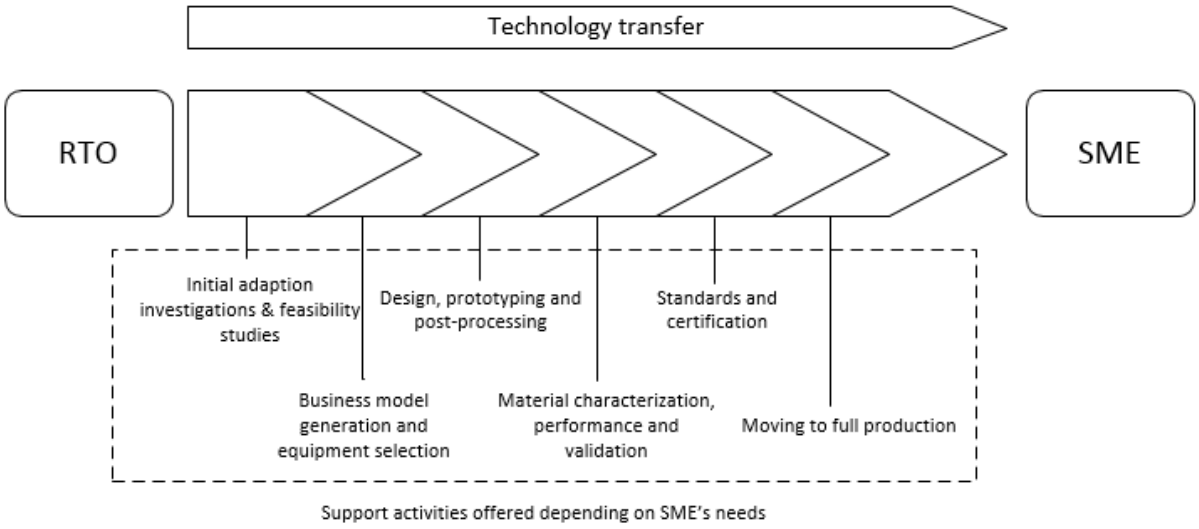

Figure 6: Technology transfer process within the Additive Manufacturing Technology Transfer project

Source: Own representation based on TWI, 2019

Evaluation

The highlight of this model is the up-to-seven-days free targeted support. Such solutions can be very beneficial for SMEs, since they are many times lacking financial means, which can many times hinder them in innovating their operation. This part of the model is recommended for use in any technology transfer project with SMEs. The concept itself is a good solution for transferring advanced manufacturing technology, which is one of the six KETs. The biggest shortcoming of the model as a whole, is that it is only focusing on advanced manufacturing, and none of the other KETs.

VTT Technical Research Centre of Finland Ltd – PrintoCent Innovation Centre

The Finnish VTT Technical Research Centre is the parent organization of the VTT Group. As an applied research organization, it conducts self- and jointly funded research as well as paid research in topics such as low carbon energy, digital society or smart industry. VTT operates under the mandate of the Finnish Ministry of Employment and the Economy as part of Finland's innovation system and generated a net turnover of 268 million euros in 2018. (VTT, 2019)

VTT is coordinating a program called PrintoCent. PrintoCent was founded by VTT, University of Oulu, Oulu University of Applied Sciences, and Business Oulu, with the aim to provide companies easy access to new business opportunities and new technologies in the field of flexible and organic electronics. PrintoCent's operation is directed by regular cluster meetings and its working mode is project based. There are three main parts of the program:

- **PrintoCent Pilot Factory:** World class design, development and manufacturing environment and support is provided by different facilities of VTT, Oulu University, and Oulu University of Applied Sciences. These offer for example: pilot scale manufacturing trials, factory planning and construction including machinery selection, product technical design and device integration, and production ramp-up support.
- **PrintoCent Industrial Cluster:** The cluster has about 40 members including startups and micro organizations, SMEs, and large-scale enterprises. The presence of companies from many parts of the value chain contributes to PrintoCent's ability

to develop novel products and services and enables them to commercialize these through the cluster members.

- **PrintoCent Innovation Accelerator:** This initiative is responsible for the growth of an efficient ecosystem around flexible and organic electronics, or printed intelligence, as they call it. They are trying to achieve growth through university programs and courses dealing with the topic, BSc and MSc theses, multidisciplinary research within a strongly cooperating global partnership and organization of events around printed intelligence. (PrintoCent, 2019)

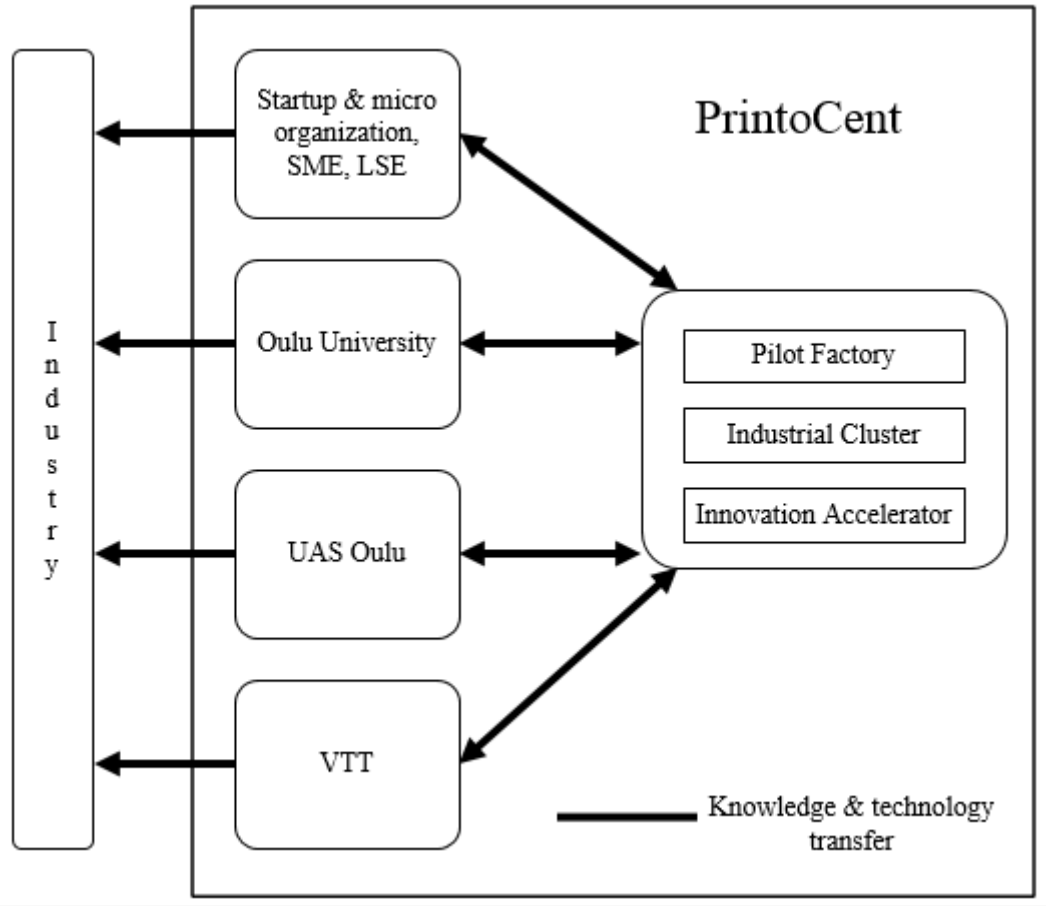

Figure 7: Paths of knowledge and technology transfer in PrintoCent
Source: Own representation based on PrintoCent, 2019

Evaluation

As it was the case with Fraunhofer's HPCs, PrintoCent also provides the benefits coming from the cross-organizational use of infrastructure as well as having expert know-how on

hand to SMEs. The model is also beneficial to RTOs because it uses many channels to promote its technologies and generate know how in the topic, while also providing the possibility to sell the technologies and services as fast as possible to the companies that are part of the cluster.

Tecnalia – Inspiring Business Forum

Tecnalia Research and Innovation was established in 2010 through the fusion of eight former research organizations in the Basque Country, Spain. As the most significant such organization in the region, it has a staff of more than 1800 people and generates ~131 million euros of turnover annually. (Tecnalia, 2019)

Tecnalia introduced the Inspiring Business Forum (IBF) as a channel to distribute its newest offerings derived from their R&D activities. IBF is a corporate investment forum where companies need to pay a membership-fee in order to be able to participate. In return for their payment, Tecnalia offers companies insight into their latest projects and the ability to join them, the possibility for companies to propose their own business opportunities to the community and the possibility of networking within the forum community. Regular IBF events are organized where business opportunities are presented and the networking can take place, and a web-based platform is also used where new business opportunities are published as they occur. (Tecnalia, 2019)

Evaluation

A big plus of the Inspiring Business Forum is that it requires no additional investment in infrastructure, only an event. It is also very beneficial, that this solution can be used for all KETs.

A big disadvantage of this model is, that it does not include some kind of a physical representation of the products. It can be hard to convince SMEs about a purchase only by presentations. It must also be noted, that organizing such a membership-based concept is very risky for institutions which are not as well established as Tecnalia.

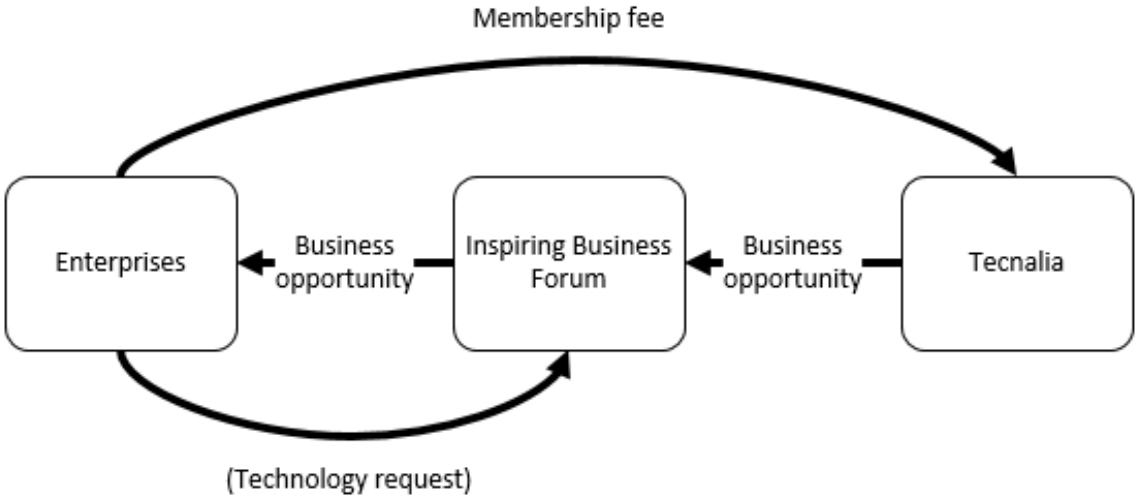

Figure 8: The Innovative Business Forum concept.
Source: Own representation based on Tecnalia, 2019

TNO – Technology Transfer Program

The Netherlands Organisation for Applied Scientific Research (TNO), is a Dutch independent research organization founded in 1932, with headquarters in The Hague.

In 2017 TNO initiated its Technology Transfer Program with the aim to bring more of their research results to the market with reduced time to market. Although this model is more focused on the transfer path of technology within an RTO, I think that it can have relevance to the subject of this thesis. This assumption was also supported by several experts working at RTOs, to whom I showcased the model, and all had the opinion, that implementing such a solution in their organization would bring great benefits to them. The Technology Transfer Program consists of two main phases. In the initial phase, the concept of the new technology and a proposal of how it could fit in TNO's portfolio is presented to the Technology Transfer Board, which consists of five executives, such as the CEO and the head of the tech transfer department, as well as four external experts. If the idea passes the TT Board, the next step is to decide whether the technology should be licensed to an existing company or a spin-off/spin-out company should be created to commercialize it. This is the last step in the program in case licensing is chosen. In case the path of creating a new company is chosen, this decision has to pass the TT Board once again. The next activities are an optional proof of concept study and preparation work for the founding of the new company, like developing

a business plan and making agreements between the future company, TNO and other stakeholders. Finally, the concept of the new company has to get accepted by the CEO of TNO. The program also supports the newly established spin-off/spin-out during the first financing round. All activities involved within the program are supported by a Technology Transfer Team, which consists of five technology transfer experts as well as six experts from departments like human resources, legal or finance. (TNO, 2018)

Evaluation

This concept focuses more on the company-internal problematics of bringing a technology to market. For this purpose, it is very much recommended. Another positive aspect, that the model can be used for any technology, including KETs. The shortcoming of the model is, that it does not give any suggestions for the transfer process after the internal stage is ended.

Steinbeis Verbund – Steinbeis Transfer Network

The German-based Steinbeis Verbund is an enormous international network of more than 1100 individual companies. On top of the hierarchy is the Steinbeis-Stiftung für Wirtschaftsförderung (StW) with the Board of Trustess and Committee and the Executive Board, which is the umbrella organization of the whole Steinbeis Transfer Network. One level below is the Steinbeis GmbH & Co. KG für Technologietransfer (StC) with the Management Board, which is responsible for the commercial activities involved in knowledge and technology transfer. The smallest units in this flat structure are the multitude of companies or centers which operate under a common framework, but with directors having the freedom to choose whether they want to operate the center as a Transfer-, Consulting- or Research Center, as a Transfer Institute or as a limited liability company. This huge network employs more than 6000 experts. They provide research and development services, consulting as well as training and human resource development. A visual representation of the Steinbeis Network's structure is shown in Figure 9. (Steinbeis, 2009)

Figure 9: Structure of the Steinbeis Network

Source: Steinbeis, 2009

There are three main paths how Steinbeis transfers knowledge and technology:

- The classic method of Steinbeis is allowing professors at public universities to commercialize their expertise. The knowledge of these professors – now also Steinbeis entrepreneurs at the mean time – gives the main asset for entrepreneurial activities. Steinbeis' role is to ensures the support in regard to contracts, bookkeeping, transfer processes and necessary agreement models.
- The second path is the path of Steinbeis companies. These can be either dependent entities within Steinbeis or they grow into independent companies with majority or minority holdings of Steinbeis. Reasons for creating such companies are mainly either that they have defined products or services to sell on the market or that they want to offer young experts to grow into entrepreneurship.
- Steinbeis' third transfer path is creating a joint transfer company with universities. In this case the company is located at the university with management, logistic etc. financed by Steinbeis. These companies are private to enable professors who join them to undertake real entrepreneurial activities. The transfer company is part of the Steinbeis Network, meaning that the university is in direct partnership with the experts for technology transfer, which gives the university a better image in the field of knowledge and technology transfer. (Steinbeis, 2009)

Graz University of Technology – SCIENCE FIT

SCIENCE FIT is a project aiming at creating a linkage between Styrian research organizations and SMEs, which is financed by the Economic Chamber of Styria, the state of Styria and the city of Graz. The project is operated by a team of around 10 professionals (with a work input of about 2-3 full time equivalent) coming from the Research and Technology House and the Institute of Machine Components and Methods of Development of the Graz University of Technology, the Technology Transfer Center of the Montanuniversität Leoben, the Office of Research Management and Service of the University of Graz and the JOANNEUM CREATIVe LAB of Joanneum Research. (Science Fit, 2019)

The technology transfer process utilized in the project is a rather conventional one, but it is a good representation of an approach that is widely used at RTOs. The first step of the process is establishing contact between SCIENCE FIT and the SME. This can either happen by a direct phone call or e-mail from SCIENCE FIT or by the SME contacting them with their inquire. Usually the next step is to organize a company visit where the project team members survey the SME about their innovation needs and paths and identify the most urgent ones. With the identified needs in hand the project team can link the needs with the appropriate specialist. Specialist can be researchers or students from within or even outside of the SCIENCE FIT team. Following up, a fitting public innovation funding scheme is presented to the SME. Once this is done, a project consortium is set up by the team and they also help with contractual matters and public funding application. To ensure that everything goes as desired, SCIENCE FIT monitors the progress of the collaboration at least in the initial phases of the project. SCIENCE FIT also provides access to students and graduates of Styrian universities by staging an annual recruiting fair called “Small can do it all”. (Miranovic, 2013)

Evaluation

A big advantage of the concept is, that it contacts SMEs directly. For a large number of SMEs this is essential, since they do not search for contact with research organizations themselves. Another positive aspect is, that finding funding solutions for the TT efforts is also included and that there is a team of TT experts involved. It is also beneficial that the

progress is also being followed up after the Science Fit completes its active participation in the process. These measures could all be applied for transferring KETs as well.

A shortcoming is that the staff of Science Fit is only dealing part-time with the Science Fit project. The project also only focuses on local research results, which can mean that they cannot provide a fitting solution to SMEs because it does not exist locally.

University of Alicante – Technology Promotion Action Plan

The University of Alicante is a public university with its main campus located San Vicente del Raspeig, Alicante, Spain. The Technology Transfer Office of the university has a model, which can be seen as an extended version of the model used by SCIENCE FIT. Their model is called Technology Promotion Action Plan and it comprises four stages. The first phase is called "Technology Map – Technology Offers" and it focuses on university staff and researchers. As a first step the TT experts from the TTO of the university visit research groups where they conduct interviews to find out about their current offerings. Next, they match these offerings with the associated industry sectors or science areas in order to form a Technology Map. In the second phase called "Technology Promotion Plan" the technology offers are listed in an easily searchable and understandable manner. Phase number three is called "Technology Diagnosis". The goal of this phase is to identify needs and technological demands of the companies. This identification is executed by the TTO's Enterprise Relations department who are sometimes accompanied by researchers. The Enterprise Relations department is formed by five administrative support and technical experts. These experts have also received special education in technology transfer, intellectual property, international projects, project management, contracting, innovation and other fields. Identification of the company's needs is initiated by making a visit the company where the experts carry out a joint reflection with the executive(s) of the company and external experts. Consequently, a team is organized who uses a predefined methodology to analyze the problems, needs and technological potential of the company. The fourth and final phase called "Fundraising for R&D (public funding), Project Management" is, as the name indicates, oriented around connecting eligible R&D projects with public funding programs. The university tries to involve as many of their researchers in these projects as possible, so that they can also exploit these opportunities for learning. Aside from this program, the

university’s center for the research of technology transfer (SGITT-OTRI) is also part of an initiative that aims to help companies who wish to participate in research projects with the university by providing them with support in managing and funding such collaborations at support centers designed for this purpose. (Miranovic, 2013)

Evaluation

Direct contact is a positive attribute of this model as well, just like the model of Science Fit. It is a positive aspect, that dedicated staff is working on this project unlike in Science Fit.

A negative attribute is, that the technology offerings are represented in a list, which may prove to be an unpleasant solution to SMEs, since they might find it hard to understand.

5. Requirements for the development of technology transfer models

After getting familiar with the theoretical background of technology transfer and some practical examples of models for technology transfer used at research organizations, the next step was to complement these learnings with the opinion of experts who work in this field by conducting interviews. While this might be a fitting supplement to almost any research work, it is especially appropriate in the case of this research, mainly because of the scarce availability of literature that focuses directly on the specific area of this work. The aim of the expert interviews was to find out what technology transfer specialists working at research organizations think are working and non-working measures and solutions in technology transfer projects with SMEs, how these projects work at the experts' organizations and to get a better understanding of the process based on the experiences of the experts, in order to be able to use this knowledge during the development of new technology transfer models. In the following part of this chapter I am going to present the methodology starting from contacting the experts until carrying out the interviews and finally the learnings from the interviews will be summarized.

5.1. Methodology of the interviews

Bogner and Menz (2002, pp 37-39) categorized expert interviews into three main types: exploratory-, systematizing- and theory-generating expert interviews. According to this categorizing, the specific type of interview needed in the case of my work was an exploratory interview. Exploratory interviews are suitable for collecting data and accordingly they represent a significant fraction of conducted expert interviews. These interviews are often used as a means of first orientation in a thematically new or complex field – both in quantitative and qualitative research projects. Exploratory interviews can help in structuring the study area thematically and generating hypotheses. The interviewed experts can be part of the study area themselves or they can be carriers of contextual knowledge about the study area. Exploratory expert interviews should be conducted as openly as possible, but it is recommended to create at least some sort of a guideline in order to ensure the comparability

of the results. This makes explorative interviews different from narrative and episodic interviews, although this does not mean, that spontaneous detours or unexpected topic changes of the expert should be prohibited. The goal of an explorative expert interview is to get a better understanding of a specific field, and so it is not cardinal to focus on the comparability, completeness or the possibility to standardize the results, which makes these interviews very different from the other two types mentioned at the beginning of the paragraph.

Development of the guidelines for the expert interviews

In order to give the interviews a structure and to ensure that all of the desired topics have been touched upon, a questionnaire was developed as a guideline. The first step was to identify the main components of a technology transfer business model based on the research done in chapter 3 and 4. These identified properties are going to represent the main components of the technology transfer models, and thus developing the questionnaire with these in mind enables the direct generation of information that can be used during the development of the models. The following parts were identified and selected as being the most important ones:

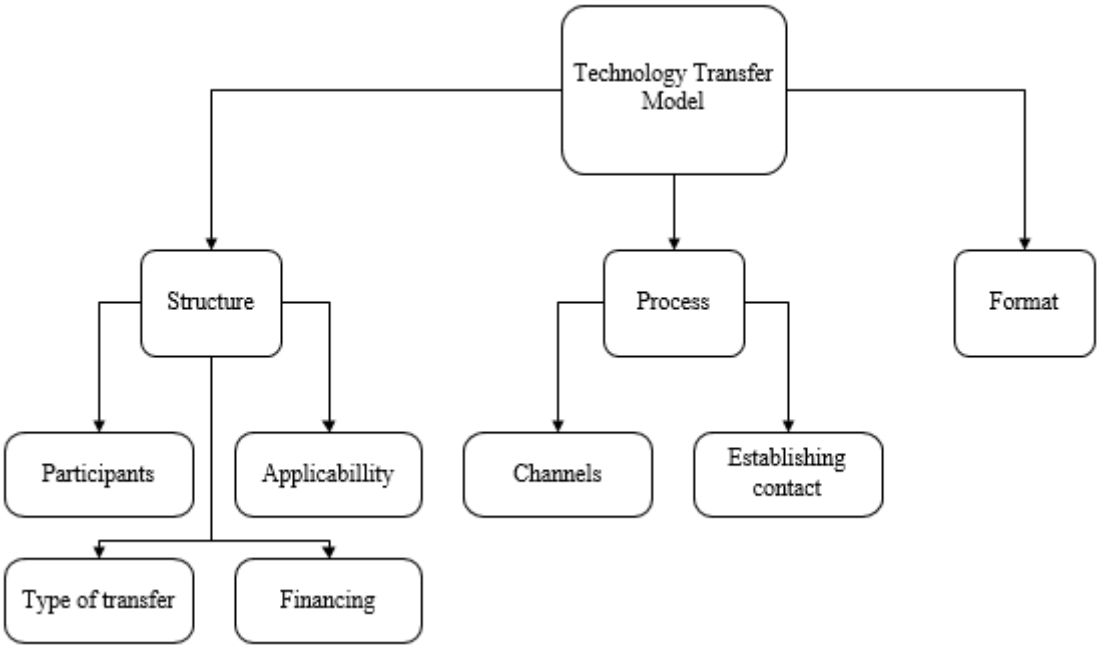

Figure 10: Main parts of a technology transfer model.
Source: Own representation.

- **Structure:** A main part of a model comprising organizational and systematical aspects.
    - **Participants:** The parties involved in the process of technology transfer.
    - **Financing:** The financing schemes of the model.
    - **Applicability:** Determines the branches in which the model should be applied (i.e. only one KET or multiple KETs).
    - **Type of transfer:** Describes whether the transfer activity is done in the existing roles of the participants in their existing operations, within a project team in their existing operation or in a new company created for this purpose.
- **Process:** Describes how the process works from getting in contact with SMEs until the end of a transfer project.
    - **Contact:** Describes how RTOs establish contact with SMEs.
    - **Channels:** Technology transfer path(s) utilized by the model.

- **Format:** Unique offering(s) of the model like organizing matchmaking events or offering free targeted support to SMEs.

Once the structuration was done, the next step was to develop a questionnaire that would help acquire information about how such technology transfer models look like at the experts' organizations and what the experts think about specific solutions used in these and other models. As the interviews were explorative, the questionnaire had mostly open questions and they were only used as a guide for the interviews – it was not planned to ask every single question in the questionnaire, but its purpose was rather to have a tool that can remind me during the interviews about what are important topics we need to touch upon. A further very important aspect of the questionnaire development was, that the questions should also be related to the SMEs side of the process of TT as much as possible in order to be able to leave out an interview round with SMEs for this part of the development process. It was also a goal to find experts who are aware of TT from SMEs' perspective from their professional experience. The developed questionnaire can be found in Appendix A.

Establishing contact with the experts

Getting in touch with potential interviewees happened through several channels. The first possibility to meet experts from RTOs was during a matchmaking event called "KETGATE: Brokerage Event"[4] organized for the KETGATE project. The event was held in Venice, Italy on 31.01.2019-01.02.2019 and its aim was to establish connections between RTOs and the industry. Participating RTO and SME staff could book appointments through an online platform for meetings with each other and they could present their needs and offerings in these meetings in hope of finding a partner – or partners – to collaborate with. I had the opportunity to participate in this event and discuss with several experts coming from RTOs all over Europe. Besides taking advantage of this opportunity to learn from very informative conversations, an appointment for an interview was arranged with one of the experts as well. Later on, e-mail addresses were collected of RTOs through the website of the European Association of Research & Technology Organisations[5] and an attempt was made to establish contact through asking some short questions via e-mail. The message sent to these RTOs can

[4] https://ketgate-brokerage-event.b2match.io/
[5] https://www.earto.eu/

be found in the Appendix B. Thankfully, a couple of RTOs replied, giving some very useful information about their TT routine and experience, which was used in the summary in chapter 5.2. I tried to make a step further and e-mailed the RTOs from whom I received an answer asking them for a short phone interview. The result of this effort was a new appointment for an interview. Next, an e-mail was sent out to the participating RTOs of the EU project "KET for Clean Production"[6]. This conversation, also leading to an interview, is to be found in the appendix. A fourth interviewee was also found, again with the help of Mr. Cozzi, who helped me get in contact with an RTO staff member from his network. Table 3 gives an overview about the interviews and some fundamental information about the interviewees.

	Interview	**Duration**	**Organization**	**Headquarters**
Interview 1:	Personal	1:10 h	RTO	Hungary
Interview 2:	Phone	0:32 h	RTO	Spain
Interview 3:	Phone	1:02 h	RTO	Germany
Interview 4:	Phone	0:28 h	RTO	Austria
Interview 5:	Written	—	RTO	Slovenia

Table 3: Overview of the expert interviews

As seen in Table 3, I had the opportunity to conduct four interviews – one personally and three on phone – and there was one more expert who offered his help to me, but due to his very busy schedule, he was only able to answer my questions in a written form. For Interview 1 and 3 I used the questionnaire already presented in the previous subchapter, while for the shorter phone interviews and the written interview I created a shortened version of the questionnaire, which can also be found in the Appendix C. Interview 1 and 3, which were more than one hour long, while Interview 2 and 4 where based on the shorter questionnaire. The questionnaires proved to have an appropriate length, since the planned duration of one hour for Interview 1 and 3 and half an hour for Interview 2 and 4 could be kept without having to miss out any important questions. All of the interviewees worked at RTOs, but

[6] https://www.ket4sme.eu/about-ket4cp

their organizations were of different size and had a different land of origin. Another common point was that all RTOs were dealing with at least one KET technology. It is very beneficial, that the pool of interviewees was so diverse, because this way the experiences also came from more viewpoints, allowing to cover a broader spectrum of the topic. For example, this allowed me to get an understanding about the differences in innovation capacity of SMEs between the different regions and the differences in the innovation system of the different countries. However, all of these organizations differed in size, operated under different circumstances with different amounts of governmental aids and so comparing them without taking these factors in account would be unfair. The learnings from the interviews as well as from the e-mail replies of RTO staff is presented in the next subchapter.

5.2. Learnings from the interviews

In this subchapter I am going to present a summary of the results of the expert interviews and the messaging with the experts sorted according to the three main parts of a model identified in chapter 5.1: structure, process and services.

5.2.1.Structural aspects

This group of topics is related to structural and systematical issues such as the participants of the process and their educational background and financing as well as structural hindering and helping factors.

Participants

In this section's focus are the "players" who are responsible for transferring technology. The number and versatility of staff dealing with TT depends on several factors like the size of the organization and organizational culture, but arguably the most important factor is cost. While it may be the best case to have a large separate department of very well trained and highly qualified technology transfer experts whose expertise cover the broadest possible spectrum, establishing such a department is not affordable for most organizations. Not surprisingly because of the relatively small size of the pool of interviewees, all experts reported of different strategies used at their organizations. In one case an expert reported that

the majority of TT projects is done by researchers who are supported by patenting experts if necessary. A similar solution was presented by another expert, who reported that at his/her institute project leaders or managers of research groups or areas were in charge of transferring technology. There was no consensus among experts about how much researchers should be involved in the process of TT, since some said that they are expected to contribute as much as possible, while others believed that researchers should focus on research and deal with other activities as little as possible. Another expert shared that they have a sales department of five people with technical or economical background and an additional person only dealing with the administrative side of TT. In the remaining two cases some kind of a TTO was responsible for transferring technologies. One expert whose organization did not have designated staff for TT noted this as the biggest barrier for them in TT. The reason for this is that staff doing TT have other activities as their primary focus and thus they are left with very limited time and energy to deal with TT. An example came up during one interview about an existing model where bachelor and master students are participating in the transfer by accomplishing their theses. Involving OEMs into the process was also mentioned in an interview. One example for involving OEMs is to ask the OEM to plant a machine at an RTO's site, on which researchers can develop new methodologies, which can then also be sold to companies as well as the machine itself can be promoted. Such a machine can also be used for training activities.

Financing

This category deals with operational topics like the financing scheme of the model or the level it operates on i.e. local, regional, national, international. All interviewees mentioned funding through national or EU projects as one of the most convenient solutions for SMEs to finance their technology transfer projects. The vast majority of SMEs have either scarce financial resources, or they are simply not willing to invest into innovating their business, mostly because they find it too risky or they simply do not feel the need to do so. All of these issues can easily be overcome with different amounts of grants. Another mentioned solution is, that the SME itself pays for the project, however this is quite rare because of the previously mentioned barriers, and as one interviewee shared, it usually only occurs if an SME needs some service urgently. In case of a joint development program, the RTO and the SME usually share the costs of the project, but it can also happen that the SME bares the

cost alone, however in this case the it also keeps the rights of the developed technology. An innovative concept described by one of the experts was an existing national model, where companies have the possibility to apply for "innovation vouchers" with minimal bureaucratic burden. The company could use this voucher to ask for any service from a university or university of applied sciences that falls into the limit of this microgrant. Companies have the possibility to apply for several of these vouchers and they do not need to do anything in exchange to receive them. Another interesting idea regarding financing shared with me during an interview was the possibility of a barter between the parties. While this idea came from a solely industry-related example, I find it to be a quite promising solution to implement in a technology transfer model. One of the experts also explained to me how their new open lab is financed: In the first phase, they provide support to SMEs in the form of consulting or they carry out collaborative research projects in order to promote themselves among companies. Year after year, they try to move towards the initially intended open lab concept and the lab also gets less and less support from organization. At the end of a five-year period the model should be self-supporting and operating according to its intended purpose. I had the opportunity to ask one expert about monetizing an RTO or a project through membership fees, and the expert's opinion was, that while this may work well at some well-established organizations, it requires tremendous trust from the companies to pay upfront to an RTO. The RTO must have a very good reputation if they want to ask SMEs to pay a membership fee. The financial aspect of technology transfer can be regarded as very important, since it is arguably one of the most significant barriers for SMEs that they lack financial means to invest into new technologies.

Applicability

Concerning the level on which their institutes operate, experts told me that most of them deal with local as well as foreign companies, only the proportions differ from organization to organization. Two experts told me, that their organizations mainly target local and regional companies, while the other three where more focused on their whole nation. All institutes wished to increase their percentage of international deals and for this they found international projects like KETGATE as the best method. Four out of the five experts' organization is operating with a more versatile approach having several departments doing research in different scientific fields, while the fifth institute was focused on one field. It is also an

important aspect to determine whether a model can be used universally or is only fitting to a specific area.

5.2.2. Processual aspects

This part of the summary deals with processual questions like how RTOs attract SMEs, which channels they use for TT or what are the processual barriers and aids in KET technology transfer projects with SMEs.

Establishing contact

There is a relatively large pool of possibilities for RTOs to get in contact with SMEs. One of the more classical methods is to promote services and offerings through newspapers or journals. Some of the interviewees told me that they use these channels, but they are not effective in reaching SMEs, most probably because journals tend to be too scientific for some companies to understand and that it is not popular among them to use such sources anyway. Promoting through the internet can also happen through several channels. All organizations have their own website where they also promote themselves, but this is not very effective in reaching SMEs. Several experts told me, that they are present on social media sites, but one expert also highlighted, that this channel is not yet effective for them to reach SMEs. Having an e-mail newsletter is also very common, but as one expert noted, it might reach a lot of companies, but they do not usually trigger their attention and so it can be stated, that it is not an effective way to communicate with SMEs. One of the methods that all interviewees reported to use is directly contacting SMEs. In this case the RTO either searches for potentially interested enterprises through the internet or in databases or they use recommendations coming from their existing network. Another form of direct contact is establishing connections at events. These events can be for instance conferences, symposiums, fares or workshops which are either organized by a third party, like an association or a project, or by the RTO. During fares for example, it is common that representative of RTOs and SMEs exchange business cards and after the event these exchanges usually lead to further discussions or meetings. All experts shared with me, that they organize at least one type of event – usually a conference or a workshop – at a regular basis. These events are mostly oriented towards specific topics and all experts shared with

me, that establishing contacts at any type of event is the most effective way they can create new connections with SMEs. One expert also shared with me, that companies should also have the possibility to present their current challenges at appropriate events. Another expert added, that they find it very effective to invite companies through associations, clusters or chambers that comprise actors of a specific topics or industry. It was also mentioned in several interviews by the experts, that for them it proves to be very effective to establish new partnerships and connections through projects like KETGATE. It can generally be told, that representatives of RTOs – researchers as well as heads of the organization – always walk with an open eye for making new contacts. Some important side notes about establishing contact with companies were also shared with me during the interviews. For example, it is very important to always deal with companies on an eye level. Any kind of arrogance should always be avoided and the interest in cooperation should be bilateral. It was also mentioned, that SMEs should be provided with as many possibilities to establish contact as possible.

Channels

Regarding the channels used for transfer, the most common answers were patenting, licensing and contract research. It can be said in general that special attention is paid to patenting and intellectual property rights since three out of the five interviewees shared with me that they have specialist dealing with these issues. These specialists are supporting researchers in these issues with consulting, holding trainings or by dealing with the administrative side of patenting. In one case joint development was also mentioned, but with the addition that such projects are quite rare because of the lack of industrial partners who have the resources and capabilities to participate in them. On the other hand, one expert stated that their organization utilizes an open lab type concept, with a center having all necessary equipment and expertise for research projects, where SMEs can come with request and ask for solutions from this center, or they can also start a research collaboration. Of course, in such cases where the infrastructure is provided, undertaking joint development becomes somewhat easier. Another expert shared with me, that they also have a kind of an open lab, but companies need to arrange an appointment to use the facility, and they can only do so with the support of experts from the organization because of safety and security reasons. Other experts also found an open lab concept promising, although one expert also noted, that establishing such a facility is very expensive and it may also prove to be difficult

to find companies who are interested. As a solution for the expensiveness of the concept, the possibility of involving OEMs was brought up. In this aspect, a pilot factory is very similar to an open lab and so the same could be said about this concept as stated before about the open lab. All experts had a very positive opinion about a concept like the High Performance Centers of the Fraunhofer Society presented in chapter 4. Involving SMEs in such a center can have several beneficial effects and not only for SMEs themselves. One expert noted, that while the RTO can use this channel to transfer technology and knowledge to SMEs, it is also good to create a critical mass in a topic allowing for a better representation of interests for all members of the group. Such a collaboration also enhances efficiency and helps in preventing the of research results. Other experts also noted, that while organizing such a center might be beneficial for all parties, it demands an enormous monetary investment and SMEs might also struggle to allocate enough time for their staff to participate in such activities.

Presentation of offerings

This section is not representing a part of a TT model, but rather an important aspect that should always be kept in mind when trying to transfer technologies to an SME: it is unlikely, that an SME is going to buy technology based on a brochure – reference installations are always preferred. RTOs have a few different options to showcase their capabilities, services or offerings. The more conservative ways that they are doing so is by the use of brochures or webpages or by making presentations about them. However, there was a relatively firm a consensus among experts, that these methods are very inefficient and have a very limited field where they can be successfully used. I asked the interviewees opinion about presenting offerings in a list to SMEs and they all thought that this was not a good solution. On the other hand, some experts told me that they use such lists internally and it is a very good way to keep track of the offerings for TT experts working at the organization. According to experts, the best solutions for showcasing an RTO's offerings are the ones that involve their or their capabilities' physical representation. One example are reference installations of equipment. A reference installation means the deployment of equipment or machinery for example at a pilot facility, open lab or an event such as a fare. It is also common for RTOs to hold tours of their premises for participants at their events, which also usually proves to be effective.

5.2.3. Format

During the interviews, experts introduced me to some innovative services that they use at their organization or they have seen others use. One expert suggested to organize meetings with companies, where they explain one-by-one what their problems are or what challenges they face currently. The results of these meetings should than provide the further path for the project. In the specific example presented by the expert, after the meetings university students had to develop solutions to the challenges of the companies. Regarding offering free targeted support as seen in the model of TWI presented in chapter 4, all experts agreed that it is a promising solution. I was also able to ask one expert's opinion about the IBF concept of Tecnalia. The expert noted, that such a concept requires a large organization with a great deal of technologies to present. On the other hand, this model requires no additional investment only the organization of an IBF event. Another solution that was positively evaluated by this expert was the one stop shop concept used by KETGATE as well as the Steinbeis Network.

6. Development of the technology transfer models

This chapter is dedicated to the presentation of the work that fulfills the ultimate goal of this thesis: the development of new models for RTOs for the transfer of technologies to SMEs. During the research work done in chapters 3,4 and 5, many possible solutions were found for the different parts of the model designated in Figure 7. The next step was to find a suitable procedure that I can utilize to build new models from these solutions based on my learnings. As a result of the research for the best-fitting method for model development, the so-called General Morphological Analysis (GAM) was chosen. In the following part of this chapter I am going to present GAM and then use it to develop new models.

6.1. General Morphological Analysis

The term "morphology" comes from the Greek "morphé", which means form. It is used in several disciplines to refer to the structural relationship between parts of the studied object. For instance, urban morphology deals with the form of human settlements, while in biology, morphology is the study of the structure and form of organisms. Based on this, a morphological analysis is classically referring to the analysis of structural relationships within the specific subject area. During the 1940's and 1950's a Swiss astronomer called Fritz Zwicky, who spent most of his life working at the California Institute of Technology, generalized this approach in his works for the use of analyzing and structuring of any type of multidimensional complex problem. (Álvarez and Ritchey, 2015, p. 1)

Zwicky (1969, p. 34) proposed to generalize and systematize the method of morphological analysis and to expand its existing field of application to study more abstract correlations among concepts, ideas or phenomena of any type. Zwicky, used the morphological approach in several very different fields such as astronomy, engineering, law or social policy and virtually any complex social-technical problem that needed

"...an integrated view, which relates... technical, political, psychological and ethical factors. ...All of these factors add up to a complex task which is beyond the power of ordinary scientific, technical and managerial experts." (Zwicky, 1960, p. 22)

GMA, also known as the "Morphological Box", became a known creativity technique and is widely used. However, the term Morphological Box is quite misleading, since the method utilizes a two-dimensional table rather than a three-dimensional box. For this reason, I think that the term "morphological matrix" is much more appropriate, although it is less frequently used. A mind map showing GMA and the concepts it is related to is shown in Figure 11.

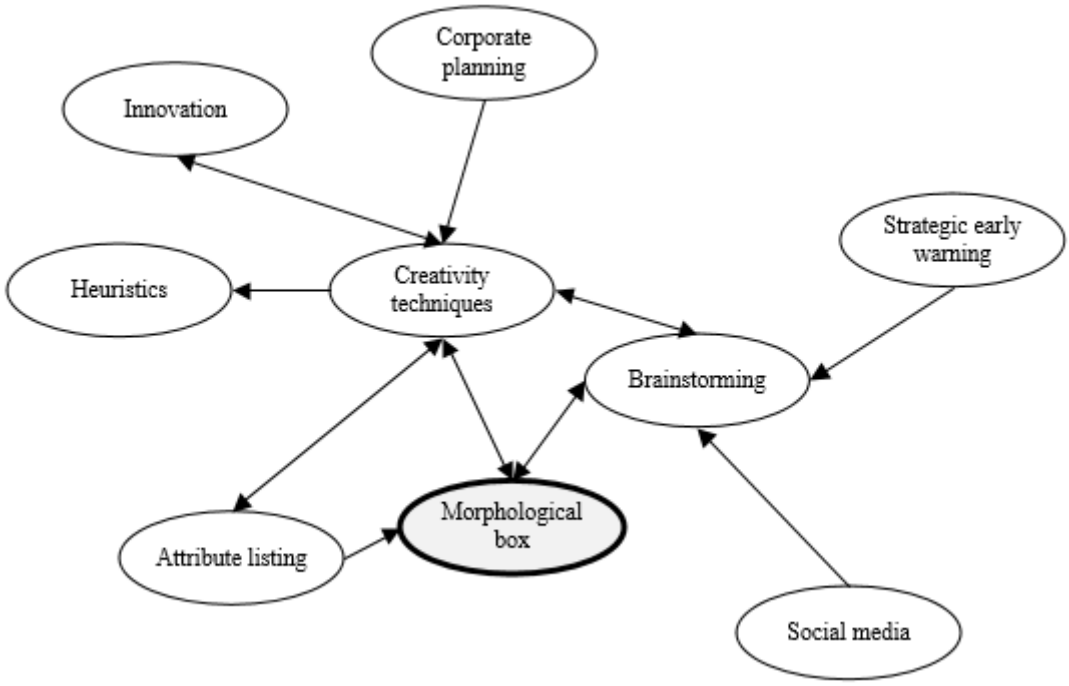

Figure 11: Taxonomy of GMA, Source: Own representation based on Markgraf, 2018.

Applying GMA

The process of applying GMA can be divided into three main steps:

1. First, the problem must be defined, analyzed, described and broken down into its relevant elements or parameters. These parameters of elements should be than inserted into the first row (or optionally first column) of a table with one column (or row in case) for each defined parameter. The parameters must be logically independent so that they can be freely combined. All parameters have to be usable for all possible solutions and they must carry relevant information about important details.

2. For each problem element, the possible characteristics must be worked out. The characteristics should than be inserted under each other below the elements.
3. In the following step, combinations of the elements' characteristics are developed as solution variants, and a preferred solution is selected.

For the sake of clarity, I am going to demonstrate the application of the method on a simple example. The goal of this arbitrary example is to develop a new car model for a car manufacturer. First the parameters are defined and filled into the matrix as seen on the upper table in Figure 9. The next step is to assign the possible characteristics to the parameters as seen on the table in the middle. The last step is to connect the chosen characteristics of all parameters in order to create a new car model, as seen in the last table in Figure 12.

Body type	Segment	Propulsion	Price segment

Body type	Segment	Propulsion	Price segment
SUV	A	Petrol	Under 10000 €
Cabriolet	B	Diesel	10000-15000 €
Sedan	C	Nuclear	15000-20000 €
Coupe	D	BEV	Above 20000 €

Body type	Segment	Propulsion	Price segment
SUV	A	Petrol	Under 10000 €
Cabriolet	B	Diesel	10000-15000 €
Sedan	C	Nuclear	15000-20000 €
Coupe	D	BEV	Above 20000 €

Figure 12: Example for the application of GAM

As seen in Figure 9, the chosen car is a B segment SUV with a petrol engine and a price of more than 25000 €. Of course, this is a very simplified example, but it showcases how GMA can be used to overview one's possibilities regarding a certain problem and help develop the best possible solutions with the help of existing knowledge about the topic of the examination. It can be seen through this short introduction about the morphological box, that it is a very versatile method, which only needs the user to have a firm knowledge about the field of activity. For these reasons and because the parameters for the TT models which I

have previously defined can easily be adapted into this concept, I think that GMA is a very convenient method for developing new models.

6.2. Creating a morphological matrix for technology transfer models

After getting familiar with the general morphological analysis as the chosen method for developing the new technology transfer models, the next step was to start using it and create the morphological matrix for the models. In this specific case, the problem was already defined, analyzed and described in previous chapters and the properties were also chosen in chapter 5.1.

Participants	Type of transfer	Financing	Applicability	Format	Channels
RTO	Project	Public funding	All KETs	Free consulting	Joint development
BSO	Within existing structures of participants' organizations	By RTO	Some KETs	Matchmaking	Sell patent or right to exploit tech.
Company	New company	By BSO	One KET	SME hackathon	Contract research
		By company		Organize fare/conference/workshop/symposium	MSc or BSc theses or PhD dissertation
		Crowd funding		SME survey	Use of technical infrastructure
		Shared financing		Promo lab	Training
		Membership fee		Prototyping	Consulting
		By SME			Publication

					Personnel transfer
					Meeting/Conference/Informal contact

Table 4: Morphological matrix for technology transfer models

For creating the morphological matrix for the new models, I used these properties with one modification. It is important to add, that SMEs are not mentioned within "Participants", since it is self-explanatory based on the topic of this work, that they are always involved in the process as receivers of technology. In chapter 5.1, a property named "Scope of operation" was identified. During the interviews, this property was used to summarize information related to the level on which the experts' organizations operate i.e. on a national level or internationally. However, since this work is done as part of the KETGATE project, it is already defined on which level the models should operate, and it would rather be important to determine, whether the model is applicable to all KET technologies or only to a reduced number of thereof. The reason why this topic was not discussed during the interviews is that none of the experts shared with me that they have processes which are specially intended for a specific branch of technology, but the Additive Manufacturing Technology Transfer project of TWI presented in chapter 4 is a good example for such a topic-specific TT model. Therefore, during the GMA the Scope of operation property was renamed to "Applicability" and it describes the type(es) of KET(s) the model is intended for. Another important new property had to be added to the model, which describes its organizational aspect. The property is named "Type of transfer" and it defines if the model should operate within the boundary of existing organizations or if a new company should be created for it. The morphological matrix for the TT models can be seen in Table 4. A summary of the characteristics under each property is presented in Table 5.

Participants	
RTO	Research and technology organizations (See chapter 3.1)
BSO	Business support organizations (See chapter 3.1)
Companies	These are companies participating in the process on the side of the "senders" of technology. They are usually manufacturers of equipment or machinery.
Type of transfer	
Project	This type refers to a setting where the participants of the TT model work within their existing organizations but as part of a separate project team created for the project.
Within existing	In this case, participants of the TT model remain in their original position in their existing companies (no project team is created)
New company	A new organization is formed, for the sake of executing the TT model.
Financing	
Public funding	The model is publicly financed for instance through a project of the state or the EU.
By RTO	The RTO is responsible for financing the model.
By BSO	The BSO is responsible for financing the model.
By company	The company (or companies) are financing the model (not the receiver SME(s)).
By SME	The SME has to bear the costs of TT.
Crowd funding	The model is financed through voluntary donations of individuals or groups of individuals.
Shared financing	The financing of the model is done by more than one party. This can mean, that for instance a participating university and a BSO are co-financing the model, or that the model is partially financed by the state and partially by the participants of the model. If the source of financing is more than one party, this field is chosen.
Membership fee	Costs related to the model are financed through periodic payments of the SME.
Applicability	
One KET	There is only one particular KET technology that fits the model.
Some KETs	The model can be used for more than one KET technology, but not all six.
All KETs	The model is applicable for all six KETs.
Format	
Free consulting	Offering free targeted consulting to the SME(s).
Matchmaking	Organizing an event where representatives of the demand and the supply side can formulate business relations.
SME hackathon	An event where SME teams compete with each other. A specified task with an explicitly measurable outcome is executed by all teams. The team with the best result could win free consulting or a discount for equipment.

Organize fare/conference/symposium	Organize an event such as a fare, a conference or a symposium to gather the participants of the model. Such events are very well suited for networking between the supply and demand side.
SME survey	Conduct interviews and audits at SMEs to understand the problems and challenges they are facing
Promo lab	A space where equipment manufacturers (company or RTO) can deploy their machines and SMEs have the opportunity to conduct pilot projects on them.
Prototyping	Create an early sample or model of a product built to test a concept or process.
Channels	
See chapter 3.3	

Table 5: Characteristics of the model's properties

6.3. Developed technology transfer models

Before presenting the developed models, I would first like to share some general remarks about the technology transfer models. One of the general and important topics that has to be regarded in all models is how RTOs promote themselves to SMEs. Of course, by utilizing as many channels as possible to contact SMEs, the chances of drawing their attention and awakening their interest is higher. It can generally be said, that it is of great importance to try and reach SMEs through as many channels as possible in order to showcase them that there are many opportunities for collaboration with RTOs. Through my research and the expert interviews, I have collected a list of possible contact channels, that can be seen in Figure 13.

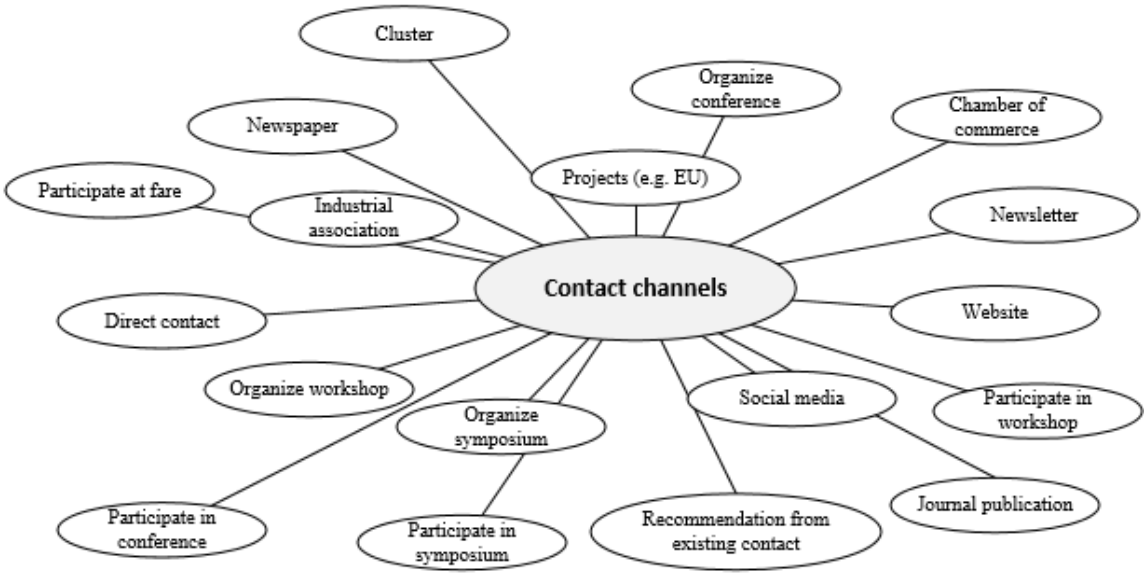

Figure 13: Channels for promoting RTO services to SMEs.

Source: Own representation based on the expert interviews.

Another important aspect that should always be considered is financing TT projects. The budget for innovation is very tight for most SMEs and so providing them with grants, zero-interest loans or other solutions that can stimulate them to innovate. Providing free consultancy should also always be very welcome from SMEs' side and it is also a good solution to promote RTO services.

Model I

Participants	Type of transfer	Financing	Applicability	Format	Channels
RTO	Project	Public funding	All KETs	Free consulting	Joint development
BSO	Within existing structures of participants' organizations	By RTO	Some KETs	Matchmaking	Sell patent or right to exploit tech.
Company	New company	By BSO	One KET	SME hackathon	Contract research
		By company		Organize fare/conference/workshop/symposium	MSc or BSc theses or PhD dissertation
		Crowd funding		SME survey	Use of technical infrastructure
		Shared financing		Promo lab	Training
		Membership fee		Prototyping	Consulting
		By SME			Publication
					Personnel transfer
					Meeting/Conference/Informal contact

Table 6: Morphological matrix of Model I

The first developed model is a solution based on the work of university students. This model envisions a trilateral collaboration between universities, RTOs and SMEs. The whole process should start with gathering companies who are open to admit their current challenges and problems. These challenges should be thoroughly assessed and summarized in form of short case studies that can be presented to students. Meanwhile, a list of one-pagers about

the offered technologies and services of participating RTOs should also be prepared. It is hereby important to mention, that while the concept could be applied to any discipline, as noted under the Applicability property, it is important to divide the pool of SMEs and students according to KETs, since it is unfair to expect from a material engineering student to find a solution for a problem in the field of nanoelectronics. The next step is to let students find solutions to the presented problems of SMEs by looking at solutions offered by RTOs and tailoring these – if necessary – to the needs of the SME. In case there is no offering found that is close to suiting the needs of the SME, the students can make a proposal for a fitting a solution. The work done by the students is the topic of their bachelor's or master's thesis. Of course, students should get support from all three sides and possibly even from TT experts from the project. The possibility for students to participate in a preparatory course before the project could also be offered if needed, and students could get the chance to work on their theses in pairs for the sake of improved efficiency. Students should be remunerated from project funds and there should be a possibility for SMEs to receive grants and favorable financing schemes from the project.

Sub-concepts

A possible alteration in the concept could be, if an RTO is large enough and has an adequate number of offered solutions by itself, then it could organize such an initiative by itself without the need of a separate project and other RTOs. It could also happen, that in order to provide a fitting solution to a problem, a mixture of the offering of more RTOs would need to be developed. Such a situation could foster other future collaborations between these participating RTOs, which in the long term could also benefit the whole research system of a country or region.

Evaluation

The biggest drawback of this model is, that it may prove difficult to conduct a whole TT project within a master's thesis (and especially a bachelor's thesis). It may also prove difficult to get SMEs to open up about their challenges.

On the other hand, this model could provide a relatively low-cost solution because of the involvement of students. The benefit for students is also clear, since they have to find a solution to a real-world problem, thus the learning potential for them is large.

The model can also provide a solution for the problem of uneven availability of KET technology providers across Europe, since the participating research institutes do not necessarily originate from the same county.

Model II

Participants	Type of transfer	Financing	Applicability	Format	Channels
RTO	Project	Public funding	All KETs	Free consulting	Joint development
BSO	Within existing structures of participants' organizations	By RTO	Some KETs	Matchmaking	Sell patent or right to exploit tech.
Company	New company	By BSO	One KET	SME hackathon	Contract research
		By company		Organize fare/conference/workshop/symposium	MSc or BSc theses or PhD dissertation
		Crowd funding		SME survey	Use of technical infrastructure
		Shared financing		Promo lab	Training
		Membership fee		Prototyping	Consulting
		By SME			Publication
					Personnel transfer
					Meeting/Conference/Informal contact

Table 7: Morphological matrix of Model II

The main feature of Model II is a space labeled with the name "Promo lab". A promo lab is a location with all necessary infrastructure for an RTO to deploy its equipment or machinery. SMEs could book appointments for pilot projects in order to allow them to test these machines or equipment and to see whether they could make use of it or if it is worth it to upgrade from their existing machinery. The RTO would also deploy staff at this facility in

order to be able to hold trainings and provide support to SMEs carrying out their projects. Another possibility would be to also have TT experts on site delegated by the project. Financing of the project can be considered as a form of cost sharing, since the project would provide the facilities – and optionally also some experts – while the RTO would need to invest by deploying machinery or equipment. SMEs should get further financial support and consulting if their experience with the project was good and they decide to invest into the acquisition of the tested machine.

Sub-concepts

A possible addition would be to financially support RTOs as well – perhaps in case of an unsuccessful SME pilot project. A big advantage of such a concept is, that in case the SME decides to invest into the new technology, they have already received training for it and also have collected some experience about its actual practical operation, which would surely make transferring the technology to them easier. The concept could be made topic-oriented, meaning that it would only deal with a certain KET, or it could also be available to all KETs. Another version of this concept would be the involvement of OEMs. In this case, the OEM would provide the pilot machinery while the RTO could deploy experts who would hold trainings and provide support for SMEs. RTOs could benefit from such a solution if they would also be allowed to use the pilot machinery to develop new methodologies on it for instance. The concept could have a pilot phase with space for one or maximum a couple of machines, and it could later be further developed to offer room for more pilot machines.

Evaluation

The biggest advantage of the model is that SMEs can experience the usage of the machines for a relatively long time, which can increase the chance of them getting used to the machine and recognizing its positive aspects.

The weakness of the model is, that if an SME does not want to purchase equipment after their pilot project, then the RTO loses a significant amount of time and money without any result.

Model III

Participants	Type of transfer	Financing	Applicability	Format	Channels
RTO	Project	Public funding	All KETs	Free consulting	Joint development
BSO	Within existing structures of participants' organizations	By RTO	Some KETs	Matchmaking	Sell patent or right to exploit tech.
Company	New company	By BSO	One KET	SME hackathon	Contract research
		By company		Organize fare/conference/workshop/symposium	MSc or BSc theses or PhD dissertation
		Crowd funding		SME survey	Use of technical infrastructure
		Shared financing		Promo lab	Training
		Membership fee		Prototyping	Consulting
		By SME			Publication
					Personnel transfer
					Meeting/Conference/Informal contact

Table 8: Morphological matrix of Model III

The next concept involves a kind of competition which is referred to as "SME marathon" in the matrix. This competition could be organized around a fitting topic like advanced manufacturing. An RTO should provide a piece of machinery or equipment, on which a group of SMEs that are active in the specific field of the competition would need to create their own solutions to a problem. Since this number of available equipment would most

probably be limited, the SME teams should provide their solution subsequently rather than simultaneously. The whole event could take place on one or two days and it could involve the basic training of the teams and it could provide matchmaking or consulting sessions for the "idling" teams. The task that the teams need to execute during the competition should have a result that can be explicitly and clearly measured in order to be able to fairly compare the teams' efforts. The winning team should receive a prize, which can be varied from offering free consultancy to giving away equipment or providing a discount for machinery. It is a positive aspect, that non-winning teams also benefit from attending the supplementary events organized as part of the competition and more importantly: they gather some experience about the machinery used at the competition, see what can be done with it and possibly get interested in investing into the acquisition of the machine for themselves. As always, providing financial aid to SMEs who are interested in the procurement of the machinery should also be kept in mind. This could possibly also be done through involving the state or the EU by requesting the financial support of the project.

Evaluation

The weakness of this model is that it can only be applied to a limited number of KETs (advanced manufacturing is probably the most fitting one or micro and nanoelectronics). It may also prove difficult for SMEs to afford to stay away from their daily business for several days in order to participate at the event.

On the other hand, a well promoted competition could bring great hype from the industry. Another very positive aspect is, that all SMEs win, even the losers: all SMEs have the possibility to try out equipment and they also can benefit from participating in the activities provided for the idling teams.

Model IV

Participants	Type of transfer	Financing	Applicability	Format	Channels
RTO	Project	Public funding	All KETs	Free consulting	Joint development
BSO	Within existing structures of participants' organizations	By RTO	Some KETs	Matchmaking	Sell patent or right to exploit tech.
Company	New company	By BSO	One KET	SME hackathon	Contract research
		By company		Organize fare/conference/workshop/symposium	MSc or BSc theses or PhD dissertation
		Crowd funding		SME survey	Use of technical infrastructure
		Shared financing		Promo lab	Training
		Membership fee		Prototyping	Consulting
		By SME			Publication
					Personnel transfer
					Meeting/Conference/Informal contact

Table 9: Morphological matrix of Model IV

Model IV is a concept that supports the market pull approach instead of the technology push approach utilized by some other models presented in this work. A big inspiration for developing such a model was the conversation with a very experienced expert in Interview 3. The main takeaway was to listen to the voice of SMEs and develop solutions that respond to their needs. For this reason, Model IV describes a concept of how new research projects

could be organized. As a first step, a group of participating RTOs should be recruited as well as a group of SMEs who are willing to share their challenges and work on finding solutions for them. Next, the challenges of SMEs are examined during interview sessions and company visits. The results of these examinations should than be examined to identify correlations between the needs of SMEs in order to use these within the development of the research goal of the project. After identifying the goals, joint research should be conducted by the RTOs and SMEs – possibly in facilities provided by the project. RTOs should be the leaders in these research projects, but SMEs should also support by giving feedback or taking over tasks that they can also execute. This does not necessary mean, that projects need to start from zero, since there is always a chance, that an RTO has a solution that can be used after making some amendments to it.

Sub-concepts

There could also be a version of this model, where only concepts of possible solutions are developed. Depending on whether concepts or actual products are developed, the outcome of a project can change between a concept presentation and some kind of an actual tangible result like machinery. Another alteration to the model would be to provide a common space where the researchers from different institutes could cooperate, however this would need enormous financial investments.

Evaluation

The weakest point of the model is, that it may need enormous efforts to organize such a project. It is also difficult for the participating RTOs to cooperate with each other without having a common space to work together.

On the other hand, such a concept can ensure, that research is always producing exactly the results that SMEs are seeking.

7. Conclusion

This section is dedicated to summarizing the work done in this thesis. In the first part of the work, a literature research was conducted to give an overview of Key Enabling Technologies and to identify the most important properties of the technology transfer process. Practical examples of technology transfer models were also collected from research institutes and examined. The found theoretical data was verified and supplemented with empirical data from expert interviews conducted with technology transfer specialists from five research institutes coming from different parts of Europe. Based on previous findings, technology transfer models were developed and presented. Implementation of the models was not part of this thesis, but the work done as part of it can be used as a basis for the implementation.

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Appendix

Appendix A

Processes

1) How do you come in touch with SMEs?
    a. What makes it hard to get in touch with SMEs?
    b. What channels seem to be effective in reaching SMEs? Why?
    c. What makes it hard to work together with SMEs?
    d. Which channels do SMEs seek for TT? Why?
    e. What critic/feedback do you usually get from SMEs about doing TT?
    f. What do you think SMEs seek the most from an RTO in TT?
    g. Which characteristics of SMEs are beneficial in TT?
    h. What channels do you prefer for TT to SMEs? Why?
2) Do you have any established process for technology transfer?
    a. What are the reasons for it being as it is?
    b. Does this process miss anything in your opinion?
    c. Are there any different processes for high-tech or low-tech transfers?
    d. If you consider Key Enabling Technologies, what makes it different in transferring them?
    e. How could a transfer process be organized for being successful? Channels? Communication? Contracts?
    f. Do you know about good practices at other RTOs that you could recommend to me?

Structures, Organization, System

1) Do you have a business development department?
    a. If yes:
        i. How big is it?
        ii. What type of professionals work there?
        iii. Which channels do they prefer for TT to SMEs?
            1. Why do they prefer these channels?
        iv. How does it work?
    b. If no:
        i. Why not?
2) Do you have a technology transfer office (TTO)?
3) Do you need specific infrastructure for successful transferring technologies? Eg. Pilot factory? Reference installations? Machining pool? …?
4) To what degree are researchers dealing with TT?

    a. Would it be better if they were less/more involved?
    b. Did they receive any special training for managing TT?
        i. Do you think this is/would be important?
5) Do you have TT experts?
    a. Is it/would it be worth it? Why?
    b. What is the educational background of the TT experts?
6) What do you think is the best way for SMEs to get their TT efforts financed? Why?
7) What do you think is the best way for SMEs to further develop their ability to work with RTOs? Why?
8) What do you think a “non-high tech” SME needs to be able to use KETs?
9) What do RTOs need to be able to efficiently do TT to non-high tech SMEs?
10) What are the most often seen barriers in TT to non-high tech SMEs and how would you overcome them?

A presentation of the models seen in chapter 4 were also presented to the experts and their opinion was asked about them.

Appendix B

Dear Sir or Madam,

my name is Márton Marinov, I am a mechanical engineering master's student at the Graz University of Technology in Austria. I am currently working on my master's thesis as part of the EU project "KETGATE". The topic of my thesis is the development of technology transfer models for research and technology organizations to transfer key enabling technologies to small and medium-sized enterprises. I would kindly ask you to support me by helping me to learn about current models and methods for technology transfer at research institutes by sharing any experience you have regarding my topic or by answering the following questions:

- How do you engage with SMEs?

- How do you make SMEs aware of your products and services?

- In what ways do you transfer technology to SMEs?

- What are the main difficulties that you encounter when dealing with SMEs?

Thank you in advance for your response!

Kind regards,

Márton Marinov

Appendix C

- What channels seem to be effective in reaching SMEs?
- Do you have any established process for technology transfer? IF NO: What channels do you prefer for technology transfer to SMEs?
- If you consider Key Enabling Technologies, what makes it different in transferring them?
- Who does technology transfer at your organization? Who should be dealing with it in an ideal case?
- What do you think is the best way for SMEs to get their technology transfer efforts financed?
- What are the most often seen barriers in tech transfer to non-high-tech SMEs and how would you overcome them?
- Do you think, that creating a center for topic-based collaboration between Uni, Non-uni research organizations and enterprises is a good solution regarding technology transfer to SMEs?
- Do you think, that offering free targeted support to SMEs could address their needs?
- Do you need specific infrastructure for successful transferring technologies? Eg.:
    - Pilot factory?
    - Reference installations?
    - Open lab?
- Do you think that organizing events to present your services and technologies is a good way to make SMEs interested?
- Do you think that maintaining a list of offered services and/or technologies is enough to make SMEs aware of your offerings?